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Faculty of Technology, Policy and Management
Department of Values, Technology & Innovation (VTI)
MSc Systems Engineering, Policy Analysis and Management

Support Policy Instruments for Offshore Wind Power in the Netherlands

Master's Thesis Project of:
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General Information

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Executive summary

In the Netherlands, the developing of offshore wind power (OWP) systems is one of options for electricity generation from renewable energy sources (RES-E) for the transition to a sustainable energy system. In 2015, the European Wind Energy Association (EWEA) announced that around 6500 MW of total offshore wind capacity required in the Netherlands could be realized by 2030.

The relatively low commercial maturity of OWP technology and also some distinct technological features (e.g. long lead-time, high capital cost) of OWP lead to certain market barriers which consequently result in market failure. Over the last 25 years, the Dutch government has applied economic policy instruments, as public resources, in order to not only overcome all the market barriers but also to create a level playing field. Despite the fact that several support systems are being implemented by the Dutch government, they could not meet the predefined objectives. Up until 2017, only 957 MW was implemented and supplied to the grid. Primary literature study confirms that the lack of investment by investors is one of the most important reasons for this failure. Therefore, this study was conducted to investigate the efficiency and effectiveness of economic policy instruments when it comes to stimulating investment in new OWP projects in the Netherlands by adopting a sustainable and distributive justice approach. This concern is formulated in the following research question:

What economic policy instrument is efficient, effective, and certain (providing certainty for investment) for stimulating investment in offshore wind power whilst not compromising considerations of equity?

This study is composed of four main parts: the literature review, the case study, the analysis, and the design. The literature study includes a review of thirty scientific documents and books to gain insight into policy instruments regarding the promotion of RES-E technologies in general and OWP technology in particular. The case study was carried out to investigate the already implemented support systems for the promotion of OWPs in the Netherlands. After that the relevant findings made during literature review and case study inform the development of a framework for the evaluation of policy instruments in order to select a policy instrument from the alternatives which will stimulate investment in new OWP projects in a sustainable way. The last part of this study, the concept of *Responsible Innovation* is used to design a new policy instrument to enable *Responsible Innovation* in OWP.

The review illustrates that these four policy instruments are either price-based or quantity-based in their approach. Investment subsidies and Feed-in Tariff (FiT) are price-based support systems where the authority sets the price, and the quantity is determined by the market. Tradable Green Certificates (TGCs) and tendering systems are two of quantity-driven schemes where the quantity is set by the authority and the price is decided by the market. A part of this literature study is devoted to the investigation of practical experiences all over the world, particularly within EU member states. This review shows that FiT and TGC have been the most commonly implemented policies among EU member states over the last 25 years.

The second part of this literature review is devoted to the identification of criteria for the evaluation of those four suggested policy instruments. Effectiveness, efficiency (static and dynamic as well), and certainty for investors are the most common criteria for evaluation of policy instruments. Equity is the fourth criterion to be considered in more recent evaluations. It is increasingly believed to be necessary to consider social aspects in newer evaluations. Therefore, in the last part of this literature study, the necessity to consider the social aspects in the evaluation of support systems is investigated. Equity in terms of distributive justice in the four suggested policy instruments is addressed. With distributive justice researchers want to investigate who is bearing the costs and who is enjoying the benefits associated with the implementation of policy instruments.

The case study confirms that Feed-in Tariff (FiT) and Tradable Green Certificates (TGCs) are the two main policy instruments implemented in the Netherlands. The lack of political stability is seen as one of main reason why they failed to meet their objectives. The lack of policy commitment by the Dutch policy-makers resulted in policy uncertainty and accordingly in policy uncertainty for investors.

The main findings in the literature study and the case study are analyzed in order to construct an assessment framework to determine what are the proper policy instruments. A multi-criteria analysis (MCA) was applied as the decision-making method for selecting applicable support system in sustainable way. Sustainable development implies that social, economic and environmental aspects must be equally considered whilst not compromising one particular aspect. This method is well-known as a method in which all criteria have equal weight. That was why this method was selected for the evaluation of those four suggested policy instruments.

The analysis shows that the selection of the policy instrument represent a trade-off between effectiveness and efficiency. Therefore, this selection depends on the policy-makers' priorities. This analysis addresses the fact that while there is not one concrete policy instrument to meet objectives effectively and efficiently at the same time, one improved and adjusted (dual) FiT system is a proper policy instrument that could stimulate investment in OWP projects in the Netherlands in the new future. This dual FiT system provides enough certainty for investors at relatively the most effective and efficient approach from policy-makers' perspective while considering equity as relevant social aspect. Of course this performance depends on various factors and conditions, such as political certainty, guaranteed grid connection, availability of budget etc.

The last part of this thesis includes the design of the new recommended support system (dual FiT) to enable responsible innovation in OWP development. In concept of responsible innovation it is aimed at designing a support system to decrease (un)expected conflicts by considering of public values.

Moving to the main research question, the current implemented policy instrument (specific TGCs) is not an effective support system to meet near-term objectives regarding OWP (6450 MW up to 2023). Therefore, an improved and adjusted FiT, as a price-based support system, is suggested to meet those objectives.

Contents

CHAPTER 1
Introduction

Increasing electricity generation from conventional resources is limited by constraints such as the availability of resources (conventional resources) and ethical concerns such as social issues, intergenerational equity, environmental issues and climate change. Fossil fuels reserves are finite (Vernon et al., 2011). Fossil fuels also are the most important reasons of the atmospheric concentrations of greenhouse gases (GHGs) such as carbon dioxide (Venkataraman et al., 2012). The social cost of carbon (SCC) that monetized environmental damages by CO2 emissions is one of main reasons for waking up us to replace conventional fossil fuels with renewables. It is estimated that in 2015 the SCC was $31 per ton of CO_2 in 2010 US$ (Nordhaus, 2017). Greenhouse gases cause climate change and global warming. Moreover, intergenerational equity forces us to revise the consumption of fossil fuels.

Electricity generation from non-conventional resources, such as wind, tidal and solar, is suggested as one option to face these latter mentioned challenges. Furthermore, according to EU 2020 Energy Policy, the Netherlands, like other EU member states, is supposed to generate a minimum share of power from renewable energy sources (RESs) in the total energy supply (Agterbosch et al., 2004). The RESs share in electricity consumption should increase to at least 21% in the EU-27 in 2020 (Klessmanna et al., 2011). In 2014, only 11.7 billion kWh of renewable electricity was generated in the Netherlands which is approximately 10 percent of total consumption (CBS, 2015a).

1.1. Offshore wind energy as a possible contribution in meeting CO2 targets in the Netherlands

Wind energy is well known as one of the cleanest and the most environmentally friendly energy sources (Bilgili et al., 2011). Therefore, wind energy is considered as a competitive and sustainable way to contribute in meeting CO2 reductions and renewable energy targets (Kaldellis et al., 2013). Onshore and offshore are two suggested alternatives for wind energy. Offshore wind is known to be the more efficient option, due to the considerably higher and steadier wind speeds in the open sea (Kaldellis & Kapsali, 2013). Furthermore, in comparison with the onshore, offshore wind energy has greater resource potential, which generally increases with distance from the shore (Kaldellis & Kapsali, 2013). On the other hand, the costs associated with offshore wind are still much higher than onshore (Kaldellis & Kapsali, 2013). Operation and maintenance costs may be up to three times higher than those of onshore (Musial et al., 2010). The rather frequent need for employing expensive transportation means is recognized as one of the main causes of these high costs (Kaldellis & Kapsali, 2013).

Offshore wind power (OWP) is of the “must-run” type, therefore a buffer is required to store the surplus when the total amount of electricity generated by OWP exceeds the total electricity (Bellekom et al., 2012). Fortunately the introduction of hybrid cars seems to be a good way not only to reduce environmental impact of the transport sector but also, as a buffer, to store (surplus) power from the grid (Bellekom et al., 2012). In the Netherlands the combination of OWP with hybrid cars could lead to achieving the target of CO2 reduction in both the electricity and transport sectors.

1.2. The Netherlands does not meet targets

The European Wind Energy Association (EWEA) expected 6000 MW of offshore wind capacity to be realized by 2030 in the Netherlands (EWEA, 2011). In 1995, the Dutch government set a target of 1500 MW in 2010 up from 228 MW back then (CBS, 2008). Up to 2017, from 1500 MW planned electricity generation from offshore wind parks, only 957 MW was implemented and supplied to the grid. Fig. 1.1 indicates the planned and the installed offshore wind capacity in the Netherlands. It is 1.80% of total electricity generation in the Netherlands (CBS, 2015b). This shows a slow penetration of OWP in the Netherlands.

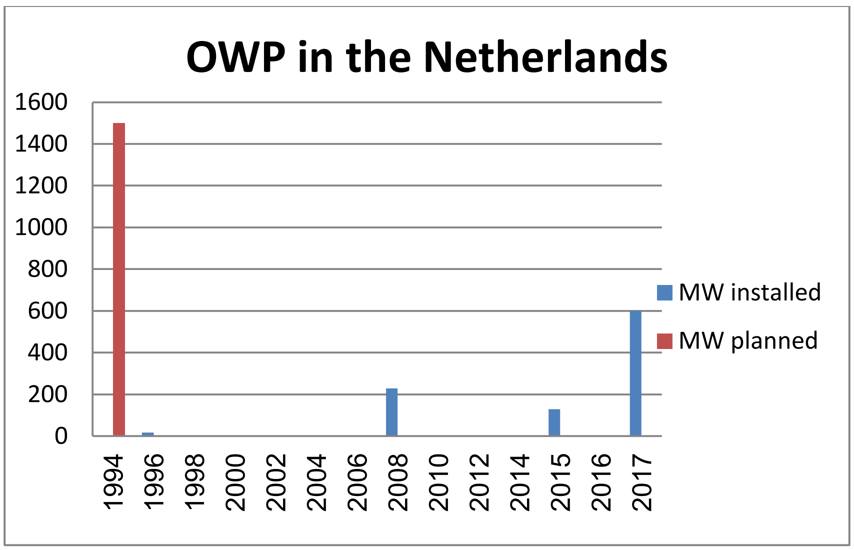

Fig. 1.1. Planned and installed OWP capacity in the Netherlands

1.3. Renewable Energy Policy Instruments

The Dutch government has planned to promote offshore wind power systems 6450 MW up to 2023[1] successfully and effectively.[2] For this, they have provided policy instruments[3] in order to form the basis for their market position in the phase of technology and market development (vanDijk et al., 2003). The Dutch policy-makers also aimed at providing and implementation of proper support system by consideration and minimizing of expected potential negative social and environmental impacts such as negative impacts on the local fishing industry, recreational boating, property values, bird life, and aesthetics (Firestone et al., 2007).

[1] https://www.noordzeeloket.nl/en/functions-and-use/Maritime_wind_energy/

[2] Effectiveness is the extent to which objectives are met (Mitchell et al., 2011). In case of OWP, the actual increase in the amount of electricity generated by OWPs in total electricity supply within a specific time period. Efficiency, in general, is defined as the ratio of outcomes to inputs (Mitchell et al., 2011). For instance, referring OWP it could be defined as the ratio of OWP targets achieved to economic resources spent (Mitchell et al., 2011).

