Shared power transport capacity implementation

Determining the factors relevant to the successful implementation of shared power transport capacity through a qualitative comparative analysis

By

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Executive Summary

The Dutch power grid does currently not have the required transport capacity to match demands. The lack of available transport capacity has resulted in long wait lists for users who either want to become connected to the power grid or expand their current usage of electricity. This problem is partially caused by the way that power transport capacity is allocated which often results in transport capacity not being used. A potential solution that could reduce grid congestion is to allow multiple users to share a single power transport capacity. This allows them to make more efficient use of the available transport capacity and thus less transport capacity is needed to meet the demand of the users. Business parks are a promising candidate for the implementation of shared transport capacity. However, cases with successful implementation are few and the implementation process has not been standardised yet. The aim of this research is therefore to determine which factors play a role in the successful implementation of shared transport capacity, if any patterns can be identified and how actors involved in the implementation process can increase the chance of successful implementation.

A qualitative comparative analysis is performed using both successful and unsuccessful cases in which shared power transport capacity systems were tried to be implemented. The aim of this analysis is to identify which combinations of factors lead to successful implementation and which combinations of factors result in failure. The data required for the analysis was gathered through interviews with various actors involved in the projects.

The QCA resulted in the identification of 8 factors that are relevant for the successful implementation of shared power transport capacity. 4 distinct scenarios have also been identified in which different combinations of which success factors are present result in success. Users that which to implement shared transport capacity can thus increase their chances of success by identifying which scenario is relevant to them which in turn tells them which success factors need to be present in order to make success possible.

The conclusion of this research is that it is possible to identify commonalities between the various cases in which shared power transport capacity has been tried to be implemented. 4 scenarios have been identified in which different conditions are required for success. Users can identify which scenario is relevant to them in order to determine the conditions required for them to successfully implement shared power transport capacity.

The results obtained in this research provide an initial overview of the current situation regarding the implementation of shared power transport capacity systems. However, the low availability of relevant cases hurts the validity of the results. Further research should aim to analyse more cases in order to determine whether all success factors have been identified and if there might be more scenarios where the conditions for success are different to the others.

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List of abbreviations

Abbreviation	Definition
RES	Renewable Energy Sources
TSO	Transmission System Operator
DSO	Distribution System Operator
SPTC	Shared Power Transport Capacity
GTO	GroepsTransportOvereenkomst
Group-CBC	Groeps-CapaciteitsBeperkingsContract
TIS	Technological Innovation Systems
ST-System	Socio-Technical System
QCA	Qualitative Comparative Analysis
EMS	Energy Management System
TF	Technical Feasibility
HU	High Urgency
LU	Low Urgency
NU	No Urgency
F	Flexibility
CC	Close-knit Community
II	Independent Intermediaries
S	Number of participants
O	Degree of Organisation
SHE A1	Smart Energy Hub A1
PoA	Port of Amsterdam
STP	Schiphol Trade Park
SZN	Smart energy hub regio Zwolle Noord

List of important terms

Terms	Definition
Shared Power Transport Capacity	A form of cooperation in which multiple users of electricity group the available electrical transport capacity together. The group is responsible for managing their use of electrical transport capacity to stay within the allowed limits as a group.
Grid congestion	A situation in which the exiting power grid infrastructure is not able to transport the required amount of electricity. Grid congestion can be compared to a traffic jam on the power grid. The effects of grid congestion is that users are not able to receive the amount of electricity they request at certain times.
Distribution Service Operator	A company that is tasked with the management of the power grid. They are tasked with ensuring a reliable power grid and allocating the available transport capacity to users.
Socio-Technical system	A technical system whose development and implementation are heavily influenced by social factors.
GTO, Group-CBC	Contract forms that allow SPTC.

1 Introduction

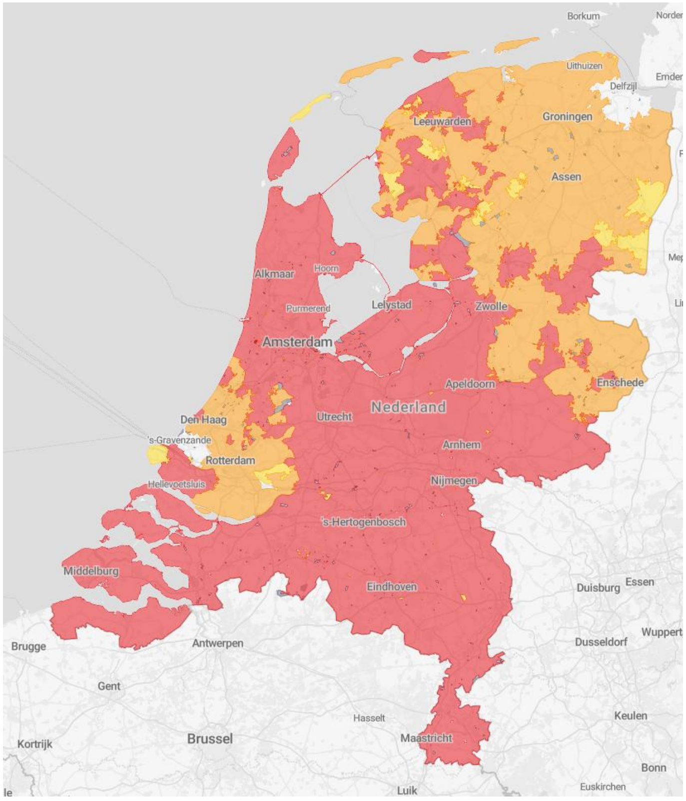
In recent years, significant increases in the demand for electricity as well as the supply of locally generated electricity could be observed in the Netherlands. This growth is largely driven by electrification initiatives aimed at reducing the reliance on fossil fuels by replacing them with electric alternatives powered by Renewable Energy Sources (RES) (IEA, 2025). While electrification through the increased usage of RES offers numerous environmental and economic benefits, new challenges arise from the increased strain on the power grid as a result from the increased amounts of electricity that need to be transported over the power grid. (Goop et al., 2017; Ramesh & Li, 2020). The primary challenge lies in the limited capacity of the power grid infrastructure to transport electricity during periods of peak demand, resulting in local imbalances between electricity supply and demand. This imbalance, referred to as grid congestion, can lead to damage to the infrastructure due to overloading or result in the inability to adequately meet the electricity demands of consumers and producers. In the presence of grid congestion, further increases in electricity demand and supply are limited. Electrification initiatives, new users, and increased demand by existing users are all harmed by the existence of grid congestion in their area. Multiple potential solutions for grid congestion are currently being developed and implemented in the Netherlands. One of these solutions is to make more efficient usage of the available transport capacity by allowing multiple users to share their allowed transport capacity within a group.

1.1 Grid congestion in the Netherlands

The Dutch power grid is one of the most reliable power grids in the world. Electricity consumers in the Netherlands will, on average, only experience 21 minutes without power each year, resulting in an uptime of over 99.99% (RVO, 2024). Grid reliability is the main concern for the actors tasked with managing the Dutch power grid. This is achieved by ensuring that the existing power grid can support the peak demand from the connected users. (Zane et al., 2012)

The Dutch power grid can be divided in three different sections. High voltage lines, which are maintained and managed by a Transmission Service Operator (TSO), medium voltage lines, and low voltage lines. The latter two are managed and maintained by a Distribution Service Operator (DSO). The Netherlands has a single TSO (TenneT) which is responsible for the high voltage power grid infrastructure, while there are six different DSOs tasked with the management and maintenance of the medium and low voltage power grid infrastructure. The DSOs Stedin, Liander, and Enexis together cover the largest part of the medium and low voltage power grid infrastructure (NetbeheerNederland, 2022). The main difference between the three sections of the power grid is the amount of electricity that can safely be transported by them. Transporting more power through a cable than it is able to accommodate results in the generation of heat which can damage the infrastructure and lead to blackouts. The TSO and DSOs are thus tasked with ensuring that overloading of the power grid does not happen. This is achieved by allocating a specified amount of transport capacity through contracts issued to individual consumers of electricity. The TSO and DSOs issue electricity contracts based on the amount of transport capacity available at a specific location. The peak demand of the users is used to determine the amount of transport capacity that is allocated and reserved.

Grid congestion is a transportation issue rather than a generation issue since grid congestion occurs once the demanded flow of electricity exceeds the maximum transport capacity of the power grid infrastructure. Figure 1 shows a map of the Netherlands in which the current availability of transport capacity is visualised. The lack of available transport capacity has resulted in long waiting lists for users looking to obtain more transport capacity.



Colour	Power transport availability
White	Capacity available / no queue
Yellow	Limited capacity available / no queue
Orange/ Red	Capacity shortage / existing queue

Figure 1: Current state of transport capacity in the Netherlands (TenneT, 2025)

The waiting list for the allocation of transport capacity has grown significantly in recent years. There are currently 14000 request for more transport capacity on the demand side and 8600 requests on the supply side. Current wait times for a new small usage connection is 44 weeks and for the expansion of an existing connection there is an average wait time of 23 weeks. The wait times for large usage connections are even longer and often dependent on an expansion of the local power grid infrastructure. (NetbeheerNederland, 2025). The long wait times have urged users to search for alternative solutions through the use of generators or RES. These solutions have large drawbacks as well as they increase the strain on the power grid infrastructure during low demand periods, further increasing the experienced grid congestion.

Grid congestion not only halts further electrification efforts and the integration of RES, there are large economic costs associated with the lost productivity caused by the inability to provide enough power to users.(RVO, 2024) The urgent need for a solution to grid congestion has therefore resulted in multiple different potential solutions being developed and implemented.

1.2 Power Capacity Sharing Systems

Grid congestion can be reduced in three different ways: Reducing the required flow of electricity, increasing the transport capacity of the power grid infrastructure, or by making more efficient use of the available transport capacity. Reducing the required flow of electricity would counteract the efforts made to reduce the need for fossil fuels. Many businesses and households have previously invested in electric systems as alternatives to fossil fuels. Undoing these investments is not an option for most users. This reduces the possible solutions to increasing the transport capacity or using the available infrastructure more efficiently. The fortification of the power grid is currently being worked on through the addition of more power cables and substations. However, it is estimate that it will take a minimum of 10 years before this project is fully completed and is therefore not a short-term solution.(TenneT, 2025) The last remaining option is to make more efficient use of the available transport capacity which is possible to be achieved in the short-term without the need for large investments into the power grid infrastructure.

Combining the allocated transport capacity of multiple users into a single shared capacity is one of the possible ways to use the existing infrastructure more efficiently. This would allow the group members to use any transport capacity that is not being used by other group members. A shared system is possible if complementary usage profiles are present within the group. Figure 2 shows an overview of how users with complementary usage profiles would be able to reduce their total required transport capacity through a shared system.

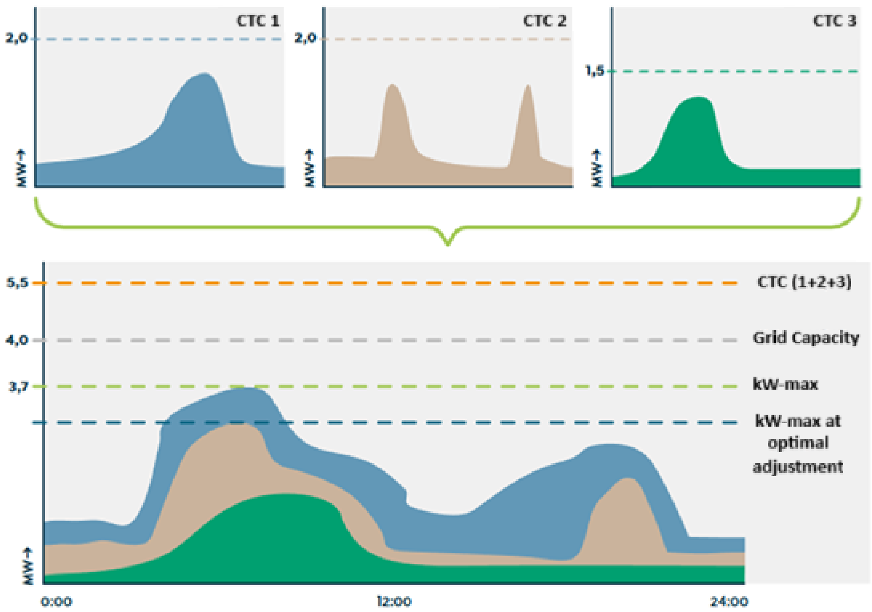


Figure 2: Example situation showing the potential of shared transport capacity. Adapted from (NetbeheerNederland, 2024)

Shared Power Transport Capacity (SPTC) can only be realised with the assistance of the DSO and TSO. Generally, the DSO only allocates capacity to single users. Implementing SPTC therefore requires new contract forms to be developed to allow multiple users to share a single transport capacity. Two new group contract forms are currently being developed. The first of these contract forms is the GroepsTransportOvereenkomst (GTO). This contract allows multiple users to share a single set transport capacity where the members of the group are responsible for ensuring that the total used transport capacity is below the allowed amount. The second contract form is the Groeps-CapaciteitsBeperkingsContract (Group-CBC). This contract allows a group of users to make use of spare transport capacity when it is available. The group is notified by the DSO whenever there is insufficient available transport capacity to supply other users. This contract form makes the members of the group responsible for ensuring that their need for transport capacity is reduced sufficiently.

SPTC cannot be implemented through just a contract. Instead, it is done through a combination of different technologies, (contractual) agreements, collaboration, and practices. The exact combination of technologies can differ from case to case. SPTC often requires the implementation and use of a combination of technologies such as operating/management systems, batteries, smart technologies, and generators. The implementation of SPTC thus requires both a technical system as well as social factors. This qualifies SPTC as a socio-technical system. Identifying SPTC as a socio-technical system allows us to develop a framework for identifying the factors involved in successfully implementing a socio-technical system. Socio-technical systems have arisen from the theory on Technological Innovation Systems (TIS) Technical innovation systems theories aim to describe the innovation process within a system that not only includes the technology itself, but also the network of actors that are involved in the process. (Carlsson & Stankiewicz, 1991) The weakness of TIS is that it mainly describes the process and actor network of the technology producer side. The lack of attention to the user side of the technology can result in TIS theories not being sufficient to explain the development and diffusion of the technology. These instances require a more extensive model that also incorporate the user side. Socio-Technical Systems (ST-systems) theories have been developed to fulfil this need.

1.3 Problem statement & research objective

Problem statement

Large scale implementation of SPTC has the potential to allow for a more efficient usage of the currently available power grid infrastructure. The system is promising to users already experiencing the effects of grid congestion as well as users at risk of being negatively impacted by grid congestion. However, there are only a few of these systems currently in use, indicating that there are still barriers preventing large-scale implementation in the Netherlands. The exact barriers preventing the implementation of SPTC have not been sufficiently identified yet. There is a need for more research into what factors contribute to the successful implementation of SPTC and which factors lead to failure.

Research objective

The aim of this research is to identify which factors are critical to the successful implementation of systems allowing for SPTC and which factors result in failure. The results and insights obtained in this research should provide recommendations for the successful implementation of SPTC in the future.

1.4 Research questions

Based on the identified need for more knowledge on the success factors for the adoption and implementation of SPTC, the following research question has been composed:

What combination of factors are key to (un)successful implementation of shared power transport capacity systems on business parks in the Netherlands, and how are actors involved in the implementation process able to address these factors to facilitate more successful implementation of SPTC?

