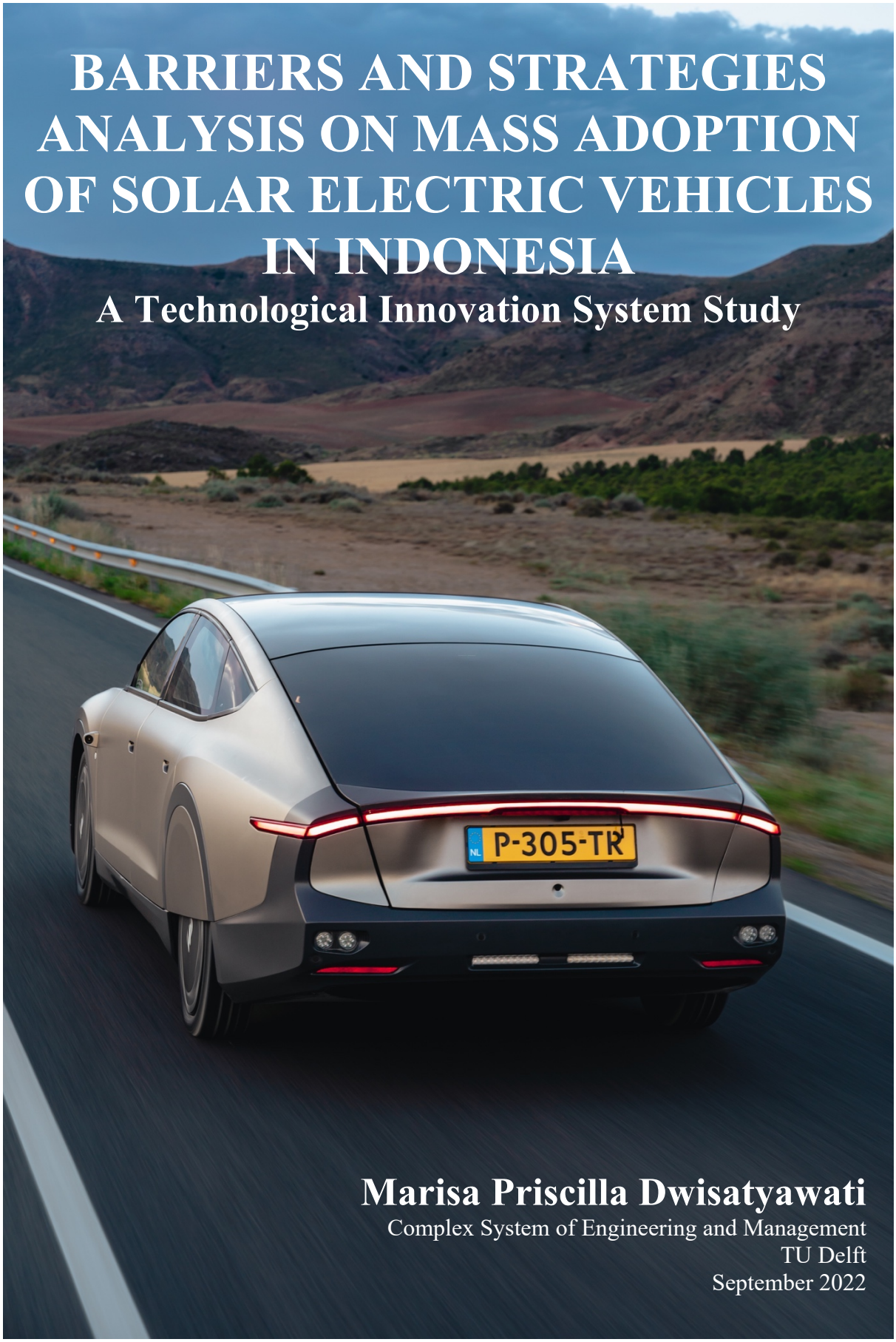
BARRIERS AND STRATEGIES ANALYSIS ON MASS ADOPTION OF SOLAR ELECTRIC VEHICLES IN INDONESIA

A Technological Innovation System Study



Marisa Priscilla Dwisatyawati
Complex System of Engineering and Management
TU Delft
September 2022

[This page is intentionally left blank]

BARRIERS AND STRATEGIES ANALYSIS ON MASS ADOPTION OF SOLAR ELECTRIC VEHICLES IN INDONESIA

A Technological Innovation System Study

Master thesis submitted to Delft University of Technology
in partial fulfilment of the requirement for the degree of

MASTER OF SCIENCE

in **Complex System Engineering and Management**
Faculty of Technology, Policy and Management

By

Marisa Priscilla Dwisatyawati
Student number: 4791150

To be defended in public in September 29, 2022

Graduation committee

Chairperson	: Dr. J.R. Ortt
First Supervisor	: Dr. L.M. Kamp
Second Supervisor	: Dr.ir. I. Bouwmans
Lightyear Supervisor	: Martijn Lammers

[This page is intentionally left blank]

Acknowledgement

Finally, it is time for me to write this page, which means that I am wrapping up my thesis to complete my master's study in Complex System Engineering and Management at TU Delft. These last three years have been interesting, amazing, and full of ups and downs. Doing a master's study twelve years after graduating with my bachelor's was very overwhelming. Not to brag, but my brain did way much better job back then! Combining the study with raising two little kids (they were one and three years old when I started this study) put the challenge to its next level. Additionally, the two years of the corona pandemic and lockdowns did not make it any easier either. It has been the toughest three years of my life. I have hit my bottom rock a couple of times. There were times when I wanted to give up. One thing made me stand up tall again: remembering that studying and living abroad have been my childhood dreams. Dreams that took me long and winding roads, as well as tons of efforts to finally come true, thus I told myself: you should not give up!

First and most importantly, I would like to thank my husband, Danny. Pursuing this master's study would not be possible without his endless support, love, and help. Thank you for your willingness to work harder in these last three years to make it possible for me to go on with my study. Second, to my kids: Kimberly and Trixie, thank you for being my other sources of strength and happiness. Thank you for accepting and understanding that mama cannot always be there during your school holidays or weekends. Abundant thanks to my big family, especially my parents who have been sending their prayers endlessly and always being very supportive in any steps of my life that lead me to who I am today. Thank you for teaching me to dream high and work hard to achieve my dreams.

To my graduation committees, I would like to express my utmost gratitude for your support and flexibility to accommodate my well-being. Thank you for reminding me to be realistic with my thesis plan and scope of work. I am very lucky to have you all. Special thanks to Linda, for your quick response and patience in answering my emails with endless questions. Also thank you for your guidance, advice, and feedback at every step of my research. This thesis would be impossible to finish without your help. For Ivo and Roland, thanks for your valuable and critical feedback that help me to enhance my report as well as myself.

To Martijn and Chris Vorster, thank you for giving me the opportunity to conduct this graduation project within Lightyear and be part of Lightyear's family. I have been enjoying my time at Lightyear. Even more, I have to say, Lightyear is the best company I ever worked for so far. Especially for Martijn, thank you for always making time to review my weekly progress and giving your valuable feedback on my analysis and report. It has been a great pleasure to work with you.

Lastly, I would like to say thank you to anyone I met during my time at TU Delft. It has been an enriching experience to be surrounded by smart, young, energetic, and ambitious people. I have learned a lot from you all. Also, for my other friends, everywhere you are, thanks for being there!

Marisa Priscilla Dwisatyawati
Dordrecht, July 2022

Executive Summary

Solar Electric Vehicles recently emerged in the market to solve dilemmas that have been hindering the EVs mass uptake: limited driving range, long charging time, and limited charging infrastructures. The SEV utilization is especially interesting for those who live in areas with many sun hours annually but have limited EV charging infrastructures. Interestingly, Indonesia is located along the equator, lacks EV charging facilities, and has a big market size for SEV. Even more, Indonesia has the urge to boost its decarbonization to meet its climate goals, especially in its transport sector. The combination of these facts leads to the overarching question if SEV could be easily mass adopted in Indonesia. However, the TIS perspective argues that, as part of a complex system of systems, SEV would need not only good technological features but also other "actors, factors and functions" to help it to reach its mass adoption (Ortt et al., 2013). Therefore, it leads to the main research question:

"From the technical innovation system perspective, how could solar electric vehicles reach mass adoption in Indonesia?"

This research is conducted in collaboration with Lightyear – a SEV producer. As Lightyear is aiming to mass produce its SEV, therefore, this research is conducted to explore and evaluate the Indonesian market, so that the best strategy recommendation could be provided to Lightyear so it could commercialize its SEV in a large scale in Indonesia. The qualitative research approach is implemented in this research by reviewing diverse online literature, including both scientific and grey literature.

The TIS Framework (Ortt & Kamp, 2022) and the Ten Niche Strategies framework (Ortt et al., 2013) are used as the starting point of the research. TIS is defined as innovation systems around a specific technology that consists of four main elements: the technology, a network of actors, the institutions, and the demand. Ortt & Kamp's TIS framework is a tool to examine the TIS of an innovation that is in its adaptation phase to judge whether the innovation is ready for its mass uptake or whether a small-scale niche introduction strategy is needed prior to the large-scale diffusion. The framework consists of three major elements: TIS building blocks (most important aspects needed for large-scale diffusion), influencing factors, and strategies. When certain influencing factors negatively affect the completeness of the TIS building blocks, they pose as barriers to the mass adoption of the innovation. Certain strategies could be implemented to circumvent these barriers, such as the generic Ten Niche Strategies proposed by Ortt et al.

The research is conducted in four major steps. First, basic information about SEV technology is explored. Second, a new framework called "the Best Strategy Framework" is developed to extend and complete the original TIS Framework and Ten Niche Strategies Framework so that the users/readers could select the best strategy based on the combination of barriers that hinder mass adoption of the innovations. Third, the newly developed framework is used to evaluate the Indonesian market and to identify the barriers that might hamper Lightyear's SEV mass adoption in Indonesia. Finally, by using the newly developed framework, the best strategy that could circumvent the identified barriers is selected and proposed to Lightyear.

In the first step of the research, it is known that compared to conventional EVs, SEV is similar to BEV, but its extra solar panels on the roof (and body). This extra feature enables SEV to generate its own "fuel" for free with zero well-to-wheels emission, as well as extends the car's driving range, makes the car less dependent on the battery and the charging facilities, and

reduces charging frequency, time, and hassle. However, SEV is weather dependent. Moreover, one might argue that looking at its life cycle, SEV might produce more emissions compared to other EVs due to its additional major component: solar panels.

In the second step of the research, the literature review resulted in the identification of seven TIS building blocks, eleven influencing factors, and forty strategies that become the basis of the new framework called the Best Strategy Framework, as listed in the following tables.

No.	TIS Bulding Blocks	(New or Adapted) Influencing Factors
1	Product availability, performance, and quality	Knowledge and awareness of technology
2	Product price	Knowledge and awareness of application and market
3	Production system	Competition
4	Complementary products and services	Macro-economic and strategic aspects
5	Network formation and coordination	Accidents and events
6	Customers	Human resources
7	Innovation-specific institutions	Natural resources
8		Financial resources
9		Socio-cultural aspects
10		Institutional aspects and political system
11		Physical/information access & infrastructure

(New) Strategies			
1	Demo, experiment, and develop niche strategy	21	Corporate restructuring strategy
2	Top niche strategy	22	Buy one - give one strategy
3	Subsidized niche strategy	23	Campaign funding strategy
4	Redesign niche strategy	24	Stepping-stone strategy
5	Dedicated system or stand-alone niche strategy	25	Network building strategy
6	Hybridization or adaptor niche strategy	26	Get specified strategy
7	Educate niche strategy	27	Local strategy
8	Geographic niche strategy	28	Complementary technologies, products, services strategy
9	Lead user niche strategy	29	Product variants strategy
10	Explore multiple markets niche strategy	30	Cross-selling and financing strategy
11	Technological R&D strategy	31	Existing social network strategy
12	Human resource management strategy	32	Result-oriented contracting strategy
13	Internal knowledge sharing strategy	33	Turnkey product strategy
14	Partnership strategy	34	Incentives strategy
15	Finance sourcing strategy	35	Local implementation strategy
16	Lobbying strategy	36	Market positioning strategy
17	Influencer marketing strategy	37	In-house network strategy
18	Crowd-sourcing strategy	38	Aggresive penetration strategy
19	Leasing strategy	39	Preannouncing strategy
20	Sharing economy platform strategy	40	Blue ocean strategy

From above tables, it could be seen that some influencing factors are the results of an adaptation from existing framework, while some factors are newly identified factors. The adaptation of existing influencing factor and the identification of new influencing factors in the present work are deemed to be very important findings as the adapted/new factors capture more possible barriers to be aware of, so that they could be well-addressed with more specific strategies.

Three influencing factors are adapted from the original framework, which originally were one combined factor called “Natural, human, and financial resources”. Agree with the importance of this factor, the author of the present work saw the needs to better address each element of the factor, as they could lead to different barriers. Therefore, in the present work, this factor split into three factors, to make them more specific. By splitting it, better and more specific links could be defined between the barriers and strategies, hence better strategy could be chosen

to overcome the barriers. In other words, the splitting of the original factor optimizes the results of the best strategy selection.

Furthermore, two new influencing factors are added in the present work: "Institutional aspects and political system" and "Physical/information access and infrastructure". These factors are especially crucial as they influence the success of penetrating new/foreign market. Even though institutional aspect has been defined as one of the TIS building blocks in the original framework, however, as the status of institutional aspect as well as political system and its stability could significantly influence the status of other TIS building blocks, therefore, the author of the present work decided to add this factor as a new influencing factor. In other words, adding the "Institutional aspect and political system" as a new influencing factor captures new barriers that was not captured by the original version of the framework. In addition, market accessibility defines the easiness for the company to gain the crucial market-related information such as the competition in the market, as well as the customers' demands, needs, and buying power. This barrier is extremely threating when the market is new, and the company has limited knowledge about the market. As this barrier was not captured in the original framework, therefore, market accessibility is added as another new influencing factor called "Physical/information access & infrastructure".

Subsequently, hundreds of links between the barriers and strategies are identified based on the previous work of other researchers, as well as by the author of the present work based on her logical thinking. To complement the framework, two scoring models are proposed to enable the selection of the best strategy. The first scoring model aimed to select the best strategy that could circumvent most of the barriers, while the second one aimed to prioritize the best strategy based on its capability in circumventing the most important and threatening barriers.

In the end of the second step of the research, the combination of the newly defined TIS building blocks, influencing factors, potential strategies, link between the barriers and strategies, and the scoring models shaped the new framework called the Best Strategy Framework.

TIS Building Blocks	Status	Influencing Factors
Product availability, performance, and quality	ORANGE	(1) knowledge and awareness of application and market (2) financial resources
Product price	ORANGE	(1) knowledge and awareness of application and market (2) competition (3) natural resources
Production system	RED	(1) knowledge and awareness of application and market (2) financial resources
Complementary products and services	GREEN	N/A
Network formation and coordination	RED	(1) knowledge and awareness of application and market
Customers	ORANGE	(1) knowledge and awareness of technology (2) financial resources (3) competition
Innovation-specific institutions	ORANGE	(1) financial resources (2) socio-cultural aspects
Note: RED: TIS building block is not available ORANGE: TIS building block is available but incomplete/insufficient to support mass adoption GREEN: TIS building block is available and complete to support mass adoption		

In the third step of the research, the implementation of the Best Strategy Framework in the Indonesia study case suggests that thirteen barriers hamper the mass adoption of Lightyear's SEV in Indonesia if Lightyear is going to penetrate the market now, as listed in the above table. Three influencing factors have the most influence on the unavailability and incompleteness of the building blocks, namely (1) knowledge and awareness of application and market, (2) financial resources, and (3) competition. Therefore, these are the most important and most threatening factors.

In the last step of the research, the best strategy recommendation is formulated based on the identified barriers. Two scoring models are used to choose the best strategy, in which the scoring model 1 aims to choose the best strategy that could circumvent most of the barriers by putting the same weight on each identified barrier, while the scoring model 2 aims to choose the best strategy that could circumvent the most important and threatening barriers by putting different weight on each barrier depends on their level of importance and threats. Interestingly, both scoring models resulted in the same best strategy. It is suggested that Lightyear should start to extend its network with relevant stakeholders in Indonesia and build strategic partnerships with them to gain more power, resources, and better access to the market. These strategies are deemed to be the best ones that could circumvent the most important and threatening barriers as well as all the identified barriers at the same time.

Rank	Best Strategies Resulted from Scoring Model 1	Best Strategies Resulted from Scoring Model 2
1st	Partnership strategy and Network building strategy	Partnership strategy and Network building strategy
2nd	Geographic strategy	Geographic strategy
3rd	Explore multiple market strategy	Educate strategy
4th	Top niche strategy, Redesign strategy, Educate strategy, Lead user strategy, Pre-announcing strategy	Pre-announcing strategy
5th		Explore multiple market strategy
6th		Lead user strategy

To maximize the adoption rate of Lightyear's SEV in Indonesia, the author included other high-ranked strategies in the recommendation. Both scoring models resulted in similar strategy recommendations. However, scoring model 2 is more specific in prioritizing the strategy based on the most important and threatening barriers. The translation of the strategy recommendation is explained in the following.

It is suggested that Lightyear should focus its early market penetration in Indonesia in its biggest cities: Jakarta, Surabaya, Medan, Bali, and Bandung, as people living in these areas, have higher buying power and better education background than average Indonesian. Additionally, Lightyear should explore different market segments in Indonesia to see if there is a better market segment to focus on. Educating the potential customers by socializing the added values and benefits of SEV is another crucial strategy to boost the adoption rate. To complement this, the framework also advises Lightyear to pre-announce its market release in Indonesia to give sufficient time for the potential customers to get familiar with the innovation as well as the chance to manage and prepare their financial resources in case they are interested to acquire the product. This strategy is even more important, seeing the fact that Indonesia is a big country with more than 230 million citizens, which means raising product and brand awareness among Indonesia's potential customers might take a while. Lastly, the framework suggests that Lightyear should focus its early market to reach top niche customers as well as lead users such as taxi and ride-hailing providers, the government agency, and car rental owners as they have less strict financial limitations.

In the end, this research provides important contributions and novelty, signified by (1) the adaptation of an existing influencing factor and the identification of new influencing factors that could influence the TIS building blocks status, and hence might lead to the emerge of new niche development barriers, (2) the identification of new potential strategies that could circumvent the niche development barriers, (3) the identification of possible relationship between all the identified barriers and strategies, (4) the approach of mapping the relationships between the barriers and strategies into a matrix to enable the selection of a strategy that could circumvent multiple barriers at the same time, (5) the utilization of the barriers and strategies matrix and two scoring models which formed the so-called the Best Strategy Framework that enable the best strategy selection, (6) the identification the latest EV development status in Indonesia, (7) the identification of Lightyear's SEV development barriers in Indonesian market, (8) the recommendation of the best strategy for Lightyear to enable it to diffuse its SEV in a large scale in Indonesia, and lastly (9) this research act as novel literature of SEV in Indonesia.

List of Abbreviations

BEV	Battery Electric Vehicle
CoSEM	Complex System Engineering and Management
EU	European Union
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
LCEV	Low-Carbon Emission Vehicles
MLP	Multi-Level Perspective
Mtoe	Million tons of oil equivalent
MRQ	Main Research Question
PHEV	Plug-in Hybrid Electric Vehicle
SEV	Solar Electric Vehicle
SRQ	Sub-Research Question
TIS	Technological Innovation System
TCO	Total Cost of Ownership
WLTP	Worldwide Harmonized Light Duty Vehicles Test Procedure

Table of Contents

Acknowledgement ..... *i*
Executive Summary ..... *ii*
List of Abbreviations ..... *vii*
Table of Contents ..... *viii*
List of Figures ..... *xi*
List of Tables ..... *xii*
Chapter 1. Introduction *1*
1.1. General Background **1**
1.1.1. The Emergence of Solar Electric Vehicles 1
1.1.2. Lightyear – The Company Profile 1
1.1.3. Indonesia's Climate Change Challenges vs it's EV Development 3
1.2. Problem Definition and Research Objectives **4**
1.3. Research Scope **5**
1.4. Literature Review to Identify Knowledge Gaps **5**
1.4.1. Literature search methodology 5
1.4.2. Knowledge Gaps Identification 8
1.5. Main Research Questions **9**
1.6. Research Approach and Sub-Research Questions **9**
1.7. Methodology **10**
1.8. Deliverables **12**
1.9. Report Structure **12**
Chapter 2. Theoretical Background *13*
2.1. Disruptive Innovations **13**
2.2. Technological Innovation System **14**
2.3. Market Introduction Strategies: Mass Market vs Niche Market **15**
2.4. Ortt & Kamp's TIS Framework **17**
2.5. Ortt's Ten Niche Strategies to Commercialize New High-Tech Products **21**
Chapter 3. Solar Electric Vehicles *24*
3.1. Solar Electric Vehicle as a Disruptive Innovation **24**
3.2. Introduction to Solar Electric Vehicles **25**
3.3. Chapter Conclusion and Summary **28**
Chapter 4. Potential Strategies to Reach Large Scale Diffusion *29*
4.1. Potential Strategies Based on Master's Thesis Reports **29**
4.1.1. Step 1: Literature Search 29
4.1.2. Step 2: Identification 31
4.1.3. Step 3: Results 42
4.2. Potential Strategies Based on Journals **44**
4.2.1. Step 1: Literature Search 44
4.2.2. Step 2: Identification 45

4.2.3. Step 3: Results 55
4.3. Chapter Conclusion and Summary 57
Chapter 5. The Best Strategy Framework 62
5.1. Potential Links between the Barriers and Strategies 62
5.2. Scoring Models to Choose the Best Strategy 65
5.2.1. Scoring Model 1: Same Weighted Scoring 66
5.2.2. Scoring Model 2: Different Weighted Scoring 69
5.2.3. Insights from the Scoring Model 1 vs Scoring Model 2 72
5.3. Chapter Conclusion and Summary 72
Chapter 6. (Solar) Electric Vehicle Development in Indonesia 76
6.1. Current Electric Vehicles Ecosystem in Indonesia 76
6.2. Barriers to Lightyear's SEV Development in Indonesia 79
6.2.1. Product availability, performance, and quality 80
6.2.2. Product price 81
6.2.3. Production system 82
6.2.4. Complementary products and services 82
6.2.5. Network formation and coordination 83
6.2.6. Customers 83
6.2.7. Innovation-specific institutions 85
6.3. Chapter Conclusion and Summary 86
Chapter 7. The Best Strategy to Reach SEV Mass Adoption in Indonesia 90
7.1. The Best Strategy Selection by Using the Scoring Model 1 90
7.2. The Best Strategy Selection by Using the Scoring Model 2 94
7.2.1. Defining the Weights of Each Identified Barrier 94
7.2.2. The Scoring Model 2 Results 95
7.3. The Best Strategy of Scoring Model 1 vs Scoring Model 2 98
7.4. Chapter Conclusion and Summary 99
Chapter 8. Discussion 101
8.1. Implications of Lightyear's SEV Mass Adoption in Indonesia 101
8.2. Reflections 101
8.2.1. Reflection on the Methodology 101
8.2.2. Reflection on the Framework 102
8.3. Research Relevance 103
8.4. Limitations 105
8.4.1. Limitations of the Study 105
8.4.2. Limitations of the Best Strategy Framework 106
8.5. Recommendation for Relevant Stakeholders 106
8.5.1. Indonesian Government 106
8.5.2. Lightyear 107
8.5.3. Taxi and Ride-Hailing Providers 107
8.5.4. PLN (State-Owned Electricity Company) 107
8.6. Recommendation for Future Research 108
Chapter 9. Conclusion 110
9.1. Answer to the Sub-Research Questions 110
9.1.1. SRQ1: "How is solar electric vehicles different than conventional electric vehicles?" 110

9.1.2. SRQ2: “Based on the existing theories in the literature, how could the niche development barriers be linked to the niche strategies so that a niche strategy that could circumvent several barriers at once could be selected?” 110
9.1.3. SRQ3: “Based on the previously developed “The Best Strategy Framework”, which actors, factors, and functions could be the barriers for SEV to reach its mass adoption in Indonesia?” 113
9.1.4. SRQ4: “Based on the identified barriers that could hinder SEV development in Indonesia, which strategy could circumvent most of the barriers or the most threatening barriers at the same time?” 114
9.2. Answer to the Main Research Question 116
References 118
Appendix A. Extra Information on Potential Strategies to Reach Large Scale Diffusion 128
A.1. Identification of Potential Strategies Based on Master’s Thesis Reports 128
A.1.1. Developing a conceptual model on strategies overcoming barriers for the introduction of radical innovations in niches by Jara Schulz 128
A.1.2. Dutch cooling technology in the desert: A market study on district cooling for Dutch companies based on niche strategies to commercialize high-tech products by Stefan Olsthoorn 131
A.1.3. Niche strategies selection in developing countries: a case study on RE-desalination by Nicole Jane van den Berg 135
A.2. Analysis of Strategies Identified from Master’s Thesis Reports 138
A.3. Identification of Potential Strategies Based on Journals 148
A.4. Analysis of Strategies Identified from Journals 149
Appendix B. Arguments on Links Between a Barrier and Strategies Identified by the Author 156
Appendix C. Supportive Institutions in Indonesia 159
C.1. National Master Plan for Industry (RIPIN) 2015 – 2035 159
C.2. National Energy Plan (RUEN) 159
C.3. Presidential Regulation No.55/2019 on Battery Electric Vehicles and Its Derivatives 160
C.4. Incentives for EV Customers 161
C.5. Incentives for EVs Industries in Indonesia 162
C.6. EV Infrastructure-related Policies 164

List of Figures

Figure 1 Various solar electric vehicles currently available in the market. Left to right: Lightyear 0 (Lightyear, 2021), Sion (Sono Motors, 2021), Aptera (Aptera Motors, 2022)..... 1
Figure 2 The technology of Lightyear 0 (Lightyear, 2022b)..... 2
Figure 3 The specification of Lightyear 0 (Lightyear, 2022a)..... 2
Figure 4 Indonesia energy supply per type of fuels (PJ). Source: (Climate Transparency, 2020)..... 3
Figure 5 Annual CO_2 emissions from fuel combustion in Indonesia per sector ($MtCO_2$/year). Source: (Climate Transparency, 2020)..... 4
Figure 6 The process of literature search step 1..... 6
Figure 7 The process of literature search step 2..... 8
Figure 8 Research flow diagram..... 12
Figure 9 Multi-level perspective on technological transitions (Geels & Schot, 2007)..... 15
Figure 10 Market introduction flow diagram..... 16
Figure 11 Ortt & Kamp's TIS framework (Ortt & Kamp, 2022)..... 18
Figure 12 Guidance on how to use the Ortt & Kamp framework..... 20
Figure 13 Comparison of different types of EVs currently available in the market (Gaton, 2018)..... 25
Figure 14 Technological map of the solar electric vehicle compared to conventional battery electric vehicle..... 26
Figure 15 Well-to-wheel efficiency comparison between various EVs (Cobbenhagen & Hoefsloot, 2015a)..... 27
Figure 16 The process of the literature search conducted to identify the potential strategies based on adapted barriers and strategies framework..... 30
Figure 17 The process of the literature search conducted to identify the potential strategies based journals..... 44
Figure 18 Socio-technical elements of sustainable innovations (Naor et al., 2015)..... 45
Figure 19 Most critical barriers and strategies of sustainable energy technologies in the construction industry in Pakistan (Iqbal et al., 2021)..... 47
Figure 20 Conceptual model of differential effectiveness of market entry strategies (Montaguti et al., 2001)..... 49
Figure 21 Stakeholder map of EV development in Indonesia..... 76
Figure 22 The implementation of the Market introduction flow diagram (Figure 10) to the study case up to this point of research..... 88
Figure 23 The implementation of the Guidance on how to use the Ortt & Kamp framework (Figure 12) to the study case up to this point of research..... 89
Figure 24 Illustration of the framework with the newly added element: Actors and Influencing factors, as well as their relationship with the current elements..... 108
Figure 25 The identified barriers and strategies, and the links between them (Schulz, 2019)..... 128
Figure 26 Summary of Fiscal and Non-Fiscal Incentives Offered by Presidential Regulation No. 55/2019 for BEV, extracted from (KPMG Indonesia, 2021)..... 160
Figure 27 Comparison of six year vehicle ownership cost of three different vehicle types in Indonesia, before and after the luxury tax incentive program (Chen et al., 2022)..... 162

List of Tables

Table 1 List of search queries used in the literature search step 1 5
Table 2 List of selected articles as the results of the literature search..... 7
Table 3 Overview of the research methods and the data analysis tools for each sub-research question..... 11
Table 4 Ten generic niche strategies developed by Ortt et al. (2013) 21
Table 5 The barriers and strategies matrix extracted from (Ortt et al., 2013) 23
Table 6 List of reviewed master's thesis reports to identify the potential strategies..... 30
Table 7 Possible barriers based on the combination of TIS building blocks and influencing conditions (Schulz, 2019) 31
Table 8 The barriers and strategies matrix based on Schulz findings 32
Table 9 The barriers and strategies matrix based on Olsthoorn findings 35
Table 10 The barriers and strategies matrix based on Van den Berg findings 39
Table 11 The list of consolidated TIS building blocks that were identified by Ortt & Kamp (2022) and various master thesis literatures 42
Table 12 The list of consolidated influencing factors that were identified by Ortt & Kamp (2022) and various master thesis literatures 42
Table 13 The list of consolidated strategies that were identified by Ortt et al. (2013) and various master thesis literatures..... 43
Table 14 List of relevant journals to identify potential strategies 44
Table 15 Identified functional barriers and strategies implemented to overcome them - insights from an EV infrastructure company (Naor et al., 2015) 46
Table 16 Identified psychological barriers and strategies implemented to overcome them - insights from an EV infrastructure company (Naor et al., 2015) 46
Table 17 Identified barriers and strategies implemented to overcome them – insights from PV deployment by various solar PV producers in the US, Japan, and Germany (Strupeit & Palm, 2015)..... 47
Table 18 Identified barriers and strategies of renewable energy technologies adoption in rural areas in Bangladesh. Information extracted from (Alam et al., 2010) 48
Table 19 Identified barriers of Tesla's BEV adoption (Hardman et al., 2014) 49
Table 20 Identified strategies of Tesla's BEV adoption (Hardman et al., 2014) 49
Table 21 The relationship between the market entry strategies and the factors that influencing their effectiveness (Montaguti et al., 2001)..... 50
Table 22 Identified barriers and strategies of Tesla (Stringham et al., 2015) 53
Table 23 The list of consolidated strategies that were identified by Ortt et al. (2013), various master thesis literatures, and journals..... 56
Table 24 The final list of TIS building blocks that were identified from reviewed literature. 57
Table 25 The final list of influencing factors that were identified from reviewed literature .. 58
Table 26 The final list of strategies that were identified from reviewed literatures and their categorization..... 59
Table 27 The Best Strategy Framework with two sets of potential links: (1) links identified by the author, indicated by purple blocks and (2) links identified by other researchers, indicated by numbers 63
Table 28 Scoring example by using the scoring scenario 1 67
Table 29 Assumed potential barriers and their weights 69
Table 30 Scoring example by using the scoring scenario 2 70
Table 31 The Best Strategy Framework..... 73

Table 32 The role of each state-owned enterprises (SOEs) within the EV battery supply chain, extracted from (KPMG Indonesia, 2021) 77
Table 33 Specifications and price of some of the EVs currently available in Indonesia (Auto Data, 2022; Ccarprice, 2022; Cekpremi, 2021; Chua, 2020; CNN Indonesia, 2022; Encycarpedia, 2018, 2019; EV Database, 2022f, 2022c, 2022b, 2022g, 2022d, 2022i, 2022e, 2022j, 2022a; Lightyear, 2022a; Mendagri, 2021; Otomotifo, 2020; Pamungkas, 2022; RCTI Plus, 2022). The price in EUR is based on June 2022 exchange rate. 80
Table 34 Number of EVs sold in Indonesia in the last three years, data extracted from (Gaikindo, 2021a, 2021b, 2022) 84
Table 35 The status of Lightyear's TIS building block for Indonesian market, factors that negatively influencing the status, and the main influencers 86
Table 36 The best strategy selection for Indonesia study case by using the scoring model 1 91
Table 37 Strategies with highest scores based on the implementation of the Best Strategy Framework with scoring model 1 93
Table 38 Weights assigned for each identified barrier to enable the best strategy selection by using the scoring model 2 94
Table 39 The best strategy selection for Indonesia study case by using the scoring model 2 96
Table 40 Strategies with highest scores based on the implementation of the Best Strategy Framework with scoring model 2 98
Table 41 The result comparison between scoring model 1 vs scoring model 2 98
Table 42 The best strategies to circumvent Lightyear's SEV development barriers in Indonesia, based on the Best Strategy Framework with scoring model 1 and scoring model 2 99
Table 43 The Best Strategy Framework (the same as Table 31) 111
Table 44 The status of Lightyear's TIS building block for Indonesian market and factors that negatively influencing the status (the same as Table 35) 113
Table 45 Weights assigned for each identified barrier to enable the best strategy selection by using the scoring model 2 (the same as Table 38) 115
Table 46 The best strategies to circumvent Lightyear 2 development barriers in Indonesia, based on the Best Strategy Framework with scoring model 1 and scoring model 2 (the same as Table 42) 115
Table 47 List of adapted and/or new core factors and influencing factors in comparison to the original ones (Olsthoorn, 2017) 131
Table 48 Brief description of proposed core factors and influencing factors (Olsthoorn, 2017) 132
Table 49 The identified barriers and strategies, and the links between them (Olsthoorn, 2017) 133
Table 50 List of adapted and/or new core factors in comparison to the original ones (Van den Berg, 2017) 135
Table 51 List of adapted and/or new influencing factors in comparison to the original ones (Van den Berg, 2017) 136
Table 52 The identified barriers and strategies, and the links between them (Van den Berg, 2017) 137
Table 53 Overview of all TIS building blocks identified by Ortt & Kamp (2022) and various master thesis literatures, actions will be implemented on them to eliminate the same or similar ones, and the supporting arguments 140
Table 54 Overview of all influencing factors identified by Ortt & Kamp (2022) and various master thesis literatures, actions will be implemented on them to eliminate the same or similar ones, and the supporting arguments 142

Table 55 Overview of all strategies identified by Ortt et al. (2013) and various master thesis literatures, actions will be implemented on them to eliminate the same or similar ones, and the supporting arguments..... 144
Table 56 Identified barriers and strategies of sustainable energy technologies in the construction industry in Pakistan (Iqbal et al., 2021)..... 148
Table 57 Brief explanation on identified strategies to the adoption of sustainable energy technologies (Iqbal et al., 2021) 149
Table 58 Overview of all identified strategies from journals, actions implemented on them to eliminate the same or similar ones, and the supporting arguments..... 151
Table 59 Three major development stages for EV industry as set by Indonesia's National Master Plan for Industry 2015 – 2035, extracted from (Mahalana & Yang, 2021) 159
Table 60 Passenger vehicle taxes in Indonesia, data extracted from (Chen et al., 2022; Mahalana & Yang, 2021) 161
Table 61 Luxury tax rate enforced in Indonesia starting October 2021, extracted from (Mahalana & Yang, 2021). Note: LCGC is car priced under IDR 95 million (around USD 6,500) with fuel economy of at least 20km/L and engine smaller than 1500cc. 161
Table 62 The amount and duration of tax holiday offered for pioneer industries who put new investments in Indonesia 163
Table 63 Pioneer industries illegible for the tax holiday (Mahalana & Yang, 2021)..... 163

[This page is intentionally left blank]

Chapter 1. Introduction

1.1. General Background

1.1.1. The Emergence of Solar Electric Vehicles

Figure 1 Various solar electric vehicles currently available in the market. Left to right: Lightyear 0 (Lightyear, 2021), Sion (Sono Motors, 2021), Aptera (Aptera Motors, 2022)

Research argued that electrifying the vehicles could significantly decarbonize the transportation sector (Climate Action Tracker, 2019; Climate Transparency, 2020). However, despite the green image that electric vehicles (EVs) have, society has been reluctant to switch their internal combustion engine (ICE) vehicles to EVs due to EVs' limited driving range, long charging time, limited charging infrastructures, and more expensive up-front investment compared to ICE vehicles (Schoeps, 2021; William, 2021). Taking advantage of these dilemmas, solar electric vehicles (SEVs) such as Lightyear 0, Sion, and Aptera (see Figure 1) emerged to solve most of these problems. The solar cells on the vehicle could extend the car driving range, especially when it drives during the day. Moreover, long charging time could be reduced as it could recharge itself during the day. In addition, the presence of solar cells could reduce car dependency on charging facilities (Lightyear, 2021). With these added values, SEVs might have big market potential in the developing countries that have limited EV charging facilities but have abundant sun. Therefore, this research is conducted as part of Lightyear's long-term strategy to have a closer look into the potential market of these specific regions, for example, Indonesia.

1.1.2. Lightyear – The Company Profile

Lightyear history started back in 2012 to achieve their mission: to provide clean mobility for everyone, everywhere. Shortly after being founded, Lightyear officially announce its Lightyear One – its first and exclusive edition - to public in 2017 and received its first orders. The design of Lightyear One was unveiled in 2018 to show the life-size model including the physical solar roof and chassis prototype, while the SEV prototype was unveiled in 2019. In June 2022, the final design is revealed, as well as the rebranding in which Lightyear One is renamed to Lightyear 0.

The first production of Lightyear 0 is expected around the end of this year. The company planned to produce only the maximum of 946 SEV for this exclusive edition which will be available in EU, Norway, and Switzerland with purchase price of €150,000 excluding taxes for the early birds and €250,000 for the normal price (Lightyear, 2021). The second version of the SEV, which is called Lightyear Two will be released at the end of 2025 aiming for a mass production globally. With the economics of scale, Lightyear aims to make the SEV more affordable with the pricing started at €30,000 (Gauthier, 2021).

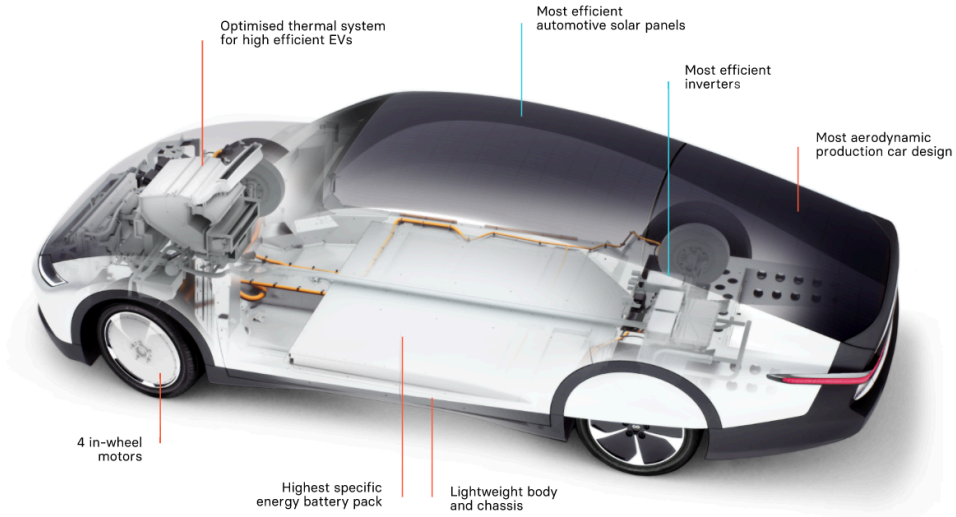


Figure 2 The technology of Lightyear 0 (Lightyear, 2022b)

General

Practical range	1,000+ km driving range between two charging moments[1]
Battery range	625 km (WLTP)[2]
Highway range (at 110 km/h)	560 km[3]
Additional daily solar range	Up to 70 km[4]
Annual solar yield	Up to 11,000 km[4]
Battery pack	60 kWh
Acceleration	0 - 100 km/h in 10 seconds
Top speed	160 km/h
Charging speeds	Amount of range in 1 hour charging
	Home charging (regular household plug) 32 km/h Public charging 200 km/h Fast charging 520 km/h

1 Based on a 50 km workday commute in Amsterdam in summer. Driving range will vary depending on driving habits, location and season.
2 Pending final verification tests.
3 Verified by Lightyear Production Intent Vehicle 012 in June 2022.
4 Based on a 35 km workday commute in Southern Spain in spring and summer.

Exterior

Dimensions (L x W x H)	5083 x 1972 x 1445 m
Weight	1,575 kg
Ground Clearance	183 mm
Solar array	5 m² double curved
Body panels	Reclaimed carbon fiber

Interior

Luggage space	Boot 640 L (seats up), Center console 12 L
Seating	5 adults
Sustainability	Vegan interior with naturally sourced materials
Infotainment	10.1" display with touchscreen, Android Automotive OS
Side and rear view	Camera system

Figure 3 The specification of Lightyear 0 (Lightyear, 2022a)

With its state-of-art technologies, Lightyear is developing its solar electric vehicle from scratch from a holistic design philosophy to achieve a vehicle with efficient energy use and maximum solar yield. To achieve these, high-tech materials are used to provide the lowest possible weight without compromising the safety. Moreover, five square meters of solar cells is integrated on its roof and hood which are shielded by safety glass. In addition, Lightyear 0 is driven by four independently driven wheels to minimize energy lost between the electric motors and the wheels. Combination of these features with an aerodynamic design resulted to Lightyear 0's coefficient drag of less than 0.20 C_d which requires only about 83Wh/km which is about half of energy needed by other EVs (Lightyear, 2022b). That means, the same range could be driven with less energy, a smaller battery, as well as less charging time and frequency. Or in other words, the same amount of energy could be used to drive much longer range. In the end, Lightyear 0 brings more values for the customers such as: less charging hassle, less dependency to EV charging facilities, less driving cost, and ultimate zero-emission driving, all thanks to the highly efficient car and its self-charging capability. More detailed information on Lightyear 0 specification is shown by Figure 2 and Figure 3.

1.1.3. Indonesia's Climate Change Challenges vs it's EV Development

Indonesia aimed to achieve 29% emissions reduction compared to 1990 levels by 2030 and net zero emissions by 2060 (Climate Action Tracker, 2021). However, it is argued that Indonesia's current national mitigation target is not ambitious enough to be on track to achieve the 1.5°C target agreed in Paris Agreement. Therefore, Indonesia is expected to boost its climate action to further decrease its emission level (Climate Transparency, 2020).

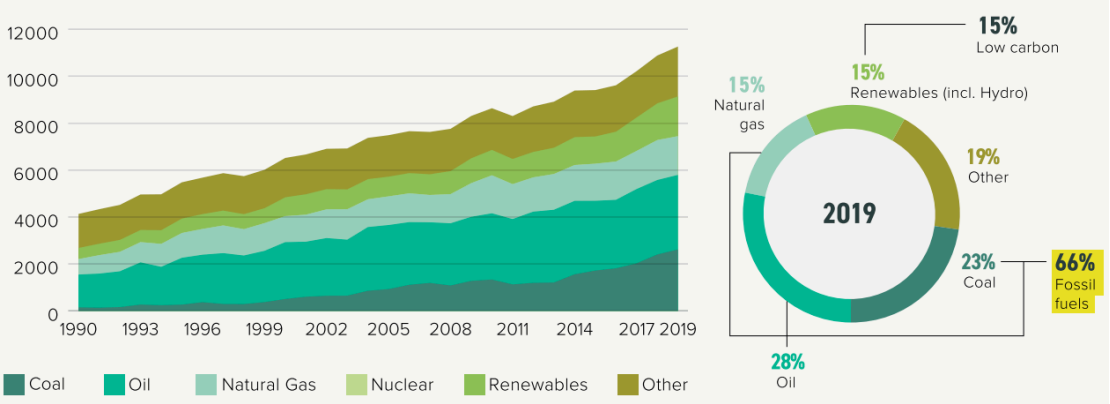


Figure 4 Indonesia energy supply per type of fuels (PJ). Source: (Climate Transparency, 2020)

As cited by Climate Transparency (2020), Enerdata (2020) argued that Indonesia has been relying its energy supply on fossil fuels for decades, as illustrated by Figure 4. In 2019 alone, 66% of its total energy supply came from fossil fuels. Compared to 1990, Indonesia's CO_2 emission in 2019 have increased significantly and expected to increase more in the coming years under current policies. Moreover, in 2020, Indonesia ranked as the 9th country with the worst air quality in the world (IQAir, 2021).

Figure 5 illustrates that the transportation sector was one of the biggest CO_2 emissions contributors in Indonesia (Climate Transparency, 2020; IEA, 2021). It is because 96% of Indonesia's transportation energy demand was fulfilled by oil (Walujanto et al., 2018). 85% of the transportation sector's emission come from the road transport which dominated by cars and motorcycles (Setiawan et al., 2019).

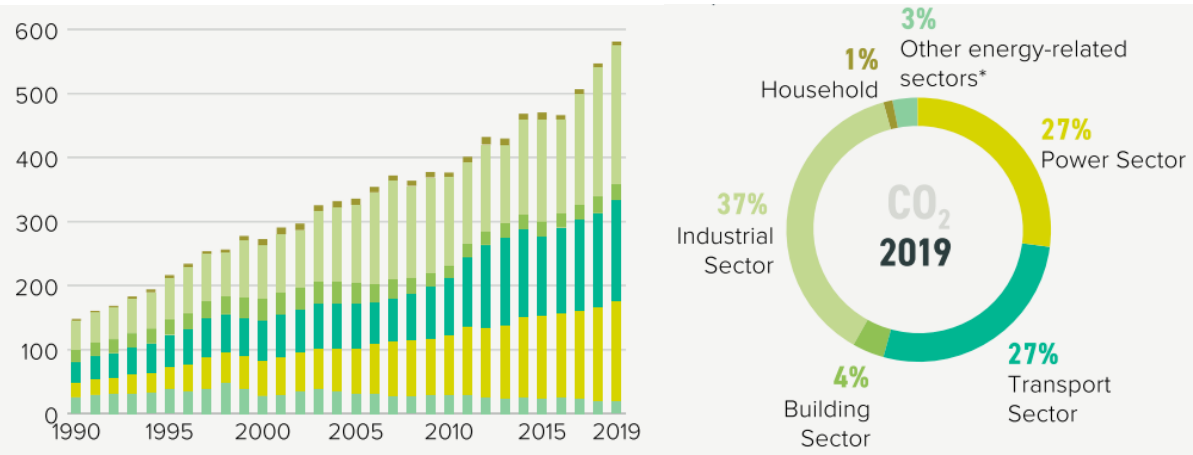


Figure 5 Annual CO_2 emissions from fuel combustion in Indonesia per sector ($MtCO_2$/year). Source: (Climate Transparency, 2020)

In 2020, there were almost 16 million of registered passenger cars In Indonesia (Badan Pusat Statistik, 2022). Due to Indonesia's high economic growth, it is predicted that the number of cars would grow up to 2.5 times in 2040 (Suehiro & Purwanto, 2019). It was estimated that in 2050 Indonesian road transports would consume 132Mtoe, which is four times energy that was consumed in 2020, which would lead to 380 million tons of CO_2 emissions in 2050 compared to 95 million tons of CO_2 emissions in 2020 (Purwanto & Lutfiana, 2021). Hence, decarbonization of transport sector could play a big role for Indonesia to achieve its climate goals.

Unfortunately, the effort to reduce the emissions from transportation sector has been slow as it has mostly focused on the adoption of biofuels (Mahalana et al., 2021). Therefore, more efforts should be put in, for example, by electrifying its vehicles. However, up to February 2022, Indonesia only had 267 EV charging facilities that are installed in 195 different locations (CNN Indonesia, 2021a; Dananjaya, 2022) which is insufficient to support EVs adoption in the country. Therefore, SEV which does not solely dependent on EV charging facility (Lightyear, 2021), could be the answer to electrify Indonesian transportation without relying completely on the EV charging facilities growth.

Additionally, adopting SEV nationally could be one a good solution, especially because Indonesia has abundant sunshine throughout the year. Jakarta – Indonesia's capital city, for example, has almost 3,000 hours of sunshine annually (Weather & Climate, 2021). That annual sun hours are significantly more than the sun hours in, for example, Europe – Lightyear's current main market. Amsterdam, the Netherlands, for example, only has around 1,600 hours of sunshine annually (Weather & Climate, 2022). As Lightyear is aiming to mass produce its SEV in 2025 (Gauthier, 2021), Indonesia could be one of the potential markets.

1.2. Problem Definition and Research Objectives

Based on the explanation in the previous sections, we see that SEV emerged in the market to offer some interesting added values that solve some of the biggest dilemmas of conventional EVs. The SEV's added values are especially interesting for those who live in areas with many sun hours annually but have limited EV charging infrastructures. In the other hand, Indonesia has the urge to boost its decarbonization to meet its climate goals, especially in its transport sector. Being located on the equator, having the lack of EV charging facilities, and having a big market, Indonesia seems to have a promising market potential for the SEV which might lead to mass adoption of SEV in Indonesia.

However, the combination of above mentioned facts do not guarantee SEV's success to penetrate Indonesian market. The technological innovation system (TIS) perspective argues that, as part of a system of systems, SEV would need not only good technological features but also other "actors, factors and functions" to help it to reach its mass adoption (Ortt et al., 2013). Therefore, as Lightyear has an interest to mass diffuse its SEV in Indonesia, this research is conducted to explore and evaluate the market by using TIS perspective. The objectives of this research are to define factors that could be the barriers for SEV mass adoption in Indonesia and to propose the best niche introduction strategy to overcome the barriers. To achieve the objectives, the latest version of barriers and strategies framework (which is now called TIS framework) developed by Ortt & Kamp (2022) and Ten Niche Strategies framework will be used as starting point of this research.

1.3. Research Scope

Even though (S)EV term is used in this research report, however, the focus of the research is limited to (solar) electric passenger cars only. Moreover, as this research is done as a graduation project at Lightyear, the research is also only focused on Lightyear and its SEVs. Indonesia was chosen as the geographical focus of the research as the representative of developing countries that has abundant sun and limited EV charging infrastructures, which could be a good future market for Lightyear. Furthermore, the timing of the research is limited to the time frame between February until September of 2022.

Barriers and strategies analysis conducted in this research is limited to barriers that might be faced by the inventors or producers of the new high-tech product, which in case is Lightyear, as well as the strategies that Lightyear could implement to overcome the SEV's adoption barriers. However, the literature review conducted in this research is focused more on finding new strategies while considering if there are newly identified barriers that could be solved by the implementation of the new strategies.

1.4. Literature Review to Identify Knowledge Gaps

This section elaborates the systematic literature search conducted to identify knowledge gaps in the body of literature by explaining the literature search methodology on Section 1.4.1. and elaborated the identified knowledge gaps in Section 1.4.2. The identified knowledge gaps will then be used as the basis to formulate the research questions, which will be elaborated in Section 1.5.

1.4.1. Literature search methodology

Table 1 List of search queries used in the literature search step 1

	Search Queries
SQ1	("electric vehicle" OR "electric car" OR "kendaraan listrik" OR "mobil listrik") AND (development OR introduction OR roadmap OR target OR pembangunan OR percepatan OR program OR adop*) AND Indonesia
SQ2	(solar OR PV OR surya) AND ("electric vehicle" OR "electric car" OR "kendaraan listrik" OR "mobil listrik") AND (development OR introduction OR roadmap OR target OR pembangunan OR percepatan OR program OR adop*) AND Indonesia
SQ3	("electric vehicle" OR "electric car" OR "kendaraan listrik" OR "mobil listrik") AND ("technological innovation system" OR TIS OR system OR "complex system" OR "system perspective") AND Indonesia
SQ4	(solar OR PV OR surya) AND ("electric vehicle" OR "electric car" OR "kendaraan listrik" OR "mobil listrik") AND ("technological innovation system" OR TIS OR system OR "complex system" OR "system perspective") AND Indonesia
SQ5	("electric vehicle" OR "electric car" OR "kendaraan listrik" OR "mobil listrik") AND (adop* OR diffusion) AND (barrier OR hinder OR hamper OR obstruct OR restrain OR penghalang OR rintangan OR strateg* OR tactic OR plan OR roadmap OR perencanaan) AND Indonesia

The literature search was conducted between November 2021 and February 2022, which was done in two steps. The first step was done by utilizing the Scopus database to find literature

that discusses (solar) electric vehicle development in Indonesia. The search was conducted by using five search queries (SQs), as listed in Table 1. Moreover, the literature search was focused only on articles written in English and Bahasa Indonesia language.

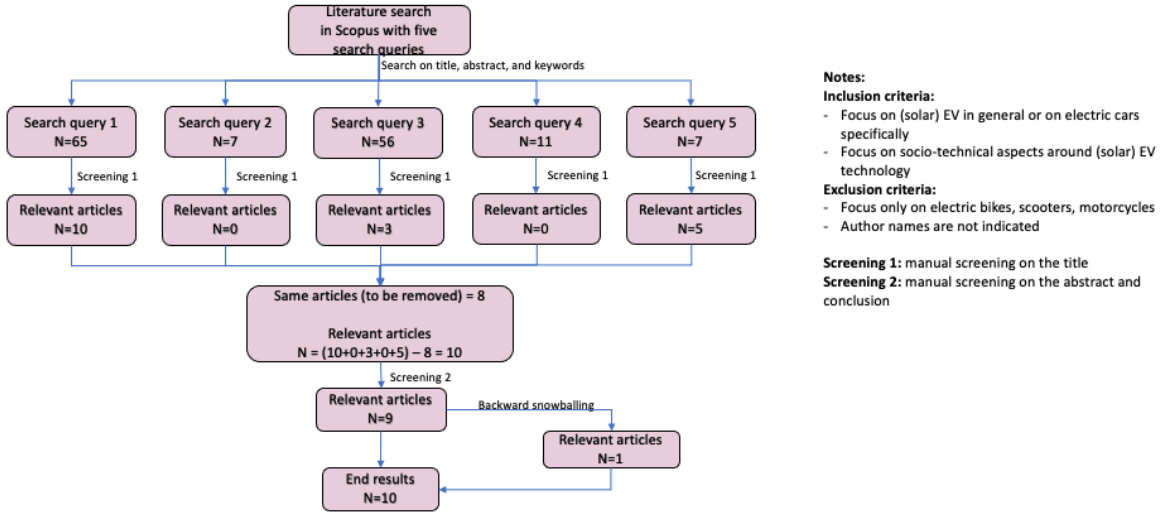


Figure 6 The process of literature search step 1

As shown in Figure 6, the literature search process was started by searching the articles based on their title, abstract, and keywords. Then, the inclusion and exclusion criteria were defined to filter down the retrieved articles. With the inclusion and exclusion criteria in mind, screening 1 was done by reading through the titles of the articles, which resulted in 18 relevant articles. These articles are checked against each other, and duplicates were excluded from the list. Therefore, there are ten relevant articles selected at the end of the screening 1 phase.

Subsequently, screening 2 was done by reading through the abstract and conclusion of the ten articles. In this step, only nine articles met the inclusion and exclusion criteria. Backward snowballing was then performed on these nine articles which resulted in 1 relevant article. By adding this article to the previous relevant articles, ten articles were then become the results of the literature search step 1, as listed in Table 2.

Table 2 List of selected articles as the results of the literature search

Step	Authors	Year	Titles	Objectives	Methods
1	F. Alamsjah et al.	2021	Potential factors affecting adoption of electric vehicle by indonesia market	To understand the level of the intention of Indonesians to buy EVs and to examine the importance of the underlying micro- and macro-level factors influencing the purchase intention of Indonesian citizens	Quantitative survey
1	D. Novizayanti et al.	2021	Agent-based modeling framework for electric vehicle adoption transition in indonesia	To create a ABM framework to investigate the effect of agents' decision-making processes at the microlevel into the number of adopted EV at the macrolevel and to enable the discovery of which incentive scheme or critical technical features effectively increase the uptake of EV according to the agents' specific	Agent-based modeling
1	E. S. Lonan and R. Ardi	2020	Electric vehicle diffusion in the indonesian automobile market: A system dynamics modelling	To developed a system dynamics model to analyze the EV adoption in Indonesia through scenario analysis in order to gain better understanding of the key factors effecting the early EV	System dynamic modeling
1	Y. Natalia et al.	2020	Conceptual Model for Understanding the Policy Challenges of Electric Vehicle Adoption in Indonesia	To explore the dynamics of a complex interaction between factors affecting EV adoption in Indonesia and to propose suitable policies to support EV adoption in Indonesia	System dynamic modeling
1	S. Damayanti et al.	2020	User Acceptance of Electric Vehicles in Indonesia: A Conceptual Model	To develop a conceptual model that can be used to investigate the complex dynamic relationships among factors and linkages of government policies affecting the EV adoption in Indonesia. The study results can be used as a basis for developing strategies and scenarios to increase EV adoption in Indonesia	System dynamic modeling
1	D. A. Asfani et al.	2020	Electric Vehicle Research in Indonesia: A Road map, Road tests, and Research Challenges	To identify Indonesia's National EV development plan and research challenges its facing	Literature review
1	M. W. Dela Utami et al.	2020	Consumer perception analysis of electric car vehicle in Indonesia	To develop factor analysis of consumer perception that could reveal business opportunities in supporting the shifting of a conventional car to electric car vehicle and to give suggestions to all relevant stakeholders especially the government to improve people's perception of electric car vehicles to support EV penetration in Indonesia. Research focus: Surakarta.	Quantitative survey
1	F. H. Syamnur et al.	2019	Barriers to the adoption, acceptance and public perceptions of Electric Vehicles (EV) in Indonesia: Case studies in the city of Surakarta	To examine the public perceptions of price, performance, infrastructure and acceptance of this technology, and to propose draft energy plans and transportation policies to policy makers	Quantitative survey
1	C. Nuryakin et al.	2019	Socioeconomic Impacts and Consumer Preferences Analysis of Electrified Vehicle in Indonesia	To estimate the necessary price incentives for each of the EV types to gain certain market exposure in the country, to utilize simulation method in estimating the impacts of various scenarios of policies, government (fiscal), environmental (CO_2 emission reduction) and macroeconomic revenues.	Quantitative survey and modeling
1	Indonesia National Electric Vehicle Team	2015	Status and Program of Research and Development on National Electric Vehicle Prototype	To define Indonesia's national electric vehicle research status and roadmap	N/A
2	Yvar in 't Veld	2020	Strategies for the diffusion of sustainable energy technologies in developing countries	To extend Ortt's framework to suit the developing countries context, to define the link between barrier-sets to strategies, and to incorporate the intervening effect of other actors in the process of circumventing the barrier-sets	Qualitative literature review and case study
2	Jara Schulz	2019	Developing a conceptual model on strategies overcoming barriers for the introduction of radical innovations in niches	To link the (new) niche strategies to the barriers which resulted to extended niche strategies per barrier-set	Qualitative literature review and case study
2	Stephanie Kartika Lestari	2017	Assessing Influencing Factors During Diffusion of a Radical Innovation: A Case Study in Urban Farming The Netherlands	To define a set of indicators to assess dynamic contextual and contemporary factors that can hamper the diffusion process of a radical innovation.	Qualitative exploratory and case study
2	Rithwick Parthasarathy	2017	Barriers and Strategies for Different Organisational Setups of Sustainable Energy Firms Operating in Developing Countries	To identify barriers and strategies in three different organizational setup, to adapt Ortt's framework into the developing countries context, and to add a new set of strategies called systemic strategies	Qualitative literature review, case study and cross-case analysis
2	Stefan Olsthoorn	2017	Dutch cooling technology in the desert: A market study on district cooling for Dutch companies based on niche strategies to commercialise high-tech products	To expand Ortt's barriers and strategies framework based on new layers of context in the district cooling market and to discover the systemic strategies category	Qualitative literature review, interview with experts, and workshop
2	Lusi Pratiwi	2016	Barriers and Strategies for Transition to Electric Vehicles in BRICS Countries: Case Study of South Africa, India, and Brazil	To adapt Ortt's framework into barriers and strategies for electric vehicles adoption in BRIC countries, to explain the relationship between the barriers and strategies, and to investigate the relative importance of the barriers and strategies	Case study
2	Vicky Bruinsma	2015	Developing a dynamic framework for the selection of niche strategies to introduce new high-tech products	To adapt Ortt's framework into a dynamic model to capture the complexity of the market.	Case study
2	Matthew F.A. Doe	2014	Niche strategy selection for kite-based Airborne Wind Energy technologies	To identify the barriers, strategies, and link between them, and the application of framework into AWE case.	Qualitative literature review and interview with experts
2	Nicole Jane van den Berg	2017	Niche strategies selection in developing countries: a case study on RE-desalination	To improve the niche strategy selection by creating a generic framework for developing countries that cover all technologies, market, and relevant countries; to test the adapted framework in the RE-desalination case	Qualitative literature review and interview with experts

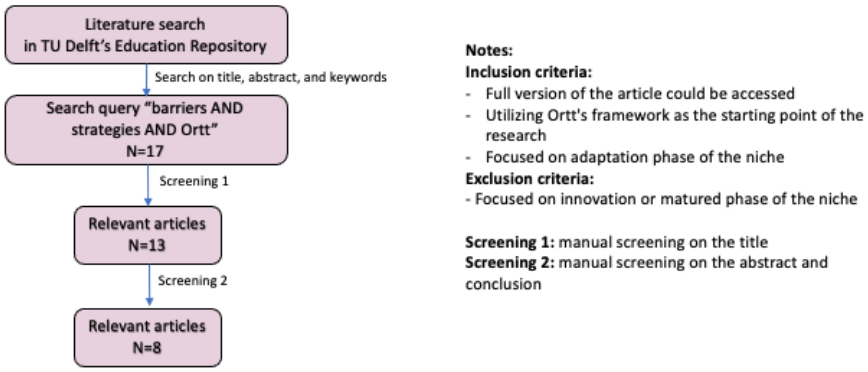


Figure 7 The process of literature search step 2

Then, the literature search was continued by looking at TU Delft's Education Repository to find literature that was using barriers and strategies framework as the focus of the research. The purpose of this literature search is to identify the type of research that has been done around Ortt & Kamp's framework in the past. For this research step, only literature in English is selected. As shown in Figure 7, the literature search process was started by filtering the title, abstract, and keywords by using the "barriers AND strategies AND Ortt" search query. Then, the retrieved literature was filtered down manually by reading the title (screening 1) and the abstract and conclusion (screening 2). During these manual filtering stages, a new set of inclusion and exclusion criteria were applied, as indicated in Figure 7. In the end, literature search step 2 resulted in eight relevant articles as listed in Table 2. Thus, in total 18 articles are selected during the literature search, which will be the basis to define the knowledge gaps.

1.4.2. Knowledge Gaps Identification

After conducting the literature search, the literature review is then continued by reading through the selected articles. Based on these articles, several insights are gained, and knowledge gaps are identified that will be elaborated on in the following.

First, several surveys were conducted to identify public perception, preference, and acceptance towards EV in Indonesia and how it could influence public willingness to adopt EV, especially when price incentives are offered, and other supportive policies are implemented (Alamsjah et al., 2021; Nuryakin et al., 2019; Syamnur et al., 2019; Utami et al., 2020). However, these surveys were only conducted at one or some specific regions in Indonesia, for example in Surakarta (Syamnur et al., 2019; Utami et al., 2020), while there is no research conducted at the national level. As Indonesia is a big country, in which the socio-cultural aspects could vary between the areas, thus, surveys that are conducted in a small specific region could not represent the whole population. Therefore, this knowledge gap needs to be filled.

Second, some researchers looked into the complex socio-technical or socio-economic aspects around EV development in Indonesia (Damayanti et al., 2020; Lonan & Ardi, 2020; Natalia et al., 2020; Novizayanti et al., 2021; Nuryakin et al., 2019). However, there is limited research on complex socio-technical systems from the perspective of EV producers. In other words, there is no comprehensive research conducted to define barriers that are faced by the EV producers who aim to commercialize their products to a large scale. Third, to boost EV adoption in Indonesia, the research focused their suggestions on the implementation of government policies (Lonan & Ardi, 2020; Natalia et al., 2020; Nuryakin et al., 2019; Syamnur et al., 2019; Utami et al., 2020), while suggestions addressed to EV producers are lacking. These knowledge gaps are especially important to be filled to provide a good basis for the EV

producers to formulate their company strategies, so that EVs development in Indonesia could be boosted.

Forth, there were limited articles that elaborate the EV roadmap in Indonesia (Asfani et al., 2020; Indonesia National Electric Vehicle Team, 2015), while there was no research conducted specifically on SEV and its roadmap in Indonesia. This knowledge gap is important to be filled to inform, guide, and encourage the EV development in Indonesia.