[3] A policy instrument is the tool to implement policy; the term is used both for the theoretical principles, and for the practical implementation (vanDijk et al., 2003).

1.3.1. Investment related causes

The Dutch government already has provided Tradable Green Certificates (TGC), as a *quantity-driven*[4] policy instrument two times; voluntary TGCs (1996-2002) and under SDE+ program (2011-ongoing). It is designed as a generic[5] policy instruments to support renewable energy production in the Netherlands. The Dutch government also provided Feed-in tariff as a *price-driven* policy instrument but in a different period: under MEP (2002-2008) and under SDE (2009-2010). In this case, it is a specific[6] technology policy, and the policy maker(s) set it only for offshore wind in the Netherlands. By providing these policy instruments the Dutch government aims to create proper conditions in order to stimulate investors to enter OWP market and invest in this field. However, although the Dutch government provided and implemented policy instruments to expand OWPs, they did not achieve the objectives. Therefore, it is necessary to investigate and assess those economic policy instruments to ascertain the more promising future instruments for promoting the development of large-scale offshore wind power systems in the Netherlands.

One of the major criteria[7] for a successful promotion of energy system is the acceptance by the investors (Haas, Resch, et al., 2011). Primary literature study shows that already implemented policy instruments did not stimulate investors to invest in this field (Kaldellis & Kapsali, 2013). In other words, lack of enough investment is recognized as one of leading reasons for slowly diffusion of OWPs in the Netherlands.

Also Haas and his colleagues (2004) suggest the major focus must be to trigger investment in new capacities of power generation by renewable energy sources (RES-E) (Haas et al., 2004). In the Netherlands, energy (electricity) companies are key players to develop OWPs and other power generation plants. Those companies invest, build, own and operate OWP projects (Negro et al., 2012). However, they argue that operation and maintenance (O&M) costs of OWPs are so high, that they prefer not to invest in this field (Kaldellis & Kapsali, 2013).

Since 1995, almost eight cabinets have formed in the Netherlands who have followed their own targets and priorities regarding renewable energy development. These governments have provided several policy instruments around offshore wind power developments. For instance in 2004 the Dutch government provided the Electricity Production Environmental Quality scheme (MEP) in order to level the playing field with fossil fuels (Verhees et al., 2015). The MEP was a guaranteed subsidy per kWh for producers of renewable energy for a period of 10 years (Verhees et al., 2015). Although it was intended to develop new capacity of OWP, it backfired because of flaws and unforeseen interests. In 2005, the ministry of economics affaires canceled the MEP for offshore wind due to out of control costs (Verhees et al., 2015). The MEP lasted only for one year and resulted in an inconsistent support trajectory. This inconsistency threatened investors to enter and invest in OWPs in the Netherlands.

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[4] The public authority sets an objective to be achieved and organize and the price would be decided by the market.

[5] Generic policy instruments treat all renewables in the same way (Kooijman et al., 2004).

[6] Technology specific policies are tailored for only one specific technology (e.g. offshore wind) (Kooijman et al., 2004).

[7] Criteria are indicators that assess to which extent the different social actors' objectives are achieved by each alternative (Gamboa et al., 2007).

In case of Production Subsidy System SDE+[8] which focuses on rollout of RESs, in practice we observe that SDE+ is not a beneficial system for offshore wind, since it is outcompeted by cheaper alternatives (e.g. small-scale solar PV).

This study will address the role and ability of policies to stimulate investments in new OWPs' capacity in the Netherlands and other countries as well.

1.3.2. Distributive justice related causes

Economic support instruments will be more effective when there is consumer acceptance of the new technology. Haas et al. (2011) describe that the acceptance by relevant consumers and communities or society is crucial while they have to pay the required expenditures impacts in the end (Haas, Resch, et al., 2011). This leads to the inclusion of consumer acceptance as an evaluation criterion. Moreover, public perception about cost of wind technology is not supportive in the Netherlands (Wieczorek et al., 2013). Generally the Dutch people think that OWP projects are very expensive, and have additional costs[9] for consumers. These additional costs or policy costs are inevitable and have to be paid by the electricity customers eventually (Haas, Resch, et al., 2011). In other words, how the costs and benefit of energy production and consumption should be distributed is another related question (Jenkins et al., 2016).

Furthermore the imposition of negative social and environmental impacts on societies, derived from the developing of OWPs, is another relevant issue. Externalities like unequally imposed costs and hazards on communities, noise, visibility, bird accidents are some of negative social and environmental impacts (Thomsen et al., 2006). For instance, in the Netherlands, there have been several recorded protests by local communities such as residents at the shore, fisheries, the oil and gas industry and environmental organizations, who are worried about the relevant dangerous impact of OWP on sea-life and birds (Eggink E., 2013).

Savacool and Dworkin (2015) describe that the degradation of the environment (e.g. negative effects of OWPs on marine mammals) and human suffering (imposed costs on communities) cause energy-related injustice (Sovacool et al., 2015). The injustice distribution of costs associated with developing of new renewable energy projects is a new concern that needs to be taken into account.

All these issues call for an investigation to understand which policy instruments can stimulate investors to enter and invest in OWPs without these policy instruments leading to injustice (e.g. unjustified imposed costs on communities). In other words, lack of an insight into usual already considered economic dimension and also social dimension at the same time in relation to stimulating investment through policy instruments, from a system perspective, is the recognized knowledge gap in this MSc graduation project.

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[8] Single (not differentiated) & lower kWh price for all renewables which has designed to favor the least expensive renewable energy options (Verhees et al., 2015).

[9] Haas et al. (2011) describes additional costs for consumers;

Additional costs for consumers = Producer Surplus + Generation costs - Revenues electricity market

(- Avoided External costs)

1.3.3. Responsible innovation in OWP development

Since support systems and consequently development of OWPs brings up some consequences and impacts, therefore investigation of those expected impacts helps to streamline implementation of policy instruments. Negative consequences impact public value such as distributional justice, procedural justice, security of supply, sustainability, environmental values, safety, profit making (Correlije et al., 2015, Kunneke et al., 2015). Responsible innovation is one of suggested approach for maximizing of positive contributions of the given action and minimizing of its negative consequences (Owen et al., 2012). Therefore, it is aimed at designing of a new and proper policy instrument to enable responsible innovation in OWP technology.

1.4. Objective

In sum, in this study an evaluation framework is designed to assess four economic policy instruments used to support and promote OWP in the Netherlands, in order to evaluate their implications in terms of efficiency, effectiveness, investors' certainty, and distributive justice as an energy justice issue. In other words, this MSc graduation project will explore a way to support the Dutch government, as the involved policy-maker, for choosing the most promising (fitting) policy instrument(s) regarding OWP market in the Netherlands that incorporates distributive justice next to stimulating investment efficiently and effectively, and providing certainty for investors. Also, as the second main objective, the new recommended policy instrument will be designed while aimed at enabling responsible innovation to the development of OWPs.

1.5. Research question

Based on the earlier discussed and mentioned Knowledge gap, problem statement, and research objective of this project, the following general research question could be formulated.

What economic policy instrument is the efficient, effective, and certain (providing certainty for investors) for stimulating investment in offshore wind power whilst not compromising considerations of equity?

In order to answer the main research question, it is separated into several sub-questions;

I. What are the most widely implemented economic policy instruments regarding renewable energies such as offshore wind power?
    a. What are main features of these economic policy instruments?
        i. From theoretical perspective how could price-driven and quantity-driven economic policy instruments be described? How do these instruments stimulate investment in OWPs?
        ii. What are Pros and Cons of these policy instruments?
    b. How does and could equity feature in these economic policy instruments?
        i. (How) do these instruments address equity issue?

II. What is the current state of policy instruments pertaining to OWP in the Netherlands?
    a. What is the current state of OWP systems in the Netherlands?

    b. What do already implemented financial policy instruments mean for OWPs in the Netherlands?
    c. To what extent do those policies stimulate investment in OWP?
        i. To what extent do those policies stimulate investment efficiently and effectively?
        ii. To what extent do those policies provide certainty for investment?
    d. To what extent do those policies address equity concerns?

III. Which policy instrument(s) could be promising future instruments for stimulating investment in OWPs in the Netherlands?
    a. Which is likely to be the most efficient and effective?
    b. Which is likely to provide the most investment certainty?
    c. Which is likely to address equity considerations more adequately?
    d. What economic instrument offers the best combination between economic issues (efficiency, effectiveness, investment certainty) and social issues (equity)?

IV. What policy could be recommended for the Dutch government?
    a. Why the recommended policy instrument is the proper support system for OWP development in the Netherlands?
    b. How does the recommended policy instrument lead to meet objectives

V. How could the responsible innovation be enabled in OWP development by implementation of the recommended policy instrument?
    a. What is responsible innovation?
    b. Why responsible innovation approach is proper framework for implementation of recommended policy instrument?
    c. How does responsible innovation enrich implementation of recommended policy instrument?

1.6. Scientific and societal relevance

The main scientific contribution would be the improvement of the policy evaluation of economic instruments regarding OWPs by the consideration of equity in policy instrument design while also considering the efficiency and effectiveness of those policies. The equity issues would be addressed in the form of distributive justice. Providing certainty for investors through mentioned policy instruments also would be clarified. Moreover, enabling responsible innovation in the development of OWPs is another scientific contribution of this study.

Moreover, the result of this study will be some recommendations for policy-makers. It presents one promised option (or a range of options) to policy-makers for achieving the desired level of OWP deployment and penetration in the Netherlands in near-time. This leads to expansion of share of electricity from a renewable energy source. Finally it contributes to achieve big national and global scale objectives such as energy supply security, and also support social and environmental issues.1.7. Research design

1.7.1. Research approach

The basic concept of this MSc graduation study is the understanding and assessment of the role and impacts of economic policy instruments for promoting the development of offshore wind power in the Netherlands. This study is underpinned by a process model[10]. This means that this study is aimed to describe how it could be that a policy instrument (X) causes unequal cost sharing (Y) or insufficient investment in OWPs (Y').

The main product of this project is an evaluation framework. An evaluation framework will be designed not only for assessment of economic instruments but also for identification of the most promising future policy instruments. This design is based on literature review and case study.

To the extent that literature is available, this MSc graduation project will assess four policy instruments based on

- how far they are able to stimulate investment efficiently and effectively,
- to what extent they provide certainty for investors,
- how they affect equity in term of distributive justice.

Hence, this is a review of four suggested policy instruments and identified criteria with reference to OWPs in the Netherlands.

1.7.2. Research method

In this MSc graduation project, the focus is on a contemporary phenomenon within a real-life context, then as Yin suggests a case study method could be used as research method (Yin, 2009). The case study would be substantiated by a comprehensive literature study. Thus this case study (study of already implemented policy instruments for OWPs in the Netherlands) aims at getting a comprehensive insight into main causes of lack of or insufficient effectiveness, efficiency, and certainty for investors in stimulating investments in OWPs in the Netherlands. This comprehensive insight is needed in order to analyze policy instruments for stimulating the development of OWPs. This research approach includes five phases; Prepare, Literature study, Case study, Analyze, Design and Sharing some formulated policy recommendation(s) (Fig. 1.2).