The main research question cannot be answered directly due to a lack of available research regarding the implementation of SPTC and smart energy systems in general. Several sub-questions need to be set up and answered in order to formulate an answer to the main research question. The first step is to determine what is already known regarding the implementation of smart energy systems in general. This information provides a foundation on which a more in-depth analysis of the factors relevant to the implementation of SPTC can be based. Secondly, the elements that make up the technical systems and processes required for SPTC need to be clearly defined to determine when a specific case can be labelled as using SPTC. Once the system has been clearly defined, the specific factors relevant to the successful implementation of SPTC can be identified. Identifying the relevant factors is required to determine how SPTC can be successfully implemented and whether specific combinations of factors result in a higher chance of success. Once it is known which factors are most relevant for success and why they are relevant, is it possible to formulate recommendations for the stakeholders involved with the implementation of SPTC in order to increase their chance of success.

Formulating answers to all the steps mentioned allows for the formulation of a complete, understandable and clearly defined answer to the main research question. Four sub-questions have been added in order to find an answer to the various steps that need to be taken in order to answer the main research questions. These sub-question can be found below. Figure 3 shows a roadmap detailing the various steps in the research and at what point the research sub-questions will be answered.

Sub-questions

What is known about the factors influencing the success or failure of the implementation of (smart) energy systems and technologies?

How can shared power transport capacity systems be defined?

Which factors are involved in the successful implementation of SPTC?

Which strategies can be employed to obtain the required combination of factors leading to successful implementation of SPTC?

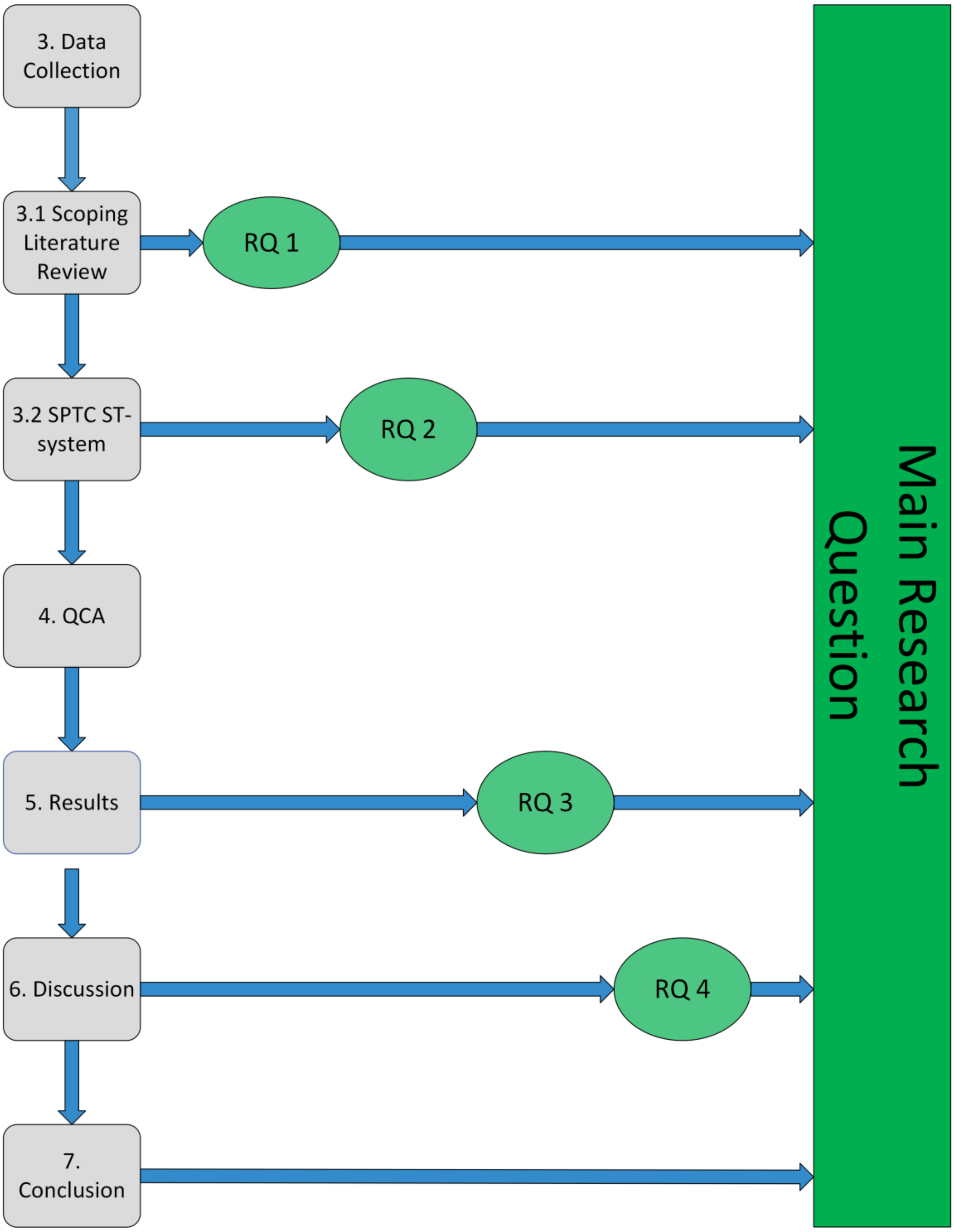


Figure 3: Research roadmap

2 Methodology

The experimental part of the research consists of two steps. The first step is formulating a description of the SPTC ST-system through a scoping literature review and interviews. From this literature, a list of factors relating to the SPTC ST-system will be constructed. The second step consists of a Qualitative Comparative Analysis (QCA) in which the factors present in both successful and unsuccessful pilot projects will be compared in order to determine which combinations of factors result in the successful implementation of SPTC and which combinations of factors result in a failure to implement SPTC.

2.1 SPTC ST-system formulation

A scoping literature study is performed in order to obtain the knowledge necessary for the formulation of the SPTC ST-system. The data from the scoping literature review will be supplemented with articles regarding SPTC pilots as well as interviews conducted with stakeholders involved in SPTC-pilots with the aim to create an overview of the ST-system. This overview will in turn be used to identify the factors involved in the (un)successful implementation of SPTC. The overview will be based on a framework developed in ST-system theories in which the factors can be divided into 6 different sub-categories or artifacts. The idea of ST-systems consisting of different artefacts that fulfil sub-functions has been adopted and developed into a framework by other researchers. Davis (Davis et al., 2014) states that any ST-system can be described as a system consisting of interrelated components which are embedded into an external environment. According to Challenger & Clegg, there are six artifacts required to describe a complex organisational system (Shepherd & Clegg, 2011). These six artifacts are: Goals, People, Processes/Procedures, Culture, Technology, and Buildings/Infrastructure. Figure 4: shows an ST-system represented as a hexagon where the relations between the different artifacts can be observed.

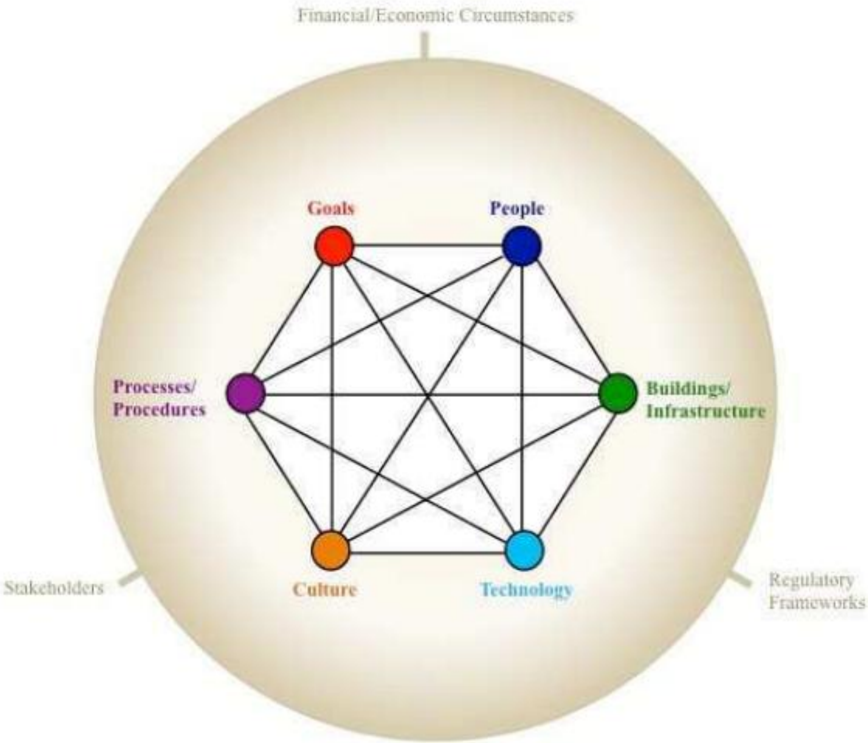


Figure 4: Socio-technical system. Adopted from (Davis et al., 2014)

Figure 4 shows that ST-systems can be described by the relations between the 6 different artifacts within the context of the external environment consisting of financial/economic circumstances, Regulatory frameworks, and stakeholders. Identifying both success factors and barriers can be done by analysing both generic factors for the various artifacts as well as domain-specific factors (Clegg et al., 2017). If the ST-system has been sufficiently described it will be possible to determine or predict if a specific case within the ST-system will be successful.

Knowledge gap

The difficulty with describing the SPTC ST-system is the lack of a general definition for a SPTC system. SPTC can exist in many forms with the simplest versions being just an agreement between different users on how the available power is distributed. However, in reality, all the currently existing instances of power sharing between different users make use of smart systems. These systems can combine the data from multiple sensors to monitor the available transport capacity between users. More advanced systems are able to regulate the consumption and the production of electricity in order to balance the used transport capacity automatically. The inclusion of smart systems increases the difficulty of defining the technologies required for SPTC due to the lack of standardised terminology regarding smart energy systems. This absence of standardised terminology has been identified as a problematic factor in defining both the technical aspects as well as social aspects. (Bayindir et al., 2016; Gopstein et al., 2021; Moreno Escobar et al., 2021; Norouzi et al., 2023). In order to create a standard concept for the various smart energy systems, a common terminology must first be accepted (Norouzi et al., 2023). Policy makers share this opinion and state that common terminology must first exist before legislation regarding the use and implementation of these systems can be created. (Rijksoverheid, 2024; RoyalHaskoningDHV, 2024; Zee, 2024). The lack of clear terminology can thus be seen as one of the reasons why the ST-system for SPTC has not been clearly described yet.

2.1.1 Scoping literature review

A scoping literature review has been selected as the research method to gain more information on the existing knowledge regarding the implementation of smart energy systems as a whole. This approach is suitable for mapping the existing literature in a chosen field that is not yet widely reviewed. (Pham et al., 2014) This is the case for the implementation of smart energy systems as there is a wide variety of technological and organisational factors that are involved in these processes. A scoping review allows for the key concepts, research areas, and knowledge gaps to be mapped within a viable timeframe. (Arksey & O'malley, 2005) The scoping literature review consists of six steps. First, the research question is identified to determine the focus and scope of the review. Second, relevant studies are identified among the available literature. Third, a study selection process is carried out to determine the relevancy of the studies in regards to the research question. Fourth, the data is charted, meaning that key information found in the studies is extracted and organised. Fifth, the findings are collated, summarised, and reported to identify common themes and knowledge gaps in the existing literature. Lastly, an optional consultation stage can be included to validate or enrich the findings through consulting with stakeholders or experts. (Arksey & O'malley, 2005) Completing these steps will result in an overview of factors relevant to the implementation of smart energy systems which can in turn be used to formulate an answer to the first sub-question and provide a basis for describing the SPTC ST-system.

Identifying the research question

The research question for the scoping literature review has already been defined as the first sub-question. The sub-question will be used as the main research question for the scoping literature review.

What is known about the factors influencing the success or failure of the implantation of (smart) energy systems and technologies?

Identifying relevant studies

The aim of the scoping review is to create a comprehensive overview of the factors regarding the implementation of innovative energy systems. The review will be conducted through Scopus as it offers multiple ways to easily sort the obtained literature. The search terms will use various terms for innovative energy systems in combination with the terms barrier, drivers, and implementation.

Data extraction and synthesis

The literature found using the search queries is tested against both inclusion criteria as well as exclusion criteria. The criteria are created in order to eliminate literature not relevant to the research question. The inclusion and exclusion criteria are listed below.

Inclusion criteria:

- Literature related to drivers and barriers for shared power capacity systems.
- Literature related to drivers and barriers for parts of a shared power capacity system.
- Literature related to drivers and barriers for local innovation.

Exclusion criteria

- Literature on shared power capacity systems or parts which do not mention any drivers or barriers.
- Unavailable full texts
- Non-English texts

Charting the data

The identified literature will be analysed by identifying the factors involved in the implementation of smart energy systems and technologies. The results will be listed using excel with the following data included:

- Author(s), title, year of publication
- Technology that is being researched
- Key factor identified.
- Reasoning behind the identification of the success factor

Summarising the results

The identified factors will be grouped together by their overarching artificats. This will create an overview of both the success factors related to the implementation of smart energy systems as well as an overview of the different categories of factors relevant for the implementation of smart energy system.

2.2 Qualitative Comparative Analysis

Qualitative Comparative Analysis can be used to identify combinations of factors that contribute to both successful as well as unsuccessful implementation of SPTC. Unlike methods that focus on the influence of individual variables, QCA is able to compare multiple cases with many different variables and describes how different combinations of factors can lead to specific outcomes. For this reason the QCA method is suitable for analysing the implementation of SPTC, since the pilot projects often differ significantly from one another and are described as requiring tailor-made solutions. This diversity suggests that there may not be a single standard situation in which SPTC is most likely to succeed, but rather that their might be multiple scenarios in which successful implementation is possible. The value of the QCA method therefore stems from its ability to analyse and compare complex cases with multiple interacting variables in order to identify common patterns across them.

The QCA consists of three steps which are described next. First, relevant cases to be used in the QCA are identified. Second, truth tables are constructed to create an overview of the presence or absence of the identified success factors across the selected cases. Third, the truth tables constructed in the second step are solved which results in the identification of the combinations of factors required for success. Solving the truth tables shows how many different combinations of factors can lead to success. This can subsequently be used to identify the different scenarios in which SPTC can be successfully implemented. (Ragin, 2008). The following sections will describe the three steps required for QCA in more detail.

Identifying relevant cases

The first step of the QCA is the identification of relevant cases. Once the qualifying terms for relevant cases have been described, will it be possible to create an overview of cases that can be used for the

QCA. The scope of the QCA performed in this study is limited to pilot projects at business parks within the Netherlands that aim to implement a technical system allowing multiple users to reliably make use of a single shared power transport capacity. Shared power transport capacity is currently only possible through special agreements granted to pilot projects deemed promising by the DSO. The cases used in the QCA will be collected from currently existing pilot projects which have stated a desire or have already signed a GTO or G-CBC contract. The QCA requires cases to be labelled as successful or unsuccessful. In this research the qualifying factor for a case to be considered successful is the signing of a GTO or G-CBC contract. Any relevant case in which the contract has not been signed is classified as an unsuccessful case.

Conducting interviews.
A list of success factors the cases are tested for is composed through interviews with stakeholders involved in SPTC pilot projects. The interviews are semi-structured were first part of the interview discusses success factors regarding the six artifacts relating to ST-systems. The second part of the interview allows the participants to discuss their personal experiences with SPTC implementation with the aim to identify new success factors not discussed during the first part of the interview. The final list of factors will subsequently be used as the success factors for the QCA. Conducting interviews is essential due to the low availability of publicly available sources describing the SPTC implementation process. Interviewing a broad range of stakeholders will not only support the collection of necessary data, but will also assist in identifying additional success factors that did not emerge from the available literature.

Constructing Truth Tables
Truth tables can be constructed once all the data for the relevant cases has been gathered. Truth tables show every possible combination of factors in a table form. The columns represent the different factors with the rows indicating the absence or presence of the factors. Presence is indicated with a 1 while a 0 being representative for the absence of a factor. Once all possible combination of factors have been put into the table, will the cases be added to the row with the combination of factors representative for that case. Doing this for every case allows observers to easily see which cases have identical combinations of factors.