Fifth, several types of research have been done to extend or adapt Ortt's framework to fit it into new contexts such as developing countries' contexts and different organizational set up (Olsthoorn, 2017; Parthasarathy, 2017; Pratiwi, 2017; Schulz, 2019; Veld, 2020). Additionally, Ortt's framework which originally was a static model was adapted into a dynamic model by several researchers (Bruinsma, 2015; Lestari, 2017). Moreover, several researchers identified several possible strategies and explained the link between the barriers and strategies in their research (Doe, 2013; Pratiwi, 2017; Schulz, 2019; Veld, 2020). However, the original, the extended, as well as the adapted frameworks do not explain the conceptual way to choose the best niche strategy that could circumvent all or most of the identified barriers at once. As choosing the best strategy is not that straight forward, therefore, filling this knowledge gap could provide a guidance for EV producers not only to choose the best strategy, but also to formulate the best investment decision.

1.5. Main Research Questions

Based on the identified knowledge gaps explained in the previous section, MRQ could be formulated. However, the focus of this research is weighted only to fill in the second, third, and fifth knowledge gaps. Thus, the purpose of this research is to answer the following MRQ:

"From the technical innovation system perspective, how could solar electric vehicles reach mass adoption in Indonesia?"

The main deliverables of this research are (1) a new framework called "the Best Strategy Framework" that is developed to explain how a strategy could be selected to circumvent multiple barriers at once and (2) the best niche strategy recommendation for Lightyear to penetrate the Indonesian market on a large scale.

1.6. Research Approach and Sub-Research Questions

A qualitative approach will be used in this research because it aims to explore, interpret, and explain the phenomena instead of estimating it quantitatively (Mahoney & Goerts, 2006; Mishra & Alok, 2017). Moreover, this approach was chosen as the center of qualitative research is to understand "the social interaction, social processes, and social change" (Agee, 2009), which fits the objectives of this research. Furthermore, it could give more detailed explanations on substantively important points based on a reflective process (Agee, 2009; Mahoney & Goerts, 2006; Mishra & Alok, 2017). However, the qualitative research approach is sensitive to each observation (Mishra & Alok, 2017). This means, one misfit might give a significant impact. Being aware of this, careful planning of research methodology would be needed. This drawback could be minimized, for example, by selecting proper articles during the literature review or choosing the right experts to be interviewed.

To answer the MRQ, four SRQs are formulated, as follows. It is advised that qualitative research should be started with a question that addresses the curiosity toward the topic (Agee,

2009). Thus, the SRQ1 aimed to give a general explanation about the SEV technology, a comparison between SEV and conventional electric cars, and (dis)advantages of SEV. For that, the **SRQ1** is formulated as the following: **"How is solar electric vehicles different than conventional electric cars?"**

Subsequently, research will be continued by exploring the existing literature qualitatively to conceptually explain how a niche strategy selection could be done. This research step is important to complement Ortt & Kamp's barriers and strategies framework as the original framework do not advise the possible strategies that could be implemented to circumvent the barriers as well as the best way of choosing the right strategies. Thus, the **SRQ2** will be: **"Based on the existing theories in the literature, how could the niche development barriers be linked to the niche strategies so that a niche strategy that could circumvent several barriers at once could be selected?"**. This SRQ will result into the Best Strategy Framework.

Once the Best Strategy Framework is developed, this framework could then be implemented into the SEV case in the Indonesian market. First, the conceptual model would be used to identify SEV's development barriers in Indonesia. Thus, the **SRQ3** will be: **"Based on the previously developed "The Best Strategy Framework", which actors, factors, and functions could be the barriers for SEV to reach its mass adoption in Indonesia?"**

Subsequently, as the SEV development barriers in Indonesia are identified, the conceptual model could be used to select the best niche strategy. Thus, the **SRQ4** will be: **"Based on the identified barriers that could hinder SEV development in Indonesia, which strategy could circumvent most of the barriers or the most threatening barriers at the same time?"** Finally, the MRQ could be answered by consolidating the answers of the SRQs.

1.7. Methodology

Table 3 gives an overview of the how the research will be conducted, as well as data needed, research methods, data analysis tools, and data output for each phase of the research. More details about each phase are elaborated in the following.

In phase 1, several data and information are needed to provide an introduction to SEV technology. Thus, a literature research on online materials is a suitable method to gather information needed to answer SRQ1. Various search engines are utilized such as Scopus, Google Scholar, and Google to search not only scientific literature but also grey literature. A literature review could provide several perspectives towards SEV technology by utilizing already existing and ready-to-use literature, and it does not need much direct contact with the SEV as the research object (Ortlieb, 2019; Ubacht & Hoppe, 2020). However, online literature might be limited and incomplete (Ortlieb, 2019). To overcome these drawback, secondary sources were used, for example, by requesting some information from Lightyear, as well as conducting an informal discussion with its representatives to validate the findings.

Subsequently, SRQ2 will be answered by conducting the two research phases: phase 2 and phase 3, which are addressed in Chapter 4 and Chapter 5 respectively. Phase 2 focused on finding new potential barriers that could hamper the adoption of innovations, as well as new potential strategies that could solve those barriers, by conducting an extensive literature review. To get the best results and to check the findings' trustworthiness and credibility, several types of literature from different sources are searched to obtain various supportive articles "to provide a complete picture of the phenomenon" (Office of Research & Doctoral Services, 2015).

Table 3 Overview of the research methods and the data analysis tools for each sub-research question

Research Approaches & Phases		Sub-Research Questions	Research Chapters	Data Needed	Research Methods	Data Analysis Tools	Outputs
Qualitative research	Phase 1	**SRQ1:** How is solar electric vehicles different than conventional electric vehicles?	Chapter 3. Solar Electric Vehicles	General explanation about SEV technology and SEV (dis)advantages compared to conventional electric vehicles	Literature research; informal discussion with Lightyear's representatives for validation	MS Word and Mendeley for qualitative information; MS Excel, Power Point and Lucid chart for visualization	General description of SEV and SEV technological map
	Phase 2	**SRQ2:** Based on the existing theories in the literature, how could the niche development barriers be linked to the niche strategies so that a niche strategy that could circumvent several barriers at once could be selected?	Chapter 4. Potential Strategies to Reach Large Scale Diffusion	Existing theories and frameworks, as well as case studies about niche development barriers and strategies	Literature review; data triangulation for validation	MS Word and Mendeley for qualitative information; MS Excel, Power Point and Lucid chart for visualization	New lists of potential barriers and strategies that could influence the mass adoption of innovations
	Phase 3		Chapter 5. The Best Strategy Framework	Existing theories and frameworks about niche development barriers and strategies, as well as the outputs of Chapter 4	Literature review; data triangulation for validation; author's analysis	MS Word and Mendeley for qualitative information; MS Excel, Power Point and Lucid chart for visualization	The Best Strategy Framework that enable the selection of the best strategy that could circumvent multiple barriers at once
	Phase 4	**SRQ3:** Based on the previously developed "The Best Strategy Framework", which actors, factors, and functions could be the barriers for SEV to reach its mass adoption in Indonesia?	Chapter 6. (Solar) Electric Vehicles Development in Indonesia	Relevant stakeholders in Indonesia, the status of TIS building blocks in Indonesia and factors that influencing their status	Literature research	MS Word and Mendeley for qualitative information; MS Excel for visualization	(S)EV stakeholder map, list of identified barriers that could hinder SEV development in Indonesia
	Phase 5	**SRQ4:** Based on the identified barriers that could hinder SEV development in Indonesia, which strategy could circumvent most of the barriers or the most threatening barriers at the same time?	Chapter 7. The Best Strategy to Reach SEV Mass Adoption in Indonesia	Output of Chapter 5 & 6	Analysis	MS Word for qualitative information; MS Excel for visualization	A list of the best strategy that could to overcome the barriers to SEV mass adoption in Indonesia

The output of phase 2 is then used in phase 3 as a basis to develop the Best Strategy Framework. In this phase, the list of barriers and strategies identified in phase 2 is transformed into a barriers and strategies matrix. Then, the relationship between each barrier and strategy is identified based on the author's analytical thinking. Subsequently, the scoring system is defined to enable the selection of best strategy that could circumvent certain barriers. The Best Strategy Framework will be later used to analyze the SEV case in Indonesia.

In phase 4, literature search is conducted to explore and evaluate the socio-technical aspects around (S)EV development in Indonesia to answer the SRQ3, especially from the perspective of Lightyear, by using the conceptual model that was developed in phase 3 as a guidance. The literature search utilizes Scopus, Web of Science, google scholar, and google to search for scientific literature as well as grey literature. Moreover, multiple literature is used to make sure the trustworthiness and credibility of each finding. In the end, phase 4 would deliver two artifacts: (1) stakeholder map that provides insights on the (S)EV ecosystems in Indonesia, and (2) the list of barriers identified in Indonesia market that would hamper the diffusion and adoption of SEV.

Subsequently, phase 5 is done to answer SRQ4 by analyzing the outputs of the research phase 3 and 4 to define the best strategy that could contribute to mass adoption of SEV in Indonesia. Finally, the consolidation of the answers to the SRQs would provide insights to the answer to the MRQ by explaining how the SEV could reach its mass adoption in Indonesia.

Throughout the whole research process, several data analytic tools are utilized, as indicated in Table 3. Microsoft Word is used to document the qualitative findings, while Mendeley is used as the reference manager. Moreover, tables or flowcharts are illustrated by using Microsoft Excel, Microsoft PowerPoint, and Lucid chart.

The flow of the research is illustrated by Figure 8.

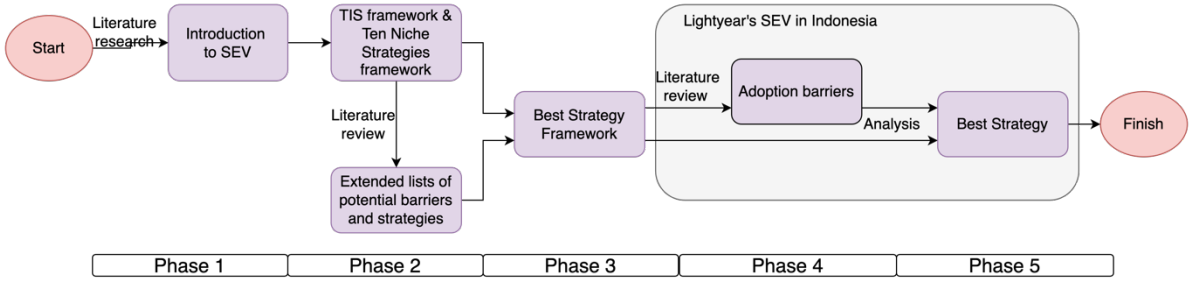


Figure 8 Research flow diagram

1.8. Deliverables

This research aims to deliver two major artifacts: (1) a new framework called "the Best Strategy Framework" that allow the selection of the best strategy that could circumvent multiple barriers at the same time, and (2) the best business strategy recommendation for Lightyear to achieve mass adoption of its SEV in Indonesia.

By delivering above mentioned artifacts, this research brings several scientific contributions as the following: (1) the adaptation of an existing influencing factor and the identification of new influencing factors that could influence the TIS building blocks status, and hence might lead to the emerge of new niche development barriers, (2) the identification of new potential strategies that could circumvent the niche development barriers, (3) the identification of possible relationship between all the identified barriers and strategies, (4) the approach of mapping the relationships between the barriers and strategies into a matrix to enable the selection of a strategy that could circumvent multiple barriers at the same time, (5) the utilization of the barriers and strategies matrix and two scoring models which formed the so-called the Best Strategy Framework that enable the best strategy selection, (6) the identification the latest EV development status in Indonesia, (7) the identification of Lightyear's SEV development barriers in Indonesian market, (8) the recommendation of the best strategy for Lightyear to enable it to diffuse its SEV in a large scale in Indonesia, and lastly (9) this research act as novel literature of SEV in Indonesia.

1.9. Report Structure

The report is structured as the following. Relevant theories are explained in Chapter 2 as the basis of the research, followed by an introduction to SEV in Chapter 3. Subsequently, Chapter 4 elaborates the identification of potential barriers and strategies to reach the mass adoption of innovations, which leads to Chapter 5 that elaborates the development of the Best Strategy Framework. Based on this framework, Chapter 6 evaluates the current development status of (S)EV in Indonesia to identify the potential barriers that could hamper Lightyear's SEV adoption. Then, Chapter 7 elaborates the best strategy selection and recommendation that could circumvent the identified barriers. Chapter 8 elaborates the discussion of relevant topics, reflecting on the research, its relevance, and its limitation, as well as providing recommendation to several relevant stakeholders and recommendation for potential research topics. In the end, Chapter 9 closes the report by answering the research questions.

Chapter 2. Theoretical Background

2.1. Disruptive Innovations

This section elaborates the definition of disruptive innovations, their characteristics, and criteria to identify whether a technology innovation is a disruptive technology. This section is presented as the basis of the analysis in Section 3.1. to understand whether SEV could theoretically be categorized as a disruptive technology.

Disruptive innovations are defined as the innovation (in a form of products or a services or the combination of both) that are significantly different compared to the incumbent technologies that have been established in the market, so that the launch of the innovations causes a disruption to the existing systems and displace the incumbents (Hardman et al., 2013).

Based on historical case studies in the literature, Hardman et al. (2013) defined several common characteristics of disruptive technologies, as explained in the following.
First, the emerge of disruptive innovations are often **unexpected**, thus, the threat poses by the disruptive innovations are often not recognized by the established market leaders. Even if the threat is recognized, often the incumbents fail to respond or adopt to the disruptive technologies, which cause them to fail and disappear completely. Some examples are: Kodak that failed to adopt to the emerge of digital camera and book sales that have been significantly reduced due to the emerge of eReaders such as iPad (Hardman et al., 2013).

Second, when the innovations first enter the market, it often costs significantly more **expensive** than the existing technologies due to various reasons: high-cost materials needed for the new technologies, high research and development costs, complex manufacturing processes, inability to reach the economies of scale yet, high marketing and salesforce costs, etc. However, these costs would eventually decrease throughout the time as it started to be adopted.

Third, when the disruptive technologies first enter the market, they often have **less quality** compared to the incumbents. However, similar to the high costs, the less quality would also eventually improve throughout the time as it started to be adopted. Thomas & Maine (2019) explained that many scholars agreed that disruptive technologies often entered the market at the low-end, however, other scholars argued that disruption could also happen at the high-end markets and eventually spreading down to the mainstream markets.

Four, the disruptive technologies offer **added values** that the incumbents failed to offer to the customers. Aulet (2013) describes these added values as solutions to "customers pain" – a problem that annoys the customers in a way that motivate the customers to pay more to alleviate the problem. The added value could be, for example, convenience, better accuracy, more sustainable, less maintenance efforts, etc. These added values could form certain emotional values that could attract the customers to switch from the existing technologies to the new ones.

Five, the disruptive technologies often start to penetrate the **niche market** first, then spread to other niches, and then eventually spread into the mass market. Niche market would be elaborated further in Section 2.3. Market Introduction Strategies

Six, socio-technical systems are complex and **ever evolving**. They are never in equilibrium state. It means that even the incumbent technology was once a disruptive technology. Once a disruptive technology penetrates the market and established, another disruptive technology

might emerge and displace it if it fails to respond to it. Thus, companies must constantly work hard, innovate, and make management decisions to maintain their positions in the market.

Furthermore, Hardman et al. (2013) argued that there are three criteria that could be used to identify whether a technology is a disruptive technology, as elaborated in the following.

1. Disruptive to market leaders. This disruption occurs when the companies producing the innovative technologies are different companies than the producers of the incumbent technologies. In this case, the disruption that created by the new companies makes the existing companies to lose their market share as well as their revenue. The disruption could also be created by the same companies as the existing market leaders. The example is Nissan who released its BEV called Nissan Leaf compared to its existing ICE vehicles that have been in the market for decades. However, this kind of disruption is less disrupting compared to BEVs that were produced by other companies such as Tesla.

2. Disruptive to end users. This disruption occurs when the innovations change the customers way of using the technologies. In other words, the adoption of the new technologies requires customers change of behavior. The adoption of BEV for example requires different way of fueling the vehicle. Innovative products that cause disruption to their end users would need to provide better products and services to make the customers willing to switch and adopt the innovative products despite of the "hassle". In the BEV example, despite the hassle of the new refueling way, the customers are willing to do it as BEV offers zero tail pipe emissions, it runs silently, and it has less running cost compared to ICE vehicles.

3. Disruptive to infrastructure. This disruption occurs when the innovations require new or different infrastructure than the existing ones. The example is, BEV that requires charging infrastructure that was not available before the emerged of BEV. In other words, BEV cannot be refueled at the existing fuel stations infrastructure.
Based on these criteria, the level of disruption of the innovations could be defined. The more criteria the innovations meet, the more disruptive the innovations are.

2.2. Technological Innovation System

Markard & Truffer (2008) explained that a system is defined as an entity that consists of elements in which all elements interact with each another, while innovation system described as a group of actors and/or entities and institutions that are related to each other in developing, diffusing, and using innovations. Thus, TIS is defined as innovation systems around a specific technology (Markard & Truffer, 2008).

Ortt & Kamp (2022) argued that TIS consists of four main elements: the technology, a network of actors, the institutions, and the demand. From the technological transitions perspective, TIS consists of three levels which are called multi-level perspective (MLP): the socio-technical landscape, the socio-technical regime, and the niche, as illustrated by Figure 9 (Geels & Schot, 2007). Both TIS and MLP argue that for a niche technology to reach its large-scale commercialization, it must go through learning processes, improve its product price/performance, build its supporting network of actors and infrastructures, and build its internal momentum. Additionally, development at landscape, regime, and niche level should be aligned so that the landscape level would change and give pressure to the regime, which then leads to the opening of a window of opportunity for the niche technology to break in (Geels & Schot, 2007; Kamp, 2008).

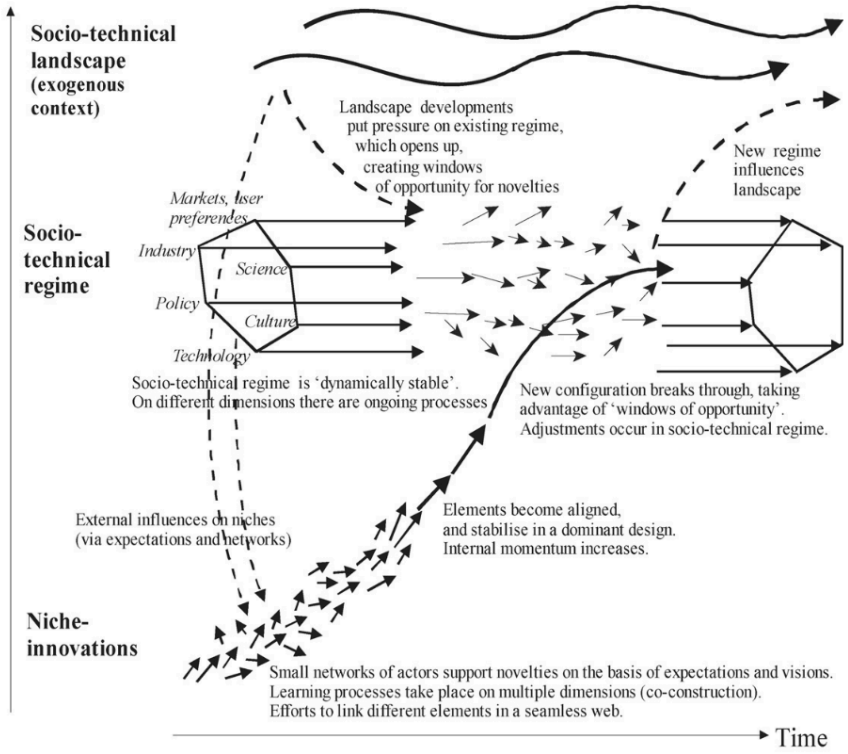


Figure 9 Multi-level perspective on technological transitions (Geels & Schot, 2007)

To achieve the objectives of this research, TIS approach and TIS framework developed by Ortt & Kamp (2022) are chosen to study the case for several reasons. First, TIS uses a system and interdisciplinary perspective that cover not only the technological aspects but also the institutional and organizational aspects, as well as the relationship and interaction among them. Combination of these perspectives help to explain not only the spatial and historical contexts of the innovation, but also the components needed to bring the innovation forward in the innovation processes (Jenson et al., 2015; Markard, 2018; Markard & Truffer, 2008). As SEV is part of complex systems, thus, understanding every aspect of the systems is important to have a holistic overview of the case.

Moreover, Ortt & Kamp's TIS framework formulates the general patterns of various innovation processes that is useful to study and evaluate the TIS, as well as to evaluate whether an innovation is ready to be commercialized in a large scale. By using this framework, the TIS of SEV in Indonesia could be evaluated, and niche strategies recommendation could be formulated and proposed to Lightyear to help them to reach large scale uptake of their innovation.

2.3. Market Introduction Strategies: Mass Market vs Niche Market

Ortt et al. (2013) argued that once a new high-tech product is invented, the inventors have two options towards their invention: whether they are going to introduce it to the market or not. When they decided to introduce their product to the market, they then need to decide whether they want to focus on mass market or niche market. Figure 10 is developed in the present work to visualize Ortt et al.'s argument regarding market introduction strategy and will be implemented in the later stage of this research.

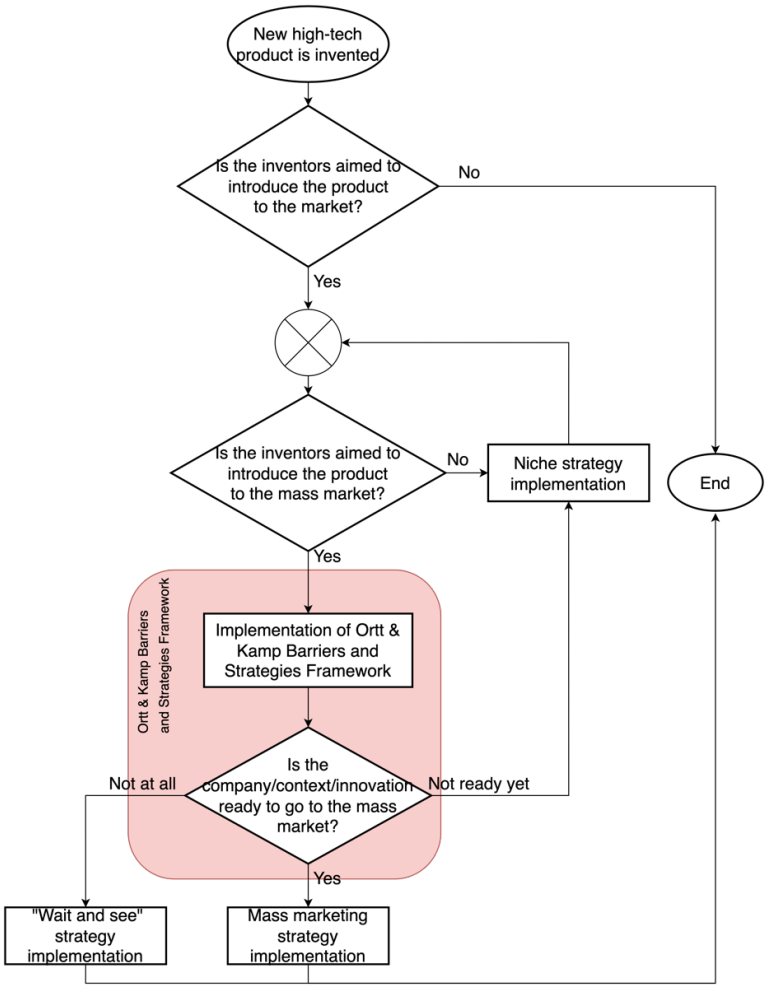


Figure 10 Market introduction flow diagram

Niche market is a small market that served homogenous customers who have specific needs and demands (Shams, 2020). Aulet (2013) refers this niche market as a beach head market that is defined as "a single market to excel in" or a focused market in which the product or new technology could easily dominate the market in a relatively short period of time. As cited by (Parrish et al., 2006), Kotler (2003) argued that niche markets have five key characteristics: the customers have special needs that the existing products or technologies could not offer, the customers are willing to pay more to get their special needs fulfilled, the niche market often do not attract any competitors, the niche marketers earn their revenue from product specialization, and the niche market has potential to grow and gain profit. Niche market is often "abandoned" by large market leaders because it does not provide enough profit for them (Thomas & Maine, 2019).

A niche strategy is defined as a strategy that is implemented by a company by limiting its target market into the niche market (Ortt et al., 2013; Startup Sloth, 2021). Implementing niche strategy is especially important for entrepreneurs as they often just started a small company and have limited resources (Aulet, 2013). Furthermore, the advantage of targeting a niche market is that the new product or technology is not seen as a threat or a competitor by the incumbents, that could give the new product or technology to grow before aiming to the mass market (Hardman et al., 2014). In order to have a successful niche strategy, several important factors have to be developed and maintained by the niche marketer: good long-term relationship with relevant stakeholders, company's reputation which often influenced by word-

of-mouth, specialized product that answer the customer's needs, and continuous research and development (Parrish et al., 2006).

On the contrary, **mass market** is a market that targeted as much customers as possible with one strategy. Thus, it usually has no market segment, and the customers are heterogeneous but has a distinct need. The success of a mass market is often associated by its mass production, low-cost production and operation, massive advertising, extensive logistics, and market-leading brands. The strategies implemented to achieve mass market is thus defined as mass marketing strategy, for example, by putting extensive amount of publications on various communication or marketing platform to reach as many people as possible (Shams, 2020).

When the new product inventors decided to aim for the mass market, Ortt & Kamp's TIS framework (see Section 2.4.) could be used to evaluate whether the factors needed for large scale commercialization are available. At the worst case, when market introduction is not feasible due to too many barriers, the product inventors should wait and see until at least some of the existing barriers are solved. This approach is then called "**wait and see**" market strategy.

Various literature investigated historical cases argued that radically new technologies often are not directly commercialized in a mass market due to various barriers that hinder its adoption in society. Hence, they usually must go through an adaptation phase that takes years or maybe decades for them to be mass adopted. In this adaptation phase, introducing the innovation into the niche market could be a good steppingstone before reaching toward the mass market. Therefore, niche strategies could be implemented to help the innovation to go further in the market by circumventing the existing barriers (Kamp et al., 2015, 2018; Ortt et al., 2013).

2.4. Ortt & Kamp's TIS Framework

Ortt & Kamp (2022) developed a so-called TIS framework to examine the TIS of an innovation that could help to see whether the innovation is ready to be diffused at large-scale or whether a small-scale niche introduction strategy is needed prior the large-scale diffusion. Additionally, the framework also helps to indicate whether the circumstances require the producer of the innovation to postpone the introduction strategies. The framework is designed specifically for an innovation that is in its adaptation phase. Means, the innovation has working prototypes but has not commercialized in large scale.

As illustrated by Figure 11, the framework consists of three important elements: the TIS building blocks (it was named as core factors in the previous version of the framework), the influencing conditions (it was named as influencing factors in the previous version of the framework), and the niche strategies. The TIS building blocks indicate not only the most important aspects of the technological and market system that is needed for large-scale diffusion of an innovation, but also the timing and scale of the introduction strategy. The status of the building blocks defines whether the large-scale diffusion of an innovation is possible. In other words, the absence, lack, or incompleteness of the TIS building blocks could act as barriers that directly hinder the mass uptake of the innovation. When all or most of the building blocks are not in place yet, it is advised that the innovation producer should postpone the introduction strategies until more building blocks are in place. However, when only some of the building blocks are missing or incomplete, the innovation must go through an adaptation phase. During this phase, the innovation could be introduced in a niche market by implementing a niche introduction strategy to circumvent the barriers.

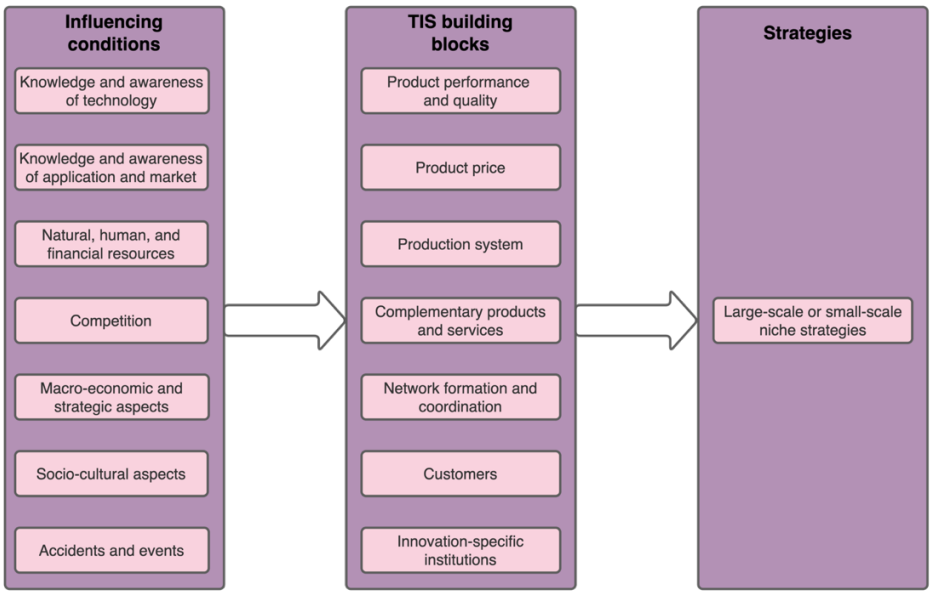


Figure 11 Ortt & Kamp's TIS framework (Ortt & Kamp, 2022)

Each of the TIS building block is explained in the following:

1. Product performance and quality

To be diffused in a large scale, the innovative product should have not only a clear purpose, function, and capability, but also good performance and quality. The product should be seen as a reasonable alternative by its prospective users by offering adequate performance and quality compared to its competitors now or soon in the future.

2. Product price

Providing an innovative product with a competitive price could be a critical point for a large-scale uptake of an innovation. From economy perspective, the price of a product consists of not only the financial cost (buying cost, taxes, maintenance cost, switching cost, etc.) but also the non-financial cost (time and effort needed to use or maintain the product). Moreover, being competitive also mean that product has a good price compared to its quality.

3. Production system

To aim at the mass market, good production system is needed. Good here means, large-scale production facilities that could produce the products in good quality at high production rate.

4. Complementary products and services

Delivering products to the market require many supporting products and services to develop, produce, distribute, adopt, use, repair, maintain, and dispose the products. The availability of these complementary products and services is thus critical for large scale adoption.

5. Network formation and coordination

Network here refers to the actors involved in the whole supply chain, such as the suppliers of the raw materials needed to build the products, the production workers who assembly or produce the products, the distributors, etc. These networks must be established and coordinated in such a way to achieve the shared vision. Moreover, the availability of multiple actors that served the same purpose is important for a good business. The example is, if there are multiple suppliers are available who could supply the same raw materials, then competitive raw materials in term of price/quality could be achieved, which in the end influence the price/quality of the end products.

6. Customers

Customer is defined as potential buyers who are aware of the product and its benefits, as well as have the knowledge, willingness, and means to acquire and use it (Ortt & Kamp, 2022). Other author described customer as an entity (organization or individual) who pays for the

acquiring and using of a product (Aulet, 2013). Therefore, Aulet argued that a business is not a business until it has paying customers. To have large number of customers accepting and adopting an innovative product, their awareness of the product needs to be built, their values should be met by the utilization of the product, their interests and opinions should be addressed.

7. Innovation-specific institutions

Institutions are defined as "systems of established and prevalent social rules that structure social interactions" (Hodgson, 2006). To achieve mass adoption, a commercialization of a product should be supported not only by formal institutions such as government policies, laws, regulations, and standards, but also by informal institutions - the commonly accepted rules, belief, or behavior. Furthermore, supporting policies and subsidies often play a big role to a better adoption of an innovative product.

Even though the knowledge about the status of the building blocks is important, however, that knowledge is not enough to define which niche strategy is best to implement. Therefore, the knowledge about the influencing conditions is needed. The influencing conditions are defined as the contextual conditions that explain why the TIS building blocks are absent, lacking, or incomplete, which indirectly hinder the mass uptake of the niche.

Each of the influencing conditions is explained in the following:

1. Knowledge and awareness of technology

Both the knowledge about the fundamental and applied technology could influence the status of the TIS building blocks. Fundamental knowledge refers to the basic knowledge of the product, its production system, and its complementary products, while applied technology knowledge refers to the knowledge needed to develop, produce, repair, maintain, and improve the product. This knowledge would influence the innovators' capability to improve the quality and performance of the product, the customers' capability to utilize the product, or the third parties' capability to develop the supporting complementary products and services.

2. Knowledge and awareness of application and market

This knowledge refers to the knowledge in using the innovation into certain applications by knowing the purpose of using it, how/where to acquire the product, and how to pay for it. When the potential customers have a lack of this knowledge, it could hinder them from adopting the innovation. From the company point of view, knowing the application of the innovative product would help to define the target customer better (Aulet, 2013). This knowledge could be gained by conducting a full life cycle analysis of the innovation product, by specifying the values of the product for the customers and what the customer will do with it.

3. Natural, human, and financial resources

The availability of the resources is critical for the large-scale commercialization of a product. The natural resources are needed not only as the raw materials to create the products but also, for example, to set up the production facilities and to support the distribution of the raw materials as well as the products. Additionally, human resources are needed to get all the job done, while financial resources are needed to acquire the necessary natural resources and to pay the labor.

4. Competition

From marketing point of view, competition refers to the existence of alternative products and services produced by other companies that cause rivalry between the companies (Carnrite, 2021). Carnrite also argued that competition would shape the offered product as it influences the product's price and value-added benefits.

5. Macro-economic and strategic aspects

Macro-economic situations such as economic growth and market structure could influence the diffusion and adoption of an innovation. Other author defined macro-economic aspects as

variables or factors that influence the monetary stability and the financial outlook of a country. Interest rates, inflation, fiscal policy, gross domestic product, national income, employment rate, economic growth rate, industrial production, international trade, retail sales, and business cycle are some of the example of the macro-economic factors (Indeed, 2021). The dynamic of these factors could encourage and discourage the status of the TIS building blocks.

6. Socio-cultural aspects

Socio-cultural aspects are the big forces that influence the society's values, behavior, way of thinking and doing things. Some example of socio-cultural aspects are education, language, reference groups, social class, and neighborhood (Reference, 2020). Socio-cultural aspects held by the stakeholders in the TIS of an innovation would influence the TIS building blocks as well as the uptake of the innovation.

7. Accidents and events

Accidents and events occurred within and outside of the TIS could influence the forming of the TIS building blocks. The Fukushima accident, for example, gave a significant influences towards the public perceptions and acceptance of the renewable energy technologies, which at the end influence the adoption of the technologies (Park & Ohm, 2014).

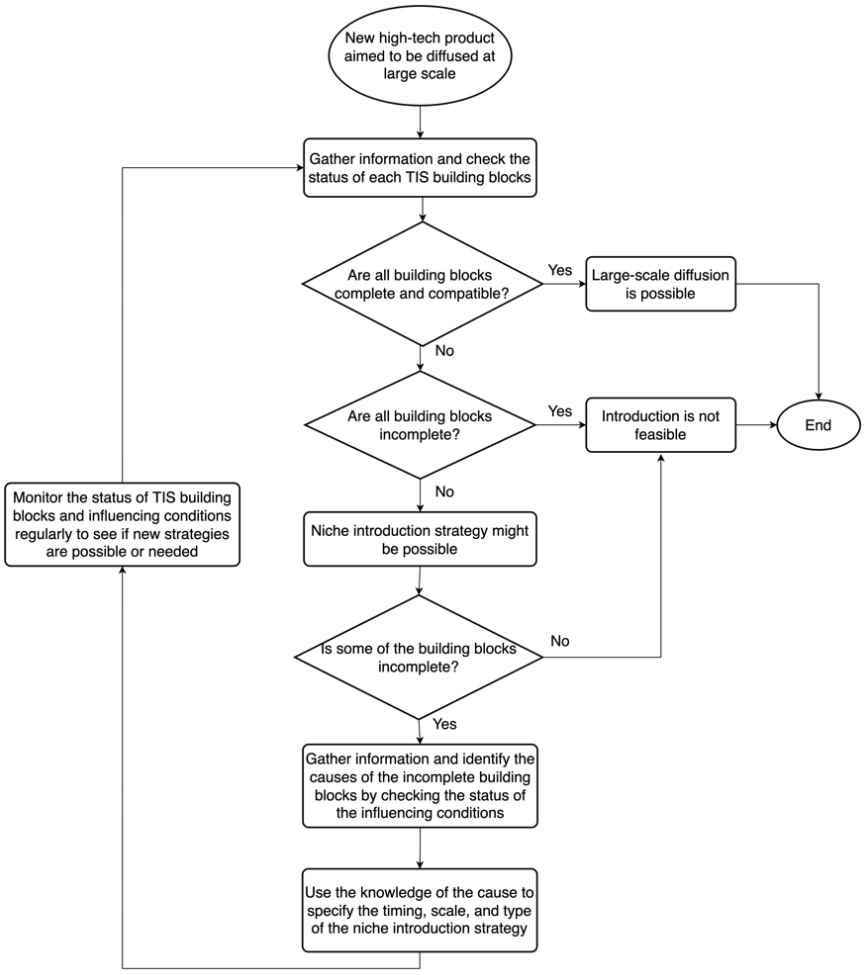


Figure 12 Guidance on how to use the Ortt & Kamp framework

Additionally, Ortt & Kamp provide a guidance to use the framework in a proper way. In the present work, a flowchart is developed to illustrate the guidance, as shown by Figure 12. This flowchart will be used at the later stage of this research when implementing the framework into the study case.

In the end, different combinations of the TIS building blocks and influencing factors would define the different market situations, which requires different strategies. Moreover, this framework is static. Means, it only captures the status of the building blocks and the influencing conditions at one point of time. Thus, a regular check is needed to update the status of each building blocks and the influencing conditions. Any change or development on the building blocks and the influencing conditions would lead to different strategy.

For this research, this framework will be used as the starting point of the research to evaluate whether Lightyear's SEV could be commercialized in a large scale in Indonesia by identifying the potential barriers that could hamper the SEV diffusion and to propose the best strategy that could circumvent all the identified barriers. However, despite the interesting and valuable insights it could bring, the Ortt & Kamp framework has a flaw as it does not specifically advise which niche strategies could overcome certain barriers. Therefore, even though the framework could help to identify the barriers that could hinder the mass adoption of an innovation, further research is needed to identify the niche strategy options and how to choose the right one(s). Hence, this knowledge gap would be addressed in Chapter 4 by looking at various literature to make a list of potential niche strategies, as well as their purpose and possible barriers that they could circumvent. The findings will be the basis to make the so-called Best Strategy Framework, which will be developed in Chapter 5. The main purpose of the framework is not only to give an overview of the potential niche strategies that could be implemented, but also to help on selecting the right strategy that could circumvent all the identified barriers at once.

2.5. Ortt's Ten Niche Strategies to Commercialize New High-Tech Products

Table 4 Ten generic niche strategies developed by Ortt et al. (2013)

No.	Niche Strategies	Description
1	Demo, experiment, and develop niche strategy	A niche strategy that suggest to demonstrate the product in public while the product research and development could be continued to overcome the limited quality of the product
2	Top niche strategy	A niche strategy that suggest a production of a special product in small scale to serve specific top niche of customers
3	Subsidized niche strategy	A niche strategy that implement subsidy on the product price to particular segment of users to provide reasonable price
4	Redesign niche strategy	A niche strategy that suggest the product to be redesign into a simpler or slightly different version either to fit an application that supported by current institutional framework, could be produced by current state of knowledge, could be supplied by existing suppliers, or could be accepted and used by the customers
5	Dedicated system or stand-alone niche strategy	A niche strategy that suggest the use of the product in a dedicated or stand-alone system to overcome the lack of widely available infrastructure or complementary products and services
6	Hybridization or adaptor niche strategy	A niche strategy that suggest the product to be coupled with the old products and system in order to re-use the existing complementary products and services
7	Educate niche strategy	A niche strategy that aimed to improve the knowledge of the suppliers and the customers
8	Geographic niche strategy	A niche strategy that suggest an exploration of new geographical areas which provide less barriers to the core factors
9	Lead user niche strategy	A niche strategy that focused on serving lead users and innovators so they could by co-develop the product to fill the innovators' knowledge gaps in applying the product/technology into certain applications and markets. This strategy could also circumvent barriers that hinder the availability of suppliers such as the socio-cultural aspects, macro-economic aspects, or accidents and events
10	Explore multiple markets niche strategy	A niche strategy that suggest an exploration of new multiple customer applications

Ortt et. al (2013) argued that different combinations of TIS building blocks and influencing conditions define different market situations, which requires different niche strategies to overcome the barriers. However, in fact some influencing conditions do not influence certain building blocks, hence, not all the combination of building blocks and influencing conditions are relevant. Based on this insight, Ortt et al. evaluate the possible barriers and identify possible strategies to overcome the barriers based on historical cases, which resulted to ten generic niche strategies as shown in Table 4.

The following Table 5 is developed in the present work to map the barriers and strategies into a matrix to explain Ortt et al.'s argument that each of the strategy could be implemented into different market situations. Based on this table, it could be seen that there is relationship between the barriers and strategies in which there might be several strategy options that could circumvent one barrier. At the other hand, one strategy might be able to circumvent several barriers at once. The latter insight is used as the objective in generating the Best Strategy Framework, which will be explained further in Chapter 5.

Furthermore, as illustrated by Table 5, the ten niche strategies do not cover all the possible barriers yet, thus, more niche strategies need to be investigated so that proper niche strategy recommendation could be proposed in which all the possible barriers could be circumvented. As explained in the previous section, this knowledge gap will be addressed in the later chapter by conducting literature review to list possible niche strategies, which will be the basis in generating the Best Strategy Framework.

Table 5 The barriers and strategies matrix extracted from (Ortt et al., 2013)

Barriers due to the incomplete of:		Ten Niche Strategies									
Influencing Conditions	TIS Building Blocks	Demo	Top niche	Subsidized	Redesign	Dedicated/ stand-alone	Hybridization / adaptor	Educate	Geographic	Lead user	Explore markets
Knowledge and awareness of technology	Product performance and quality	✓			✓						
Knowledge and awareness of application and market										✓	
Natural, human, and financial resources									✓		
Competition											
Macro-economic and strategic aspects											
Socio-cultural aspects											
Accidents and events											
Knowledge and awareness of technology	Product price		✓	✓	✓						
Knowledge and awareness of application and market											
Natural, human, and financial resources			✓	✓	✓						
Competition											
Macro-economic and strategic aspects											
Socio-cultural aspects											
Accidents and events											
Knowledge and awareness of technology	Production system		✓		✓						
Knowledge and awareness of application and market											
Natural, human, and financial resources					✓						
Competition											
Macro-economic and strategic aspects											
Socio-cultural aspects											
Accidents and events											
Knowledge and awareness of technology	Complementary products and services					✓	✓				
Knowledge and awareness of application and market											
Natural, human, and financial resources							✓		✓		
Competition											
Macro-economic and strategic aspects											
Socio-cultural aspects											
Accidents and events											
Knowledge and awareness of technology	Network formation and coordination							✓			
Knowledge and awareness of application and market										✓	
Natural, human, and financial resources											
Competition											
Macro-economic and strategic aspects									✓	✓	
Socio-cultural aspects					✓				✓	✓	
Accidents and events										✓	
Knowledge and awareness of technology	Customers							✓			
Knowledge and awareness of application and market										✓	✓
Natural, human, and financial resources											
Competition											
Macro-economic and strategic aspects									✓	✓	
Socio-cultural aspects					✓				✓	✓	
Accidents and events										✓	
Knowledge and awareness of technology	Innovation-specific institutions								✓		
Knowledge and awareness of application and market					✓				✓		
Natural, human, and financial resources											
Competition											
Macro-economic and strategic aspects									✓		
Socio-cultural aspects					✓				✓		
Accidents and events									✓		

Chapter 3. Solar Electric Vehicles

This section aimed to answer the first sub-research question: **"How is solar electric vehicles different than conventional electric vehicles?"**. SEV is chosen as the focus of this research as it seems to be an interesting disruptive innovation that brings a new dynamic into the automotive market. Therefore, Section 3.1. looks into the disruptive innovations theory that was elaborated in Section 2.1. to evaluate whether SEV could theoretically be categorized as a disruptive innovation. Subsequently, an introduction to SEV is provided in Section 3.2. to provide a general knowledge of the technology. In the end, Section 3.3. summarized the content of this chapter.

3.1. Solar Electric Vehicle as a Disruptive Innovation

Electric vehicle and solar PV are actually cannot be considered as new innovations as they have been existed since the 18th century via series of breakthroughs developed by multiple scientists (Matulka, 2014; Richardson, 2018). The combination of both technologies in a product called solar electric vehicle is also not a new thing. World Solar Challenge – an international solar car competition, for example, has been facilitating the development of solar electric cars since 1987 (Bridgestone, 2019). However, the commercialization of SEV is just started recently by the emergence of various SEV producers aiming to deliver their first SEVs at the end of this year or in the coming years (Aptera Motors, 2022; Lightyear, 2021; Sono Motors, 2021). Thus, if we look from the commercialization point of view, SEV could be seen as an innovative product.

Based on the definition and characteristics of disruptive innovations explained in Chapter 2.1., SEV could be defined as a disruptive innovation for several reasons as explained in the following. First, the commercialization of SEV was unexpected. The EV market leaders know that they have to solve EV's drawbacks to pace-up the EV adoption. However, they are reluctant to significantly change their cars design, for example, to significantly reduce the coefficient drag or to add the solar panels on the car to improve the car's driving range and to reduce the charging hassle because they have been locked into their existing designs and production systems that have cost them high sunk investment cost. Therefore, new start-up companies emerged to take this opportunity to build their own SEVs from scratch and commercialize them.

Secondly, as explained in the previous section, the newly emerged SEVs are not necessarily more expensive than their EVs rivals as well as the fossil fueled vehicles, which contradict Hardman et al. (2013)'s theory on disruptive innovations. However, SEV producers' capability to provide price competitive SEVs make them more disruptive, especially because they provide better benefits and values to the customers.

Hardman et al. (2013) also argued that disruptive innovations often have less quality than their competitors, but they often offer more added values. SEV's quality could be seen less than the incumbent vehicles in term of driving range, especially when they are compared to the fossil-fueled vehicles. However, SEVs have better quality in many other things, such as they produce less emission, more energy efficient, silent, require less maintenance, less "fuel" cost, have possibility to be self-sufficient, etc. Moreover, utilizing SEVs bring added values to the customers as they produce well-to-wheel zero emission when they are run by the electricity produced by their solar panels and they require less time to charge and less charging needs which reduce the charging hassle, which in the end give more freedom to their users in driving.

These advantages and added value enable the SEVs to be disruptive enough to penetrate the market.

Lastly, Hardman et al. (2013) explained that disruptive innovations often started the market penetration by targeting niche market. This case is true for Lightyear's first generation SEV as they are targeting high-end customers. However, other SEV producers took a totally different path by aiming at mainstream customers by providing affordable SEVs since the start of the market entry. Despite the different approach they took, still the SEVs pose the same threat and disruption not only to the EV market but also to the passenger cars market in general, as now the customers are having a new passenger car alternative that is sustainable and affordable.

Based on above explained points, it could be seen that SEVs do not fully comply the characteristics of disruption innovations theory explained by Hardman et al. (2013). However, the combination of SEVs' advantages and added values somehow still poses a disruption to the existing well-established fossil-fueled automotive market as well as the EV market, which created a window opportunity for them to grow and get adopted in the society.

3.2. Introduction to Solar Electric Vehicles

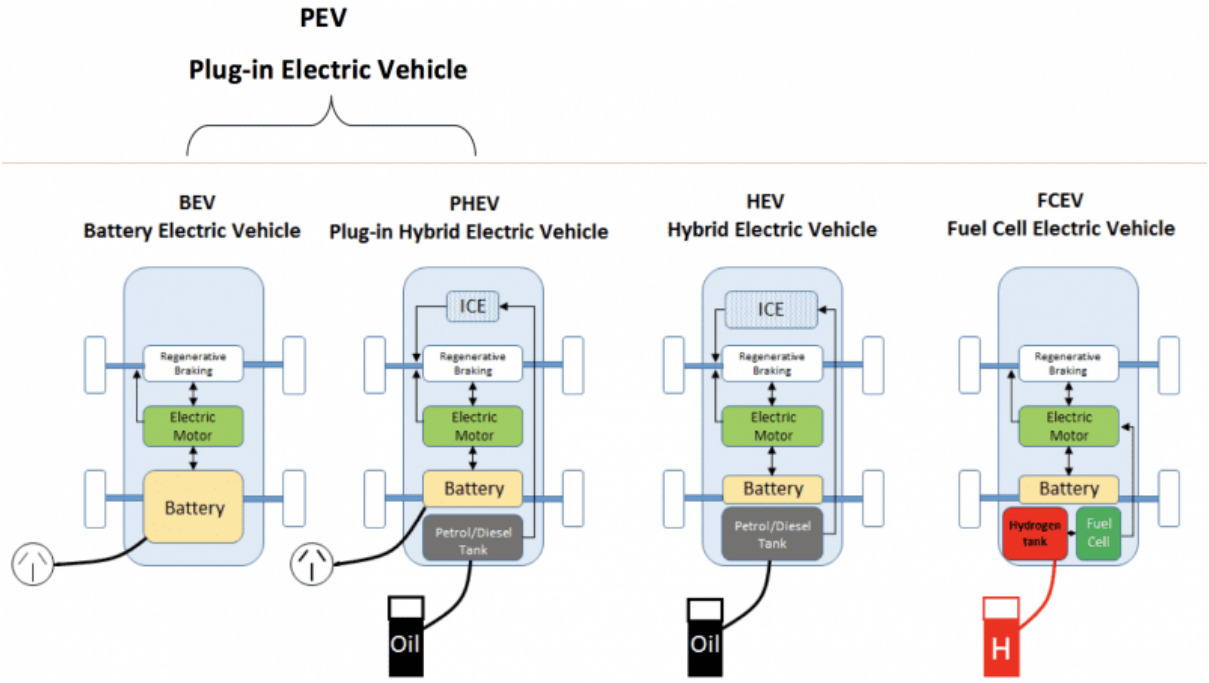


Figure 13 Comparison of different types of EVs currently available in the market (Gaton, 2018)

Currently, there are four types of EV available in the market namely BEV, PHEV, HEV, and FCEV. As illustrated by Figure 13, the differences between these EVs lie on the energy sources, drive systems, and the plug-in facility. As explained in Chapter 1, currently several SEVs have emerged in the market. SEV has a similar configuration compared to BEV. The distinguish between SEV and BEV is that SEV equipped with solar cells on its roof (and body) to convert the sunlight into electricity to run the electric motor or to charge the battery when the car is not in used. In other words, the solar cells provide an alternative power source to the car other than the conventional plug-in charging facilities. A technological map of SEV vs BEV is developed in the present work to illustrate their differences, as shown by Figure 14. This additional feature brings many advantages that makes SEV become more attractive than the conventional BEV and other types of EVs, as elaborated in the following.

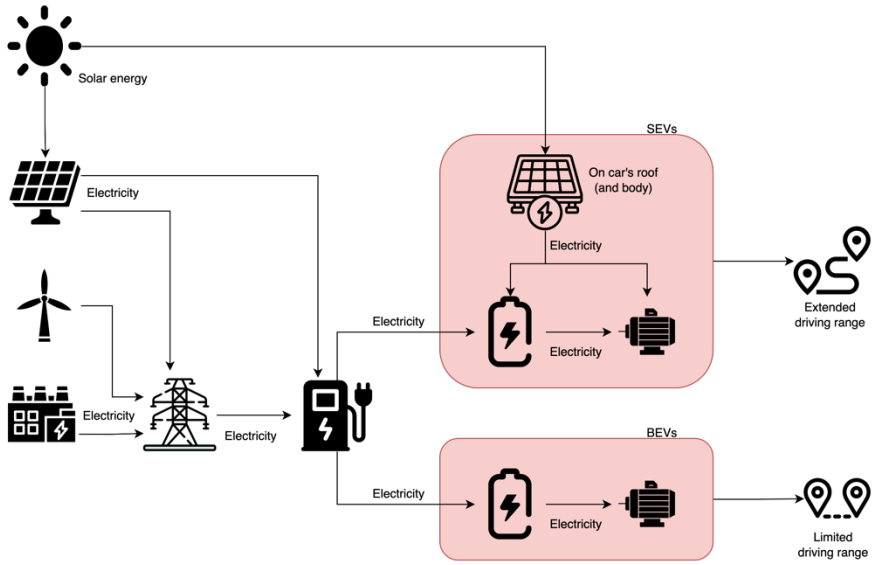


Figure 14 Technological map of the solar electric vehicle compared to conventional battery electric vehicle

Range anxiety is one of the major factors that hinder the uptake of conventional electric vehicles in society (Adiatma & Marciano, 2020; Egbue & Long, 2012). It is argued that range anxiety could be reduced by improving the charging infrastructures (Egbue & Long, 2012; Trip et al., 2012) specially in the "charging desert" - areas that have minimum charging facilities. However, with the solar cells feature that SEV has, SEV is not solely depending on its onboard batteries and hence also the charging infrastructures. Instead, SEV could charge itself during the day while driving or while being parked, which could extend its driving range and reduce SEV's charging frequency and time at the plug-in charging facility.

Moreover, SEV could be energy self-sufficient when it only drives a short range daily (Aptera Motors, 2022; Lightyear, 2022b; Sono Motors, 2021). Lightyear 0, for example, could drive 1000+ km between two charging moments if the user drives around 50km per day in Amsterdam during summer (Lightyear, 2022a). In this case, it takes about 20 days until the user needs to recharge the car's battery.

Furthermore, having the solar cells feature could reduce the charging hassle that often experienced by the conventional EV users (Ahmadi, 2019; Alamsjah et al., 2021; Damayanti et al., 2020), such as the possibility of having run out battery and/or unavailable charging station nearby during the trip, having to always check in advance whether the travel routes and destinations have charging facilities, and having to put extra time during long trips for recharging. In other words, SEV's solar cells feature makes SEV users become less dependent to the charging facilities and therefore have more freedom in driving.

From economic point of view, driving an SEV is cheaper than other EVs (Cobbenhagen & Hoefsloot, 2015b; Hediu, 2021), thanks to the solar panels installed on its roof (and body). When the sun is shining, the SEV could generate free "fuel" by itself. If the SEV is driven mostly during daytime in the area with abundant sun throughout the year, the SEV require less operating cost compared to other BEVs. Moreover, from a bigger system perspective, mass adoption of SEV could significantly reduce the system cost due to their less dependency on the charging infrastructure. The Netherlands, for example, could save around €8 billion until 2050 on building less charging infrastructure if the passenger cars would be 100% SEV (Noteboom, 2021). Additionally, less dependency on charging infrastructure also means that higher

penetration of SEV would reduce the potential electricity grid congestion, which is one of the challenges of the high EV uptake (Gonzalez, 2015).

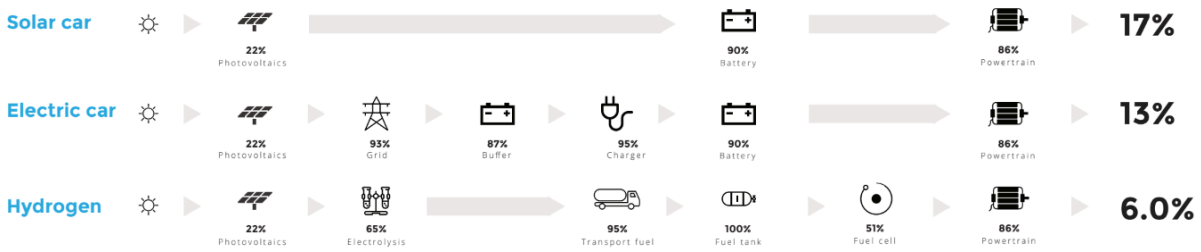


Figure 15 Well-to-wheel efficiency comparison between various EVs (Cobbenhagen & Hoefsloot, 2015a)

Many research argued that EV adoption could boost the decarbonization, however, the source of the electricity fed into the EV would ultimately define whether the EVs are really producing zero emission (Suehiro & Purwanto, 2019). From the well-to-wheels perspective, any energy used by the SEV that come from the solar energy is absolutely emission free. In other words, SEV adaption gives immediate impact on decarbonization (Hediu, 2021). Moreover, as illustrated by Figure 15, SEV has the highest well-to-wheel efficiency compared to other EVs because the electricity used by the SEV's electric motors go through less production and distribution cycles (Cobbenhagen & Hoefsloot, 2015a).

Despite many advantages SEV could offer, SEV also has some downside. Hediu (2021) argued that SEV price is more expensive compared to its conventional BEVs rival due to its solar panels feature. However, it is proved untrue for Sion and Aptera case as they set their purchasing price at €28,500 (305 km battery range) and $25,900 (250 miles/400 km battery range) respectively (Aptera Motors, 2022; Sono Motors, 2021). Even though Lightyear 0 is currently priced at €150,000 excluding taxes (Lightyear, 2021), however, Lightyear planned to sell its later version, Lightyear Two, at €30,000 in 2025 (Gauthier, 2021). With these prices, these SEV are actually quite competitive in the market.

Furthermore, Hediu argued that SEV is weather dependant (Hediu, 2021). Means, it could only deliver its solar panels related advantages when the sun is shining. During rainy or cloudy day, the energy generated from sun is significantly less. As the cars need to be parked with fully exposure to the sun to maximize its electricity generation, it could be a limitation if there are many trees or high buildings around the parking area. Moreover, it is argued that parking the car in the sun could fade the car paint as well as damage the interior and the tires (New Roads, 2018). This led to common behaviour to park the car indoor or in the shade. Thus, a behaviour change is needed for those who are planning to adopt the SEV.

Furthermore, Hediu (2021) argued that SEV might produce more pollution as it use more scarce materials during its manufacturing, especially for its battery and solar panels. However, it is probably untrue of it is seen from the full lifetime of the vehicle.

In the end, despite of its flaws, SEV is indeed providing many interesting advantages that overcome many barriers that have been hindering the electrification and decarbonization of passenger's transport. With the urge to meet the net zero emissions goals globally, SEV could be one of the solutions to significantly reduce the emissions in transport sector.

3.3. Chapter Conclusion and Summary

This chapter is written to answer the first sub-research question: **"How is solar electric vehicles different than conventional electric vehicles?".** However, before answering this question, the author looked at the disruptive innovation theory presented by Hardman et al. (2013) to see whether SEV is actually a disruptive innovation. As elaborated in Section 2.1., Hardman et al. (2013) explain that there are several common characteristics that disruptive innovations have: they emerged unexpectedly, they cost significantly more expensive, and have less quality than the alternatives or existing solutions; they offer added values; and they initially enter the market through the niche markets. If we look at SEVs and their characteristics, they only comply with some of the disruptive innovations' characteristics: they emerged unexpectedly by offering interesting added values. The first edition of Lightyear's SEV is indeed expensive and targeted the high-end niche market, however, other SEV producers such as Aptera Motors and Sono Motors are aiming at the mainstream market by offering affordable SEVs. Moreover, SEVs quality could be seen less compared to the fossil-fueled vehicles in terms of driving range, but most of them provide similar or more driving range than their EVs competitors. Additionally, SEVs' advantages and added values weigh off their disadvantages as they could solve most of the major problems that EVs have. In the end, even though SEVs do not comply with the whole disruptive innovations' characteristics mentioned by Hardman et al., however, SEVs' advantages and added values have created certain strong points for SEVs to disrupt the automotive markets with their innovations.

Four types of EVs are currently available in the market namely BEV, PHEV, HEV, and FCEV. The differences between these EVs lie in the energy sources, drive systems, and the plug-in facility, as illustrated in Figure 13. Compared to these EVs, SEV is very similar to BEV technology. The only distinctive difference is that SEV has solar panels on its roof (and body), as illustrated by Figure 14, which bring several interesting added values: it generates its own "fuel" for free with well-to-wheels zero emission; it extends the car's driving range; it makes the car less dependent on the battery and the charging facilities; it could be energy self-sufficient; it reduces charging frequency, time as well as the charging hassle; and it potentially reduces the system cost due to the less charging facilities that need to be built to accommodate EV mass adoption. On the other hand, SEV is weather dependent and might produce more emissions during the extracting of its raw material and manufacturing of its major components such as the battery and solar panels. However, SEV is still an interesting and promising low-emission vehicle alternative because of its capability to solve most of the major drawbacks of EVs that have been hindering the decarbonization of transportation.

Chapter 4. Potential Strategies to Reach Large Scale Diffusion

The purpose of Chapter 4 and Chapter 5 is to answer the second sub-research question: **"Based on the existing theories in the literature, how could the niche development barriers be linked to the niche strategies so that a niche strategy that could circumvent several barriers at once could be selected?"** As explained previously in Section 2.4. and Section 2.5., the Ortt & Kamp's TIS framework explained that niche strategy could be implemented to overcome barriers that emerged due to combination of TIS building block and influencing factor. However, Ortt & Kamp did not specify which niche strategy is best to overcome certain diffusion barriers. Meanwhile, Ortt's Ten Niche Strategies framework only proposed ten generic strategies to overcome the barriers. Thus, a new framework called "Best Strategy Framework" needs to be developed in the present work to enable the users/readers to choose a strategy that could circumvent multiple barriers at the same time. To do this, the list of potential strategies needs to be generated beforehand. Therefore, this chapter is elaborating the proses of identifying the potential strategies that could be implemented to circumvent the potential barriers that could hinder the large-scale commercialization. The results of this chapter will be used as the basis to develop the "Best Strategy Framework", which will be elaborated in the next chapter.

To identify the potential strategies, literature search is conducted to go through various academic literatures namely master's thesis reports and journals. The literature search is focused on potential strategies that could be implemented by the inventors or producers of an innovation. Master's thesis reports are chosen as the first sources because there have been many thesis research conducted around Ortt's framework (Ortt et al., 2013) - the earlier version of Ortt & Kamp's TIS framework, which could be valuable inputs for this research. In addition, various journals are explored to get new insights on strategies that were implemented by various successful innovators.

This chapter is structured as the following. Section 4.1. and Section 4.2. elaborates the strategies identification from master's thesis reports and journals respectively. Please note that the results of analysis in Section 4.2 is build up from the results of the Section 4.1. In the end, Section 4.3. summarizes the findings.

4.1. Potential Strategies Based on Master's Thesis Reports

4.1.1. Step 1: Literature Search

To identify the potential strategies, a literature search is done in which the process is illustrated by Figure 16. It is started by looking back to the results of the literature search that was conducted earlier (see literature search step 2 in Section 1.4.1.). Back then, it was known that various research has been done in the previous years to adapt or extend the barriers and strategies framework to fit certain contexts. Among all that previous research, there were eight literatures selected due to their relevance to this research. Thus, these literatures are prioritized to be the basis to develop the best strategy conceptual model.

However, during the further review of these literatures, it was identified that Olsthoorn (2017)'s research was conducted based on the research that was earlier done by Doe (2014) and Pratiwi (2016). For this reason (exclusion criteria 1), Doe's and Pratiwi's research is not reviewed

further to optimize the time used for this research. Furthermore, exclusion criteria 2 is applied to the remaining literature which unfortunately eliminate other four literatures. Additionally, the author of the present work received a recommendation of two relevant literatures from her supervisors. However, when exclusion criteria 2 is applied to these literatures, only one literature is considered relevant. Thus, in the end, there are only three relevant literatures.

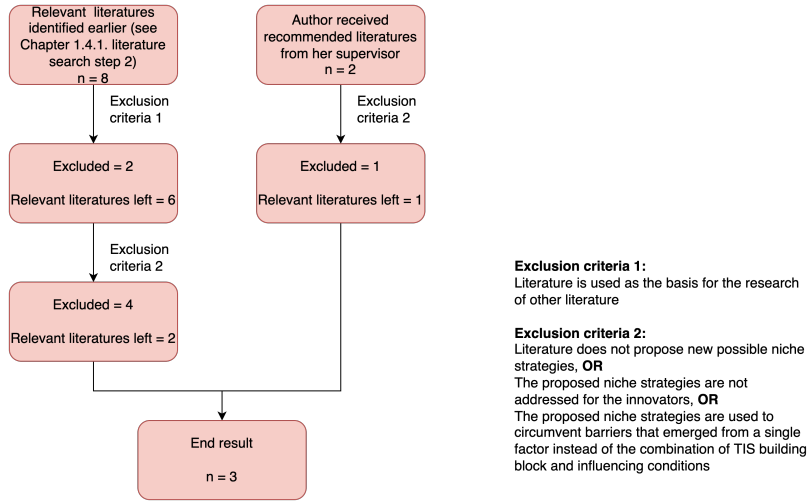


Figure 16 The process of the literature search conducted to identify the potential strategies based on adapted barriers and strategies framework

The overview of the ten literatures is shown in Table 6 while the results of the literature review on Schulz, Olsthoorn, and Van den Berg's research is explained in the following subsections.