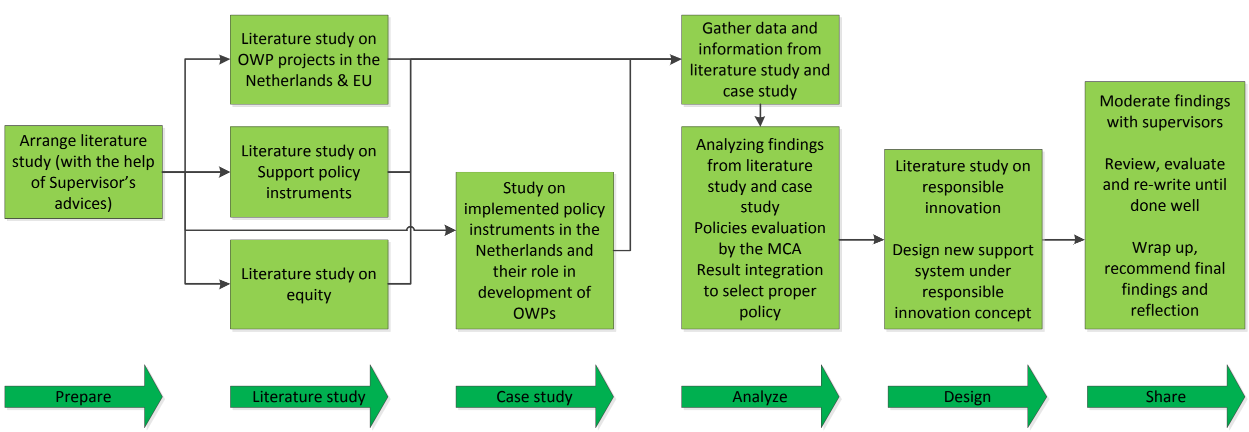

Fig. 1.2. Research method of the study

[10] Process model aims to give meaning to a specific sequence of events (Verhees et al., 2015).

After this introduction and formulation of problem, literature study will form the second step in this MSc graduation project. Focus is on main issues;

- As the first, investment in OWP projects will be studied.
- The second part of literature study is about the getting insight into the most investigated policy instruments for promoting the development of OWPs.
- The focus of the third part is on finding out the main criteria to evaluate economic policy instruments for stimulating of investment in OWPs, and in order to improve those mentioned policy instruments.

It is aimed that this literature study will lead to a comprehensive assessment of those four mentioned support schemes according to some main criteria.

Case study is needed for getting insight into actual experiences and success of already implemented policy instruments in the Netherlands. Focus will be on;

- First, as a master SEPAM graduation project, offshore wind parks in the Netherlands would be investigated from system perspective. This investigation will give insight into OWPs in the Netherlands.
- The second part includes an analytical review of the role of implemented policy instruments on stimulating investment in OWP projects in the Netherlands.
- The case study will be wrapped up by listing lessons learned and some recommendations.

The case study will be followed by the gathering of all of findings. Then analysis will be done in order to synthesize those findings for elaboration of that evaluation framework and also to assess those four policy instruments in order to find out one promising policy instrument(s) for promoting the development of OWPs in the Netherlands in near-time. For assessment of those support systems the Multi-Criteria Analysis (MCA) method would be used. After evaluation and selection, the fifth chapter includes the design of new selected policy instrument. In that chapter, the way to implement the selected policy by enabling responsible innovation in the development of OWPs will be investigated. All of these results would be discussed with supervisors to purify and correct results during this study. The results would be published as final report of Master Thesis project for the MSc.

CHAPTER 2
Support Policy Instruments and Offshore Wind Power

Stimulating investors for development of offshore wind parks in the Netherlands is recognized as a necessary task for the Dutch government to reach targets regarding EU Renewable Energy Directive 2009/28/EC. The Dutch government provides economic policy instruments, as one of public resources, to overcome regarding market failures and consequently to achieve this objective. In this chapter, firstly investment in the OWP projects as socio-technical systems will be investigated. Subsequently, a detailed review of four suggested economic policy instruments will be conducted. This will be substantiated by looking at relevant experiences in other countries especially some EU member states. In the third part of this chapter, relevant literature will be studied in order to list and analyze the most frequent criteria for evaluation of those four selected support schemes. In the fourth part, the necessity of considering social dimensions in policy instruments will be discussed.

2.1. Investment in OWP project as a socio-technical system

As discussed earlier in the introduction, lack of enough investment is recognized as a main market barrier (market failure) to diffusion of OWPs in the Netherlands. This section includes an extensive discussion about the way to stimulate investment in new OWP projects in the Netherlands.

A large-scale offshore wind park can be considered as a socio-technical system. A socio-technical system consists of three interconnected dimensions: (1) network of actors and social groups (social dimension), (2) formal, normative and cognitive rules (institutional dimension), and (3) material and technical elements such as an offshore wind park (technological dimension) (Verbong et al., 2007). Utilities (electricity companies), financial agency, Minister of Economic affairs, Minister of Infrastructure and the Environment, TSO (TenneT), Energy companies are main involved actors in one OWP system in the Netherlands. Formal rules, regulations standards, laws, role relationships are some of formal, normative and cognitive rules that shape and guide the activity of actors. Among those mentioned involved actors, utilities, as investors, and two ministries[11], as relevant policy makers, are directly involved for stimulating investment and development of OWPs in the Netherlands. Therefore, stimulating investment in new OWP projects could be analyzed from a socio-technical perspective.

2.1.1. Uncertainties as barriers

Costs needed for deployment of a large-scale offshore wind parks run in the hundred millions of Euros. Construction of large-scale OWP have typically been funded by either utility companies (large power companies like Eneco) from their general revenues or by a combination of investors and banks providing dedicated financing for each individual project[12]. Although it does need a large upfront investment for construction, but operation costs are relatively low. However, the large upfront investment must be repaid over a long period of time therefore predictable revenues are

[11] The Ministry of Economic Affairs and the Ministry of Infrastructure and the Environment
[12] http://green-giraffe.eu/article/offshore-wind-clean-energy-sea

the best way for that repayment. This implies that guarantee of getting a fixed price for electricity they generate or security of market are needed to ensure investors to invest in large-scale OWP projects. Then investment in OWPs depends on market and policy uncertainties (Eryilmaz et al., 2016). In other words, policy uncertainty and market uncertainty are two sorts of uncertainties surrounding investment in OWPs.

Policy uncertainties could be categorized in two classes; uncertainty caused by frequently changing of national policy instruments, and uncertainties that arose by regulatory changing (e.g. liberalization of electricity market, uncertainty in future climate policy etc.).

Market uncertainty discuses about future demand, prices and costs. There are caused due to uncertainties in future carbon price, future energy prices, future maturity level of OWP technology. All of these uncertainties impact electricity generation from OWPs. As J. Lipp (2007) describes "fixed prices for generated electricity over medium- to long-time horizons are also thought to create a market certainty needed to attract investment and grow the industry" (Lipp, 2007). These fixed payments often decline over time to reflect cost reductions (Sawin, 2004).

OWP developers (investors) must balance the relevant uncertainty and opportunities associated with that large amount of investments (Geels, 2010). Due to future uncertainties in government regulations, and also price fluctuations, it may be rational that firms postpone investments on OWPs (Rugman et al., 1998). These uncertainties lead investors to wait for more clarity and stability. On the other side, it should be mentioned that the first OWP developers/leaders could benefit from first mover advantages such as brand recognition, creation of market positions, technology lead, and creation of patent barriers (Geels, 2010). These create desirable positions in future race. In addition, those leaders (utilities) may also convince policy-makers to issue stricter regulations and thus impose imitation costs on competitors (Geels, 2010).

2.1.2. Overcoming barriers by economic policy instruments under stable policy environment

Governments, as the second main involved actor, do need to establish the conditions under which markets can work (Hajer, 2011). In this case, two ministries, as government and/or policy-makers, create desirable condition for the successful completion of a business case for deployment of OWP, as a relatively new technology. For this, they set clear objective(s)[13] then mainly facilitate and support OWPs' developers. Therefore, they use some proper instruments for intervention. They apply public resources such as regulation, financial instruments, monitoring etc.

Economic policy instruments are designed in order to create stimulant environment that motivate investors to invest in electricity generation from renewable energy sources (e.g. OWP). Investment subsidies, Feed-in Tariff (FiT), tradable green certificates (TGC), and bidding systems are four policy instruments that are suggested to be investigated in this study. In one conceptual model (Fig. 2.1), Masini and Menichetti (2012) illustrate that how type, level and duration of policies determine "renewable energy share in the investment portfolio" and accordingly the behavior of

[13] Increasing offshore wind capacity from todays (2015) 1,000 MW to 4,500 MW in 2023

investors regarding decision-making for investment in renewable energy projects (Masini et al., 2012). Investors will reduce RE share in their investment portfolio in case of unreliable government(s); the situation wherein support duration is decreased by uncertain regulations.

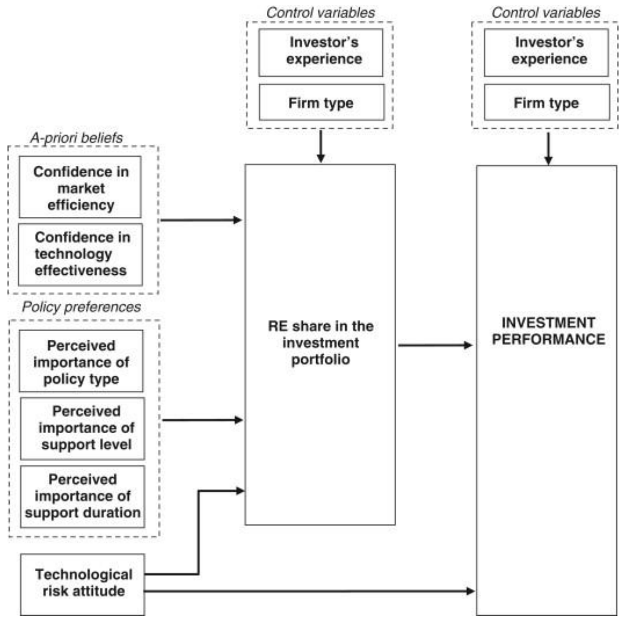

Fig.2.1. Conceptual model of influence of behavioral factors on the decision-making for investment in renewable energy projects (Masini & Menichetti, 2012)

Governments, as policy-makers, apply economic policy instruments "to alter the economic framework conditions for the relevant market players in a suitable way to make the desired behavior more economically attractive than the undesired one" (Enzensberger et al., 2002). It is expected that implementation of these policy instruments beside stability of policy environment result in a more stimulant regulatory environment. Because a stable policy framework creates a confident environment which is desirable for market actors such as developers, investors (utilities) and banks for investment and providing needed funds, and accordingly they get more and more comfortable with the risk of building such big projects in the middle of the sea. In other words, successful implementation of policy instruments regarding developing renewable energies (e.g. OWP) depends on a long-term and stable policy environment (Bürer et al., 2009). As de Jager et al. (2008) explain "commitment, stability, reliability and predictability are all elements that increase confidence of market actors, reduce regulatory risks, and hence significantly reduce the cost of capital". Briefly, a stable and consistent policy framework is required to help creation of the conditions for sustained investment for development of renewable energy technologies (Foxon et al., 2007). Hence, in the Netherlands the problem of lack of investment for development of offshore wind parks could be solved by designing and implementation of stable and consistent policy framework that creates the stimulant environment for sustained investment.