The main purpose of a truth table is to verify if enough factors are present to make a distinction between successful and unsuccessful cases. This is done by calculating the consistency of each row. The consistency will be 1 if all cases in a row have the same result. A row in which half of the cases are successful and half are unsuccessful will result in a consistency of 0.5. Three successful cases and one unsuccessful case will result in a consistency of 0.75. Table 1 shows an example truth table with three factors and different consistencies.

Table 1: Truth table example

Factor 1	Factor 2	Factor 3	**Positive cases**	**Negative cases**	**Consistency**
0	0	0	**0**	**0**	**NA**
1	0	0	**2**	**0**	**1**
0	1	0	**1**	**1**	**0.5**
0	0	1	**0**	**2**	**1**
1	1	0	**3**	**1**	**0.75**
1	0	1	**0**	**0**	**NA**
0	1	1	**0**	**0**	**NA**
1	1	1	**0**	**0**	**NA**

In the above table there are two cases in the second row with the same combination of factors present. Both of these cases resulted in success which results in a consistency of 1.0. Row three has two cases with the same combination of factors. One of the cases yielded a successful result while the other yielded an unsuccessful result and therefore results in a consistency for this row of 0.5. There are four cases in row 5 that have the same combination of factors. Three of the four cases were successful and one was not successful so the consistency is 0.75.

The presence of row with a consistency lower than 1.0 indicates that the used success factors are not sufficient for the actual analysis. The goal of a QCA is to determine which combinations of factors result in success or failure. This distinction cannot be made if there are cases with the same combination of factors resulting in different outcomes. More factors have to be added to the truth table in order to properly make the distinction between successful and unsuccessful cases. Identifying new factors can be done through a qualitative analysis of the contradictory cases. A deeper understanding of these cases can bring causal differences to light that can be used to identify new factors. The relevancy of these factors can subsequently be verified by identifying their presence or absence in other cases. The process of adding new factors that aid in distinguishing between success or failure is repeated until there are no contradictory rows left. It is possible that there is an explanation for the contradictory result on a case level. The case review gives insight into the specific conditions that lead to the contradictory outcome and could result in the contradictory row to still be used for the QCA.

Truth Table Analysis

The final truth table will be analysed using the QCA package in RStudio. This software compares rows in the truth table that differ by only one variable. If the examined variable does not lead to a different outcome, it is removed and the two rows are combined into a simplified configuration. These simplified rows are then compared again to identify further opportunities for elimination. This iterative process continues until no more factors can be removed. The result is a set of the most simplified combinations of factors that lead to either success or failure. This analysis may produce multiple solutions indicating that more than one distinct combination of factors can result in the same outcome. Such findings indicate that SPTC can be successfully implemented under different conditions. A final case-based analysis will be performed to assess the plausibility and relevance of each solution.

The results of both the truth table analysis and the case-level analysis will be used to formulate recommendations for the various stakeholders involved in SPTC implementation. The truth table analysis identifies which combinations of factors are associated with success, while the case-level analysis helps explain why the particular combinations resulted in success. By understanding the mechanisms behind successful combinations, it becomes possible to derive strategies that stakeholders can adopt to create favourable conditions for the implementation of SPTC in their own contexts.

3 Data collection

The following chapter describes the process of creating an overview of the socio-technical system regarding shared power transport capacity systems. A scoping literature review is performed as the first step in creating the ST-system overview. Secondly, an overview of the SPTC socio-technical system is made using the collected data.

3.1 Scoping literature review

Identifying the research question
The scoping literature review aims to answer the following sub-question:

What is known about the factors influencing the success or failure of the implantation of (smart) energy systems and technologies?

Various (smart) energy system terms have been combined with terms regarding the success or failure of implementing novel technological systems to identify studies relevant to the research question. An overview of the different search queries with the corresponding hits can be found in the appendix. Fifteen queries were made resulting in 217 hits. Subsequent removal of duplicates and further selection rounds through more in-depth reviews of the literature yielded a final total of 25 studies that were deemed relevant in the formulating an answer to the research question of the literature review. An overview of the selection process can be seen in figure 5.

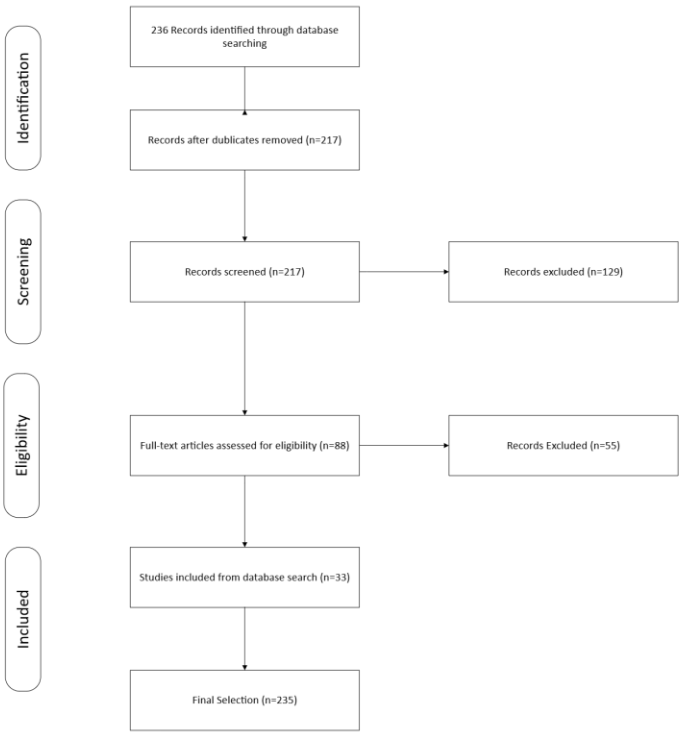


Figure 5: Scoping literature review process overview

3.1.1 Review results

The scoping literature review resulted in the identification of a range of success and failure factors that influence the implementation of SPTC. These factors can be grouped into seven main categories: macro developments, technological factors, social factors, economic factors, institutional factors, organisational factors, and security factors. These categories reflect the key themes that consistently emerged across the literature reviewed.(Boon & Dieperink, 2014; Dieperink et al., 2004; Mohseni & Brent, 2025; Norouzi et al., 2022) The following sections will discuss each of these categories in more detail.

Macro Developments

The implementation and adoption of ST-systems is not solely dependent on factors within the system itself. External developments on the macro scale can have substantial impact on the success rates of the implementation of innovative systems. Changes in the way that a population consumes or generates electricity due to grid congestion can be seen as a macro development that stimulates the development, adoption and implementation of innovative energy systems. The failure of the current system leads to the introduction of new systems with the ability to solve the problems the failed system was not able to do. Electrification efforts and the increased usage of RES are stimulating macro developments as well since they also contribute to the experienced grid congestion. Grid congestion can also be seen as a development that indirectly discourages the implementation of smart energy systems as grid congestion stimulates the development of alternative solutions that cannot be classified as smart energy systems. An increased interest in these alternatives would result in less support for smart energy systems. (Hojckova et al., 2022) Therefore, the speed of development, adoption, and implementation of alternatives can be regarded as a macro development. Incremental innovations relating to the existing power grid infrastructure can be regarded as an alternative solution as well. (Boon & Dieperink, 2014) The expected timeline of ten years for the fortification of the power grid thus acts as an encouraging macro development regarding the implementation of smart energy systems.

Technological factors

The technological factors of ST-systems can both increase and decrease the chance of successful implementation. This is not necessarily caused by how far the development of a system has progressed, but rather by the knowledge that users possess of the possibilities of the system. Users that have knowledge of the capabilities of a specific technological system are often more inclined to adopt the system relative to uninformed users.(Goulden et al., 2014) Once a user becomes more informed about the system, their willingness to adopt and participate in the development of a technological system increases. In regard to smart energy systems this entails that more easily understood technical systems are more likely to be adopted by users. Participation and involvement of users in the development of technologies increases the chance of successful adoption. The feeling of self-reliance and independence from the central grid makes users feel that they are actively working on accomplishing personal goals when being involved in the development and implementation process. (Boon & Dieperink, 2014; Coelho et al., 2017) The long-term usefulness of the innovative system can be regarded as another factor that is highly influential to success rates. The fear of obsolescence has the opposite effect and can act as a barrier if users feel that a system will only be useable for a short period of time. (El-hawary, 2014) Both the lock-in effect and path dependencies will discourage the implementation of novel systems as well. New systems requiring new infrastructure are often not implemented because of the infrastructure that is already in place. The same goes for systems that require users to change their energy consumption profiles, since their electricity usage is often intertwined in a complex system of actors and actions. (Hojckova et al., 2022; Norouzi et al., 2022) However, once users become more familiar with a new system, they are less discouraged by the lock-in effect as they discover new possibilities. (Goulden et al., 2014)

Economic Factors

Multiple economic factors contributing to both the success and failure of the implementation of smart energy systems can be identified. The main economic factors resulting in the failure of implementation are financial constraints. The inability to finance the required technical systems can suspend or cancel implementation projects. The biggest economic success factor is the return on investment. Projects in which the return on investment is estimated to be large are more likely to be implemented than those that are expected to see lower returns. In the case of smart energy systems this return on investment would come through profits generated by RES or reduced energy costs. However, reduced energy costs do not necessarily result in higher success rates. The driving effect of the long term benefits of reduced costs is often negated by high initial investment costs and a long investment payback time. The reduction in costs needs to be very large in order to increase the adoption and implementation of a system without any other benefits. (Boon & Dieperink, 2014; Goulden et al., 2014; Norouzi et al., 2022; von Wirth et al., 2018) The negative influence of high investment costs can also be reduced when the costs can be distributed over a larger number of users. A large number of users willing to participate thus also increases the chances that a new system is successfully implemented. (El-hawary, 2014)

Institutional Factors

Governmental policies, incentives, and regulation can all affect the success rates of smart energy systems. Institutional barriers can be observed through long bureaucratic processes. The absence of a long term and consistent policy framework will reduce the success rate as well. The uncertainty created by inconsistent policies will greatly reduce the willingness of users and other stakeholders to implement a new system. (Boon & Dieperink, 2014; von Wirth et al., 2018) On the other hand, the existence of incentives by a government can increase success rates. Governments can create these incentives either by subsidising the implementation of new systems, or by assisting in the distribution of knowledge and expertise. (Boon & Dieperink, 2014; Norouzi et al., 2022) However, the incompetence of a government to successfully solve problems can actually increase the implementation of new systems developed through initiatives of citizens (Boon & Dieperink, 2014). Contrary to the previous statements, government regulation could also potentially reduce success rates. Once a government creates requirements that systems need to meet, it removes most incentive to develop a system further beyond the minimum requirements. (Hemmelskamp, 1997) The main ways in which a government can stimulate the implementation of new systems is thus to create policies and incentives that promote the development of innovative energy systems, facilitating the transfer of knowledge, and refraining from creating strict regulations for new systems.

Organisational Factors

Many forms of smart energy systems require a form of organisation. The degree of organisation has a large influence of the potential success of the project. Involvement of local communities is seen as an important success factor to the adoption of cooperative energy systems. (Boon & Dieperink, 2014) Cooperations that consist of representatives from the actual group of users can have a large positive effect on the willingness of other users to cooperate. (von Wirth et al., 2018) The opposite situation in which users feel that they lose ownership of their personal assets reduces success rates. Users that feel controlled by others are less willing to cooperate leading to lower success rates. It is possible to prevent this situation by creating a transparent organisation with clearly defined policies. (Goulden et al., 2014; Norouzi et al., 2022) This is also complementing the fact that the degree of social cohesion and trust can influence the acceptance of cooperative energy systems. (Boon & Dieperink, 2014)

Social Factors

The social interactions of users can have a large impact on the success chance of implementing an innovative energy system. Two types of energy users can be identified. The energy consumer and the energy citizen. The energy consumers see electricity only as a resource while the energy citizen is more conscious about their use of electricity. These personas are not mutually exclusive and users can alter between both depending on the context. The results is that in order to develop a successful strategy to encourage the implementation of an innovative energy system, it is first necessary to know the target population. (Goulden et al., 2014) The energy consumer does not want to spend a lot of time on managing their electricity usage. They value energy independence a lot less so heavily so involving energy consumers into the development process early on only creates animosity towards the project. However, once the energy consumers become more familiar with the system, their willingness to participate often increases. This means that the way in which knowledge and information are being shared, also influences the adoption rate. Using trusted local suppliers and installers is also seen as a driver for energy consumers as it increase their familiarity with the project. (Boon & Dieperink, 2014; El-hawary, 2014) Energy citizens are more conscious about their electricity usage and being actively involved in the development of a system is one of their main drivers. Energy citizens often have a sense of social responsibility that drives them to participate in the development and implementation of new systems. (Goulden et al., 2014) Lastly, a big benefactor for social support for new energy systems is how well the involved stakeholders are able to collaborate and exchange knowledge. This is not only the case for stakeholders within the local system, but also between the different networks of innovative energy projects. The sharing of knowledge and practical information will both increase the creditability of the project as well as the degree of local support. (Boon & Dieperink, 2014; Coelho et al., 2017; Goulden et al., 2014; Norouzi et al., 2022)

Security Factors

The factors regarding security can be divided into two smaller categories: data security and energy security. Data security is mentioned as a factor which acts as a barrier the implementation of smart and shared energy systems due to privacy concerns. The fear that important information might be leaked through smart energy systems can be a factor that prevents the adoption of a smart energy system. Increased energy security can often assist in the implementation of smart energy systems. Small local grids that can operate independently make users less reliant on the main power grid and would allow them to continue using electricity if there are problems on the main grid (Mohseni & Brent, 2025). However, the fear that a smart energy system could also be hacked and disabled has been mentioned as a reason for users not to implement a smart system.

3.1.2 Literature review conclusion

The scoping literature review has provided an overview of the various factors that influence the success or failure of smart energy system implementation. This knowledge forms the basis for answering the sub-question 1:

What is known about the factors influencing the success or failure of the implementation of (smart) energy systems and technologies?

The factors influencing the success or failure of the implementation of (smart) energy systems and technologies can be classified into 7 distinct categories. The categories being: macro developments, technological factors, economic factors, institutional factors, organisational factors, social factors, and security factors. Factors that either increase or decrease the success rate of implementation were identified in all categories. Overlapping themes between the categories and factors were the need for knowledge sharing and informed users. The need for inclusion of end users during the development process and a high degree of organisation were observed in multiple categories as well.

3.2 SPTC ST-System

The literature review yielded sufficient information to create an overview of the SPTC ST-system. The three external factors that form the environment in which the ST-system is embedded can be described as well as various factors relating to the 6 interrelated components that make up the ST-system itself. An overview of the factors related to the internal components can be found in figure 6. The various factors were inserted into the figure based on the literature review. The sections following figure 6 will discuss the external factors that make up the environment in which the ST-system exists in more detail.