Table 6 List of reviewed master's thesis reports to identify the potential strategies

Authors	Year of Publication	Titles	Original Contexts	Adapted Contexts		Framework Basis	Potential Barriers	Links between Barriers and Strategies	Potential Strategies
Yvar in 't Veld	2020	Strategies for the diffusion of sustainable energy technologies in developing countries	Developed countries, new high-tech products	N/A					Identified potential strategies that could be implemented by various actors to help to circumvent the barriers. However, there is no strategies are suggested to the inventors of the innovative products (Exclusion criteria 2)
Jara Schulz	2019	Developing a conceptual model on strategies overcoming barriers for the introduction of radical innovations in niches		General	Radical innovations in general	7 core factors and 7 influencing factors	Adapted the framework into 7 core factors and 8 influencing factors	Links between barriers and strategies are identified	Proposed 29 niche strategies
Stephanie Kartika Lestari	2017	Assessing Influencing Factors During Diffusion of a Radical Innovation: A Case Study in Urban Farming The Netherlands		N/A					No new strategies were proposed (Exclusion criteria 2)
Rithwick Parthasarathy	2017	Barriers and Strategies for Different Organisational Setups of Sustainable Energy Firms Operating in Developing Countries		N/A			Identified 23 potential barriers but the barriers are not come from the combination of TIS building blocks and influencing conditions. Instead each building blocks, influencing conditions, and newly added factors are acted as barriers (Exclusion criteria 2)	N/A	
Stefan Olsthoorn	2017	Dutch cooling technology in the desert: A market study on district cooling for Dutch companies based on niche strategies to commercialise high-tech products		Dutch companies	District cooling	6 core factor and 6 influencing factors	Adapted the framework into 9 core factors and 10 influencing factors	Links between barriers and strategies are identified	Proposed 18 niche strategies
Lusi Pratiwi	2016	Barriers and Strategies for Transition to Electric Vehicles in BRICS Countries: Case Study of South Africa, India, and Brazil		These literature are used as the basis for Olsthoorn's research (Exclusion criteria 1)					
Matthew F.A. Doe	2014	Niche strategy selection for kite-based Airborne Wind Energy technologies							
Vicky Bruinsma	2015	Developing a dynamic framework for the selection of niche strategies to introduce new high-tech products		N/A					No new strategies were proposed (Exclusion criteria 2)
Mariah C.L.K. Joukes	2021	The Diffusion of Maritime Autonomous Surface Ships		N/A					No new strategies were proposed (Exclusion criteria 2)
Nicole Jane van den Berg	2017	Niche strategies selection in developing countries: a case study on RE-desalination		Developing countries	RE-desalination	6 core factor and 6 influencing factors	Adapted the framework into 10 core factors and 10 influencing factors	Links between barriers and strategies are identified	Proposed 13 niche strategies

Exclusion criteria 1
Exclusion criteria 2

4.1.2. Step 2: Identification

4.1.2.1. Literature 1: Developing a conceptual model on strategies overcoming barriers for the introduction of radical innovations in niches by Jara Schulz

Schulz (2019) conducted intensive research to adapt the earlier version of barriers and strategies framework to provide insights on new possible barriers and strategies. In the adapted version of the framework, Schulz split the human and natural resources into two different influencing conditions. The author of the present work agrees with this approach because the lack of human and natural resources would influence the TIS building block differently, and hence pose as different barriers. Therefore, different strategies might be required to circumvent the barriers.

Table 7 Possible barriers based on the combination of TIS building blocks and influencing conditions (Schulz, 2019)

		TIS Building Blocks						
		Product performance and quality	Product price	Production system	Complementary products and services	Network formation and coordination	Customers	Innovation-specific institutions
Influencing conditions	Knowledge and awareness of technology	✓	✓	✓	✓	✓	✓	✓
	Knowledge and awareness of application and market					✓	✓	✓
	Human resources	✓		✓				
	Natural resources		✓		✓			
	Financial resources	✓	✓	✓	✓			
	Macro-economic and strategic aspects				✓	✓	✓	✓
	Socio-cultural aspects	✓				✓	✓	✓
	Accidents and events					✓	✓	✓

Agreed with Ortt et al. (2013), Schulz argued that not all combination of TIS building blocks and influencing conditions are relevant as some influencing conditions do not influencing certain building blocks. Therefore, Schulz identified the possible barriers as shown in Table 7. Interestingly, Schulz thought that accident and events might not have a link to the product price and production system, while in fact they do. Covid pandemic and the war in Ukraine, for example, had significantly influence the price of various products in the market, as well as slowing down the operation of various production systems of the affected areas. Another striking insight from Table 7 is that there is no link identified between customers building blocks and any of the resources. At the opposite, financial resources, for example, significantly influencing customers' decision on adopting an innovation.

Based on potential barriers identified in Table 7, Schulz investigated the possible niche strategies, their link to the possible barriers, and the types of the niche strategy by conducted literature research and case study. The research resulted to 29 possible niche strategies as shown in Figure 25 in the Appendix A.1.1. In the present work, these findings are mapped to the barriers and strategies matrix as shown by Table 8.

Table 8 The barriers and strategies matrix based on Schulz findings

		Niche Strategies																												
Niche Strategy No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Influencing Conditions	TIS Building Blocks	Different application	Technological R&D	Pilot R&D	Pilot project	Human resource management	Market research	Internal knowledge sharing	Redesign	Partnership	Finance sourcing	Direct lobbying	Changing behavior	Indirect lobbying	Crowd-sourcing	Lead-user	Top-end	Leasing	Sharing platform	Subsidy	Geographical	Hybridization	Adaptor	Stand-alone	Dedicated	Education	Restructuring business	Buy one - give one	Joining regulation agency	Campaign funding
Knowledge and awareness of technology	Product performance and quality		✓	✓		✓	✓	✓	✓																					
Knowledge and awareness of application and market																														
Human resources						✓		✓		✓																				
Natural resources		✓																												
Financial resources									✓		✓									✓										
Macro-economic and strategic aspects																														
Socio-cultural aspects									✓			✓	✓	✓	✓	✓														
Accidents and events																														
Knowledge and awareness of technology	Product price		✓	✓		✓	✓		✓								✓	✓	✓	✓	✓									
Knowledge and awareness of application and market																														
Human resources																														
Natural resources									✓	✓																				
Financial resources									✓		✓																			
Macro-economic and strategic aspects																														
Socio-cultural aspects																														
Accidents and events																														
Knowledge and awareness of technology	Production system	✓	✓	✓		✓	✓		✓								✓													
Knowledge and awareness of application and market																														
Human resources						✓		✓		✓																				
Natural resources																														
Financial resources									✓		✓						✓			✓										
Macro-economic and strategic aspects																														
Socio-cultural aspects																														
Accidents and events																														
Knowledge and awareness of technology	Complementary products and services		✓	✓		✓	✓																	✓	✓					
Knowledge and awareness of application and market																														
Human resources																														
Natural resources										✓											✓	✓	✓	✓	✓					
Financial resources											✓									✓				✓	✓					
Macro-economic and strategic aspects												✓	✓											✓	✓					
Socio-cultural aspects																														
Accidents and events																														
Knowledge and awareness of technology	Network formation and coordination		✓	✓			✓		✓																	✓				
Knowledge and awareness of application and market				✓	✓		✓						✓		✓	✓										✓				
Human resources																														
Natural resources						✓				✓											✓									
Financial resources																														
Macro-economic and strategic aspects												✓	✓			✓														
Socio-cultural aspects									✓			✓	✓	✓		✓										✓				
Accidents and events																														

		Niche Strategies																												
Niche Strategy No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Influencing Conditions	TIS Building Blocks	Different application	Technological R&D	Pilot R&D	Pilot project	Human resource management	Market research	Internal knowledge sharing	Redesign	Partnership	Finance sourcing	Direct lobbying	Changing behavior	Indirect lobbying	Crowd-sourcing	Lead-user	Top-end	Leasing	Sharing platform	Subsidy	Geographical	Hybridization	Adaptor	Stand-alone	Dedicated	Education	Restructuring business	Buy one - give one	Joining regulation agency	Campaign funding
Knowledge and awareness of technology	Customers		✓	✓		✓	✓		✓				✓													✓				
Knowledge and awareness of application and market				✓	✓		✓						✓		✓	✓										✓				
Human resources						✓																								
Natural resources																					✓									
Financial resources									✓		✓		✓				✓	✓	✓	✓								✓		
Macro-economic and strategic aspects												✓	✓			✓				✓										
Socio-cultural aspects									✓			✓	✓	✓	✓	✓														
Accidents and events																														
Knowledge and awareness of technology	Innovation-specific institutions		✓	✓		✓	✓					✓									✓					✓			✓	✓
Knowledge and awareness of application and market				✓			✓					✓		✓	✓	✓										✓			✓	✓
Human resources						✓																								
Natural resources									✓												✓									
Financial resources																														
Macro-economic and strategic aspects												✓		✓															✓	✓
Socio-cultural aspects												✓	✓	✓	✓	✓													✓	✓
Accidents and events																													✓	✓

4.1.2.2. Literature 2: Dutch cooling technology in the desert: A market study on district cooling for Dutch companies based on niche strategies to commercialise high-tech products by Stefan Olsthoorn

Olsthoorn (2017) conducted another research to adapt Ortt et al. (2013) framework to fit district cooling context in the Netherlands by conducting literature review and interview with the industry experts. In this research, Olsthoorn included literature that were written by Pratiwi (2016) and Doe (2014) as the basis of his research as they have had done similar adaptation on the framework despite their different contexts. Olsthoorn research resulted to a framework consists of nine core factors and ten influencing factors by adding some new factors and splitting some original factors, as elaborated in Table 47 in Appendix A.1.2. The definition of each factor is explained in Table 48 in Appendix A.1.2.

Furthermore, Olsthoorn added/adapted several strategies to overcome the potential barriers. The definition of these strategies is briefly explained in Appendix A.1.2., while the relationship between the barriers and the strategies is explained in Table 49 in Appendix A.1.2. In the present work, these findings are mapped to the barriers and strategies matrix as shown by Table 9.

From Olsthoorn findings, it is striking to see that "Innovativeness of the customers" and "Financing aspects" are defined as new building blocks instead of as new influencing factors. The author of the present work agrees that both the "Innovativeness of the customers" and "Financing aspects" are important to have to enable the mass uptake of the innovation, however, the author sees these more like factors that influencing the customers' adoption decision.

Table 9 The barriers and strategies matrix based on Olsthoorn findings

Barriers due to the incomplete of:		Niche Strategies															
Influencing Conditions	TIS Building Blocks	Demo	Adapted Top niche	Subsidized	Redesign	Dedicated/ stand-alone	Hybridization / adaptor	Educate	Geographic	Lead user	Explore markets	Market Preparation	Stepping-stone	References	Network building	Increase collaboration	Lobby	Get Specified
Knowledge of technology	New high-tech product	✓		✓	✓													
Natural resources, labors, and skills				✓	✓				✓									
Knowledge of application				✓	✓				✓									
Socio-cultural business aspects																		
Socio-cultural demand and application aspects																		
Economic aspects																		
Accidents or events and (perceived) risk and uncertainty																		
Knowledge of the market																		
Foreign institutional aspects		✓			✓				✓						✓		✓	
Competition																		
Knowledge of technology	Production system			✓	✓													
Natural resources, labors, and skills				✓	✓													
Knowledge of application																		
Socio-cultural business aspects																		
Socio-cultural demand and application aspects				✓	✓								✓					
Economic aspects																		
Accidents or events and (perceived) risk and uncertainty																		
Knowledge of the market																		
Foreign institutional aspects				✓	✓										✓		✓	
Competition																		
Knowledge of technology	Complementary products and services					✓	✓									✓		
Natural resources, labors, and skills							✓		✓									
Knowledge of application																		
Socio-cultural business aspects																		
Socio-cultural demand and application aspects																		
Economic aspects																		
Accidents or events and (perceived) risk and uncertainty																		
Knowledge of the market																		
Foreign institutional aspects																		
Competition																		

Barriers due to the incomplete of:		Niche Strategies																
Influencing Conditions	TIS Building Blocks	Demo	Adapted Top niche	Subsidized	Redesign	Dedicated/ stand-alone	Hybridization / adaptor	Educate	Geographic	Lead user	Explore markets	Market Preparation	Stepping-stone	References	Network building	Increase collaboration	Lobby	Get Specified
Knowledge of technology	Suppliers (network of organization)							✓								✓		
Natural resources, labors, and skills																		
Knowledge of application										✓						✓		
Socio-cultural business aspects										✓			✓		✓			
Socio-cultural demand and application aspects					✓				✓	✓			✓					
Economic aspects									✓	✓								
Accidents or events and (perceived) risk and uncertainty										✓								
Knowledge of the market								✓				✓						
Foreign institutional aspects									✓	✓					✓		✓	
Competition																		
Knowledge of technology	Customers							✓						✓		✓		
Natural resources, labors, and skills																		
Knowledge of application										✓	✓			✓		✓		
Socio-cultural business aspects										✓			✓		✓			
Socio-cultural demand and application aspects					✓				✓	✓			✓	✓				
Economic aspects									✓	✓								
Accidents or events and (perceived) risk and uncertainty										✓								
Knowledge of the market								✓				✓						
Foreign institutional aspects									✓	✓					✓		✓	
Competition			✓															✓
Knowledge of technology	Domestic institutional aspects																	
Natural resources, labors, and skills																		
Knowledge of application																		
Socio-cultural business aspects																		
Socio-cultural demand and application aspects																		
Economic aspects																	✓	
Accidents or events and (perceived) risk and uncertainty									✓									
Knowledge of the market																		
Foreign institutional aspects																		
Competition																		

Barriers due to the incomplete of:		Niche Strategies																
Influencing Conditions	TIS Building Blocks	Demo	Adapted Top niche	Subsidized	Redesign	Dedicated/ stand-alone	Hybridization / adaptor	Educate	Geographic	Lead user	Explore markets	Market Preparation	Stepping-stone	References	Network building	Increase collaboration	Lobby	Get Specified
Knowledge of technology	Foreign institutional aspects								✓						✓		✓	
Natural resources, labors, and skills																		
Knowledge of application					✓				✓								✓	
Socio-cultural business aspects																		
Socio-cultural demand and application aspects					✓				✓				✓				✓	
Economic aspects									✓								✓	
Accidents or events and (perceived) risk and uncertainty									✓									
Knowledge of the market																		
Foreign institutional aspects																		
Competition																		
Knowledge of technology	Innovativeness of the customers																	
Natural resources, labors, and skills																		
Knowledge of application																		
Socio-cultural business aspects																		
Socio-cultural demand and application aspects								✓		✓			✓					
Economic aspects																		
Accidents or events and (perceived) risk and uncertainty				✓														
Knowledge of the market																		
Foreign institutional aspects																		
Competition																		
Knowledge of technology	Financing aspects																	
Natural resources, labors, and skills				✓														
Knowledge of application																		
Socio-cultural business aspects																		
Socio-cultural demand and application aspects																		
Economic aspects				✓					✓								✓	
Accidents or events and (perceived) risk and uncertainty										✓								
Knowledge of the market																		
Foreign institutional aspects																		
Competition																		

4.1.2.3. Literature 3: Niche strategies selection in developing countries: a case study on RE-desalination by Nicole Jane van den Berg

Van den Berg (2017) conducted another research based on Ortt et al (2013)'s framework by combining literature review, interviews, and case studies methodologies to adapt the original framework to fit the RE desalination context in the developing countries. This research resulted to a framework that consist of ten core factors and ten influencing factors by splitting some of the original factors and adding a new influencing factor. The comparison between original and adapted/new core and influencing factors is shown in Table 50 and Table 51 in Appendix A.1.3. respectively, including the definition of the adapted and new factors. The author of the present work, however, disagree with the splitting of some of the factors. Customers building block, for example, is split into Customers market information, Customer knowledge, and Public awareness. Even though, these three factors are important to have for the mass adoption, however, the author of the present work sees these factors as the results of the Customers building block when it is influenced by certain influencing factors, such as Knowledge and awareness of the technology and Knowledge and awareness of the market and application. Therefore, splitting the Customer building blocks makes them redundant.

To solve the potential barriers that came from the combination of these core factors and influencing factors, Berg proposed thirteen niche strategies, by adding three new niche strategies into Ortt's existing ten niche strategies, namely (1) Generation of social network strategy, (2) Participation strategy, and (3) Local strategy. Brief explanation of these newly defined strategies is presented in Appendix A.1.3.

In the end, Van den Berg summarized the identified barriers as well as strategies that could overcome the barriers as shown in Table 52 in Appendix A.1.3. In the present work, these findings are mapped to the barriers and strategies matrix as shown in Table 10.

Table 10 The barriers and strategies matrix based on Van den Berg findings

Barriers due to the incomplete of:		Niche Strategies												
Influencing Conditions	**TIS Building Blocks**	**Demo**	**Top niche**	**Subsidized**	**Redesign**	**Dedicated/ stand-alone**	**Hybridization / adaptor**	**Educate**	**Geographic**	**Lead user**	**Explore markets**	**Generation of social network**	**Participation**	**Local**
Developers' knowledge	Relative affordability		✓											
Appropriately- skilled labour			✓	✓	✓									
Natural resources			✓	✓	✓									
Knowledge of application														
Cultural methods														
Cultural norms and values														
Market structure														
Purchasing power														✓
Accident or events														
Physical/information access & infrastructure														
Developers' knowledge	Production system	✓	✓	✓	✓									
Appropriately- skilled labour														
Natural resources														
Knowledge of application										✓				
Cultural methods														
Cultural norms and values														
Market structure														
Purchasing power														
Accident or events														
Physical/information access & infrastructure						✓								
Developers' knowledge	Complementary products and services					✓	✓							
Appropriately- skilled labour							✓		✓					
Natural resources							✓		✓					
Knowledge of application														
Cultural methods														
Cultural norms and values														
Market structure														
Purchasing power														
Accident or events														
Physical/information access & infrastructure														

Barriers due to the incomplete of:		Niche Strategies												
Influencing Conditions	TIS Building Blocks	Demo	Top niche	Subsidized	Redesign	Dedicated/ stand-alone	Hybridization / adaptor	Educate	Geographic	Lead user	Explore markets	Generation of social network	Participation	Local
Developers' knowledge	Network of organization							✓						
Appropriately- skilled labour														
Natural resources														
Knowledge of application										✓				
Cultural methods					✓				✓	✓				
Cultural norms and values					✓				✓	✓				✓
Market structure									✓	✓				
Purchasing power									✓	✓				
Accident or events										✓				
Physical/information access & infrastructure														
Developers' knowledge	Customer market information							✓						
Appropriately- skilled labour														
Natural resources														
Knowledge of application										✓				
Cultural methods					✓				✓	✓				
Cultural norms and values					✓			✓	✓	✓				
Market structure									✓	✓				
Purchasing power									✓	✓				
Accident or events										✓				
Physical/information access & infrastructure														
Developers' knowledge	Customer knowledge							✓						
Appropriately- skilled labour														
Natural resources														
Knowledge of application										✓	✓			
Cultural methods					✓				✓	✓				
Cultural norms and values					✓				✓	✓			✓	
Market structure									✓	✓				
Purchasing power									✓	✓				
Accident or events										✓				
Physical/information access & infrastructure														
Developers' knowledge	Public awareness							✓						
Appropriately- skilled labour														
Natural resources														
Knowledge of application										✓				
Cultural methods					✓				✓	✓				
Cultural norms and values		✓			✓				✓	✓				
Market structure									✓	✓				
Purchasing power									✓	✓				
Accident or events										✓				
Physical/information access & infrastructure														

Barriers due to the incomplete of:		Niche Strategies												
Influencing Conditions	TIS Building Blocks	Demo	Top niche	Subsidized	Redesign	Dedicated/ stand-alone	Hybridization / adaptor	Educate	Geographic	Lead user	Explore markets	Generation of social network	Participation	Local
Developers' knowledge	Standards and support								✓					
Appropriately- skilled labour														
Natural resources														
Knowledge of application					✓				✓					
Cultural methods					✓			✓	✓			✓		
Cultural norms and values					✓				✓					
Market structure									✓					
Purchasing power									✓					
Accident or events									✓					
Physical/information access & infrastructure														
Developers' knowledge	Political system								✓					
Appropriately- skilled labour														
Natural resources														
Knowledge of application					✓				✓					
Cultural methods					✓				✓					
Cultural norms and values					✓				✓					
Market structure									✓					
Purchasing power									✓					
Accident or events									✓					
Physical/information access & infrastructure														
Developers' knowledge	Legal system								✓					
Appropriately- skilled labour														
Natural resources														
Knowledge of application					✓				✓					
Cultural methods					✓				✓					
Cultural norms and values					✓				✓					
Market structure									✓					
Purchasing power									✓					
Accident or events									✓					
Physical/information access & infrastructure														

4.1.3. Step 3: Results

Based on the previous section, many new factors and strategies are identified by three different researchers: Schulz (2019), Olsthoorn (2017), and Van den Berg (2017). However, many of the factors and strategies are the same or similar to Ortt & Kamp's factors, Ortt's ten niche strategies, or factors and strategies identified by other researchers. Therefore, an analysis is conducted in the present work to list and go through all the identified factors and strategies, to compare them against each other, and then to eliminate the similarities between them. The detailed analysis and arguments are presented in Table 53, Table 54, and Table 55 in Appendix A.2.

This analysis resulted to the list of consolidated TIS building blocks, influencing factors, and strategies as shown in Table 11, Table 12, and Table 13 respectively. The new or adapted factors or strategies compared to the original framework are indicated by red texts.

Table 11 The list of consolidated TIS building blocks that were identified by Ortt & Kamp (2022) and various master thesis literatures

No.	TIS Bulding Blocks	Identified by
1	Product availability, performance, and quality	Ortt & Kamp (2022), Schulz (2019), Olsthoorn (2017)
2	Product price	Ortt & Kamp (2022), Schulz (2019), Van den Berg (2017)
3	Production system	Ortt & Kamp (2022), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
4	Complementary products and services	Ortt & Kamp (2022), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
5	Network formation and coordination	Ortt & Kamp (2022), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
6	Customers	Ortt & Kamp (2022), Schulz (2019), Olsthoorn (2017)
7	Innovation-specific institutions	Ortt & Kamp (2022), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)

Table 12 The list of consolidated influencing factors that were identified by Ortt & Kamp (2022) and various master thesis literatures

No.	(New/Adapted) Influencing Factors	Identified by
1	Knowledge and awareness of technology	Ortt & Kamp (2022), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
2	Knowledge and awareness of application and market	Ortt & Kamp (2022)
3	Competition	Ortt & Kamp (2022), Olsthoorn (2017)
4	Macro-economic and strategic aspects	Ortt & Kamp (2022), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
5	Accidents and events	Ortt & Kamp (2022), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
6	Human resources	Ortt & Kamp (2022), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
7	Natural resources	Ortt & Kamp (2022), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
8	Financial resources	Ortt & Kamp (2022), Schulz (2019)
9	Socio-cultural aspects	Ortt & Kamp (2022), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
10	Institutional aspects and political system	Olsthoorn (2017)
11	Physical/information access & infrastructure	Van den Berg (2017)

Table 13 The list of consolidated strategies that were identified by Ortt et al. (2013) and various master thesis literatures

No.	(New) Strategies	Identified by
1	Demo, experiment, and develop niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
2	Top niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
3	Subsidized niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
4	Redesign niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
5	Dedicated system or stand-alone niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
6	Hybridization or adaptor niche strategy	Ortt et al. (2013) , Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
7	Educate niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
8	Geographic niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
9	Lead user niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
10	Explore multiple markets niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
11	Technological R&D strategy	Schulz (2019)
12	Human resource management strategy	Schulz (2019)
13	Internal knowledge sharing strategy	Schulz (2019)
14	Partnership strategy	Schulz (2019), Olsthoorn (2017)
15	Finance sourcing strategy	Schulz (2019)
16	Lobbying strategy	Schulz (2019), Olsthoorn (2017)
17	Influencer marketing strategy	Schulz (2019)
18	Crowd-sourcing strategy	Schulz (2019), Van den Berg (2017)
19	Leasing strategy	Schulz (2019)
20	Sharing economy platform strategy	Schulz (2019)
21	Corporate restructuring strategy	Schulz (2019)
22	Buy one - give one strategy	Schulz (2019)
23	Campaign funding strategy	Schulz (2019)
24	Stepping-stone strategy	Olsthoorn (2017)
25	Network building strategy	Olsthoorn (2017), Van den Berg (2017)
26	Get specified strategy	Olsthoorn (2017)
27	Local strategy	Van den Berg (2017)

4.2. Potential Strategies Based on Journals

4.2.1. Step 1: Literature Search

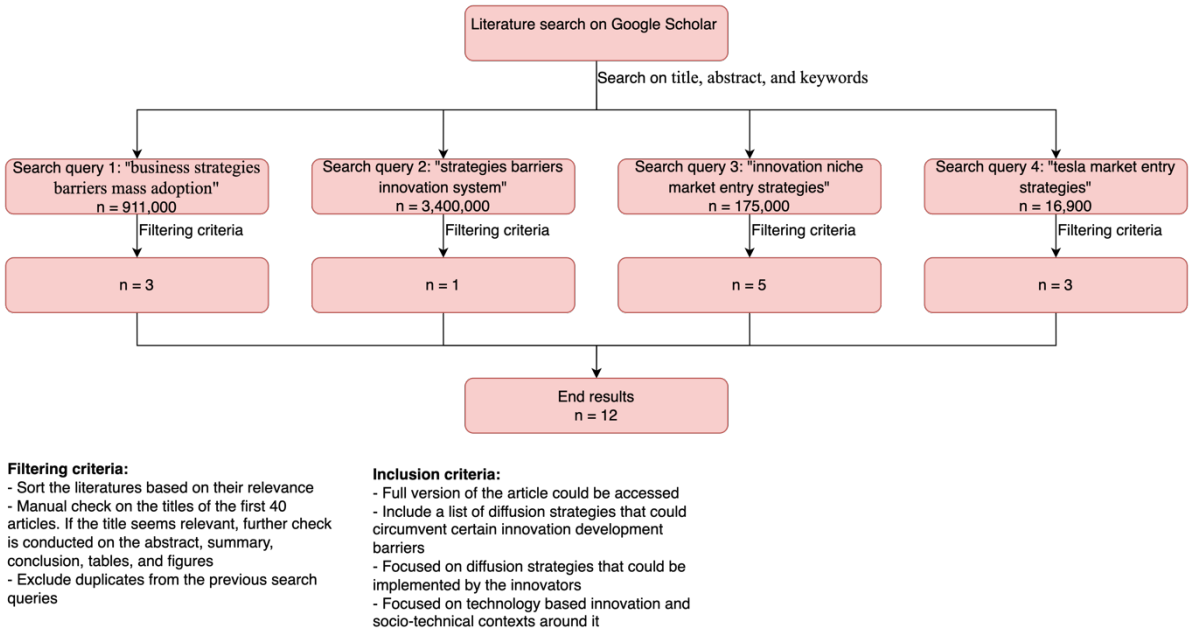


Figure 17 The process of the literature search conducted to identify the potential strategies based journals

To get new ideas of potential strategies that could be implemented to circumvent the innovation development barriers, another literature search is conducted by looking at relevant literatures in Google Scholar. As illustrated by Figure 17, first, the literatures are searched based on their title, abstract, and keywords by using four different search queries. The results are then filtered further by implementing the filtering and inclusion criteria. In the end, this literature search process resulted to twelve most relevant articles, as listed in Table 14. The insights gained from each literature are elaborated in the next subsection.

Table 14 List of relevant journals to identify potential strategies

Search Query	Authors	Year of Publication	Titles
SQ1	Naor et al.	2015	Overcoming barriers to adoption of environmentally-friendly innovations through design and strategy. Learning from the failure of an electric vehicle infrastructure firm
SQ1	Strupeit & Palm	2015	Overcoming barriers to renewable energy diffusion: business models for customer-sited solar photovoltaics in Japan, Germany and the United States
SQ1	Iqbal et al.	2021	Uptake and Adoption of Sustainable Energy Technologies: Prioritizing Strategies to Overcome Barriers in the Construction Industry by Using an Integrated AHP-TOPSIS Approach
SQ2	Alam et al.	2010	Drivers, barriers, and strategies for implementation of renewable energy technologies in rural areas in Bangladesh - An innovation system analysis
SQ3	Hardman et al.	2014	Changing the fate of Fuel Cell Vehicles: Can lessons be learnt from Tesla Motors?
SQ3	Montaguti et al.	2001	Entry strategy for radical product innovations: A conceptual model and propositional inventory
SQ3	Hardman et al.	2013	Disruptive innovations: The case for hydrogen fuel cells and battery electric vehicles
SQ3	Bart Kamp	2017	Competitive Strategies on behalf of International Niche Market Leaders: Evidence from the Basque Country
SQ3	Parrish et al.	2006	Niche market strategy for a mature marketplace
SQ4	Thomas & Maine	2019	Market entry strategies for electric vehicle start-ups in the automotive industry - Lessons from Tesla Motors
SQ4	Stringham et al.	2015	Overcoming Barriers to Entry in an Established Industry: Tesla Motors
SQ4	Sonali Sharma	2016	The Tesla Phenomena: A Business Strategy Report

4.2.2. Step 2: Identification

4.2.2.1. Literature 1: Overcoming barriers to adoption of environmentally-friendly innovations through design and strategy. Learning from the failure of an electric vehicle infrastructure firm by Naor et al.

Naor et al. (2015) conducted semi-structured interviews, direct observation in the company, and examination of various data sources to identify the strategies implemented by an EV infrastructure company to solve the diffusion barriers. It was argued that there is relationship between the sustainable innovations and the socio-technical aspects around them as illustrated by Figure 18. Moreover, Naor et al. argued that diffusion barriers could be categorized into two: functional and psychological barriers. Functional barriers are related to the way the customers would use the innovative product, while psychological barriers are related to how the innovative product is perceived by the customers.

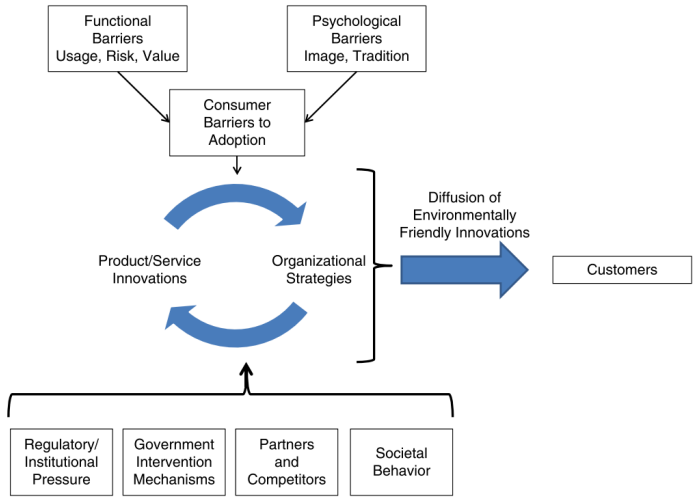


Figure 18 Socio-technical elements of sustainable innovations (Naor et al., 2015)

Furthermore, it is argued that to overcome the barriers, there are two types of strategies that could be implemented: product/service innovations strategies and organizational strategies. Product/service innovations strategies aimed to overcome the product-related barriers by providing or developing complementary products and services, while organizational strategies aimed to enhance the diffusion of the product in the society. Table 15 and Table 16 shown the summary of the identified functional and psychological barriers, as well as the strategies implemented to overcome them.

The insights gained from the identification and categorization of the barriers confirm the importance of seeing the innovation from a bigger perspective, such as the TIS perspective. Naor et al. findings confirm that to enable innovation to be mass adopted, the innovators should not focus only on the technical issues, but also on the other aspects around it. Moreover, circumventing product-related barriers do not necessarily enough to make the innovation adopted on a large scale. Additional strategies are needed to make sure that the innovation is diffused in the market.

Table 15 Identified functional barriers and strategies implemented to overcome them - insights from an EV infrastructure company (Naor et al., 2015)

	Product/service innovation	Diffusion strategy
Functional barriers	*Usage (performance)*: EV range is limited to 150 miles Battery-switching stations to extend range Connectivity to smart grid *Usage (convenience)* Deployment of charging and switching station infrastructure country wide Switching process takes about two minutes Switching process is automatic *Value (cost)* EVs have low maintenance costs due to lack of oil filters, belts, and pumps *Risk (performance)*: battery depletion Intelligent Transportation System on board vehicle manages energy level automatically *Risk (safety)* Waterproof batteries and charging cables Cord is locked to the station for charging EV has artificial noise to alert pedestrians *Risk (system failure)*: grid overload System integration control center prioritizes the EV fleet based on customer profile Charging is managed discontinuously in pulses to diminish load	*Usage (knowledge)*: public lack technical knowledge about both infrastructure and EV functionality Disseminate knowledge and raise public awareness through both the Taxi Project in Tokyo, Japan, and the visitor centers in Israel and Denmark. Provide information to public about available infrastructure, charging time, EV performance, usage, and safety *Value (cost)*: battery cost causes EV to be too expensive Establish a leasing model (separating purchase of car from battery) with various options for mileage subscription *Value (cost)* Entry in international markets to create economies of scale and eventually lower price of both infrastructure and EVs *Value (alternatives)*: performance-to-price of EV is lower compared to ICE Launch a family type EV sedan with similar specifications and competitive price to incumbent sedans

Table 16 Identified psychological barriers and strategies implemented to overcome them - insights from an EV infrastructure company (Naor et al., 2015)

	Product/service innovation	Diffusion strategy
Psychological barriers	*Tradition*: stopping at gas stations for refueling and refreshing during trips Switching stations for EVs built at Dor Alon's existing gas stations locations *Tradition*: process of using nozzle for gas tank refilling The process of connecting a cord from EV to charging station emulates gas tank refilling *Tradition (design)*: EVs appearance is too different in public's eye due to large battery and many cords EV design similar to comparable ICE. The battery is flat and located beneath the vehicle	*Image*: misconception that EVs are not for mainstream customers Initial family sedan launched is similar to ICE Renault Fluence and targets corporate fleets and private customers *Image*: limited offerings of EVs types in future multiple types of EVs to be launched targeting different niches such as ultra-compact, van and sport cars

4.2.2.2. Literature 2: Overcoming barriers to renewable energy diffusion: business models for customer-sited solar photovoltaics in Japan, Germany and the United States by Strupeit & Palm

Strupeit & Palm (2015) conducted research to compare approaches taken by several solar PV producers in Germany, Japan, and the United States to overcome various barriers they faced in diffusing their residential PV to the market. These countries were chosen not only because they have the significant experience in PV diffusion, but also because the total PV installed in these countries accounted for 45% of the global installed PV capacity. Additionally, Strupeit & Palm argued that these countries have developed distinguishing organizational approaches that could be interesting to be analyzed and learned from. The research was conducted by using an analytical framework called business model morphology by identifying the contextual conditions of each case from available literatures such as research reports, standards, legislation, academic literatures, solar PV companies' websites, trade journals, etc. In the end, the identified barriers and strategies are concluded, as shown in Table 17.

Interestingly, from Table 17, it could be seen that different approaches and strategies were implemented by those three countries, with only minor overlap between them. It explains the fact that different geographical areas might have different socio-economic backgrounds that make a successful approach in an area might not be the right approach at other areas. Therefore, the innovators might need to do a proper market research if they are aiming to penetrate other market in other geographical areas.

Table 17 Identified barriers and strategies implemented to overcome them – insights from PV deployment by various solar PV producers in the US, Japan, and Germany (Strupeit & Palm, 2015)

	US	Japan	Germany
Overcoming consumer inertia	- Advertising - Existing sales channels	- Cross-selling (with homes)	- Existing sales channels - Non-commercial intermediates - Peer-effects
Reduction of customer transaction cost, risk and uncertainty	- Result-oriented contracting - Performance warranties - Transactions cost transferred to firm	- Mass-customised turnkey products - Advisory support to customers - Extended warranties & service contracts - Brand and credibility of housing manufacturer and PV component suppliers	- Advisory support to customers - Turnkey products - Extended product warranties - Product and installer certification - Solar PV insurance - Optional maintenance contracts - High accessibility to local, trusted installer firm
Financing	- No customer upfront cost - Pay-per-use	- Cross-financing with housing mortgage - Private finance initiative (*Ichijo Co., Ltd.*) - Advisory support on public support schemes	- Advisory support on dedicated soft loan programme

4.2.2.3. Literature 3: Uptake and Adoption of Sustainable Energy Technologies: Prioritizing Strategies to Overcome Barriers in the Construction Industry by Using an Integrated AHP-TOPSIS Approach by Iqbal et al.

Iqbal et al. (2021) identified the adoption barriers and strategies of sustainable energy technologies in the construction industry in Pakistan by conducting comprehensive literature review. The list of the potential barriers and strategies as well as the brief explanation about the strategies are presented in Table 56 and Table 57 respectively in Appendix A.3. Furthermore, these barriers and strategies are then weighted by using fuzzy analytical hierarchy process (FAHP) and then ranked by using fuzzy technique for order performance (F-TOPSIS) methodology to define the most critical barriers and strategies. The results of the research suggested that the governmental and economic barriers are the most critical ones that could block the SET adoption in Pakistan. For that, several policies recommendation were formulated to overcome the barriers, as illustrated by Figure 19.

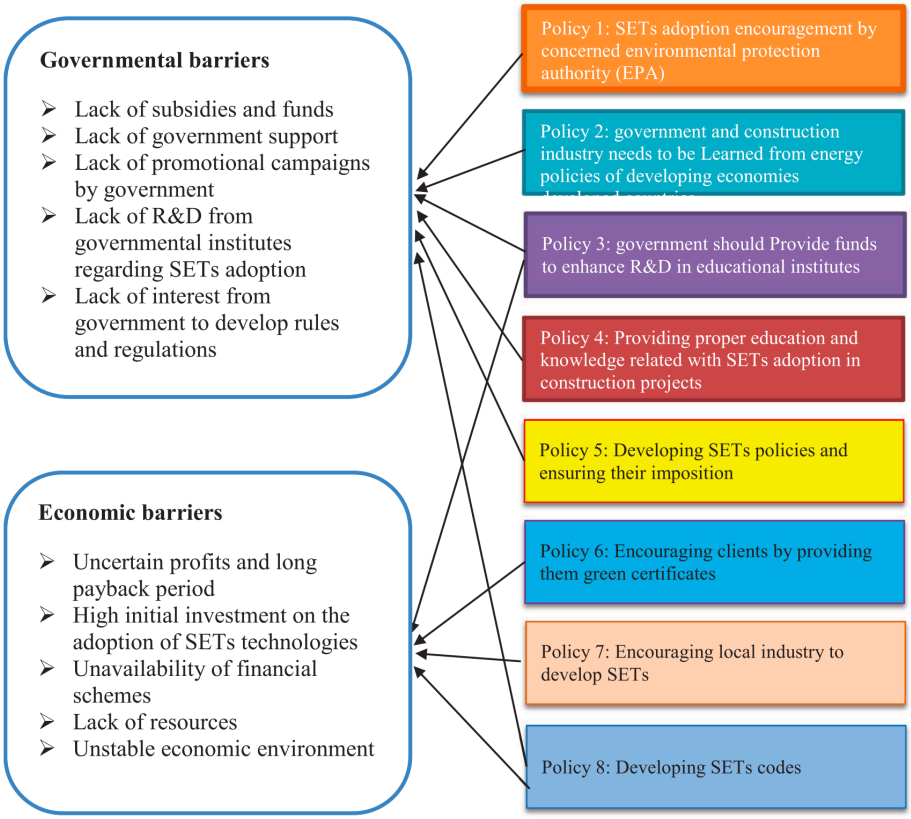


Figure 19 Most critical barriers and strategies of sustainable energy technologies in the construction industry in Pakistan (Iqbal et al., 2021)

These policies recommendation may not seem relevant for this research as we are looking for potential strategies that could be implemented by the innovators. However, these policies could be rephrased into strategies that that could be implemented by the innovators. The rephrasing of these policies into strategies is be done in the analysis step as explained in Appendix A.4.

4.2.2.4. Literature 4: Drivers, barriers, and strategies for implementation of renewable energy technologies in rural areas in Bangladesh - An innovation system analysis by Alam et al.

Alam et al. (2010) conducted research to identify the drivers, barriers, and strategies of renewable energy technologies (RET) adoption in rural areas in Bangladesh, by combining the innovation system analysis and the appropriate technology analysis. The analysis includes not only reviews on the policy and institutional settings, but also reviews on the latest status of the RET projects and lesson learned from those project implementation from the perspective of different organizations. The result of the research is summarized in Table 18.

Table 18 Identified barriers and strategies of renewable energy technologies adoption in rural areas in Bangladesh. Information extracted from (Alam et al., 2010)

Drivers/Barriers Identified by Alam et al.	Explanation of Identified Drivers/Barriers	Strategies Identified by Alam et al.
Local implementation context	Taking the local contexts into consideration when implementing a technology. Local contexts here could be, for example, involving local stakeholders' as early as possible to understand their needs and values, addressing local knowledge and expertise, addressing local financial viability	Making the technology accepted easily by local level of knowledge; providing training programs for local people to get familiar with the new technology; providing technology that is affordable for local people; providing technology that could bring extra income for local people; collaboration with local stakeholders
Knowledge and skills	Public awareness of the technologies as well as the knowledge on costs and benefits of the technologies	Awareness program (fairs, exhibitions, posters, etc); training programs; generation of new knowledge such as R&D on suitable technologies for certain area by taking into account its local contexts (locally available materials and knowledge)
Market and financial mechanisms	Investment costs as well as supportive financing mechanisms	Providing supportive financial mechanisms and institutions such as by providing microcredits mechanisms to make it more affordable or fee-for-service mechanism; government act as a demand side actor by using the technologies in a big scale to increase the market, economics of scale, and to raise the public awareness
Supportive institutions	Supportive policies and regulations should be established and unfavorable policies and regulations should also be removed. Lengthy administration processes, for example, process for project approval could be a barrier for technology adoption.	Developing local level institutions to implement and manage local based RET implementation programs as well as to interact better with local stakeholders.

4.2.2.5. Literature 5: Changing the fate of Fuel Cell Vehicles: Can lessons be learnt from Tesla Motors? by Hardman et al.

Hardman et al. (2014) conducted a historical case study to identify barriers and market entry strategy implemented by Tesla Motors. Various data sources were collected in this research. The main data source came from Tesla's financial reports, video footage of its annual shareholders meetings, as well as Tesla's press releases. The purpose of this research is to see how Tesla's expensive automotive technology could managed to penetrate the market through high-end encroachment. As Tesla Motors is perceived as a successful disruptive innovator, Hardman et al. argued that their market entry strategy could be implemented to other expensive disruptive innovations such as Fuel Cell Vehicles (FCVs). Interestingly, Lightyear's SEV is currently also an expensive disruptive innovation. Therefore, the insights from this research could also be useful for Lightyear.

The identified barriers and strategies are shown in Table 19 and Table 20 respectively.

Table 19 Identified barriers of Tesla's BEV adoption (Hardman et al., 2014)

Barriers Identified by Hardman et al.	Explanation of Identified Barriers
Expensive price and long payback times	Even though BEV is framed as a potential fuel savings, however BEV prices are considered too high that lead to unacceptably long payback period
Limited driving range	BEV driving range is perceived limited even though most of the customers often travel within the range of the BEV. Longer driving range is usually needed on a monthly or annually basis
Lower performance of core & ancillary attributes	Compared to ICE incumbents, the BEV still has many lower performance of its core & ancillary attributes
Customer negative perceptions	The customers set their perceptions towards BEV based on the previously existing BEV. As the BEV technologies developed rapidly, unfortunately, the customers perceptions do not shifted as rapid as the technologies development
Price vs performance	For BEV, cost reduction is less important compared to improvement of the performance. The cost could still be high and accepted by the customers as long as it has an exceptional performance

Table 20 Identified strategies of Tesla's BEV adoption (Hardman et al., 2014)

Strategies Identified by Hardman et al.
Market positioning: target a market in which the product could excel in performance, promote reduction of running costs, and in the end provide a shorter payback period
Develop a new (and better) network of infrastructure that could overcome current performance flaws, for example by developing super charger infrastructure
Organize events that could show off the current performance of the BEV, for example, by carry out a coast-to-coast road trip to prove that a long distance driving is possible with the current product or technology
Sell the product via its own sales channels to prevent misinformation towards the product, as well as to minimize the margins so that the product price could be more competitive

4.2.2.6. Literature 6: Entry strategy for radical product innovations: A conceptual model and propositional inventory by Montaguti et al.

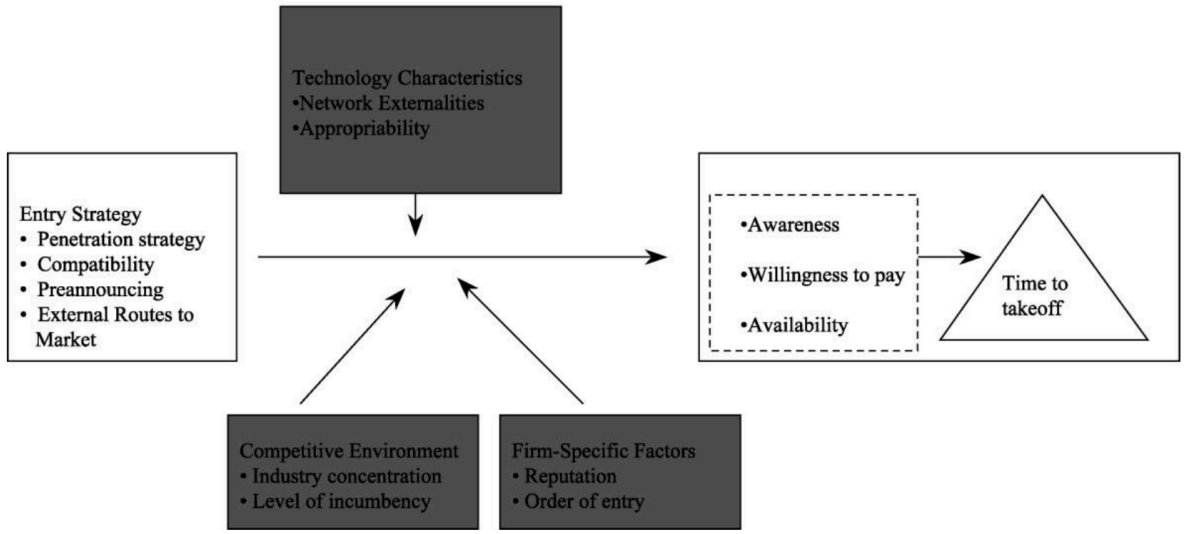


Figure 20 Conceptual model of differential effectiveness of market entry strategies (Montaguti et al., 2001)

As illustrated by Figure 20, Montaguti et al. (2001) argued that there are four market entry strategies that could be implemented by firms to boost its rapid adoption and to shorten the market introduction phase. Each of the strategy is briefly explained in the following.

1. **Penetration strategy**: implementing aggressive pricing as well as putting a big resource for advertising, marketing, and sales force to draw mass attention. This strategy is argued to be good to create maximum awareness towards the innovation

which then could stimulate demand, as well as to boost the company's learning curve, and to discourage competitors.

2. **Compatibility**: making the innovative product compatible with the existing technologies to enable the product to access a larger network such as infrastructure, to make the product more familiar to the customers, to eliminate perceived uncertainties compared to the existing technologies, and to increase customers' perspective towards the product which will influence their willingness to pay.
3. **Preannouncing**: spreading the information about the innovation in advance before the product launch. This strategy could help to increase customers awareness, to eliminate uncertainty, to reduce uncertainties and misinformation about the product, and to increase willingness to pay.
4. **External route to market**: forming marketing alliances to overcome the company's lack of competencies and resources to rapidly commercialize the innovation. It is called external route because the company should expand its cooperation with other manufacturers or companies to introduce the product to the market instead of only relying to its own salesforce. Marketing alliances could be established, for example, with companies who provide the complementary products and services for the new innovation.

Furthermore, Montaguti et al. argued that the effectiveness of these strategies is influenced by various factors (see black boxes in Figure 20) that could influence customers awareness of the product, their willingness to pay, and the availability of the product, which in the end, would define the amount of "takeoff" time. Takeoff time here defined as the time needed by an innovation since its launch to get its mass acceptance. As shown in Table 21, the influencing factors could positively or negatively influence the effectiveness of the market entry strategy. Therefore, to reduce the takeoff time, the right combination of market entry strategy and supportive factors should be considered.

Table 21 The relationship between the market entry strategies and the factors that influencing their effectiveness (Montaguti et al., 2001)

	Proposition	Impact on effectiveness of entry strategy			
		Penetration strategy	Product compatibility	Preannouncing	External route to market
Technology characteristics					
Network externalities	Proposition 1	+	+	+	+
Appropriability	Proposition 2	+	+	–	+
Competitive environment					
Industry concentration	Proposition 3	[a]	+	–	+
Level of incumbency	Proposition 4	+	+	–	–
Firm-specific factors					
Reputation	Proposition 5	+	–	+	–
Order of entry	Proposition 6	–	–	–	–

[a] No proposition provided.

Compared to Ortt & Kamp's TIS framework (2022), Montaguti et al.'s conceptual model consists of similar elements: factors needed by an innovation to be mass adopted, and strategies that could help the factors to really achieve the mass adoption. Interestingly, Montaguti et al. added the "influencing factors" as factors that could influence the effectiveness of the strategy, which is not considered in the TIS framework. The author of the present work strongly agrees with the importance of these influencing factors to maximize the change of success of the large-scale diffusion. Therefore, this insight is included in the recommendation for future research (see Section 8.6.).

4.2.2.7. Literature 7: Disruptive innovations: The case for hydrogen fuel cells and battery electric vehicles by Hardman et al.

Hardman et al. (2013) argued that society's state of lock-in could pose a major barrier for a disruptive innovation. In their research, Hardman et al. analyzed how the fuel cell vehicle had difficulty to penetrate the market as the existing petrol and diesel vehicles have been locked-in for decades in the society. The lock-in could be caused by various factors such as the economics of scale of existing technologies that is difficult to compete by a newly launched innovation, the learning difficulties experienced by the customers that hinder them to adopt the new technologies, or the network effect of the established incumbents that makes them more resilient to a small change.

Therefore, Hardman et al. argued that the lock-in issue could be overcome by several ways, such as:

1. Providing **added value** that could solve the problems that the incumbents failed to fulfill
2. The present of **regulation**, either the regulation that support the innovations or regulation that discourage the incumbent technologies
3. **Achieved or expected cost breakthrough strategy**. Achieved cost breakthrough strategy means the innovation could now be sold with competitive price, while expected cost breakthrough strategy means that the innovation is expected to be competitive in the near future. Thus, the expected cost breakthrough strategy sells the innovation with reduced price in the beginning until profitability is achieved.
4. **Changes in tastes** or customers' preferences could bridge the switching from the incumbent technologies into the new technologies
5. The presence of **niche markets** could protect the innovative product from the competition which then would give more time for the innovation to break through the lock-in created by the incumbents
6. **Support from the scientific community** is important not only to support the development of the new technologies, but also to discourage the existing technologies that have, for example, negative impacts to the environment

Similar to FCEV, SEV is also a disruptive innovation. Therefore, the above explained lock-in phenomena are also valid for SEV case. Hence, the author of the present work is confident that above mentioned strategies are relevant to circumvent SEV's lock in issues.

4.2.2.8. Literature 8: Competitive Strategies on behalf of International Niche Market Leaders: Evidence from the Basque Country by Bart Kamp

Kamp (2017) conducted research to identify strategies implemented by various Spanish companies that successfully made them international niche market leaders. The research concluded that several common strategies were perceived to play a big role to the success, such as:

1. (Light) **diversification** of products and services as well as extension of the currently successful markets into adjacent markets could help to increase the size of the market
2. Continuously looking at **new geo-economic** market opportunities
3. **Lead users** could bring not only positive influence on company's development skills, but also positive word-of-mouth effects to the broader audience as they act as reference buyers and could create new market trends
4. **Being the first mover** to benefit from the blue ocean strategy and to set the standard of the new product-market combination

5. **Being a specialist in a specific niche market** to take the opportunities to gain hegemonic power in highly oligopolies or quasi-monopolistic markets

4.2.2.9. Literature 9: Niche market strategy for a mature marketplace by Parrish et al.

Parrish et al. (2006) conducted qualitative research on eight market leaders in clothing and textile sector in the USA to identify how they implement and maintain their successful niche market strategy. The research was done by interviewing the representative executives as well as completing online questionnaire. Even though Parrish et al. did not suggest a list of potential niche strategies in their report, however, they identified various factors that could influence the success of niche strategies, which categorized into two groups: niche market success factors and niche product success factors, as explained in the following.

To make a successful niche market strategy, three factors are important: customer base, market research, and differentiate factors. Having loyal customers as customer base is proven important for a company to survive from the market competition as these customers do not sway easily by another new product or technology. Moreover, knowledge of the customers is important to know what they want and need. Additionally, a company could reach and maintain its position in the market only if it knows the market better than its competitors. Therefore, a good market research is needed to gain this knowledge. Furthermore, it is important for the company to differentiate itself with others, for example, by providing specific services to make the company superior to others. Specific services could be a good customer service, easy product returning procedure, quick lead times, etc.

From a product perspective, to make a successful niche product, four factors are important: specialized product, marketing, brand image, and differentiate factors. Offering a specialized product that could meet customers' needs in certain segments of the market is important to make it appealing and to gain adoption. Marketing is not only good to boost the customers awareness of the product, but also could help to build emotional and intrinsic differentiation when the product is perceived not unique enough. Additionally, strong brand image could maintain and even extend the loyal customer base, as well as to strengthen company's differentiation. Lastly, providing some differentiate factors that are not offered by the competitors such as better quality, new technology, or innovation could define a successful niche product.

Based on above elaboration, interesting to see that Parrish et al.'s factors categorization is in line to Naor et al. (2015)' strategies categorization (see Section 4.2.2.1.), in which both categorizations are based on product perspective and organizational/market perspective. These insights confirm the importance of looking at the innovation from a bigger perspective than only looking at the technology itself.

4.2.2.10. Literature 10: Market entry strategies for electric vehicle start-ups in the automotive industry - Lessons from Tesla Motors by Thomas & Maine

Thomas & Maine (2019) conducted case study research to examine Tesla's market entry strategies based on various data such as Tesla's company documents, publicly available information (Tesla's interviews and presentations), and government data. The purpose of the research is to identify strategies implemented by Tesla that have made Tesla a start-up that successfully penetrate the well-established automotive industry. Based on the research, several Tesla's strong points were identified that made Tesla successful: exceptional performances (acceleration and range), technology and production competencies, and customers linkages.

It was discovered that Tesla entered the market by offering its exceptional BEV performance called the Roadster by targeting the high-end buyers. The Roadster was comparable to other high-end luxury cars namely Ferrari, Lamborghini, or Bugatti that priced more than a million dollars while the Roadster was priced around US$110,000. Moreover, Tesla was able to provide its BEV with a much longer range compared to its competitors which answered one of the biggest concerns towards BEV. Based on data collected by Thomas & Maine, up to 2015 most of the competitors could only provide maximum 127 miles of range with their fully charged battery while Tesla has been providing its BEVs that could go beyond 200 miles since 2008. With these exceptional performances, Tesla eventually spread down the market to reach the mainstream market.

As the automotive incumbents are constrained by their existing technology and production competencies, they become inflexible in their design choices. Even the existing market leaders are very advance with their ICE technologies, however, when the EV era emerged, the existing market leaders have very limited time and resources to adopt to the disruption. At the other side, it brought an advantage for Tesla. As Tesla was not locked-in to certain existing technologies, it had more flexibility to set its own unique design, company culture, production, and sales competencies.

Lastly, Tesla boldly build its own sales channels to commercialize its product instead of doing it conventionally such as selling the products through automotive dealers. Tesla argued that selling its cars through automotive dealers might limit its access to the customers, while direct sales could provide better educative information about the product to the customers. Tesla also utilized internet for its direct sales as well as using mobile retail store in regions where retail outlets were not available yet.

Compared to Tesla's case, the author of the present work argued that Lightyear is now dealing with the same situations as Tesla years ago, in many ways. As explained in Section 1.1.2., Lightyear's SEV has exceptional performance, expensive price, and now targeting the high-end buyers. As Tesla is now considered to be successful in driving the change, lesson learned from this case could be very beneficial for Lightyear.

4.2.2.11. Literature 11: Overcoming Barriers to Entry in an Established Industry: Tesla Motors by Stringham et al.

Table 22 Identified barriers and strategies of Tesla (Stringham et al., 2015)

Barriers Identified by Stringham et al.	Strategies Identified by Stringham et al.	Explanation of Identified Strategies
High product price and long learning curves	Forming partnerships; leveraging other firms' capital; quickly bringing products to market	Quickly bringing products to market through partnerships could shorten the learning curves. It could then make the economies of scale be reached quicker and product price could be lowered faster
Lack of network externalities (a network effect in which the value of a product is higher when the number of users increasing)	Owning and subsidizing parts of the network; providing certain parts of customer experience for free; providing all patents for free to public domain	In the beginning, Tesla created Destination Charging Program by subsidizing the installation of charging facilities at various hotels, resorts, and restaurant, as well as developing its own fast charging network. Moreover, Tesla provide the electricity from these charging stations for free for its customers. Additionally, Tesla opened up its patents to public to encourage other companies to enter the market.

Stringham et al. (2015) conducted similar case study towards Tesla to identify major barriers faced by Tesla and strategies implemented to overcome them that is summarized by Table 22. It is striking to see how much efforts Tesla put into the market to open the window opportunity for itself. Tesla strategies to overcome the lack of network externalities might have seen as a brave (read: crazy) investment decision back then due to the big investment needed, the

uncertainties on how the market would develop, and the risk that the investment would not be paid off. However, with its perseverance, Tesla in the end manage to break through the old regime of ICE.

Learning from Tesla's success story, Stringham et al. advised several entrepreneurship tips, as the following.

1. Market is changing, so just do not follow trends. Innovation could be beneficial for society, as well as profitable for business as it could profit from a new market
2. Good ideas do not necessarily economically achievable. Thus, focus only on economically achievable ideas
3. Starting small has lower risks than starting big at once
4. Listen to the customers and their negative feedback
5. Use feedback loop to iterate, improve the design, bring it to the market, and repeat
6. Learn by doing and be flexible for any changes. Sometimes, it is fine to change direction when necessary
7. "Do not reinvent the wheels", instead work with existing industries, do not build everything in house
8. Enhance the total product experience by accommodating and subsidizing the complementary products and services
9. Expand the network externalities to increase the value of the product
10. Scale up to improve the network externalities, learning curves, and product costs
11. Stay innovative and adopt to the changing market to stay competitive

4.2.2.12. Literature 12: The Tesla Phenomena: A Business Strategy Report by Sonali Sharma

Sonali (2016) wrote a comprehensive business strategy report on Tesla, in which he elaborated various strategies implemented as well as strong points poses by Tesla that has brought Tesla to success. The findings are summarized in the following.

1. Commitment to provide excellence service despite being unprofitable. One example of this commitment is shown by Tesla effort on developing super charger networks and battery swap stations as well as allowing the customers to charge their cars for free at these charging facilities
2. Successful high-end disruption innovation approach that is the opposite of the classic disruptive innovation theory
3. Blue ocean innovation strategy by creating innovative products and services that creating a new demand in the market, instead of the red ocean approach in which EVs were known as low speed and not reliable cars
4. Open innovation philosophy by open sourcing their patents instead of protecting their intellectual property
5. Focus on building network externalities by providing massive charging infrastructure
6. Crowd sourcing, collaborating, and building alliances to innovate better
7. Creating competition to build network externalities even further to strengthen its competition against ICE vehicles
8. Focus on architectural innovation by building the car from scratch but outsourcing the necessary parts. With the architectural innovation, even though Tesla open source its patents, still the competitors have difficulty to imitate Tesla's design as the competitors have been locked-in into their existing systems

Furthermore, based on his analysis, Sonali also provides strategy recommendation for Tesla based on Tesla's latest business development and situation. The recommendation is as the following, in order of priority.

First, it was advised that Tesla should put all its efforts on its Model 3 production. This recommendation was given as Tesla received 373,000 orders but had difficulty to deliver them in time due to its low production rate at that moment. To solve this, Sonali advised Tesla to rise fund, expand the production facilities, provide trainings for the production line workers, hire experts, and outsource the battery production.

Second, it was advised that Tesla should evaluate its business model to increase revenue and profit. This recommendation was intended to address Tesla's direct sales strategy that is perceived to be effective at the first move to enter the market, but no longer effective if Tesla is aiming at global market. Therefore, collaboration with the right partners and combined it with necessary trainings would help Tesla to penetrate new markets. Another issue is Tesla's unprofitable business strategy despite its market expansion. This could be solved by selling the products aggressively, not only limited to the cars, but also the powertrain as well as the EV tools.

Third, it was advised that Tesla needs a more comprehensive marketing strategy to put Tesla at a better market position and to boost the sales of other products. Several strategies are proposed to overcome this barrier:

1. Market penetration strategy by focusing the business development of existing products in the existing markets and implementing aggressive marketing such as offering different pricing, innovating the promotional campaigns, and increasing the distribution networks. The example is to promote Model S, powertrain, and EV tools in the existing USA and European markets
2. Product development strategy by focusing the business development of new products in the existing markets. The example is to introduce Powerwall into the existing USA and European markets
3. Market development strategy by focusing the business development of existing products in the new market such as India and China, complemented by educating advertisements to gain customers awareness and to create products' status value
4. Market/product diversification strategy by focusing the business development on the emerging economies. It could be done by focusing the advertising to create brand awareness and good image, for example promoting Powerwall in developing countries as electricity backup to solve high power outage.

Four, it was advised that Tesla should put more R&D into their battery to reduce cost and increase profit. Lastly, it was advised that Tesla should create an exclusive marketing and sales plan for its Powerwall as it is perceived as an amazing product that could address power outage problems in the developing countries.

4.2.3. Step 3: Results

Based on the previous sub-sections, many new strategies are identified from the literature. However, many of them are the same or similar to the strategies that were identified in Chapter 4.2. Therefore, in the present work, an analysis is done to eliminate the similarities by listing the newly identified strategies, comparing them with previously identified strategies, and then comparing them with other newly identified strategies. The detailed analysis and arguments are presented in Table 58 in Appendix A.4. This analysis resulted to the final list of consolidated strategies as shown by Table 23. The newly identified strategies are indicated by red texts.

Table 23 The list of consolidated strategies that were identified by Ortt et al. (2013), various master thesis literatures, and journals

No.	(New) Strategies	Identified by
1	Demo, experiment, and develop niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017), Hardman et al. (2014), Stringham et al. (2015)
2	Top niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017), Sonali (2016)
3	Subsidized niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
4	Redesign niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017), Naor et al. (2015)
5	Dedicated system or stand-alone niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
6	Hybridization or adaptor niche strategy	Ortt et al. (2013) , Schulz (2019), Olsthoorn (2017), Van den Berg (2017), Naor et al. (2015), Montaguti et al. (2001)
7	Educate niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017), Naor et al. (2015), Strupeit & Palm (2015), Iqbal et al. (2021), Alam et al. (2010)
8	Geographic niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017)
9	Lead user niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017), Kamp (2017)
10	Explore multiple markets niche strategy	Ortt et al. (2013), Schulz (2019), Olsthoorn (2017), Van den Berg (2017), Naor et al. (2015), Kamp (2017), Sonali (2016)
11	Technological R&D strategy	Schulz (2019), Stringham et al. (2015), Sonali (2016)
12	Human resource management strategy	Schulz (2019), Sonali (2016)
13	Internal knowledge sharing strategy	Schulz (2019)
14	Partnership strategy	Schulz (2019), Olsthoorn (2017), Strupeit & Palm (2015), Montaguti et al. (2001), Hardman et al. (2013), Stringham et al. (2015), Sonali (2016)
15	Finance sourcing strategy	Schulz (2019), Sonali (2016)
16	Lobbying strategy	Schulz (2019), Olsthoorn (2017), Iqbal et al. (2021), Alam et al. (2010), Hardman et al. (2013)
17	Influencer marketing strategy	Schulz (2019)
18	Crowd-sourcing strategy	Schulz (2019), Van den Berg (2017), Stringham et al. (2015), Sonali (2016)
19	Leasing strategy	Schulz (2019), Naor et al. (2015), Strupeit & Palm (2015), Alam et al. (2010)
20	Sharing economy platform strategy	Schulz (2019)
21	Corporate restructuring strategy	Schulz (2019)
22	Buy one - give one strategy	Schulz (2019)
23	Campaign funding strategy	Schulz (2019)
24	Stepping-stone strategy	Olsthoorn (2017)
25	Network building strategy	Olsthoorn (2017), Van den Berg (2017)
26	Get specified strategy	Olsthoorn (2017)
27	Local strategy	Van den Berg (2017), Strupeit & Palm (2015), Iqbal et al. (2021), Alam et al. (2010)
28	Complementary technologies, products, services strategy	Naor et al. (2015), Hardman et al. (2014), Stringham et al. (2015), Sonali (2016)
29	Product variants strategy	Naor et al. (2015), Kamp (2017), Sonali (2016)
30	Cross-selling and financing strategy	Strupeit & Palm (2015)
31	Existing social network strategy	Strupeit & Palm (2015)
32	Result-oriented contracting strategy	Strupeit & Palm (2015)
33	Turnkey product strategy	Strupeit & Palm (2015)
34	Incentives strategy	Iqbal et al. (2021)
35	Local implementation strategy	Alam et al. (2010)
36	Market positioning strategy	Hardman et al. (2014), Hardman et al. (2013), Kamp (2017), Parrish et al. (2006), Thomas & Maine (2019), Sonali (2016)
37	In-house network strategy	Hardman et al. (2014), Thomas & Maine (2019)
38	Aggresive penetration strategy	Montaguti et al. (2001), Hardman et al. (2013), Sonali (2016)
39	Preannouncing strategy	Montaguti et al. (2001)
40	Blue ocean strategy	Kamp (2017), Sonali (2016)

4.3. Chapter Conclusion and Summary

Chapter 4 and Chapter 5 aimed to answer the second sub-research question: **"Based on the existing theories in the literature, how could the niche development barriers be linked to the niche strategies so that a niche strategy that could circumvent several barriers at once could be selected?".** To answer this question, literature review is conducted in this chapter to identify potential strategies that could be implemented by innovators to circumvent various barriers that might hamper the large-scale diffusion of innovations. These potential strategies will be then used in the upcoming chapter as a basis to develop the Best Strategy Framework – a tool to select the best strategy.