Thus governments should choose one of policy instruments to stimulate and to support investment in this sort of projects effectively and efficiently. The rest of this chapter will provide more insights into policy instruments that secure a stable regulatory environment.

2.2. Policy instruments for stimulating investment in OWP

As discussed earlier, although electricity generation from renewable energy sources has advantages compared to fossil fuels, currently it faces economic, institutional, political, legislative, social and environmental barriers (Haas, Resch, et al., 2011). However governments want to promote renewable energy systems successfully and effectively.

Therefore, Policy-makers have provided economic policy instruments[14] in order to overcome those obstacles properly. Moreover, by these strategies, they are aiming at forming the basis for their market position in the phase of technology and market development (vanDijk et al., 2003). In other words, policy-makers (governments) in many countries are interested to support electricity generation from renewable energy (RES-E) technologies for increasing the share of renewable energy sources for electricity generation in order to reach their targets regarding sustainable development[15].

2.2.1. Debate between Price-based vs. Quantity-based policy instruments

Policy-makers have several policy instruments at their disposal to foster the development of renewable energies. Those policy instruments are based on the same approaches as environmental policies: price-based approaches (e.g. Feed-in Tariff, and Investment subsidies) and quantity-based approaches (e.g. Tradable Green Certificates, and Tendering system) (Menanteau et al., 2003). These two approaches aim at the same target, but start from different points (Haas et al., 2004). As Haas et al. (2004) describe, in the case of price-driven the price is set and the quantity is decided by the market, and in the case of quantity-driven the quantity is set and the price is decided by the market (Fig. 2.2) (Haas et al., 2004).
This implies that these two kinds of system (price-driven and quantity-based) works under a combination of state-setting and market conforming. In detail, in price-based system, states set price and market confirm the quantity, and conversely and more directive, by quantity-based systems (e.g. TGCs) states fix the quantity and market confirms the price (Haas, Resch, et al., 2011).

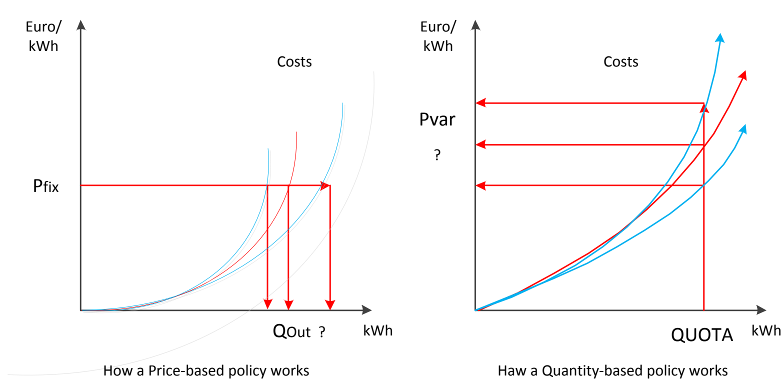

Fig. 2.2. How Price-based and Quantity-based policy instruments work (Haas et al., 2004)

[14] A policy instrument is the tool to implement policy; the term is used both for the theoretical principles, and for the practical implementation (vanDijk et al., 2003).

[15] Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987).

For instance the Dutch government already has provided Tradable Green Certificates (TGC) as a quantity-driven policy instrument. It is designed as a generic[16] policy instruments to support renewable energy production in the Netherlands. The Dutch government also provided Feed-in tariff as a price-driven policy instrument. It is a specific[17] technology policy only for offshore wind in the Netherlands. By providing these policy instruments the Dutch government aims to create stable and consistent policy environment in order to stimulate investors to enter renewable energy market and invest in this field. Observations show both approaches are not equivalent in situation where there is uncertainty (Fig. 2.2). Imperfect information and also dynamic electricity market are two of reasons for these uncertainties. As Weitzman describes since information is not complete in the market (energy market), price-based and quantity based are not equivalent (Weitzman, 1974).

In the following paragraphs, these two main categories of promotion policy instruments (promotion scheme/strategy) would be discussed based on the concept of static cost resource curves (cost curve or supply curve) of renewable energy sources. Generally, in economics, cost curves (graph of the costs of productions, as a function of total quantity produced) are studied in two situations; theoretically existing, and in real life situation. In theory, cost curves are considered continuously. It means a continuous cost curve emerges by to looking at all locations wherein every location is slightly different from each other with a high accuracy (Haas, Resch, et al., 2011). On the other side, in real life situation, that accuracy is impossible, therefore a discrete (stepped) cost curve (cost curve or supply curve) is formed (Fig. 2.2). A continuous cost curve is used to illustrate that cost curve regarding one technology (e.g. OWP) at every geographical location is slightly different from other locations while by the stepped cost curve sites with similar economic characteristics are located in one step. In this case (static cost resource curve) it is assumed, RESs are limited resources, (costs are considered as no cost dynamics) and costs would rise with increased utilization (Ragwitz et al., 2006). As Fig. 2.3 shows there are uncertainties regarding cost curve or supply curve. These uncertainties increase as we move towards the right side of curve (Fig. 2.3).

It is noteworthy to mention that the static cost resource curve (Fig. 2.3) is the same as typical conventional merit order supply curve[18]. Both curves based on short-term marginal costs for a specific point of time. But merit order curve does illustrate the differences in the costs of different technologies, but the static cost curve shows the fact that every location (of the site) is different from each other. In other words, different offshore wind parks (sites) are put into different categories and hence a stepped (discrete) supply curve is emerged. In addition, as Fig. 2.3 shows, associated uncertainty with static cost curve is another difference between static cost curve and typical conventional merit order curve.

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[16] Generic policy instruments treat all renewable energy sources in the same way (Kooijman et al., 2004).

[17] Technology specific policies are tailored for only one specific technology (e.g. offshore wind) (Kooijman et al., 2004).

[18] Short-term marginal costs of electricity which include fuel costs and CO2 costs, and are depicted from lower to highest in the curve (merit order supply curve) (Cludius et al., 2014).

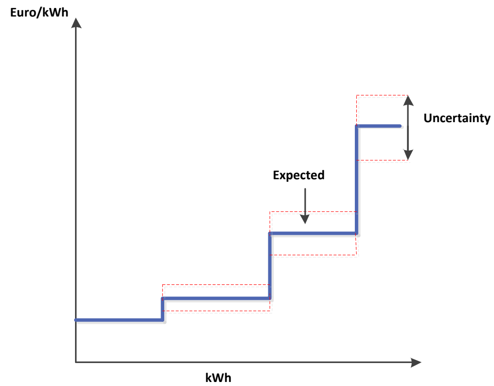

Fig. 2.3. Stepped cost curve (Adapted from Haas et al., 2011)

2.2.1.1. Price-based policy instruments

Under these promotion strategies, the focus is on electricity producers with financial support in the form of subsidies per kW of capacity installed or of generation based payment per kWh of electricity generated (Haas, Panzer, et al., 2011). Haas et al. (2011) categorize this scheme into two main groups; investment focused strategies, and generation based strategies (Table 2.1) (Haas, Resch, et al., 2011). Under *investment focused schemes,* such as investment subsidies, generators receive financial support per unit of generating capacity installed. Whiles under *generation based schemes*, such as feed-in-tariff (FiT), a fixed payment or premium per unit of electricity generated is offered (Haas, Resch, et al., 2011).

Table 2.1. Main promotion strategies (Adapted from Haas et al., 2011)

Promotion strategies	Price-based	Quantity-based
Investment focused	• Investment subsidies • Tax credits • Low interest/soft loans	• Tendering system for investment grant
Generation focused	• (Fixed) Feed-in-tariff • Fixed Premium system	• Tendering system for long-term contracts • Tradable Green Certificate system (TGC)

- Investment subsidy

Investment subsidy is a (investment focused) price-based policy instrument which is implemented to help overcome the obstacles of a high initial investment (e.g. investment in novel development of RES-E technologies) by stimulating investment in less economical renewable energy technologies with long-term horizons for investment returns. This impetus is linked to not only investment itself, but also is linked to operation of the plant. Investment subsidies usually covers 20-50% of eligible investment costs (vanDijk et al., 2003). Due to a limited (fixed) total annual budget, the subsidy would be allocated in the form of "first-come-first-in". Investment subsidy schemes may take different forms; rebates on general energy taxes, rebates from special emission taxes, proposals for lower VAT rates, tax exemption for green funds, to fiscal attractive depreciation schemes (vanDijk et al., 2003).

Investment subsidy was the first mechanism introduced to improve performance and stimulate the diffusion of less economical renewable energy technologies (Menanteau et al., 2003). This policy increases certainty for industry by reducing both technical risks[19] and market risks[20] (vanDijk et al., 2003). In addition, this policy is easy to understand and implement (Gan et al., 2007). On the other side, due to long lead time[21] of OWP projects, policy adaptations (due to budget limitations, changed political priorities, or market and technological developments) could threaten this certainty. Or even some technical development of one RES-E technology could convince policy-makers to mitigate those direct investment subsidies. This uncertainty decreases likelihood of success of the policy initiative. This mechanism also leads to high administrative costs, as far as some times it is not cost effective yet (Gan et al., 2007). Effective monitoring is needed to minimize the relevant risks. Nowadays this support scheme is only used for the most immature technologies (Menanteau et al., 2003) such as offshore wind power which still remains relatively immature (Sun et al., 2012). Furthermore this system is vulnerable in terms of one equity-related weakness. Because larger companies are often better equipped and better informed to apply for subsidies (vanDijk et al., 2003). Thus equity issues play a role in subsidy allocation.

- Feed-in tariff

FiT policy definition

The Feed-in Tariff is another price-based (generation focused) policy instrument. This support system involves an obligation on the part of electric utilities to buy the electricity generated by renewable energy producers in their service area at a tariff determined by the public authorities and guaranteed for a specified period of time, typically 15-20 years (Menanteau et al., 2003). This guarantee of payment would be paid in Euro/Dollar per kilowatt hour ($/kWh), and the payment amount is differentiated according to various plant characteristics, such as technology type, plant size, quality of the resource, project location, and fuel type (Klein et al., 2010). In addition, FiT would be structured based on a standard power purchase contract (Cory et al., 2009).

Valuation of Feed-in tariff[22]

Calculation of overall FiT payments received by RES-E technology developers is an important issue. RES-E technology developers, as receiver of subsidy, obtain the FiT payments based on two approaches: the Levelized Cost of Electricity (LCOE) generation from RESs, and the value of that generation to the utility and/or society (Cory et al., 2009).