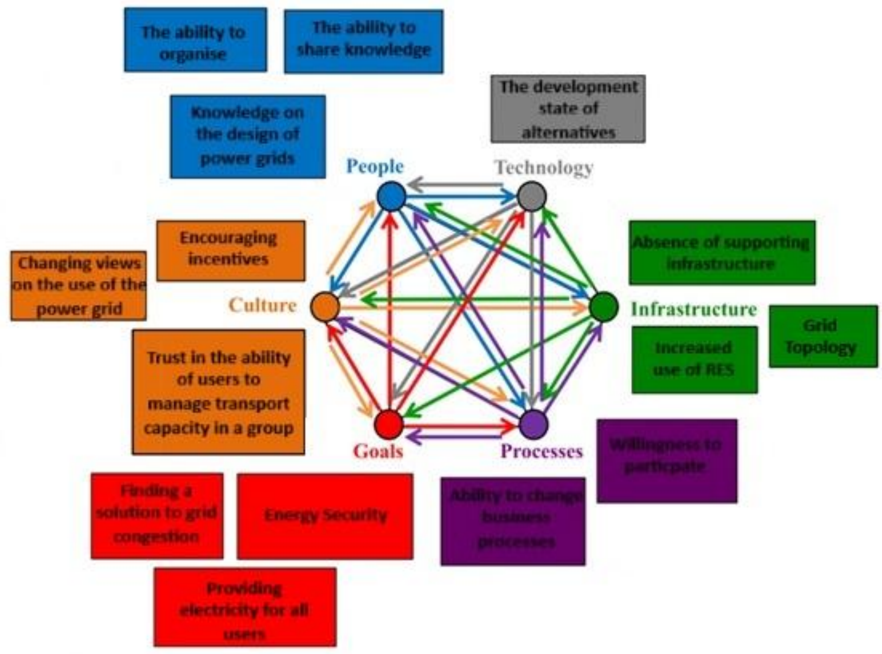


Figure 6: SPTC ST-system success factors and barriers. Adapted from (Clegg et al., 2017)

The external factors encompass the stakeholders, financial circumstances and regulatory frameworks. The section below describes the current situation for the SPTC ST-system.

The main stakeholders involved with SPTC are entrepreneurs and businesses who act as the users within the system. The users are required to work together to implement a system allowing the shared usage of a transport capacity. The willingness to work together is often based on the urgency of the participants to develop a solution to the grid congestion experienced by them. The DSO and TSO act as regulators in this ST-system. The DSO and TSO are bound by the existing regulatory frameworks which do not allow for much flexibility. There are multiple other stakeholders acting as supporting actors the most important ones being local governments and independent intermediaries. Both of these stakeholders can support implementation through directing the process, offering financial assistance and sharing knowledge and expertise.

The currently existing regulatory frameworks are still largely based on a centralised power grid with a large focus on grid reliability. These frameworks do not allow for a lot of flexibility. Group contracts are only given to pilot projects and cannot yet be given out on a large scale. The absence of standard group contracts lead to obtaining a contract for pilot projects becoming a time consuming process.

The economic circumstances are relatively neutral to the successful implementation of SPTC. There are some subsidies available for sustainable development which can be used for SPTC systems as well. However, acquiring financing can delay the implementation process in some cases. The economic returns are not large enough to act as a driver or play a factor in the successful implementation of SPTC.

Technology map

A technology map was created based on the information available and is shown in figure 7. The technology map shows 2 core components that need to be present in all SPTC systems. The first is a system monitoring the amount of power used by the individual members. The second component is an Energy Management System (EMS) which is able to add up the individual power usage to calculate the total usage. The EMS is subsequently also able to intervene whenever the total power usage nears the maximum allowed value. The method of intervention can differ per system. Some EMSs only notify the members that the power usage has reached a critical point after which the members are required to manually stop business processes in order to reduce their demand for power. Other EMSs are able to automatically change business processes in order to reduce the demand or make use of supporting assets that can provide the needed power. The use of manageable supporting assets, consisting of assets that can generate electricity and assets that are able to store energy, is in theory not required. However, all the currently running SPTC systems make use of at least one form of a supporting asset.

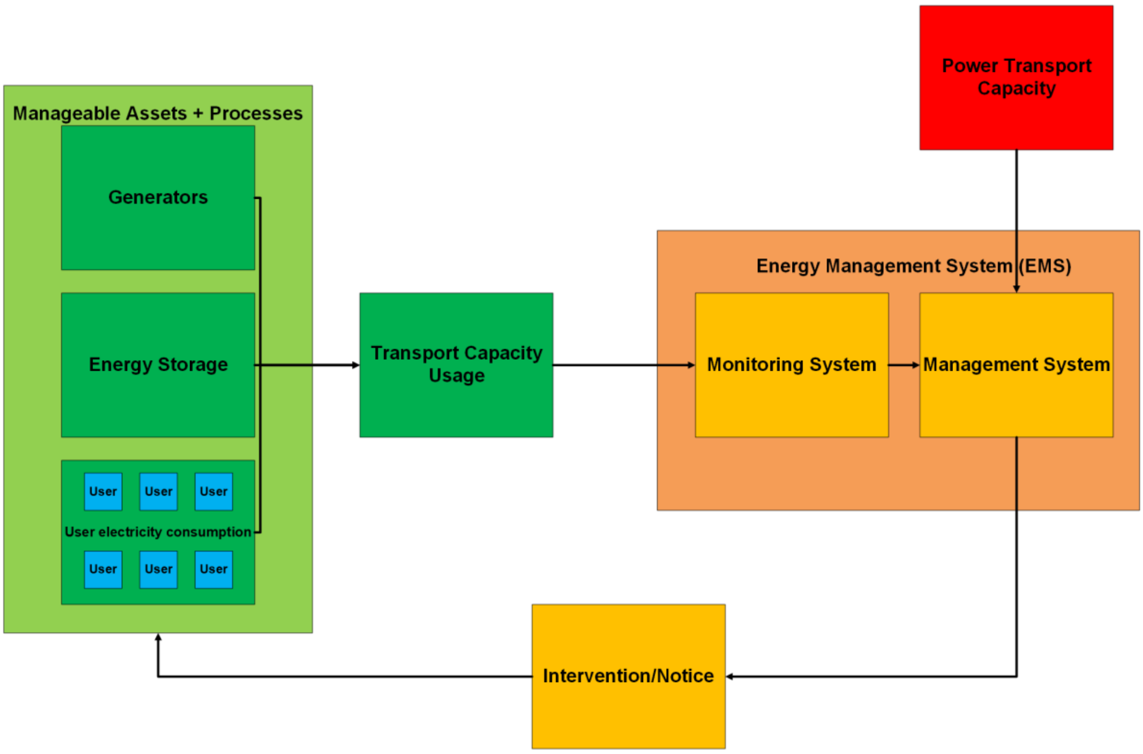


Figure 7: SPTC technology map

Sub-question 2 can be answered based on the knowledge gained from creating the ST-system overview and the development of the technology map.

How can shared power transport capacity systems be defined?

A shared power transport capacity system can be defined as a technical system in which multiple individual users can share a set power transport capacity through the use of a combination of technologies. The technical system consists of two core components; sensors monitoring the power usage of the individual members and an energy management system which monitors the total transport capacity used by the group and able to intervene if the amount of transport capacity used is nearing a critical level. The energy management system can intervene in multiple ways with the simplest versions notifying the users that the used transport capacity should manually be reduced and fully automatic systems, which can control the required transport capacity through managing business processes, generators, and batteries automatically. The way in which the transport capacity is distributed among the users adds a social aspect to the system that requires collaboration between the users to ensure that the maximum allowed transport capacity is not exceeded.

4 Qualitative Comparative Analysis

This chapter describes the qualitative comparative analysis as it was carried out in this research. The chapter starts with a description of the relevant cases included in the analysis, followed by an overview and definition of the success factors used in the analysis. Next, a table is constructed that indicates presence of absence for each factor per case. This table is then used to create the truth tables. Finally, the truth tables are analysed to identify the combinations of factors that lead to the successful implementation of SPTC

4.1 Identifying Relevant Cases and Factors

Relevant cases were identified through the qualifying conditions as described in the methodology. Any case in which the signing of a GTO or group-CBC contract was attempted, qualified as a relevant case. The cases were found through energy hub databases, assorted media and interviews. Thirteen projects were identified in which SPTC was either implemented or failed to be implemented. Eight of the identified cases have implemented SPTC and were considered a successful case. The remaining five cases have either failed or have not been successful yet. The following section presents a description of identified relevant cases. Figure 7 gives an overview of where the identified cases are located in the Netherlands and which DSO is responsible for the power grid in the area.

Figure 8: Map of relevant cases and their representative DSO

4.1.1 Successful cases

This section presents several pilot projects in which SPTC has been successfully implemented. For each project, key characteristics are described, including the pilot name, the responsible DSO, the contract type issued, and the level of urgency experienced by participants. In addition, the number of participants, the organisational structure, the type of flexibility available, and the main actors involved are outlined as well. Together, these descriptions provide insight into the context and environment in which SPTC has been implemented successfully.

Smart Energy Hub A1

The SEH A1 SPTC pilot was initiated out of necessity. The municipality of Deventer had developed a new business park which would only have connections for electricity and not for natural gas. However, on the day that the first lots were put up for sale, the TSO announced that grid congestion was present in the area and no more transport capacity could be issued. A solution had to be found or the business park would become completely useless. The solution was found through three businesses already present in Deventer who planned on relocating to the A1 business park. These three businesses already had a contract issuing transport capacity which could be transferred to the new location as it was connected to the same sub-station. The municipality of Deventer was also able to join as the owner of the unsold lots. The DSO Liander allowed the four participants to combine the transport capacity already available into a group. This new group now aims to make the most efficient use of the available transport capacity through changing their business processes and the use of solar panels. The remaining transport capacity left unused by the group can subsequently be used to allow new businesses to establish at the business park. The project was directed by an independent director. The municipality and the province both supported the project financially (Deventer, 2025), (Liander, 2025), (Faas, 2025), (Stadszaken, 2025).

Table 2: SEH pilot information

Pilot name	Smart Energy Hub (SEH) A1
DSO	Liander
Contract type	GTO
Participant urgency	High, Low
Number of involved participants	4
Organisation type	Energy Cooperative
Flexibility	Solar panels, Change in business processes
Involved actors	Businesses, DSO, Municipality, Province

Port of Amsterdam

Grid congestion at the Port of Amsterdam resulted in the first two group-CBCs being issued in the Netherlands. New businesses were not able to establish at the port and existing businesses could not expand their power usage due to grid congestion. This led to the affected businesses uniting and discussing a potential solution with their DSO Liander. These discussions and a subsequent analysis of the electricity usage profiles showed that there was often transport capacity available. A group-CBC was chosen as the most optimal way to free up more transport capacity while minimising the impact on the way the participants have to organise their business processes. A consortium of advisors with differing areas of expertise was set up to direct the process. The participants were also organised into an energy cooperative. The energy cooperative is responsible for ensuring that the total use of transport capacity of the group stays within the allowed limits. The cooperative is tasked with the development and implementation of large scale supporting assets as well. (van de Vegte, 2024b), (ECAH, 2024), (de Jonge Baas, 2024), (Laan, 2024)

Table 3: PoA pilot information

Pilot name	Port of Amsterdam (PoA)
DSO	Liander
Contract type	Group-CBC (2)
Participant urgency	High, Low
Number of involved participants	29
Organisation type	Energy Cooperative
Flexibility	Change in business processes
Involved actors	Businesses, DSO

Energyhub Almere

The Energyhub Almere project was initiated based on a research that indicated the potential for cooperation at business park de Vaart in Almere. The municipality organised for an energy cooperative to be set up with the aim to increase the energy security for businesses located at the business park. Four businesses and a recycling station operated by the municipality have formed a group that aims to make more efficient use of the available transport capacity by organising their business processes in an optimal way. The process was directed by a company specialising in assisting businesses with the energy transition (Roelofs, 2024), (Laeven, 2025), (Almere, 2025).

Table 4: Energyhub Almere pilot information

Pilot name	Energyhub Almere
DSO	Liander
Contract type	GTO
Participant urgency	Low
Number of involved participants	5
Organisation type	Energy Cooperative
Flexibility	Change in business processes
Involved actors	Businesses, DSO, Municipality

Lage Weide

The SPTC pilot project at business park Lage Weide was started by a single person who became interested in grid congestion. A group of businesses at Lage Weide became interested in the topic as well after the potential effects of grid congestion were mentioned during a meeting. The plan made by the group was initially rejected by the authorities. However, the authorities did become interested in developing a plan or system which would allow for the shared usage of transport capacity within the existing legislation. The DSO responsible for the area, Stedin, was also involved in the development of the new system which would eventually become a GTO with five initial participants. One of the challenges encountered by the group during the implementation process was the reduction in total allocated transport capacity. However, once it became clear that this reduction in transport capacity would be manageable without the need to drastically alter existing business processes, the participants accepted the conditions set by the DSO. A walk-in freezer was used as an energy buffer.

The freezer could be turned off during moments where little to no transport capacity was available and be turned on again once more transport capacity was available. The project was initially started with the aim to increase energy security and stimulate sustainability. However, during the implementation process, grid congestion did become an issue at the business park (Groendus, 2024), (Tennet, 2024), (PVBNederland, 2024), (Stedin, 2024a), (Energiehubs, 2024), (Hartkamp, 2024).

Table 5: Lage Weide pilot information

Pilot name	Energie Hub Lage Weide
DSO	Stedin
Contract type	GTO
Participant urgency	Low, No urgency
Number of involved participants	5
Organisation type	Energy cooperative
Flexibility	Solar panels, energy buffer
Involved actors	Businesses, DSO, Municipality, Province

Schiphol Trade Park

Schiphol Trade Park saw the first implementation of SPTC in the Netherlands. The cause for the project was grid congestion preventing businesses from settling at a newly developed area of the Schiphol Trade Park. Some of the businesses were able to obtain transport capacity while others were not able to. The developer of the business park was able to bring all the businesses together to explore a potential solution allowing all the businesses to establish at the business park. The secluded location of the business park on the power grid was the reason for Liander to take a risk with the first SPTC system in the Netherlands. The GTO or group-CBC contracts did not exist yet and sharing transport capacity among multiple users was not allowed by the existing legislation. The Schiphol Trade Park was given an exemption to the existing legislation in order to test the viability of a SPTC system. The participants were not given a set amount of transport capacity. Instead, the DSO would communicate the available transport capacity to the group and the group was responsible for staying within the allocated transport capacity. This was achieved through the use of batteries, solar panels and gas generators able to compensate for moments in which the demand for power would exceed the available transport capacity. The isolated location of the business park on the power grid meant that there was little to no risk for other users in case the group would exceed the allowed limits. The process was directed by the developer of the business park in cooperation with a company specialised in assisting businesses with the energy transition (SADC, 2022; Spectral, 2021), (Joulz, 2025), (energie, 2021), (SADC, 2023)

Table 6: Schiphol Trade Park pilot information

Pilot name	Schiphol Trade Park
DSO	Liander
Contract type	Special exemption
Participant urgency	High, low
Number of involved participants	12
Organisation type	Energy Cooperative
Flexibility	Solar panels, gas generators, batteries
Involved actors	Businesses, DSO, Business park developer

Smart Energy hub regio Zwolle Noord (SZN)

The SZN SPTC pilot project was one of the first projects to be initiated due to supply-side grid congestion. Businesses present at business park Hessenpoort generated more renewable energy than the power grid was able to handle. The businesses decided that rather than reducing their power generation, they would try to develop a system allowing them to exchange their generated electricity. Close cooperation with the DSO, the municipality, and the province resulted in the signing of a GTO contract. The system incorporated an EMS allowing the users to optimise their use of transport capacity. Unique for this project was the addition of an electrolyser to the business park to be used as an energy sink for any excess generated electricity. The electrolyser utilises electricity to produce hydrogen and oxygen. The produced hydrogen is used for sustainable transport while the oxygen is used by a local water treatment facility. The GTO was initially started with three participating businesses, eight more have joined since then. The intention is for all businesses at Hessenpoort to eventually join the cooperative. (*Smart Energy Hub regio Zwolle Noord van start*, 2024), (NL, 2025), (Energy, 2025)

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Table 7: SZN pilot information

Pilot name	Smart Energy Hub regio Zwolle Noord
DSO	Enexis
Contract type	GTO
Participant urgency	High, low
Number of involved participants	3
Organisation type	Energy Cooperative
Flexibility	Solar panels, Wind turbines, electrolyser
Involved actors	Businesses, DSO, Municipality, Province

Tholen

Businesses on a business park in Tholen were interested in using the available transport capacity more efficiently with the aim to increase their future energy security. The implementation of SPTC was made possible through the introduction of a large communal battery powered by solar panels. This battery allows businesses in Tholen to expand their power usage without using more power capacity in other parts of the grid. The participants created an energy cooperative and appointed a company specialised in increasing sustainability at business parks as the project director. A close cooperation with the DSO Stedin and the municipality led to the implementation of the communal battery and the signing of a GTO. Four businesses have started sharing transport capacity since the GTO has started. The aim is to expand the total number of participants to 31 in the future and to implement similar systems in neighbouring business parks : (Stedin, 2024b), (Simonse, 2025), (Firan, 2025b), (Simonse, 2024), (Kenter, 2023).