Based on the literature review, fifteen relevant literatures were found by using relevant keywords. Three of them are master's thesis reports extracted from TU Delft Education Repository in which follow-up research were conducted on the earlier version of barriers and strategies framework developed by Ortt et al. (2013), while the other twelve are general journals extracted from Google Scholar.

By reviewing these literatures, new potential strategies are extracted and listed (from both master's thesis reports and journals), as well as new potential TIS building blocks and influencing factors (only from master's thesis reports). Each of the strategy, building block, and influencing factor are then analyzed and checked against each other to eliminate the similar ones. Subsequently, new lists are generated which consist of seven building blocks, eleven influencing factors, and forty potential strategies, as listed by Table 24, Table 25, and Table 26 respectively. The new/adapted influencing factors and strategies are indicated by red and purple texts respectively.

Table 24 The final list of TIS building blocks that were identified from reviewed literature

No.	TIS Bulding Blocks	Definition
1	Product availability, performance, and quality	The product should be available and seen as a reasonable alternative by its prospective users by offering adequate performance and quality compared to its competitors now or soon in the future. Moreover, the product should meet required technical circumstances and standards
2	Product price	The innovative product could be provided with a competitive price compared to similar alternatives. Being competitive also mean that product has a good price compared to its quality
3	Production system	Large-scale production facilities that could produce the products in good quality at high production rate
4	Complementary products and services	Supporting products and services to develop, produce, distribute, adopt, use, repair, maintain, and dispose the products
5	Network formation and coordination	The established and coordinated network of actors involved in the whole supply chain, such as the suppliers of the raw materials needed to build the products, the production workers who assembly or produce the products, the distributors, etc
6	Customers	Potential buyers who are aware of the product and its benefits, as well as have the knowledge, willingness, and means to acquire and use it
7	Innovation-specific institutions	Supporting formal and informal institutions

Table 25 The final list of influencing factors that were identified from reviewed literature

No.	(NEW/ADAPTED) Influencing Factors	Definition
1	Knowledge and awareness of technology	Knowledge and awareness about the fundamental and applied technology around the product as well as the complementary products and services that are needed to make the product available
2	Knowledge and awareness of application and market	(1) Knowledge in using the innovation into certain applications: company's knowledge to develop a product to fit into certain application, customers' knowledge to utilize the product in certain application, as well as the knowledge of other relevant stakeholders that could support the development and the commercialization of the innovation, and (2) Knowledge about market's socio-technical characteristics as well as business opportunities and threats that might emerged due to the market characteristics
3	Competition	Existence of alternative products and services produced by other companies that cause rivalry between the companies
4	Macro-economic and strategic aspects	Macro-economic situations that could influence the diffusion and adoption of an innovation
5	Accidents and events	Unexpected accidents and events occurred within and outside of the TIS could influence the forming of the TIS building blocks
6	Human resources	Human resources needed for the large-scale commercialization of a product
7	Natural resources	Natural resources needed for the large-scale commercialization of a product
8	Financial resources	Financial resources needed for the large-scale commercialization of a product
9	Socio-cultural aspects	The big forces that influence the society's values, behavior, way of thinking and doing things
10	Institutional aspects and political system	Supporting formal and informal institutions, as well as supporting political system and situations
11	Physical/information access & infrastructure	Accessibility to the market and related information sources needed to support the development of the market, as well as the availability of related infrastructures

As shown by Table 25, three factors are adapted from the original framework. These three factors were originally one factor called "Natural, human, and financial resources". Even though the author of the present work agrees with the importance of this factor, however, she saw the needs to better address each element of the factor as each of element could lead to different barriers, hence solving them would require different approach and strategies. Therefore, in the present work, "Natural, human, and financial resources" influencing factor is split into three different influencing factors. By doing this, better and more specific links between the barriers and strategies could be defined, and in the end, better strategies could be chosen to overcome each of the specific barriers. In other words, the splitting of the factor optimizes the results of the best strategy selection.

Table 25 also shows that two new influencing factors are added in the present work. Based on the literature research, the author of the present work understood that political stability and market accessibility are especially important when the targeted markets are new/foreign. Targeting a market that has instable political system might poses uncertainties and big risks for the company, as the political situations might change in the future unexpectedly. At the other hand, a stable political system could be a supportive factor for innovation adoption. Even though institutional aspect has been defined as one of the TIS building blocks in the original framework, however, as the status of institutional aspect as well as political system and its stability could significantly influence the status of other TIS building blocks, therefore, the author of the present work decided to add this factor as a new influencing factor. In other words, adding the "Institutional aspect and political system" as a new influencing factor captures new barriers that was not captured by the original version of the framework.

Additionally, lack of access to the market would hinder the company capability to understand the competition in the market, as well as the customers' demands, needs, buying power and other important market-related information. This barrier is extremely threating when the market is new, and the company has limited knowledge about the market. As this barrier was not captured in the original framework, therefore, market accessibility is added as another new influencing factor called "Physical/information access & infrastructure".

Finally, as indicated at the right side of Table 26, the new potential strategies could be categorized into two groups: (1) niche introduction strategies: strategies that aimed to sell the innovation into certain niche markets and (2) building-up TIS strategies: strategies that aimed to improve the TIS so that it would be ready for large scale diffusion.

Table 26 The final list of strategies that were identified from reviewed literatures and their categorization

No.	(NEW) Strategies	Definition, Examples & Author's Notes on Strategies	Niche Introduction Strategies	Building-up TIS Strategies
1	Demo, experiment, and develop niche strategy	Quickly bringing the product to the market to demonstrate the product in public while the product research and development could be continued to overcome the limited quality of the product. Demonstrating the product helps to create public awareness towards the product, to attract potential customers, partners, and investors, as well as to give the innovators opportunity to re-evaluate their product while preparing it for the demonstration. Moreover, by demonstrating the product, the innovators might also receive feedbacks from public that could help the innovators to improve its product and the way of developing it.	✓	✓
2	Top niche strategy	Producing a special product in small scale to serve specific top niche of customers: ones that are willing to acquire the product despite the high price because of their high buying power and their interest towards the product and its extremely high performance	✓	
3	Subsidized niche strategy	Implementing subsidy on the product price to particular segment of users to provide reasonable price. This strategy is best implemented to the money-related barriers such as expensive product price, financing issues, or other relevant factors that may influence financing capability.	✓	
4	Redesign niche strategy	Redesigning the product in such a way to make it more acceptable or better fit certain purposes. Example: redesigning the product into a simpler or slightly different version that match the current state of knowledge; making it similar to the alternative products to make it easier for the customers to compare the product's price/performance; making it fit into the needs of mainstream customers	✓	
5	Dedicated system or stand-alone niche strategy	Suggesting the use of the product in a dedicated or stand-alone system to overcome the lack of widely available infrastructure or complementary products and services. This strategy could also be implemented when the market is very competitive as providing a dedicated or stand-alone system could create an exclusive brand image which leads to a more competitive brand.	✓	
6	Hybridization or adaptor niche strategy	Coupling the product with the old products and system in order to re-use the existing complementary products and services, or designing and providing an adaptor so that the new product is compatible with the existing systems and their complementary products and services. In a wider context, this strategy could also be defined as mimicking the way of using the existing products into the new product to suit customers' existing embedded tradition, habits, or behaviors. Coupling the product with the old products and system could also circumvent barriers that emerged due to the lack of knowledge, resources, supportive institutions, and access to certain information needed to build the whole new system and infrastructure.	✓	
7	Educate niche strategy	Improving the knowledge of the suppliers and the customers, as well as the company's internal knowledge. Example: conducting or joining various related events to provide information to public about the product, its technology, and available infrastructure; providing advisory support to the customers, for example, to advice them on how to finance the product; learn from energy policies of developed countries to get inspiration of possible supporting policies. Providing necessary education to the relevant stakeholders is not only important to improve their knowledge about the product and its application, but also to overcome the barriers that emerged due to the negative influence of certain socio-cultural aspects. Moreover, when the market is competitive, implementation of educate strategy is also important to raise the awareness of the customers so that they could be aware of the benefits and values of the product.	✓	✓
8	Geographic niche strategy	Exploring new geographical areas which provide less barriers to the core factors. This strategy could mean (1) to focus the market diffusion at other areas, (2) to move the development of the product or complementary products and services to other locations, or (3) to get supports from relevant stakeholders from other locations. This strategy is best implemented when the availability of certain factors are geographically-related. Thus, looking for the right areas that could provide the needed factors is important to prevent the emergence of the barriers.	✓	
9	Lead user niche strategy	Serving lead users and innovators so they could by co-develop the product. This strategy could also circumvent barriers in which the availability of the product and suppliers are limited due to the influence of socio-cultural aspects, macro-economic aspects, or accidents and events. This strategy could also circumvent barriers that emerged due to the lack of resources that limit the production system as well as the availability, performance, or quality of the product due to the limited number of lead users and innovators that need to be served	✓	
10	Explore multiple markets niche strategy	Conducting market research continously to explore new markets and multiple customer applications, to improve the understanding of current trends, demand, and competition in those markets.	✓	
11	Technological R&D strategy	Putting more effort on experimentation in a research environment to further develop the company's technological knowledge, to stay innovative, and to reduce product costs.		✓
12	Human resource management strategy	Hiring new employees or interns that have expertise on the new technological fundamentals to improve the company's internal knowledge.		✓

No.	(NEW) Strategies	Definition, Examples & Author's Notes on Strategies	Niche Introduction Strategies	Building-up TIS Strategies
13	Internal knowledge sharing strategy	Improving the technical knowledge within the company by initiating various meeting sessions or in-house training to facilitate the transfer of knowledge among the employees.		✓
14	Partnership strategy	Starting a mutualism and long-term partnership, especially with manufacturers, suppliers, and other relevant stakeholders that have good brands and credibility to overcome the company's lack of competencies and resources, as well as to shorten the learning curves. Example: establishing partnership with other company who needs the same raw material so that it could be bought in bulk to get a cheaper price; working together with the scientific community to develop the new technologies and to discourage the existing technologies; outsourcing the production of some components of the product. Partnership strategy enables company to gain more power in the market which is very important when the market is very competitive.		✓
15	Finance sourcing strategy	Initiating certain actions to bring additional financial resources into the company or to support customers in financing the acquisition of the product. Example: rise fund to finance several improvement on bottlenecks that has been hindering company expansion such as limited production facilities.		✓
16	Lobbying strategy	Initiating an approach towards strategic and important stakeholders to gain support from them. Example: lobbying the policy makers to proposed new or adapted institutions and policies that could support the development and adoption of the product or discourage the incumbent technologies; taking part as a member of certain regulation agency to influence the policy making; lobbying the government to get financial supports for R&D and to act as a demand side actor by using the technologies in a big scale to increase the market.		✓
17	Influencer marketing strategy	Establishing a good cooperation with certain influencers to raise the brand/product awareness.		✓
18	Crowd-sourcing strategy	Involving the public to generate ideas and solutions to improve the product. Example: providing all patents for free to public domain to encourage other companies to enter the market.		✓
19	Leasing strategy	Selling the product with leasing contract with various subscription options to spread the high initial cost of the product or its major components into a certain time period which could improve the affordability of the product. Example: separate the purchase of the car and the battery by offering the leasing of the battery.		✓
20	Sharing economy platform strategy	Initiating a sharing economy platform in which the multiple users could share the use of the product.		✓
21	Corporate restructuring strategy	(1) Split the company into two different companies. This strategy could be adopted, for example, to give a new and better image to the company to the new potential customers or related stakeholders, or (2) merge or acquire multiple companies into one larger company to reduce competition, to achieve better economies of scale, to increase market share, as well as to gain higher corporate status.		✓
22	Buy one - give one strategy	Selling a product, for example, to the top-end customers who could afford the product with current price and at the same time giving one free product to the targeted customer who still could not afford it.		✓
23	Campaign funding strategy	Influencing the policy maker who design the institutions by funding their campaigns.		✓
24	Stepping-stone strategy	Targeting other markets that are geographically or culturally closer to the targeted market as a steppingstone towards the targeted market to obtain references from those adjacent markets to then use them as marketing tool at the targeted market. This strategy could also be implemented when the company has a lack of knowledge of the targetted market/application but has a better knowledge on a similar market. Thus, the company could first penetrate that similar market while buidling up its knowledge on the targeted market.	✓	✓
25	Network building strategy	Broadening and establishing required networks by attending formal and informal meetings. The implementation of this strategy is important as it could enhance the effectiveness of other strategies such as the partnership strategy and lobbying strategy. Building the network enables the company to find the right people or partners to work with, as well as the right people to lobby to reach its goals. Therefore, network building strategy is suggested for any barriers that could be solved by partnership or lobbying strategy.		✓
26	Get specified strategy	Persuading, for example, consultants of big projects to get the new product/technology mentioned in the technical specification of the projects.		✓
27	Local strategy	Providing/establishing various solutions locally, especially by working together with local well-trusted firms. Example: establishing local financing, local partners, and local purchase agreements. The focus of this strategy is to maximize the use of local resources and partnership in developing and delivering the product in order to involve local people, as well as to raise their awareness of the product and to attract them.		✓
28	Complementary technologies, products, services strategy	Providing necessary technologies, products, and services that could overcome or compensate current limited quality and performance of the product so that the product limitation do not reduce customers' comfort, convenience, and safety when using the product. Example: providing battery charging and switching stations infrastructures at national level, as well as better connectivity to smart grid to overcome EV's limited range; make the battery charging or switching process automatic and taking minimum time; subsidize parts of the infrastructure network so that other relevant stakeholders could take part in supporting the development of the infrastructure.		✓
29	Product variants strategy	Producing more product variants with different designs, specifications, or attributes to provide more options for the customers to choose from. Providing product variants is especially important when the market is competitive. Providing products with multiple different specifications and types could improve the price competitiveness, as well as to address different customers' needs and demands, which in the end could improve the adoption rate.		✓
30	Cross-selling and financing strategy	Bundling the selling and financing of the new product with other products in one transaction to reduce customers' hassle, transaction costs, risk and uncertainty, and to make mortgage rate more competitive. Example: bundling the selling of solar PVs with the newly built houses, battery storage, fuel cells, or heat pumps. This strategy is important especially when the market is competitive as the benefits from the implementation of this strategy could be seen as additional values by the customers.		✓
31	Existing social network strategy	Maximizing the use of the existing well-established network to support the initial diffusion the product to overcome customers' passive reaction towards the introduction of the new product due to their lack of trust and confidence towards the new product/company. Example: selling the product to the existing customer base; selling the product through the existing well-established sales channels; working together with trusted financiers who could provide soft loan to the customers.		✓

No.	(NEW) Strategies	Definition, Examples & Author's Notes on Strategies	Niche Introduction Strategies	Building-up TIS Strategies
32	Result-oriented contracting strategy	Offering a result-oriented contract to the customers so that they are well informed about the estimated return of investment if they obtain the product. The purpose of this strategy is to eliminate customers' perceived investment risk and uncertainties. Example: offering certain feed-in tariff to the customers who have solar PV on their house which could be projected into an interesting return of investment.		✓
33	Turnkey product strategy	Selling the product as a complete set (designed, supplied, built, and installed) that is ready to use by the customers, as well as by including necessary complementary technologies, products, and services such as performance warranties, extended warranties, insurance, service and maintenance contracts, product and installer certification, etc. Example: selling the solar PV complete with the installation and connection to the existing electricity and billing system. The focus of this strategy is to attract the customers by providing added value to the selling of the product to provide hassle free product acquisition. Thus, it is suitable to overcome customers-related barriers.		✓
34	Incentives strategy	Giving incentives to the relevant partners to gain their support, as well as to the customers to make the product adoption more attractive and beneficial. Example: encouraging the involvement and cooperation of strategic clients by giving them certain certificates such as green certificate. To incentivize certain relevant stakeholders, the company might need to establish good partnership with other stakeholders to provide/support the incentives. For example, support from the government is needed to enforce the green certificate policy.		✓
35	Local implementation strategy	Making the design and specification of the product as well as the supportive institutions suitable for local market needs, knowledge, and available resources so that the product could be accepted easily by local people. Example: provide training programs for local people to get familiar with the new technology; provide technology that is affordable for local people; provide technology that could bring extra income for local people. This strategy might sounds similar to Local strategy, however, the different is that this strategy focus on making sure that the product and its application match the local contexts, demands, and needs, so that it brings benefits to locals and attract them to adopt it.	✓	
36	Market positioning strategy	Choosing the right market to penetrate to make sure that the product performance could be better, the product provide more benefits and added value, or the product is financially more attractive compared to any available alternatives. Example: being a specialist by providing exceptional performances in a specific niche market to take the opportunities to gain hegemonic power in highly oligopolies or quasi-monopolistic markets; differentiate itself (the company) and its product with others, for example, by providing specific services to make the company superior to others for example by providing good customer service, easy product returning procedure, quick lead times, etc. The implementation of Explore multiple market strategy is important before implementing this strategy because having the insights of the potential markets is important to decide on which market to focus on.	✓	
37	In-house network strategy	Maximizing the use of the in-house network to support the initial diffusion the product instead of relying on third parties to prevent misinformation towards the product, as well as to minimize the margins so that the product price could be more competitive. Example: selling the product through company's own sales channels.		✓
38	Aggresive penetration strategy	Penetrating the market by implementing aggressive pricing, as well as putting large resources for advertising, marketing, and sales force to draw mass attention, assuming that the innovation is expected to breakthrough and make profits in the near future.		✓
39	Preannouncing strategy	Establishing a strategic relationship with potential customers by publishing the information about the product in advance before the product launch to increase customers awareness, to eliminate investment uncertainty, to reduce uncertainties and misinformation about the product, and to increase willingness to pay. The implementation of preannouncing strategy gives the company extra time to educate as well as influence the relevant stakeholders so that in the end the product adoption could be improved. Therefore, this strategy is best to implement when relevant stakeholders have lack of knowledge and awareness of the product/technology and its application or when certain social-cultural aspects influence how the product perceived by the relevant stakeholders.		✓
40	Blue ocean strategy	Targeting a new market as a first mover by creating innovative products and services that creating a new demand in the market. This strategy is best to implement to avoid competition that might influence the (perceived) status of the building blocks.	✓	

Chapter 5. The Best Strategy Framework

In the previous chapter, seven TIS building blocks, eleven influencing factors, and forty different strategies are identified from the literature review. Based on these findings, this chapter aims to answer the second sub-research question: **"Based on the existing theories in the literature, how could the niche development barriers be linked to the niche strategies so that a niche strategy that could circumvent several barriers at once could be selected?"**, by developing the Best Strategy Framework. This framework will be used in the later stage of the research as a tool to choose the best strategy to circumvent multiple barriers that will be identified in the study case.

To develop the framework, two important elements of the framework need to be established. First, the potential links between the barriers and strategies need to be identified, which is elaborated in Section 5.1. Then, scoring models need to be defined to score the barriers and strategies so that the best strategy could be selected, which is elaborated in Section 5.2. In the end, the summary of this chapter is explained in Section 5.3.

5.1. Potential Links between the Barriers and Strategies

Table 27 below shows the identified links between the barriers and strategies, which consists of two sets of links. The first set, which is indicated by purple blocks was identified by the author of the present work based on her own logical thinking. The second set, which is indicated by numbers (1 to 4) was identified by master's thesis reports that were reviewed in the previous chapter (see Section 4.1.). The numbers are correlated to the authors who propose the links, as explained under the table. In the end, only the links that were identified by the author of the present work will be use for The Best Strategy Framework, however, the second set of links was consolidated to validate the links that were identified by the author of the present work.

Supportive arguments are provided by the author of the present work to explain why the combination of certain TIS building blocks and influencing factors could pose as barrier, as well as why certain strategies could overcome the barrier. These arguments could be found in Appendix B. However, please note that the written supportive arguments are only for some of the links due to the author's limited research time.

In her approach in identifying the links, the author not only considered the direct influences of the influencing factors to the building blocks, but also the indirect influences. Moreover, the author looked at the barriers and strategies from a bigger perspective to understand their complex relationship. One example of the approach is as follows. Based on the definition of Hybridization/adaptor strategy, this strategy aims to circumvent barriers that are related to the complementary products and services, such as the unavailability of the supportive infrastructure. However, if we look from a bigger perspective, the lack of resources may lead to the lack of production system (developing a production system requires some resources) and network formation (suppliers of certain materials would not be available when the materials themselves are not available), which in the end may also influence the availability of the complementary products and services. Thus, Hybridization/adaptor strategy could also be implemented for these barriers.

Table 27 The Best Strategy Framework with two sets of potential links: (1) links identified by the author, indicated by purple blocks and (2) links identified by other researchers, indicated by numbers

		Niche Strategies																																						
Niche Strategy No.		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Influencing Conditions	**TIS Building Blocks**	**Demo**	**Top niche**	**Subsidy**	**Redesign**	**Dedicated/ stand-alone system**	**Hybridization /Adaptor**	**Educate**	**Geographic**	**Lead user**	**Explore markets**	**Tech. R&D**	**Human resource management**	**Internal knowledge sharing**	**Partnership**	**Finance sourcing**	**Lobbying**	**Influencer**	**Crowd-sourcing**	**Leasing**	**Sharing economy platform**	**Corporate restructuring**	**Buy one - give one**	**Campaign funding**	**Stepping-stone**	**Network building**	**Get specified**	**Local**	**Complementary technologies, products, services**	**Product variants**	**Cross-selling and financing**	**Existing social network**	**Result-oriented contracting**	**Turnkey product**	**Incentives**	**Local implementation**	**Market positioning**	**In-house network**	**Aggresive penetration**	**Pre-announcing**	**Blue ocean**
Knowledge and awareness of technology	Product availability, performance, and quality	1, 3		3	1, 2, 3						2	2	2	2																										
Knowledge and awareness of application and market									3	1	2																														
Competition																																								
Macro-economic and strategic aspects											2																														
Accidents and events											2																													
Human resources				3	3				1, 3		2		2	2	2																										
Natural resources				3	3				1, 3		2																														
Financial resources				2	2				1		2					2																										
Socio-cultural aspects					2					2	2						2	2	2																						
Institutional aspects and political system		3			3				3								3								3																
Physical/information access & infrastructure																																								
Knowledge and awareness of technology	Product price		1, 2, 4	1, 2	1, 2						2	2	2							2	2																				
Knowledge and awareness of application and market			2	2																2	2																				
Competition																																								
Macro-economic and strategic aspects			2	2																2	2																				
Accidents and events			2	2																2	2																				
Human resources			1, 2, 4	1, 2, 4	1, 4															2	2																				
Natural resources			1, 2, 4	1, 2, 4	1, 2, 4				2						2					2	2																				
Financial resources			1, 2	1, 2	1, 2											2				2	2						4														
Socio-cultural aspects			2	2																2	2																				
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								
Knowledge and awareness of technology	Production system	4	1, 2, 4	3, 4	1, 2, 3, 4						2	2	2																												
Knowledge and awareness of application and market										4	2																														
Competition																																								
Macro-economic and strategic aspects											2																														
Accidents and events											2																														
Human resources				3	1, 3						2		2	2	2																										
Natural resources				3	1, 3						2																														
Financial resources			2	2	1, 2						2					2																										
Socio-cultural aspects				3	3						2														3																
Institutional aspects and political system				3	3												3									3															
Physical/information access & infrastructure						4																																		
Knowledge and awareness of technology	Complementary products and services					1, 2, 3, 4	1, 2, 3, 4				2	2	2		3																										
Knowledge and awareness of application and market							2																																		
Competition																																								
Macro-economic and strategic aspects						2	2										2																								
Accidents and events							2																																		
Human resources							1, 2, 3, 4		1, 3, 4																																		
Natural resources						2	1, 2, 3, 4		1, 2, 3, 4						2																											
Financial resources				2		2	1, 2		1							2																										
Socio-cultural aspects							2																																		
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								

Niche Strategy No.		Niche Strategies																																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Influencing Conditions	TIS Building Blocks	Demo	Top niche	Subsidy	Redesign	Dedicated/ stand-alone system	Hybridization /Adaptor	Educate	Geographic	Lead user	Explore markets	Tech. R&D	Human resource management	Internal knowledge sharing	Partnership	Finance sourcing	Lobbying	Influencer	Crowd-sourcing	Leasing	Sharing economy platform	Corporate restructuring	Buy one - give one	Campaign funding	Stepping-stone	Network building	Get specified	Local	Complementary technologies, products, services	Product variants	Cross-selling and financing	Existing social network	Result-oriented contracting	Turnkey product	Incentives	Local implementation	Market positioning	In-house network	Aggresive penetration	Pre-announcing	Blue ocean
Knowledge and awareness of technology	Network formation and coordination				2			1, 2, 3, 4	2		2	2	2		2, 3																											
Knowledge and awareness of application and market		2						2, 3	2	1, 2, 3, 4	2	2	2		2, 3				2																							
Competition																																									
Macro-economic and strategic aspects									1, 2, 3, 4	1, 2, 3, 4			2		2		2																								
Accidents and events										1, 3, 4			2		2																										
Human resources									2				2		2																										
Natural resources									2				2		2																										
Financial resources									2, 4	4			2		2																										
Socio-cultural aspects					1, 2, 3, 4				1, 2, 3, 4	1, 2, 3, 4			2		2		2	2			2			3	3		4													
Institutional aspects and political system									3	3							3																							
Physical/information access & infrastructure																																								
Knowledge and awareness of technology	Customers				2			1, 2, 3	2		2	2	2		3										3															
Knowledge and awareness of application and market		2						2, 3	2	1, 2, 3	1, 2, 3	2			3				2						3															
Competition			3																								3													
Macro-economic and strategic aspects				2					1, 2, 3	1, 2, 3							2																							
Accidents and events									2	1, 3																														
Human resources									2				2																											
Natural resources									2																															
Financial resources			2	2	2				2							2				2	2		2																
Socio-cultural aspects					1, 2, 3				1, 2, 3	1, 2, 3							2	2	2						3	3													
Institutional aspects and political system									3	3							3									3													
Physical/information access & infrastructure																																								
Knowledge and awareness of technology	Innovation-specific institutions				2			2	1, 2, 3, 4		2	2	2				2, 3							2		3														
Knowledge and awareness of application and market					1, 2, 3, 4			2	2, 3, 4	2	2	2					2, 3	2	2					2															
Competition																																								
Macro-economic and strategic aspects					2				1, 2, 3, 4								2, 3	2						2															
Accidents and events					2				1, 2, 3, 4								2							2															
Human resources					2				2				2																											
Natural resources					2				2																															
Financial resources					2				2, 4																															
Socio-cultural aspects					1, 2, 3, 4				1, 2, 3, 4	2							2, 3	2	2					2	3														
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								

Links between barriers and strategies:	
1	Ortt et al. (2013)
2	Schulz (2019)
3	Olsthoorn (2017)
4	Van den Berg (2017)
	Marisa Dwisatyawati

Furthermore, the author correlates multiple stakeholders with the building blocks, the influencing factors, and the strategies. Product performance and quality, for example, could be correlated with the innovators and the customers. In correlation with the innovators, the product performance and quality could be lacking because the innovators have a lack of knowledge and awareness of the technology, which hinder them in developing the product or technology. At the other hand, in correlation with the customers, product performance and quality could be perceived lacking by the customers because they have a lack of knowledge and awareness of the technology, which hinder the customers in accepting and acquiring the product. Both barriers could be circumvented by Educate strategy, however, the implementation will be different for different actors. For the first barrier, the company should educate themselves to gain more knowledge about the technology so that they could improve the product, while for the second barrier, the company should educate the customers to raise their awareness towards the product and its technology. Thus, the same combination of building block and influencing factor that could be circumvented by the same strategy, could have different interpretation depends on different actors' point of view.

By comparing the two sets of links, it could be seen that some links identified by the author are in line with the links identified by other researchers. However, there are some discrepancies due to the author and other researchers' different ways of looking at the barriers and strategies. Schulz (2019), for example, argued that socio-cultural aspects may influence the way the product availability, performance, and quality is perceived in the society. To solve this barrier, Schulz proposed the implementation of Redesign strategy. The author of this paper, however, have a different opinion on this because the product availability, performance, and quality might not be the main issue here. The product might actually have no lack of availability, performance, and quality but it perceived to be lacking due to the different ways of people looking at it due to their different socio-cultural backgrounds. Therefore, the socio-cultural aspects that influence their way of judging the product is the main problem. To solve this barrier, the strategy should focus on the main problem: to change/shift the way people look at the product or to explore and focus on other markets in which the socio-cultural aspects influencing people's opinion is in the favor of innovation. This example explained the different ways of looking at the barriers and strategies between the author and the other researchers which resulted to different identified links. Unfortunately, there is no detail explanation of each discrepancy written in this report due to author's limited time.

5.2. Scoring Models to Choose the Best Strategy

Based on the previously developed barriers and strategies matrix, it could be seen that a strategy could circumvent one or more barriers, and a barrier could be circumvented by multiple strategies. The overarching question remain on how to choose the best strategy when a combination of barriers hindering the mass adoption. Therefore, in this section scoring models are defined to enable the selection of the best strategy that could circumvent most of the identified barriers.

Scoring model is defined as a tool that could be used "to assign comparative value" to various available options (Weller, 2021). Therefore, for this research, two different scoring models are proposed: same weighted scoring and different weighted scoring as explained in the following subsections. This approach aims to provide better insights on strategies selection as the best strategy from these scenarios might be different.

5.2.1. Scoring Model 1: Same Weighted Scoring

In this scoring model, each identified barriers is assigned with the same weight: 1 point. This approach is chosen to emphasize that each barrier has the same importance (Weller, 2021). By looking at the relationships between the barriers and strategies that are shown by Table 27, every strategy that could circumvent the identified barriers receive 1 point. Then, the points assigned to each strategy could be summed and compared against each other. The strategy that has the highest point is the best strategy as it could circumvent most of the identified barriers.

One scoring example is provided as follows. Assumed that six barriers hamper the mass adoption of the innovation namely (1) the lack of product availability, performance, and quality due to the lack of innovators' knowledge and awareness of technology, (2) the high product price due to the lack of innovators' knowledge and awareness of technology, (3) the lack of production system due to the lack of natural resources, (4) the lack of the complementary products and services due to the lack of innovators' knowledge and awareness of technology, and (5 & 6) the lack of customers due to the competition and the socio-cultural aspects. Therefore, these barriers are assigned with 1 point, as well as the strategies that could circumvent them, as illustrated by Table 28. The sum of the points assigned for each strategy is indicated at the bottom of the matrix.

Comparing the total points of each strategy provide us some interesting insights. First, there are a few strategies that could be implemented to overcome all the barriers (ones that have total score of 6), namely: Redesign strategy, Partnership strategy, and Network building strategy. Second, some other strategies are also important to be implemented as they could circumvent most of the barriers, such as the ones that have total score 5 as they could circumvent 5 out of 6 barriers. Those strategies are Demo, experiment, and develop strategy, Top niche strategy, Hybridization/Adaptor strategy, Educate strategy, Technological Research and Development strategy, Influencer strategy, Corporate restructuring strategy, and Pre-announcing strategy.

Table 28 Scoring example by using the scoring scenario 1

		Niche Strategies																																						
Niche Strategy No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Influencing Conditions	TIS Building Blocks	Demo	Top niche	Subsidy	Redesign	Dedicated/ stand-alone system	Hybridization /Adaptor	Educate	Geographic	Lead user	Explore markets	Tech. R&D	Human resource management	Internal knowledge sharing	Partnership	Finance sourcing	Lobbying	Influencer	Crowd-sourcing	Leasing	Sharing economy platform	Corporate restructuring	Buy one - give one	Campaign funding	Stepping-stone	Network building	Get specified	Local	Complementary technologies, products, services	Product variants	Cross-selling and financing	Existing social network	Result-oriented contracting	Turnkey product	Incentives	Local implementation	Market positioning	In-house network	Aggresive penetration	Pre-announcing	Blue ocean
Knowledge and awareness of technology	Product availability, performance, and quality	1			1		1	1	1			1	1	1	1			1	1			1				1			1											1	
Knowledge and awareness of application and market																																								
Competition																																								
Macro-economic and strategic aspects																																								
Accidents and events																																								
Human resources																																								
Natural resources																																								
Financial resources																																								
Socio-cultural aspects																																								
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								
Knowledge and awareness of technology	Product price	1	1	1	1		1	1			1	1	1	1	1			1	1	1	1	1				1												1	1	
Knowledge and awareness of application and market																																								
Competition																																								
Macro-economic and strategic aspects																																								
Accidents and events																																								
Human resources																																								
Natural resources																																								
Financial resources																																								
Socio-cultural aspects																																								
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								
Knowledge and awareness of technology	Production system																																							
Knowledge and awareness of application and market																																								
Competition																																								
Macro-economic and strategic aspects																																								
Accidents and events																																								
Human resources																																								
Natural resources			1	1	1		1		1	1		1			1							1				1		1												
Financial resources																																								
Socio-cultural aspects																																								
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								
Knowledge and awareness of technology	Complementary products and services	1	1		1	1	1	1				1	1	1	1			1	1			1				1												1		
Knowledge and awareness of application and market																																								
Competition																																								
Macro-economic and strategic aspects																																								
Accidents and events																																								
Human resources																																								
Natural resources																																								
Financial resources																																								
Socio-cultural aspects																																								
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								

Niche Strategy No.		Niche Strategies																																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Influencing Conditions	TIS Building Blocks	Demo	Top niche	Subsidy	Redesign	Dedicated/ stand-alone system	Hybridization /Adaptor	Educate	Geographic	Lead user	Explore markets	Tech. R&D	Human resource management	Internal knowledge sharing	Partnership	Finance sourcing	Lobbying	Influencer	Crowd-sourcing	Leasing	Sharing economy platform	Corporate restructuring	Buy one - give one	Campaign funding	Stepping-stone	Network building	Get specified	Local	Complementary technologies, products, services	Product variants	Cross-selling and financing	Existing social network	Result-oriented contracting	Turnkey product	Incentives	Local implementation	Market positioning	In-house network	Aggresive penetration	Pre-announcing	Blue ocean
Knowledge and awareness of technology	Network formation and coordination																																						
Knowledge and awareness of application and market																																							
Competition																																							
Macro-economic and strategic aspects																																							
Accidents and events																																							
Human resources																																							
Natural resources																																							
Financial resources																																							
Socio-cultural aspects																																							
Institutional aspects and political system																																							
Physical/information access & infrastructure																																							
Knowledge and awareness of technology	Customers																																						
Knowledge and awareness of application and market																																							
Competition		1	1	1	1			1	1	1	1	1			1			1		1	1	1	1		1	1	1		1	1	1	1	1	1	1	1	1	1	1	1
Macro-economic and strategic aspects																																							
Accidents and events																																							
Human resources																																							
Natural resources																																							
Financial resources																																							
Socio-cultural aspects		1			1		1	1	1	1	1				1			1							1	1						1	1	1	1	1		1	1	1	
Institutional aspects and political system																																							
Physical/information access & infrastructure																																							
Knowledge and awareness of technology	Innovation-specific institutions																																						
Knowledge and awareness of application and market																																							
Competition																																							
Macro-economic and strategic aspects																																							
Accidents and events																																							
Human resources																																							
Natural resources																																							
Financial resources																																							
Socio-cultural aspects																																							
Institutional aspects and political system																																							
Physical/information access & infrastructure																																							
TOTAL POINTS		5	4	3	6	1	5	5	4	3	3	5	3	3	6	0	0	5	3	2	2	5	1	0	2	6	1	1	2	1	1	2	2	2	2	2	1	2	3	5	1

Legends:

Links between barriers and strategies

Identified barriers

x Points assigned to the strategies as it could circumvent the identified barriers

5.2.2. Scoring Model 2: Different Weighted Scoring

Weighted scoring is used for many decision-making model, for example, to prioritize decisions, features, tasks, or actions, by quantifying the value, advantage, or the efforts needed of particular activity (Chisel Glossary, 2021). For this research, a simple weighted scoring is used, in which each identified barriers are assigned with different weights between 1 to 10 to represents its importance and capability in hindering the mass adoption. Barrier that poses as a big threat to the success of the mass adoption should be assigned with higher point compared to barrier that slightly hamper the mass adoption. Then, by looking at the barriers and strategies matrix (Table 27), every strategy that could circumvent the barriers received the same point as the barriers that it circumvents. In the end, the point accumulation of each strategy could be compared against each other. The strategy that has the highest point is the best strategy as it could circumvent the most threatening barriers.

The weights for the barriers could be identified by several ways, depends on the goal of the scoring. First, an interview could be conducted with experts, in which the experts would advise the weights of the barriers. With this approach, the weights represent the real circumstances. Hence, the goal of this approach is to provide advice for the innovators on how to circumvent the barriers. Another approach is by assigning the weights of the barriers hypothetically. This approach could be done when there is no sufficient information available to weight the barriers, or when the readers want to simulate how the importance and capability of each barrier could lead to different best strategy. Alternatively, the weights could be assigned by the company itself. With this approach, the company could decide or prioritize the barriers it wants to overcome.

One scoring example is provided as follows. By using the same assumptions as the scenario 1, six potential barriers are present, and the assumption of their weights is shown by Table 29. Consequently, the relevant strategies are scored as shown by Table 30.

Table 29 Assumed potential barriers and their weights

Influencing Factors	TIS Building Blocks	Weights
Knowledge and awareness of technology	Product availability, performance, and quality	6
Knowledge and awareness of technology	Product price	10
Natural resources	Production system	6
Knowledge and awareness of technology	Complementary products and services	2
Competition	Customers	8
Product-related socio-cultural aspects	Customers	5

Based on Table 30, the highest scores of 37 are achieved by multiple strategies namely Redesign strategy, Partnership strategy, Network building strategy. At the second highest, two strategies received the scores of 32, namely the Technological research and development strategy and Corporate restructuring strategy.

Table 30 Scoring example by using the scoring scenario 2

		Niche Strategies																																						
Niche Strategy No.		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Influencing Conditions	**TIS Building Blocks**	**Demo**	**Top niche**	**Subsidy**	**Redesign**	**Dedicated/ stand-alone system**	**Hybridization /Adaptor**	**Educate**	**Geographic**	**Lead user**	**Explore markets**	**Tech. R&D**	**Human resource management**	**Internal knowledge sharing**	**Partnership**	**Finance sourcing**	**Lobbying**	**Influencer**	**Crowd-sourcing**	**Leasing**	**Sharing economy platform**	**Corporate restructuring**	**Buy one - give one**	**Campaign funding**	**Stepping-stone**	**Network building**	**Get specified**	**Local**	**Complementary technologies, products, services**	**Product variants**	**Cross-selling and financing**	**Existing social network**	**Result-oriented contracting**	**Turnkey product**	**Incentives**	**Local implementation**	**Market positioning**	**In-house network**	**Aggresive penetration**	**Pre-announcing**	**Blue ocean**
Knowledge and awareness of technology	Product availability, performance, and quality	6			6		6	6	6			6	6	6	6			6	6			6				6			6											6	
Knowledge and awareness of application and market																																								
Competition																																								
Macro-economic and strategic aspects																																								
Accidents and events																																								
Human resources																																								
Natural resources																																								
Financial resources																																								
Socio-cultural aspects																																								
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								
Knowledge and awareness of technology	Product price	10	10	10	10		10	10			10	10	10	10	10			10	10	10	10	10				10												10	10	
Knowledge and awareness of application and market																																								
Competition																																								
Macro-economic and strategic aspects																																								
Accidents and events																																								
Human resources																																								
Natural resources																																								
Financial resources																																								
Socio-cultural aspects																																								
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								
Knowledge and awareness of technology	Production system																																							
Knowledge and awareness of application and market																																								
Competition																																								
Macro-economic and strategic aspects																																								
Accidents and events																																								
Human resources																																								
Natural resources			6	6	6		6		6	6		6			6							6				6		6												
Financial resources																																								
Socio-cultural aspects																																								
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								
Knowledge and awareness of technology	Complementary products and services	2	2		2	2	2	2				2	2	2	2			2	2			2				2													2	
Knowledge and awareness of application and market																																								
Competition																																								
Macro-economic and strategic aspects																																								
Accidents and events																																								
Human resources																																								
Natural resources																																								
Financial resources																																								
Socio-cultural aspects																																								
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								

Niche Strategy No.		Niche Strategies																																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Influencing Conditions	TIS Building Blocks	Demo	Top niche	Subsidy	Redesign	Dedicated/ stand-alone system	Hybridization /Adaptor	Educate	Geographic	Lead user	Explore markets	Tech. R&D	Human resource management	Internal knowledge sharing	Partnership	Finance sourcing	Lobbying	Influencer	Crowd-sourcing	Leasing	Sharing economy platform	Corporate restructuring	Buy one - give one	Campaign funding	Stepping-stone	Network building	Get specified	Local	Complementary technologies, products, services	Product variants	Cross-selling and financing	Existing social network	Result-oriented contracting	Turnkey product	Incentives	Local implementation	Market positioning	In-house network	Aggresive penetration	Pre-announcing	Blue ocean
Knowledge and awareness of technology	Network formation and coordination																																						
Knowledge and awareness of application and market																																							
Competition																																							
Macro-economic and strategic aspects																																							
Accidents and events																																							
Human resources																																							
Natural resources																																							
Financial resources																																							
Socio-cultural aspects																																							
Institutional aspects and political system																																							
Physical/information access & infrastructure																																							
Knowledge and awareness of technology	Customers																																						
Knowledge and awareness of application and market																																							
Competition		1	1	1	1			1	1	1	1	1			8			8		8	8	8	8		8	8	8		8	8	8	8	8	8	8	8	8	8	8	8
Macro-economic and strategic aspects																																							
Accidents and events																																							
Human resources																																							
Natural resources																																							
Financial resources																																							
Socio-cultural aspects		1			1		1	1	1	1	1				5			5			5				5						5	5	5	5	5		5	5	5	
Institutional aspects and political system																																							
Physical/information access & infrastructure																																							
Knowledge and awareness of technology	Innovation-specific institutions																																						
Knowledge and awareness of application and market																																							
Competition																																							
Macro-economic and strategic aspects																																							
Accidents and events																																							
Human resources																																							
Natural resources																																							
Financial resources																																							
Socio-cultural aspects																																							
Institutional aspects and political system																																							
Physical/information access & infrastructure																																							
TOTAL POINTS		20	19	17	26	2	25	20	14	8	12	25	18	18	37	0	0	31	18	18	18	32	8	0	13	37	8	6	14	8	8	13	13	13	13	13	8	13	23	31	8

Legends:

Links between barriers and strategies

Identified barriers

x — Points assigned to the strategies as it could circumvent the identified barriers

5.2.3. Insights from the Scoring Model 1 vs Scoring Model 2

Based on the examples provided in the previous subsections for each of the scoring model, two insights are gained. First, the same strategy recommendation is proposed by both scoring models if we look at the highest score of the strategies. However, if we look at the strategies with the second highest scores, slightly different recommendation is proposed, in which there are seven strategies are proposed by scoring model 1, while there are only two strategies are proposed by scoring model 2. The strategies recommended by scoring model 1 is based on the most barriers that could be circumvented by the strategies. In other words, if the readers or framework users want to select the best strategies to circumvent as much as barriers at once, they could use the scoring model 1. Meanwhile, the strategies recommended by scoring model 2 is based on the strategies capability in addressing the biggest threats to the innovation diffusion and adoption.

Second, choosing one best strategy might not always possible as sometimes some strategies scored with the same total points. However, the use of scoring model 2 could be considered when the framework users want to prioritize the implementation of the best strategies as the company might have limited resources to implement several strategies at once.

These insights illustrate how putting the same or different weight into the barriers may lead to different strategy recommendation. Therefore, these two different scoring approaches will be used in the later stage of the research to analyze the study case to gain different perspectives on the best strategy selection.

5.3. Chapter Conclusion and Summary

Based on the identified strategies, building blocks, and influencing factors elaborated in the previous chapter, this chapter elaborates the development of the Best Strategy Framework to answer the second sub-research question: **"Based on the existing theories in the literature, how could the niche development barriers be linked to the niche strategies so that a niche strategy that could circumvent several barriers at once could be selected?"**.

The framework is developed in two major steps. First, the potential links between the barriers and strategies were identified. For this step, two different sets of links are generated: (1) potential links identified by the author of the present work and (2) potential links identified by multiple master's thesis reports which is used to validate and evaluate the links identified by the author. In the end, only the links identified by the author of the present work is used as the basis of the framework, as shown by Table 31.

Furthermore, by identifying the links, interesting insights gained. First, several strategies could be implemented to circumvent most of the barriers, namely Geographic strategy, Partnership strategy, and Network building strategy. This insight emphasis that choosing the right geographic areas as the focus of the market penetration is important for the success of the product adoption. Moreover, expanding the network and establishing good relationship with strategic partners are important to do in anyway as the innovators could gain many benefits from it. Another interesting insight is that the Explore multiple market strategy and Lobbying strategy could circumvent almost half of the potential barriers. This insight emphasis that when there are too many barriers that could hamper the product diffusion and adoption, the innovators should re-evaluate their targeted market and look further to see if there are better opportunities available at other markets. Additionally, to support product mass adoption, the company should actively lobby the relevant stakeholders to seek for their supports, as well as maintaining good relationship with them.

Table 31 The Best Strategy Framework

		Niche Strategies																																						
Niche Strategy No.		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Influencing Conditions	**TIS Building Blocks**	**Demo**	**Top niche**	**Subsidy**	**Redesign**	**Dedicated/ stand-alone system**	**Hybridization /Adaptor**	**Educate**	**Geographic**	**Lead user**	**Explore markets**	**Tech. R&D**	**Human resource management**	**Internal knowledge sharing**	**Partnership**	**Finance sourcing**	**Lobbying**	**Influencer**	**Crowd-sourcing**	**Leasing**	**Sharing economy platform**	**Corporate restructuring**	**Buy one - give one**	**Campaign funding**	**Stepping-stone**	**Network building**	**Get specified**	**Local**	**Complementary technologies, products, services**	**Product variants**	**Cross-selling and financing**	**Existing social network**	**Result-oriented contracting**	**Turnkey product**	**Incentives**	**Local implementation**	**Market positioning**	**In-house network**	**Aggresive penetration**	**Pre-announcing**	**Blue ocean**
Knowledge and awareness of technology	Product availability, performance, and quality	■			■		■	■	■			■	■	■	■			■	■			■				■			■										■	
Knowledge and awareness of application and market		■						■	■	■	■		■	■	■			■								■			■							■				
Competition		■	■		■			■	■	■	■	■						■				■				■			■							■			■	■
Macro-economic and strategic aspects			■	■					■		■				■	■						■				■										■				
Accidents and events			■						■	■	■				■							■				■										■				
Human resources			■		■			■	■	■	■	■	■	■	■				■			■				■	■													
Natural resources			■						■	■	■	■			■							■				■														
Financial resources		■	■	■					■	■	■	■				■			■			■				■														
Socio-cultural aspects		■						■	■	■	■							■							■										■	■			■	
Institutional aspects and political system		■			■			■	■		■				■		■							■		■														
Physical/information access & infrastructure		■			■				■		■	■			■		■									■														
Knowledge and awareness of technology	Product price	■	■	■	■		■	■			■	■	■	■	■			■	■	■	■	■				■												■	■	
Knowledge and awareness of application and market			■					■			■		■	■	■			■	■	■	■	■			■	■										■		■		
Competition		■	■	■	■	■	■	■	■		■	■			■	■		■		■	■	■	■			■			■	■		■		■			■			■
Macro-economic and strategic aspects			■	■					■		■				■	■				■	■	■	■			■				■		■					■		
Accidents and events			■	■					■		■				■					■	■	■				■					■						■		
Human resources			■	■			■	■	■		■	■	■	■	■				■		■	■				■	■												
Natural resources			■	■	■				■		■				■					■	■	■				■													
Financial resources		■	■	■					■		■	■			■	■	■		■	■	■	■				■											■		
Socio-cultural aspects																																							
Institutional aspects and political system		■	■	■				■	■		■				■		■			■	■			■		■												■		
Physical/information access & infrastructure			■	■			■		■		■	■			■		■			■	■					■												■		
Knowledge and awareness of technology	Production system	■	■		■		■	■				■	■	■	■							■				■														
Knowledge and awareness of application and market								■		■			■	■	■											■														
Competition																																								
Macro-economic and strategic aspects			■	■					■	■					■	■						■				■														
Accidents and events																																								
Human resources			■	■	■		■	■	■	■		■	■	■	■							■				■		■												
Natural resources			■	■	■		■		■	■		■			■							■				■														
Financial resources			■	■	■		■	■	■	■		■			■	■	■					■				■														
Socio-cultural aspects		■						■	■																■														
Institutional aspects and political system					■			■	■						■		■							■		■														
Physical/information access & infrastructure					■	■	■		■			■			■		■									■														
Knowledge and awareness of technology	Complementary products and services	■	■		■	■	■	■				■	■	■	■			■	■			■				■												■		
Knowledge and awareness of application and market							■	■		■	■		■	■	■			■	■							■												■		
Competition		■	■		■					■	■	■						■				■				■													■	■
Macro-economic and strategic aspects			■	■		■	■		■	■	■				■	■						■				■														
Accidents and events			■			■	■		■	■	■				■							■				■														
Human resources			■		■	■	■	■	■	■	■	■	■	■	■				■			■				■	■													
Natural resources			■		■	■	■		■	■	■	■			■							■				■														
Financial resources		■	■	■	■	■	■		■	■	■	■			■	■	■		■			■				■	■													
Socio-cultural aspects								■	■						■										■														
Institutional aspects and political system					■		■	■	■		■				■		■							■		■														
Physical/information access & infrastructure					■	■	■		■		■	■			■		■									■														

Niche Strategy No.		Niche Strategies																																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Influencing Conditions	TIS Building Blocks	Demo	Top niche	Subsidy	Redesign	Dedicated/ stand-alone system	Hybridization /Adaptor	Educate	Geographic	Lead user	Explore markets	Tech. R&D	Human resource management	Internal knowledge sharing	Partnership	Finance sourcing	Lobbying	Influencer	Crowd-sourcing	Leasing	Sharing economy platform	Corporate restructuring	Buy one - give one	Campaign funding	Stepping-stone	Network building	Get specified	Local	Complementary technologies, products, services	Product variants	Cross-selling and financing	Existing social network	Result-oriented contracting	Turnkey product	Incentives	Local implementation	Market positioning	In-house network	Aggresive penetration	Pre-announcing	Blue ocean
Knowledge and awareness of technology	Network formation and coordination	■	■		■		■	■	■			■	■	■	■		■									■									■			■		■	
Knowledge and awareness of application and market		■					■	■	■	■		■	■		■		■									■									■			■		■	
Competition			■				■		■	■					■		■									■															
Macro-economic and strategic aspects			■				■		■	■					■		■									■															
Accidents and events			■				■		■	■					■		■									■															
Human resources			■				■	■	■	■			■		■		■									■	■								■						
Natural resources			■				■		■	■		■			■		■									■															
Financial resources															■	■										■									■						
Socio-cultural aspects		■	■					■	■	■					■		■								■	■		■						■						
Institutional aspects and political system					■			■	■						■		■							■		■													■	
Physical/information access & infrastructure					■		■		■						■		■									■														
Knowledge and awareness of technology	Customers	■	■		■		■	■	■	■					■			■	■						■	■	■		■		■	■		■	■		■	■	■	
Knowledge and awareness of application and market		■	■		■		■	■	■	■	■				■			■	■						■	■	■		■	■	■	■		■	■		■	■	
Competition		■	■	■	■		■		■	■	■	■			■					■	■	■	■		■	■				■		■	■			■		■	■	■
Macro-economic and strategic aspects			■	■					■	■	■				■	■				■	■		■		■	■						■	■		■	■		■		
Accidents and events			■	■					■	■	■				■					■	■		■		■	■						■	■		■	■				
Human resources																																									
Natural resources																																									
Financial resources			■	■	■				■	■	■				■	■				■	■		■			■		■		■	■	■	■		■	■	■	■	■	
Socio-cultural aspects		■					■	■										■							■								■							
Institutional aspects and political system			■		■		■		■		■				■		■							■	■	■					■							■		
Physical/information access & infrastructure					■		■		■		■	■			■		■								■	■			■			■						■		
Knowledge and awareness of technology	Innovation-specific institutions	■			■		■	■	■				■		■		■		■							■												■		
Knowledge and awareness of application and market		■			■		■	■	■		■		■		■		■		■							■												■		
Competition		■			■										■		■							■														■		■
Macro-economic and strategic aspects		■							■		■				■		■									■														
Accidents and events											■																														
Human resources								■			■		■		■		■									■														
Natural resources																																									
Financial resources									■		■				■		■									■														
Socio-cultural aspects					■		■	■																	■	■														
Institutional aspects and political system																																									
Physical/information access & infrastructure									■		■				■		■									■														

Links between barriers and strategies identified by the author

In the second step of framework development, scoring models are developed to enable the selection of the best strategy based on the barriers that might hamper the diffusion of the innovations. Two different scoring models are proposed in which: (1) all the barriers are weighed the same in the first scoring model, and (2) all the barriers are weighed differently in the second scoring model, depends on their level of importance and threats. By using these two different scoring models, different dimension of the barriers could be captured, and different insights could be gained. The first scoring model focuses on finding the best strategy to circumvent the most barriers, while the second scoring model focuses on the best strategy that could circumvent the most important or the biggest threats to the innovation diffusion and adoption.

The implementation of scoring model 1 is useful when there is no detail information about the importance and level of threat poses by the barriers, but the framework users need to select the best strategies that could circumvent most of the barriers. When the information about the importance and level of threat poses by the barriers is available, the use of scoring model 2 could help the framework users to prioritize the implementation of the best strategies, which is important to do as the company might have limited resources to execute the strategies. However, the scoring models are just decision support systems. The readers should decide for themselves whether they would like to use both scoring models or if they prefer to use only one of them.

Important to note that, even though the original frameworks are adapted into the Best Strategy Framework, however, the Market introduction flow diagrams (Figure 10 in Section 2.3.) and the Guidance on how to use the Ortt & Kamp framework (Figure 12 in Section 2.4.) that were developed based on the original frameworks, could still be used as guidance in implementing the Best Strategy Framework. Therefore, in the present work, both Figure 10 and Figure 12 are utilized, as will be explained in the coming chapters.

Chapter 6. (Solar) Electric Vehicle Development in Indonesia

As the Best Strategy Framework has developed in the previous chapters, in this chapter, the framework is implemented to the Lightyear's SEV case in Indonesia market. The purpose of this chapter is to answer the third sub-research question: **"Based on the previously developed "The Best Strategy Framework", which actors, factors, and functions could be the barriers for SEV to reach its mass adoption in Indonesia?".** Before answering this question, an overview of the current EV ecosystem in Indonesia is explained in Section 6.1. by listing the actors involved in the EV development in Indonesia and how they are related to each other's. Subsequently, literature research on scientific literature as well as grey literature written in English and Indonesian language is conducted to collect relevant information about the status of Lightyear's TIS building blocks in Indonesia and whether certain factors hamper the availability of the TIS building blocks. The insights gained from this literature research are elaborated in Section 6.2. In the end, Section 6.3. concludes the insights gained in this chapter.

6.1. Current Electric Vehicles Ecosystem in Indonesia

As highlighted by Indonesia's national masterplan of industry (RIPIN), the development of EV industry is included as Indonesia's ten priority industries as it deemed to be important to support Indonesia's economic growth (Kementrian Perindustrian, 2015). Moreover, the development of EVs in Indonesia is also in line with the Indonesia's national energy plan (RUEN) (Mahalana & Yang, 2021), which aiming for energy self-sufficiency, energy security, and sustainable energy development. More explanation about RIPIN and RUEN could be found in Appendix C.1. and Appendix C.2. respectively.

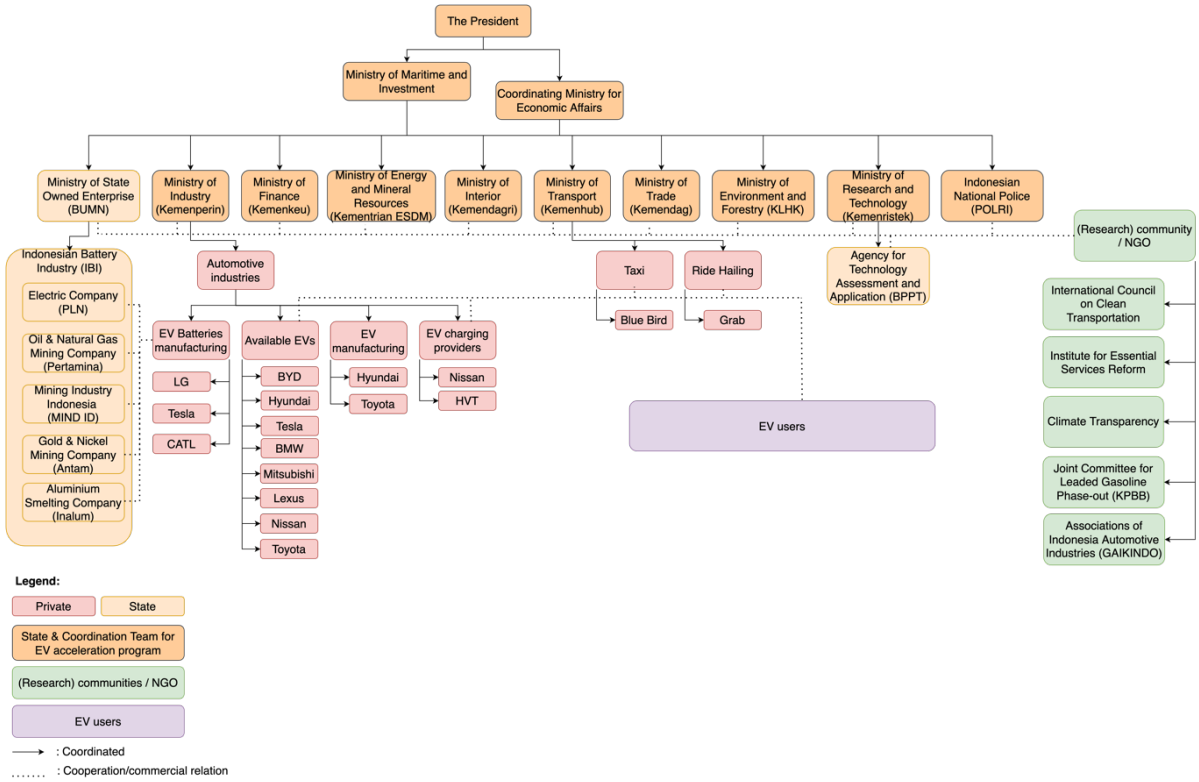


Figure 21 Stakeholder map of EV development in Indonesia

To understand the existing EVs ecosystem in Indonesia, a stakeholder map is presented in Figure 21 which shows the relevant stakeholders that are involved in the development of EVs in Indonesia and how they are related to each other. A brief explanation of each stakeholder is provided in the following.

Indonesia is aiming to be a major player in global EV market by establishing integrated EV supply chain domestically (Cekindo, 2021; KPMG Indonesia, 2021). To reach this goal, in 2019, the **President of Republic Indonesia** signed the Presidential Regulation No. 55/2019 to direct, regulate, support, and accelerate the development of EV in Indonesia (Presiden Republik Indonesia, 2019). Based on this presidential decree, the acceleration of the EV in Indonesia will be focused on several things namely the acceleration of domestic EV industries development, the offering of fiscal and non-fiscal incentives, the acceleration of EV charging infrastructures development, and the regulation of electricity tariffs for EV charging.

The **Ministry of Maritime and Investment** and the **Coordinating Ministry for Economic Affairs** were appointed as the chairman and vice chairman of the coordination team for EV acceleration program (later will be addressed as coordination team). The responsibilities of the coordination team cover not only to coordinate, plan, and execute the EV acceleration program, but also to solve and regulate any issues related to EV acceleration program.

Outside of the coordination team, **Ministry of State-Owned Enterprise (BUMN)** plays a big role in the EV acceleration program as elaborated in the following. According to Statista, Indonesia holds around 22% of global nickel reserves which is one of the biggest shares next to Australia. Moreover, Indonesia is the largest nickel producer globally that produced around one million metric tons in 2021 (Statista, 2022). As nickel is one of the major raw materials for batteries, therefore, Indonesia aims to develop EV batteries and Energy Storage System (ESS) ecosystem in Indonesia by establishing **Indonesia Battery Industry (IBI)** which consists of four state-owned companies (see Table 32).

Table 32 The role of each state-owned enterprises (SOEs) within the EV battery supply chain, extracted from (KPMG Indonesia, 2021)

SOEs	Sector	Activities
Inalum & Antam	Upstream	Mining and refining nickel for production of batteries
Pertamina	Intermediate	• Construction and operation of precursor plants, cathode plants, battery cells and battery packs • Battery recycling (with PLN)
PLN	Downstream	• Distributor for batteries • Battery recycling (with Pertamina)

Furthermore, IBI collaborates with **LG Energy Solution** (**LGES**) – a Korean electronics company to establish Indonesia Battery Corporation (IBC) by building an EV battery plant which will serve the whole ecosystem from the upstream to the downstream. This plant planned to produce nickel-cobalt-manganese-aluminum (NCMA) batteries which have 90% nickel in their cathodes, with total production of 10 GWh per year starting 2024, and will be used by Hyundai and Kia (Huber, 2022). Other than this, Contemporary Amperex Technology (**CATL**) – a big China's battery supplier who usually supply its batteries to Tesla, BMW, and VW, recently signed an agreement to mine and process nickels, as well as to manufacture, and recycle the batteries in Indonesia. The construction of the plant will be started this year and it

is expected to start its production in 2026 (Doll, 2022; NS Energy, 2022; Pertamina, 2021). **Tesla**, in the other hand, also recently agreed to manufacture its EVs as well as the batteries in Indonesia. The plant is planned to be constructed in central Java at the end of 2022 (Lambert, 2022; Schmidt, 2022).

Other than within EV battery supply chain, PLN and Pertamina have more responsibilities as the following. **The electric company (PLN)** is responsible for the development of the EV charging infrastructures, as well as to manage the electricity supply and the electricity pricing scheme for the EV charging. **The oil and natural gas mining company (Pertamina)** is responsible not only to provide energy security but also diversification of energy to the country. In national EV development context, Pertamina contributing by, for example, making a space for the EV charging infrastructures at its gas stations to provide centralized EV charging services.

In the automotive industry itself, there are many stakeholders playing their important roles to boost the EV market in Indonesia. Various EV brands have been penetrating Indonesian market up to 2021, namely **BYD, Hyundai, Tesla, BMW, Mitsubishi, Lexus, Nissan, and Toyota** (Mahalana & Yang, 2021). In 2019, **Blue Bird** – the biggest taxi operator in Indonesia included EVs into their fleet which received positive feedbacks from the users (CNBC International TV, 2020). Blue Bird bought 25 units of BYD E6 and five units Tesla X 75D and installed 11 EV charging station at its headquarter for its own use. This number is still insignificant compared to total taxis owned by Blue Bird, which reached around 25,000 taxis across Indonesia. Therefore, Blue Bird planned to add 200 more EVs in 2020. However, this plan was postponed due to the corona pandemic crisis (Baskoro, 2019; Herman, 2019). In 2020, **Grab Indonesia** – a ride hailing company and Hyundai started their cooperation to provide their new service which is called GrabCar Elektrik by using Hyundai's EVs (Grab, 2020).