[19] Forasmuch as the subsidy is granted at the beginning of operation, and it is independent of the operation itself, it means that grant covers not only market risks but also technical risks (vanDijk et al., 2003). Moreover from the technical point of view, since the OWP technology is well proven, almost all of the risks are related to the maintenance and the loss of efficiency of the module, and there are no technical risks related to the construction of the OWP.

[20] The risk of collision between service vessels and offshore wind turbines, the risk for a shortage of vessels for construction and repair purposes are two of typical technical risks associated with OWP. Price risks (e.g. electricity price) and financial risks (e.g. interest rate) are two of market risks regarding development of OWPs.

[21] For offshore wind projects, the average total lead time is 32 months in the EU (EWEA, 2010)

[22] By valuation we means the evaluation of policy instrument against economic objectives (how much does a policy instrument cost for policy-maker).

Levelized Cost of Electricity (LCOE) is defined “as the price (escalating with inflation) that would be paid to a generator that equals the present value direct costs (construction, operation and decommissioning) for the energy generated over the plant's lifetime and included connection and transmission costs” (Branker et al., 2011). LCOE is a method to evaluate the efficiency of different electricity generation technologies. In case of the Levelized Cost of Electricity generation from RESs (RES-E project cost-based approach), policy-makers set a stipulated return and add it to the levelized cost of RES-E generation.

The Levelized cost of electricity depends on engineering and economic factors (Borenstein, 2012). Engineering factors vary with technology (e.g. OWP, PV, Gas). But economic factors are more important and make more differences for estimation of LCOE. Assumptions about inflation rates, real interest rates, how much the generator is going to be used, and future input costs, including fuel costs are some of those economic factors. For a given generation plant, as illustrated under equation 2.1, it is "the constant (in real terms) price for power that would equate the net present value of revenue from the plant’s output with the net present value of the cost of production" (Borenstein, 2012).

$$\sum_{n=1}^{N} qn \frac{LCOE}{(1+r)n} = \sum_{n=0}^{N} \frac{Cn(q1, \dots, qN)}{(1+r)n} \leftrightarrow LCOE = \frac{\sum_{n=0}^{N} \frac{Cn(q1, \dots, qN)}{(1+r)n}}{\sum_{n=1}^{N} \frac{qn}{(1+r)n}}$$

Equation 2.1: LCOE for a given electricity generation plant (adapted from Borenstein, 2012)

Equation 2.1 illustrates LOCE for a given plant while that plant lasts N periods and generates q_n in period n, and r is the discount rate where $C_n(q_1, \dots, q_N)$ is the real (in period 0 €) expenditures in period n to generate the stream of output $(q_1, \dots, q_N)$ (Borenstein, 2012). Since in this method, economic factors, such as inflation rate or interest rate, are very different and unstable therefore the estimation of the LCOE for a given plant is a task full of challenges and disputes.

Through this approach, policy-makers (regulators) pursue two main goals; they want to create more favorable conditions for RE market growth, and they also aim at ensuring that project developers (investors) receive a proper rate of return. In this approach, policy makers apply three methods to establish FiT payment levels (Couture et al., 2010). The first method is *market research and empirical analysis* of current RES-E costs. As the most widely used of these three approaches, regulators use this method to ensure the profitability of RES-E projects. As the second cost-based method, policy-makers apply an *auction-based mechanism* to establish FiT prices for various projects. An auction is separate from FiT policy itself. The *profitability index method (PIM)* is the third cost-based approach to set FiT prices according to the targeted profitability of a specific RE project. By this method policy-makers could evaluate and rank efficiency of RES-E technologies.

The second method is a value-based method, wherein the amount of FiT is set according to estimating the value of the generated renewable energy. The value could be estimated according to the utility's avoided cost, or by internalizing of the externality costs[23] of conventional generation of electricity (Cory et al., 2009). However, as Cory (2009) explains, the estimation (quantification) of these values is quite complex, accordingly they believe this could lead to cost inefficiency due to inadequate or over-estimated payments (Cory et al., 2009). Due to these complexities, policy-makers prefer to apply the levelized cost of RES-E generation.

In the value-based approach, policy-makers had difficulty to estimate the actual cost of electricity generation from renewable energy sources such as offshore wind (Cory et al., 2009). This could lead to insufficient payment for stimulation of investment in power generation from RESs. This results in inefficiency if payments are higher than RE generation costs. And if payments are less than RES-E generation costs, it results in no investment to install new capacity (ineffectiveness). Therefore, it is more likely that the value-based approach does lead to less efficiency and effectiveness in compared to LCEO method.

Functioning of Feed-in tariff

The functioning of Feed-in Tariff is another issue. To describe this issue, the trend of the marginal cost curve of the RES-E supply should be analyzed. Fig. 2.4 represents the functioning of the optimal FiT scheme.

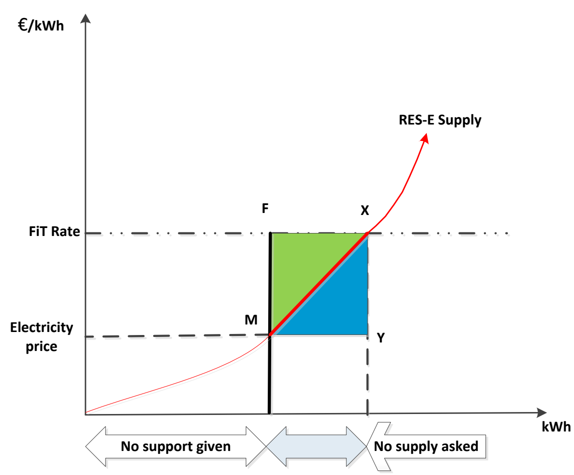

Fig. 2.4. Functioning of the optimal FiT (Adapted from Verbruggen et al., 2009)

As the Fig. 2.4 presents, the supply of RES-E is depicted as an up-ward long-run marginal cost curve that includes three main parts; marginal costs less than electricity price, marginal costs more than electricity price but yet less than the FiT rate, and marginal costs higher than the FiT rate (Verbruggen et al., 2009).

In case of "costs less than electricity price", as the cheapest section of the supply, since producers (utilities) make profit, therefore they do not need support (by the FiT). In the middle section,

[23] Externality costs of conventional generation such as environmental impacts, negative effects on health and air quality, impacts on the energy security etc.

although marginal costs are higher than electricity price, but cover the expenses by the introduced FiT rate. At the last part, beyond the FiT rate, investors could not cover the expenses at all. The total cost of support is the FiT Rate (the difference between FiT Rate and Electricity price) times RES electricity output (Fig. 2.4). From this amount, MFX part (green triangle) is the total rent received by more efficient producer(s).

Feed-in Tariff is a dynamic incentive (Fig. 2.5). Since lower marginal costs of RES-E supply increase the rent which producers could earn, therefore FiT has ability to stimulate project investors to improve technology in order to reduce the long-term marginal costs of the project (Verbruggen & Lauber, 2009). As Fig. 2.5 indicates, during the time (e.g. three phases/periods) the marginal cost curve of the RES-E supply shift to right-down side, this increases the total rent paid to (innovative) investors.

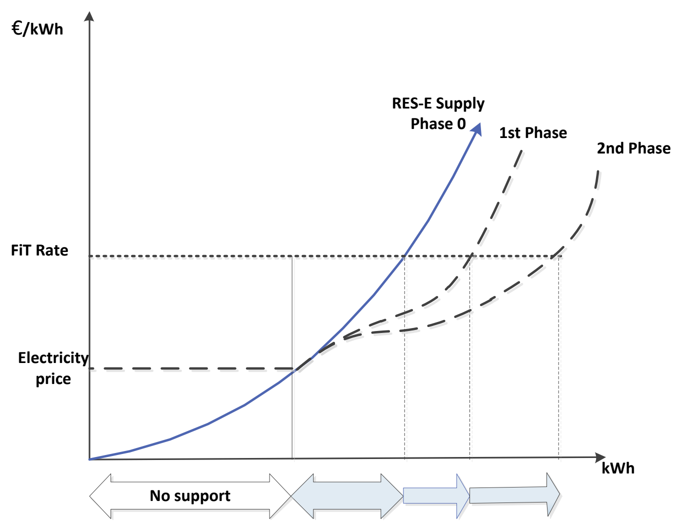

Fig. 2.5. Dynamic functioning of the FiT (Adapted from Verbruggen et al., 2009)

Feed-in Tariff payment options

As discussed earlier, the use of cost-based approach (the levelized cost of RE generation) is more favorable for policy-makers to estimate the level of the FiT payment. Therefore, in this section, the focus would be on FiT policies which are according to the generation cost of renewable energies. There are two cost-based policy options for the FiT payment; fixed-price policy, and premium-price policy (Cory et al., 2009). As Cory et al. (2009) mention the main difference between these two policy options is related to the fluctuation in the actual market price of electricity (Cory et al., 2009).

In the case of the fixed price, RES-E investors receive FiT payment as an overall remuneration (Klein et al., 2010). As Fig. 2.6 presents, in this case, in a targeted time, project investors (producers) receive a constant remuneration (€/kWh) and payment rate is independent from the market electricity price.

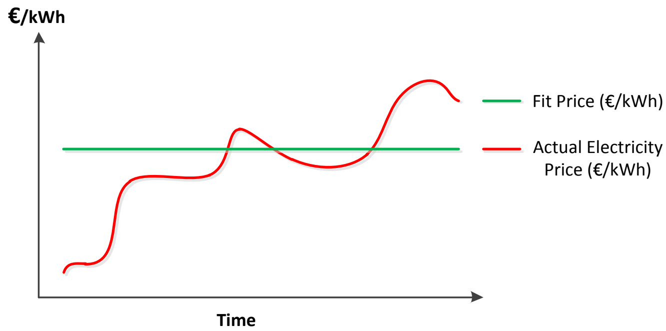

Fig. 2.6. Fixed price FiT payment option

And premium-price is another policy option for payment and FiT is paid to RES-E project investors on top of the electricity market price (Fig. 2.7). Therefore, the development of actual electricity price has a crucial role on determination of the remuneration level (Klein et al., 2010). Klein et al. (2010) believe this option is a modified form of the fixed price option in order to provide a more market-based FiT (support instrument) in a liberalized electricity market (Klein et al., 2010).

The premium FiT payment policy includes two models; non-variable premium, and variable premium. In the non-variable premium, investors receive a fixed predetermined premium (Fig. 2.7). But in the variable premium payments policy, payments will change as a function of the electricity price (Cory et al., 2009).

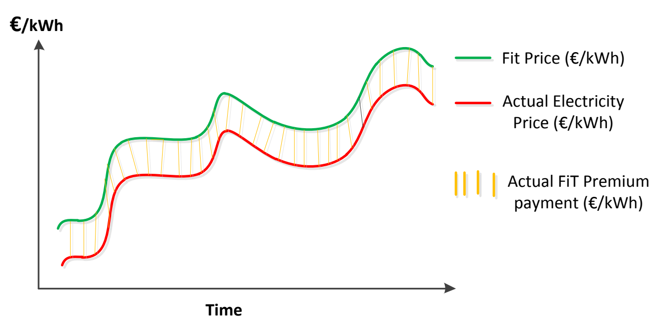

Fig. 2.7. Non-variable premium FiT payment option (Adapted from Cory et al. 2009)

Although designing a non-variable premium is simpler, but in case of significant fluctuation (increasing/falling) of spot-market price, there is the pitfall of windfall profits for developers, and the investment return risks as well (over and under compensation problems) (Cory et al., 2009).