Table 8: Tholen pilot information

Pilot name	E-hub Tholen
DSO	Stedin
Contract type	GTO
Participant urgency	Low, No urgency
Number of involved participants	4
Organisation type	Energy cooperative
Flexibility	Batteries, solar panels
Involved actors	Businesses, DSO, municipality

XL Business park Twente

The XL business park Twente has been in use since 2015 and is inhabited by businesses with large buildings allowing for many solar panels to be installed on their roofs. A large part of the businesses have already done this or are planning to install solar panels. The influx of electricity generated through RES caused supply congestion. As a result, grid congestion at the business park has halted any efforts aiming to make the business park more sustainable. The province decided to start a project where the possibility for a smart energy hub was explored. An independent process director was appointed who contacted interested parties located at the business park and brought them together to develop a system to reduce the supply congestion. The project became more urgent when the DSO, Enexis, gave notice of demand-side congestion as well. Seven businesses were involved in the initial signing of a GTO with Enexis. The GTO allows the participating businesses to share their generated electricity within the group thus allowing them to reduce both forms of grid congestion. The GTO is seen as the first step in the development of a local power grid. The participants did not opt to create a formal energy cooperative, but have rather composed a legal framework describing the various agreements made by the participants (Firan, 2025a), (Oost-Nederland, 2024c), (van de Vegte, 2024a), (NL, 2024)

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Table 9: XL business park pilot information

Pilot name	XL business park Twente
DSO	Enexis
Contract type	GTO
Participant urgency	High, Low
Number of involved participants	7
Organisation type	Legal Framework
Flexibility	Solar panels
Involved actors	Businesses, DSO, Province

4.1.2 Unsuccessful cases

This section presents the identified pilot projects in which SPTC implementation was not successful. For each project, key characteristics are described, including the pilot name, the responsible DSO, the contract type applied, and the level of urgency experienced by participants. In addition, the number of participants, the organisational structure, the type of flexibility available, and the main actors involved are outlined as well. Together, these descriptions provide insight into the contexts and environment in which SPTC was not able to be implemented.

Energiehub Twenterand

The energiehub Twenterand project was an initiative by the local municipality and a business to develop an energy hub where electricity produced by solar panels was used to power an electrolyser producing hydrogen that could subsequently be used by local businesses to store and produce electricity. This system would allow for the development of a highly sustainable business park. However, the project was never realised as no businesses in the area had any urgency to implement such a system. This resulted in the project never being developed far enough to discuss a potential group contract with the DSO (Hydronex, 2024).

Table 10: Energiehub Twenterand pilot information

Pilot name	Energiehub Twenterand
DSO	Unknown, either Enexis or Coteq
Contract type	N/A
Participant urgency	No urgency
Number of involved participants	2
Organisation type	N/A
Flexibility	Solar panel, electrolyser
Involved actors	Businesses, municipality

Energy hub Veldzicht

The Energy hub Veldzicht SPTC pilot project was initiated by local businesses interested in increasing their future energy security. The business park is located in an area with a close-knit community that care for the wellbeing of other businesses located at the business park. Many of these businesses were therefore willing to participate in the development and implementation of a shared system. The participants set up an energy cooperative and got in touch with Liander to see what could be arranged. Liander saw the potential for SPTC at the business park and in cooperation with an independent process director, plans were made to sign a GTO. The initial date for the signing of the GTO did however not go through. The businesses who wanted to implement SPTC have stated that the reason for this is that the DSO is not willing to take any risk by allowing all participants to be included in the group. The DSO stated that this was not possible due to the participating users being spread too far apart on the power grid. Although all of the participants were connected to the same sub-station, there were too many non-participating users connected to the grid between the different participating group members to implement SPTC without increasing the risk for users outside of the group. The participants of Energy hub Veldzicht have recently signed a provisional GTO with a group size that was reduced to twelve members. This development occurred too recently to be incorporated into the QCA which is why this project is still designated as an unsuccessful case (Kooijmans, 2025), (Liander, 2024), (Courant, 2025), (Enerzien, 2025).

Table 11: Energy Hub Veldzicht pilot information

Pilot name	Energy hub Veldzicht
DSO	Liander
Contract type	GTO
Participant urgency	Low, No urgency
Number of involved participants	15
Organisation type	Energy cooperative
Flexibility	Solar Panels
Involved actors	Businesses, DSO

InnoFase

The pilot project at InnoFase was initiated with the intent to develop and implement an energy hub where the participants would be able to share available transport capacity, heat, biogas, hydrogen, and supporting assets. A process director was appointed to unite the businesses established at the business park to discuss how an energy hub could be realised. The initial process was difficult since most of the businesses were not interested in cooperating and sharing their resources. Eventually, seventeen businesses indicated that they were interested in participating in the development and implementation of an energy hub. However, the project was eventually cancelled due to the obstacles related to implementing a complex energy hub at an existing business park. The obstacles ranged from technical difficulties to differences in the intended use of the energy hub. The process director has stated that they do not think it is possible to implement complex energy hubs at existing business parks, but that greenfield projects show a lot of potential for the implementation of energy hubs (Sohl, 2023), (Firan, 2023).

Table 12: InnoFase pilot information

Pilot name	InnoFase
DSO	Liander
Contract type	GTO
Participant urgency	Low
Number of involved participants	17
Organisation type	N/A
Flexibility	Solar panels, wind turbines, energy storage
Involved actors	Businesses, DSO, Municipality

Lorentz

The SPTC pilot project at business park Lorentz III was initiated because of grid congestion. The business park was still in development and aimed to be a sustainable business park. Therefore, the new lots were only allowed to make use of electricity. However, grid congestion stopped the new businesses from obtaining any transport capacity. An inquiry was done to see which businesses would be interested in sharing available transport capacity. There was little to no organisation or direction during this initial process which led to a group of 22 users joining in the process. However, the various businesses had different ideas on what the project would yield for them. Some of the participating businesses that still had enough transport capacity available saw the implementation of an energy hub as an easy way to make profit, while others saw it as a way to obtain a cheap energy contract. The businesses without any transport capacity due to grid congestion saw it as a way for them to be connected to the power grid. The general lack of direction during the early stages of the implementation process led to many different issues during the later phases which eventually halted the implementation process altogether (Oost-Nederland, 2024b), (Oost-Nederland, 2024a).

Table 13: Lorentz pilot information

Pilot name	Smart Energy Hub Lorentz
DSO	Liander
Contract type	GTO
Participant urgency	High
Number of involved participants	22
Organisation type	N/A
Flexibility	Solar panels
Involved actors	Businesses, DSO, municipality, province

Veghel

An increase in issues relating to grid congestion initiated the pilot project in Veghel. The local municipalities started a project which should lead to the implementation of energy hubs on multiple business parks in the vicinity of Veghel. The municipalities were joined by the DSO, Enexis, as well as by several local businesses in their efforts to implement an energy hub. The project was started with a lot of ambition and the aim was to develop an energy hub which not only allows transport capacity to be shared, but would also include a collective heat grid, shared EV charging infrastructure, multiple forms of RES, and the production of hydrogen. The project has been in development for multiple years with little progress. The reasons given for the lack of process were the many different initiatives that were started, differing interests of the participants, complex legislation and regulation, long throughput times, and high costs (Energy, 2025), (PVBNederland, 2025)

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Table 14: Veghel pilot information

Pilot name	LCE Veghel
DSO	Enexis
Contract type	GTO
Participant urgency	High, Low, No urgency
Number of involved participants	27
Organisation type	Energy cooperative
Flexibility	Solar panels, wind turbines, hydrogen production
Involved actors	Businesses, DSO, municipality, province

4.1.3 Identifying success factors

The success factors used for the QCA were identified through interviews with stakeholders involved in at least one SPTC pilot project. 2 interviewees represented a DSO, 2 interviewees were independent advisors/project directors, and 1 interviewee acted as a project director/energy cooperative representative. The various steps and interactions observed during the implementation process were the main topics discussed. The following section shows a summary of the interviews with the most important topics as mentioned by the interviewees highlighted. The final list of success factors used during the QCA can be found in the second part of the section.

Interview summary

Grid congestion was mentioned in all interviews as the biggest macro development behind the initiation of projects aiming to implement SPTC. Both users and DSOs were encouraged to search for alternative ways to create or free up transport capacity in areas suffering from grid congestion. The interviewees mentioned that technology has advanced far enough to make shared energy systems possible. The acquisition of supporting assets like solar panels or batteries by many users are beneficial since they allow for more flexibility in the shared system. The major technological challenge is not that the systems still need to be developed, but rather that it is difficult to connect the different systems already used by participants in order to function as a single entity. “The first six months were very difficult in terms of connecting. This was because there were occasional problems with the control system. A company had installed some software incorrectly, or it turned out that if you have 10 inverters for the solar panels, one inverter is connected to a different connection, which means that not everything can be controlled at the same time.”(interview #4) The DSO identified technological issues related to the grid topology. Users can be neighbours geographically, but still be connected to a different sub-station. The situation regarding the available transport capacity can differ greatly between individual sub-stations. The DSO stated that in some cases it is physically not possible for some users to share their transport capacity. “And the basic principle is actually very simple. If you want to help each other, you have to be part of the same problem, i.e. the same bottleneck. And if you are connected to a different part of our infrastructure, then it is simply of no use.” (interview #1)

The users noticed more challenges from a social viewpoint. Most electricity users regard it as a given that transport capacity will always be available in case they need it. This creates a situation in which many users are not interested in investing time, effort and resources into a solution for a problem they do not feel responsible for. The interviewees stated that it is often necessary to first inform the users on the workings of the power grid and its limitations. Once the users have become better informed about the current situation, they are often more inclined to participate and invest into the project. However, designating someone as the process director is still required since only a handful of users are usually interested in actually investing a lot into the project. A form of organisation is also necessary to allow less interested participants to be more passive. Nearly all interviewees stated that it was important to make clear agreements and policies with a small group of participants at the start of the project. Too many participants will make the decision process harder and since all participants want to gain something from the project it will be harder to make agreements that satisfy all users. “It is fine that everyone can join in later on, but you have to start with a small group, because you can't decide what their energy cooperative will look like with 80 people.” (interview #5)
The economic side was discussed during the interviews as well. One of the main points mentioned by the interviewees was that the lack of any incentive for users to accept SPTC for economic reasons. Possible reduction in costs or profits made from selling generated electricity within a group were not mentioned as a reason for users to join the project. This was explained due to the fact that energy costs do not compose a large share of the monthly costs for most businesses. As a result there would be a relatively small reduction of the monthly costs for users while the initial investment costs are relatively high. “Look, for the average entrepreneur in the Netherlands, I believe an SME's energy supply accounts for less than 5% of its total annual costs. And it always works. So if it's a low cost item and it always works, why should I, as an entrepreneur, concern myself with it?” (interview #1)

The slow adoption and implementation of regulatory frameworks encouraging and allowing the use of SPTC by the government and other regulatory institutions were mentioned as a large barrier by both the DSO and the users. Institutions in the role of process director were also mentioned as resulting in failure to implement SPTC. Institutions are often not the end-users and do not gather enough support from the actual users to implement SPTC. This was mainly attributed to the fact that the end-users were often not involved in the implementation process. “The government is very much thinking in terms of “we'll just fix that”. But they forget that the entrepreneur has to sign the contract. You also see that all these projects fail because they don't even sit down with the entrepreneurs.” (interview #5)

The interviewed representatives of the DSO differed the most from the interviewed users on the topic of safety. Data security was not mentioned as an important factor in the implementation process. However, energy security was regarded as a driving factor for the users, while the DSO regarded energy security as an obstacle. This difference in viewpoint regarding energy security illustrated the different ways in which both stakeholders view the power grid. The users see the implementation of SPTC as a way to increase their energy security. The ability to potentially make use of more transport capacity through a shared usage gives the users the feeling that they will be able to keep growing in the coming years. “Well, I think that for most of the companies involved, it wasn't just a matter of urgency, but also a matter of ensuring that you get your energy in the future.” (interview #5) The DSO sees the implementation of SPTC as a potential risk to energy security. The reason for this is that while the use of SPTC reduces the peak demand for transport capacity, it increases the total demand for transport capacity as the users will optimise their power usage and in turn increase the use of transport capacity during previously low demand periods. This increase in demand could lead to problems in a different part of the power grid. The DSO tries to balance the use of transport capacity as well so an increase in the consumption of power during moments that otherwise see low demand can lead to grid congestion in a different location or time. “If we proceed with this, will it also work in our energy system, because we also need to be able to keep the grid secure and guarantee that we can continue to supply power to other parties.” (interview #3) However, the risk is that if SPTC is not implemented, users will start to individually maximalise their power usage. This would increase the required transport capacity even further and cause more problems than the implementation of SPTC. The last reason for the DSO to view energy security as a barrier to the implementation of SPTC is that they have to trust the groups of users to police themselves. The responsibility to ensure that the power consumption remains below the maximum allowed amount shifts from the DSO to the group with SPTC. Failure of the group to stay within their limits could result in users outside of the group to experience the negative effects. The main difference between the viewpoint of the DSO and the users is that the DSO views energy security as the ability to provide all users with electricity while the users view energy security as the ability to ensure enough transport capacity for themselves.

SPTC success factors

The success factors were identified through the answers given in the interviews in combination with any supporting media regarding the relevant cases. Several success factors mentioned during the interviews could be grouped together to reduce the total number of success factors that needed to be included in the analysis. Ultimately, nine success factors were identified in total: technical feasibility, high urgency, low urgency, no urgency, flexibility, close-knit community, independent intermediaries, number of participants, and degree of organisation. Table 15 shows a description of the individual success factors as well as the abbreviation used during the analysis.

Table 15: SPTC Success factors

Success Factor	Description
Technical Feasibility (TF)	Does the local power grid allow for a SPTC system? The technical feasibility factor was created by combining the topology and complementary factors.
High Urgency (HU)	High urgency participants can be defined by having an immediate need for more transport capacity.
Low Urgency (LU)	Low urgency participants can be defined by not having an immediate need for more transport capacity, but a lack of available transport capacity would cause problems in the near future.
No Urgency (NU)	No urgency participants can be defined as participants that do not experience any negative effects of grid congestion and are not at risk for the foreseeable future.
Flexibility (F)	The flexibility factor indicates if any manageable assets or processes are present in the system. The flexibility factor was created by combining the usage profile flexibility and supporting assets factors.
Close-knit community (CC)	Are the participants part of a close-knit community? Close-knit communities are defined as communities in which the participants are involved together either in different projects or in their personal lives.
Independent Intermediaries (II)	Are any independent intermediaries involved with the implementation process? Independent intermediaries are defined as any third party involved with the implementation process that is not one of the main stakeholders (users, regulators, institutions).
Number of Participants (S)	How many participants are involved with the project? Participants are defined as all users within a project that aim to share transport capacity among themselves. Groups smaller than 10 participants were considered as small groups.
Degree of organisation (O)	Can a high degree of organisation be observed among the participants? Projects in which the participants have set up rules regarding entering and leaving the group as well as rules regarding the distribution of transport capacity are defined as having a high degree of organisation.