PT. Hyundai Motor Manufacturing Indonesia (HMMI) is the first automotive company that produce its EVs in Indonesia. It started its first production in March 2022 and currently able to produce 1.000 EVs per year. However, it expected to increase its capacity in the future (Kemenperin, 2021a). Additionally, **Toyota** is now busy preparing its factory in Indonesia to produce its hybrid cars, which is expected to start its production this year (Radityasani, 2022). Furthermore, several other EV producers are going to build their EV plants in Indonesia, namely **Tesla, Mitsubishi, Honda, and Suzuki** (KPMG Indonesia, 2021).

The EV charging facilities are supplied not only by the government, but also by private companies such as Nissan and High Voltage Technology (HVT). **PT Nissan Motor Distributor Indonesia** is the first private company who develop EV charging infrastructures in Indonesia by working together with PLN (Ruang Energi, 2021). The first EV chargers were installed in Nov 2021 in several locations in Jakarta. These chargers are available for public, means, it could be used not only by Nissan's EVs but also by other EV brands (OTO, 2021). However, there is no further information available on the number of install Nissan's EV charger to date. **HVT**, in the other hand, recently established an agreement to collaborate with PLN that aim to provide 150 new EV charging facilities nationally until 2026 (Nguyen, 2022).

Furthermore, various (research) communities and NGOs influences the EV development dynamic in Indonesia, as they raise various issues around transport sector which shape the transport policies in Indonesia. Some of the communities and NGOs are as the following.
1. Associations of Indonesia Automotive Industries (GAIKINDO) is a non-profit organization established by various vehicle producers, distributors, and manufacturers.

GAIKINDO helps to boost the development of automotive industry in Indonesia by, for example, facilitating its members towards government policies, holding a yearly international automotive exhibition and conference, providing a platform for knowledge exchange between the members and the government, and socializing the automotive technology development to the society (Gaikindo, 2020).

2. Joint Committee for Leaded Gasoline Phase-out (KPBB) is a non-governmental organization that aims advocate for the elimination of leaded gasoline to improve air quality in Indonesia. KPBB vision is to accommodate public opinion and suggestions on matters relating to the elimination of leaded gasoline and advocate it to the decision makers in the government, as well as to educate the society of the importance of phasing out the technologies that produce emissions (KPBB, 1999). In line with this vision, KPBB supports the acceleration of EV development in Indonesia, for example, by proposing the implementation of carbon tax to discourage the use of ICE vehicle and to make EV more competitive (GridOTO, 2021, 2022).

3. Climate Transparency is a global partnership of multiple research organizations and NGOs to encourage climate actions by providing information and assistance on research, finance and vulnerability of G20 countries. Climate Transparency reports on Indonesia cover information such as the country profile and proposals on adaptation and mitigation actions to address climate change on various sectors such as energy, transport, building, industry, and land use and agriculture (Climate Transparency, 2019).

4. Institute for Essential Services Reform (IESR) is an Indonesian energy and environmental think-tank that support Indonesia's energy transition by providing public policy advocacy, conducting capacity building assistance, and setting up strategic partnership with non-governmental actors (IESR, 2022). Indonesia Energy Transition Dialogue (IETD) is one of IESR yearly programme to facilitate Indonesia's energy transition discussion among related stakeholders.

5. International Council on Clean Transportation (ICCT) is an independent non-profit organization that conduct various research in road, marine, and air transportation sectors to provide technical and scientific analysis and advocacy for the environmental regulators to support energy transition and to benefit public health (ICCT, 2022).

Lastly, potential **EV users** play the crucial roles in the EV ecosystem. Up to 2021, there are only four thousand EV passenger cars registered in Indonesia (Gaikindo, 2021a, 2021b, 2022), which is very insignificant compared to the total of 16 millions registered passenger cars In Indonesia in 2020 (Badan Pusat Statistik, 2022). It means that Indonesia has a big market potential for SEV.

6.2. Barriers to Lightyear's SEV Development in Indonesia

This section elaborates the research conducted to identify Lightyear's SEV development barriers in Indonesia by using the newly developed Best Strategy Framework as a basis of the research. Moreover, as explained in Section 5.3., the Market introduction flow diagrams (Figure 10) and the Guidance on how to use the Ortt & Kamp framework (Figure 12) are used as guidance in implementing the Best Strategy Framework.

The research is done by going through various literature such as journals, press releases, online news, governmental websites, as well as by conducting informal discussion with Lightyear's representative. To identify the development barriers, the analysis is described per TIS building blocks by evaluating their status, as well as by identifying the factors that influencing their status. Once the status of each TIS building blocks is identified, traffic light indication (GREEN-ORANGE-RED) is given to summarize the TIS building blocks status. GREEN indicates that the building block is available and complete to support mass adoption, ORANGE

indicates that the building block is available but incomplete, while RED indicates the unavailable building block.

6.2.1. Product availability, performance, and quality

Table 33 Specifications and price of some of the EVs currently available in Indonesia (Auto Data, 2022; Ccarprice, 2022; Cekpremi, 2021; Chua, 2020; CNN Indonesia, 2022; Encycarpedia, 2018, 2019; EV Database, 2022f, 2022c, 2022b, 2022g, 2022d, 2022i, 2022e, 2022j, 2022a; Lightyear, 2022a; Mendagri, 2021; Otomotifo, 2020; Pamungkas, 2022; RCTI Plus, 2022). *The price in EUR is based on June 2022 exchange rate.*

Brand	Model	EV Type	Battery & Engine Capacity	WLTP Driving Range [km]	Acceleration 1-100km/h [s]	Top speed [km/h]	Price* [M IDR]	Price* [EUR]
Lightyear	Lighyear 0	SEV	60kWh	625	10	160	-	250,000
Hyundai	Ioniq Electric	BEV	40.4kWh	311	9.7	165	413	26,500
Hyundai	Kona 2.0 EV	BEV	42Wh	305	9.9	155	476	30,600
Hyundai	Ioniq 5 EV 2WD AT	BEV	58kWh	400	8.5	185	450	28,900
Tesla	Model X 75D	BEV	75kWh	335**	5.2	210	2,850	182,700
Tesla	Model 3 Std Plus	BEV	52kWh	409	5.6	225	653	41,900
Tesla	Model Y	BEV	82kWh	542	5.0	217	593	38,100
Tesla	Model S P100D	BEV	100kWh	475**	2.7	250	4,400	282,100
BMW	i3S	BEV	42.2kWh	283	6.9	160	899	57,700
Mitsubishi	Outlander PHEV	PHEV	13.8kWh, 2.4L	-	10.5	170	719	46,100
Lexus	UX300e	BEV	54.3kWh	315	7.5	160	611	39,200
Nissan	Kicks e-Power Mid	HEV	1.57kWh, 1.2L	-	9.7	145	282	18,100
Nissan	Leaf	BEV	40kWh	270	7.9	144	417	26,800
Toyota	Corolla Cross Hybrid	HEV	1.3kWh, 1.8L	-	?***	?***	395	25,400
Toyota	Prius Hybrid	HEV	1.3kWh, 1.8L	-	10.6	180	539	34,600
Toyota	Prius PHEV	PHEV	8.8kWh, 1.8L	-	11.1	163	724	46,500
Mini	Mini Electric	BEV	32.6kWh	234	7.3	150	945	60,600

*based on off the road price
***no information available in the sources
**based on real EV range; no WLTP range is provided in the sources

Theoretically, in order to make an innovation adopted in a large scale, the product should be available, as well as having sufficient performance and quality, so that it could be seen as a good alternative to the existing product (Ortt & Kamp, 2022). Table 33 is developed in the present work to show the comparison of Lightyear 0 specifications compared to some of other EVs that are currently available in Indonesia market. From the table, it could be seen that Lightyear 0 outperformed other EVs by providing the longest driving range while only using relatively small batteries. In term of acceleration and top speed, Lightyear 0 is not the best, but they are similar to average EVs. Therefore, product performance and quality could be considered as sufficient and will not hinder Lightyear's SEV adoption. Instead, as explained in Chapter 3, SEV provides additional values and benefits that other EVs failed to deliver: less charging time and frequency, as well as charging hassle. However, unfortunately Lightyear 0 is currently not available yet in Indonesia. Based on Lightyear's roadmap, in the coming years the company is only focusing its market on EU, Norway, and Switzerland. Then, in 2025, Lightyear will release its second generation SEV called Lightyear Two, which will aim mass production and eventually will enter Asia-pacific market around 2030.

Even though this road map was a conscious decision made by Lightyear to step by step widen their market, however, there are other factors that influencing the current unavailability of Lightyear's SEV in Indonesia market. Being based in the Netherlands, Lightyear has good knowledge of European market, while, Lightyear has a limited knowledge and awareness of the market outside of Europe, especially Indonesia. Due to this lack of knowledge and awareness, Lightyear could not see or judge whether there is a big opportunity for SEV in Indonesia.

Additionally, financial resources might be the other influencing factor. Making the product available in certain market regions require massive sunk cost to get the logistic, production,

transportation, and distribution facilities available. As Lightyear is a start-up company, they have a limited financial resource and very dependent to their investors. Therefore, Lightyear had to prioritize their financial spending by focusing the initial market to the market that they are familiar with such as Europe. However, as argued by Lightyear's representative, this issue could be seen from a different perspective. If Lightyear could have seen big opportunities in Indonesia and decided to penetrate Indonesian market, the company could have managed to raise sufficient funds to finance and support the market penetration.

With above-mentioned facts, therefore, the status on the product availability, performance and quality is ORANGE, that is influenced by several factors namely (1) knowledge and awareness of application and market and (2) financial resources. Lightyear's conscious decision not to currently aim for Indonesian market is not considered as influencing factor as the decision itself was established due to the present of the above-mentioned influencing factors.

6.2.2. Product price

To make an innovation adopted in a large scale, the innovation should be offered at a competitive price. As indicated by Table 33, the price of Lightyear 0 is currently not competitive as it is sold at the second highest base price compared to other EVs that are available in Indonesia. This high price is caused by several factors as explain in the following.

As a start-up, Lightyear had to design their SEV from scratch with its limited knowledge of the technology, its application and market. Therefore, big amount of money was invested on research and development of the product and its application, as well as the market research. Furthermore, Lightyear had to build its offices, production facilities, and other supporting facilities from scratch that also cost a high sunk investment. As a start-up with limited financial resources, Lightyear decided to limit the production scale of its 1st SEV generation to only 946 cars. Thus, all the development cost has to be spread into this limited number of products. Additionally, some expensive materials are used to build the SEV such as the batteries, double curved solar panels, carbon fibers body panels, and other components that drives up the car's cost price.

From the perspective of Indonesian market, it is argued that there is a significant different between Indonesian market compared to western markets, in which western people are generally willing to pay more for sustainable and clean technologies and energy, while affordability is the biggest concerns for Indonesian people (Maghfiroh et al., 2021). This argument is confirmed by Gui who explained that high up-front is one of the biggest factor that hinder EV adoption in Indonesia (Gui, 2021). Gaikindo explained that up to 80% of passenger cars bought by Indonesian is at price range between IDR 200 million to 300 million (€13,000 to €19,000 based on June 2022 rate) (Rayanti, 2022). Therefore, various researchers argued that to make EVs adopted in large scale in Indonesia, the price of EVs should be around IDR 300 million (equal to €19,000 based on June 2022 rate) to better match customers' buying power (Iskandarsjah, 2020; Kemenperin, 2021b).

However, Lightyear is not planning on selling the Lightyear 0 into Indonesian market. Instead, by taking the advantages of economies of scale as well as knowledge and awareness of technology gained in building their first SEV, Lightyear is planning to mass produce its next generation of SEV, Lightyear Two, in 2025 with targeted price of €30,000 (Gauthier, 2021), and start to penetrate Asia-Pacific market around 2030. With this targeted price, Lightyear Two price is getting closer to the Indonesian' average buying power. One could argue that Indonesian's average buying power might be increased in the coming years in line with the

country's fast-growing economy (Suehiro & Purwanto, 2019). However, Lightyear Two adoption might still be hindered by the competition as several other EV producers are now already selling their cars with price range of €25,000 to €35,000 which might be even cheaper by 2030.

Based on above explanation, the status of product price building block is ORANGE, that is influenced by several factors namely (1) knowledge and awareness of application and market, (2) competition, and (3) natural resources. Knowledge and awareness of technology, at the other hand, is no longer seen as a barrier as Lightyear has successfully built its SEV.

6.2.3. Production system

To enable an innovation to reach its mass adoption, sufficient production system is needed to mass produce the innovation. However, as explained in Section 6.2.1., Lightyear consciously decided that it will only focus their attention on Asia-pacific market starting 2030 onwards. Therefore, there is no supportive production system currently available to support the market in Indonesia.

Other factors are also influencing the unavailability of the production system. First, Lightyear's lack of knowledge and awareness of the Indonesian market led to Lightyear's decision not to put Indonesia as the priority countries to penetrate in its early market entrance. Second, as establishing a production system costs a high sunk cost, Lightyear's limited funds as a start-up restricts the company to immediately aim for mass production. Therefore, Lightyear had to limit the size of its initial market so that it could penetrate the market with a small-scale production system.

With these facts, thus the status of production system building block is RED, that is influenced by several factors namely (1) knowledge and awareness of application and market and (2) financial resources. Lightyear's conscious decision not to currently aim for Indonesian market is not considered as influencing factor as the decision itself was established due to the present of the above-mentioned influencing factors. Moreover, the conscious decision is not a contextual factor. Instead, it is the company's internal factor.

6.2.4. Complementary products and services

The availability of complementary products and services is also important to make an innovation adopted in a large scale. For SEV case, the availability of EV charging infrastructure, home charging services, as well as regulated electricity tariff and payment instruments for EV charging are important. The availability of these complementary products and services is explained in the following.

The insufficient EV infrastructure has been hampering the adoption of EVs in Indonesia. Up to February 2022, Indonesia has only installed 267 EV charging points that are spread in 195 different locations (mostly in Java Island, while only a few are in Sumatera, Bali, Maluku, dan Sulawesi). By collaborating with various stakeholders, the government aimed to further increase this amount to reach about 4,900 charging points by the end of this year (CNN Indonesia, 2021a; Dananjaya, 2022; Hampel, 2019), which seems to be very ambitious. At the other hand, the insufficient EV infrastructure is not a barrier for SEV adoption. Instead, it is an advantage for Lightyear's SEV as it has less dependency to EV chargers, thanks to its high efficiency and solar panels.

In 2020, PLN - the state owned electricity company - released "Charge.IN" app that could be used to search available charging points, to find directions to those charging points, as well as to pay the electricity charged to the EVs (Mahalana & Yang, 2021). The availability of this app provides easiness and comfort for EVs users which support EVs adoption. Additionally, the electricity tariff for EV charging is regulated by PLN of maximum IDR 2,466/kWh (equal to €0.16/kWh based on June 2022 rate) (Kementrian ESDM, 2021; Ruang Energi, 2021).

Furthermore, PLN collaborates with the EVs producers in Indonesia by including the home charging facility for free in every EV purchase. Additionally, PLN offers discount for power upgrade of the house to enable the operation of the home charging, as well as 30% electricity tariff discount for home charging from 22.00 until 05.00 (Purnama, 2022). Based 2022 household electricity tariff, with this discounted tariff, EV users only need to pay IDR 1.189/kWh instead of IDR 1.699/kWh (around €0,08/kWh and €0,11/kWh respectively) for home charging (Kompas, 2022). This collaboration and services provided by PLN supports the adoption of EVs in Indonesia as it reduces customers' hassle in acquiring the product.

Based on above explanation, it could be concluded that complementary products and services do not pose any barriers for SEV adoption in Indonesia. Thus, the status is GREEN.

6.2.5. Network formation and coordination

Based, on the company's road map, Lightyear is planning to enter Asia-Pacific market starting 2030 onwards. As it is still far in the future, therefore, Lightyear currently has not yet established any relationship with any stakeholders in Indonesia. Moreover, the absent of the network formation and coordination with Indonesian market is also caused by Lightyear's current lack of knowledge and awareness of Indonesian market that hinders Lightyear capability to find and connect to the right stakeholders in Indonesian market. Hence, this research serves as pre-market research to provide insights for Lightyear of the possibilities. The stakeholder map indicated in Section 6.1. is provided to inform Lightyear about current players in EVs ecosystem in Indonesia which could be a starting point if Lightyear is going to establish its network in the future.

Thus, the status of network formation and coordination is RED, with the knowledge and awareness of application and market as the main influencing factor. Lightyear's conscious decision not to currently aim for Indonesian market is not considered as influencing factor as the decision itself was established due to the present of the above-mentioned influencing factor. Moreover, the conscious decision is not a contextual factor. Instead, it is the company's internal factor.

6.2.6. Customers

Indonesia has a big market potential for (S)EVs to tapped in. Until 2020, 16 million passenger cars were registered In Indonesia (Badan Pusat Statistik, 2022), in which only less than four thousands of them are EVs (Gaikindo, 2021a, 2021b, 2022). Even more, the car ownership ratio in Indonesia is currently only 99 passenger cars per 1,000 inhabitants (Gaikindo, 2021a), which is very low compared to EU average of 505 cars per 1,000 inhabitants (CBS, 2019). With Indonesia's fast growing economy, the number of cars is expected to be 2.5 times in 2040 (Suehiro & Purwanto, 2019). Furthermore, 75% of Indonesia's internet users (around 22 million people) are actively using ride-hailing services due to its affordability (Cekindo, 2021). Even though Cekindo (2021) does not specify the exact number of car ride-hailing users, however, it is still an interesting untapped opportunity for EV producers or manufacturers as

the ride-hailing providers have started to adopt a few EVs into their fleets. Thus, the availability of potential customers of SEV is not an issue in Indonesia.

However, even though EVs recently have gained their popularity in Indonesia, EVs adoption rate in Indonesia is still very low compared to other countries (Mahalana & Yang, 2021). Moreover, the EVs adoption rate in Indonesia is still insignificant compared to the number of new passenger cars sold, as shown by Table 34. Therefore, to achieve large scale adoption of EVs in Indonesia, it is important to identify the factors that influencing people decision in adopting EVs. In the following, several papers are reviewed to identify factors that hindering Indonesian people in adopting EVs.

Table 34 Number of EVs sold in Indonesia in the last three years, data extracted from (Gaikindo, 2021a, 2021b, 2022)

Year	Sold EVs				Sold New Passenger Cars	Sold EVs/New Pas. Cars
	HEV	PHEV	BEV	Total		
2019	685	20	-	705	1,030,126	0.07%
2020	1,108	6	120	1,234	532,027	0.23%
2021	1,378	34	488	1,900	887,200	0.21%
Grand Total				**3,839**	**2,449,353**	

Nuryakin et al. (2019) conducted research to identify customers knowledge and preferences towards EVs by surveying 400+ car users and non-users in Great Jakarta area. The research concluded that the public knowledge and acceptance towards EVs are relatively high, and 30% of them is interested to buy an EV. However, most of them prefer PHEV compared to BEV and HEV due to its longer range. Moreover, BEV is the less favorable due to its long charging time and its significantly more expensive price compared to other EVs (Nuryakin et al., 2019). In line with the results of this research, Gaikindo argued that EVs prices and the availability of the infrastructures are the biggest barriers that holding back the EVs adoption (Gaikindo, 2021a).

Another research was done by BMW Group Asia who conducted an online survey on 4,000 drivers from South-east Asia (BMW Group Asia, 2022). The survey suggests that most of these drivers are aware of the EVs contribution in reducing the emissions, and almost half of the survey participants are interested to adopt EVs due to their environmental benefits, lower operational cost, and premium experience. However, they admitted that EVs costs is a big concern that hinder them to do so and prefer to have the EVs with price similar or even less than the conventional cars. Furthermore, most of the participant has sufficient knowledge of BEV technology and how it works. However, several misconceptions exist among the them, in which they thought that EVs could only travel the maximum of 100km before they need to be recharged, while most of the EVs nowadays could drive way more than (EV Database, 2022h). Other than that, some of the participants thought that maintenance cost of EVs might be more expensive than conventional cars after ten years, while EVs have less maintenance costs due to their fewer moving parts.

Based on above explanation, it could be concluded that the status of customer building block is ORANGE as several factors hampering Indonesian's willingness to adopt EVs, namely (1) customers' financial resources (customers' buying power is less than EVs' prices), (2) competition between EV technologies as well as between EVs and ICE vehicles, and (3) customers' knowledge of the EVs technologies.

6.2.7. Innovation-specific institutions

The availability of supportive institutions is important to protect the niche from the existing well-established regime and to give the niche opportunity to grow and to be mature. Appendix C elaborates EV-related documents and policies in Indonesia. From this Appendix, it could be seen that Indonesian government has implemented various policies to encourage both potential EV users and EV industries or manufacturers, as summarized in the following.

To encourage EV adoption, several policies are in place such as EV's luxury taxes reduction, EV's transfer tax reduction in Jakarta and West Java provincial government, 0% down payment and lower interest rates for the financing of new EVs, discounted price for house's power upgrade to enable the operation of home charging facility, and 30% electricity tariff discount for home charging during off-peak hours (Chen et al., 2022; Kemenperin, 2021b; Mahalana & Yang, 2021; Maskur, 2020; Purnama, 2022).

To help the EV industries or manufacturers to reduce EVs manufacturing cost and to attract them to invest in Indonesia, the government offers tax holidays, tax allowances, supertax deduction for R&D activities, and import duties exemption for Incompletely Knocked Down (IKD) EVs (Adelayanti, 2020; BKPM, 2018; Kemenperin, 2021b; D. Kurniawan, 2022; Mahalana & Yang, 2021; Nugroho, 2022; Putri, 2022c).

Moreover, to boost EV adoption in Indonesia, the government agencies are encouraged to switch their fleets into EVs (Iskandarsjah, 2021), and Indonesia planned to stop the selling of new fossil-fueled cars starting 2050 (CNN Indonesia, 2021b; Mardika, 2021). Jokowi, the current President of Indonesia even banned the ICE vehicles to operate in the new capital city of Indonesia (Aszhari, 2022; CNN Indonesia, 2020; Dananjaya, 2021). Additionally, MoU between various strategic stakeholders is signed to support the further development of EV infrastructures.

However, despite the implementation of these policies, researchers argued that the policies are not providing enough incentives for Indonesian customers to switch their ICEs to EVs (Chen et al., 2022; Mahalana et al., 2021; Mahalana & Yang, 2021). In their papers, these researchers argued that EV's total cost of ownership (TCO) is still significantly more expensive than ICE's TCO despite the taxes reduction and exemption EVs (Chen et al., 2022; Mahalana et al., 2021; Mahalana & Yang, 2021). Moreover, despite Indonesia's effort to phase-out its fossil fuel subsidies, Indonesia still offering subsidies for its diesel and gasoline RON 88 until today as regulated by Presidential Decree No. 117/2021 (Asian Development Bank, 2015; Mahalana et al., 2021; Ministry of Finance, 2019; Putri, 2022a), which discourage EV adoption. At the other hand, not all the EV producers and manufacturers are maximizing the use of tax holidays, tax allowances, supertax deduction for R&D activities, and import duties exemption offered by Indonesian government. The author of the present work believes that if the EV producers and manufacturers would manufacture their products in Indonesia, the offered incentives would significantly reduce the products cost and price. Additionally, there is no coherent EV road map in Indonesia. Instead, the EV road map releases by the National Energy Plan (see Appendix C.2.) is conflicting and less ambitious compared to the one released by the Ministry of Energy and Mineral Resources (see Appendix C.3.).

Based on above mentioned facts, therefore, the status of innovation-specific institutions is ORANGE. As identified from the literatures, this status is influenced by two factors (1) Indonesia's limited financial resources and (2) its complex socio-cultural aspects. Learning for the success of the developed countries, EV purchasing subsidy is a good incentive to boost EV

adoption. However, as a developing country, Indonesia does not have strong fiscal capability to provide EV purchasing subsidy to its citizens (Arvirianty, 2019; H. Kurniawan et al., 2021). Moreover, Indonesia's complex socio-cultural aspects influencing the government ability in implementing the right supportive policies for EVs. As EVs are too expensive for the middle class, providing EV purchasing subsidy could be politically unjust (AHK, 2022; H. Kurniawan et al., 2021), and might cause negative reaction from lower class citizens. Additionally, the removal of fossil fuels subsidies would have considerable implications to the livelihood of low-income families (Satya, 2022).

6.3. Chapter Conclusion and Summary

This chapter uses the Best Strategy Framework that was developed in the previous chapters to identify the status of Lightyear's TIS building blocks for Indonesian market and factors that influencing their status. The purpose of this chapter is to answer the third sub-research question: **"Based on the previously developed "The Best Strategy Framework", which actors, factors, and functions could be the barriers for SEV to reach its mass adoption in Indonesia?".**

Based on the literature research, it is known that the development of EV industry has been part of Indonesia's ten top priority industries as it deemed to be important to support Indonesia's economic growth, as highlighted in Indonesia's national masterplan of industry (RIPIN). Moreover, Indonesia's national energy plan (RUEN) supports EV development as part of its energy self-sufficiency, energy security, and sustainable energy development goals. In 2019, the EVs era in Indonesia is started when the President of Indonesia signed the Presidential Regulation No. 55/2019 to direct, regulate, support, and accelerate the development of EV in Indonesia. With this regulation in place, Indonesia aimed to be an important player in global EV market.

A stakeholder map is presented by Figure 21 to provide an overview of current EV ecosystem in Indonesia. As indicated in the stakeholder map, various ministries are appointed as coordination team to accelerate EV development in Indonesia. Moreover, various EV brands have penetrated Indonesian market. Even more, EVs are also adopted by taxi and ride-hailing company as part as their fleet. To support EV adoption, the government has established a cooperation with private companies to develop the EV charging infrastructures. Furthermore, Indonesia facilitates the development of the EV and EV battery manufacturing domestically. Lastly, various research communities have been contributing their work to support EV development, for example, by providing policy recommendation to the government.

Table 35 The status of Lightyear's TIS building block for Indonesian market, factors that negatively influencing the status, and the main influencers

TIS Building Blocks	Status	Influencing Factors	Main Influencers
Product availability, performance, and quality	ORANGE	(1) knowledge and awareness of application and market and (2) financial resources	Lightyear
Product price	ORANGE	(1) knowledge and awareness of application and market, (2) competition, and (3) natural resources	Lightyear, Indonesia
Production system	RED	(1) knowledge and awareness of application and market and (2) financial resources	Lightyear
Complementary products and services	GREEN	N/A	Indonesia

Network formation and coordination	RED	(1) knowledge and awareness of application and market	Lightyear
Customers	ORANGE	(1) knowledge and awareness of technology, (2) financial resources, and (3) competition	Indonesia
Innovation-specific institutions	ORANGE	(1) financial resources and (2) socio-cultural aspects	Indonesia

To answer the third sub-research question, the status of Lightyear's TIS building blocks for Indonesian market and their influencing factors is summarized in Table 35. The status is indicated by traffic light indication (GREEN-ORANGE-RED). GREEN indication is given when the TIS building block status is available and complete to support mass adoption, ORANGE indication is given when the TIS building block status is available but incomplete, while RED indication is given when the building block is not available. For the building block that has a GREEN status, no influencing factor is identified.

Table 35 shows that currently six out of seven TIS building blocks are unavailable or incomplete that lead to 13 barriers that hinder Lightyear's SEV adoption in Indonesia. Only complementary products and services building blocks that are currently available and complete to support SEV adoption in Indonesia, as Indonesia has provided and regulated the home charging services, EV charging electricity tariff, and payment instruments. Fortunately, the currently insufficient amount of charging infrastructure is an enabler to support the adoption of SEV, thanks to its capability to charge itself. As this building block do not pose as a barrier, therefore, no influencing factors need to be identified.

Product availability, performance, and quality building block is almost complete as the performance and quality of Lightyear 0 is perceived sufficient compared to its alternatives. Thus, if Lightyear could make its SEV available in Indonesia market, this building block status would turn green. To make its product available, Lightyear needs to establish the necessary Production system and Network formation and coordination building blocks. However, these building blocks are also not available yet to support Indonesian market. The unavailability of these building blocks is caused by the same factor namely the lack of Lightyear knowledge and awareness of Indonesian market. Additionally, due to its limited financial resources, Lightyear decided to limit its market entry only at familiar markets such as Europe. This decision therefore explains the unavailability of Product availability and Production system building blocks in Indonesia.

Other building blocks namely product price, customers, and innovation-specific institutions must be improved further to support SEV adoption in Indonesia. Lightyear 0' price of €250,000 is deemed not affordable as Indonesian average car buying power is within price range of €13,000 to €19,000. This expensive price is influenced by the company's lack of knowledge of the market, market competition which enable the customers to compare the product with its alternatives, and the expensive materials used to build the SEV. Regarding the customers, even though Indonesia has a high market potential in term of number of passenger cars, however, the EV adoption rate is still relatively low due to customers' lack of knowledge and awareness of EV technologies and their added values and benefits, limited financial resources (customers' buying power is less than the EV average price), and competition in the market that provides perceived better and cheaper alternatives. Furthermore, the currently enforced supportive policies and incentives are deemed to be insufficient to boost EV adoption rate. However, the implementation of more aggressive incentives is hindered by Indonesia's limited fiscal capability as well as its complex socio-cultural aspects which deemed EV subsidy as a political unjust.

From the main influencer point of view (see the rightest column of Table 35), Lightyear has the biggest role on the unavailable or incomplete TIS building blocks as Lightyear mainly responsible to make the product, production system, and network formation available. Indonesia, at the other hand, has provide sufficient complementary product and services to support SEV adoption, despite the incomplete Customers and Innovation-specific institutions building blocks. Product price building block is influenced by both Lightyear and Indonesia sides as there should be a match between the Lightyear's capability to provide affordable SEV and Indonesian's average buying power.

Additionally, from Table 35 it could be seen that several influencing factors hindering the availability of more than one building blocks, namely (1) knowledge and awareness of application and market, (2) financial resources, and (3) competition. Therefore, circumventing these factors should be prioritized to significantly improve the status of the building blocks, as these are the most important and most threatening factors.

Lastly, Figure 22 and Figure 23 are provided to look back to the two important guidance: Figure 10 and Figure 12 elaborated in Section 2.3. and Section 2.4. respectively. The implementation of the Best Strategy Framework up to this point of research is indicated by the green arrows. From both flowcharts, some insights are gained. First, it is suggested that Lightyear is currently not ready yet for the mass marketing strategy as some of the TIS building blocks are incomplete. Second, based on the influencing conditions identified earlier in this research, it could be concluded that Lightyear would need some years to reduce or overcome the negative effects of the influencing conditions, as well as to complete all its TIS building blocks, so that it will be ready for the large-scale diffusion. Third, Lightyear could, for now, implement niche strategy to prepare itself to reach the mass market. Based on the last insight, the next chapter elaborates the implementation of the Best Strategy Framework to define the best strategy for Lightyear.

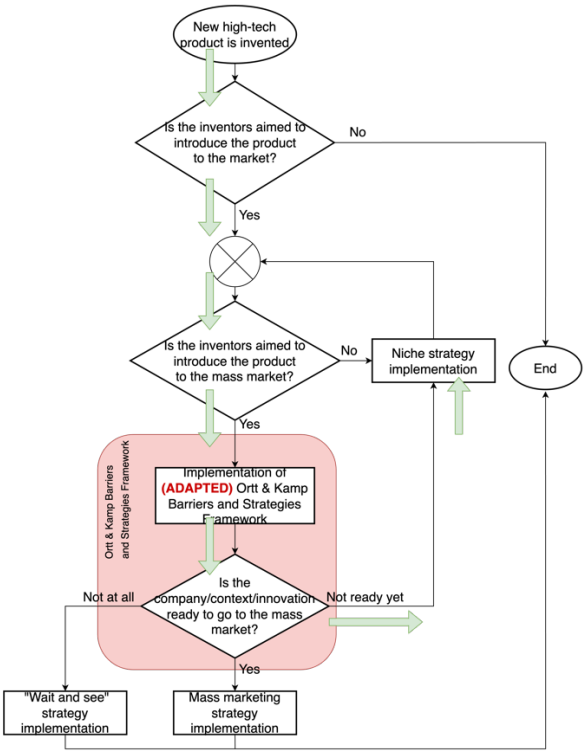


Figure 22 The implementation of the Market introduction flow diagram (Figure 10) to the study case up to this point of research

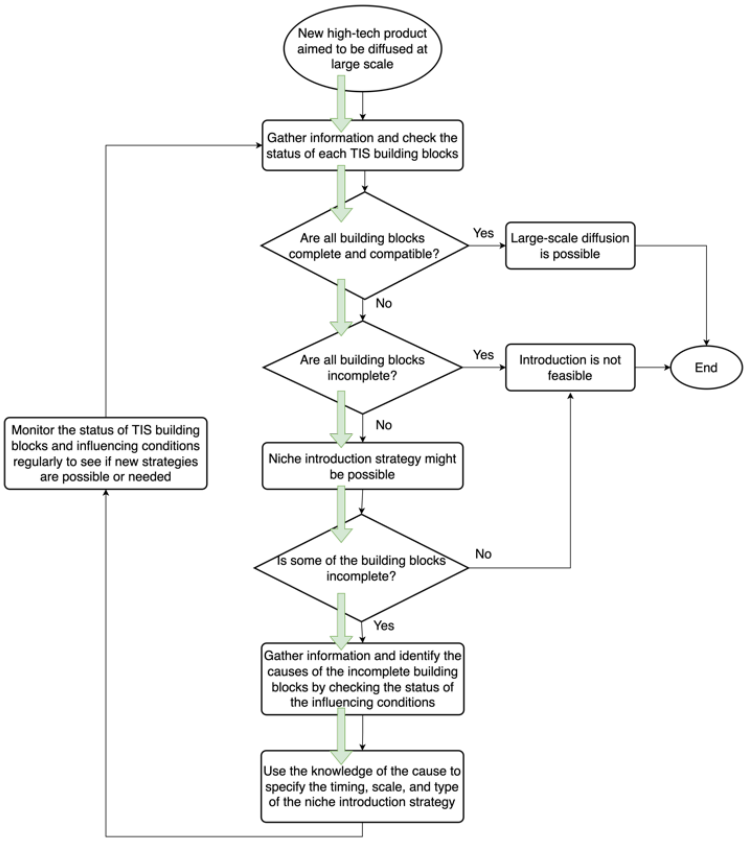


Figure 23 The implementation of the Guidance on how to use the Ortt & Kamp framework (Figure 12) to the study case up to this point of research

As indicated by Figure 22 and Figure 23, the analysis of the present research is done only at one point of time: present time. Hence, the flow of the present work stops at the one iteration. In other words, the feedback loop of Figure 22 that require the implementation of the niche strategies and the feedback loop of Figure 23 that require a regular monitor on the TIS building blocks' status are excluded from the research scope.

Chapter 7. The Best Strategy to Reach SEV Mass Adoption in Indonesia

As elaborated in the previous chapter, currently there are many barriers hindering Lightyear's SEV adoption in Indonesia. Based on these findings, this chapter implement the use of the Best Strategy Framework that was developed in Chapter 5 to choose the best strategy that could circumvent most of the identified barriers or the biggest threats to the adoption so that Lightyear's SEV could be mass adopted at all in Indonesia. Thus, this chapter aimed to answer the last sub-research question: **"Based on the identified barriers that could hinder SEV development in Indonesia, which strategy could circumvent most of the barriers or the most threatening barriers at the same time?"**.

The structure of this chapter is as follows. The implementation of the Best Strategy Framework is done in Section 7.1. and Section 7.2. by using the scoring model 1 and 2 respectively. The results and insights gained from the results are discussed at the respective sections. Section 7.3. compares the results of the two scoring models, and in the end the chapter is concluded in Section 7.4.

7.1. The Best Strategy Selection by Using the Scoring Model 1

Table 36 shows the implementation of the Best Strategy Framework to select the best strategy based on identified barriers by using scoring model 1 (giving the same weight to the identified barriers). Based on Table 36, the strategies that have the highest scores are summarized in Table 37.

As explained in Chapter 5.2.1., scoring model 1 aims to select the best strategies that could circumvent most of the barriers. As shown by Table 37, with the 13 barriers currently blocking the mass uptake of Lightyear's SEV in Indonesia, two separate strategies: Partnership strategy and Network building strategy are chosen as the best strategies, as each of the strategy could circumvent all the barriers (score 13 out of 13). The author of the present work agrees with this strategy recommendation as the implementation of these strategies are indeed important for the company to gain more power and resources, as well as better access to the market, which could significantly remove the barriers.

If we look at the second and third top scores, the strategy recommendations could be translated into two different point of view. First, seems that the framework does not emphasis that Indonesia is a good market to penetrate for Lightyear as there are currently too much incomplete TIS building blocks that hinder SEV mass adoption. Therefore, the recommendations are to look for other markets or geographical areas in which more TIS building blocks are completed to support the mass uptake of SEV. At the other hand, as most of the unavailable or incomplete TIS building block are mainly influenced by Lightyear (see Section 6.3.), while Indonesia has a big market share and suitable geographic area for the utilization of SEV, the strategies recommendation could be translated differently.

Table 36 The best strategy selection for Indonesia study case by using the scoring model 1

		Niche Strategies																																				
Niche Strategy No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Influencing Conditions	TIS Building Blocks	Demo	Top niche	Subsidy	Redesign	Dedicated/ stand-alone system	Hybridization /Adaptor	Educate	Geographic	Lead user	Explore markets	Tech. R&D	Human resource management	Internal knowledge sharing	Partnership	Finance sourcing	Lobbying	Influencer	Crowd-sourcing	Leasing	Sharing economy platform	Corporate restructuring	Buy one - give one	Campaign funding	Stepping-stone	Network building	Get specified	Local	Complementary technologies, products, services	Product variants	Cross-selling and financing	Existing social network	Result-oriented contracting	Turnkey product	Incentives	Local implementation	Market positioning	In-house network	Aggresive penetration	Pre-announcing	Blue ocean
Knowledge and awareness of technology	Product availability, performance, and quality																																							
Knowledge and awareness of application and market		1						1	1	1	1		1	1	1			1	1							1			1							1			1	
Competition																																								
Macro-economic and strategic aspects																																								
Accidents and events																																								
Human resources																																								
Natural resources																																								
Financial resources		1	1	1	1				1	1	1	1			1	1			1			1				1		1												
Socio-cultural aspects																																								
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								
Knowledge and awareness of technology	Product price																																							
Knowledge and awareness of application and market			1	1				1			1		1	1	1			1	1	1	1				1	1										1		1	1	
Competition		1	1	1	1	1	1	1	1		1	1			1	1		1		1	1	1	1			1				1	1		1		1		1	1	1
Macro-economic and strategic aspects																																								
Accidents and events																																								
Human resources																																								
Natural resources			1	1	1		1		1		1	1			1					1	1	1				1		1												
Financial resources																																								
Socio-cultural aspects																																								
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								
Knowledge and awareness of technology	Production system																																							
Knowledge and awareness of application and market								1		1			1	1	1											1														
Competition																																								
Macro-economic and strategic aspects																																								
Accidents and events																																								
Human resources																																								
Natural resources																																								
Financial resources			1	1	1		1		1	1		1			1	1	1					1				1		1												
Socio-cultural aspects																																								
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								
Knowledge and awareness of technology	Complementary products and services																																							
Knowledge and awareness of application and market																																								
Competition																																								
Macro-economic and strategic aspects																																								
Accidents and events																																								
Human resources																																								
Natural resources																																								
Financial resources																																								
Socio-cultural aspects																																								
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								

Niche Strategy No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Influencing Conditions	TIS Building Blocks	Demo	Top niche	Subsidy	Redesign	Dedicated/ stand-alone system	Hybridization /Adaptor	Educate	Geographic	Lead user	Explore markets	Tech. R&D	Human resource management	Internal knowledge sharing	Partnership	Finance sourcing	Lobbying	Influencer	Crowd-sourcing	Leasing	Sharing economy platform	Corporate restructuring	Buy one - give one	Campaign funding	Stepping-stone	Network building	Get specified	Local	Complementary technologies, products, services	Product variants	Cross-selling and financing	Existing social network	Result-oriented contracting	Turnkey product	Incentives	Local implementation	Market positioning	In-house network	Aggresive penetration	Pre-announcing	Blue ocean
Knowledge and awareness of technology	Network formation and coordination																																								
Knowledge and awareness of application and market		1					1	1	1	1		1	1		1		1									1								1			1		1	
Competition																																								
Macro-economic and strategic aspects																																								
Accidents and events																																								
Human resources																																								
Natural resources																																								
Financial resources																																								
Socio-cultural aspects																																								
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								
Knowledge and awareness of technology	Customers	1	1		1		1	1	1	1					1			1	1						1	1	1		1		1	1		1	1	1		1	1	1	
Knowledge and awareness of application and market																																									
Competition		1	1	1	1			1	1	1	1	1			1			1		1	1	1	1		1	1	1		1	1	1	1	1	1	1	1	1	1	1	1
Macro-economic and strategic aspects																																									
Accidents and events																																									
Human resources																																									
Natural resources																																									
Financial resources			1	1	1				1	1	1				1	1				1	1		1			1		1		1	1	1	1		1	1	1	1	1	1	
Socio-cultural aspects																																									
Institutional aspects and political system																																									
Physical/information access & infrastructure																																									
Knowledge and awareness of technology	Innovation-specific institutions																																								
Knowledge and awareness of application and market																																									
Competition																																									
Macro-economic and strategic aspects																																									
Accidents and events																																									
Human resources																																									
Natural resources																																									
Financial resources									1		1				1		1									1															
Socio-cultural aspects					1		1	1	1		1				1		1								1	1														
Institutional aspects and political system																																									
Physical/information access & infrastructure																																									
TOTAL POINTS		6	8	7	8	1	6	8	11	8	9	6	4	3	13	4	4	5	4	5	5	5	3	0	4	13	2	4	3	3	4	3	3	2	5	3	5	5	5	8	2

Legends:

- Links between barriers and strategies
- Status of the building blocks and its identified influencing factors
- Status of the building blocks and its identified influencing factors
- Status of the building blocks and its identified influencing factors
- x — Points assigned to the strategies as it could circumvent the identified barriers

Table 37 Strategies with highest scores based on the implementation of the Best Strategy Framework with scoring model 1

Top scores	Strategies
13	Partnership strategy; Network building strategy
11	Geographic strategy
9	Explore multiple market strategy
8	Top niche strategy; Redesign strategy; Educate strategy; Lead user strategy; Pre-announcing strategy

Geographic strategy could also mean that Lightyear should first focus the market penetration at certain areas in Indonesia which, for example, have better socio-economic backgrounds such as the biggest and well-developed cities like Jakarta, Surabaya, Medan, Bali, and Bandung. People live in these cities has higher average buying power and better education background compared to other cities in Indonesia, which better suit the SEV's customer profile. The Explore market strategy could be translated as a recommendation to look for certain market segment in Indonesia market that better suit the product so that, for example, the affordability is not the main consideration of the customers in acquiring the product.

Furthermore, the strategies that are at the 4th top scores are included into the overview to see if other strategies could improve the TIS building block status so that Lightyear's SEV could be adopted in Indonesia, which is explained in the following.

The framework recommends Lightyear to target top niche market in Indonesia. This is a good strategy as by 2030 the Lightyear might still be more expensive than the average Indonesian buying power. As explained in Section 6.2.2., 80% of passenger cars bought in Indonesia is at the price range of €13,000 to €19,000. Assuming that there is a very limited number of cars sold at the price of less than €13,000, therefore, the size of the top niche market is almost 20% of total market size. With 16 million passenger cars currently registered in Indonesia, the top niche market covers over three million passenger cars, which is still a considerably big market.

The framework advises that Lightyear could also focus the initial market penetration in Indonesia by working together with the lead users, for example the taxi and ride hailing provider, the government agency, car rental owners, etc. However, if Lightyear is aiming to be more ambitious and willing to serve the mainstream market, the framework proposed that Lightyear should redesign its SEV to make it more affordable.

Education strategy is another important one. This strategy emphasis the company to educate both itself and the customers. As Lightyear's knowledge and awareness of Indonesian market is still lacking, Lightyear should put extra effort to conduct market research to improve it. Moreover, educating the customers is also important as customers' awareness of the product quality over the price would be a good tipping point to boost the adoption.

In addition, the framework advises to pre-announce the product launch to give sufficient time for the customers to get familiar with the innovation, the additional values and benefits it brings, and to possibly prepare and plan their financial resources in case they are interested to acquire the product.

7.2. The Best Strategy Selection by Using the Scoring Model 2

This section is divided into two sections in which Section 7.2.1. elaborates the identification of weights for each barrier and Section 7.2.2. explains the outcome of the framework implementation.

7.2.1. Defining the Weights of Each Identified Barrier

As explained in Section 5.2.2., for the scoring method 2, each identified barriers are assigned with different weights in the scale of 1 to 10 to describe their importance and capability in hindering the mass adoption. For this research, the weight for each barrier is defined hypothetically by the author of the present work based on her understanding on the topic. This approach is chosen due to the limited time of the research that made the experts interview is not possible to conduct within the research time frame.

Table 38 Weights assigned for each identified barrier to enable the best strategy selection by using the scoring model 2

TIS Building Blocks	Influencing Factors	Weights
Product availability, performance, and quality	Knowledge and awareness of application and market Financial resources	10 3
Product price	Knowledge and awareness of application and market Competition Natural resources	8 8 8
Production system	Knowledge and awareness of application and market Financial resources	10 3
Complementary products and services	N/A	N/A
Network formation and coordination	Knowledge and awareness of application and market	10
Customers	Knowledge and awareness of technology Financial resources Competition	10 10 6
Innovation-specific institutions	Financial resources Socio-cultural aspects	5 7

Table 38 shows the weights assigned to each identified barriers. The arguments of the assigned weights are explained in the following.

As explained in Section 6.2.1., Lightyear's product performance and quality is sufficient to compete in the market. The only barrier of the first building block is that the product is not available yet in Indonesia. This barrier is very important as the market uptake in Indonesia would only start when the product is available in the market. Therefore, Lightyear's knowledge and awareness about Indonesia should be improved significantly to enable the market penetration. The financial resources needed to make the product available, however, might not be too threatening as Lightyear is confident that it could raise enough funds if needed. The same arguments apply for the production system building block and the network formation and coordination building block as they must be available to make the product available for Indonesian market. Therefore, these barriers are assigned with the same weights as the product availability barriers.

Regarding product price related barriers, the lack of knowledge and awareness of the market, competition in the market, and use of expensive materials would pose a relatively high threat to SEV uptake as affordable price is a key driver for Indonesian in adopting an innovation. Therefore, relatively high weights are assigned for this building block.

Customers' knowledge and awareness of technology as well as customers' buying power or financial resources are other crucial barriers that directly and highly threatening SEV uptake. Even though Indonesia has a big market share, however, if the customers are not aware or have no knowledge about the product, the chance that they would adopt the product is relatively small. Moreover, if they have no sufficient means to acquire the product, they will not be able to adopt it. Therefore, these barriers are assigned with very high weights. Other than these barriers, competition in the market also hinder customers' willingness to adopt the product as they could compare the product with alternatives and choose the best suitable one. However, this barrier, do not pose such high threat as the customers' knowledge and awareness of technology and financial resources because Lightyear's product has a good quality over price (based on Lightyear Two's price). Therefore, this barrier is assigned with medium weight.

Lastly, supportive institutions pose medium to high threat to SEV adoption in Indonesia. Even though Indonesia has limited financial resources to provide stronger incentives to support EV adoption, however, currently Indonesia has offered significant incentives especially for the EV producers and manufactures. Therefore, this barrier deemed to have minimum threat. The complex socio-cultural aspect of Indonesia, however, poses as a bigger threat to the implementation of more supportive incentives, as there often a conflict of interests, as explained in Section 6.2.7. Therefore, this barrier received a higher weight.

7.2.2. The Scoring Model 2 Results

The implementation of the Best Strategy Framework on the study case, by putting in different weights on each identified barriers are shown by Table 39, while Table 40 summarized the results by listing the strategies that received the highest scores.

Based on Table 40, it could be seen that Partnership strategy and Network building strategy are the best strategies that could circumvent the most important and threatening barriers (the lack of knowledge and awareness of the market and the price-related barriers). The author of the present work agrees with this result as the implementation of these strategies would help the company to get better knowledge and access to the market, as well as to gain more resources and power to set up the market and eventually make the product more affordable.

At the second best, the framework advises the implementation of Geographic strategy. Similar to the explanation provided in the Section 7.1., this recommendation could be translated into two different point of views: either Indonesian market has no good potential for Lightyear or Lightyear should first focus on certain geographical areas in Indonesia where the barriers less hindering the adoption. However, the author confident that the later one is the better translation of the strategy recommendation, due to Indonesia's big market size and suitable geography for SEV utilization.

Furthermore, more top scores strategies are included into the overview to see if certain strategies could help to improve the current TIS building blocks status. As the knowledge and awareness of the product, its application and market are the most threatening factors that hinder the completeness of many building blocks, the framework recommends Educate strategy to circumvent these barriers, as could be seen from the third highest score. Educate strategy emphasis the importance of conducting market research to improve company's knowledge towards the market, as well as educating the customers to understand the added values and benefits of the product.

Table 39 The best strategy selection for Indonesia study case by using the scoring model 2

		Niche Strategies																																				
Niche Strategy No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Influencing Conditions	TIS Building Blocks	Demo	Top niche	Subsidy	Redesign	Dedicated/ stand-alone system	Hybridization /Adaptor	Educate	Geographic	Lead user	Explore markets	Tech. R&D	Human resource management	Internal knowledge sharing	Partnership	Finance sourcing	Lobbying	Influencer	Crowd-sourcing	Leasing	Sharing economy platform	Corporate restructuring	Buy one - give one	Campaign funding	Stepping-stone	Network building	Get specified	Local	Complementary technologies, products, services	Product variants	Cross-selling and financing	Existing social network	Result-oriented contracting	Turnkey product	Incentives	Local implementation	Market positioning	In-house network	Aggresive penetration	Pre-announcing	Blue ocean
Knowledge and awareness of technology	Product availability, performance, and quality																																							
Knowledge and awareness of application and market		10						10	10	10	10		10	10	10			10	10							10			10							10			10	
Competition																																							
Macro-economic and strategic aspects																																							
Accidents and events																																							
Human resources																																							
Natural resources																																							
Financial resources		3	3	3	3				3	3	3	3			3	3			3			3				3		3											
Socio-cultural aspects																																							
Institutional aspects and political system																																							
Physical/information access & infrastructure																																							
Knowledge and awareness of technology	Product price																																						
Knowledge and awareness of application and market			8	8				8			8		8	8	8			8	8	8	8				8	8									8		8	8	
Competition		8	8	8	8	8	8	8	8		8	8			8	8		8		8	8	8	8			8			8	8		8		8		8	8	8	8	8
Macro-economic and strategic aspects																																							
Accidents and events																																							
Human resources																																							
Natural resources			8	8	8		8		8		8	8			8					8	8	8				8		8											
Financial resources																																							
Socio-cultural aspects																																							
Institutional aspects and political system																																							
Physical/information access & infrastructure																																							
Knowledge and awareness of technology	Production system																																						
Knowledge and awareness of application and market								10		10			10	10	10											10														
Competition																																							
Macro-economic and strategic aspects																																							
Accidents and events																																							
Human resources																																							
Natural resources																																							
Financial resources			3	3	3		3		3	3		3			3	3	3					3				3		3											
Socio-cultural aspects																																							
Institutional aspects and political system																																							
Physical/information access & infrastructure																																							
Knowledge and awareness of technology	Complementary products and services																																						
Knowledge and awareness of application and market																																							
Competition																																							
Macro-economic and strategic aspects																																							
Accidents and events																																							
Human resources																																							
Natural resources																																							
Financial resources																																							
Socio-cultural aspects																																							
Institutional aspects and political system																																							
Physical/information access & infrastructure																																							

Niche Strategy No.		Niche Strategies																																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Influencing Conditions	TIS Building Blocks	Demo	Top niche	Subsidy	Redesign	Dedicated/ stand-alone system	Hybridization /Adaptor	Educate	Geographic	Lead user	Explore markets	Tech. R&D	Human resource management	Internal knowledge sharing	Partnership	Finance sourcing	Lobbying	Influencer	Crowd-sourcing	Leasing	Sharing economy platform	Corporate restructuring	Buy one - give one	Campaign funding	Stepping-stone	Network building	Get specified	Local	Complementary technologies, products, services	Product variants	Cross-selling and financing	Existing social network	Result-oriented contracting	Turnkey product	Incentives	Local implementation	Market positioning	In-house network	Aggresive penetration	Pre-announcing	Blue ocean
Knowledge and awareness of technology	Network formation and coordination																																							
Knowledge and awareness of application and market		10					10	10	10	10		10	10		10		10								10									10			10		10	
Competition																																								
Macro-economic and strategic aspects																																								
Accidents and events																																								
Human resources																																								
Natural resources																																								
Financial resources																																								
Socio-cultural aspects																																								
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								
Knowledge and awareness of technology	Customers	10	10		10		10	10	10	10					10			10	10						10	10	10		10		10	10		10	10	10		10	10	10	
Knowledge and awareness of application and market																																								
Competition		10	10	10	10			10	10	10	10	10			10			10		10	10	10	10			10	10		10	10	10	10	10	10	10	10	10	10	10	10
Macro-economic and strategic aspects																																								
Accidents and events																																								
Human resources																																								
Natural resources																																								
Financial resources			6	6	6				6	6	6				6	6				6	6		6			6		6		6	6	6	6		6	6	6	6	6	6	
Socio-cultural aspects																																								
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								
Knowledge and awareness of technology	Innovation-specific institutions																																							
Knowledge and awareness of application and market																																								
Competition																																								
Macro-economic and strategic aspects																																								
Accidents and events																																								
Human resources																																								
Natural resources																																								
Financial resources									5		5				5		5									5														
Socio-cultural aspects					7		7	7	7		7				7		7								7	7												7	
Institutional aspects and political system																																								
Physical/information access & infrastructure																																								
TOTAL POINTS		51	56	46	55	8	46	73	80	62	65	42	38	28	98	20	25	46	31	40	40	32	24	0	35	98	20	20	30	24	34	26	24	20	44	26	42	44	42	69	18

Legends:

- Links between barriers and strategies
- Status of the building blocks and its identified influencing factors
- Status of the building blocks and its identified influencing factors
- Status of the building blocks and its identified influencing factors
- x — Points assigned to the strategies as it could circumvent the identified barriers

Table 40 Strategies with highest scores based on the implementation of the Best Strategy Framework with scoring model 2

Top scores	Strategies
93	Partnership strategy; Network building strategy
80	Geographic strategy
73	Educate strategy
69	Pre-announcing strategy
65	Explore multiple market strategy
62	Lead user strategy

Furthermore, the framework also advises Lightyear to also explore the market further to see if certain market segment in Indonesia could be more suitable for the SEV. Additionally, Pre-announcing strategy is recommended to overcome knowledge and financial resources related barriers as well as the market competition barrier. As explained in the Section 7.1., the implementation of this strategy gives extra time for the customers to get familiar to the innovation and to save up or plan their financial resources so that they could acquire the product. Lastly, the framework advises Lightyear to first focus the market entry to serve the lead users as they often are less limited by the knowledge and financial resources related barriers.

7.3. The Best Strategy of Scoring Model 1 vs Scoring Model 2

Table 41 The result comparison between scoring model 1 vs scoring model 2

Rank	Best Strategies Resulted from Scoring Model 1	Best Strategies Resulted from Scoring Model 2
1st	Partnership strategy and Network building strategy	Partnership strategy and Network building strategy
2nd	Geographic strategy	Geographic strategy
3rd	Explore multiple market strategy	Educate strategy
4th	Top niche strategy, Redesign strategy, Educate strategy, Lead user strategy, Pre-announcing strategy	Explore multiple market strategy

Table 41 listed the strategies that received the highest scores from each scoring model. From the overview, it could be seen that even though there are some strategies that are recommended by both scoring models, however, their ranks might be slightly different. Interestingly, both scoring models agree that Partnership strategy, Network building strategy, and Geographic strategy are the best strategies to implement that could circumvent most of the barriers, as well as the most threatening barriers.

At the third and fourth positions, the strategies recommendation is slightly different due to the nature of the scoring models. Scoring model 1 recommends Explore multiple market strategy at the third position as this strategy could circumvent almost all the barriers. However, when the barriers are weighted based on their importance and level of threat, Educate strategy is apparently more suitable to circumvent the most important and the biggest threats. This insight is in line with the fact that the lack of knowledge and market competition are the most dominant influencing factors that hinder the completeness of many building blocks, as well as posing the biggest threats.

An interesting insight is provided by the 4th best strategies. By only looking at the number of barriers that could be circumvented, the scoring model 1 recommends five strategies. However,

if the importance and the level of threat poses by the barriers are considered, the scoring model 2 recommend only one strategy, namely Explore multiple market strategy, as it could circumvent the most threatening barriers: ones related to the lack of resources, knowledge, and competition.

In the end, as explained in Chapter 5, these scoring models are provided as decision support system. The readers or users of the framework could decide for themselves whether they want to use one of the scoring models or both to help them to select the best strategy. Scoring model 1 could help the users to quickly select the best strategy only based on the information of barriers existence. However, when there is more detail information is available such as the level of importance and threats the barriers pose to the product adoption, the utilization of scoring model 2 is better as it could help prioritize the best strategies.

7.4. Chapter Conclusion and Summary

This chapter aimed to answer the last sub-research question: **"Based on the identified barriers that could hinder SEV development in Indonesia, which strategy could circumvent most of the barriers or the most threatening barriers at the same time?"**, by implementing the Best Strategy Framework that was developed in Chapter 5 into the study case. The barriers that were identified in Chapter 6 is used as inputs of the framework and the two scoring models are utilized to score the strategies. For scoring model 2, ideally interviews should be conducted with experts to define the weights for each barrier. However, due to the limited research time, the author of the present work defines the weights of each barrier based on her understanding.

Table 42 The best strategies to circumvent Lightyear's SEV development barriers in Indonesia, based on the Best Strategy Framework with scoring model 1 and scoring model 2

Rank	Best Strategies Resulted from Scoring Model 1	Best Strategies Resulted from Scoring Model 2
1st	Partnership strategy and Network building strategy	Partnership strategy and Network building strategy
2nd	Geographic strategy	Geographic strategy
3rd	Explore multiple market strategy	Educate strategy
4th	Top niche strategy, Redesign strategy, Educate strategy, Lead user strategy, Pre-announcing strategy	Pre-announcing strategy
5th		Explore multiple market strategy
6th		Lead user strategy

Table 42 shows the results of the framework implementation. The author includes the lower ranks of best strategies into the overview so that the insights gained are not only about the best strategies that could circumvent most of the barriers or the most threatening barriers at the same time, but also to see if some strategies could help to improve the status of the TIS building blocks. Moreover, this overview also helps to compare the results of the scoring models. However, the 5th and 6th rank of best strategies of the scoring model 1 are not included in the overview as the scoring model 1 has deemed to proposed sufficient best strategies.

From Table 42, it could be seen that despite the different ways of scoring, both scoring models proposed similar best strategies recommendation. Even more, both scoring models agree that Partnership strategy and Network building strategy are the best strategies to implement as they could circumvent most of the barriers, as well as the most threatening barriers: knowledge and financial related barriers, and market competition barrier. These strategies even received the highest scores with the scoring model 1, which means that these strategies could circumvent all the identified barriers. The author agrees with these findings as Partnership strategy and Network building strategy could boost the company capability to set up the market by gaining

more power and resources from its partners and networks, as well as could improve company's knowledge and access to the market.

Geographic strategy and Explore multiple market strategy are the next best strategies (even though Explore multiple market strategy is scored at a lower rank by the scoring model 2). These strategies could be translated in two different ways: (1) Lightyear should look at other geographical areas and market as there are too many barriers in Indonesia market, or (2) Lightyear should focus the market penetration in certain areas and market segments in Indonesia in which the barriers are less hindering the product adoption. As most of the unavailable and incomplete building blocks is mainly influenced by Lightyear, while Indonesia actually has a big market size and a suitable geography to utilize SEVs, the author confident that the second approach is worth trying. Therefore, Lightyear should first focus on Indonesian big cities where the buying power and education background are higher than average Indonesian, such as Jakarta, Surabaya, Medan, Bali, and Bandung. Moreover, Lightyear should explore different market segments in Indonesia to see if there is a better market segment to focus on.

Another important strategy to be implemented is Educate strategy. Even though this strategy is scored at the 4th rank by the scoring model 1, however, the scoring model 2 emphasis that it has a higher priority as the strategy is able to circumvent the most threatening barriers in Indonesia: the knowledge related barriers and the competition related barriers.

Furthermore, some strategies are proposed to address the customers and product price related barriers such as the Top niche strategy, Lead user niche strategy, and Pre-announcing strategy. Top niche strategy and Lead user niche strategy focus on circumventing the high product price by focusing the market to serve customers that have no strict limitation on financial resources. Some relevant lead users in Indonesia are the taxi and ride hailing provider, the government agency, car rental owners. Pre-announcing strategy, at the other hand, focus on circumventing the lack of knowledge and high product price by giving the customers chance to absorb the information about the innovation and manage their financial resources to enable them to acquire the product once it is released to the market.

In the end, even though the Partnership strategy and Network building strategy are able to circumvent all the barriers as well as most of the threatening ones at the same time, however, it is wise to also implement more strategies so that they could complement and strengthen each other, and the mass adoption goal could be achieved faster and easier.

Chapter 8. Discussion

8.1. Implications of Lightyear's SEV Mass Adoption in Indonesia

Despite the advantages that it brings, the mass adoption of Lightyear's SEV in Indonesia would bring some implications that are worth mentioning, as follows.

As explained in Section 1.1.3., Indonesia is a suitable region to mass adopt SEV, due to its abundant sun and lack of EV charging infrastructure. However, people often prefer to park their cars in covered areas to prevent the car to be overheated during the day. Even more, in big cities like Jakarta and Surabaya, the public parking spaces are often stapled in the buildings due to the limited outdoor spaces. Therefore, mass adoption of SEV in Indonesia would require a shift in customers' parking habits and parking space infrastructures to maximize the benefits of the SEV.

Moreover, even though SEV has less dependency on EV charging infrastructure, however, the SEV would still need to be charged conventionally now and then by plugging it into the EV charger facility. Therefore, mass adoption of SEV would lead to the increment of electricity demand in Indonesia, hence the capacity of the power plants and the power grid, especially to cover the steep increment of peak demand (assuming that most of the SEV are charged at the same time at night). However, it is important to highlight that mass adoption of Lightyear's SEV would give less impact on the increment of electricity demand, as well as the capacity of the power plants and the power grid, thanks to its high energy efficiency and capability to charge itself. Nevertheless, coordination and alignment with PLN (the electricity provider and grid owner) should be established to make sure that the infrastructure will be ready by then. Additionally, relevant incentives should be offered to SEV users to discourage charging during peak hours.

From a bigger perspective, SEV mass adoption would bring many benefits to Indonesia. Every fossil-fueled car switched into SEV means the reduction of fossil-fueled use. As certain fossil fuels are still subsidized by the government until now, every reduction of fossil fuel means a reduction of subsidy hence saving for the government. Additionally, as Indonesia is still importing fossil fuels, this reduction also means less geopolitical concern for Indonesia (Satya, 2022). Combining it with the increment of RE in its energy mix would lead to energy security and self-sufficiency.

8.2. Reflections

8.2.1. Reflection on the Methodology

As explained in Section 1.6. and Section 1.7., qualitative research on online literature is the methodology chosen for this research. The implementation of this methodology is deemed to be suitable to develop the framework as well as to evaluate the study case, for the following reasons. First, the careful search of literature leads to the most relevant literature that provides useful information and insights. In addition, the use of multiple search engines and keywords leads to a big amount of relevant literature. Moreover, different kinds of literature are used in this research to obtain the whole puzzle pieces by including not only scientific literature but also grey literature and Lightyear's company information. Furthermore, multiple innovations evaluated by different researchers are reviewed to gain insights on the cases' success stories (see Section 4.2.2.). Therefore, even though one could argue that online literature might be limited and incomplete (Ortlieb, 2019), however, using diverse literature to confirm every

finding could reduce this disadvantage as they could validate and complete each other, and hence improve the findings' trustworthiness and credibility. Unfortunately, this research also has its limitations, as explained in Section 8.4.1.

8.2.2. Reflection on the Framework

This subsection aimed to reflect on the Best Strategy Framework in general, as well as the relations between the elements of the framework, as explained in the following.

First, the author of the present work is confident that the framework developed in this research is sufficient and useful to evaluate the study case and to select the best strategy.

Second, regarding its generalizability, similar to the original TIS framework developed by Ortt & Kamp (2022), the Best Strategy Framework is quite general. Therefore, it could be used to evaluate any high-tech innovations that are in their adaptation phase (the products are invented and introduced to the market but have not started their large-scale diffusion), to see whether they are ready to be diffused on a large scale.