Sliding premium model, and spot-market gap model are two variable premium FiT methods which are designed to overcome the challenges of over or under compensation (Cory et al., 2009). In the sliding premium model, policy-makers set a price cap and a price floor for the variable premium payments. It is already introduced in Spain. By setting a price floor, they aim at providing more stable revenues for investors in case of significant decreasing of actual spot-market price of electricity. Policy-makers also limit the exposure of the ratepayers by setting a price cap in case of significant increasing of electricity price.

The spot-market gap is the second designed method for dealing with overcomes the challenges of over or under compensation. This model is implemented in the Netherlands and it is based on renewable energy project cost (Fig. 2.8).

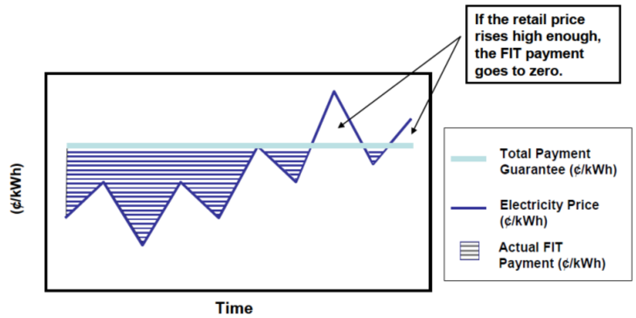

Fig. 2.8. Netherlands' premium price FiT - spot-market gap model (Cory et al., 2009)

In the spot-market gap model, policy-makers try to make a hybrid system by combination of fixed price and premium price payment approaches. For this aim, they set a minimum total payment in order to ensure that investors will receive that minimum payment. Although from investors' perspective, this model is almost the same as the fixed price payment scheme, but FiT payments are not awarded to projects as it is in the fixed price payment scheme (Cory et al., 2009). The FiT payments would be awarded through two different revenue streams. The first stream is the dominant spot-market price of electricity. The second option is a variable FiT payment (Cory et al., 2009). This FiT payment is fluctuating over time and covers the potential difference between them actual spot-market price of electricity and the predetermined minimum payment. It is remarkable that in both models (sliding premium model, and the spot-market gap) the FiT premium payment drops to zero if market price of electricity is too high and it does increase above the guaranteed payment (Cory et al., 2009).

FiT – Strength and weakness points

As an advantage of this support system, it is noteworthy that it provides lower risk to investors compared to other support mechanisms (Menanteau et al., 2003). Lower risk is provided by (predetermined) payments based on the cost of electricity generation from RESs. This is more highlight in case of fixed-price FiT, policy offers market-independent payments, then it creates stable conditions for investors (Cory et al., 2009). Moreover, as de Jager and Rathmann (2008) mention this risk reduction could result in lower project-financing costs (deJager et al., 2008). FIT policies also could ensure long-term return for investors, and at the same time it is relatively simple to implement (Gan et al., 2007). This long-term warranty depends on continuity and stability of the legal RES-E promotion systems howbeit governments change. As del Rio and Gual (2007) describe in Spain, despite governments change (since 1980 to 2007), and consequently legislative changes, continuity and stability in the legal RES-E promotion systems leads to the policies' commitments (delRio et al., 2007). This continuity and stability in the legal RES-E promotion systems comes from the national priority (in Spain) over the promotion of power generation from renewable energy sources. However it needs a good monitoring mechanism, and there is no guarantee for achievement of long-term target (Gan et al., 2007). In addition, the cost of subsidizing producers of

RES-E is covered either through cross-subsidies among all electricity consumers or simply by those customers of the utility obliged to buy green electricity, or by the taxpayer, or a combination of both systems (Menanteau et al., 2003). However calling simply on customers of local companies to finance green power generation is considered unfair (Menanteau et al., 2003). Unfair in term of distributive justice means unequal distribution of ills and benefits that could leads to unequal access to a given product or service. This payment is a different proportion of households' (customers') budget. Therefore, it is not equitable distribution of costs within one community (local customers). Furthermore it causes that only some people (customer of local companies) pay a higher payment that promote power generation from RESs and cooperate to overcome climate changes that threaten all of people.

2.2.1.2. Quantity-based policy instruments

Under quantity-based (quota[24]-based) promotion strategies, government (policy-maker) determines the desirable level of generation or market penetration of electricity generated by different technologies (Haas, Panzer, et al., 2011). Usually policy-makers also set a target date for achieving that desirable level of electricity generation. That desirable amount of electricity could be generated by the construction of new plants, by buying it from independent generators, or by employing a tradable certificate system. The price of generated electricity would be set through competition between electricity generators. As Table 2.1 indicates, the same as price-based approach, quantity-based scheme includes two main categories; investment focused strategies, and generation based strategies (Table 2.1).

- Tradable Green Certificates

Tradable Green Certificate is a quantity-based support system which a fixed quota of the electricity sold by operators on the market has to be generated from renewable energy resources (Menanteau et al., 2003). By this policy, policy-makers try to deploy RES-E technologies under liberalized market condition (Jansen et al., 2003). Operators regarding TGCs could be suppliers such as distributers or retailers (in liberalized electricity markets), or could be electricity producers (as in Italy). In some countries, such as Denmark, consumers have to purchase (consume) a certain amount of electricity from renewable energy sources. This certain amount (quota) of green electricity is set by national government for the whole of country and they are considered as financial assets and thus tradable on the certificate market.

This type of support system is used in the Netherlands, Denmark, and the UK. Tradable Green Certificates stimulate competition between producers, which will lead to decrease costs of generation (vanDijk et al., 2003). But there is not high certainty for investors created by this quota-based policy instrument. This uncertainty arises from possible fluctuations in market prices (vanDijk et al., 2003). Fig. 2.9 illustrates a schematic representation of a typical TGC system.

[24] Quota does mean a certain percent of electrical power must be generated from RESs.

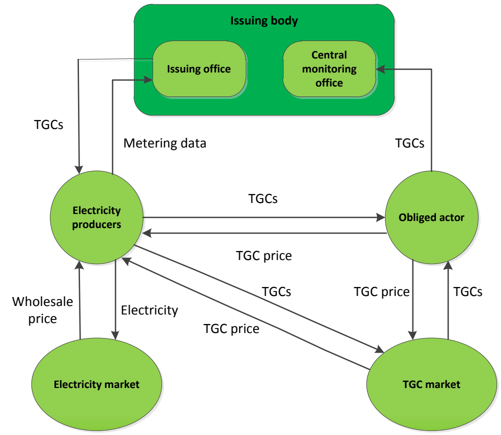

Fig. 2.9. Illustration of the TGC system (adapted from van der Linden et al. 2005)

TGC market

The system of the TGC consists of supply and demand of green certificates. Although generation of electricity from RESs are more costly than generation from conventional sources but on the energy (electricity) market, electricity from conventional sources and electricity generated from RESs are sold under the same price, and they are not distinguishable in grid. Therefore, green certificate is suggested in order to award certificates to green suppliers for compensation of those extra costs. Green suppliers can sell those certificates on the certificate market. In other words, in this system, producers supply green electricity to the grid, and at the same time they are awarded a corresponding number of green certificates (Jansen & Skytte, 2003). Hence, electricity producers have revenue of the market price of green certificates beside the revenue of the market price of electricity. These producers could fulfill the mandated quota through three manners (Enzensberger et al., 2002). They could install own RES-E based plants. As the second way, producers can contract with green power producers to buy and sell their mandated quota. They also can obtain the required certificates on the certificate market. Producers also could sell their extra certificates on the market.

Estimation of TGC

As mentioned earlier, national government (e.g. the Dutch government) determines the amount of electricity generated from RESs. The amount of green electricity would be divided among all of the power operators including consumers, retailers, distributors/retailers, or producers. Due to the fact that producers have not the same opportunity for deployment of RES-E technologies (e.g. different wind speed in different locations), then they have different marginal production cost curves (Menanteau et al., 2003). For this reason efficient allocation of quota obligations among operators is a challenge. To overcome this barrier (inefficiency), the TGC system should be flexible as much as possible. A flexible TGC system allow producers to operate in equal production marginal cost, and this stimulates new specialized producers (investors) to enter the market (Menanteau et al., 2003).

Functioning the TGC

In a TGC system, a specific quota (q) is assigned, and it should be reached by operators (N operators) within a predetermined period of time. For understanding of this mechanism, assume there are two distributors A and B. Distributor A has poorer quality resources in compare with distributor B. Thus distributor B reaches the objective quota (q) with lower marginal production costs (MC_B curve) than distributor A (MC_A curve). The functioning of a tradable green certificate market, by two operators, is illustrated on Fig. 2.10.

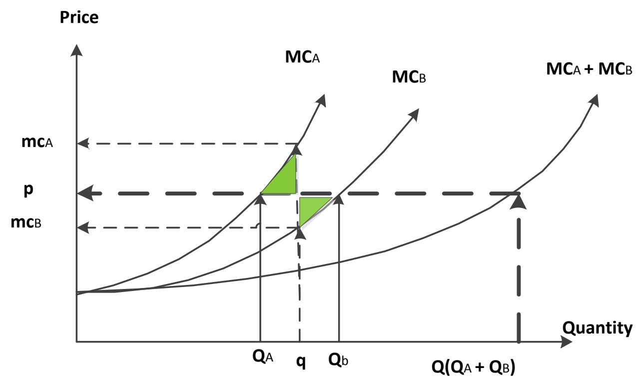

Fig. 2.10. Operation of TGC market (Adapted from Menanteau et al., 2003)

About Figure 2.10, producers are assumed to maximize profits. This happens at a level of output at which their MC = MR = P. Firms have different MC-schedules. For (the least efficient) firm A, profits are maximum at a level of production Qa which is below its RES quota q. Firm A now has two options: produce more (from Qa to q) or purchase additional TGCs without producing more. The cost of producing more is given by the area between Qa and q and below MCa. The cost of buying TGCs depends on the price of certificate, but it will be cheaper than producing. The situation for more efficient firm B is exact opposite: Qb > q where Qb is the profit-maximizing level of output for firm B. Firm B will in any case produce more RES than q, and hence firm B can sell TGCs (to firm A). The green areas indicate the "payment" which B wants to receive and the "payment" firm A can offer.

TGC – Strength and weakness points

As every support mechanism, TGC has its own strength(s) and weakness(s). Study by Gan et al. (2007) shows that this policy could encourage competition (Gan et al., 2007). As mentioned earlier, TGC creates a green certificates market. Under the certificate market, competition for certificates stimulates investment in cheaper RES-E technologies. This leads to achieve the required amount of energy from RESs theoretically at a minimum cost (Fagiani et al., 2013). However the TGC does not work for high cost RES-E technologies. This policy also requires transparency and verification systems. As the last, transaction costs associated with TGC will be high (Gan et al., 2007). (There is no doubt that costs of monitoring and operating this market will be high).