Data table

All relevant cases were reviewed to determine whether the success factors were either present or absent. The presence of a success factors was noted with a 1 in the corresponding cell and a 0 in the case of absence. This process resulted in a crisp dataset. The only exception is the factor “number of participants (S)” This factor was collected as fuzzy data first and then converted to crisp data. The number of participants in the corresponding case can be found in brackets in column S. Any number of participants lower than 10 was noted as a 0 while any number of participants even or higher than 10 was noted as a 1. The absence or presence of certain success factors could not be verified for every case which has led to some gaps in the dataset. The absence of this data will be addressed in the truth table analysis section.

Table 16: SPTC pilot cases with success factors

Case	TF	HU	LU	NU	F	CC	II	S	O	**Success**
Smart Energy Hub A1 (SEH A1)	1	1	1	0	1	0	1	0 (3)	-	**1**
Port of Amsterdam (PoA)	1	1	1	0	1	0	1	1 (20+)	1	**1**
Energiehub Twenterand	1	0	0	1	1	0	1	0 (4)	0	**0**
Energyhub Almere	1	-	1	-	1	-	1	0 (5)	1	**1**
Energy hub Veldzicht	1	0	1	0	1	1	1	1 (15)	1	**0**
InnoFase	1	0	1	1	1	1	0	1 (17)	0	**0**
Lage Weide	1	0	1	1	1	1	1	0 (5)	1	**1**
Lorentz	1	1	0	1	1	0	1	1 (22)	0	**0**
Schiphol Trade Park (STP)	1	1	1	0	1	0	1	1 (12)	1	**1**
Smart Energy hub regio Zwolle Noord (SZN)	1	1	1	0	1	0	1	0 (3)	1	**1**
Tholen	1	0	1	1	1	-	1	0 (4)	1	**1**
Veghel	1	1	1	1	1	1	1	1 (27)		**0**
XL Business park	1	1	-	-	1	0	1	0 (7)	1	**1**

Table 16 shows the presence or absence of success factors for each case as well as the outcome of the case. The case of Port of Amsterdam (PoA) in the second row can be used to explain the table more clearly. The PoA case has a ‘1’ in the first three columns containing the factors TF, HU, and LU. This data shows that in this case it was technically feasible to implement a SPTC system (TF), users experiencing high urgency are present (HU), and users experiencing low urgency are present as well (LU). The following column containing the factor NU has a value of ‘0’ which indicates an absence of users with no urgency (NU). The following columns containing the factors F, CC, and II have a value of ‘1’, ‘0’ and ‘1’ respectively. Once again corresponding with a presence of flexibility (F), absence of a close-knit community (CC), and present of an independent intermediary (II). The next column containing the factor S has a value of ‘1’ with a value of ‘20+’ between brackets next to it. The ‘20+’ value corresponds to the number of users participating in the implementation of SPTC. Since the number is higher than ten it is given a ‘1’ for the crisp notation. The ‘1’ in the cell for factor O corresponds with a high degree of organisation being present. Lastly, the value of ‘1’ in column “Success” shows that SPTC has successfully been implemented in the PoA case.

Truth table construction

The truth tables were constructed using the QCA package on RStudio. A standard truth table shows all possible combinations of factors, which combinations of factors are represented by cases and the consistency of the outcome for each combination. The absence of data in some cases led to an issue during the creation of the truth table. The QCA package was not able to function properly without complete data. Therefore, the decision was made to construct an initial truth table using only the cases with complete data. This initial truth table can be seen in a simplified form in table 17. The reasoning for showing only the simplified version of the truth table is that there are 512 different combinations of factors when using 9 factors. For the sake of clarity only the combinations of factors that correspond with one or more of the cases are presented in the truth table.

Table 17: Initial truth table

TF	HU	LU	NU	F	CC	II	S	A	OUT	n	Con	Cases
1	0	0	1	1	0	1	0	0	0	1	1.0	Twenterand
1	0	1	0	1	1	1	1	1	0	1	1.0	Veldzicht
1	0	1	1	1	1	0	1	0	0	1	1.0	InnoFase
1	0	1	1	1	1	1	0	1	1	1	1.0	Lage Weide
1	1	0	1	1	0	1	1	0	0	1	1.0	Lorentz
1	1	1	0	1	0	1	0	1	1	1	1.0	SZN
1	1	1	0	1	0	1	1	1	1	2	1.0	PoA,STP

The initial truth table shows the combinations of factors that are represented in the cases as well. As an example, the final row shows PoA and STP as the corresponding cases. This means that the PoA and the STP cases have the exact same combination of success factors. The combination of factors can be found in the first nine columns corresponding to the success factors. The column ‘OUT’ corresponds to the outcome of the case. The column with heading ‘n’ corresponds with the number of cases containing that specific combination of factors. Lastly, the ‘Con’ column shows the consistency of the outcomes of the cases with the specific combination of factors. The value of ‘1.0’ in this column means that all cases in that row have the same outcome.

The initial truth table contained 8 cases with 2 cases showcasing an identical combination of factors. The decision was made to also include the cases with incomplete data to increase the available data in the subsequent analysis of the truth table. The missing data was completed by first solving the initial truth table resulting in two different combinations of factors that result in success. The solutions obtained from analysing the initial truth table can be found in the Truth Table Solution section. The missing data was then completed in a way that would not contradict the solutions found from the initial truth table. The missing data in the Energyhub Almere case could not reliably be filled in without contradicting the already identified solutions which is why this case was omitted from the final truth table. A second and final truth table was constructed using the cases which previously contained missing data. This truth table can be found in table 18.

Table 18: Final truth table

TF	HU	LU	NU	F	CC	II	S	O	OUT	n	Con	cases
1	0	0	1	1	0	1	0	0	0	1	1.0	Twenterand
1	0	1	0	1	1	1	1	1	0	1	1.0	Veldzicht
1	0	1	1	1	1	0	1	0	0	1	1.0	InnoFase
1	0	1	1	1	1	1	0	1	1	2	1.0	Lage Weide, Tholen
1	1	0	0	1	0	1	0	1	1	1	1.0	SHE A1
1	1	0	1	1	0	1	1	0	0	1	1.0	Lorentz
1	1	1	0	1	0	1	0	1	1	2	1.0	SZN,XL Business Park
1	1	1	0	1	0	1	1	1	1	2	1.0	PoA, STP
1	1	1	1	1	1	1	1	0	0	1	1.0	Veghel

Table 18 shows the final truth table containing three combinations of factors represented by two cases. The fact that the consistency is '1.0' in each row suggests that it is possible to make a clear distinction between successful and unsuccessful cases using the chosen success factors. Both the initial and the final truth table were analysed and solved resulting in different combinations of success factors resulting in the successful implementation of SPTC.

Truth table solution

The truth tables were solved using the QCA package on RStudio. The software eliminates factors by comparing two different combinations of factors in which only one factor differs between the two. If the factor that differs does not result in a different outcome, it is eliminated and both rows are combined into one. The software will continue doing this until no more factors can be eliminated anymore. This method can result in multiple solutions which indicate that there are multiple situations in which different combinations of factors can result in a successful outcome. The solutions are given in a formulaic form. The *-sign indicates that the variables are required for the same combination. The +-sign indicates that the following factors belongs to a different solution. The ~-sign indicates that the absence of that factor is required for success.

The analysis of the of the initial truth table resulted in the following solution:

TF*HU*LU*~NU*F*~CC*II*O + TF*~HU*LU*NU*F*CC*II*~S*O <-> Success

The presence of the +-sign indicates that there are two different combinations possible that result in success. The first combination of factors is: TF*HU*LU*~NU*F*~CC*II*O and the second combination of factors is: TF*~HU*LU*NU*F*CC*II*~S*. The solution can be read as follows:

The presence of Technical Feasibility (TF) AND the presence of High Urgency (HU) AND the presence of Low Urgency (LU) AND the ABSENCE of No Urgency (NU) AND the presence of Flexibility (F) AND the ABSENCE of a Close-knit Community (CC) AND the presence of Independent Intermediaries (II) AND the present of a high degree of Organisation (O)

OR

the presence of Technical Feasibility (TF), AND the ABSENCE of High Urgency (HU) AND the presence of Low Urgency (LU) AND the presence of No Urgency (NU) AND the presence of Flexibility AND the presence of a Close-knit Community AND the presence of Independent Intermediaries (II) AND the Absence of 10+ participants (S) AND the presence of a high degree of organisation (O)

results in SUCCESS.

This solution implies that there are two different situations in which the implementation of SPTC is successful. Five factors are consistent in both combinations with the other four being different in both combinations. One of the combinations requires the presence of high urgency participants, the absence of no urgency participants, and the absence of a close-knit community. The second situation requires the absence of high urgency participants, the presence of no urgency participants, the presence of a close-knit community and the absence of 10+ participants. The success factor ‘S’ is absent in the first combination of factors. This indicates that the number of participants is not relevant for success for cases showcasing the combinations of factors given.

The solution obtained from the analysis of the initial table was used to complete the data for the incomplete cases. The final truth table created by using the incomplete cases was subsequently analysed and resulted in the following solution:

TF*HU*LU*~NU*F*~CC*II*O + TF*HU*~NU*F*~CC*II*~S*O + TF*~HU*LU*NU*F*CC*II*~S*O <-> Success

The presence of two +-signs in the solution indicates three different combinations of factors resulting in a positive outcome. To show the differences between the combinations more clearly, the formula can be simplified by grouping factors that remain constant throughout all three combinations. This simplification yields the following solution:

TF*F*II*O*(HU*LU*~NU*~CC + HU*~NU*~CC*~S + ~HU*LU*NU*CC*~S <-> Success

Splitting the constant factors from the variable factors results in the following overview:

	*	HU*LU*~NU*~CC	
TF*F*II*O	*	HU*~NU*~CC*~S	<-> Succes
	*	~HU*LU*NU*CC*~S	

The overview shows three different combination of four success factors resulting in the successful implementation of SPTC. An analysis of the solution on the case-level is required to determine the underlying reasons behind the presence of three different possible solutions. This is done in the results section.

5 Results

The results section will analyse the solutions obtained from the QCA. The solutions are analysed on the case-level to determine if any situations can be identified that explain why different combinations of factors can all lead to success. This is followed by an analysis of the individual factors and the reasoning for their need to be present or absent for a successful outcome. Lastly, recommendations based on the QCA result analysis will be given on strategies that can be employed identify the combination of factors required for success in specific scenarios.

5.1 QCA Results

Solving the final truth table has yielded the following solution:

	*	HU*LU*~NU*~CC	
TF*F*II*O	*	HU*~NU*~CC*~S	<-> Succes
	*	~HU*LU*NU*CC*~S	

TF	Technical Feasibility
F	Flexibility
II	Independent Intermediary
O	Degree of Organisation

HU	High Urgency
LU	Low Urgency
NU	No Urgency
CC	Close Community
S	Number of Participants

This solution identifies four factors consistently required for a successful outcome: technical feasibility, flexibility, independent intermediaries, and a high degree of organisation. The relevance and validity of these factors will be discussed further in this section. Before doing so, the three possible combinations of factors resulting from solving the truth tables will be analysed.

Combination 1: Presence of high urgency participants, presence of low urgency participants, absence of no urgency participants, absence of a close-knit community

The first combination of factors is present in four successful cases. These cases being: Smart Energy hub regio Zwolle Noord, XL Business park, Port of Amsterdam, and Schiphol Trade Park. The combination indicates that when the group is comprised of both users with high urgency and users with low urgency, with a close-knit community being absent, the outcome will be success, regardless of the number of participants. When analysing this combination on a case level, more conclusions can be made. Two distinct groups can be identified within the relevant cases. The number of participants in the Smart Energy hub regio Zwolle Noord, and XL business park case were less than ten while the number of participants for the Port of Amsterdam and Schiphol Trade Park case exceeded ten. Furthermore, a comparison of the cases shows that a GTO contract has been signed in the Smart Energy hub regio Zwolle Noord, and XL business park cases. In the cases of Port of Amsterdam and Schiphol Trade Park the contract has either been a group-CBC (Port of Amsterdam) or an experimental agreement which closely resembles the group-CBC. This distinction suggests that the first combination of factors resulting in success can be split into two combinations based on the contract form used in the case. This results in the following combinations:

HU*LU*~NU*~CC***S** for cases with a group-CBC contract.
HU*LU*~NU~*CC***~S** for cases with a GTO contract.

HU	High Urgency
LU	Low Urgency
NU	No Urgency
CC	Close Community
S	Number of Participants

While the number of participants can be used to differentiate between two different situations, four factors are constant in both situations. The necessity for the presence of high urgency participants is one of those factors. An explanation regarding the need for high urgency participants was given during the interviews. Multiple interviewees stated that users urgently needing more transport capacity are needed as they are motivated enough to continue the implementation process in case issues arise. High urgency participants are more willing to make concessions to let the project result in a success.

Both solution require a presence of low urgency participants as well. Low urgency participants are required since they can provide usage profiles complementary to the profiles of high urgency participants. Low urgency participants do often not have the same intrinsic motivation as high urgency participants, but they are still willing to invest some time and resources. Low urgency participants are also more likely to agree with a system that does not yield the highest possible benefits than no urgency participants. The most important reason for low urgency participants to participate is that their future power demands are secured. An absence of low urgency participants would thus most likely lead to failure due to a lack of complementary usage profiles being present in the group.

The absence of no urgency participants is given as a requirement in both of the situations described by combination 1. The interviews were able to provide a reason for this. No urgency participants were often observed to show free rider behaviour. Participants with no urgency are not inclined to invest time and resources into the project and are often not willing to agree with a sub-optimal solution as there have no reason to do so. The inclusion of users without any urgency does therefore often result in a failure to reach an agreement between the different participants.

The final constant factor that in both situations is the absence of a close-knit community. However, on a case-level basis there is no indication that the absence of a close-knit community is a requirement for success. No cases were observed in which the presence of a close-knit community was the only difference between a successful and unsuccessful case. Therefore, it cannot be stated with certainty that the absence of a close-knit community is actually required for a successful outcome.

Combination 2: Presence of high urgency participants, absence of a close-knit community, small number of participants

The second combination of factors corresponds to three successful cases. Smart Energy hub regio Zwolle Noord, XL business park, and Smart Energy Hub A1 display the second combination of factors. The only difference between the cases is the absence or presence of low urgency participants. A case-level review once again results in the identification of circumstances explaining the difference in factors. The Smart Energy hub regio Zwolle Noord, and XL business park cases were completed on an already developed business park while the Smart Energy Hub A1 case was completed on a greenfield project. A newly constructed business park suffering from grid congestion will only have participants with a high urgency. Low urgency participants are needed on developed business parks in order to provide complementary profiles for the high urgency participants. Participants on a greenfield project suffering from grid congestion do not have an existing usage profile yet and thus their flexibility is higher as they have to design their business processes around the available transport capacity.

The second combination of factors can be split into two different combinations of factors resulting in success. This allows for the distinction to be made between the success factors for GTO contracts on established business parks and greenfield projects resulting in the following combinations:

HU***LU***~NU*~CC*~S for cases on established business parks.
HU***~LU***~NU*~CC*~S for cases at greenfield projects.

HU	High Urgency
LU	Low Urgency
NU	No Urgency
CC	Close Community
S	Number of Participants

The combination of factors required for a successful implementation of SPTC at greenfield projects is only relevant for projects in which at least some transport capacity is available. A project aiming to implement SPTC without any of the participants already having transport capacity available will not be technically feasible. Implementing SPTC at a greenfield project should therefore always start with participants that already have access to transport capacity. The Smart Energy Hub A1 case only succeeded due to the businesses that formed the group already having transport capacity available. The three business were all relocating to the business park and were able to bring their allocated transport capacity to the new location. These companies could still be classified as high urgency participants as the reason for the relocation was to expand their current business for which they required more transport capacity.