Third, knowing the main influencer that causing the unavailable or incomplete building blocks is important to get a better insight into the circumstances and to better interpret the best strategy recommendation (Please note that the main influencer is not the same as the influencing condition. See Section 6.3. for the explanation about the main influencer). This point is especially important as the relevant actors do not always have the same level of influence towards the building blocks. In our study case, for example, the framework proposed the Geographic strategy as the Indonesian market does not seem like a good market to penetrate due to the lack of many building blocks at this moment. However, as the main influencer identified, it is known that most of the unavailable or incomplete building blocks are influenced by Lightyear instead of the Indonesian market itself (see Section 6.3.). Therefore, the strategy recommendation should be interpreted differently, as explained in Chapter 7.

Fourth, the framework could only be used to capture the status of the TIS building block at one point in time: the present time. Thus, it cannot be used to capture the dynamic of the status. However, the framework could be reimplemented at different points in time to evaluate whether there has been some progress or changes on the TIS building blocks status which then would lead to different best strategy recommendations. In other words, the timing of the framework implementation might lead to different strategy recommendations.

Fifth, several TIS building blocks could at the same time act as influencing factors as their availability is influencing and/or influenced by the availability or completeness of other building blocks. Even more, some building blocks are prerequisites for the availability or completeness of other building blocks. Production system building block and Network formation and coordination building block, for example, are important to be established to make the product available in the market. In other words, the unavailability or incompleteness of the Production system building block and Network formation and coordination building block would affect the status of Product availability, performance, and quality building block. Similar to this, influencing factors could also influence each other. Macro-economic factors, for example, could influence the availability of resources, and vice versa. In other words, the availability of a supportive influencing factor could be a prerequisite for the availability of other supportive influencing factors. For example, customers' sufficient knowledge of innovative technology and its application would reduce the influence of competition in the market. Another example is that the political system and stability of a country would influence

its macro-economic situations that in the end would influence the availability of many TIS building blocks. These insights are in line with the fact that TIS is a complex system with many interconnections and interdependencies between its elements.

Sixth, certain strategies may seem to be a good solution to circumvent certain barriers. However, in some cases, it may also create dilemmas or lead to other barriers when the strategies are not implemented the right way. The Dedicated/stand-alone strategy, for example, seems to be a good solution to overcome the lack of infrastructure needed by a product to perform well. However, on the other hand, making the product stand-alone means the product should be able to perform well without any supporting infrastructure. This may lead to over-spec products and hence higher product prices, which pose a new barrier to adoption.

Seventh, the implementation of a strategy might conflict with itself. The Corporate restructuring strategy, for example, could increase the company's power, resources, and market share by merging the company with other relevant companies. However, merging multiple companies would also cost some time and resources. Therefore, good research and estimation should be done to measure the real benefits of the merging in solving the barriers.

Eighth, some strategies might conflict other strategies. The implementation of Top niche strategy, for example, should not be combined with the Subsidy strategy as they conflict each other. Top niche strategy aimed to solve high price related barriers by focusing the top customers as the main market, while Subsidy strategy aimed to make the product price more affordable so that it could be adopted by the mainstream market. Therefore, subsidizing the product price that aimed the top niche customers is a waste of the subsidy money.

Lastly, even though the Best Strategy Framework can select the best strategy that could circumvent most of the barriers as well as the most important and threatening barriers, however, in reality, it is better to implement multiple strategies than one best strategy. From the list of identified strategies, it could be seen that some strategies could be combined to strengthen each other. Moreover, some strategies could be prerequisites to implement other strategies. The Explore multiple market strategy, for example, could be a good prerequisite to implementing the Market positioning strategy, Blue ocean strategy, or Redesign strategy. Therefore, the combination of the Explore multiple market strategy with one of the above-mentioned strategies would lead to better results.

8.3. Research Relevance

This section elaborates the scientific and societal relevance of this research, as well as its relevance with the author's study background.

Scientifically, as explained in Section 2.5., this research extends and completes the TIS framework (Ortt & Kamp, 2022) and Ten Niche Strategies framework (Ortt et al., 2013) to design company strategies recommendation for Lightyear so that Lightyear's SEV could be diffused in a large scale in Indonesia. The novelty of this research is signified by (1) the adaptation of an existing influencing factor and the identification of new influencing factors that could influence the TIS building blocks status, and hence might lead to the emerge of new niche development barriers, (2) the identification of new potential strategies that could circumvent the niche development barriers, (3) the identification of possible relationship between all the identified barriers and strategies, (4) the approach of mapping the relationships between the barriers and strategies into a matrix to enable the selection of a strategy that could circumvent multiple barriers at the same time, (5) the utilization of the barriers and strategies

matrix and two scoring models which formed the so-called the Best Strategy Framework that enable the best strategy selection, (6) the identification the latest EV development status in Indonesia, (7) the identification of Lightyear's SEV development barriers in Indonesian market, (8) the recommendation of the best strategy for Lightyear to enable it to diffuse its SEV in a large scale in Indonesia, and lastly (9) this research act as novel literature of SEV in Indonesia.

The adaptation of existing influencing factor and the identification of new influencing factors are deemed to be very important findings in the present work as it captures more possible barriers to be aware of, so that they could be well-addressed with more specific strategies. As explained earlier in Section 4.3., "Natural, human, and financial resources" factor from the original framework is adapted by splitting it into three separated factors in the present work. This approach is chosen as the author of the present work agrees with the importance of this factor. Even more, she sees the need to address every element of the factor individually as they could lead to different barriers, hence solving them would require different approach and strategies. Therefore, by splitting the original factor, better and more specific links between the barriers and strategies could be defined, and in the end, better strategies could be chosen to overcome each of the specific barriers. In other words, the adaptation of the factor optimizes the results of the best strategy selection.

Two new influencing factors are added in the present work: "Institutional aspects and political system" and "Physical/information access and infrastructure" because based on the literature research, the author of the present work understood that political stability and market accessibility are especially important when the targeted markets are new/foreign.
Instable political system might expose the company and its business to uncertainties and big risks as the political situations might change in the future unexpectedly, while a stable political system might be more conducive for the business. Even though institutional aspect has been defined as one of the TIS building blocks in the original framework, however, as the status of institutional aspect, as well as political system and its stability could significantly influence the status of other TIS building blocks, therefore, the author of the present work decided to add this factor as a new influencing factor. In other words, adding the "Institutional aspect and political system" as a new influencing factor captures new barriers that was not captured by the original version of the framework.
Additionally, market accessibility defines the easiness for the company to gain crucial market-related information such as the competition in the market, as well as the customers' demands, needs, and buying power. In other words, when the market is new and the company has limited knowledge about the market, the lack of market accessibility poses a serious threat to the product adoption. As this barrier was not captured in the original framework, therefore, market accessibility is added as another new influencing factor called "Physical/information access & infrastructure".

Societally, the application of these novelties is very useful for innovators who are aiming to commercialize their product on a large scale in certain markets but have difficulty choosing or prioritizing the strategy to implement. Moreover, the framework could also be used by the innovators to evaluate their current business strategy. Specifically for Lightyear, this research provides new insights into their current business strategy and serves as preliminary market research on Indonesia. Furthermore, the implementation of the framework in the SEV study case in Indonesia helps to promote SEV among the researchers as well as to promote Indonesia as a big potential market for SEV. In the end, this research aimed to bring many other benefits

to Indonesian society in the long term, such as reducing Indonesia's dependency on fossil fuels for transport and providing better air quality to Indonesian citizens.

Finally, this research has high relevance to the author's study background in Complex System Engineering and Management (CoSEM). Several complex systems are part of the research, namely the SEV system, Lightyear as a company, Indonesia's passenger car market, Indonesia's EV ecosystem, etc. This research focused on the system level by analyzing the complex socio-technical aspects around the adoption of technology innovations in general, as well as the SEV technology specifically. In other words, this research looks beyond the design of SEV and focuses on what is needed to make SEV adopted on a large scale. Additionally, the research aims to design interventions for the existing complex systems, which is the main purpose of the CoSEM study program, by designing a framework to enable the selection of the best strategy. The implementation of this strategy would therefore be the intervention in the existing market as well as the innovators' business strategy. Energy as the author's main study program is also in line with the topic as the focus of the SEV design is to achieve energy sustainability and self-sufficiency as well as to promote energy transition through green mobility.

8.4. Limitations

Even though this research shed a light on enabling the selection of the best strategy to circumvent barriers that hamper the mass adoption of an innovation in the market, however, there are some limitations that the readers should be aware of, as elaborated in the following.

8.4.1. Limitations of the Study

As explained in Section 8.2.1., a diverse and big amount of literature is used to develop the framework and to evaluate the study case. Even though the literature could complement each other and confirm each other's trustworthiness and credibility, however, this methodology has limitations: (1) the gathered information may not sufficiently explain the relevant actors' views and interests and (2) the information from the literature might be outdated or no longer applicable in the current situation.

Moreover, some parts of the research were identified by the author based on her understanding of the topic that she gained from the literature research, namely: (1) the links between the barriers and strategies and (2) the weights for each identified barriers for the utilization of scoring model 2. One could argue that the author might not have sufficient knowledge and expertise on the topic which influence the links identification and the barriers' weights, hence the best strategy recommendation. Additionally, no validation is done on the new Best Strategy Framework as well as the best strategy recommendation resulted by the framework, due to the time constraint of this research.

Ideally, to overcome these limitations, respondent validation such as interviews or a semi-structured questionnaire with experts could be conducted to confirm the research findings and results if they are make sense and trustworthy (Noble & Smith, 2015). Interviews with business experts, for example, could validate the newly identified potential barriers and strategies, the links between them, as well as the resulted best strategy recommendation for the study case. Additionally, interviews with Indonesia's EV experts could confirm the status of the SEV's TIS building blocks and influencing factors in Indonesia, as well as the level of importance and threat of each barrier.

Another limitation of the study is related to the information obtained about the EV development in the Indonesian market. As the EV ecosystem in Indonesia is currently growing and changing rapidly, any mentioned data/information in this report might be outdated shortly after the release of this report. However, the mentioned data is deemed to be the latest ones during the writing of this report, as much as it is concerned by the author.

8.4.2. Limitations of the Best Strategy Framework

As a framework is a simplified representation of a complex system of systems, therefore, the Best Strategy Framework might not fully represent the whole reality. Additionally, the implementation of the framework in certain study cases would require some assumptions to simplify the reality to fit it into the framework. For this reason, the utilization of the framework might be subjective and depends on the approach and assumptions taken by the framework users. Furthermore, the best strategy recommendation presented by the framework is limited to the barriers, strategies, and links that are previously identified in this research even though there might be more barriers, strategies, and links that exist in the real world.

8.5. Recommendation for Relevant Stakeholders

As diffusing an innovation in a large scale require a coordination and alignment from many actors, therefore, this section provides recommendations for relevant stakeholders to accentuate SEV mass adoption in Indonesia.

8.5.1. Indonesian Government

The Indonesian government here includes the policymakers and the ministries. The recommendations are as the following.

- A coherent roadmap should be established, communicated, and socialized by and among the government agencies to provide clear targets and guidance on EV development (Adiatma & Marciano, 2020). Moreover, Indonesia should include and specify SEV in its related policies.
- More aggressive incentives should be designed and offered to boost EV development in Indonesia. Considering Indonesia's limited fiscal resources and complex socio-cultural aspects (see Chapter 6.2.7), the feebate (bonus malus) policy could be implemented by penalizing/taxing the high CO2 emitting cars and then using the collected money to provide subsidies on the EV buying price (Mahalana et al., 2021). Additionally, non-financial incentives could be offered to EV users, such as special lane access, free parking, access to low-emission zones, and road toll exemption (Adiatma & Marciano, 2020; Mahalana et al., 2021).
- The development of the EV charging infrastructure should be continued even though SEV has a lower dependency on it compared to conventional EVs. Prioritizing the EV charging infrastructure development within and between Indonesia's big cities is especially important as the early SEV adopters might mostly live in the big cities. Thus, facilitating them to travel around and between these cities would increase their convenience, hence the willingness to adopt SEV. Additionally, the government should continue its engagement with private sectors to convince them to invest in EV charging infrastructure.
- The government agencies shall continue the switch of their ICE fleets into EV and eventually to SEV (once SEV is available in the Indonesian market) to lead the change.
- The subsidies for diesel and gasoline RON 88 in Indonesia should be reduced gradually to encourage the adoption of (S)EV.
- The plan to ban the operation ICE passenger cars in the new capital city of Indonesia (Aszhari, 2022; CNN Indonesia, 2020; Dananjaya, 2021), as well as the sales of ICE passenger cars starting 2050 (CNN Indonesia, 2021b; Mardika, 2021) should be continued.

- As Indonesia is aiming to be a global EV hub (Cekindo, 2021; KPMG Indonesia, 2021), thus the EV industry in Indonesia might create many new jobs. Therefore, the government should prepare its human resources to enable them to tap this opportunity, for example, by providing related training and workshops.

8.5.2. Lightyear

- Looking at Indonesia's ambitious goal to be EVs global market leader, complemented by its suitable geography to utilize SEV, big market size, large reserves of natural resources needed for the EV industry, and its strategic location along major sea lanes connecting Oceania, South Asia, and East Asia, Indonesia seems to be a potential EV hub. Therefore, Lightyear should consider investing in Indonesia by partially or fully manufacturing its SEV as well as its batteries in Indonesia so that Lightyear could maximize the utilization of financial incentives that are provided by the Indonesian government (See Section 6.2.7. and Appendix C.5.). The SEV produced in Indonesia could then be exported to Oceania as well as South and East Asia.
- As currently Indonesian's knowledge towards EV and especially SEV is still lacking (see Section 6.2.6.), while Lightyear is aiming to enter the Asia-Pacific market in 2030, Lightyear should soon start to introduce and educate potential customers to increase their awareness of the brand and product. As Indonesia is a big country separated into many islands, Lightyear should be aware that spreading the awareness throughout the country might take some time.
- Lightyear should approach and lobby the related policymakers to make sure that SEV is specified and included in the government regulations and policies in Indonesia, as that is not the case at this moment.
- Various research communities are available in Indonesia that has been conducting many EV-related research (see Section 6.1.). Lightyear should establish joint research with them to get an extra eye on the market.

8.5.3. Taxi and Ride-Hailing Providers

- The adoption of EVs (and eventually SEV) into the taxi and ride-hailing fleets should be continued, not only because they provide more comfort to the users, require less operational cost, and bring some other benefits, but also because the adoption of EVs would improve the taxi and ride-hailing companies' images in the society.

8.5.4. PLN (State-Owned Electricity Company)

To accommodate the mass uptake of (S)EV in the future, PLN should:
- Upgrade its power plants (preferably with renewable and sustainable ones) and power grids to accommodate the future increment of electricity demand.
- Convince the government to include SEV into the EV acceleration program as SEV has better scalability than EVs (mass adoption of SEV gives fewer impacts on the systems: less significant increment of electricity demand and charging infrastructure, as explained in Section 3.2.).
- Make sure that its system can ramp up and down the electricity supply timely to follow the electricity demand fluctuation caused by the charging of the (S)EV.
- Consider the implementation of suitable incentives to encourage the (S)EV charging during off-peak hours to reduce the need for high investment in upgrading the power plants and power grids. One incentive example could be time-of-use (TOU) charging tariff.
- Continue the EV-related incentives such as the free home charging service to attract the customers and reduce their hassles in acquiring EVs.

8.6. Recommendation for Future Research

Several future research topics or focuses are recommended to improve or complement the insights gained from this research, as explained in the following.

First, the drivers/enablers that could boost the large diffusion of the SEV in Indonesia or the innovation, in general, should be identified and added to the framework. This research is important to provide better insights into the targeted market so that the innovators could better justify if penetrating the targeted market is worth the efforts. Moreover, considering the enablers in choosing the best strategy might lead to different strategy recommendations because there might be a possibility that the enablers could eventually circumvent the currently existing barriers without the need for any strategy implementation. In other words, the innovators might save some efforts by not implementing any strategy to solve the barriers as the barriers might be solved by themselves throughout time due to the existence of certain enablers.

Second, more major elements should be added to the framework: Actors and Influencing factors (defined as factors that could influence the effectiveness of the strategies), as illustrated by Figure 24. "The Actors" element is important to be added as the status of the building blocks could be seen differently from the perspective of different actors. The product quality and performance building block, for example, could be deemed as sufficient by the innovators but perceived as insufficient by the customers. Moreover, the unavailability or incompleteness of the building block could be influenced by actors' influencing conditions. For example, product quality and performance could be deemed as lacking due to the innovators or customers' lack of knowledge of the technology. These lead to different barriers that require slightly different strategies. Therefore, the additional "Actor" element into the framework would give a better explanation of the barriers, hence leading to a better way of identifying the links between the barriers and strategies, as well as a better strategy recommendation. Additionally, as explained in Section 4.2.2.6., the addition of another set of influencing factors into the framework is important to maximize the chance for the innovation to get adopted in a large scale.

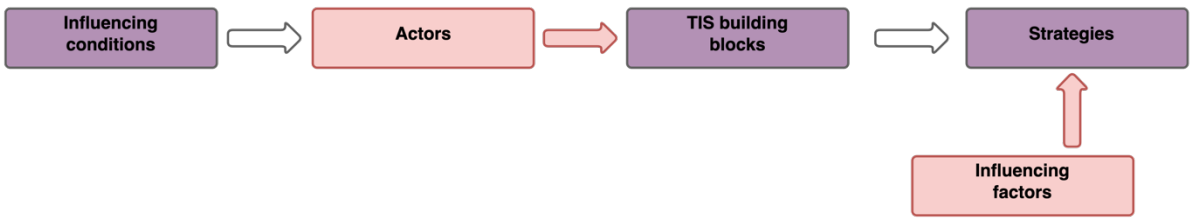


Figure 24 Illustration of the framework with the newly added element: Actors and Influencing factors, as well as their relationship with the current elements

Third, as explained in the previous subsection, the Best Strategy Framework is a static model. Therefore, the development and implementation of a dynamic model or system-dynamic modelling might be a good future research topic to provide more insights. Additionally, the use of Agent-Based Modelling could also give interesting insights into how the dynamic of the status of the TIS building blocks and influencing factors, as well as the implementation of certain strategies, would influence the customers' decision to adopt the product.

Fourth, as explained earlier in Chapter 1 and Chapter 6, there are several characteristics or conditions of Indonesia that makes it a potential market for SEV. Based on this insight, another interesting future research topic emerged, as the characteristics or conditions could be used to

distinguish the potential countries to consider next to Indonesia. This research topic would give a valuable contribution for any SEV producers as they would know best where to focus their market penetration.

Lastly, as explained in Section 1.4.2., several knowledge gaps are identified in the literature. As this research only filling some of those gaps, therefore, some gaps still need to be filled. First, comprehensive research should be conducted at a national level to identify public perception, preference, and acceptance of (S)EV in Indonesia and how it influences public willingness to adopt (S)EV. Second, a clear (S)EV roadmap needs to be designed and aligned between relevant stakeholders to guide the (S)EV development in Indonesia.

Chapter 9. Conclusion

This chapter aimed to close and conclude the master thesis report by answering all the sub-research questions in Section 9.1., which then lead to the answer to the main research question that is explained in Section 9.2.

9.1. Answer to the Sub-Research Questions

9.1.1. SRQ1: "How is solar electric vehicles different than conventional electric vehicles?"

Based on the energy sources, drive systems, and plug-in facility, SEV is similar to BEV, but its additional feature: solar panels on its roof (and body), which brings many benefits and added values: it generates its own free "fuel" with well-to-wheels zero-emission and high efficiency, extends the car's driving range, reduces the car's dependency on the battery and the charging facilities, could be energy self-sufficient, as well as reduces the charging frequency, time, and hassle. With its less dependency on the charging facilities, the mass adoption of SEV could potentially reduce the system cost due to the less charging facilities that need to be built to accommodate SEV mass adoption. This added value is even more important as the increment of the charging facility would not be sufficient to support all the EVs in the future.

Despite the advantages, SEV also has downsides. First, SEV is weather dependent. Second, one could argue that compared to other EVs, SEV might produce more emissions with its extra major component: the solar panels, especially during their raw material extraction and manufacturing. But it would probably not be true if it is seen from the full lifetime of the vehicle. In any way, SEV is still an interesting and promising low-emission vehicle alternative because of its capability to solve most of the major drawbacks of EVs that have been hindering the decarbonization of transportation.

9.1.2. SRQ2: "Based on the existing theories in the literature, how could the niche development barriers be linked to the niche strategies so that a niche strategy that could circumvent several barriers at once could be selected?"

A new framework called The Best Strategy Framework, as shown in Table 43, is developed in the present work to answer this sub-research question. This new framework consists of seven TIS building blocks, eleven influencing factors, forty different strategies, and hundreds of links between the barriers and strategies that are mapped into a barriers-strategies matrix. The list and definition of building blocks, influencing factors, and strategies could be found in Chapter 4.3. (Table 24, Table 25, Table 26 respectively).

Furthermore, the framework is complemented with two scoring models as decision support systems to enable the selection of the best strategy. The first scoring model assigns the same weight for all the barriers, while the second scoring model assigns different weights depending on the level of importance and threats posed by the barriers. Thus, the first scoring model focuses on finding the best strategy to circumvent the most barriers, while the second scoring model focuses on the best strategy that could circumvent the most important or the biggest threats to innovation diffusion. In the end, the readers should decide for themselves whether they would like to use both scoring models or if they prefer to use only one of them.

Table 43 The Best Strategy Framework (the same as Table 31)

		Niche Strategies																																						
Niche Strategy No.		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Influencing Conditions	**TIS Building Blocks**	**Demo**	**Top niche**	**Subsidy**	**Redesign**	**Dedicated/ stand-alone system**	**Hybridization /Adaptor**	**Educate**	**Geographic**	**Lead user**	**Explore markets**	**Tech. R&D**	**Human resource management**	**Internal knowledge sharing**	**Partnership**	**Finance sourcing**	**Lobbying**	**Influencer**	**Crowd-sourcing**	**Leasing**	**Sharing economy platform**	**Corporate restructuring**	**Buy one - give one**	**Campaign funding**	**Stepping-stone**	**Network building**	**Get specified**	**Local**	**Complementary technologies, products, services**	**Product variants**	**Cross-selling and financing**	**Existing social network**	**Result-oriented contracting**	**Turnkey product**	**Incentives**	**Local implementation**	**Market positioning**	**In-house network**	**Aggresive penetration**	**Pre-announcing**	**Blue ocean**
Knowledge and awareness of technology	Product availability, performance, and quality	■			■		■	■	■			■	■	■	■			■	■			■				■			■										■	
Knowledge and awareness of application and market		■						■	■	■	■		■	■	■			■								■			■								■			
Competition		■	■		■			■	■	■	■	■						■				■				■													■	■
Macro-economic and strategic aspects			■	■					■		■				■	■						■				■														
Accidents and events			■						■	■	■				■							■				■														
Human resources			■		■			■	■	■	■	■	■	■	■				■			■				■	■													
Natural resources			■		■				■	■	■	■			■							■				■														
Financial resources		■		■					■	■	■	■			■	■			■			■				■														
Socio-cultural aspects		■						■	■	■	■							■							■										■	■				
Institutional aspects and political system		■			■			■	■		■				■		■							■		■														
Physical/information access & infrastructure		■			■				■		■	■			■		■									■														
Knowledge and awareness of technology	Product price	■	■	■	■		■	■			■	■	■	■	■			■	■	■	■	■				■												■	■	
Knowledge and awareness of application and market			■					■			■		■	■	■			■	■	■	■				■	■										■				
Competition		■	■	■	■	■	■	■	■		■	■			■	■		■				■	■			■			■	■		■		■			■	■	■
Macro-economic and strategic aspects			■	■					■		■				■	■				■	■	■	■			■				■		■					■		
Accidents and events			■	■					■		■				■					■	■	■				■												■		
Human resources			■	■			■		■		■	■		■	■				■	■	■	■				■	■													
Natural resources			■	■	■		■		■		■	■			■					■	■	■				■														
Financial resources		■	■	■	■		■		■		■	■			■	■	■		■	■	■	■				■											■			
Socio-cultural aspects																																								
Institutional aspects and political system		■	■	■				■	■		■				■		■			■	■			■		■												■		
Physical/information access & infrastructure			■	■			■		■		■	■			■		■			■	■					■												■		
Knowledge and awareness of technology	Production system	■	■		■		■	■				■	■	■	■							■				■														
Knowledge and awareness of application and market								■		■			■	■	■											■														
Competition																										■														
Macro-economic and strategic aspects			■	■					■	■					■	■						■				■														
Accidents and events			■						■	■					■							■				■														
Human resources			■	■	■		■	■	■	■		■	■	■	■							■				■	■													
Natural resources			■	■	■		■		■	■		■			■							■				■	■													
Financial resources																■	■									■														
Socio-cultural aspects		■																							■														
Institutional aspects and political system					■			■	■						■		■							■		■														
Physical/information access & infrastructure					■	■	■		■			■			■		■									■														
Knowledge and awareness of technology	Complementary products and services	■	■		■	■	■	■				■	■	■	■			■	■			■				■													■	
Knowledge and awareness of application and market							■	■		■	■		■	■	■			■	■							■													■	
Competition		■	■		■	■	■	■	■	■	■	■			■			■				■				■													■	■
Macro-economic and strategic aspects			■	■		■	■		■	■	■				■	■						■				■														
Accidents and events			■			■	■		■	■	■				■							■				■														
Human resources			■		■	■	■	■	■	■	■	■	■	■	■				■			■				■	■													
Natural resources			■		■	■	■		■	■	■	■			■							■				■														
Financial resources		■	■	■	■	■	■		■	■	■	■			■	■	■		■			■				■														
Socio-cultural aspects								■																	■														
Institutional aspects and political system					■		■	■	■		■				■		■							■		■														
Physical/information access & infrastructure					■	■	■		■		■	■			■		■									■														

Niche Strategy No.		Niche Strategies																																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Influencing Conditions	TIS Building Blocks	Demo	Top niche	Subsidy	Redesign	Dedicated/ stand-alone system	Hybridization /Adaptor	Educate	Geographic	Lead user	Explore markets	Tech. R&D	Human resource management	Internal knowledge sharing	Partnership	Finance sourcing	Lobbying	Influencer	Crowd-sourcing	Leasing	Sharing economy platform	Corporate restructuring	Buy one - give one	Campaign funding	Stepping-stone	Network building	Get specified	Local	Complementary technologies, products, services	Product variants	Cross-selling and financing	Existing social network	Result-oriented contracting	Turnkey product	Incentives	Local implementation	Market positioning	In-house network	Aggresive penetration	Pre-announcing	Blue ocean
Knowledge and awareness of technology	Network formation and coordination																																								
Knowledge and awareness of application and market																																									
Competition																																									
Macro-economic and strategic aspects																																									
Accidents and events																																									
Human resources																																									
Natural resources																																									
Financial resources																																									
Socio-cultural aspects																																									
Institutional aspects and political system																																									
Physical/information access & infrastructure																																									
Knowledge and awareness of technology	Customers																																								
Knowledge and awareness of application and market																																									
Competition																																									
Macro-economic and strategic aspects																																									
Accidents and events																																									
Human resources																																									
Natural resources																																									
Financial resources																																									
Socio-cultural aspects																																									
Institutional aspects and political system																																									
Physical/information access & infrastructure																																									
Knowledge and awareness of technology	Innovation-specific institutions																																								
Knowledge and awareness of application and market																																									
Competition																																									
Macro-economic and strategic aspects																																									
Accidents and events																																									
Human resources																																									
Natural resources																																									
Financial resources																																									
Socio-cultural aspects																																									
Institutional aspects and political system																																									
Physical/information access & infrastructure																																									

Links between barriers and strategies identified by the author

9.1.3. SRQ3: "Based on the previously developed "The Best Strategy Framework", which actors, factors, and functions could be the barriers for SEV to reach its mass adoption in Indonesia?"

The development of the EV industry has been part of Indonesia's ten top priority industries, as well as supported by the national energy plan as part of Indonesia's energy self-sufficiency, energy security, and sustainable energy development goals (see Appendix C.1. and C.2.). 2019 was a big milestone of the EV era in Indonesia as the President of Indonesia signed Presidential Regulation No. 55/2019 to direct, regulate, support, and accelerate the development of EVs in Indonesia. With this regulation in place, Indonesia is aiming to be an important player in the global EV market.

Figure 21 in Section 6.1. shows the current EV ecosystem in Indonesia, while the status of Lightyear's SEV TIS building blocks in Indonesia is summarized by Table 44, which is indicated by traffic light indication (GREEN-ORANGE-RED). For the building block that has a GREEN status, no influencing factor is identified.

Table 44 The status of Lightyear's TIS building block for Indonesian market and factors that negatively influencing the status (the same as Table 35)

TIS Building Blocks	Status	Influencing Factors	Main Influencers
Product availability, performance, and quality	ORANGE	(1) knowledge and awareness of application and market and (2) financial resources	Lightyear
Product price	ORANGE	(1) knowledge and awareness of application and market, (2) competition, and (3) natural resources	Lightyear, Indonesia
Production system	RED	(1) knowledge and awareness of application and market and (2) financial resources	Lightyear
Complementary products and services	GREEN	N/A	Indonesia
Network formation and coordination	RED	(1) knowledge and awareness of application and market	Lightyear
Customers	ORANGE	(1) knowledge and awareness of technology, (2) financial resources, and (3) competition	Indonesia
Innovation-specific institutions	ORANGE	(1) financial resources and (2) socio-cultural aspects	Indonesia
Note: RED: TIS building block status is not available ORANGE: TIS building block status is available but incomplete/insufficient to support mass adoption GREEN: TIS building block status is available and complete to support mass adoption			

Six out of seven TIS building blocks are currently unavailable or incomplete which leads to thirteen barriers to SEV adoption if Lightyear is going to penetrate the Indonesian market now. Complementary product and services building block is the only supportive building blocks, thanks to Indonesia's regulated EV charging electricity tariff, payment instruments, and home charging services. Additionally, the currently insufficient EV charging infrastructure is an enabler for SEV adoption in Indonesia.

By comparing Lightyear 0 with its alternatives, the performance and quality of Lightyear 0 are deemed sufficient and do not pose a barrier to its adoption. However, the product is currently unavailable yet in the Indonesian market. If Lightyear would make the product available in Indonesia, this building block would immediately turn green. Unfortunately, the relevant production system, as well as the network formation and coordination building blocks, are also not available yet to support the Indonesian market. The unavailability of these three building

blocks is influenced by the same factor namely Lightyear's lack of knowledge and awareness of the Indonesian market. In addition, due to its limited financial resources, Lightyear decided to limit its market entry only to familiar markets such as Europe. This decision, therefore, explains the unavailability of Product availability and Production system building blocks in Indonesia.

Furthermore, Product price, Customers, and Innovation-specific institution building blocks must be improved to support SEV adoption in Indonesia. Regarding the product price, the Lightyear 0 price of €250,000 is deemed unaffordable for the average Indonesian as their car buying power is within the price range of €13,000 to €19,000. Several factors influenced this relatively expensive price namely the company's lack of knowledge of the market, the market competition which enables the customers to compare the product with its alternatives, and the expensive materials used to build the SEV. Regarding the availability of customers, it is known that Indonesia has a big market size with 16 million passenger cars registered in 2020. However, the EV adoption rate is still relatively low due to customers' lack of knowledge and awareness of EV technologies and their added values and benefits, limited financial resources (customers' buying power is less than the EV average price), and competition in the market that provides perceived better and cheaper alternatives. Moreover, the currently enforced supportive policies and incentives are deemed to be insufficient to boost the EV adoption rate. However, the implementation of more aggressive incentives is hindered by Indonesia's limited fiscal capability as well as its complex socio-cultural aspects which, for example, deemed EV subsidy as politically unjust.

By looking at the main influencers of the TIS building block status, Lightyear has the biggest role in the unavailable or incomplete TIS building blocks as it is responsible to make the product, production system, and network formation available. Meanwhile, despite the incomplete Customers and Innovation-specific institutions building blocks, Indonesia has provided sufficient complementary products and services to support SEV adoption. Product price building block, however, is influenced by both Lightyear and Indonesia sides as there should be a match between Lightyear's capability to provide affordable SEV and Indonesia's average buying power.

Lastly, from Table 44, it could be seen that several influencing factors hinder the availability of more than one building block, namely (1) knowledge and awareness of application and market, (2) financial resources, and (3) competition. Therefore, circumventing these factors should be prioritized to significantly improve the status of the building blocks, as these are the most important and most threatening factors.

9.1.4. SRQ4: "Based on the identified barriers that could hinder SEV development in Indonesia, which strategy could circumvent most of the barriers or the most threatening barriers at the same time?"

This sub-research question is answered by implementing the Best Strategy Framework with two different scoring models. For the implementation of scoring model 2, ideally, interviews should be conducted with experts to define the weights for each barrier. However, for this research, the weights are defined by the author of the present work based on her understanding of the topic due to the research time constraint. The identified weights for each barrier based on their level of importance and threat are indicated in Table 45.

Table 45 Weights assigned for each identified barrier to enable the best strategy selection by using the scoring model 2 (the same as Table 38)

TIS Building Blocks	Influencing Factors	Weights
Product availability, performance, and quality	Knowledge and awareness of application and market Financial resources	10 3
Product price	Knowledge and awareness of application and market Competition Natural resources	8 8 8
Production system	Knowledge and awareness of application and market Financial resources	10 3
Complementary products and services	N/A	N/A
Network formation and coordination	Knowledge and awareness of application and market	10
Customers	Knowledge and awareness of technology Financial resources Competition	10 10 6
Innovation-specific institutions	Financial resources Socio-cultural aspects	5 7

The implementation of the Best Strategy Framework with two different scoring models resulted in the best strategy selection shown in Table 46. The lower ranks of best strategies are included in the overview to see if some strategies could help to improve the status of the TIS building blocks and to compare the results of the scoring models. The 5th and 6th rank of best strategies of the scoring model 1 is not included in the overview as the scoring model 1 has been deemed to propose sufficient best strategies.

Table 46 The best strategies to circumvent Lightyear 2 development barriers in Indonesia, based on the Best Strategy Framework with scoring model 1 and scoring model 2 (the same as Table 42)

Rank	Best Strategies Resulted from Scoring Model 1	Best Strategies Resulted from Scoring Model 2
1st	Partnership strategy and Network building strategy	Partnership strategy and Network building strategy
2nd	Geographic strategy	Geographic strategy
3rd	Explore multiple market strategy	Educate strategy
4th	Top niche strategy, Redesign strategy, Educate strategy, Lead user strategy, Pre-announcing strategy	Pre-announcing strategy
5th		Explore multiple market strategy
6th		Lead user strategy

Despite the different ways of scoring, both scoring models proposed similar strategies and recommendations. Even more, both scoring models agree that the Partnership strategy and Network building strategy are the best strategies to implement as they could circumvent most of the barriers, as well as the most threatening barriers: knowledge and financial related barriers, and market competition barriers. These strategies even received the highest scores with the scoring model 1, which means that these strategies could circumvent all the identified barriers. The author agrees with these findings as the Partnership strategy and Network building strategy could boost the company's capability to set up the market by gaining more power and resources from its partners and networks, as well as could improve the company's knowledge and access to the market.

The next best strategies are Geographic strategy and Explore multiple market strategy (even though Explore multiple market strategy is scored at a lower rank by the scoring model 2), which could be translated in two different ways: (1) Lightyear should look at other

geographical areas and market as there are too many barriers in Indonesia market, or (2) Lightyear should focus the market penetration in certain areas and market segments in Indonesia in which the barriers are less hindering the product adoption. As Lightyear is the main influencer of the unavailable and incompleteness of most of the building blocks, while Indonesia has a big market size and suitable geography to utilize SEVs, the author is confident that the second approach should be considered. Thus, Lightyear should first focus on Indonesian big cities where the customers' buying power and education background are higher than average Indonesian. The suitable cities to focus on are Jakarta, Surabaya, Medan, Bali, and Bandung. Moreover, Lightyear should explore different market segments in Indonesia to see if there is a better market segment to focus on.

Educate strategy is another important strategy to be implemented. Despite being ranked at 4th position by scoring model 1, scoring model 2 emphasizes that it has a higher priority as the strategy is not only able to circumvent the knowledge-related barriers (which are the most threatening barriers in Indonesia), but also the resources and competition related barriers.

Furthermore, some strategies are proposed to address the customers and product price-related barriers such as the Top niche strategy, Lead user niche strategy, and Pre-announcing strategy. Top niche strategy and Lead user niche strategy focus on circumventing the high product price by focusing on the market to serve customers that have no strict limitation on financial resources. Some relevant lead users in Indonesia are taxi and ride-hailing providers, government agencies, and car rental owners. Pre-announcing strategy, on the other hand, focuses on circumventing the lack of knowledge and high product price by giving the customers chance to absorb the information about the innovation and manage their financial resources to enable them to acquire the product once it is released to the market.
In the end, even though the Partnership strategy and Network building strategy can circumvent all the barriers as well as most of the threatening ones at the same time, however, it is wise to also implement more strategies so that they could complement and strengthen each other, and the mass adoption goal could be achieved faster and easier.

9.2. Answer to the Main Research Question

"From the technical innovation system perspective, how could solar electric vehicles reach mass adoption in Indonesia?"

The answers to the sub-research questions as explained in the previous sub-section are building up the answer to the main research question. Therefore, in this sub-section, a broader perspective is taken to summarize the answers.

Even though the EV and solar panel, as well as the combination of both, are not so new, however, SEV is recently commercialized to solve most of the major drawbacks of EVs. SEV's added values and benefits not only advantage the users but also the whole EV system and the environment, thanks to its capability to charge itself. Lightyear - one of the SEV producers is aiming to mass produce its SEV starting in 2025 and enter the Asia-Pacific market around 2030, including Indonesia. Therefore, this research uses the TIS perspective to see how Lightyear's SEV could be mass adopted at all in Indonesia, by using Ortt & Kamp's TIS framework (2022) and Ortt et al. (2013)'s ten niche strategies as the starting point of the research.

TIS is defined as innovation systems around a specific technology that consists of four main elements: the technology, a network of actors, the institutions, and the demand. Ortt & Kamp's

TIS framework is a tool to examine the TIS of an innovation that is in its adaptation phase to judge whether the innovation is ready for its mass uptake or whether a small-scale niche introduction strategy is needed before the large-scale diffusion. The framework consists of three major elements: TIS building blocks (most important aspects needed for large-scale diffusion), influencing factors, and strategies. When certain influencing factors negatively affect the completeness of the TIS building blocks, they pose barriers to the mass adoption of the innovation. Certain strategies could be implemented to circumvent these barriers, such as the generic ten niche strategies proposed by Ortt et al.

Based on this theory, a new framework called Best Strategy Framework is developed in the present work to provide an extensive list of possible barriers and strategies as well as to indicate the relations between the barriers and strategies, and more importantly, to enable the selection of the best strategy that could circumvent the barriers at the same time. This new framework, similar to the TIS framework, is looking into the system level perspective.

Subsequently, the Best Strategy Framework is used to evaluate Lightyear's TIS building blocks in Indonesia, to see if Lightyear's SEV is ready to be diffused in a large scale in Indonesia. It was found that many barriers might hamper SEV adoption if Lightyear is going to penetrate the market now. As Lightyear only plans to enter Indonesia around 2030, there has been no effort put in to prepare the market which explains the absence of most of the TIS building blocks. As the EV era just started in Indonesia a few years ago, Indonesia needs to improve some of the TIS building blocks to enable the mass adoption of SEV. However, as Indonesia has a big market size and suitable geographical area for the utilization of SEV, Lightyear might want to consider the implementation of certain strategies to tap this opportunity.

To circumvent the SEV adoption barriers in Indonesia, the Best Strategy Framework suggest that Lightyear should start to extend and establish its network with relevant stakeholders in Indonesia and to form strategic partnerships to improve its capability to access the market and to build up the necessary TIS building blocks. Furthermore, Lightyear should start the market penetration in Indonesia by focusing on the biggest and most developed cities such as Jakarta, Surabaya, Medan, Bali, and Bandung, where the socio-economic background is higher than the Indonesian average. Additionally, Lightyear needs to explore the Indonesian market further to see if a certain market segment is better to focus on at the early market entry. The framework also suggests that Lightyear should educate the potential customers in Indonesia as they still have a lack of knowledge of EV in general, as well as SEV and its added values. Pre-announcing the product launch is also an important strategy to implement as it gives more time for the customers to get familiar with the product, as well as enables them to plan or manage their financial resources in case they are interested to acquire the product. Lastly, a few strategies that are deemed to be important to address high product price-related barriers: to focus the market penetration to serve top customers and lead users who have less restricted financial resources, or to redesign the product to make it more affordable.

References

Adelayanti, N. (2020). *Government Grants Super Tax Deduction Incentives for R&D Activities*. https://ugm.ac.id/en/news/20446-government-grants-super-tax-deduction-incentives-for-r-d-activities

Adiatma, J. C., & Marciano, I. (2020). *The Role of Electric Vehicles in Decarbonizing Indonesia's Road Transport Sector*.

Agee, J. (2009). Developing qualitative research questions: A reflective process. *International Journal of Qualitative Studies in Education*, *22*(4), 431–447. https://doi.org/10.1080/09518390902736512

AHK. (2022). *Indonesia issues legal framework for electric vehicles*. https://indonesien.ahk.de/infothek/indonesia-issues-legal-framework-for-electric-vehicles

Ahmadi, P. (2019). *Environmental impacts and behavioral drivers of deep decarbonization for transportation through electric vehicles*. https://doi.org/10.1016/j.jclepro.2019.03.334

Alam, M., Mondal, H., Kamp, L. M., & Pachova, N. I. (2010). Drivers, barriers, and strategies for implementation of renewable energy technologies in rural areas in Bangladesh-An innovation system analysis. *Energy Policy*, *38*, 4626–4634. https://doi.org/10.1016/j.enpol.2010.04.018

Alamsjah, F., Siahaan, A., Santoso, Y. A., Syahruddin, Handoko, D., Gunawan, F. E., Asrol, M., Redi, A. A. N. P., & Persada, S. F. (2021). Potential factors affecting adoption of electric vehicle by indonesia market. *ICIC Express Letters, Part B: Applications*, *12*(11), 1081–1090. https://doi.org/10.24507/icicelb.12.11.1081

Aptera Motors. (2022). *Aptera - Driven by the sun*. https://aptera.us/

Arvirianty, A. (2019). *Masa Depan Mobil Listrik di Indonesia: Cerah atau Suram?* https://www.cnbcindonesia.com/news/20190314100403-4-60562/masa-depan-mobil-listrik-di-indonesia-cerah-atau-suram

Asfani, D. A., Negara, I. M. Y., Nugraha, Y. U., Yuniarto, M. N., Wikarta, A., Sidharta, I., & Mukhlisin, A. (2020). Electric Vehicle Research in Indonesia: A Road map, Road tests, and Research Challenges. *IEEE Electrification Magazine*, *8*(2), 44–51. https://doi.org/10.1109/MELE.2020.2985485

Asian Development Bank. (2015). *Fossil Fuel Subsidies in Indonesia: Trends, Impacts, and Reforms*. www.adb.org

Aszhari, A. (2022). *Tak Hanya Kendaraan Listrik, Basis Transportasi di Ibu Kota Baru juga Bakal Otonomos*. https://www.liputan6.com/otomotif/read/4909866/tak-hanya-kendaraan-listrik-basis-transportasi-di-ibu-kota-baru-juga-bakal-otonomos

Aulet, B. (2013). *Disciplined Entrepreneurship*. John Wiley & Sons, Inc.

Auto Data. (2022). *2018 Mitsubishi Outlander III (facelift 2018) 2.4 MIVEC (224 Hp) PHEV 4WD | Technical specs, data, fuel consumption, Dimensions*. https://www.auto-data.net/en/mitsubishi-outlander-iii-facelift-2018-2.4-mivec-224hp-phev-4wd-33489

Badan Pusat Statistik. (2022). *Perkembangan Jumlah Kendaraan Bermotor Menurut Jenis (Unit), 2018-2020*. https://www.bps.go.id/indicator/17/57/1/jumlah-kendaraan-bermotor.html

Baskoro, Y. (2019). *Blue Bird Introduces Indonesia's First Fleet of Electric Taxis*. https://jakartaglobe.id/vision/blue-bird-introduces-indonesias-first-fleet-of-electric-taxis

BKPM. (2018). *Pedoman dan tata cara pemberian fasilitas tax holiday dan tax allowance*.

BMW Group Asia. (2022). *8 in 10 drivers in Southeast Asia want to live in a more environmentally conscious world with more electric vehicles.*

https://www.press.bmwgroup.com/asia/article/detail/T0375913EN/8-in-10-drivers-in-southeast-asia-want-to-live-in-a-more-environmentally-conscious-world-with-more-electric-vehicles?language=en
Bridgestone. (2019). *2019 Bridgestone World Solar Challenge*. https://www.bridgestone.com/bwsc/
Bruinsma, V. (2015). *Developing a dynamic framework for the selection of niche strategies to introduce new high-tech products*.
Carnrite, J. (2021). *What is Competition in Marketing? - Definition & Types*. https://study.com/academy/lesson/what-is-competition-in-marketing-definition-types-quiz.html
CBS. (2019). *Car ownership - The Netherlands on the European scale*. https://longreads.cbs.nl/european-scale-2019/car-ownership/
Ccarprice. (2022). *Tesla Model 3 Standard Plus 2022 Price In Indonesia , Features And Specs*. https://www.ccarprice.com/id/tesla-model-3-standard-plus-2022-price-in-indonesia-8437
Cekindo. (2021). *Indonesia EV Market: A Broad Opportunity for Foreign Investors*. https://www.cekindo.com/blog/investing-indonesia-battery-electric-vehicle
Cekpremi. (2021). *Daftar Harga Mobil Tesla Indonesia Terbaru 2021*. https://www.cekpremi.com/blog/harga-mobil-tesla/
Chen, Z., Yang, Z., & Wappelhorst, S. (2022). *Overview of Asian and Asia-Pacific Passenger Vehicle Taxation Policies and Their Potential to Drive Low-Emission Vehicle Purchases*. www.theicct.orgcommunications@theicct.org
Chisel Glossary. (2021). *What Is Weighted Scoring Model and How To Create It?* https://chisellabs.com/glossary/what-is-weighted-scoring/
Chua, J. (2020). *Nissan Kicks e-POWER review: No kicking or screaming*. https://www.torque.com.sg/reviews/nissan-kicks-e-power-review-no-kicking-or-screaming/
Climate Action Tracker. (2019). *Scaling up climate action - Key opportunities for transitioning to a zero emissions society - Indonesia Full Report*.
Climate Action Tracker. (2021). *Indonesia's Targets*. https://climateactiontracker.org/countries/indonesia/targets/
Climate Transparency. (2019). *About | Climate Transparency*. https://www.climate-transparency.org/about
Climate Transparency. (2020). *CLIMATE TRANSPARENCY REPORT | 2020 INDONESIA*. www.climate-transparency.org
CNBC International TV. (2020). *Blue Bird CEO says passengers "love" its EV taxis | Managing Asia - YouTube*. https://www.youtube.com/watch?v=0RrwA_BJLiY
CNN Indonesia. (2020). *Arahan Jokowi, Ibu Kota Baru Eksklusif Mobil Listrik-Otonom*. https://www.cnnindonesia.com/teknologi/20200116181124-384-466028/arahan-jokowi-ibu-kota-baru-eksklusif-mobil-listrik-otonom
CNN Indonesia. (2021a). *Daftar Lengkap SPKLU Kendaraan Listrik di Indonesia*. https://www.cnnindonesia.com/teknologi/20210804150958-384-676361/daftar-lengkap-spklu-kendaraan-listrik-di-indonesia
CNN Indonesia. (2021b). *Penjualan Motor Bensin Disetop pada 2040, Mobil pada 2050*. https://www.cnnindonesia.com/ekonomi/20211014160707-85-707859/penjualan-motor-bensin-disetop-pada-2040-mobil-pada-2050
CNN Indonesia. (2022). *Harga Hyundai Ioniq 5 Berdasarkan NJKB, di Bawah Rp500 Juta*. https://www.cnnindonesia.com/teknologi/20220317172410-384-772731/harga-hyundai-ioniq-5-berdasarkan-njkb-di-bawah-rp500-juta
Cobbenhagen, R., & Hoefsloot, L. (2015a). *The car of the future*.

Cobbenhagen, R., & Hoefsloot, L. (2015b). *What it takes to achieve clean, cheap, safe mobility for everyone (part 1) | Steinbuch*. https://maartensteinbuch.com/2015/11/12/what-it-takes-to-achieve-clean-cheap-safe-mobility-for-everyone-part-1/
Damayanti, S., Hidayatno, A., & Setiawan, A. D. (2020). User Acceptance of Electric Vehicles in Indonesia: A Conceptual Model. *PervasiveHealth: Pervasive Computing Technologies for Healthcare*, 110–115. https://doi.org/10.1145/3400934.3400956
Dananjaya, D. (2021). *Kendaraan Listrik Bakal Mendominasi Ibu Kota Baru*. https://otomotif.kompas.com/read/2021/05/27/070200515/kendaraan-listrik-bakal-mendominasi-ibu-kota-baru
Dananjaya, D. (2022). *Sampai Februari 2022, Jumlah SPKLU Nasional Diklaim Mencapai 267 Unit*. https://otomotif.kompas.com/read/2022/03/28/110200915/sampai-februari-2022-jumlah-spklu-nasional-diklaim-mencapai-267-unit
Doe, M. F. A. (2013). *Niche strategy selection for kite-based Airborne Wind Energy technologies*.
Doll, S. (2022). *CATL invests in $6 billion battery project to manufacture, recycle, and mine material in Indonesia - Electrek*. https://electrek.co/2022/04/15/catl-invests-in-6-billion-battery-project-to-manufacture-recycle-and-mine-material-in-indonesia/
Egbue, O., & Long, S. (2012). *Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions*. https://doi.org/10.1016/j.enpol.2012.06.009
Encycarpedia. (2018). *Toyota Prius Plug-In Tech Specs: Top Speed, Power, MPG, Range + All 2017-2022*. https://www.encycarpedia.com/toyota/17-prius-plug-in-fastback
Encycarpedia. (2019). *Toyota Prius 1.8 Hybrid Tech Specs: Top Speed, Power, MPG + All 2016-2019*. https://www.encycarpedia.com/toyota/16-prius-1-8-hybrid-fastback
EV Database. (2022a). *BMW i3s 120 Ah (2018-2022) price and specifications*. https://ev-database.org/car/1149/BMW-i3s-120-Ah
EV Database. (2022b). *Hyundai IONIQ 5 Standard Range 2WD price and specifications - EV Database*. https://ev-database.org/car/1476/Hyundai-IONIQ-5-Standard-Range-2WD
EV Database. (2022c). *Hyundai IONIQ Electric (2019-2022) price and specifications - EV Database*. https://ev-database.org/car/1165/Hyundai-IONIQ-Electric
EV Database. (2022d). *Hyundai Kona Electric 39 kWh (2019-2021) price and specifications - EV Database*. https://ev-database.org/car/1239/Hyundai-Kona-Electric-39-kWh
EV Database. (2022e). *Lexus UX 300e price and specifications*. https://ev-database.org/car/1251/Lexus-UX-300e
EV Database. (2022f). *Mini Cooper SE (2020-2021) price and specifications*. https://ev-database.org/car/1163/Mini-Cooper-SE
EV Database. (2022g). *Nissan Leaf (2018-2022) price and specifications*. https://ev-database.org/car/1106/Nissan-Leaf
EV Database. (2022h). *Range of full electric vehicles cheatsheet - EV Database*. https://ev-database.org/cheatsheet/range-electric-car
EV Database. (2022i). *Tesla Model X 75D (2016-2018) price and specifications*. https://ev-database.org/car/1052/Tesla-Model-X-75D
EV Database. (2022j). *Tesla Model Y Long Range Dual Motor price and specifications*. https://ev-database.org/car/1619/Tesla-Model-Y-Long-Range-Dual-Motor
Foster, S. (2022). *Indonesia bans mineral exports to move up value chain*. https://asiatimes.com/2022/02/indonesia-bans-mineral-exports-to-move-up-value-chain/
Gaikindo. (2020). *Profil – GAIKINDO*. https://www.gaikindo.or.id/profil/
Gaikindo. (2021a). *Harga dan Infrastruktur Jadi Tantangan Mobil Listrik Indonesia*. https://www.gaikindo.or.id/gaikindo-harga-dan-infrastruktur-jadi-tantangan-mobil-

listrik-indonesia/
Gaikindo. (2021b). *Tahun 2020: Wabah, Resesi Ekonomi, dan Turunnya Penjualan Mobil 48 Persen*. https://www.gaikindo.or.id/wabah-resesi-ekonomi-dan-turunnya-penjualan-mobil-48-persen-pada-2020/
Gaikindo. (2022). *Daftar Mobil Terlaris di Indonesia 2021*. https://www.gaikindo.or.id/daftar-mobil-terlaris-di-indonesia-2021/
Gaton, B. (2018). *The ICE age is over: Why battery cars will beat hybrids and fuel cells*. https://thedriven.io/2018/11/14/the-ice-age-is-over-why-battery-cars-will-beat-hybrids-and-fuel-cells/
Gauthier, M. (2021). *Lightyear Two Announced, Arrives In 2024 / 2025 With €30,000 Price Tag | Carscoops*. https://www.carscoops.com/2021/12/lightyear-two-announced-arrives-in-2024-2025-with-e30000-price-tag/
Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy*, *36*(3), 399–417. https://doi.org/10.1016/j.respol.2007.01.003
Gonzalez, M. (2015). *How will electric cars affect the energy grid? | World Economic Forum*. https://www.weforum.org/agenda/2015/02/how-will-electric-cars-affect-the-energy-grid/
Grab. (2020). *Grab dan Hyundai Luncurkan GrabCar Elektrik, Dorong Pengembangan Ekosistem Kendaraan Listrik di Indonesia | Grab ID*. https://www.grab.com/id/press/tech-product/grab-dan-hyundai-luncurkan-grabcar-elektrik-dorong-pengembangan-ekosistem-kendaraan-listrik-di-indonesia/
GridOTO. (2021). *KPBB Prediksi Kendaraan Listrik Bisa Bawa Manfaat Ekonomi Hingga Triliunan Rupiah pada 2030 Mendatang*. https://www.gridoto.com/read/222670462/kpbb-prediksi-kendaraan-listrik-bisa-bawa-manfaat-ekonomi-hingga-triliunan-rupiah-pada-2030-mendatang
GridOTO. (2022). *Masuk Era Elektrifikasi, KPBB Minta Pemerintah Terbitkan Cukai Karbon untuk Dongkrak Penjualan Kendaraan Listrik*. https://www.gridoto.com/read/223168182/masuk-era-elektrifikasi-kpbb-minta-pemerintah-terbitkan-cukai-karbon-untuk-dongkrak-penjualan-kendaraan-listrik
Gui, E. (2021). *Indonesia has set an ambitious target for electric vehicles: what factors can support the nation's shift to an electric-dominated transport sector?* https://www.climateworkscentre.org/news/indonesia-has-set-an-ambitious-target-for-electric-vehicles-what-factors-can-support-the-nations-shift-to-an-electric-dominated-transport-sector/
Hampel, C. (2019). *Indonesia backs EVs with state utility PLN*. https://www.electrive.com/2019/10/22/indonesia-moves-on-ev-development-and-infrastructure/
Hardman, S., Shiu, E., & Steinberger-Wilckens, R. (2014). *Changing the fate of Fuel Cell Vehicles: Can lessons be learnt from Tesla Motors?* https://doi.org/10.1016/j.ijhydene.2014.11.149
Hardman, S., Steinberger-Wilckens, R., & Van Der Horst, D. (2013). *Disruptive innovations: The case for hydrogen fuel cells and battery electric vehicles*. https://doi.org/10.1016/j.ijhydene.2013.09.088
Hediu. (2021). *10 Benefits And Disadvantages of Solar Energy Cars | Solar Power Nerd*. https://solarpowernerd.com/benefits-of-solar-energy-cars/
Herman. (2019). *Blue Bird Goes Electric With Tesla and BYD Cars*. https://jakartaglobe.id/context/blue-bird-goes-electric-with-tesla-and-byd-cars
Hodgson, G. M. (2006). *What Are Institutions?* https://www-jstor-org.tudelft.idm.oclc.org/stable/4228221?seq=1#metadata_info_tab_contents
Huber, I. (2022). *Indonesia's Battery Industrial Strategy | Center for Strategic and*

International Studies. https://www.csis.org/analysis/indonesias-battery-industrial-strategy
ICCT. (2022). *Home - International Council on Clean Transportation*. https://theicct.org/
IEA. (2021). *CO2 emissions by sector in Indonesia*. https://www.iea.org/data-and-statistics/data-browser/?country=INDONESIA&fuel=CO2 emissions&indicator=CO2BySector
IESR. (2022). *Homepage - IESR*. https://iesr.or.id/en
Indeed. (2021). *Macroeconomic Factors: What Are They and How Do They Impact the Economy?* https://www.indeed.com/career-advice/career-development/macroeconomics-factors
Indonesia National Electric Vehicle Team. (2015). *Status and Program of Research and Development on National Electric Vehicle Prototype*.
IQAir. (2021). *Indonesia Air Quality Index (AQI) and Air Pollution information | AirVisual*. https://www.iqair.com/indonesia
Iqbal, M., Ma, J., Ahmad, N., Ullah, Z., & Ahmed, R. I. (2021). *Uptake and Adoption of Sustainable Energy Technologies: Prioritizing Strategies to Overcome Barriers in the Construction Industry by Using an Integrated AHP-TOPSIS Approach*. https://doi.org/10.1002/adsu.202100026
Iskandarsjah, E. (2020). *Berapa Idealnya Rentang Harga Mobil Listrik di Indonesia?* https://republika.co.id/berita/qkijau368/berapa-idealnya-rentang-harga-mobil-listrik-di-indonesia
Iskandarsjah, E. (2021). *Produksi Mobil Listrik di Indonesia Ditarget Capai 1 Juta | Republika Online*. https://www.republika.co.id/berita/qwa2t2368/produksi-mobil-listrik-di-indonesia-ditarget-capai-1-juta
JDIH BPK RI. (2019). *Peraturan BKPM No. 1 Tahun 2019 tentang Rincian Bidang Usaha dan Jenis Produksi Industri Pionir yang Dapat Diberikan Fasilitas Pengurangan Pajak Penghasilan Badan serta Pedoman dan Tata Cara Pemberian Fasilitas Pengurangan Pajak Penghasilan Badan*. https://peraturan.bpk.go.id/Home/Details/169080/peraturan-bkpm-no-1-tahun-2019
JDIH BPK RI. (2020). *PMK No. 150/PMK.010/2018 tentang Pemberian Fasilitas Pengurangan Pajak Penghasilan Badan*. https://peraturan.bpk.go.id/Home/Details/113460/pmk-no-150pmk0102018
Jenson, I., Leith, P., Doyle, R., West, J., & Miles, M. P. (2015). *Testing innovation systems theory using Qualitative Comparative Analysis*. https://doi.org/10.1016/j.jbusres.2015.10.093
Kamp, L. M. (2008). Socio-technical analysis of the introduction of wind power in the Netherlands and Denmark. *International Journal of Environmental Technology and Management*, *9*(2–3), 276–293. https://doi.org/10.1504/IJETM.2008.019038
Kamp, L. M., Ortt, J. R., & Doe, M. F. A. (2018). Niche strategies to introduce kite-based airborne wind energy. *Green Energy and Technology*, *0*(9789811019463), 665–678. https://doi.org/10.1007/978-981-10-1947-0_27
Kamp, L. M., Ortt, J. R., & Harahap, B. (2015). Barriers and strategies for innovations entering BOP markets. *IAMOT 2015 - 24th International Association for Management of Technology Conference: Technology, Innovation and Management for Sustainable Growth, Proceedings*, 1593–1609.
Kemenperin. (2021a). *Kemenperin: Bangun Ekosistem Kendaraan Listrik, Kemenperin Terapkan Peta Jalan Pengembangan KBLBB*. https://kemenperin-go-id.translate.goog/artikel/22889/Bangun-Ekosistem-Kendaraan-Listrik,-Kemenperin-Terapkan-Peta-Jalan-Pengembangan-KBLBB?_x_tr_sl=id&_x_tr_tl=en&_x_tr_hl=en&_x_tr_pto=op,sc

Kemenperin. (2021b). *Upaya Pemerintah Jadikan Indonesia Pemain Utama Industri Kendaraan Listrik*. https://kemenperin.go.id/artikel/22645/Upaya-Pemerintah-Jadikan-Indonesia-Pemain-Utama-Industri-Kendaraan-Listrik
Kementrian ESDM. (2021). *Akselerasi Implementasi KBLBB Butuh Kolaborasi dan Inovasi*. https://www.esdm.go.id/id/berita-unit/direktorat-jenderal-ketenagalistrikan/akselerasi-implementasi-kblbb-butuh-kolaborasi-dan-inovasi
Kementrian Perindustrian. (2015). *RENCANA INDUK PEMBANGUNAN INDUSTRI NASIONAL REPUBLIK INDONESIA*. www.kemenperin.
Kompas. (2022). *Update Tarif Listrik Per kWh 2022, Cek Beda Listrik Subsidi dan Non-subsidi*. https://money.kompas.com/read/2022/06/20/111510226/update-tarif-listrik-per-kwh-2022-cek-beda-listrik-subsidi-dan-non-subsidi?page=all
KPBB. (1999). *KPBB Profile*. https://kpbb.org/profile/
KPMG Indonesia. (2021). *Decarbonization of Transport: EV & EV Battery Development Plan in Indonesia*.
Kurniawan, D. (2022). *Pemerintah Gratiskan Bea Masuk Impor Kendaraan Listrik IKD, Ini Tujuannya*. https://otomotif.tempo.co/read/1567168/pemerintah-gratiskan-bea-masuk-impor-kendaraan-listrik-ikd-ini-tujuannya
Kurniawan, H., Dinda, S., & Chayoputra, L. (2021). *Mobil Listrik Butuh Tambahan Insentif*. https://investor.id/business/242753/mobil-listrik-butuh-tambahan-insentif
Lambert, F. (2022). *Tesla agrees to build battery and EV factory in Indonesia, official says*. https://electrek.co/2022/05/20/tesla-agrees-build-battery-ev-factory-indonesia-official/
Lestari, S. K. (2017). *Assessing Influencing Factors During Diffusion of a Radical Innovation: A Case Study in Urban Farming the Netherlands*. *August*. https://frameworks.ced.berkeley.edu/category/degrees/urban-design/
Lightyear. (2021). *Homepage | Lightyear*. https://lightyear.one/
Lightyear. (2022a). *Long Range Solar Electric Vehicle*. https://lightyear.one/lightyear-0
Lightyear. (2022b). *Technology | Solar Electric Vehicle*. https://lightyear.one/technology
LinkedIn. (2022). *Lightyear: Overview*. https://www.linkedin.com/company/lightyear.one/
Lonan, E. S., & Ardi, R. (2020). Electric vehicle diffusion in the indonesian automobile market: A system dynamics modelling. *IEEE International Conference on Industrial Engineering and Engineering Management*, *2020-Decem*, 43–47. https://doi.org/10.1109/IEEM45057.2020.9309988
Maghfiroh, M. F. N., Pandyaswargo, A. H., & Onoda, H. (2021). Current readiness status of electric vehicles in indonesia: Multistakeholder perceptions. *Sustainability (Switzerland)*, *13*(23), 1–25. https://doi.org/10.3390/su132313177
Mahalana, A., & Yang, Z. (2021). *Overview of vehicle fuel efficiency and electrification policies in Indonesia*. https://www.
Mahalana, A., Yang, Z., & Posada, F. (2021). *Indonesia transport electrification strategy*. https://www.
Mahoney, J., & Goerts, G. (2006). A tale of two cultures: Contrasting quantitative and qualitative research. *Political Analysis*, *14*(3), 227–249. https://doi.org/10.1093/pan/mpj017
Mardika, R. (2021). *Pemerintah Bakal Stop Jual Mobil-Motor BBM di 2040, Kelamaan?* https://www.kompas.tv/article/222135/pemerintah-bakal-stop-jual-mobil-motor-bbm-di-2040-kelamaan
Markard, J. (2018). *The life cycle of technological innovation systems*. https://doi.org/10.1016/j.techfore.2018.07.045
Markard, J., & Truffer, B. (2008). Technological innovation systems and the multi-level perspective: Towards an integrated framework. *Research Policy*, *37*, 596–615. https://doi.org/10.1016/j.respol.2008.01.004

Maskur, F. (2020). *DP Kredit 0 Persen, Ini Daftar Mobil Listrik Baterai Lulus Uji Tipe*. https://otomotif.bisnis.com/read/20201001/275/1299533/dp-kredit-0-persen-ini-daftar-mobil-listrik-baterai-lulus-uji-tipe

Matulka, R. (2014). *The History of the Electric Car | Department of Energy*. https://www.energy.gov/articles/history-electric-car

Mendagri. (2021). *Permendagri No. 40/2021*. 6.