- Tendering systems

Tendering or bidding system is another quantity-based economic instrument. It calls for tenders to acquire specific amounts of capacity or generation from specified types of renewable energy sources (Haas, Resch, et al., 2011). In competitive bidding, the exact amount of electricity generated by RESs is a prior known (by the bids), and the marginal cost and the overall cost of gaining the target is not predetermined (Fig. 2.11); due to the exact shape of the cost curve is not known (Menanteau et al., 2003).

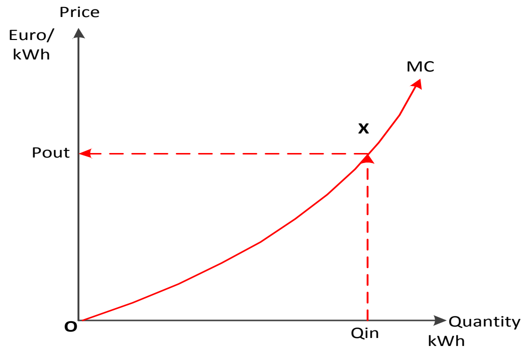

Fig. 2.11. Tendering system (Adapted from Menanteau et al. 2003)

This support scheme is implemented in the UK[25] and France[26]. In this type of support system, a competition is between bidders for contracts which will receive a guaranteed tariff for a specified period of time (Haas, Panzer, et al., 2011). This policy leads to the lowest cost option by selection of the most cost-effective offers in each bidding round (vanDijk et al., 2003). Moreover, in this support system, the level of subsidies for electricity generation from RESs is controllable (Menanteau et al., 2003). However there is the risk that the actual cost of realization of the project turns out to be higher than that predicted when drafting the bid, or that the project will not be bankable after all (deJager & Rathmann, 2008).

As Haas et al (2004) argue "there is no single, universally applicable 'best' support mechanism or policy for the bundle of different technologies known as RES. A mix of policy instruments needs to be tailored to the particular RES and the specific national situation to promote the evolution of the RES from niche to mass markets. This policy mix needs to evolve with the technology" (Haas et al., 2004).

2.2.2. Practical experiences (overview of applications)

This part deals with the practical experiences of countries in implementation of four mentioned policy instruments. Since the focus of this study is on stimulating of OWPs in the Netherlands, I am going to explore experiences in the EU countries. This is because of not only similarity of regulations (EU-based legislation system) but also similarities in culture, geography, and economic level.

2.2.2.1. Investment subsidy

Direct investment subsidy is implemented in some EU countries such as Germany, Finland, and the Netherlands. This policy is applied, but often they are limited to a small fund. Those governments have introduced this support scheme to subsidize a part of investment in promotion of electricity generation from RESs. Usually policy-makers prefer a combination of investment subsidy and Feed-in Tariff to ensure that they will achieve their targets for promotion of electricity generation from

[25] The Non-Fossil Fuel Obligation (NFFO) set up in 1991 and which concerns different renewable energy technologies (Menanteau et al., 2001).
[26] The Eole 2005 program set up in 1996 to promote wind energy (Menanteau et al., 2001).

RES-E technologies. For instance in Germany, by implementation of combination of those policies an increasing of PVs installation is occurred, but there is any acceptable witness that which instruments (direct investment subsidy/the cheap loan or FiT) had more influence to promote PV installations (Haas, Panzer, et al., 2011).

2.2.2.2. Feed-in Tariff

Feed-in Tariff (FiT) strategies are implemented in more than forty countries around the world (Cory et al., 2009). However, in some countries (e.g. Germany and Spain) the FiT is considered as the main reason for successful diffusion of renewable energy markets up to now (Cory et al., 2009).

In Denmark, this policy resulted in very successful results, because implementation of this policy (FiT) is supported by general energy policies and long-term strategies agreed by majorities in changing Parliaments. This created a stable investment climate in the 1990s, and results in installation of 3000 MW in 2003. This was two times more than expected target. Flexibility of this policy instrument is a determinant advantage. For instance, in Germany, tariffs were differentiated on technology level and also within a specific technology. Therefore, they considered location and size of the plant to determine the amount of tariff. In Spain, successful implementation of FiT depended on the stability of the renewable energy policy even under changing governments (Haas et al., 2007). But this success is demolished due to policy changing since 2012. Since 2012 the Spanish government decreased that support gradually due to huge costs associated to national energy policies (Gallego-Castillo et al., 2015). However this policy has been brought up some windfall profits for wind generators that are considered as weak point of this policy system. These three cases highlight the key role of continuity and stability of the renewable energy policy, differentiation on technology level and within a specific technology.

2.2.2.3. Tradable Green Certificates

Since this study (MSc Thesis Project) does focus on a specific RES-E technology (OWP) in the Netherlands hence the overview only concentrates on the EU member states (e.g. Belgium, Italy, Sweden, the UK). Because of those countries have similar technical and institutional environments. The obligation is placed on either supplier (producers or importers of electricity) or consumers to supply or consume a portion of their power from renewable electricity sources. In all of reviewed cases, the TGC system is more beneficial for existing technologies (e.g. biomass Combined Heat and Power (CHP) and for onshore wind power in Sweden). There is a penalty system, for compensation if obligators do not meet obligations. But in practice, if the penalty is almost in the same range of certificate prices (e.g. in case of Belgium), this does not pose a serious threat if obligators do not meet obligations.

TGCs result in windfall profits for the old existing capacity if the required capacity to meet a quota be generated by already existing capacity (Haas, Panzer, et al., 2011). This is caused by generating new electricity from renewable energy sources are socialized, and therefore end-consumers have to pay it.

2.2.2.4. Tendering systems

In 1990s some European governments set tendering system in order to promote electricity generation from RESs. In France they set the bidding system for wind energy and biomass. Danish government used this promotion system for offshore wind farms. Ireland[27] and the UK[28] set up this system too. But due to low effectiveness (low installation of new RES-E capacities) of this system, almost all of these countries decided to change the strategy. Fig. 2.12 indicates this poor effectiveness by comparison of feed-in tariff and bidding strategies for promoting wind electricity from 1990 up to 2001.

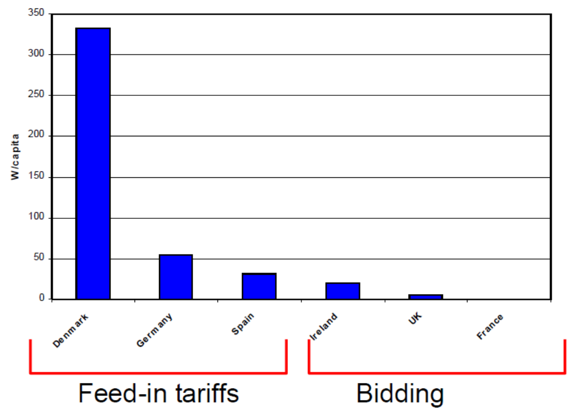

Fig. 2.12. Wind power deployment by FiT and Tendering system from 1990 up to 2001 (Haas et al. 2008)

These experiences show the FiT and the TGC are implemented more than other two policy instruments in EU. Furthermore this review implies that the FiT is a more successful policy than the TGC in EU.

2.3. Performance assessment criteria for policy instrument selection

Up to now, the large number of policy instruments have been implemented or at least proposed by different governments. These raise the question of how to choose the most appropriate instrument to increase green power generation in a specific market. To answer this question, several evaluation criteria have been proposed by different authors. However, the importance and the weight of criteria depend on the problem owner's objectives or anticipations which a specific party (problem owner/government in this case) has (Enzensberger et al., 2002). Governments seeking to improve the effectiveness and efficiency of the support schemes to realize their relevant objective as much as possible. Since problem owner in this study is the Dutch government, this study aims at exploring four discussed economic policy instruments to find out the most promised (neoclassic) economic policy (most effectiveness and efficient) in stimulating investment in offshore wind power in the Netherlands whilst not compromising the social dimension considerations.

In this study, I am going to look at those four mentioned economic policy instruments from government's perspective. As mentioned earlier, it is important for governments to assess effectiveness and efficiency of those support mechanisms. It is expected, during this study some

[27] The Irish Alternative Energy Requirement (AER)

[28] The Non-fossil fuel obligation (NFFO)

new relevant criteria be identified that have crucial role for stimulating investment in offshore wind power in the Netherlands.

2.3.1. Evaluation criteria for economic policy instruments

The majority of literature on RES-E incentives relies on exploratory analyses, wherein the study has an explorative nature that includes case studies (Trianni et al., 2013). Some use case studies (Gan et al., 2007; Del Rio et al. 2007) and others use additional qualitative evaluation techniques (Van der Linden et al. 2005; Regwitz et al. 2006; Harmelink et al., 2006). As the first step thirty articles have been reviewed.

This literature study starts by three famous articles (Menanteau et al, 2003; Haas et al., 2004; Haas et al., 2011). Combination of some key words is used to find these three desirable literatures: policy instrument, renewable energy, price-based, quantity-based, efficiency, effectiveness. Effectiveness and efficiency are used due to these two words were two key words in the main research question. In addition, since this study is conducted to find a promised and proper policy instrument, a comparison between existing policies is one of ways to find the proper one. By this presumption, a primary literature study demonstrated that support systems for promoting RES-E technologies are categorized in price-based and quantity-based therefore these two words (price-based and quantity-based) are selected. This literature study demonstrates that the degree of success of implemented policies is assessed by some criteria. Also, the study shows there are several criteria could be used to evaluate the success of support systems. Then it is decided to choose the most frequent used criteria for assessment of four selected policy instruments.

These three main articles establish the structure of this study, and lead not only to some useful articles or books, but also to find some professional and academic journals such as “Energy”, “Renewable Energy”, “Energy Policy” and “Renewable and Sustainable Energy Reviews”. These academic journals all are related to this field; policy instruments for promoting RES-E technologies. In other words, these journals are representative of this field. These literature review shows that researchers used several criteria to evaluate economic policy instruments for promotion of RES-E technologies (Table 2.2).