The need for a small number of participants to be present for implementing SPTC at greenfield projects can be explained based on the need for businesses to bring transport capacity as well. Newly established businesses do not add any transport capacity to the group. As a result, they are not able to join at the start of the project. Once the businesses with transport capacity available have formed a group and gained insights into the available transport capacity in their group, is there a possibility for new businesses without any transport capacity to join.

The need for an absence of a close-knit community is likely due to greenfield projects not having an established community yet so it would also not be possible to have a close-knit community.

Combination 3: Absence of high urgency, presence low urgency participants, presence of no urgency participants, presence of a close-knit community, small number of participants
The third combination of factors resulting in a successful outcome are displayed by two successful cases: Lage Weide and Tholen. The ability to successfully implement SPTC without the presence of high urgency participants maintaining urgency can be explained on a case level. In both the Lage Weide and the Tholen case, the process was initiated by participants with an high interest in sustainability and the energy transition. The initiators were located within a close-knit community had previously completed projects with the other participants. The presence of a close-knit community results in a higher willingness to participate in the project and adapt to the requirements for successful implementation. This results in the following combination of factors:

~HU*LU*NU*CC*~S for cases within close-knit communities

HU	High Urgency
LU	Low Urgency
NU	No Urgency
CC	Close Community
S	Number of Participants

The necessity for an absence of high urgency participants cannot fully be explained on a case-level basis. However, it can be argued that there is more flexibility in the final agreement with the presence of only low urgency and high urgency participants. The absence of high urgency participants allows the group to start with a simple system which can be expanded through the use of supporting assets later on.

Based on a case-level analysis of the different combinations of solutions resulting in a positive outcome, four combinations resulting in success have been identified. An overview of the four combinations is presented below.

	*	HU*LU*~NU*~CC*S:	Group-CBC contracts
	*	HU*LU*~NU*~CC*~S:	GTO contracts at established business parks
TF*F*II*O	*	HU*~LU*~NU*~CC*~S:	GTO contracts at greenfield projects
	*	~HU*LU*NU*CC*~S:	GTO contracts within close-knit communities and dedicated initiators.

TF	Technical Feasibility
F	Flexibility
II	Independent Intermediary
O	Degree of Organisation

HU	High Urgency
LU	Low Urgency
NU	No Urgency
CC	Close Community
S	Number of Participants

The four success factors required to be present in all combinations for a successful outcome have yet to be discussed. The following section discusses the relevance and validity of the factors that are required to be present throughout all combinations.

Technical feasibility

The need for technical feasibility to be present in all situations cannot reliably be confirmed by the QCA since the factor is present in all cases both successful and unsuccessful. The technical feasibility factor therefore requires a more in-depth analysis to determine whether its presence is truly needed for a successful outcome. The answer to this is presented in the demands made by the DSO for projects that intend to implement SPTC. Projects where technical feasibility is absent will not receive the pilot project status needed to obtain a group contract. All the relevant cases for the QCA show the presence of technical feasibility as they would not qualify as a relevant case if the factor was absent. Based on an in-depth analysis of the technical feasibility, it can be stated that the presence of the factor is required in all cases with a successful outcome. The absence of technical feasibility will always lead to failure as the DSO demands the factor to be present to obtain a group contract allowing the use of SPTC.

Flexibility

Flexibility in the usage, storage and generation of electricity is a factor present throughout all cases. An in-depth analysis of the factor is needed to determine the necessity of the factor. As the technology map shows, supporting assets are theoretically not necessary for a system that allows the use of SPTC. However, many users have already invested in various types of supporting assets which leads to a high presence of supporting assets in projects that focus on novel and innovative energy systems. While the absence of flexibility is theoretically possible in a successful situation, it is not observed in practice. Only in a perfect case would it be possible to implement SPTC without any flexibility through complementary usage profiles. The flexibility factor thus needs to be present in nearly all situations to compensate for the lack of perfectly complementary usage profiles.

Independent Intermediaries

The use of independent third parties that direct and lead the project is observed in most cases. The InnoFase case was the only relevant case in which an independent intermediary was absent. However, this case does not reliably prove that independent intermediaries are required for success as there was also an absence of a high degree of organisation which is a factor required to be present for success as well. The failure of the InnoFase case can therefore be attributed to the lack of organisation and the lack of independent intermediaries. A further review of the InnoFase case is required to determine whether anything can be concluded on the necessity of independent intermediaries. The InnoFase case seemed to have failed because of overambition without any proper organisation or leadership. It is mentioned that the InnoFase case did not just explore SPTC but also a combination of different forms of energy. During the interviews it was mentioned multiple times that the inclusion of an independent intermediary is necessary for the management of expectations. Independent intermediaries were also mentioned as being helpful with the organisation within the group. The need for independent intermediaries can thus be seen as a requirement for a successful outcome since they can manage expectations, bring expertise and knowledge, and assist in the communication with the DSO. As long as there is no yet standardised process for the implementation of SPTC, independent intermediaries are required.

Degree of organisation

The final factor constant in all combinations is the need for a high degree of organisation. There are four cases (Twenterand, InnoFase, Lorentz, Veghel) in which there is an absence of sufficient organisation resulting in a negative outcome. This indicates that the QCA was able to reliable show that a high degree of organisation is necessary for a positive outcome. The reason for the necessity of a high degree of organisation was provided during the interviews. The implementation process for SPTC can take multiple years with multiple rounds of talks with the DSO in which the amount of transport capacity available to the group can change. Any groups not organised well enough will need to discuss this with all their member to make new plans regarding the new situation. If more members have joined between different rounds there will also be more people who want the best possible situation for themselves and these meetings can therefore require a large investment of time most participants are not willing to do. Groups that immediately organise themselves at the start of a project are able to make robust policies regarding the use of transport capacity, appoint directors which can make decisions independently from the other members, and set up rules for other users interested in joining. Organisation allows the group to deal with new situations more efficiently and the addition of new members does not change the initial set goals. Another reason for the need for organisation is that it eliminates free rider behaviour as all participants are required to be actively involved from the onset.

Identified scenarios

The qualitative comparative analysis has resulted in the identification of four distinct scenarios in which the successful implementation of SPTC is possible. The scenarios are described in the following section. An overview of the different scenarios can be found in table 19.

Scenario 1: Group-CBC contract with 10+ high and low urgency participants and an absence of low urgency participants.
SPTC can be successfully implemented through group-CBC contracts in cases with more than ten participants. The participants are only required to cooperate during times in which the total transport capacity is reduced. These moments can be endured through the use of supporting assets which allows the participants to continue their existing business processes. A higher number of participants allows the transport capacity reduction to be spread over more users. This makes it easier for the group to stay within the allowed limit and reduces the costs per user for implementing supporting assets. Group-CBC contracts can therefore be implemented with more starting participants than GTO contracts.

Scenario 2: GTO contracts at established business parks through collaboration between high and low urgency participants.
GTO contracts can allow for the successful implementation of SPTC at business parks where a combination of high urgency users and low urgency users is present. Small groups of users are able to implement technical systems allowing for the use of SPTC through a high degree of organisation and an experienced process director. The main challenge in this scenario is to assemble a group of users whose grid topology and usage profiles allow them to share transport capacity.

Scenario 3: GTO contracts at greenfield projects with high urgency participants
Any newly developed projects suffering from grid congestion can qualify for this scenario. The main challenge in this scenario is to locate available transport capacity which can be shared by the users. The absence of existing usage profiles eliminates the need for low urgency participants as the users can adapt their business processes to the available transport capacity.

Scenario 4: GTO contracts at business parks with low and no urgency participants in close-knit communities
SPTC is possible through a GTO contract in business parks where there no grid congestion is present yet on the condition that there are motivated and interested initiators. Due to the nature of close-knit communities, they are more likely to invest time and resources into projects that are not greatly beneficial to them. This allows the group to accept less favourable terms from the DSO which in turn increase the potential for a successful implementation of SPTC.

Table 19: Successful SPTC implementation scenarios

Scenario	Required combination of factors	Representative cases
Group-CBC contract with 10+ high and low urgency participants and an absence of low urgency participants	**TF*F*II*O*HU*LU*~NU*~CC*S** Presence of technical feasibility, presence of flexibility, presence of a high degree of organisation, presence of an independent intermediary, presence of high urgency participants, presence of low urgency participants, absence of no urgency participants, absence of a close-knit community, high number of participants	Port of Amsterdam, Schiphol Trade Park
GTO contracts at established business parks through collaboration between high and low urgency participants	**TF*F*II*O*HU*LU*~NU*~CC*~S** Presence of technical feasibility, presence of flexibility, presence of a high degree of organisation, presence of an independent intermediary, presence of high urgency participants, presence of low urgency participants, absence of a close-knit community, small number of participants	Smart Energy hub regio Zwolle Noord, XL business park
GTO contracts at greenfield projects with high urgency participants	**TF*F*II*O*HU*~LU*~NU*~CC*~S** Presence of technical feasibility, presence of flexibility, presence of a high degree of organisation, presence of an independent intermediary, presence of high urgency participants, absence of low urgency participants, absence of a close-knit community, small number of participants	Smart Energy Hub A1
GTO contracts at business parks with low and no urgency participants in close-knit communities	**TF*F*II*O*~HU*LU*NU*CC*~S** Presence of technical feasibility, presence of flexibility, presence of a high degree of organisation, presence of an independent intermediary, absence of high urgency participants, presence low urgency participants, presence of no urgency participants, presence of a close-knit community, small number of participants	Lage Weide, Tholen

The analysis of the QCA results allow for the formulation of an answer to the third sub-question:

Which factors are involved in the successful implementation of SPTC?

Nine factors have been identified to be involved in the successful implementation of SPTC. The factors are the following: Technical Feasibility, High Urgency, Low Urgency, No Urgency, Flexibility, Close-knit Communities, Independent Intermediaries, Number of participants, and degree of Organisation. Of these nine factors, four have been identified to be required for a successful outcome in all scenarios. Technical Feasibility is needed in all scenarios as it indicates that the infrastructure is able to support SPTC. Independent Intermediaries are needed in all scenarios in order to manage expectations and progress the implementation process. As long as the process to implement SPTC is not standardised, independent intermediaries are required to provide the knowledge and expertise necessary. A high degree of organisation is a requirement in all scenarios to allow the group to efficiently make decisions and react to changes. Flexibility is theoretically not required in a scenario where the usage profiles of all participants are perfectly complementary. However, in practice, flexibility is necessary in most cases.

Next to the constant factors required for the implementation of SPTC, four scenarios have been identified in which different combinations of the remaining five success factors result in a positive outcome. The four scenarios are: Group-CBC contracts with 10+ high and low urgency participants and an absence of low urgency participants, GTO contracts at established business parks through collaboration between high and low urgency participants, GTO contracts at greenfield projects with high urgency participants, and GTO contracts at business parks with low and no urgency participants in close-knit communities

5.2 Success factor analysis

The case-level analysis of the results has yielded more in depth information on the validity of the used factors, factors that should be added, and factors that should be refined. The following section will discuss these topics for various success factors.

Independent intermediaries can exist in many different form some of which are not always beneficial to the successful outcome of the SPTC implementation process. There are cases in which the negative impact of an independent process director was explicitly stated (Lorentz). The need for a qualified independent intermediary was mentioned during several interviews. The interviewees stated that in order to achieve success, the independent intermediary should focus on progressing the implementation process. Independent process directors who let the implementation process stall due to inaction were mentioned as being detrimental to the success chance.

The role of local government is not fully expanded upon either. Local governments as the initiators of projects without the support of businesses that should be included were mentioned as the reason for the failure of many projects in the interviews. However, local governments can be the initiator of a project if they appoint an independent process director whose first action is to involve any interested businesses. Several cases have also shown that a municipality can be involved as a participant in the group by joining with an electricity user managed by the municipality. A local water treatment plant and a recycling station operated by the municipality have both allowed local government to be involved with an SPTC project. In the case of Smart Energy Hub A1 the municipality was even involved as the owner of the lots that have yet to be sold. The businesses that will eventually establish these spots most likely need to join the group to be able to use any transport capacity. Another way the local government could be involved in these projects is through a supporting role. This could either be through financial support or by providing support in the form of knowledge or assets. While the involvement of local government is not required for success, they could play a supporting role and increase the chance of success. Any future QCA should therefore add the role of the local government as one of the success factors to identify whether any of the various roles that the local government can play is essential to the success or failure of the SPTC implementation projects.

The success factor relating to the organisation of the participants has not been defined in the correct way. Multiple issues with the definition can be identified after the case-level analysis. Firstly, there is not a single organisation type required for the successful implementation of SPTC. Establishing an energy cooperative is the most common form in which participants of both failed and successful cases have organised. However, a less organised form can also result in success. This indicates that the degree of organisation is not the factor that determines success, but rather the moment at which the participants start to officially organise themselves. Organising too early will most likely lead to the initial participants not being able to convince other users to join the group and obtain a diverse range of usage profiles that would make SPTC possible. This was explained in an interview to be caused due to the agreements made when organising only being beneficial to the initial participants and not any participants joining at a later moment. Organising too late is also a factor that leads to failure. If the size of the group is too large, there are too many opinions and demands, thus making it impossible to reach an agreement. Rather than the degree of organisation, the timing of when the participants organise should be used as a factor. The interviews indicate that the ideal time to organise is when the minimum number of participants needed to implement SPTC has been reached. This allows SPTC to be implemented under conditions beneficial to all participants. Any other interested user can join at a later date given that they accept the conditions already in place and have a usage profile which complements the group. The number of participants needed to reach this moment is different for all situations. However, the correlation between the number of participants and the ideal timing for the participants to organise would suggest that it might be possible to group the size and organisation factor together as one factor which differentiates between participants that started organising when the minimum number of participants was reached and participants that added more members before they organised.

The minimum number of participants needed to implement SPTC is also correlated to the technical feasibility. The grid topology and usage profiles of the users present determines which and how many users are required to allow SPTC. An interviewee stated that the number of participants could be irrelevant as long as the technical feasibility is there and all the participants are willing to invest time and resources into the project. The number of participants can also be larger is participants are willing to accept that other participants might benefit more from the shared transport capacity than themselves.

6 Discussion

This research utilised the QCA method with aiming to identify which factors affected the chances of successful implementation of SPTC. The QCA resulted in the identification of four scenarios in which different combinations of the relevant success factors resulted in success. However, the validity of the results cannot fully be guaranteed. The following chapter will discuss the potential shortcomings of the used method and data. The chapter concludes with recommendations for different stakeholders to increase the chances of successful implementation.

Method discussion
This section reflects on the analytical methods used in this research and evaluates whether they were appropriate for answering the research questions. The data collection and analysis method employed in this research were a scoping literature review, interviews, and a QCA. The scoping literature review was selected with the aim to provide a basic overview of the existing knowledge on success factors for the implementation of smart energy systems, with SPTC implementation being an example of this. The aim was to create a foundation for a more detailed analysis of the factors relevant to SPTC implementation. The review identified seven categories under which most success factors relevant to the implementation of smart energy systems could be grouped. While this provided some initial direction, these categories closely aligned with general success factors known for any smart energy system, and therefore the review did not yield sufficient new insights to justify the time invested. Interviews were conducted to gain deeper insights into the specific success factors relevant to SPTC implementation in addition to collecting detailed data on the cases selected for the QCA. This approach was necessary due to the limited availability of written sources regarding both SPTC implementation in general and the implementation processes of individual pilot projects. The interviews provided useful information, and by engaging multiple types of stakeholders, different perspectives on success factors were discussed. This helped clarify why certain factors influenced the likelihood of successful SPTC implementation and created a clearer picture of the SPTC socio-technical system. The QCA was chosen as the main analysis method due to the considerable variation between the cases. Success or failure in one project could not be attributed to a single differing factor. QCA allowed for the comparison of cases with multiple interacting factors, identifying which combinations led to success and which led to failure. The analysis revealed multiple combinations of factors that could result in successful implementation, as well as different scenarios in which these combinations were relevant. Ultimately, QCA proved to be a suitable method for answering the research questions, effectively capturing the complexity of SPTC implementation across diverse cases.