Mihalascu, D. (2021). *Lightyear One Solar EV Maker Has Raised $110 Million In 2021 So Far*. https://insideevs.com/news/534881/lightyear-raised-110-million-2021/

Ministry of Finance. (2019). *Indonesia's Effort to Phase Out and Rationalise Its Fossil-Fuel Subsidies - A self report on the G-20 peer review of inefficient fossil fuel subsidies that encourage wasteful consumption in Indonesia*.

Mishra, S., & Alok, S. (2017). *Handbook of Research Methodology*. 28. https://doi.org/10.1097/00003465-199001000-00018

Montaguti, E., Kuester, S., & Robertson, T. S. (2001). *Entry strategy for radical product innovations: A conceptual model and propositional inventory*. www.elsevier.com/locate/ijresmar

Naor, M., Bernardes, E. S., Druehl, C. T., & Shiftan, Y. (2015). Overcoming barriers to adoption of environmentally-friendly innovations through design and strategy: Learning from the failure of an electric vehicle infrastructure firm. *International Journal of Operations and Production Management*, *35*(1), 26–59. https://doi.org/10.1108/IJOPM-06-2012-0220

Natalia, Y., Rahman, I., & Hidayatno, A. (2020). Conceptual Model for Understanding the Policy Challenges of Electric Vehicle Adoption in Indonesia. *PervasiveHealth: Pervasive Computing Technologies for Healthcare*, 113–117. https://doi.org/10.1145/3429551.3429557

New Roads. (2018). *How Sunlight Damages your Vehicle*. https://www.newroads.ca/blog/sunlight-damages-vehicle/

Nguyen, H. (2022). *PLN Collaborates with HVT to Build Five SPKLUs in Jakarta, Including in Kokas*. https://www.newsdelivers.com/2022/05/31/pln-collaborates-with-hvt-to-build-five-spklus-in-jakarta-including-in-kokas/

Noble, H., & Smith, J. (2015). *Issues of validity and reliability in qualitative research*. https://doi.org/10.1136/eb-2015-102054

Noteboom, G. N. (2021). *The system costs of future electric mobility - Comapring battery electric vehicles with solar electric vehicles*.

Novizayanti, D., Prasetio, E. A., Siallagan, M., & Santosa, S. P. (2021). Agent-based modeling framework for electric vehicle adoption transition in indonesia. *World Electric Vehicle Journal*, *12*(2), 1–17. https://doi.org/10.3390/wevj12020073

NS Energy. (2022). *CATL to take part in $6bn EV battery integration project in Indonesia*. https://www.nsenergybusiness.com/news/catl-indonesia-ev-battery-integration-project/

Nugroho, A. (2022). *What is needed to improve the electric vehicle population in Indonesia*. https://thesmedia.id/posts/what-is-needed-to-improve-the-electric-vehicle-population-in-indonesia

Nuryakin, C., Riyanto, Riyadi, S. A., Damayati, A., Pratama, A. P., & Gerald Massie, N. W. (2019). Socioeconomic Impacts and Consumer Preferences Analysis of Electrified Vehicle in Indonesia. *ICEVT 2019 - Proceeding: 6th International Conference on Electric Vehicular Technology 2019*, 80–87. https://doi.org/10.1109/ICEVT48285.2019.8993989

Office of Research & Doctoral Services. (2015). *Overview of Qualitative Research Methods - YouTube*. https://www.youtube.com/watch?v=IsAUNs-IoSQ

Olsthoorn, S. (2017). *Dutch cooling technology in the desert - a market study on district*

cooiling for Dutch companies based on niche strategies to commercialise high-tech products.
Ortlieb, E. (2019). *Common Qualitative and Quantitative Data Collection Tools - YouTube*. https://www.youtube.com/watch?v=mUfYXr4VKgI
Ortt, J. R., & Kamp, L. M. (2022). *A Technological Innovation System Framework to Formulate Niche Introduction Strategies for Companies Prior to Large-scale Diffusion*.
Ortt, J. R., Langley, D. J., & Pals, N. (2013). Ten niche strategies to commercialize new high-tech products. *2013 International Conference on Engineering, Technology and Innovation, ICE 2013 and IEEE International Technology Management Conference, ITMC 2013*. https://doi.org/10.1109/ITMC.2013.7352687
OTO. (2021). *Nissan Resmikan SPKLU Swasta Pertama di Wisma Indomobil MT Haryono | Oto*. https://www.oto.com/berita-mobil/nissan-resmikan-spklu-swasta-pertama-di-wisma-indomobil-mt-haryono
Otomotifo. (2020). *21 Harga Mobil Tesla Termurah dan Termahal di Indonesia 2022*. https://www.otomotifo.com/harga-mobil-tesla-indonesia/
Pamungkas, S. (2022). *Daftar Model dan Harga Mobil Listrik yang Beredar di Indonesia*. https://www.liputan6.com/otomotif/read/4986127/daftar-model-dan-harga-mobil-listrik-yang-beredar-di-indonesia
Park, E., & Ohm, J. Y. (2014). Factors influencing the public intention to use renewable energy technologies in South Korea: Effects of the Fukushima nuclear accident. *Energy Policy*, *65*, 198–211. https://doi.org/10.1016/J.ENPOL.2013.10.037
Parrish, E. D., Cassill, N. L., & Oxenham, W. (2006). Niche market strategy for a mature marketplace. *Marketing Intelligence and Planning*, *24*(7), 694–707. https://doi.org/10.1108/02634500610711860
Parthasarathy, R. (2017). *Barriers and Strategies for Different Organisational Setups of Sustainable Energy Firms Operating in Developing Countries*.
Pertamina. (2021). *Dari EV Battery hingga Energy Storage, Pertamina Siap Kembangkan Ekosistem Industri Baterai di Indonesia*. https://www.pertamina.com/id/news-room/news-release/dari-ev-battery-hingga-energy-storage-pertamina-siap-kembangkan-ekosistem-industri-baterai-di-indonesia
Pratiwi, L. (2017). Barriers and Strategies for Transition to Electric Vehicles in BRICS Countries. *International Association for Management of Technology*, 1–17.
Presiden Republik Indonesia. (2019). Peraturan Presiden Nomor 55 Tahun 2019 Tentang Percepatan program Kendaraan Bermotor Listrik Berbasis Baterai (Battery Electric Vehicle) Untuk Transportasi Jalan. *Republik Indonesia*, *55*.
Purnama, S. (2022). *PLN akan manjakan pemilik mobil listrik dengan layanan "home charging."* https://www.antaranews.com/berita/2793637/pln-akan-manjakan-pemilik-mobil-listrik-dengan-layanan-home-charging
Purwanto, A. J., & Lutfiana, D. (2021). *Vehicle Technology Impact Assessment Model for Indonesia (VEIA-ID): Concept and First Results*. http://www.springer.com/series/13451
Putri, C. A. (2022a). *Blak-Blakan Wamenkeu Soal Subsidi Bensin Premium di 2022*. https://www.cnbcindonesia.com/news/20220112120435-4-306680/blak-blakan-wamenkeu-soal-subsidi-bensin-premium-di-2022
Putri, C. A. (2022b). *Pemerintah Pede 400 Ribu Mobil Listrik Ngaspal di 2025*. https://www.cnbcindonesia.com/news/20220209175734-4-314169/pemerintah-pede-400-ribu-mobil-listrik-ngaspal-di-2025
Putri, C. A. (2022c). *Sri Mulyani Bebaskan Bea Masuk Mobil Listrik*. https://www.cnbcindonesia.com/news/20220301072439-4-319061/sri-mulyani-bebaskan-bea-masuk-mobil-listrik
Radityasani, M. F. (2022). *Kesiapan Toyota Indonesia Produksi Mobil Hybrid di Pabrik*

Karawang. https://otomotif.kompas.com/read/2022/05/20/120200015/kesiapan-toyota-indonesia-produksi-mobil-hybrid-di-pabrik-karawang
Rayanti, D. (2022). *Daftar Harga Mobil Listrik di Indonesia, Tak Ada yang di Bawah Rp 500 Juta*. https://oto.detik.com/mobil/d-6117368/daftar-harga-mobil-listrik-di-indonesia-tak-ada-yang-di-bawah-rp-500-juta
RCTI Plus. (2022). *Daftar Mobil Tesla Di Indonesia dari Tipe Termahal dan Termurah*. https://www.rctiplus.com/news/detail/seleb/2130614/daftar-mobil-tesla-di-indonesia-dari-tipe-termahal-dan-termurah
Reference. (2020). *What Are Examples of Sociocultural Factors?* https://www.reference.com/world-view/examples-sociocultural-factors-16d3d81637f83a47
Richardson, L. (2018). *History of Solar Energy: Timeline & Invention of Solar Panels | EnergySage*. https://news.energysage.com/the-history-and-invention-of-solar-panel-technology/
Riyanto, Nuryakin, C., Riyadi, S. A., & Massie, N. W. G. (2020). *ESTIMATING THE TOTAL COST OF OWNERSHIP (TCO) OF ELECTRIFIED VEHICLE IN INDONESIA*.
Ruang Energi. (2021). *Gandeng Nissan, PLN Hadirkan Mitra Swasta Pertama Penyediaan SPKLU di Indonesia*. https://www.ruangenergi.com/gandeng-nissan-pln-hadirkan-mitra-swasta-pertama-penyediaan-spklu-di-indonesia/
Satya, F. E. (2022). *Controversies Surrounding the Removal of Subsidized Fuel*.
Schmidt, B. (2022). *Tesla to build EV and battery storage factory in Indonesia*. https://thedriven.io/2022/05/23/tesla-to-build-ev-and-battery-storage-factory-in-indonesia/
Schoeps, N. (2021). *Disadvantages of Electric Cars: Pros, Cons, and Tradeoffs of EVs*. https://autowise.com/top-7-disadvantages-of-electric-cars/
Schulz, J. (2019). *Developing a conceptual model on strategies overcoming barriers for the introduction of radical innovations in niches*. *March*.
Shams. (2020). *Mass Marketing vs Niche Marketing - A Comprehensive Beginners Guide*. https://appsero.com/digital-marketing/mass-marketing-vs-niche-marketing-compared/
Sono Motors. (2021). *The Sion - the car that charges itself | Sono Motors*. https://sonomotors.com/en/sion/
Startup Sloth. (2021). *What is a niche strategy?* https://startupsloth.com/what-is-a-niche-strategy/
Statista. (2022). *Nickel reserves worldwide by country 2021*. https://www.statista.com/statistics/273634/nickel-reserves-worldwide-by-country/
Stringham, E. P., Miller, J. K., & Clark, J. R. (2015). Overcoming barriers to entry in an established industry: Tesla motors. *California Management Review*, *57*(4), 85–103. https://doi.org/10.1525/cmr.2015.57.4.85
Strupeit, L., & Palm, A. (2015). *Overcoming barriers to renewable energy diffusion: business models for customer-sited solar photovoltaics in Japan, Germany and the United States*. https://doi.org/10.1016/j.jclepro.2015.06.120
Suehiro, S., & Purwanto, A. J. (2019). *Study on Electric Vehicle Penetrations' Influence on 3Es in ASEAN*.
Syamnur, F. H., Pambudi, N. A., Biddinika, M. K., & Wardani, N. S. (2019). Barriers to the adoption, acceptance and public perceptions of Electric Vehicles (EV) in Indonesia: Case studies in the city of Surakarta. *Journal of Physics: Conference Series*, *1402*(4). https://doi.org/10.1088/1742-6596/1402/4/044061
Thomas, V. J., & Maine, E. (2019). *Market entry strategies for electric vehicle start-ups in the automotive industry - Lessons from Tesla Motors*. https://doi.org/10.1016/j.jclepro.2019.06.284

Trip, J. J., Lima, J., & Bakker, S. (2012). *Electric mobility policies in the North Sea Region countries*.
Ubacht, J., & Hoppe, T. (2020). *SEN2321 Research methods and tools final*.
Utami, M. W. Dela, Haryanto, A. T., & Sutopo, W. (2020). Consumer perception analysis of electric car vehicle in Indonesia. *AIP Conference Proceedings*, *2217*(April). https://doi.org/10.1063/5.0000541
Veld, Y. in ’t. (2020). *Strategies for the diffusion of sustainable energy technologies in developing countries*.
Walujanto, Suharyati, Pambudi, S. H., Wibowo, J. L., & Pratiwi, N. I. (2018). *INDONESIA ENERGY OUTLOOK 2018*.
Weather & Climate. (2021). *Average monthly hours of sunshine in Jakarta (Jakarta Province), Indonesia*. https://weather-and-climate.com/average-monthly-hours-Sunshine,Jakarta,Indonesia
Weather & Climate. (2022). *Climate and average monthly weather in Amsterdam (Noord-Holland), Netherlands*. https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,Amsterdam,Netherlands
Weller, J. (2021). *Project Management Scoring Models*. https://www.smartsheet.com/content/project-scoring
William. (2021). *Disadvantages of Electric Cars: Should You Buy One? - Electric Car FAQs*. https://electriccarfaqs.com/disadvantages-of-electric-cars/

Appendix A. Extra Information on Potential Strategies to Reach Large Scale Diffusion

A.1. Identification of Potential Strategies Based on Master's Thesis Reports

This section consists of extra information such as the summary of the relevant findings extracted from master's thesis reports to complement Chapter 4.2.2.

A.1.1. Developing a conceptual model on strategies overcoming barriers for the introduction of radical innovations in niches by Jara Schulz

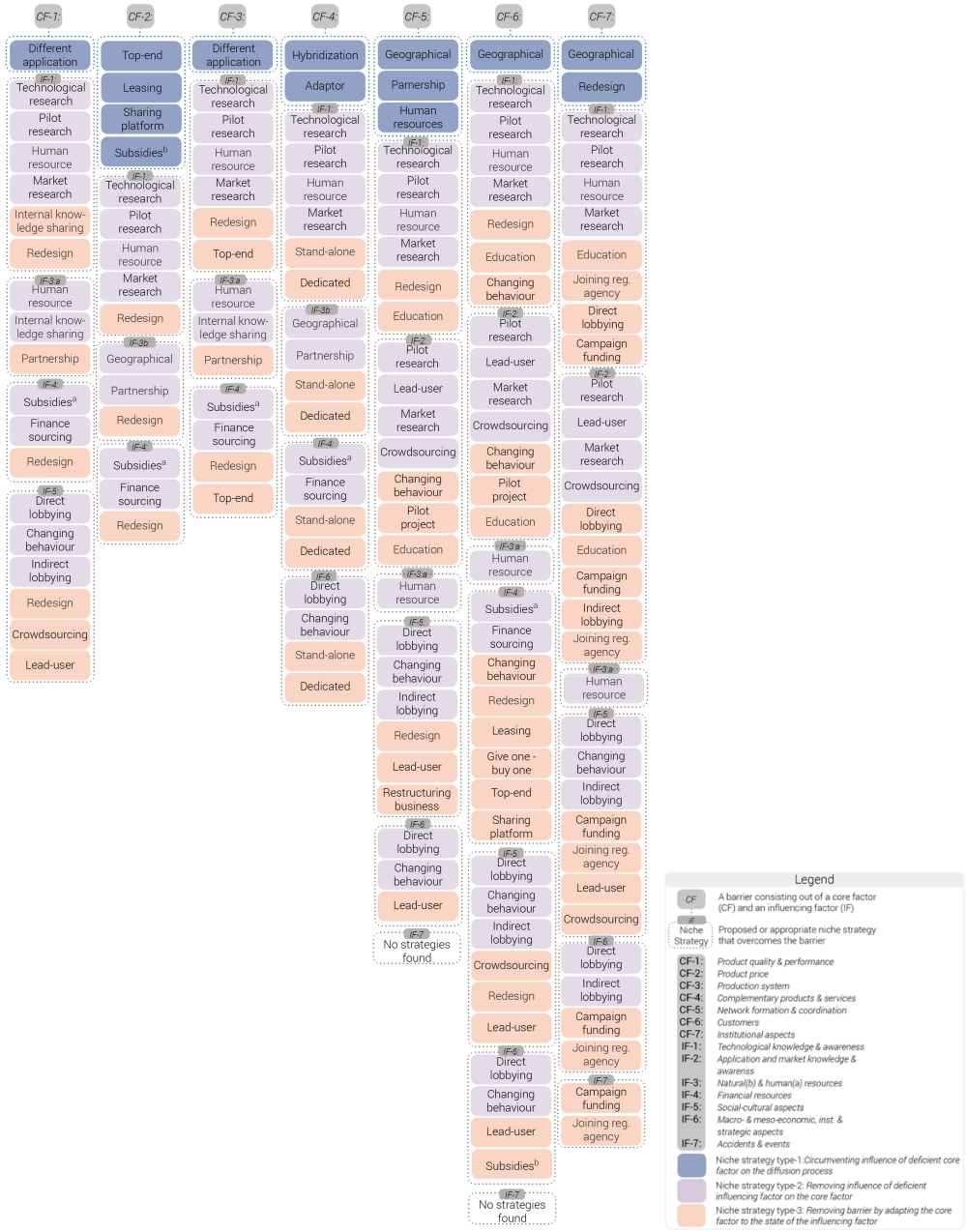


Figure 25 The identified barriers and strategies, and the links between them (Schulz, 2019)

The definition of each niche strategies is briefly explained in the following:

1. **Different application strategy**: adopting the product into a different or simpler application that match the current state of knowledge. Implementation of this strategy would give some time for the company to develop its product further to its performance and quality
2. **Technological research and development strategy**: putting more effort on experimentation in a research environment to further develop the company's technological knowledge, for example, by finding ways to improve the quality and performance of the product, the easiness of using the product, and the production productivity and efficiency.
3. **Pilot research and development strategy**: Performing a small-scale research project by using the innovation in practice to gain real-life insights of the product, its limitations and issues in practice and subsequently learning on how to solve these. In the end, this whole experience would contribute to the development of the technological knowledge
4. **Pilot project**: conducting pilot project to show the use and benefits of the product to the public and potential stakeholders. The purpose of this strategy is to create public awareness and acceptance
5. **Human resource management strategy**: hiring new employees or interns that have expertise on the new technological fundamentals to improve the company's internal knowledge
6. **Market research strategy**: conducting further market research to improve the understanding of current trends, demand, and competition in the market. This knowledge would be useful for the company to adjust the product's portfolio to meet the trends and demands, as well as to maintain its competitiveness
7. **Internal knowledge sharing strategy**: improving the technical knowledge within the company by initiating various meeting sessions or in-house training to facilitate the transfer of knowledge among the employees
8. **Redesign strategy**: redesigning the product into a simpler or slightly different version either to fit an application that supported by current institutional framework, could be produced by current state of knowledge and current available resources, could be supplied by existing suppliers, or could be accepted and used by the customers (Ortt et al., 2013)
9. **Partnership strategy**: starting a partnership, for example, with the third parties who have expertise on certain knowledge and competence that are still lacking within the company or with other company who needs the same raw material so that it could be bought in bulk to get a cheaper price
10. **Finance sourcing strategy**: initiating certain actions that could bring additional financial resources into the company, for example, by applying for a bank loan, initiating a crowd funding campaign, pitching the innovation in front of potential investors, applying for financial support or subsidy from the government or related supportive organizations, or taking part in an innovation incubator program
11. **Direct lobbying strategy**: initiating an approach towards the policy makers to proposed new or adapted institutions and policies that could support the development and adoption of the product in the society
12. **Changing behavior strategy**: initiating certain actions that could help to shift the society's habits and behaviors that could positively influence the position of the product in the market. This could be done, for example, by involving some influencers (people who has influence power towards the certain group of people in the society), by facilitating the habits and behaviors change, or by proposing distinguish additional values to the product that attract the customers

13. **Indirect lobbying strategy**: establishing a good cooperation with certain actors to raise the awareness of the negative influence of the existing systems and to highlight the benefits that the new product could bring. The relevant actors could be influencers, NGOs, or media
14. **Crowdsourcing strategy**: involving the public to generate ideas and solutions to improve the quality of the product
15. **Lead-user strategy**: focusing on serving lead users and innovators so they could co-develop the product (Ortt et al., 2013)
16. **Top-end strategy**: aiming to sell the product to the top-end users - people with higher financial status and buying power (Ortt et al., 2013)
17. **Leasing strategy**: selling the product with a leasing contract to spread the high initial cost of the product into a certain time period which could improve the affordability of the product
18. **Sharing platform strategy**: initiating a sharing platform in which the multiple users could share the use of the product
19. **Subsidy strategy**: implementing subsidy on the product price to particular segment of users to provide reasonable price (Ortt et al., 2013)
20. **Geographical strategy**: exploration of new geographical areas which provide less barriers to the core factors (Ortt et al., 2013)
21. **Hybridization strategy**: coupling the product with the old products and system in order to re-use the existing complementary products and services (Ortt et al., 2013)
22. **Adaptor strategy**: designing and providing an adaptor so that the new product is compatible with the existing systems and their complementary products and services (Ortt et al., 2013)
23. **Stand-alone strategy**: offering the product in stand-alone system so that the product could be use without the need of complementary products and services (Ortt et al., 2013)
24. **Dedicated strategy**: offering the product in a dedicated system in which the complementary products and services are designed based on the current state of knowledge or resources (Ortt et al., 2013)
25. **Education strategy**: improving the knowledge of the suppliers and the customers, for example, by conducting trainings, workshops, or other knowledge sharing platforms (Ortt et al., 2013)
26. **Restructuring business strategy**: splitting the company into two different companies. This strategy could be adopted, for example, to give a new and better image to the company to the new potential customers or related stakeholders
27. **Buy one – give one strategy**: selling a product, for example, to the top-end customers who could afford the product with current price and at the same time giving one free product to the targeted customer who still could not afford it
28. **Joining regulation agency strategy**: taking part as a member of certain regulation agency to influence the policy making
29. **Campaign funding strategy**: influencing the policy maker who design the institutions by supporting their campaigns

A.1.2. Dutch cooling technology in the desert: A market study on district cooling for Dutch companies based on niche strategies to commercialize high-tech products by Stefan Olsthoorn

Table 47 List of adapted and/or new core factors and influencing factors in comparison to the original ones (Olsthoorn, 2017)

Core factors Ortt et al. (2013)	Core factors adapted framework
New high-tech product	New high-tech product (change in description)
Production system	Production system (no change)
Complementary products and services	Complementary products and services (no change)
Suppliers (network of organisations)	Suppliers (network of organisations) (change in description)
Customers	Customers (change in description)
Institutional aspects	Domestic institutional aspects (split)
	Foreign institutional aspects (split)
	Innovativeness of the customer (new)
	Financing aspects (new)
Influencing factors Ortt et al. (2013)	**Influencing factors adapted framework**
Knowledge of technology	Knowledge of technology (no change)
Natural resources labour and skills	Natural resources, labour and skills (renamed and new description)
Knowledge of application	Knowledge of application (no change)
Socio-cultural aspects	Socio-cultural business aspects (split)
	Socio-cultural demand and application aspects (split)
Macro-economic aspects	Economic aspects (change in description)
Accidents or events	Accidents or events and (perceived) risk and uncertainty (renamed and new description)
	Knowledge of the market (new)
	Foreign institutional aspects
	Competition (new)

Table 48 Brief description of proposed core factors and influencing factors (Olsthoorn, 2017)

Case specific framework	Brief description
New high-tech product (change in description)	(1) The product should be functional, (2) the technological principle should be available and work and (3) other components of the system need to be present. These three elements should form a product that meets required technical circumstances and standards in foreign markets, while remaining competitive on price and quality.
Production system (no change)	The production system needs to be able to meet the required demand of the product.
Complementary products and services (no change)	Goods that contribute to the production, distribution, adoption and use of the product should be present.
Suppliers [network of organisations] (change in description)	The network of organisations are all present in the supply chain, either in the domestic market or foreign market, including foreign representatives and agents.
Customers (change in description)	Customers are defined as a segment of potential buyers that identified the application of the product, are willing to use the product for this application, sees the benefits of using the product and has the means to acquire the product. This segment is not necessarily the same segment in geographic different markets.
Domestic institutional aspects (split)	Domestic institutional aspects refer to the set of official rules, laws and standards present in the domestic market that can either block or stimulate the diffusion of a product.
Foreign institutional aspects (split)	Foreign institutional aspects refer to the set of official rules, laws and standards present in the foreign market that can either block or stimulate the diffusion of a product.
Knowledge of technology (no change)	All knowledge required to develop, replicate and control the technology on which the product relies.
Natural resources, labour and skills (renamed and new description)	The natural resources, labour resources and specific skills required to launch a product in an (export) market.
Knowledge of application (no change)	(1) Knowledge embedded in the firm, to develop a product with a certain application. (2) Knowledge embedded in the customer, on how to use the product
Socio-cultural business aspects (split)	The effects of foreign social norms and values on the way of doing business.
Socio-cultural demand and application aspects (split)	The effects of foreign social norms and values on how the product and its application are perceived.
Economic aspects (change in description)	The micro- (e.g. sunk costs) and international macro- (e.g. currency fluctuations) economic situation that influences the diffusion of the technology.
Accidents or events and (perceived) risk and uncertainty (renamed and new description)	Unexpected unfortunate events and the perceived risk on the future possibility of these events that influence the diffusion of the product.
Knowledge of the market (new)	Knowledge embedded in the firm about the socio-technical characteristics of a foreign market and possible business opportunities or threads following from these characteristics.
Innovativeness of the customer (new)	The degree to which a customer is motivated and driven to innovate and to acquire new products.
Financing aspects (new)	All aspects related to financing the release of a new product in an (export) market.
Competition (new)	Competition in export market from foreign companies with lower wages or local production facilities.

Table 49 The identified barriers and strategies, and the links between them (Olsthoorn, 2017)

Missing influencing factor	Missing core factor	Strategy mentioned by Ortt et al. (2013)
Knowledge of technology	New high-tech product	1: Demo, experiment and develop niche strategy; 3: Subsidised niche strategy; 4: Redesign niche strategy;
	Production system	3: Subsidised niche strategy; 4: Redesign niche strategy;
	Complementary products and services	5: Dedicated system or stand-alone niche strategy; 6: Hybridisation or adaptor niche strategy; **U1: Increase collaboration**
	Suppliers [network of organisations]	7: Educate niche strategy; **U1: Increase collaboration**
	Customers	7: Educate niche strategy; **U1: Increase collaboration** **E1: References**
	Foreign institutional aspect	8: Geographic niche strategy; **G1: network building** **U2: Lobby**
Natural resources, labour and skills	New high-tech product	3: Subsidised niche strategy; 4: Redesign niche strategy; 8: Geographic niche strategy;
	Production system	3: Subsidised niche strategy; 4: Redesign niche strategy;
	Complementary products and services	6: Hybridisation or adaptor niche strategy; 8: Geographic niche strategy;
	Financing	3: Subsidised niche strategy;
Knowledge of application	New high-tech product	3: Subsidised niche strategy; 4: Redesign niche strategy; 8: Geographic niche strategy;
	Suppliers (network of organisations)	9: Lead user niche strategy; **U1: Increase collaboration**
	Customers	9: Lead user niche strategy; 10: Explore multiple markets; **U1: Increase collaboration** **E3: References**
	Foreign institutional aspects	4: Redesign niche strategy; 8: Geographic niche strategy; **U2: Lobby**
Socio-cultural business aspects	Suppliers	9: Lead user niche strategy; **E2: Stepping stone strategy** **G1: network building**
	Customers	9: Lead user niche strategy; **E2: Stepping stone strategy** **G1: network building**
Socio-cultural demand and application aspects	Production system	3: Subsidised niche strategy; 4: Redesign niche strategy; **E2: Stepping stone strategy**
	Suppliers	4: Redesign niche strategy; 8: Geographic niche strategy; 9: Lead user niche strategy; **E2: Stepping stone strategy**
	Customers	4: Redesign niche strategy; 8: Geographic niche strategy; 9: Lead user niche strategy; **E2: Stepping stone strategy** **E3: References**
	Foreign institutional	4: Redesign niche strategy;

	aspects	8: Geographic niche strategy; **E2: Stepping stone strategy** **U2: Lobby**
	Innovativeness of the customer	7: Educate niche strategy; 9: Lead user niche strategy; **E2: Stepping stone strategy**
Economic aspects	Suppliers	8: Geographic niche strategy; 9: Lead user niche strategy;
	Customers	8: Geographic niche strategy; 9: Lead user niche strategy;
	Domestic institutional aspects	**U2: Lobby**
	Foreign institutional aspects	8: Geographic niche strategy; **U2: Lobby**
Economic aspects	Financing	(Macro) 3: Subsidised niche strategy; **U2: Lobby** 8: Geographic niche strategy (Micro) 1: Subsidised niche strategy; **U2: Lobby**
Accidents or events and (perceived) risk and uncertainty	Suppliers	9: Lead user niche strategy;
	Customers	9: Lead user niche strategy;
	Domestic institutional aspects	8: Geographic niche strategy;
	Foreign institutional aspects	8: Geographic niche strategy;
	Innovativeness of the customer	1: Subsidised niche strategy;
	Financing	9: Lead user niche strategy;
Knowledge of the market	Suppliers	7: Educate (staff) niche strategy (case specific) **E1: Market preparation**
	Customers	7: Educate (staff) niche strategy (case specific) **E1: Market preparation**
Foreign institutional aspects	New high-tech product	1: Demo, experiment and develop niche strategy; 4: Redesign niche strategy 8: Geographic niche strategy **G1: network building** **U2: Lobby**
	Production system	3: Subsidised niche strategy 4: Redesign niche strategy **G1: network building** **U2: Lobby**
	Suppliers (network of organisations)	8: Geographic niche strategy 9: Lead user niche strategy **G1: network building** **U2: Lobby**
	Customers	8: Geographic niche strategy 9: Lead user niche strategy **G1: network building** **U2: Lobby**
Competition	Customers	**G2: adapted top niche strategy** **C1: Get specified**

The definition of the newly identified strategies is as the following:

1. **Market preparation strategy**: acquiring necessary information about the market as well as improving the required skills before actually entering the market
2. **Steppingstone strategy**: targeting other markets that are geographically or culturally closer to the targeted market as a steppingstone towards the targeted market
3. **References strategy**: obtaining references from adjacent markets to then use them as marketing tool at the targeted market

4. **Network building strategy**: establishing required networks by attending formal and informal meetings
5. **Adapted top niche strategy**: aiming at the upper segment market by providing a very high-quality product
6. **Increase collaboration strategy**: improving the mutualism and long-term collaboration with other relevant actors
7. **Lobby strategy**: approaching the policy makers to influence the decision-making process
8. **Get specified strategy**: persuading, for example, consultants of big projects to get the new product/technology mentioned in the technical specification of the projects

A.1.3. Niche strategies selection in developing countries: a case study on RE-desalination by Nicole Jane van den Berg

Table 50 List of adapted and/or new core factors in comparison to the original ones (Van den Berg, 2017)

Core factors		
Original	**Adapted**	**Adapted Description**
New high-tech product	Relative affordability	The price of the product compared to its similar alternatives
Production system	Production system	(no change of description)
Complementary products and services	Complementary products and services	(no change of description)
Suppliers	Network of organizations	The coordination of multiple actors such as suppliers, NGOs, and communities
Customers	Customers market information	Any related information regarding the market application and customer segments
	Customers knowledge	Customers knowledge about the product
	Public awareness	Public knowledge about the product and its functions
Institutional aspects	Standards and support	All kind of standards and supporting systems needed to support the adoption of the product
	Political system	The stability of the political situation and the supports from the government in term of policy
	Legal system	Transparent and fair regulatory framework

Table 51 List of adapted and/or new influencing factors in comparison to the original ones (Van den Berg, 2017)

Influencing factors		
Original	**Adapted**	**Adapted Description**
Knowledge of technology	Developers' knowledge	Knowledge of technology that the developers have regarding how to develop, produce, control, and replicate the product as well as the complementary products and services
Natural resources and labours	Appropriately-skilled labours	The availability of skilled labours not only at the production of the product but also the complementary products and services
	Natural resources	All natural resouces needed to produce the product, the production facilities, and the complementary products and services
Knowledge of application	Knowledge of application	(no change of description)
Socio-cultural aspects	Cultural methods	Cultural related ways of doing something
	Cultural norms and values	Cultural related norms and values
Macro-economic aspects	Market structure (financial)	The structure of the market (for example the level of market liberalization or market transparency) and how the businesses are connected one to another.
	Purchasing power (financial access)	Supportive financial instruments that could enable the purchase of the product
Accidents or events	Accidents or events	(no change of description)
-	Physical/information access & infrastructure	Accessibility to the market and related information sources needed to support the development of the market, as well as the availability of related infrastructures

The three new strategies identified by Van den Berg (2017) are briefly explained in the following:

1. **Generation of social network strategy**: developing a social network by getting connected to various important actors and building trust and transparency within the network to, in the end, gain support from them
2. **Participation strategy**: putting more efforts to get the customers more involved and up to date to any development of the product; providing necessary support for the customers to access relevant information they need
3. **Local strategy**: providing/establishing various solutions locally, for example local financing, local partners, and local purchase agreements

Table 52 The identified barriers and strategies, and the links between them (Van den Berg, 2017)

Niche strategies	Suitable market situation		Description
Demo, experiment and develop	Technology developers' knowledge	Production system	Public demonstration; controlled; to improve quality; tackle uncertainties of technology; experimentation; adjustments for cultural values
	Cultural values and norms	Public awareness	
Top	Technology developers' knowledge	Relative affordability	Small-scale; hand-made products; top-end niche; special product to top niche customers; skimming strategy
	Technology developers' knowledge	Production system	
	Natural resources Appropriately-skilled labour	Relative affordability	
Subsidized	Technology developers' knowledge	Production system	Particular user segment; important/relevant for society
	Natural resources Appropriately-skilled labour	Relative affordability	
Redesign	Technology developers' knowledge	Production system	Simpler product; matching knowledge; low resources; lower price Exploration of application; favourable institutional aspects; no resistance from suppliers or customers
	Natural resources Appropriately-skilled labour	Relative affordability	
	Knowledge of application Cultural norms & values Cultural methods	Standards & support Political system Legal system	
	Cultural methods Cultural norms & values	Customers Suppliers	
Dedicated system or stand-alone	Technology developers' knowledge	Complementary products & services	Product/complementary products and services; dedicated system; self-sufficient; low maintenance
	Physical/ information infrastructure & access	Production system	
Hybridisation or adaptor	Technology developers' knowledge	Complementary products & services	Combination new product & old product; reuse of present complementary products & services.
	Natural resources Appropriately-skilled labour	Complementary products & services	
Educate	Technology developers' knowledge	Customers Suppliers	Knowledge transfer to suppliers; education/experimentation for customers; education certain mind-set; two-way learning/sharing
	Cultural methods	Standards & support	
	Cultural norms & values	Customer market information	
Geographic	Technology developers' knowledge Knowledge of application	Standards & support Political system Legal system	Location choices: less strict institutions; available resources, customers & suppliers; accidents & event uncommon; favourable standards & support
	Natural resources Appropriately-skilled labour	Complementary products & services	
	Cultural methods Cultural norms & values Purchasing power (financial access) Market structure (financial)	Suppliers Customers Standards & support Political system Legal system	
	Accidents or events	Standards & support Political system Legal system	

Niche strategies	Suitable market situation		Description
Lead user	Knowledge of application	Production system Customers Suppliers	Search for innovators experiment/co-develop product
	Purchasing power (financial access) Market structure (financial) Cultural methods Cultural norms & values Accidents or events	Customers Suppliers	
Explore multiple markets	Knowledge of application	Customer knowledge	Multiple customer applications; first applications analysed; new explorative uses stimulated in new applications
Generation of social network	Cultural methods	Standards & support	Involving government, NGO's, church; transparency & trust created
Participation	Cultural values & norms	Customer knowledge	Involving customers; deal with queries and requests; creating value
Local	Purchasing power (financial access)	Relative affordability	Local financing; local purchase agreements; local partners; less cultural gap; stronger organization network
	Cultural norms & values	Network of organizations (suppliers, NGOs, communities)	

A.2. Analysis of Strategies Identified from Master's Thesis Reports

As explained in Section 4.2.3., many new factors and strategies are identified by three different researchers, in which some of them are similar to each other. This appendix section elaborates the analysis done to eliminate the similarities between those identified factors and strategies.

Table 53, Table 54, and Table 55 shows the lists of identified TIS building blocks, the influencing factors, and the strategies respectively. By comparing each of the factor or building block with each other, one of the following actions is done to eliminate the similarities between them.

- **Removing** any duplicates from the list. Duplicates could be factors or strategies with (slightly) different names but have the same definition, purpose, and approach, as well as addressing the same problems. These factors and strategies are highlighted with **grey** color
- **Combining** any similar factors or strategies that have the same purpose but different approaches or slightly different definition. When the different approach does not necessarily require them to be split, then they could be combined. With this approach, we keep the factors and strategies at a general level, so that it could be implemented at many contexts. These factors and strategies are highlighted with **green** color
- Putting "**new building block**", "**new influencing factor**" or "**new strategy**" label to the ones that have no overlap definition, purpose, and approach with the previously defined factors or strategies. These new factors and strategies are highlighted with **yellow** color

- **Removing** factors or strategies that give too broad suggestion because they could be replaced by other factors or strategies that propose more specific suggestion. These factors and strategies are highlighted with **purple** color
- **Splitting** factors or strategies that contain of two or more different definitions and approaches. These factors and strategies are highlighted with **blue** color

The comparison is done by first comparing the newly identified factors and strategies with Ortt & Kamp's factors or Ortt's Ten Niche Strategies, and then comparing them with other factors and strategies identified by other researchers. Arguments are provided to support any chosen actions.

As shown by the tables, author's arguments towards certain factors changed after several iterations. In this case, the iterations were done while working on the analysis of Chapter 5, which help the author to re-evaluate the analysis that was done in this chapter, and lead to the revised arguments.

Table 53 Overview of all TIS building blocks identified by Ortt & Kamp (2022) and various master thesis literatures, actions will be implemented on them to eliminate the same or similar ones, and the supporting arguments

No.	TIS Bulding Blocks	Identified by	Definition	Initial Arguments (1st iteration)	Revised Arguments (after several iterations)
1	Product performance and quality	Ortt & Kamp (2022)	The product should be seen as a reasonable alternative by its prospective users by offering adequate performance and quality compared to its competitors now or soon in the future.	-	Other than having an adequate performance and quality, the product itself must be available for adoption. Therefore this building block should be rephrased to "Product availability, performance, and quality"
2	Product price	Ortt & Kamp (2022)	The innovative product could be provided with a competitive price. Being competitive also mean that product has a good price compared to its quality	-	-
3	Production system	Ortt & Kamp (2022)	Large-scale production facilities that could produce the products in good quality at high production rate	-	-
4	Complementary products and services	Ortt & Kamp (2022)	Supporting products and services to develop, produce, distribute, adopt, use, repair, maintain, and dispose the products	-	-
5	Network formation and coordination	Ortt & Kamp (2022)	The established and coordinated network of actors involved in the whole supply chain, such as the suppliers of the raw materials needed to build the products, the production workers who assembly or produce the products, the distributors, etc	-	-
6	Customers	Ortt & Kamp (2022)	Potential buyers who are aware of the product and its benefits, as well as have the knowledge, willingness, and means to acquire and use it	-	-
7	Innovation-specific institutions	Ortt & Kamp (2022)	Supporting formal and informal institutions	-	-
8	Product performance and quality	Schulz (2019)	The same as "Product performance and quality" building block by Ortt & Kamp (2022)	-	-
9	Product price	Schulz (2019)	The same as "Product price building block" by Ortt & Kamp (2022)	-	-
10	Production system	Schulz (2019)	The same as "Production system building block" by Ortt & Kamp (2022)	-	-
11	Complementary products and services	Schulz (2019)	The same as "Complementary products and services" building block by Ortt & Kamp (2022)	-	-
12	Network formation and coordination	Schulz (2019)	The same as "Network formation and coordination" building block by Ortt & Kamp (2022)	-	-
13	Customers	Schulz (2019)	The same as "Customers" building block by Ortt & Kamp (2022)	-	-
14	Innovation-specific institutions	Schulz (2019)	The same as "Innovation-specific institutions" building block by Ortt & Kamp (2022)	-	-
15	New high-tech product	Olsthoorn (2017)	The product functions well, the technological principle works well, and the other components of the system are present. Moreover, the product should meet required technical circumstances and standards	This building block could be combined with "Product performance and quality" building block by Ortt & Kamp (2022) because they have the same focuses: the product with sufficient quality and performance	-
16	Production system	Olsthoorn (2017)	The same as "Production system" building block by Ortt & Kamp (2022)	-	-
17	Complementary products and services	Olsthoorn (2017)	The same as "Complementary products and services" building block by Ortt & Kamp (2022)	-	-
18	Suppliers (network of organization)	Olsthoorn (2017)	The relevant network of actors are available either at domestic or foreign market, as well as foreign representatives and agents	This building block could be combined with "Network formation and coordination" building block by Ortt & Kamp (2022) because they have the same focus: network of actors despite the different contexts. Olsthoorn focused more at the foreign markets while Ortt & Kamp focused on general markets. However, for the framework, it is better to keep it at a general level so that it could be implemented in many contexts	-
19	Customers	Olsthoorn (2017)	The same as "Customers" building block by Ortt & Kamp (2022)	-	-
20	Domestic institutional aspects	Olsthoorn (2017)	Supporting formal and informal institutions at the domestic market	These building blocks could be combined with "Innovation-specific institutions" building block by Ortt & Kamp (2022). "Innovation-specific institutions" building block is indeed could be applied in different contexts (in this case domestic and foreign markets), but I personally do not see the need to split this building block for each context because other cases might require other different contexts. Thus, it is better to keep the framework at a general level	-
21	Foreign institutional aspects	Olsthoorn (2017)	Supporting formal and informal institutions at the foreign markets		

No.	TIS Bulding Blocks	Identified by	Definition	Initial Arguments (1st iteration)	Revised Arguments (after several iterations)
22	Innovativeness of the customers	Olsthoorn (2017)	Customers' degree of motivation to be innovative and acquire the product	I agree that customers' degree of innovativeness could influence their willingness to adopt a new innovative product. However, I disagree that customers' degree of innovativeness should be put as a TIS building block. Instead, the root cause of the customers' low innovativeness should be defined to find good strategies to solve it. For example, customers' low innovativeness could be caused by customers' lack of knowledge of the product, lack of financial resources, or could be influenced by norms/values/habits in their society. Addressing the customers' low innovativeness issue in more specific way would lead to a more effective strategy. Thus, this building block could be removed	-
23	Financing aspects	Olsthoorn (2017)	All financing aspects required to introduce the product in the market	New building block. Introducing a new product into the market require high initial investment. Thus, it is important for an innovator to have a strong financial back-ups, especially because it might take some time for a product to get adopted and the innovator could gain profits from it. Moreover, even though financial resources is already addressed as an influencing factor, it is also important to address financing aspects as a TIS building block because the availability of financing aspects could be influenced by many factors, which could pose as barriers and would need some strategies to overcome them	I agree that introducing a new product into the market require high investment. Thus, it is important for an innovator to have a strong financial, especially because it might take some time for a product to get adopted and the innovator could gain profits from it. However, as financial condition influences the dynamic of many other TIS factors and it has been addressed by Ortt & Kamp (2022) as an influencing factor, thus I do not see the need of adding "Financial aspects" as a new building block. Therefore, this factor could be removed
24	Relative affordability	Van den Berg (2017)	The price of the product compared to its similar alternatives	This building block could be combined with "Product price" building block by Ortt & Kamp (2022) because they have the same focus: competitive price of the product	-
25	Production system	Van den Berg (2017)	The same as "Production system" by Ortt & Kamp (2022)	-	-
26	Complementary products and services	Van den Berg (2017)	The same as "Complementary products and services" by Ortt & Kamp (2022)	-	-
27	Network of organization	Van den Berg (2017)	The same as "Network formation and coordination" by Ortt & Kamp (2022)	-	-
28	Customer market information	Van den Berg (2017)	Any related customer-related information needed to define the market application and customer segments so that the demand could be met	New building block. However, it could be rephrased to "Information" building block to make it more general. The reason is because all information about the company as well as the product need to be spread well among the related stakeholders to create awareness, which is very important for the diffusion and adoption of the product	I agree that customer-related information is an important factor that could influence the innovators capability to gain the market. However, there is no need to add this factor as a new TIS building block because then it will be redundant with the "Knowledge of the market" and "Knowledge of application" influencing factors. When the innovators have a good knowledge of the market and application, they should know the customers needs and demands. Thus, this factor could be removed
29	Customer knowledge	Van den Berg (2017)	Customers knowledge about the product	I agree that customers knowledge would influence their willingness to adopt a new product. However, there is no need to add this factor as a new TIS building block because it is already addressed by "Customers" building block combined by either "Knowledge and awareness of technology" or "Knowledge and awareness of application and market" influencing factor. Thus, this building block could be removed	-
30	Public awareness	Van den Berg (2017)	Public knowledge about the product and its functions	I agree that public awareness would influence their willingness to adopt a new product. However, there is no need to add this as a new TIS building block because public awareness is created when the customers have the knowledge about the product and/or its application. Thus, it is already addressed by "Customers" building block combined by either "Knowledge and awareness of technology" or "Knowledge and awareness of application and market" influencing factor. Therefore, this building block could be removed	-
31	Standards and support	Van den Berg (2017)	All kind of standards and supporting systems needed to support the adoption of the product	This building block could be removed because standards and supporting systems are part of institutions. Thus, it has been addressed by "Innovation-specific institutions" building block by Ortt & Kamp (2022)	-
32	Political system	Van den Berg (2017)	The stability of the political situation and the supports from the government in term of policy	New building block. A stable political situation is indeed important for the development and diffusion of an innovation. At the opposite, an unstable political situation would pose bigger risks for related stakeholders would then influence the development, diffusion, and adoption of the product	A stable political situation is indeed important for the development and diffusion of an innovation. At the opposite, an unstable political situation would pose bigger risks for related stakeholders which then would influence the development, diffusion, and adoption of the product. However, I disagree to make this factor as a new building block as it is not a core element that the innovator must have to reach mass adoption. Instead, I prefer to frame it as an influencing factor because it influences the dynamic of other building blocks. Hence, this factor could be combined with "Institutional aspects" influencing factor that will be explained in the next section
33	Legal system	Van den Berg (2017)	Transparent and fair regulatory framework	This building block could be combined with "Innovation-specific institutions" building block by Ortt & Kamp (2022) because the availability of the supportive institutions should be complemented by a transparent and fair regulatory framework to make the institutions effective	-

Table 54 Overview of all influencing factors identified by Ortt & Kamp (2022) and various master thesis literatures, actions will be implemented on them to eliminate the same or similar ones, and the supporting arguments

No.	Influencing Factors	Identified by	Definition	Initial Arguments (1st iteration)	Revised Arguments (after several iterations)
1	Knowledge and awareness of technology	Ortt & Kamp (2022)	Knowledge and awareness about the fundamental and applied technology around the product as well as the complementary products and services that are needed to make the product available	-	-
2	Knowledge and awareness of application and market	Ortt & Kamp (2022)	Knowledge in using the innovation into certain applications	This influencing factor could be splitted into two different influencing factors as proposed by Olsthoorn (2017): "Knowledge of application" and "Knowledge of the market" because each of these influencing factors could lead to different barriers that might need different strategies to overcome them	Knowledge of market and knowledge of application are two different things, however, there is no need to split them up as they influence the building blocks in a similar way, hence require the same strategies to circumvent them
3	Natural, human, and financial resources	Ortt & Kamp (2022)	Natural, human, and financial resources needed for the large-scale commercialization of a product	This influencing factor could be splitted into three different influencing factors as proposed by Schulz (2019): "Natural resources", "Human resources", and "Financial resources" because each of these influencing factors could lead to different barriers that might need different strategies to overcome them	-
4	Competition	Ortt & Kamp (2022)	Existence of alternative products and services produced by other companies that cause rivalry between the companies	-	-
5	Macro-economic and strategic aspects	Ortt & Kamp (2022)	Macro-economic situations such as economic growth and market structure that could influence the diffusion and adoption of an innovation	-	-
6	Socio-cultural aspects	Ortt & Kamp (2022)	The big forces that influence the society's values, behavior, way of thinking and doing things	This influencing factor could be splitted into two different influencing factors as proposed by Olsthoorn (2017): "Socio-cultural business aspects" and "Socio-cultural demand and application aspects" because each of these influencing factors could lead to different barriers that might need different strategies to overcome them	Apparently, splitting this influencing factor makes it too specific and it does not address the whole possible socio-cultural aspects. Therefore, it is better to keep this influencing factor as it is
7	Accidents and events	Ortt & Kamp (2022)	Accidents and events occurred within and outside of the TIS could influence the forming of the TIS building blocks	-	-
8	Knowledge and awareness of technology	Schulz (2019)	The same as "Knowledge and awareness of technology" by Ortt & Kamp (2022)	-	-
9	Knowledge and awareness of application and market	Schulz (2019)	The same as "Knowledge and awareness of application and market" by Ortt & Kamp (2022)	-	-
10	Human resources	Schulz (2019)	Human resources needed for the large-scale commercialization of a product	New influencing factor, split from "Natural, human, and financial resources" influencing factor by Ortt & Kamp (2022)	-
11	Natural resources	Schulz (2019)	Natural resources needed for the large-scale commercialization of a product	New influencing factor, split from "Natural, human, and financial resources" influencing factor by Ortt & Kamp (2022)	-
12	Financial resources	Schulz (2019)	Financial resources needed for the large-scale commercialization of a product	New influencing factor, split from "Natural, human, and financial resources" influencing factor by Ortt & Kamp (2022)	-
13	Macro-economic and strategic aspects	Schulz (2019)	The same as "Macro-economic and strategic aspects" by Ortt & Kamp (2022)	-	-
14	Socio-cultural aspects	Schulz (2019)	The same as "Socio-cultural aspects" by Ortt & Kamp (2022)	-	-
15	Accidents and events	Schulz (2019)	The same as "Accidents and events" by Ortt & Kamp (2022)	-	-
16	Knowledge of technology	Olsthoorn (2017)	The same as "Knowledge and awareness of technology" by Ortt & Kamp (2022)	-	-
17	Natural resources, labors, and skills	Olsthoorn (2017)	Natural resources, labors, and specific skills required to introduce the product into the market	This influencing factor could be removed because natural resources and labors are already addressed by Schulz (2019) as separate influencing factors, while skills factor is already addressed by Ortt & Kamp (2022) as "Knowledge and awareness of technology" influencing factor	-
18	Knowledge of application	Olsthoorn (2017)	Company's knowledge to develop a product to fit into certain application, as well as customers' knowledge to utilize the product in certain application	New influencing factor, split from "Knowledge and awareness of application and market" influencing factor by Ortt & Kamp (2022). However, it could also include the knowledge owned by relevant stakeholders that could help the development and commercialization of the innovation	This influencing factor could be removed because knowledge of application is already addressed by Ortt & Kamp (2022) as "Knowledge and awareness of application and market"
19	Socio-cultural business aspects	Olsthoorn (2017)	The influences of social norms and values on how to do the business	New influencing factor, split from "Socio-cultural aspects" by Ortt & Kamp (2022). However, this influencing factor could be rephrased to "Business related socio-cultural aspects" to make it easier to understand	These influencing factors could be removed as it is addressed by the socio-cultural aspects identified by Ortt & Kamp (2022)
20	Socio-cultural demand and application aspects	Olsthoorn (2017)	The influences of social norms and values on how the product is perceived	New influencing factor, split from "Socio-cultural aspects" by Ortt & Kamp (2022). However, this influencing factor could be rephrased to "Product related socio-cultural aspects" to make it easier to understand	

No.	Influencing Factors	Identified by	Definition	Initial Arguments (1st iteration)	Revised Arguments (after several iterations)
21	Economic aspects	Olsthoorn (2017)	The micro- and macro-economic aspects that affect the diffusion of the product	This influencing factor could be combined with "Macro-economic and strategic aspects" influencing factor by Ortt & Kamp (2022) because both micro- and macro-economic aspects could influence the diffusion of the product	This influencing factor could be removed because economic aspects is already addressed by Ortt & Kamp (2022) as "Macro-economic" influencing factor, while micro-economic could be framed as "Financial resources" which was addressed by Schulz (2019)
22	Accidents or events and (perceived) risk and uncertainty	Olsthoorn (2017)	Unexpected unfortunate events and risks that affect the diffusion of the product	This influencing factor could be combined with "Accidents and events" influencing factor by Ortt & Kamp (2022) because it has the same focus: unexpected accidents or events. However, fortunate events could also affect the difussion of the product, for example, unexpected economic growth could increase customers buying power which then could increase the adoption of an innovation. Thus, the word "unfortunate" should be removed from the definition	-
23	Knowledge of the market	Olsthoorn (2017)	Company's knowledge about market's socio-technical characteristics as well as business opportunities and threats that might emerged due to the market characteristics	New influencing factor, split from "Knowledge and awareness of application and market" influencing factor by Ortt & Kamp (2022). However, it could also include the knowledge owned by relevant stakeholders that could help the development and commercialization of the innovation	This influencing factor could be removed because knowledge of the market is already addressed by Ortt & Kamp (2022) as "Knowledge and awareness of application and market"
24	Foreign institutional aspects	Olsthoorn (2017)	Supporting formal and informal institutions at the foreign markets	New influencing factor. The present or absent of institutions could influence the status of other factors in supporting the diffusion of the product. However, this influencing factor could be rephrased to "Institutional aspects" to make it more general so that it could be applied to different contexts	New influencing factor. The present or absent of institutions could influence the status of the building blocks in supporting the diffusion of the product. However, the "foreign" term here could be removed to make it more general, so it could be implemented in a wider context. Moreover, this influencing factor could be combined with "Political system" influencing factor that was identified in the previous section. Thus, this factor couls be rephrased to "Institutional aspects and political system"
25	Competition	Olsthoorn (2017)	The same as "Competition" by Ortt & Kamp (2022)	-	-
26	Developers' knowledge	Van den Berg (2017)	Knowledge of technology that the developers have regarding how to develop, produce, control, and replicate the product as well as the complementary products and services	The definition of this influencing factor is similar to "Knowledge and awareness of technology" by Ortt & Kamp (2022). The only different is that Van den Berg specifically focused this influencing factor to the knowledge owned by the product developer, while Ortt & Kamp addressed it as knowledge owned by any relevant stakeholders. For this research, I personally prefer to address this influencing factor in a general context, even though I agree that splitting this influencing factor into knowledge owned by different actors might lead to different barriers that would require different strategies to overcome them. However, due to limited duration of this research, it is better to keep this influencing factor at a general level and address it as a future research	-
27	Appropriately-skilled labour	Van den Berg (2017)	The availability of skilled labours not only at the production of the product but also the complementary products and services	This influencing factor is the same as "Human resources" influencing factor by Schulz (2019)	-
28	Natural resources	Van den Berg (2017)	All natural resouces needed to produce the product, the production facilities, and the complementary products and services	This influencing factor is the same as "Natural resources" influencing factor by Schulz (2019)	-
29	Knowledge of application	Van den Berg (2017)	The same as "Knowledge application" by Olsthoorn (2017)	-	-
30	Cultural methods	Van den Berg (2017)	Cultural related ways of doing something	These influencing factors should not be split because norms and values influence ways of people doing things. Moreover, these influencing factors could be removed as they are covered by previously defined	-
31	Cultural norms and values	Van den Berg (2017)	Cultural related norms and values		
32	Market structure	Van den Berg (2017)	The structure of the market (for example the level of market liberalization or market transparency) and how the businesses are connected one to another.	Market structure is one of macro-economic aspects. Thus, this influencing factors could be removed because it is covered by "Macro-economic and strategic aspects" influencing factors proposed by Ortt & Kamp (2022)	-
33	Purchasing power	Van den Berg (2017)	Supportive financial instruments that could enable the purchase of the product	The customers have a good purchasing power when they have good financial resources. Thus, this influencing factors could be removed because it is covered by "Customers" building block combined with "Financial resources" influencing factors	-
34	Accident or events	Van den Berg (2017)	The same as "Accidents and events" by Ortt & Kamp (2022)	-	-
35	Physical/information access & infrastructure	Van den Berg (2017)	Accessibility to the market and related information sources needed to support the development of the market, as well as the availability of related infrastructures	New influencing factor. This influencing factor is important because market accessibility could directly influence the adoption rate. Moreover, the availability and access to the infrastructure would give significant support to the diffusion and adoption of the product	-

Table 55 Overview of all strategies identified by Ortt et al. (2013) and various master thesis literatures, actions will be implemented on them to eliminate the same or similar ones, and the supporting arguments

No.	Strategies	Identified by	Definition	Analysis
1	Demo, experiment, and develop niche strategy	Ortt et al. (2013)	Demonstrating the product in public while the product research and development could be continued to overcome the limited quality of the product	-
2	Top niche strategy	Ortt et al. (2013)	Producing a special product in small scale to serve specific top niche of customers	-
3	Subsidized niche strategy	Ortt et al. (2013)	Implementing subsidy on the product price to particular segment of users to provide reasonable price	-
4	Redesign niche strategy	Ortt et al. (2013)	Redesigning the product into a simpler or slightly different version that match the current state of knowledge	-
5	Dedicated system or stand-alone niche strategy	Ortt et al. (2013)	Suggesting the use of the product in a dedicated or stand-alone system to overcome the lack of widely available infrastructure or complementary products and services	-
6	Hybridization or adaptor niche strategy	Ortt et al. (2013)	Coupling the product with the old products and system in order to re-use the existing complementary products and services	-
7	Educate niche strategy	Ortt et al. (2013)	Improving the knowledge of the suppliers and the customers	-
8	Geographic niche strategy	Ortt et al. (2013)	Exploring new geographical areas which provide less barriers to the core factors	-
9	Lead user niche strategy	Ortt et al. (2013)	A niche strategy that focused on serving lead users and innovators so they could by co-develop the product. This strategy could also circumvent barriers in which the availability of the product and suppliers are limited due to the influence of socio-cultural aspects, macro-economic aspects, or accidents and events	-
10	Explore multiple markets niche strategy	Ortt et al. (2013)	Exploring new multiple customer applications	-
11	Different application strategy	Schulz (2019)	Integrating the product/technology into a different application	This strategy could be removed as it has similar purpose with Explore multiple markets niche strategy by Ortt et al. (2013) in which multiple alternative applications/markets are explored to then integrate the product/technology into those new applications/markets
12	Technological R&D strategy	Schulz (2019)	Putting more effort on experimentation in a research environment to further develop the company's technological knowledge	New strategy. This strategy is important as its implemented could bring many benefits: to improve product's quality and performance, to maintain product's technical competitiveness and innovativeness, to make the product easier to use and produce, to lower the cost of the product, etc.
13	Pilot R&D strategy	Schulz (2019)	Performing a small scale research project by using the innovation in practice to gain real-life insights of the product	This strategy could be combined with Schulz's Technological R&D strategy because they have exactly the same purpose despite the different approach in conducting the research: either in a research environment or in practice. However, the different approach does not necessarily require these strategies to be split
14	Pilot project strategy	Schulz (2019)	Conducting pilot project to show the use and benefits of the product to the public and potential stakeholders	This strategy could be combined with Demo, experiment, and develop niche strategy by Ortt et al. (2013) because it has the same purpose and approach
15	Human resource management strategy	Schulz (2019)	Hiring new employees or interns that have expertise on the new technological fundamentals to improve the company's internal knowledge	New strategy. As human resource is one of the most important factors in TIS, thus human resource management strategy is important. Having more experts in the loop and putting the right person at the right place could significantly influence the TIS dynamic which then could potentially solve some barriers. Moreover, hiring experts could save company's money and time because the experts have invested their money and time to build up their expertise, so the company do not need to train them further. Additionally, hiring experts also good for company's reputation
16	Market research strategy	Schulz (2019)	Conducting further market research to improve the understanding of current trends, demand, and competition in the market	This strategy could be combined with Explore multiple markets niche strategy by Ortt et al. (2013) because it has the same purpose: to do further market research to see if the technology innovation could be applied in another new market
17	Internal knowledge sharing strategy	Schulz (2019)	Improving the technical knowledge within the company by initiating various meeting sessions or in-house training to facilitate the transfer of knowledge among the employees	New strategy. This strategy could be a good complement of the "Human resource management strategy". Having the right experts and putting them at the right strategic positions is important, but it would be significantly more effective if these experts could also share their expertise to their colleagues which could improve overall results and productivity
18	Redesign strategy	Schulz (2019)	The same as Redesign strategy by Ortt et al. (2013)	-

No.	Strategies	Identified by	Definition	Analysis
19	Partnership strategy	Schulz (2019)	Starting a partnership, for example, with the third parties who have expertise on certain knowledge and competence that are still lacking within the company or with other company who needs the same raw material so that it could be bought in bulk to get a cheaper price	New strategy. Strategic partnership is indeed important to strengthen the collaborating companies as well as to help them to reach mutual goals faster and easier by overcoming many barriers. Other examples of partnership: collaboration with the providers of the complimentary products and services to put massive advertisements on social medias to create product awareness, collaboration with competitors in expensive R&D and then use the results of the R&D together
20	Finance sourcing strategy	Schulz (2019)	Initiating certain actions that could bring additional financial resources into the company	New strategy. To achieve company's short and long term goals, the company must have a good finance. It is even more critical in the phase in which the product is just invented and about to be released to the market because this phase require high investment cost with no revenue and profit. Thus, acquiring financial supports from the third parties could influence company's success
21	Direct lobbying strategy	Schulz (2019)	Initiating an approach towards the policy makers to proposed new or adapted institutions and policies that could support the development and adoption of the product in the society	New strategy. When innovations just invented, they often do not have supporting institutions around them because of various reasons: the technologies were not existed previously, low public awareness towards the products or technologies, etc. Thus, direct lobbying is not only important for the innovators to get an access to government legislators to get institutional support, but also to help the government to be more productive in designing its policies as the legislators are not able to oversee all the interests of the citizens. However, this strategy could be rephrase into "Lobbying strategy" to make it more general. Thus, the definition could also be generalized other than only focus on lobbying policy makers
22	Indirect lobbying strategy	Schulz (2019)	Establishing a good cooperation with certain actors to raise the awareness of the negative influence of the existing systems and to highlight the benefits that the new product could bring	New strategy. However, this strategy could be rephrased to "Influencer marketing strategy". Influencers are individuals who have strong impact on certain industries and have big followers base. They could be beauty bloggers, photographers, designers, athletes, etc. Establishing a good collaboration with these influencers could help to boost brand awareness and trust because they have gained certain level of trust from their followers. Moreover, a recommendation from an influencer look more authentic which could be accepted easily by the followers
23	Changing behavior strategy	Schulz (2019)	Initiating certain actions that could help to shift the society's habits and behaviors that could positively influence the position of the product in the market	This strategy could be removed because the suggestion is too broad. Some other strategies are actually addressing this issue in more specific ways, such as Lobbying strategy (to establish supportive institutions that could shift society's habits and behaviors as well as providing necessary incentives to motivate them), Influencer marketing strategy (to influence customers' perception and image towards the product), and Educate strategy (to provide them necessary knowledge to understand the importance and benefits of switching to the new product), which I think a more effective way of proposing strategies
24	Crowd-sourcing strategy	Schulz (2019)	Involving the public to generate ideas and solutions to improve the quality of the product	New strategy. Involving more people is not only good for ideation process but also good to create better awareness and word-of-mouth. Moreover, ideation process could be faster and unexpected better solution could be generated
25	Lead-user strategy	Schulz (2019)	The same as Lead user niche strategy by Ortt et al. (2013)	-
26	Top-end strategy	Schulz (2019)	The same as Top niche strategy by Ortt et al. (2013)	-
27	Leasing strategy	Schulz (2019)	Selling the product with a leasing contract to spread the high initial cost of the product into a certain time period which could improve the affordability of the product	New strategy. Leasing is beneficial for both the lessor and lessee. For the lessor, it could help to make the product more financially interesting and competitive which then deliver cash flow for the lessor. For the lessee, leasing is not only giving him a low financing option, but also eliminate ownership risks as well as giving a flexibility (he could just return the product when the leasing contract ended instead of having the hassle to find another buyer to handover the ownership)
28	Sharing platform strategy	Schulz (2019)	Initiating a sharing platform in which the multiple users could share the use of the product	New strategy. However, "Sharing economy platform" strategy is a better term for it because it is not only about building the platform to facilitate the sharing use of the product, but it also require the development of the sharing business models. The implementation of this strategy provide similar benefits to both lessor and lessee compared to the leasing strategy
29	Subsidy strategy	Schulz (2019)	The same as Subsidized niche strategy by Ortt et al. (2013)	-
30	Geographical strategy	Schulz (2019)	The same as Geographic niche strategy by Ortt et al. (2013)	-

No.	Strategies	Identified by	Definition	Analysis
31	Hybridization strategy	Schulz (2019)	Coupling the product with the old products and system in order to re-use the existing complementary products and services	These strategies are the split of Hybridization or adaptor niche strategy by Ortt et al. (2013). Eventhough these strategies require different approaches that need to be done by the company, however, the purpose of the strategies is the same. Thus, there is no need to split them
32	Adaptor strategy	Schulz (2019)	Designing and providing an adaptor so that the new product is compatible with the existing systems and their complementary products and services	
33	Stand-alone strategy	Schulz (2019)	Offering the product in stand-alone system so that the product could be use without the need of complementary products and services	These strategies were split due to their different definition and approach despite their same purpose: to overcome the lack of complementary products and services. However, the different approach does not necessarily require these strategies to be split. Thus these strategies could be removed as they are the same as Dedicated system or stand-alone niche strategy by Ortt et al. (2013)
34	Dedicated strategy	Schulz (2019)	Offering the product in a dedicated system in which the complementary products and services are designed based on the current state of knowledge or resources	
35	Education strategy	Schulz (2019)	The same as Educate niche strategy by Ortt et al. (2013)	-
36	Restructuring business strategy	Schulz (2019)	Splitting the company into two different companies. This strategy could be adopted, for example, to give a new and better image to the company to the new potential customers or related stakeholders	New strategy. However, I prefer to frame this strategy at a more general level, in which restructuring could be done not only to split the company (as argued by Schulz), but also to merge or acquire multiple companies into one larger company. Thus, the name of the strategy could be rephrase to "Corporate restructuring" strategy. Mergers and acquisitions could bring benefits such as to reduce competition, to achieve better economies of scale, to increase market share, to gain higher corporate status, etc.
37	Buy one - give one strategy	Schulz (2019)	Selling a product, for example, to the top-end customers who could afford the product with current price and at the same time giving one free product to the targeted customer who still could not afford it	New strategy. This strategy could help to build the network externalities which in the end could lead into better public awareness, better perceived value of the product, and boost the adoption of the product. Public could be attracted easily with this strategy because it gives them a better feeling to know that when they buy the product, they are contributing into a good cause: donating another product for someone else
38	Joining regulation agency strategy	Schulz (2019)	Taking part as a member of certain regulation agency to influence the policy making	This strategy could be combined with Direct lobbying strategy by Schulz (2019) because it has the same purpose despite their different approaches. However, I think the different approaches do not require these strategies to be split
39	Campaign funding strategy	Schulz (2019)	Influencing the policy maker who design the institutions by supporting their campaigns	New strategy. Funding politicians campaigns could help to influence their moral values as well as to give a stronger position towards the funder and its interests
40	Demo, experiment, and develop niche strategy	Olsthoorn (2017)	The same as Demo, experiment, and develop niche strategy by Ortt et al. (2013)	-
41	Adapted top niche strategy	Olsthoorn (2017)	Aiming at the upper segment market by providing a very high-quality product	This strategy is the same as Top niche strategy by Ortt et al. (2013) because the main focus of top niche strategy it to target high-end customers who has more buying power so that the expensive product price will not be an issue for them to acquire the product
42	Subsidized niche strategy	Olsthoorn (2017)	The same as Subsidized niche strategy by Ortt et al. (2013)	-
43	Redesign niche strategy	Olsthoorn (2017)	The same as Redesign niche strategy by Ortt et al. (2013)	-
44	Dedicated/ stand-alone niche strategy	Olsthoorn (2017)	The same as Dedicated/ stand-alone niche strategy by Ortt et al. (2013)	-
45	Hybridization/ adaptor niche strategy	Olsthoorn (2017)	The same as Hybridization/ adaptor niche strategy by Ortt et al. (2013)	-
46	Educate niche strategy	Olsthoorn (2017)	The same as Educate niche strategy by Ortt et al. (2013)	-
47	Geographic niche strategy	Olsthoorn (2017)	The same as Geographic niche strategy by Ortt et al. (2013)	-
48	Lead user niche strategy	Olsthoorn (2017)	The same as Lead user niche strategy by Ortt et al. (2013)	-
49	Explore markets niche strategy	Olsthoorn (2017)	The same as Explore markets niche strategy by Ortt et al. (2013)	-
50	Market Preparation strategy	Olsthoorn (2017)	Acquiring necessary information about the market as well as improving the required skills before actually entering the market	This strategy could be removed because the suggestion is too broad. Some other strategies are actually addressing similar preparation and improvement approach in more specific way such as the Educate strategy, Technological R&D strategy, etc. which I think a more efficient way of proposing a strategy
51	Stepping-stone strategy	Olsthoorn (2017)	Targeting other markets that are geographically or culturally closer to the targeted market as a steppingstone towards the targeted market	These strategies could be combined because entering other markets that are geographically or culturally closer to the targeted market is basically an approach to get good references before pursuing the targeted market
52	References strategy	Olsthoorn (2017)	Obtaining references from adjacent markets to then use them as marketing tool at the targeted market	

No.	Strategies	Identified by	Definition	Analysis
53	Network building strategy	Olsthoorn (2017)	Establishing required networks by attending formal and informal meetings	New strategy. However, it could be rephrased to "Networking" strategy to make it more concise. Networking could bring many benefits for the company. It helps the company to gain the latest news about the new trends as well as to meet new important people who could be valuable for the company and its business such as technological experts, potential investors or potential partners. Additionally, networking could help a company to gain access to certain valuable resources that could foster the company's development
54	Increase collaboration strategy	Olsthoorn (2017)	Improving the mutualism and long-term collaboration with other relevant actors	This strategy could be combined with Partnership strategy by Schulz (2019) because the purpose of the networking is to establish a good partnership with relevant stakeholders, to then bring benefits for each others
55	Lobby strategy	Olsthoorn (2017)	Approaching the policy makers to influence the decision-making process	This strategy could be combined with Direct lobbying strategy by Schulz (2019) because it has exactly the same purpose and approach
56	Get specified strategy	Olsthoorn (2017)	Persuading, for example, consultants of big projects to get the new product/technology mentioned in the technical specification of the projects	New strategy. Getting the new product/technology mentioned in the technical specification of the projects could indeed improve the awareness of important decision makers in the project towards the new product/technology. This would in the end lead to higher chance of product adoption
57	Demo, experiment, and develop niche strategy	Van den Berg (2017)	The same as Demo, experiment, and develop niche strategy by Ortt et al. (2013)	-
58	Top niche strategy	Van den Berg (2017)	The same as Top niche strategy by Ortt et al. (2013)	-
59	Subsidized niche strategy	Van den Berg (2017)	The same as Subsidized niche strategy by Ortt et al. (2013)	-
60	Redesign niche strategy	Van den Berg (2017)	The same as Redesign niche strategy by Ortt et al. (2013)	-
61	Dedicated/ stand-alone niche strategy	Van den Berg (2017)	The same as Dedicated/ stand-alone niche strategy by Ortt et al. (2013)	-
62	Hybridization/ adaptor niche strategy	Van den Berg (2017)	The same as Hybridization/ adaptor niche strategy by Ortt et al. (2013)	-
63	Educate niche strategy	Van den Berg (2017)	The same as Educate niche strategy by Ortt et al. (2013)	-
64	Geographic niche strategy	Van den Berg (2017)	The same as Geographic niche strategy by Ortt et al. (2013)	-
65	Lead user niche strategy	Van den Berg (2017)	The same as Lead user niche strategy by Ortt et al. (2013)	-
66	Explore markets niche strategy	Van den Berg (2017)	The same as Explore markets niche strategy by Ortt et al. (2013)	-
67	Generation of social network strategy	Van den Berg (2017)	Developing a social network by getting connected to various important actors and building trust and transparency within the network to, in the end, gain support from them	This strategy could be combined with Network building strategy by Olsthoorn (2017) because it has exactly the same purpose and approach
68	Participation strategy	Van den Berg (2017)	Putting more efforts to get the customers more involved and up to date to any development of the product; providing necessary support for the customers to access relevant information they need	This strategy could be combined with Crowd-sourcing strategy by Schulz (2019) because it has exactly the same purpose and approach
69	Local strategy	Van den Berg (2017)	Providing/establishing various solutions locally, for example local financing, local partners, and local purchase agreements	New strategy. This strategy could give the company more control on the solutions, as well as to receive better support from the local partners due to more efficient communication (face to face meeting or site survey is easier to conduct as the partners are close by) and more efficient and reliable supply chain. Additionally, as it gives economic contributions to the local community, it probably would bring back more benefits to the company such as better brand awareness

A.3. Identification of Potential Strategies Based on Journals

This section consists of extra information extracted from Iqbal et al. (2021)'s journal to complement Chapter 4.2.2.3.

Table 56 Identified barriers and strategies of sustainable energy technologies in the construction industry in Pakistan (Iqbal et al., 2021)

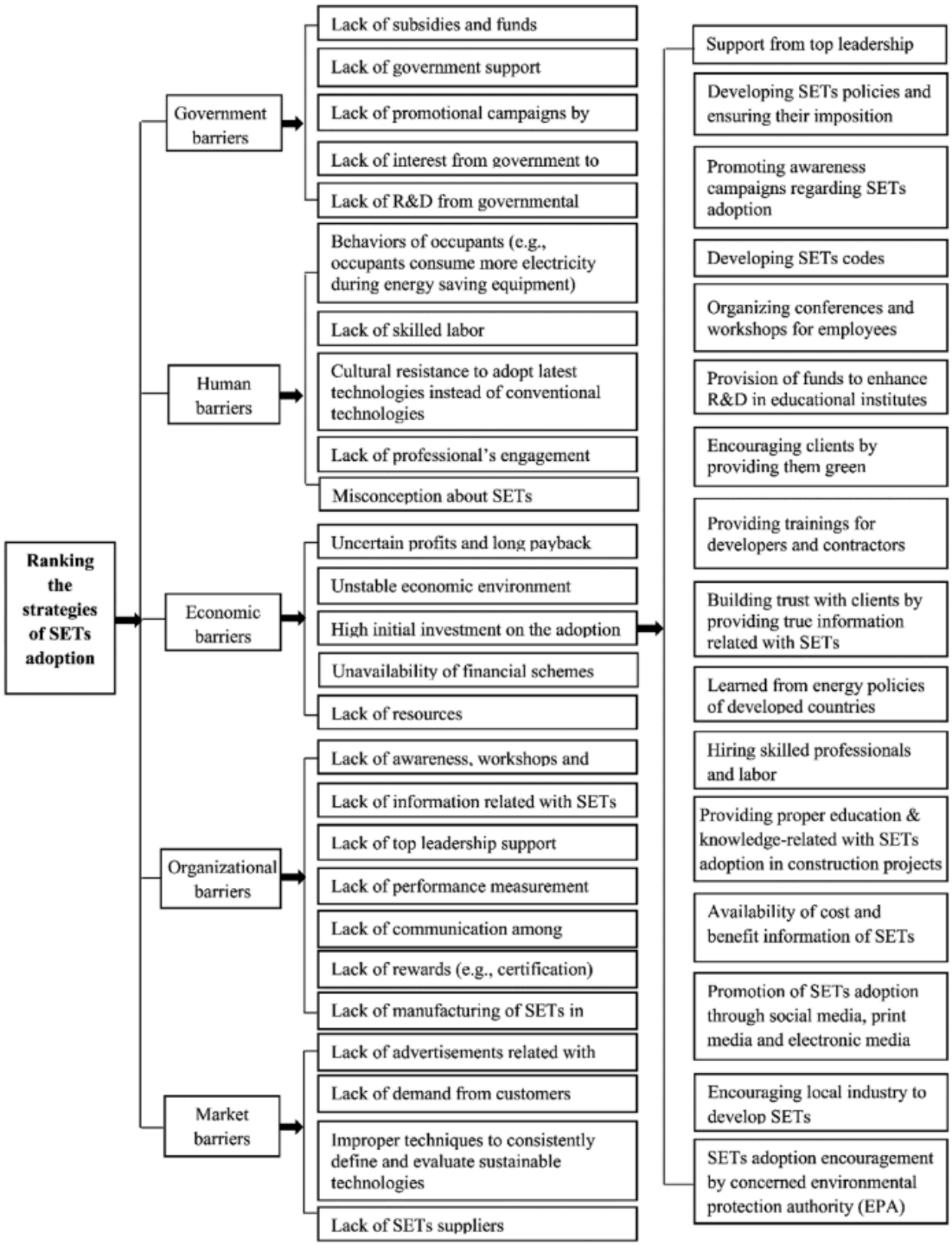


Table 57 Brief explanation on identified strategies to the adoption of sustainable energy technologies (Iqbal et al., 2021)

Strategies	Explanation
Support from top leadership	Support from top leadership is a crucial factor, could build up a strong relationship with their employees and enhance their capabilities and commitment through the application of SETs
Developing SETs policies and ensuring their imposition	Government plays a significant role to promote SETs. So, involvement of government regarding development of SETs policies and their enforcement could encourage stakeholder to draw their attention towards adoption of SETs.
Promoting awareness campaigns regarding SETs adoption	Effective SETs promotion requires greater community awareness regarding SETs advantages
Developing SETs codes	Developing SETs codes for buildings assists buyers to adopt energy efficient technologies.
Organizing conferences and workshops for employees	Conferences and workshops sessions should be conducted to create awareness among stakeholders regarding SETs adoption
Provision of funds to enhance R&D in educational institutes	Government should provide enough funds to conduct research in institutes regarding SETs.
Encouraging clients by providing them green certificates	A green certification policy should be introduced to enhance the SETs adoption which could encourage customers.
Providing trainings for developers and contractors	Training activities should be introduced to developers and contractors to increase their capabilities and understanding about SETs, which could expedite the SETs adoption.
Building trust with clients by providing true information related with SETs	A good relationship between developers and clients will enhance through the provision of smooth and real information about SETs.
Learned from energy policies of developed countries	Developing countries should follow the energy policies of developed countries.
Hiring skilled professionals and labor	Recruitment of experienced and skilled employees can increase the energy efficiency in construction process.
Providing proper education and knowledge related with SETs adoption in construction projects	Provision of proper education and sound knowledge about SETs in construction projects for employees can encourage working positively.
Availability of cost and benefit information of SETs	Transparent information about SETs expense and long-term financial advantages is essential for smooth application of SETs in construction sector.
Promotion of SETs adoption through social media, print media and electronic media	Advertisements through traditional and digital media can grab the attention of clients to adopt SETs.
Encouraging local industry to develop SETs	Government needs to interact more frequently with local industry and facilitate them through incentives and subsidies.
SETs adoption encouragement by concerned environmental protection authority (EPA)	Single authority can't apply some new technology; therefore, encouragement and interest by all relevant authorities is significant. It could also push construction companies for SETs adoption and leads to win-win situation for all stakeholders.

A.4. Analysis of Strategies Identified from Journals

As explained in Section 4.3.3., many new strategies are identified from the journals in which some of them are the same or similar to the strategies that were identified in Section 4.2. This appendix section elaborates the analysis done to eliminate the similarities among those strategies by implementing one of the following actions.

- **Removing** any duplicates from the list. Duplicates could be strategies with (slightly) different names but have the same definition, purpose, and approach, as well as addressing the same problems. These strategies are highlighted with **grey** color
- **Combining** any similar strategies that have the same purpose but different approaches or slightly different definition. When the different approach does not necessarily require

them to be split, then they could be combined. With this approach, we keep the strategies at a general level, so that it could be implemented at many contexts. These strategies are highlighted with **green** color

- Putting "**new strategy**" label to the ones that have no overlap definition, purpose, and approach with the previously defined strategies. These new strategies are highlighted with **yellow** color
- **Remove** the strategies that were mentioned by the literature without providing enough explanation. These strategies are highlighted with **red** color

The comparison is done by comparing the newly identified strategies with previously identified strategies, and then comparing them with other newly identified strategies. Moreover, as the focus of this research is to identify strategies that could be implemented by the innovators, thus, some identified strategies are rephrased to fit this purpose, which are indicated by red texts. Furthermore, arguments are provided to support any chosen actions. The overview of the analysis is shown in Table 58.

Table 58 Overview of all identified strategies from journals, actions implemented on them to eliminate the same or similar ones, and the supporting arguments

No.	From the Literature		Analysis		
	(Rephrased) Strategies vs Barriers	Identified by	(New) Strategy	Definition	Argument
1	Provide battery charging and switching stations infrastructures at national level, as well as better connectivity to smart grid to overcome EV's limited range and to improve users' convenience during (long) trips; make the battery charging or switching process automatic and taking minimum time; provide Intelligent Transport System that could manage the energy level automatically; waterproof the batteries and charging cables; etc.	Naor et al. (2015)	Complementary technologies, products, services strategy	Providing necessary technologies, products, and services that could overcome or compensate current limited quality and performance of the product so that the product limitation do not reduce customers' comfort, convenience, and safety when using the product	New strategy. In the early stage of product's development and introduction to the market, often the product quality and performance is still limited compared to existing well-established products or alternatives due to the innovator's limited resources. To make this product accepted and adopted despite its limitation, the innovator could develop or provide certain other technologies, products, and services that could help to minimize the impact of the limitation to the users
2	Conduct or join various related events to provide information to public about the product, its technology, and available infrastructure to improve public awareness	Naor et al. (2015)	Educate strategy	Similar to the Educate strategy by Ortt et al. (2013)	The description from this literature could be added to the definition of the original Educate strategy to provide a good example
3	Separate the purchase of the car and the battery by offering the leasing of the battery with various subscription to overcome the high product price due to the expensive price of its major component(s)	Naor et al. (2015)	Leasing strategy	Similar to the Leasing strategy by Schulz (2019)	The main purpose of offering leasing contract is to make the product more affordable for the customers. There are many type of leasing contracts/schemes could be offered. The example given by this liteature could be added to the definition of the original Leasing strategy to provide a good example
4	Enter international markets to faster reach economies of scale	Naor et al. (2015)	Explore multiple markets niche strategy	Similar to the Explore multiple markets niche strategy by Ortt et al. (2013)	The main purpose of the original strategy is to explore new multiple markets to find new opportunities. However, this definition could be extended to actually expanding the market to those newly identified markets to have bigger opportunity to gain adoption, which in the end could help to reach the economies of scale faster.Thus, he description from this literature could be added to the definition of the original Explore multiple markets niche strategy
5	Launch a product that has similar specification as alternative products but with lower price to show the customers that with the new technology, the product could be cheaper with the same performance	Naor et al. (2015)	Redesign strategy	Similar to the Redesign strategy by Ortt et al. (2013)	The focus of the original Redesign strategy by Ortt et al. (2013) is to overcome the limited available knowledge of the technology. However, with this case, the definition of the strategy could be expanded to also overcome the product price/performance ratio compared to the alternatives. Thus, the description from this literature could be added to the definition of the original Redesign strategy
6	Build the infrastructures for the new product at the existing infrastructures or mimic the way of using the existing product into the new product to suit customers' existing embedded tradition, habits, or behaviors	Naor et al. (2015)	Hybridization strategy	Similar to the Hybridization strategy by Ortt et al. (2013)	The description from the literature could be added to the definition of the original Hybridization strategy to provide a good example
7	Launch a product that could fit the needs of mainstream customers to overcome the image that the product does not suit the mainstream customers	Naor et al. (2015)	Redesign strategy	Similar to the Redesign strategy by Ortt et al. (2013)	This strategy has the same approach but different purpose compared to the original strategy which focused on overcoming the limited state of knowledge. However, the new purpose of redesigning as explained in this literature could be added to the definition of the original Redesign strategy
8	Launch multiple types of products to provide enough options for the customers to choose from to overcome the limited offering of similar products	Naor et al. (2015)	Product variants strategy	Producing more product variants with different designs, specifications, or attributes to provide more options for the customers to choose from	New strategy. As the customers might have different tastes, needs, and preferences, offering more product variants could drive up the demand and adoption rate because the customers have options to choose the most suitable product to themselves
9	Bundling the new product with the selling of other products, for example bundling the selling of solar PVs with the newly built houses, battery storage, fuel cells, or heat pumps to overcome customers' passive reaction towards the introduction of the new product, as well as to reduce customers' transaction costs, risk and uncertainty, and to make mortgage rate more competitive	Strupeit & Palm (2015)	Cross-selling and financing strategy	Bundling the selling and financing of the new product with other products in one transaction	New strategy. Selling and financing more than one product in one transaction could eliminate multiple transaction costs and hassle which make the selling more affordable and less administrative. Additionally, the bundling might make the mortgage rate more interesting for the customers. Moreover, if the customers already have certain trust and confident about the providers of the other products, it could help to make them confidence to obtain and bundle them with the new product, which reduce the perceived risk and uncertainty.
10	Sell the product through the existing well-established sales channels or selling the product to the existing customer base, as well as work together with several trusted financiers who could provide soft loan to the customers. The purpose of this strategy is to overcome customers' passive reaction towards the introduction of the new product due to their lack of trust and confidence towards the new product/company	Strupeit & Palm (2015)	Existing social network strategy	Maximizing the use of the existing well-established network to support the initial diffusion the product	New strategy. This strategy could only be applied when the existing social network is already present which is not the case or very limited for a radically new technology. Thus, the implementation of this strategy should be combined with other strategies, such as Influencer marketing strategy (Schulz, 2019) and Network building strategy (Olsthoorn, 2017; Van den Berg, 2017)
11	Maximize the peer-effects (word-of-mouth) to influence other potential customers to overcome customers' passive reaction towards the introduction of the new product	Strupeit & Palm (2015)	Word-of-mouth strategy	Initiating actions that could maximize the word-of-mouth effects	Positive word-of-mouth is important to create public awareness and to influence customers way of seeing the product, which could positively increase the chance of product adoption. However, positive word-of-mouth supposed to be one of the purposes of the strategy implementation instead of being framed as the strategy itself. For example, positive word-of-mouth could be achieved by implementing product demonstration strategy. Therefore, positive word-of-mouth could be removed from the strategy list

No.	From the Literature		Analysis		
	(Rephrased) Strategies vs Barriers	Identified by	(New) Strategy	Definition	Argument
12	Non-commercial intermediates strategy	Strupeit & Palm (2015)	???	???	Not enough explanation was provided by the author on this strategy
13	Offering certain feed-in tariff to the customers who have solar PV on their house which could be projected into an interesting return of investment and eliminate customers' perceived investment risk and uncertainties	Strupeit & Palm (2015)	Result-oriented contracting strategy	Offering a result-oriented contract to the customers so that they are well informed about the estimated return of investment if they obtain the product	New strategy. Knowing the expected return of investment could motivate the customers to obtain the product as it gives them confidence that their investment could really bring financial benefits among other benefits. This strategy is very important when the product price is very high
14	Provide advisory support to customers to reduce customers' risk and uncertainties	Strupeit & Palm (2015)	Educate strategy	Similar to the Educate strategy by Ortt et al. (2013)	Provide advisory support is a good example of educating the customers. Thus, this example could be added to the definition of the original Educate strategy
15	Provide mass-customised turnkey product by including performance warranties, extended warranties, insurance, service and maintenance contracts, product and installer certification, as well as advisory support into the product purchase contract to reduce customers' risk and uncertainties	Strupeit & Palm (2015)	Turnkey product strategy	Selling the product as a complete set (designed, supplied, built, and installed) that is ready to use by the customers , as well as by including necessary complementary technologies, products, and services	New strategy. This strategy could increase customers convenience in acquiring the product as it reduce many hassle. Moreover, making sure that the product is installed properly and ready to use as well as having the warranties, insurance, etc. included in the purchase of the product reduces the customers' perceived risks and could motivate them to adopt the product
16	Work together with manufacturers and suppliers that has good brands and credibility to improve customers trust as well as to reduce customers' risk and uncertainties	Strupeit & Palm (2015)	Partnership strategy	Similar to the Partnership strategy by Schulz (2019) and Olsthoorn (2017)	The description from this literature could be added to the definition of the original Partnership strategy to provide another good example
17	Provide high access to local and trusted supporting firms (for example: local product installer) to reduce customers' transaction cost, risk and uncertainties	Strupeit & Palm (2015)	Local strategy	Similar to the Local strategy by Van den Berg (2017)	The description from this literature could be added to the definition of the original Local strategy to provide a good example
18	Offer pay-per-use contract with no upfront cost to ease the customers in financing the product	Strupeit & Palm (2015)	Leasing strategy	Similar to the Leasing strategy by Schulz (2019)	The description from this literature could be added to the definition of the original Leasing strategy to provide a good example
19	Private finance initiative	Strupeit & Palm (2015)	???	???	Not enough explanation was provided by the author on this strategy
20	Provide advisory support to customers to advice them on how to finance the product, for example by informing them about certain soft loan programme	Strupeit & Palm (2015)	Educate strategy	Similar to the Educate strategy by Ortt et al. (2013)	In this case, the definition of "educating the customers" is not only limited to informing them about the product, its technology, and benefits, but also on how to get financial support to acquire the product
21	Work together with related organizations such as environmental protection authority to overcome various governmental related barriers such as lack of government supports, subsidies, funds, promotional campaigns, as well as lack of interest to develop supporting policies	Iqbal et al. (2021)	Partnership strategy	Similar to the Partnership strategy by Schulz (2019) and Olsthoorn (2017)	In this case, strategic partnership with relevant stakeholders should be combined with Direct lobbying strategy to create awareness among the government and policy makers of the benefits and importance of the adoption of the product so that they could initiate some supports
22	Learn from energy policies of developed countries as well as provide product related education and knowledge to the related projects to overcome various governmental related barriers such as lack of government supports, subsidies, funds, promotional campaigns, as well as lack of interest to develop supporting policies	Iqbal et al. (2021)	Educate strategy	Similar to the Educate strategy by Ortt et al. (2013)	In this case, the company is not only educating relevant stakeholders about the product, but the company should also educate itself to figure out potential policies that could support the diffusion of its product. Moreover, this strategy should be follow-up with Direct lobbying strategy to propose and implement the identified supportive policies
23	Lobby the government to get financial supports for R&D as well as to implement certain supporting policies to overcome governmental barriers (lack of government supports, subsidies, funds, promotional campaigns, as well as lack of interest to develop supporting policies) and economic barriers (high product price, profit uncertainty, long payback period, unavailable of financial schemes, lack of resources, unstable economic environment)	Iqbal et al. (2021)	Lobbying strategy	Similar to the Lobbying strategy by Schulz (2019) and Olsthoorn (2017)	In this case, the purpose of the lobbying is not only focused on the policies design process but also to get financial support from the government. Thus, the description from this literature could be added to the definition of the original Lobbying strategy to extent its context
24	Encourage clients by giving them certain certificates such as green certificate to overcome economic barriers (high product price, profit uncertainty, long payback period, unavailable of financial schemes, lack of resources, unstable economic environment)	Iqbal et al. (2021)	Incentives strategy	Giving incentives to the relevant partners to gain their support, as well as to the customers to make the product adoption more attractive and beneficial	New strategy. Giving incentives could be seen as an investment for a company because it basically gives a little investment on something by expecting something in return in the near future. Incentives could be given not only in the beginning to attract the partners or customers, but also should be given continously to retain them. Depends on the incentives, some incentives work better when they are supported by institutions. The example mentioned by this literature would only work when the government implement green certificate policy. Thus, giving green certificate to clients would encourage their willingness to adopt the technology. Incentives for customers could be, for example, reward-based incentives, coupons, or discounts
25	Encourage local industry to develop the product to overcome economic barriers (high product price, profit uncertainty, long payback period, unavailable of financial schemes, lack of resources, unstable economic environment)	Iqbal et al. (2021)	Local strategy	Similar to the Local strategy by Van den Berg (2017)	By maximizing local resources to develop the product, high product price could be reduced due to reduced transportation cost of local workers and raw materials. Additionally, it could improve customers' trust by knowing that if something wrong happens to the product, they could get fast support from local service team
26	Put local contexts into consideration when implementing a technology to make the technology accepted easily by local level of knowledge; provide training programs for local people to get familiar with the new technology; provide technology that is affordable for local people; provide technology that could bring extra income for local people	Alam et al. (2010)	Local implementation strategy	Making the design and specification of the product as well as the supportive institutions suitable for local market needs so that the product could be accepted easily by local people	New strategy. This strategy is important because markets in different geography might have different needs. Thus, to make the product accepted, the product should be designed/adapted in such a way to address those different needs. This strategy could be combined with Educate strategy to educate local people so that they know how to use the product and take benefits from it

No.	From the Literature		Analysis		
	(Rephrased) Strategies vs Barriers	Identified by	(New) Strategy	Definition	Argument
27	Collaborate with local stakeholders to make the technology accepted easily by local	Alam et al. (2010)	Local strategy	Similar to the Local strategy by Van den Berg (2017)	With the same collaborating approach, this strategy has a bit different purpose than the original Local strategy. The original Local strategy aims to improve efficiencies which might lead to reduction of costs and better customers' trust, while this new strategy aims to improve the customers acceptance. However, these purposes could be combined to expand the context of the collaboration
28	Establish awareness program by conducting fairs, exhibitions, posters, and training programs to overcome the lack of knowledge and skills	Alam et al. (2010)	Educate strategy	Similar to the Educate strategy by Ortt et al. (2013)	The description from this literature could be added to the definition of the original Educate strategy to provide a good example
29	Generate new knowledge on suitable technologies for certain area by taking into account its local contexts (locally available materials and knowledge) to overcome the lack of knowledge and skills	Alam et al. (2010)	Local implementation strategy	Similar to the previously explained Local implementation strategy	This description could be added to the definition of the original Local implementation strategy to provide a better definition
30	Provide supportive financial mechanisms and institutions such as by providing microcredits mechanisms or fee-for-service mechanism to make the product more affordable	Alam et al. (2010)	Leasing strategy	Similar to the Leasing strategy by Schulz (2019)	The description from this literature could be added to the definition of the original Leasing strategy to provide a good example
31	Lobby the government to act as a demand side actor by using the technologies in a big scale to increase the market, economics of scale, and to raise the public awareness	Alam et al. (2010)	Lobbying strategy	Similar to the Lobbying strategy by Schulz (2019) and Olsthoorn (2017)	The purpose of this strategy is different than the original Lobbying strategy as the purpose is focused more on asking the government to be the lead user while the focus of the original strategy is to influence the government to implement supportive institutions. However, these purposes could be combined to extent the context of the strategy
32	Develop local level institutions to implement and manage local based implementation programs as well as to interact better with local stakeholders	Alam et al. (2010)	Local implementation strategy	Similar to the Local implementation strategy strategy that was previously explained	The description from this literature could be added to the definition of the original Local implementation strategy to extend its context
33	Target a market in which the product could excel in performance, promote reduction of running costs, and in the end provide a shorter payback period	Hardman et al. (2014)	Market positioning	Choosing the right market to penetrate to make sure that the product performance could be better, the product provide more benefits, and the product is financially more attractive compared to any available alternatives	New strategy. The purpose of this strategy is to make sure that the product is marketed where it belongs so that it gets appreciation and acceptance from the customers. It also could help to define the right targetted customers and reduce financial waste by focusing the marketing and sales forces only at those targetted customers. The implementation of this strategy should be combined with Explore multiple markets niche strategy to gain the necessary insights to then decide on how to position the product.
34	Develop a new (and better) network of infrastructure that could overcome current performance flaws	Hardman et al. (2014)	Complementary technologies, products, services strategy	The same as Complementary technologies, products, services strategy by Naor et al. (2015)	-
35	Organize events that could show off the current performance of the product	Hardman et al. (2014)	Demo, experiment, and develop niche strategy	Similar to the Demo, experiment, and develop niche strategy by Ortt et al. (2013)	The description from this literature could be added to the definition of the original Demo, experiment, and develop niche strategy to provide more explanation
36	Sell the product via its own sales channels to prevent misinformation towards the product, as well as to minimize the margins so that the product price could be more competitive	Hardman et al. (2014)	In-house network strategy	Maximizing the use of the in-house network to support the initial diffusion the product instead of relying on third parties, for example selling the product through company's own sales engineers	New strategy. This strategy could be implemented in the early stage of market introduction when the knowledge about the product among relevant third parties is still very limited due to radically new technologies and/or there is an urge to cut down the margin to make the product price more competitive. However, once the market is settle and penetrating global market is the next target, this strategy is no longer effective as the company might not be able to do everything by themselves. Thus, Partnership strategy should be considered to follow-up the market growth
37	Implement aggressive pricing, advertising, marketing, and sales to draw mass attention	Montaguti et al. (2001)	Aggresive penetration strategy	Penetrating the market by implementing aggressive pricing, as well as putting large resources for advertising, marketing, and sales force	New strategy. The purpose of this strategy is to make a little profit through the exploitation of economies of scale. Good marketing and advertising would increase customers awareness and might increase the product adoption. Profit gained per product might be little but as the volume of the product sold is large, in the end, the total profit is also large. Moreover, when more products are sold, the marginal cost is less, means the profit is increasing
38	Make the product compatible with existing technologies to enable the product to access a larger network such as infrastructure, to make the product more familiar to the customers, to eliminate perceived uncertainties compared to the existing technologies, and to increase customers' perspective towards the product which will influence their willingness to pay	Montaguti et al. (2001)	Hybridization strategy	Similar to the Hybridization strategy by Ortt et al. (2013)	The description from this literature could be added to the definition of the original Hybridization strategy to extent the definition
39	Spread the information about the innovation in advance before the product launch to increase customers awareness, to eliminate investment uncertainty, to reduce uncertainties and misinformation about the product, and to increase willingness to pay	Montaguti et al. (2001)	Preannouncing strategy	Establishing a strategic relationship with potential customers by publishing the information about the product in advance before the product launch	New strategy. This strategy could stimulate demand by triggering customers' interest and curiousity towards the coming up product which could also help to spread the words towards other customers. Additionally, this strategy gives extra time for the customers to observe and evaluate the new product and its benefits, to then decide whether they are going to adopt it or not. Moreover, it gives more time for the company to build favorable reputation which is important for the adoption rate
40	Form marketing alliances to overcome the company's lack of competencies and resources to rapidly commercialize the innovation	Montaguti et al. (2001)	Partnership strategy	Similar to the Partnership strategy by Schulz (2019) and Olsthoorn (2017)	The description from this literature could be added to the definition of the original Partnership strategy to provide better definition

No.	From the Literature		Analysis		
	(Rephrased) Strategies vs Barriers	Identified by	(New) Strategy	Definition	Argument
41	Provide added value that could solve the problems that the incumbents failed to fulfill	Hardman et al. (2013)	Market positioning	Similar to the Market positioning by Hardman et al. (2014)	This strategy could be categorized within the previously identified Market positioning strategy because providing certain added value that could distinguish the company/product from the incumbents which would definitely put the company/product in a certain market position
42	Initiate the establishment of regulation, either the regulation that support the innovations or regulation that discourage the incumbent technologies	Hardman et al. (2013)	Lobbying strategy	Similar to the Lobbying strategy by Schulz (2019) and Olsthoorn (2017)	The description from this literature could be added to the definition of the original Lobbying strategy to provide better definition
43	Expected breakthrough strategy: sell the product with competitive price since the beginning, assuming that the innovation is expected to breakthrough and make profits in the near future	Hardman et al. (2013)	Aggresive penetration strategy	Similar to the Aggresive penetration strategy by Montaguti et al. (2001)	The description from this literature could be added to the definition of the original Aggresive penetration strategy to provide better definition
44	Ask for support from the scientific community to support the development of the new technologies and to discourage the existing technologies	Hardman et al. (2013)	Partnership strategy	Similar to the Partnership strategy by Schulz (2019) and Olsthoorn (2017)	The description from this literature could be added to the definition of the original Partnership strategy to provide better definition
45	Develop (light) diversification of products and services as well as extension of the currently successful markets into adjacent markets to increase the size of the market	Kamp (2017)	Product variants strategy	Similar to the Product variants strategy by Naor et al. (2015)	The description from this literature could be added to the definition of the original Product variants strategy to provide better definition
46	Continuously looking at new geo-economic market opportunities	Kamp (2017)	Explore multiple markets niche strategy	Similar to the Explore multiple markets niche strategy by Ortt et al. (2013)	The description from this literature could be added to the definition of the original Explore multiple markets niche strategy to provide better definition
47	Focus the initial selling to lead users to bring positive influence on company's development skills and positive word-of-mouth effects to the broader audience as they act as reference buyers and could create new market trends	Kamp (2017)	Lead user niche strategy	Similar to the Lead user niche strategy by Ortt et al. (2013)	The description from this literature could be added to the definition of the original Lead user niche strategy to provide better definition
48	Being the first mover to benefit from the blue ocean strategy and to set the standard of the new product-market combination	Kamp (2017)	Blue ocean strategy	Targeting a new market as a first mover	New strategy. The advantage of this strategy is that it could maximize the opportunities as well as minimize the risk because of no competitition. The implementation of this strategy should be combined with the implementation of Explore multiple markets niche strategy to identify the market opportunities. The blue ocean might turn red after some time as other companies started to imitate the product. Thus, it is important to stay innovative and differentiate the product/company position to maintain the market
49	Being a specialist in a specific niche market to take the opportunities to gain hegemonic power in highly oligopolies or quasi-monopolistic markets	Kamp (2017)	Market positioning	Similar to the Market positioning strategy by Hardman et al. (2014)	The description from this literature could be added to the definition of the original Market positioning strategy to provide better definition
50	Differentiate itself (the company) and its product with others, for example, by providing specific services to make the company superior to others for example by providing good customer service, easy product returning procedure, quick lead times, etc. as well as providing product with better quality, newer technology, etc.	Parrish et al. (2006)	Market positioning	Similar to the Market positioning strategy by Hardman et al. (2014)	The description from this literature could be added to the definition of the original Market positioning strategy to provide better definition
51	Offer a specialized product that could meet customers' needs in certain segments of the market to make the product appealing	Parrish et al. (2006)	Market positioning	Similar to the Market positioning strategy by Hardman et al. (2014)	The description from this literature could be added to the definition of the original Market positioning strategy to provide better definition
52	Provide exceptional performances	Thomas & Maine (2019)	Market positioning	Similar to the Market positioning strategy by Hardman et al. (2014)	This strategy could be categorized within the previously identified Market positioning strategy because providing exceptional performance could distinguish the company/product from the incumbents which would definitely put the company/product in a certain market position
53	Sell the product through company's own sales channels to have better access and to provide better educative information to the customers	Thomas & Maine (2019)	In-house network strategy	The same as In-house network strategy by Hardman et al. (2014)	The description from this literature could be added to the definition of the original In-house network strategy to provide better definition
54	Form partnership to shorten the learning curves to reach economies of scale faster	Stringham et al. (2015)	Partnership strategy	Similar to the Partnership strategy by Schulz (2019) and Olsthoorn (2017)	The description from this literature could be added to the definition of the original Partnership strategy to provide better definition
55	Quickly bring product to the market to shorten the learning curves to reach economies of scale faster	Stringham et al. (2015)	Demo, experiment, and develop niche strategy	Similar to the Demo, experiment, and develop niche strategy by Ortt et al. (2013)	The important purpose of the implementation of this strategy is to not spend too much time, energy, cost, and other resources to develop the product in the laboratory to make that one perfect product. Instead, bring the product to the market despite its limitation to then see how the market reacted and learn from it to further develop the product. Thus, the description from this literature could be added to the definition of the original Demo, experiment, and develop niche strategy to provide better definition
56	Subsidize parts of the infrastructure network so that other relevant stakeholders could take part in supporting the development of the infrastructure; providing certain parts of customer experience for free to overcome the lack of network externalities	Stringham et al. (2015)	Complementary technologies, products, services strategy	Similar to the Complementary technologies, products, services strategy by Naor et al. (2015)	The availability of infrastructure is important for the growth of network externalities. When the development of infrastructure is expensive, giving subsidies to other stakeholders to help to build the infrastucture could stimulate their willingness to collaborate. Moreover, providing certain facilities that could improve customer experience for free could also help to boost the network externalities. Thus, the description from this literature could be added to the definition of the original Complementary technologies, products, services strategy to provide better definition

No.	From the Literature		Analysis		
	(Rephrased) Strategies vs Barriers	Identified by	(New) Strategy	Definition	Argument
57	Providing all patents for free to public domain to encourage other companies to enter the market	Stringham et al. (2015)	Crowd-sourcing strategy	Similar as Crowd-sourcing strategy by Schulz (2019) and Van den Berg (2017)	Opening up the patents for public for free could encourage other stakeholders to take part on developing the new technology which could help to boost the development pace of the technology. It would in the end bring many benefits such as improving the product performance, lower the cost, improve the production efficiency, etc. Moreover, having more companies working on the same technology could help the company to beat the stronger competitors: producers of well-established existing products (for example, EVs experience more competition towards ICE vehicle than the other EVs)
58	Stay innovative to overcome the changing market and to stay competitive	Stringham et al. (2015)	Technological R&D strategy	Similar to the Technological R&D strategy by Schulz (2019)	The description from this literature could be added to the definition of the original Technological R&D strategy to provide better definition
59	Provide excellence service despite being unprofitable (in the beginning of market penetration)	Sonali (2016)	Aggresive penetration strategy	Similar to the Aggresive penetration strategy by Montaguti et al. (2001)	Aggresive also means that the company put large resources and investments to provide excellence service eventhough it does not directly bring any profit to the company, knowing that eventually it would pay off once the network externalities is build up and adoption rate increasing. Thus, the description from this literature could be added to the definition of the original Aggresive penetration strategy to provide better definition
60	Enter the market via high-end innovation approach	Sonali (2016)	Top niche strategy	The same as Top niche strategy by Ortt et al. (2013)	-
61	Create innovative products and services that creating a new demand in the market	Sonali (2016)	Blue ocean strategy	Similar to the Blue ocean strategy by Kamp (2017)	The description from this literature could be added to the definition of the original Blue ocean strategy to provide better definition
62	Open innovation philosophy by open sourcing the patents instead of protecting the intellectual property	Sonali (2016)	Crowd-sourcing strategy	The same as Crowd-sourcing strategy by Schulz (2019) and Van den Berg (2017)	
63	Providing massive infrastructure to build network externalities	Sonali (2016)	Complementary technologies, products, services strategy	Similar to the Complementary technologies, products, services strategy by Naor et al. (2015)	The description from this literature could be added to the definition of the original Complementary technologies, products, services strategy to provide better definition
64	Collaborating and building alliances to innovate better	Sonali (2016)	Partnership strategy	The same as Partnership strategy by Schulz (2019) and Olsthoorn (2017)	-
65	Rise fund to finance several improvement on bottlenecks that has been hindering company expansion such as limited production facilities	Sonali (2016)	Finance sourcing strategy	Initiating certain actions to bring additional financial resources into the company or to support customers in financing the acquisition of the product	New strategy. This strategy is important to overcome financial issues experienced by the company or the customers. With good financial conditions, the company could continously strive for improvements to gain the market share. At the other hand, financial supports for the customers would improve the chance that they would adopt the new product.
66	Hire experts to overcome limited high-skilled workers	Sonali (2016)	Human resource management strategy	The same as Human resource management strategy by Schulz (2019)	-
67	Outsource the production of some components of the product, collaboration with the right partners, and combined it with providing necessary trainings for the business partners	Sonali (2016)	Partnership strategy	Similar to the Partnership strategy by Schulz (2019) and Olsthoorn (2017)	The description from this literature could be added to the definition of the original Partnership strategy to provide better definition
68	Market penetration strategy: implement aggressive marketing such as offering different pricing, innovating the promotional campaigns, and increasing the distribution networks to overcome unprofitable business despite company's market expansion	Sonali (2016)	Aggresive penetration strategy	Similar to the Aggresive penetration strategy by Montaguti et al. (2001)	The description from this literature could be added to the definition of the original Aggresive penetration strategy to provide better definition
69	Product development strategy: develop new products in the existing markets	Sonali (2016)	Product variants strategy	The same as Product variants strategy by Naor et al. (2015)	-
70	Market development strategy: focus the business development of existing products in the new market	Sonali (2016)	Explore multiple markets niche strategy	Similar to the Explore multiple markets niche strategy by Ortt et al. (2013)	The description from this literature could be added to the definition of the original Explore multiple markets niche strategy to provide better definition
71	Market/product diversification strategy: focusing the business development on the new product and new market to create brand awareness and good brand image	Sonali (2016)	Blue ocean strategy	Similar to the Blue ocean strategy by Kamp (2017)	This strategy could be categorized as blue ocean strategy as it has the same purpose: aiming at new markets
72	Put more R&D into expensive major components to reduce cost and increase profit	Sonali (2016)	Technological R&D strategy	Similar to the Technological R&D strategy by Schulz (2019)	The description from this literature could be added to the definition of the original Technological R&D strategy to provide better definition
73	Offer an exclusive marketing and sales plan for new amazing products that could solve certain problems in certain markets. For example, by offering Tesla's Powerwall to the developing countries to overcome power outage problem	Sonali (2016)	Market positioning	Similar to the Market positioning strategy by Hardman et al. (2014)	The description from this literature could be added to the definition of the original Market positioning strategy to provide better definition

Appendix B. Arguments on Links Between a Barrier and Strategies Identified by the Author

In this Appendix aimed to complement Section 5.1. However, due to the limited time of the research, the author only provides written supportive arguments of the identified links between a barrier and possible strategies. The same approach and way of thinking are used to analyze the rest of the barriers and strategies to identify the links.

Barrier: **Product availability, performance and quality** is lacking due to the lack of **knowledge and awareness of technology.**

Innovator's lack of knowledge and awareness of technology influences its capability in delivering the product with sufficient performance and quality. It leads to customers hesitant to adopt the product as it does not meet their expectation. At the other hand, when the customers have a lack of knowledge and awareness of technology, their willingness to adopt the product is lower as they perceive the product differently due to their inability to see the benefits and values of the product. Possible strategies to overcome this barrier:

- Demo, experiment, and develop niche strategy

Quickly bringing/demonstrating the product to the market let the innovators go through an additional iteration to evaluate their product while preparing it for the demonstration. Moreover, it gives the innovators an extra time to develop the product further while the market is already aware of the product, as well as to receive useful feedbacks from the market in advance. This feedback could help to shape the further development of the product. Furthermore, product demo brings benefits to the potential customers as they could experience the product as well as get the right information about the product from the innovators themselves. This increases customers' knowledge and awareness towards the product which may lead to higher willingness to adopt the product.

- Redesign niche strategy

Customers often hesitate to adopt a product that using unfamiliar technologies or underdeveloped product as it might create hassles for them. Moreover, when the innovators have limited knowledge about the technologies needed for the product, the development of the product might be stagnant. Thus, it is advised to redesign the product to fit the current state of the knowledge so that the product could be developed properly, and the customers are familiar with it as well as willing to adopt and use it.

- Hybridization or adaptor niche strategy

When the company has a lack of knowledge of the new technologies to develop the new product further, making a hybrid product could be considered as the new product could still take the advantages of the old technologies as well as its existing complementary products and services. It also helps to bridge the transition between the old and new product, to give more time for the customers to absorb the new technologies.

- Educate niche strategy

The innovators need to educate themselves to develop the product further, for example by attending courses or workshops about the required technologies so that the product development is not hindered by the lack of knowledge of the innovators. Moreover, when the product performance and quality is perceived lacking by the customers due to customers' lack of knowledge, the innovators could educate the customers to raise their knowledge and

awareness about the new product, its technologies, and its benefits, for example by providing educational advertisements.

- Geography

Customers' demands and needs as well as knowledge about the technology vary between different areas. Moreover, making the product available in different locations might need different level of efforts. Therefore, focusing the market penetration at other geographic locations might circumvent this barrier.

- Technological R&D strategy

Putting extra effort in research and development could help the innovators to find better technologies alternatives for the product.

- Human resource management strategy

When there is a lack of knowledge in a company that hinder the development of the product, the company could consider hiring more experts or interns to improve the company's internal knowledge and to give a new eye on the problems. Moreover, having more experts working together could make the goals achievable in a shorter period.

- Internal knowledge sharing strategy

This strategy could be implemented in addition to the Human resource management strategy. Having more experts to work together could help the company to develop the product further, however, making sure that the new experts share their expertise to their colleagues could boost their productivity and efficiency even further.

- Partnership strategy

As the company have a lack of knowledge of the technologies, the partnership strategy could be implemented by working together with other companies that have the necessary knowledges to overcome the limited product's performance and quality. It could be done, for example, by collaborating with the competitors to work together on an expensive R&D and then use the results of the R&D for mutual benefits, or by collaborating with the providers of complementary products and services that could overcome the product limitation.

- Influencer strategy

Empower influencers is a good way to educate the customers by increasing their awareness and knowledge. It also helps to minimize customers' misconception about the product and its technologies. In the end, it could help to increase customers' adoption rate

- Crowdsourcing strategy

Crowdsourcing the technologies development such as by opening the patents for public for free could encourage other stakeholders to take part on developing the new technology which could enhance the creative process, improve the productivity, and boost the technology development pace. Moreover, the company could choose the best result out of many developers which might deliver unexpected solutions.

- Corporate restructuring strategy

Combining multiple companies means combining their resources to reach the same goals. Thus, it means more experts and human resources are on board to improve the current limited knowledge.

- Network building strategy

Meeting new people could open many new opportunities which might be valuable for the company. For example, by extending its network the company might come across some new experts who have better knowledge on the technologies.

- Complementary technologies, products, and services strategy

When knowledge of the technology is limited that limit the product quality and performance, the company could consider using other technologies, products, and services that could lessen the negative impacts of the product limitation to support the operation of the product.

- Pre-announcing strategy

Pre-announcing the product release help to increase customers awareness and curiosity about the products. However, to make sure that the customers have the right knowledge about the product, this strategy should be combined with other strategies such as Demo, experiment, and develop niche strategy, Educate niche strategy, and Influencer strategy.

Appendix C. Supportive Institutions in Indonesia

This appendix complements Chapter 6 by providing more explanation about EV-related institutions in Indonesia.

C.1. National Master Plan for Industry (RIPIN) 2015 – 2035

RIPIN is set by Government Regulation No. 14/2015 as a guideline for the government and industry players in planning and developing the industries in Indonesia (Kementrian Perindustrian, 2015). This document highlights that vehicle industry including EVs is one of Indonesia's ten priority industries as it deemed to be important to support Indonesia's economic growth. Three development stages were set in this document to guide the EVs industry, as indicated by Table 59.

Table 59 Three major development stages for EV industry as set by Indonesia's National Master Plan for Industry 2015 – 2035, extracted from (Mahalana & Yang, 2021)

Phase and Goal	Automotive industry development
2015 – 2019 (first stage) Enhance human resources capacity and increase adoption of technology	Automotive parts (Regulate automotive parts and attract investment for automotive parts manufacturers, increase local content requirement, and enhance capacity to produce automotive parts) Conventional engines and electric motors (Encourage further development of manufacturing for both domestic market and exporting) Power trains (develop more precise and efficient power trains) Heavy equipment
2020 – 2024 (second stage) Achieve competitiveness and environmental awareness through the enhancement of industrial structure, technology adoption, and enhanced human resources capacity	Engines (Encourage development of electric motors and fuel cells) Power trains (develop more precise and efficient power trains)
2025 – 2035 (third stage) Build a strong industry with a robust structure that is highly competitive globally and based on innovation and technology	Engines (further development from second stage)

C.2. National Energy Plan (RUEN)

RUEN provides energy-related guidance for Indonesia's national and sub-national level to achieve energy self-sufficiency, energy security, and to support sustainable energy development. Several EVs-related guidance set by RUEN is elaborated by Mahalana & Yang (2021) as follows:

- Indonesia aimed for the uptake of 2,200 EVs by 2025
- Indonesia is to prepare and implement fiscal policies to support EVs production and adoption in 2016 - 2019
- Indonesia is to design and implement carbon tax policy on fossil fuels in 2017 – 2019

- Indonesia is to set fuel economy standard for EVs 2017 - 2019

C.3. Presidential Regulation No.55/2019 on Battery Electric Vehicles and Its Derivatives

This regulation marks Indonesia's commitment in boosting EVs development in Indonesia by appointing a coordination team consist of various ministries as explained in Section 6.1., setting an ambitious goal to produce an increasing share of EVs locally, providing fiscal and non-fiscal incentives (see Figure 26), and deploying more charging infrastructure in the coming years.

Fiscal incentives	Non-fiscal incentives
• Import duty incentives for Completely Knock Down (CKD) and Incompletely Knock Down (IKD) EVs • Tax incentives based on emissions and engine capacity of the EVs • Tax incentives and tax holidays for imports of materials and machinery for EVs • Incentives for research & development • Incentives for certification of human resources within the EV battery industry • Incentives for certification of EVs, EV batteries and EV-related products	• Exceptions for limitations on road usage • Rights for production of EV-related technology and products whose license/ patents are held by the central/regional government

Figure 26 Summary of Fiscal and Non-Fiscal Incentives Offered by Presidential Regulation No. 55/2019 for BEV, extracted from (KPMG Indonesia, 2021)

In 2020, Kemenperin released two regulations to support the Presidential mandate on EV acceleration program to provide guidance on strategies, policies, and programs to the automotive industry stakeholders. The regulations are: (1) Regulation of the Minister of Industry No. 27/2020 which regulates EV specifications, roadmaps development, and the provisions for calculation of its domestic component levels and (2) Regulations Minister of Industry Number 28/2020 which regulates the scheme for EV imports to gradually increase the domestic component levels until 2030. Additionally, this regulation specifies the definition of Completely Knock Down (CKD), Incompletely Knock Down (IKD), and part-by-part importation. With these regulations, Kemenperin targeted to produce 750,000 EVs by 2030 locally (Kemenperin, 2021a).

Furthermore, Ministry of Energy and Mineral Resources aimed to have 400,000 EVs running on Indonesia's roads by 2025 (Putri, 2022b). To meet this target, the government agencies are expected to adopt 65,000 EVs by 2025 and up to 130,000 EVs in 2030 (Iskandarsjah, 2021) and Indonesia planned to stop the selling of new fossil-fueled cars starting 2050 (CNN Indonesia, 2021b; Mardika, 2021).

C.4. Incentives for EV Customers

Table 60 Passenger vehicle taxes in Indonesia, data extracted from (Chen et al., 2022; Mahalana & Yang, 2021)

Taxes		Tax Tariff (% of the vehicle purchase price)	Regulated by
One-time paid	Value-added tax (VAT)	10%	Central government: MoF
	Luxury tax	up to 125%	Central government: MoF
	Circulation tax	1% - 2%	Provincial governments
	Transfer tax	Max. 20% (new), 1% (used cars)	Provincial governments
Use-phase	Road traffic accident contribution	USD 2.4 per year	Central government: MoF

Table 60 gives a general overview of vehicle taxes need to be paid on top of the vehicle's off the road price in Indonesia. However, in 2019, the government released the Government Regulation No. 73/2019, to provide purchase incentives for EVs by reducing EVs' luxury tax. Vehicle luxury tax that was previously defined based on vehicle type and engine displacement, was changed by defining it based on the vehicle type and CO_2 emissions, as indicated by Table 61. This regulation has been enforced since October 2021. Additionally, Jakarta provincial government provides 0% transfer tax for EV that is regulated by Governor Regulation No. 3/2020 (Chen et al., 2022; Mahalana & Yang, 2021), while West Java provincial government enforce 10% transfer tax for EV as regulated by Regional Regulation No. 9/2019 (Kemenperin, 2021b).

Table 61 Luxury tax rate enforced in Indonesia starting October 2021, extracted from (Mahalana & Yang, 2021). *Note: LCGC is car priced under IDR 95 million (around USD 6,500) with fuel economy of at least 20km/L and engine smaller than 1500cc.*

Category		CO_2* (g/km)	Tax tariff based on engine capacity (cc)			
			<1500	1500 (incl.) to 3000	3000 (incl.) to 4000	Above 4000 (Super car)
PV (<10 seats)		<150	15%		40%	95%
		150 - 200	20%		50%	
		200 - 250	25%		60%	
		>250	40%		70%	
PV (10 incl. to 15 seats)		<200	15%		25%	
		≥200	20%		30%	
Incentive Program	Low Cost Green Car (LCGC)	≤120	3%	-	-	-
	Full hybrid	<100	2%		20%	-
		100 - 125	5%		25%	-
		125 - 150	8%		30%	-
	Mild Hybrid	<100	8%		20%	-
		100 - 125	10%		25%	-
		125 - 150	12%		30%	-
	Flexy Engine (E100/B100)	-	8%			-
	PHEV, BEV, FCEV	≤100	0% (15%**)			

* Equivalent fuel economy targets (km/l) for gasoline and diesel vehicles, also specified in the regulation, are not presented in this table

** If the production of the vehicles does not meet the minimum local content requirement (e.g. imported EVs)

Despite their advantages, these new regulations are deemed to be insufficient to encourage EVs adoption and to reduce emissions, as argued by Chen et al. (2022) and Mahalana & Yang (2021) respectively. In their research, Chen et al. compared the six-year vehicle ownership cost of 1.8L Gasoline Corolla, 1.8L Hybrid Corolla, and 40kWh BEV Leaf as the representatives of three different vehicle types. As shown by Figure 27, despite the implementation of the new

regulations, the BEV still has not reach the cost parity with its competitors (Chen et al., 2022). Moreover, Mahalana & Yang (2021) argued that defining the tax rates based on too wide CO_2 bands do not provide enough incentives for the EV producers to improve the efficiency of passenger cars.

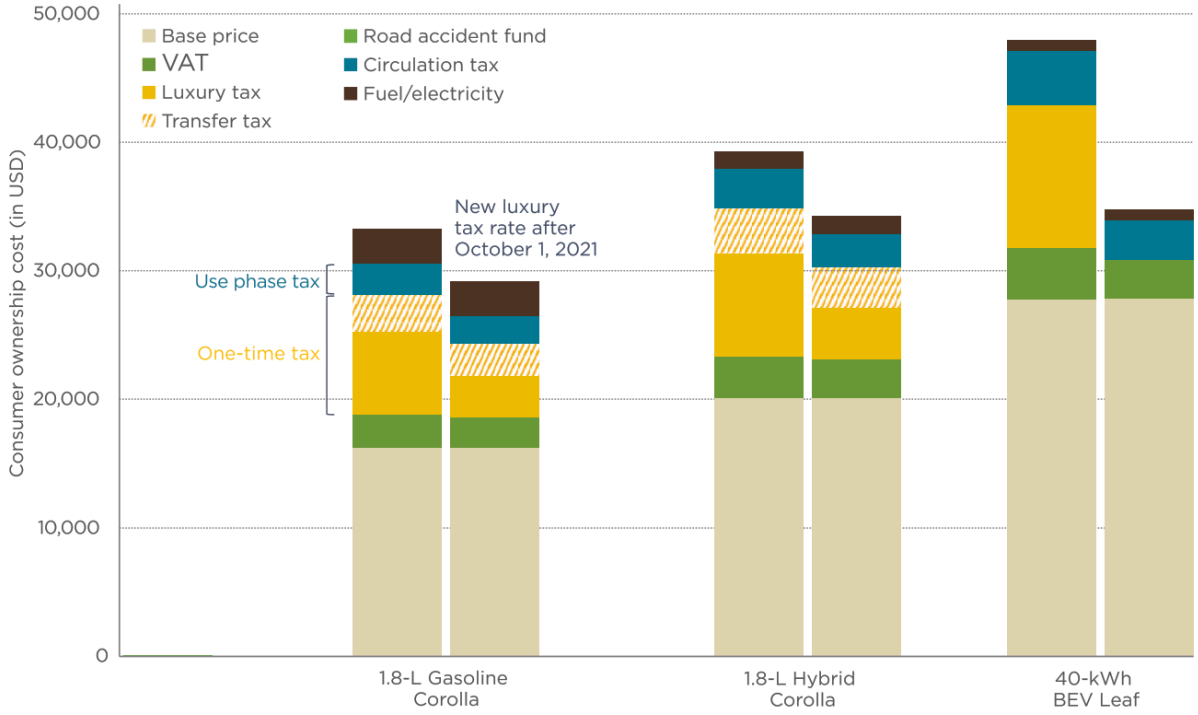


Figure 27 Comparison of six year vehicle ownership cost of three different vehicle types in Indonesia, before and after the luxury tax incentive program (Chen et al., 2022)

Other incentives are promoted by Bank Indonesia by providing 0% down payment and lower interest rates for the financing of new EVs since Oct 2020, as regulated by Bank Indonesia Regulation No. 22/13/PBI/2020 (Kemenperin, 2021b; Maskur, 2020). However, there is no source quantify specifically the mentioned lower interest rates. Additionally, PLN offers discounted price for house's power upgrade to enable the operation of home charging unit, as well as 30% electricity tariff discount for home charging from 22.00 until 05.00 (Kemenperin, 2021b; Purnama, 2022).

C.5. Incentives for EVs Industries in Indonesia

To support the development of EVs ecosystem in Indonesia, in 2020 the Ministry of Industry released the Minister of Industry Regulation No. 27/2020 that was designed to regulate the specification of BEV, development road map of Indonesia's BEV industry, and the detailed requirements to calculate BEV's local manufacturing content (Mahalana & Yang, 2021).

In February 2022, the Ministry of Finance Regulation No. PMK-13/PMK.010/2022 was designed to regulate the stipulation of goods classification system and imposition of import duty tariff on imported goods. This regulation provides free import duty for Incompletely Knocked Down (IKD) BEV which then will be assembled domestically. The purpose of this regulation is to support the development of EV industries in Indonesia, as well as to reduce EVs production costs and to make them more affordable (D. Kurniawan, 2022; Putri, 2022c).

Table 62 The amount and duration of tax holiday offered for pioneer industries who put new investments in Indonesia

Investment value [IDR billion]	Tax holiday [%]	Tax holiday duration [years]
100 - 500	50	5
500 - 1,000	100	5
1,000 - 5,000	100	7
5,000 - 15,000	100	10
15,000 - 30,000	100	15
> 30,000	100	20

Moreover, Indonesia also implemented "Tax Holiday" to provide incentives for pioneer industries or manufacturers to invest in Indonesia, which is regulated by Regulation No. 130/PMK.010/2020 under the Ministry of Finance (JDIH BPK RI, 2020) and Regulation No. 1/2019 under the Indonesia Investment Coordinating Board (JDIH BPK RI, 2019). These regulations offer up to 100% deduction on corporate income tax on income from main business activity. The amount and duration of tax holiday vary depends on the investment value, as indicated in Table 62. Furthermore, Table 63 shows the specification on pioneer industries eligible for the tax holiday.

Table 63 Pioneer industries illegible for the tax holiday (Mahalana & Yang, 2021)

Indonesia Standard Industrial Classification (KBLI)	Type of Production
29100	Manufacturing of electric vehicles with 4 wheels or more that integrate the battery and electric motor
29300	Manufacturing of battery for electric vehicles with 4 wheels or more Manufacturing of electric motor for electric vehicles with 4 wheels or more Manufacturing of flexy engine compatible with 100% biodiesel for electric vehicles with 4 wheels or more Manufacturing of a minimum of 2 main components for the engine of a motor vehicle with four wheels or more (i.e, piston, cylinder head, cylinder block, camshaft, crankshaft, and connecting rod, that is integrated with manufacturing of electric vehicles with 4 wheels or more Manufacturing of electric power control units (PCU) for electric vehicles with 4 wheels or more
30912	Manufacturing of battery for 2-wheeled or 3-wheeled electric motor vehicle Manufacturing of electric motor for 4-wheeled or 3-wheeled electric motor vehicle Manufacturing of electric power control unit (PCU) for 4-wheeled or 3-wheeled electric motor vehicle

Additionally, the government also provide tax allowance of 30% taxable income deduction, as regulated by Government Regulations No. 18/2015 and Investment Coordinating Board Regulation No. 13/2017, which is offered to the new investors after their tax holiday period (BKPM, 2018). Lastly, supertax deduction incentives are offered for R&D activities, as regulated by Minister of Finance Regulation (PMK) No. 153 of 2020 and Government Regulation No. 45/2019 (Adelayanti, 2020; Kemenperin, 2021b).

Lastly, as Indonesia has around 22% of global nickel reserves (Statista, 2022), starting Jan 1, 2020, Indonesia banned the export of nickel ore to prevent the depletion of its nickel ore reserves and to encourage the development of domestic processing facilities and nickel-based batteries supply chains (Foster, 2022; Riyanto et al., 2020).

C.6. EV Infrastructure-related Policies

To support the development of EV charging infrastructure, PLN established the so called "sharing economy model" by offering several business models namely ROSO (retail, own, self-operated), ROPO (retail, own, privately operated), RPOO (retail, privately owned & operated), RLSO (retail, lease, self-operated), and RLPO (retail, lease, privately operated), while PLN supplies and sells the electricity as well as the information and communication technology platform to its partners. Under this sharing economic model, PLN sells the electricity at bulk price of IDR 714/kWh (EUR 0.05/kWh) to its partners while the partners are allowed to sell it to the EV charging users at maximum price of IDR 2,466/kWh (EUR 0.16/kWh based on June 2022 rate) (Kementrian ESDM, 2021; Ruang Energi, 2021)