Result validation
The data used for the QCA was primarily obtained from news articles issued by project stakeholders, often in a positive tone and containing limited details. Consequently, much of the data relied on a single source per case, raising reliability concerns. Information on failed projects was particularly limited, and most stakeholders were unresponsive to interview requests. To address missing data, incomplete values were supplemented based on patterns identified in fully documented cases, which allowed the QCA to proceed but further limited reliability. Despite these challenges, the QCA identified four distinct combinations of factors associated with successful SPTC implementation. A case-level review was conducted to validate the scenarios, which seemed to support the findings,

though the exact combinations of the required factors in real-world situations may be different. For instance, the analysis suggested that the presence of high-urgency participants requires the absence of a close-knit community for success. However, no cases were identified where high-urgency participants differed only on the factor of close-knit communities, illustrating the limitations of the available data. Out of 512 theoretically possible combinations of nine success factors, only nine were represented by actual cases, limiting comparisons between cases differing by a single factor. As such, additional combinations similar to those identified could potentially also lead to successful outcomes. The relatively low amount of available cases hurt the validity of the obtained results. The actual success factors required for successful implementation cannot be confirmed as the variety of present and absent success factors small between the different solutions. Ideally, QCA is iterative, allowing factors to be refined based on previous results; due to time constraints and limited data, this refinement was not performed in this research. Nevertheless, the results are able to identify multiple scenarios for successful SPTC implementation and provide practical insights for stakeholders involved in relevant projects.

Research limitations
Several limitations can be identified in this research. First, data availability and reliability were limited, mainly for unsuccessful projects. Second, the scoping review contributed limited new insights. Third, time and data constraints prevented iterative refinement of QCA factors. Finally, the number of cases and the representation of factor combinations restricted the ability to fully explore all possible scenarios. Despite these limitations, the used methods provided useful insights and the research identified multiple scenarios for SPTC implementation. These insights and scenarios were used to formulate recommendations for stakeholders involved with the implementation of SPTC . The findings also revealed gaps in both literature and data availability. A QCA is designed to be an iterative process in which the chosen factors are refined, changed, and added based on the results of the previous QCA. This was not done during this research due to time constraints and a lack of reliable data. A large share of the research time had to be invested in composing the initial list of success factors for the implementation of SPTC which did not leave any time to revisit the cases using new success factors. The research did manage to identify SPTC systems as a ST-system and show that the issues faced during the implementation process are in line with those described for ST-systems. ST-systems theories can thus be used to predict if implementation will be successful and which other issues could potentially arise in the future.

6.1.1 Stakeholder recommendations
Based on the research findings, several practical strategies can increase the likelihood of successful SPTC implementation. These recommendations are tailored to the different stakeholder groups and are based on the scenarios identified through the QCA, interviews, and case-level analysis. The following recommendations can therefore be seen as an answer to sub-question 4:

Which strategies can be employed to obtain the required combination of factors leading to successful implementation of SPTC?

User recommendations
Identify the applicable scenario
Four distinct scenarios were identified, each requiring a different combination of factors for success. Users should first determine which scenario is most relevant to their situation. This ensures that the chosen contract type and project conditions align with the specific combination of factors that are

most likely to lead to successful implementation. By understanding the scenario, users can focus their efforts on meeting the conditions that matter most, avoiding wasted resources on less critical factors.

Start with a small number of dedicated participants
SPTC implementation is not yet standardized, and the process can take multiple years, with outcomes often differing from initial plans. Starting with a smaller, committed group reduces the risk of stagnation and ensures that all participants are fully engaged. A highly motivated core group is more capable of navigating the complexities of the implementation process, maintaining momentum, and making timely decisions, which increases the chance of success.

Involve independent intermediaries early
Independent intermediaries with relevant expertise can guide the project and help avoid early-stage missteps that may compromise later stages. Early involvement ensures that crucial strategic and technical decisions are made correctly from the outset. Additionally, intermediaries facilitate communication with DSOs and other stakeholders, preventing miscommunication and encouraging cooperation. Their early guidance can be decisive in developing a project that is technically feasible and organisationally sound.

Organise effectively once technical feasibility is confirmed
After confirmation from the DSO that SPTC is technically feasible, users should establish clear organisational structures to effectively manage any challenges that might occur. An example of this is to appoint directors with decision-making authority which allows the group to respond efficiently to changes, such as participant turnover or shifts in project conditions. Effective organisation prevents delays, reduces confusion, and ensures that critical tasks are completed in a timely manner, all of which contribute to a smoother implementation process.

DSO recommendations
Manage expectations and inform participants
Miscommunication is a key source of conflict between users and DSOs. By clearly explaining the limitations and technical challenges of the grid early in the process, DSOs can reduce resistance and increase participant cooperation. Well-informed users are more likely to accept changes in capacity or system configuration, making implementation smoother and less prone to delays. This also builds trust, which is crucial for collaborative projects like SPTC.

Local government recommendations
Adopt a supporting rather than directing role
User-led projects have consistently shown higher success rates than those directed by municipalities. When local governments provide support through funding, resources, or advisory assistance, without taking control, users retain ownership of the process. This encourages engagement and commitment. Direct municipal leadership often results in user disengagement, reducing the likelihood of success. The exception occurs when the municipality is directly involved as a participant in the system, in which case active coordination may be justified.

7 Conclusion

This research set out to answer the following main research question:

What combination of factors are key to (un)successful implementation of shared power transport capacity systems on business parks in the Netherlands, and how are actors involved in the implementation process able to address these factors to facilitate more successful implementation of shared power transport capacity?

To structure the research, four sub-questions were developed. The conclusions to each sub-question are repeated below and subsequently integrated into an overall answer to the main research question.

Sub-question 1

What is known about the factors influencing the success or failure of the implementation of (smart) energy systems and technologies?

The factors influencing the success or failure of the implementation of (smart) energy systems and technologies can be classified into 7 distinct categories. The categories being: Macro developments, technological factors, economic factors, institutional factors, organisational factors, social factors, and security factors. Factors that either increase or decrease the success rate of implementation were identified in all categories. Overlapping themes between the categories and factors were the need for knowledge sharing and informed users. The need for inclusion of end users during the development process and a high degree of organisation were observed in multiple categories as well

Sub-question 2

How can shared power transport capacity systems be defined?

A shared power transport capacity system can be defined as a technical system in which multiple individual users can share a set power transport capacity through the use of a combination of technologies. The technical system consists of two core components; sensors monitoring the power usage of the individual members and an energy management system which monitors the total transport capacity used by the group and able to intervene if the amount of transport capacity used is nearing a critical level. The energy management system can intervene in multiple ways with the simplest versions notifying the users that the used transport capacity should manually be reduced and fully automatic systems, which can control the required transport capacity through managing business processes, generators, and batteries automatically. The way in which the transport capacity is distributed among the users adds a social aspect to the system that requires collaboration between the users to ensure that the maximum allowed transport capacity is not exceeded.

Sub-question 3

Which factors are involved in the successful implementation of SPTC?

Nine factors have been identified to be involved in the successful implementation of SPTC. The factors are the following: Technical Feasibility, High Urgency, Low Urgency, No Urgency, Flexibility, Close-knit Communities, Independent Intermediaries, Number of participants, and degree of

Organisation. Of these nine factors, four have been identified to be required for a successful outcome in all scenarios. Technical Feasibility is needed in all scenarios as it indicates that the infrastructure is able to support SPTC. Independent Intermediaries are needed in all scenarios in order to manage expectations and progress the implementation process. As long as the process to implement SPTC is not standardised, independent intermediaries are required to provide the knowledge and expertise necessary. A high degree of organisation is a requirement in all scenarios to allow the group to efficiently make decisions and react to changes. Flexibility is theoretically not required in a scenario where the usage profiles of all participants are perfectly complementary. However, in practice, flexibility is necessary in most cases.

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Sub-question 4
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User-led projects have consistently shown higher success rates than those directed by municipalities. When local governments provide support through funding, resources, or advisory assistance, without taking control, users retain ownership of the process. This encourages engagement and commitment. Direct municipal leadership often results in user disengagement, reducing the likelihood of success. The exception occurs when the municipality is directly involved as a participant in the system, in which case active coordination may be justified.

Main conclusion
What combination of factors are key to (un)successful implementation of shared power transport capacity systems on business parks in the Netherlands, and how are actors involved in the implementation process able to address these factors to facilitate more successful implementation of SPTC?

This research set out to identify which factors determine whether shared power transport capacity (SPTC) systems are successfully implemented on business parks in the Netherlands, and how the actors involved can influence these factors to improve the likelihood of success.
The study identified nine factors that play a role in successful implementation. Of these, four factors proved essential in every successful case:
Technical feasibility: the local grid must be able to support SPTC.
Flexibility: users must be able to adjust their power use when required. This can be either be accomplished through the use of supporting assets or flexible business processes.
Independent intermediaries : neutral experts are needed to guide the process and coordinate between parties.
A high degree of organisation: participants must be well-organised, with clear agreements and decision-making structures.

In addition, four different combinations of these and the remaining factors were found to lead to successful implementation under different circumstances. These combinations correspond to four types of situations in which SPTC can work effectively. **Group-CBC contracts**, **GTO contracts on**

existing business parks, **GTO contracts in new (greenfield) developments**, and **GTO contracts on business parks without grid congestion that have close-knit business communities.**

The research also identified how actors can actively influence these factors. Six strategies were recommended.
For users, success is most likely when they: identify which scenario applies to their situation, begin with a small, committed group of participants, involve independent intermediaries from an early stage, and organise themselves effectively once technical feasibility is confirmed.
For DSOs, the key strategy is to manage expectations and clearly inform users about technical conditions and limitations.
For local governments, the most effective role is a supporting rather than directing one, unless the municipality is itself a participant.
Together, these findings provide both an overview of the key success factors and practical guidance for how actors can shape the conditions required for the successful implementation of SPTC systems on Dutch business parks.

Reflection

The following section reflects on the relevance of the research, what I learned from this research, what lessons it thought me as a researcher, and recommendations for future research based on this thesis.
The research has become more relevant in recent times as the current problems surrounding grid congestion are still increasing. A lack of transport capacity is not affecting businesses anymore, residential neighbourhoods are also being affected. These problems lead to delays in the construction of residences and thus also increases the current shortage of living spaces seen in the Netherlands. The demand for electricity is only expected to increase the coming years and because of the slow expansion and fortification of the current power grid infrastructure every innovation that would allow for the available transport capacity to be used more efficiently is relevant. Creating a clear understanding of the implementation process for SPTC could greatly improve the speed at which these systems can be implemented later on while also preparing the users for any challenges that might arise. My recommendations for future research would therefore be to focus on understanding the SPTC ST-system even further. Any future research based on this thesis could either focus on improving the QCA or by expanding on the aspects of ST-system this research has not fully explored yet. My recommendation are the following: Refine the QCA using more reliable and complete data, including additional relevant cases. Conduct a temporal QCA to identify which factors are critical at different stages of the implementation process. Expand research into the economic and regulatory aspects of SPTC, complementing the current focus on stakeholder interactions. Evaluate the actual impacts of SPTC on the power grid and user outcomes, testing whether the system delivers anticipated short- and long-term benefits.

This research has challenged me in many ways. Often forcing me to rethink my approach and come up with new ideas to obtain the data needed or deal with data not being available. At the start of the research I was mainly sticking to just the theory and expected all my findings to neatly fit within the chosen theories and models. The real world has shown me that theory can be used to effectively predict how things will behave in a general sense, but that reality often does not fully conform to theory. Flexibility and the courage to not see theory as the absolute truth allowed me to follow what was logical and not what the theory prescribed. The interactions with entrepreneurs showed me that most people are looking for a clear and concise answer. All the conditions and exceptions should definitely not be ignored, but should come second to giving a clear and understandable answer. As a researcher I learnt that research steps should be logical. A lot of time was spent on things that ultimately were not relevant as I forgot to ask myself if the steps I was taking were supported by the previous steps. Extensive preparation is important for doing research. However, if the topic is fairly unexplored as was the case for SPTC, the exact planning of the research will often change. Identifying step one, completing it and subsequently determining what the next logical step should be would have been the better approach for this research. Ultimately I am happy with my research. I think that I was able to at least provide a basic overview of factors involved with the implementation of an ST-system that is becoming increasingly relevant.

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8 Appendix

Scoping Literature Search Queries

Search Strategy	Search query	Hits
Title, abstract, and keywords	TITLE-ABS-KEY (energy W/0 hub AND (implementation OR integration OR adoption) AND (barrier OR driver)):	15
Title, abstract, and keywords	TITLE-ABS-KEY (virtual W/0 grid AND (implementation OR integration OR adoption) AND (barrier OR driver))	1
Title, abstract, and keywords	TITLE-ABS-KEY (energy W/0 management W/0 system AND (implementation OR integration OR adoption) AND (barrier OR driver)) AND (LIMIT-TO (SUBJAREA , "SOCI"))	21
Title, abstract, and keywords	TITLE-ABS-KEY (scada AND (implementation OR integration OR adoption) AND (barrier OR driver))	72
Title, abstract, and keywords	TITLE-ABS-KEY ((electricity OR electrical) W/0 meter AND (implementation OR integration OR adoption) AND barrier OR driver) AND (LIMIT-TO (LANGUAGE , "English"))	4
Title, abstract, and keywords	TITLE-ABS-KEY ((decentralised OR decentralized) W/0 energy AND system AND (implementation OR integration OR adoption) AND (barrier OR driver)) AND (LIMIT-TO (LANGUAGE , "English"))	62
Title, abstract, and keywords	TITLE-ABS-KEY (grassroots W/0 innovation) AND stakeholder AND involvement AND (barrier OR driver) AND (LIMIT-TO (LANGUAGE , "English"))	3
Title, abstract, and keywords	TITLE-ABS-KEY (grassroots W/0 innovation) AND user AND involvement AND (barrier OR driver) AND (LIMIT-TO (LANGUAGE , "English"))	4
Title, abstract, and keywords	TITLE-ABS-KEY (grassroots W/0 innovation) AND knowledge W/0 sharing AND (barrier OR driver) AND (LIMIT-TO (LANGUAGE , "English"))	3
Title, abstract, and keywords	TITLE-ABS-KEY (community W/0 (project OR initiative)) AND knowledge W/0 sharing AND	16

	(barrier OR driver) AND (LIMIT-TO (LANGUAGE , "English"))	
Title, abstract, and keywords	TITLE-ABS-KEY (community W/0 (project OR initiative)) AND user W/0 involvement AND (barrier OR driver) AND (LIMIT-TO (LANGUAGE , "English"))	6
Title, abstract, and keywords	TITLE-ABS-KEY (community W/0 (project OR initiative)) AND stakeholder W/0 involvement AND (barrier OR driver) AND (LIMIT-TO (LANGUAGE , "English"))	2
Title, abstract, and keywords	TITLE-ABS-KEY (local W/0 (project OR initiative)) AND stakeholder W/0 involvement AND (barrier OR driver) AND (LIMIT-TO (LANGUAGE , "English"))	7
Title, abstract, and keywords	TITLE-ABS-KEY (local W/0 (project OR initiative)) AND user W/0 involvement AND (barrier OR driver) AND (LIMIT-TO (LANGUAGE , "English"))	3
Title, abstract, and keywords	TITLE-ABS-KEY (local W/0 (project OR initiative)) AND knowledge W/0 sharing AND (barrier OR driver) AND (LIMIT-TO (LANGUAGE , "English"))	17