Table 2.2. List of criteria for the evaluation of policy instruments by thirty studies

	Criteria	Authors
1	**Efficiency**	Kuhn 1999; Enzensberger et al. 2002; Jansen et al. 2002; Finnon et al. 2003; Van dijk et al. 2003; Menanteau et al. 2003; Haas et al. 2004; Van der Linden et al. 2005; Held et al. 2006; Regwitz et al. 2006; Contaldi et al. 2007; Del Rio et al. 2007; Held et al. 2007; Gan et al. 2007; Klein et al. 2007; Haas et al. 2008; Fouquet et al. 2008; Cory et al. 2009; Burer et al. 2009; Bergek et al. 2010; Couture et al. 2010; Fischer et al. 2010; Haas et al. 2011; Haas et al 2011; Mitchell et al. 2011; Del Rio 2014;
2	**Effectiveness**	Enzensberger et al. 2002; Finnon et al. 2003; Van dijk et al. 2003; Menanteau et al. 2003; Haas et al. 2004; Van der Linden et al. 2005; Harmelink et al. 2006; Held et al. 2006; Regwitz et al. 2006; Contaldi et al. 2007; Del Rio et al. 2007; Held et al. 2007; Gan et al. 2007; De Jager 2008; Haas et al. 2008; Fouquet et al. 2008; Burer et al. 2009; Bergek et al. 2010; Couture et al. 2010; Fischer et al. 2010; Haas et al. 2011; Haas et al 2011; Mitchell et al. 2011; Del Rio 2014; Kilinc-Ata 2016;
3	**Certainty for**	Van dijk et al. 2003; Menanteau et al. 2003; Van der Linden et al. 2005; Del Rio

	investors	et al. 2007; Gan et al. 2007; Fouquet et al. 2008; Cory et al. 2009; Haas et al. 2011;
4	**Equity**	Van dijk et al. 2003; Van der Linden et al. 2005; Bergek et al. 2010; Mitchell et al. 2011; Del Rio 2014;
5	**Technical improvement**	Kuhn 1999; Menanteau et al. 2003; Bergek et al. 2010;
6	**Practicability**	Enzensberger et al. 2002; Menanteau et al. 2003; Couture et al. 2010
7	**Flexibility**	Kuhn 1999; Gan et al. 2007;
8	**System conformity**	Enzensberger et al. 2002; Mitchell et al. 2011;
9	**Cost for society**	Held et al. 2007;
10	**Contribution to job creation**	Del Rio et al. 2007;
11	**Social acceptance**	Del Rio 2014;

This literature review shows that efficiency and effectiveness are the main criteria for evaluation of policy instruments for promotion of RES-E technologies. After those two criteria, certainty for investors and equity are two most popular criteria for evaluation of both price-based and quantity-based support mechanisms. Table 2.3 lists the eleven used criteria and their frequency in those studies (Table 2.3).

Table 2.3. Used criteria and their frequency in studies on policy instruments

Criteria	Frequency	Criteria	Frequency
Effectiveness	25	Certainty for investors	8
Efficiency	26	Equity	5
Practicability	3	Technical improvement	3
Flexibility	2	Social acceptance	1
System conformity	2	Contribution to job creation	1
Cost for society	1		

In following paragraphs, the first (the most common) four criteria would be discussed. These four criteria will be selected for evaluation of those four mentioned economic policy instruments.

2.3.2. Criteria definition and operationalization

2.3.2.1. Effectiveness

By effectiveness we are going to investigate the role of one specific policy instrument in significant growth of deployment of electricity generation from renewable energy sources in relation to the additional potential (Haas, Panzer, et al., 2011).

Effectiveness is the extent to which objectives are met (Mitchell et al., 2011). In case of OWP, effectiveness of policy instruments means the actual increase in the amount of electricity generated by OWPs in total electricity supply within a specific time period. This literature study also shows that the effectiveness of support mechanisms depends on many factors (variables) that limit or block new investment in OWP and other RES-E technologies, and usually they are not easy to predict (Harmelink et al., 2006). These include (international and national) political situation, economic situation, easiness of implementation, administrative barriers, technical barriers (grid access), technological risks, energy price, environmental damages/disasters, public acceptance, and also policy uncertainty. These factors and some of their impacts are listed in Table (2.4).

Table 2.4: Variables impact the degree of effectiveness of policy instruments (Adapted from Painuly 2001)

Factor category	Factor	Impact(s)
Market-based	Lack of information (market imperfection)	It increases uncertainty
	High investment requirements	Entry barrier for entrepreneurs
	High transaction costs	Economic viability is influenced
Economic and financial	Economic crisis (unstable macro-economic stability)	It increases uncertainty
	High Up-front capital costs	It increases risks (perception)
	Lack of access to fund	It decreases investor's willingness
Institutional	Lack of political stability	It increases uncertainty
	Lack of legal framework	Investors may face market, economic, financial barriers without this
	Administrative barriers	Less willingness for investment
Technological	Immature technology	Less effectiveness
	Lack of infrastructure	No access to national grid
	Lack of needed technical facilities (e.g. due to sanctions)	It increases technical risks
Social	Lack of investors' acceptance	No investment
	Lack of social acceptance	Block implementation (deployment)
Environmental	Environmental disasters (tornado)	Low deployment

The suitability of individual institutions that develop and finance projects impacts effectiveness of given implemented policy instrument (Butler et al., 2008). It means that an economic policy instrument should create suitable condition (context) for project developers (power companies in the Netherlands), and provide financial agents which are needed for development of new OWP projects. For instance policy instrument should consider and streamline not only construction activities but also operational activities such as grid connection. Moreover, it is notable that, improvement of existing policy instruments may be more effective than a switch to a different policy instrument (deJager & Rathmann, 2008).

Furthermore, Harmelink et al. (2006) mention that there is distinction between characteristics of the instruments determining the theoretical effectiveness and characteristics determining the actual effectiveness (Harmelink et al., 2006). Whiles the theoretical effectiveness discusses "the basic elements for each instrument that have to be in place in order for the instrument to have any effect on the implementation of renewable at all", the actual effectiveness focuses on necessary conditions that streamline achievement of theoretical effectiveness (Harmelink et al., 2006).

Theoretical effectiveness depends on some factors such as sufficient compensation, enough demand for TGCs, definitive price cap (In case of tendering) etc. Thus policy-makers must consider those factors during designing and development of a support mechanism to stimulate electricity generation from RESs. And actual effectiveness is determined by some factors which form "all kinds of preconditions that have to be in place in order to be able to reach the theoretical effectiveness"

(Harmelink et al., 2006). For example, a subsidy scheme may have the right size, but if there is no adequate information campaign to announce it, no one will make use of the scheme (Harmelink et al., 2006).

For operationalization of this criterion, as the first step, we should look at the quantities installed as outcome variable of implemented policy, and the amount of power planned as target. To measure the effectiveness, the following equation would be used:

$$E_t = C_t / T_t \times 100\%$$

Equation 1

Where,

E_t : the effectiveness in year t [%]

C_t : accumulative installed new capacity in year t [MW]

T_t : Specific OWP power target for year t [MW]

Since sometimes the target is less ambitious, and it would be easier to achieved, then given no indication of the effectiveness (influence) of given policy, therefore effectiveness is regarded in a quantitative sense (vanDijk et al., 2003). For this reason, usually effectiveness refers to achievement of larger amount of capacity (target). As mentioned earlier some events (Table 2.4) impact the degree of effectiveness, some of these uncertainties (or risks) impacts only effectiveness of RES-E technologies, then it implies some support (public support or government intervention) are needed to compensate this ineffectiveness.

Of course there are some other factors (e.g. geographical conditions/location, macro-economic situation etc.) beside implemented policy scheme that determine this outcome variable. This variable is computed by dividing annual amount of electricity generated from RESs (in this case generated by OWPs), measured in megawatt-hours, by the total annual amount of electricity is planned as the target. This outcome variable is the percentage of electricity generated by RES-E technologies out of total predetermined target. In the second manner, the outcome variable is the total amount of annual electricity generated from RESs that is measured in megawatt-hours.

2.3.2.2. Efficiency

Efficiency, in general, is defined as the ratio of outcomes to inputs (Mitchell et al., 2011). For instance, referring electricity from OWP, it could be defined as the ratio of OWP targets achieved to economic resources spent (Mitchell et al., 2011). This shows that the criterion of the efficiency is interwoven with the criterion of the effectiveness. Efficiency is a measure of the amount of result (relative to a target) per € spent (vanDijk et al., 2003). In the case of promoting OWP by policy instruments, efficiency can be expressed both in terms of €/Kw (capacity) or €/kWh (production). As Menanteau et al. (2003) explain the notion of efficiency is a two-layered concept (Menanteau et al., 2003). Static efficiency, as one of those two folds, discusses about efforts to minimize overall costs in order to achieve the final predetermined objective according to cost effectiveness approach (Menanteau et al., 2003). The second fold is dynamic efficiency. Dynamic efficiency "involves producing permanent incentives to cost reductions through technical progress, so that ultimately competitively will be achieved" (Menanteau et al., 2003).

Static efficiency is more relevant to evaluate renewable technologies which are in the mature phase of the product cycle. Dynamic efficiency is the focus of policy instruments regarding renewable energy technologies which are in the early phases of product-cycle (Midttun et al., 2007). Since OWP is relatively an immature RE technology thus dynamic efficiency is more relevant to examine the efficiency of policy instruments for promotion of OWPs in the Netherlands. However in the next paragraphs these two aspects of efficiency would be discussed.

Static efficiency

By static efficiency it is aimed to demonstrate the ability of given policy instrument to achieve its predetermined targets in the least possible cost for policy-makers. But as it is mentioned earlier, static efficiency is more relevant for mature technologies, and since OWP is not a commercial mature technology, then the notion of static efficiency has no meaning for support systems for stimulating OWPs. Moreover, as Weitzman (1974) explains, one cannot say anything meaningful in terms of the static efficiency in real situation, when there is imperfect competition and transactions costs. In other words all of policies (price-driven or quantity-driven) are statically efficient when there is perfect competition and zero transactions costs.

Regarding renewable energy, static efficiency will be assayed in terms of how attune was the support level with the evolution of the technology costs. Within this method, every policy instrument level is measured with RES-E technology (OWP in this case) generation costs. According to this definition, from policy-makers' point of view, a support system is efficient while there is minimum difference between the policy costs and generation costs. By implementation of policy instruments, governments are aiming at compensate extra costs which power companies pay above electricity price, therefore a support system is efficient while it covers the minimum extra (difference) costs. In case of offshore wind parks, the generation cost is dominated by capital costs (Fig. 2.14).

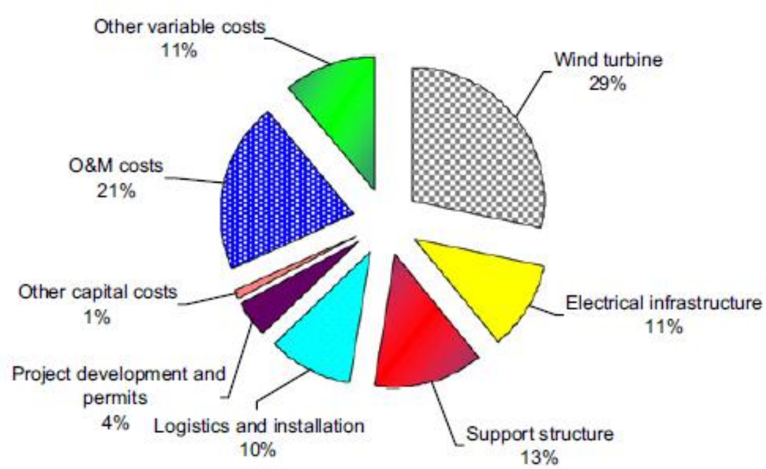

Fig. 2.14. Life-cycle cost breakdown for a typical offshore wind farm (Kaldellis & Kapsali, 2013)

For instance, if it is likely that the expected marginal cost (MC) curve by policy designers be higher than marginal cost (MC') curve in reality (Fig. 2.15). This situation would be happened because of technological progress (e.g. improvement of support systems in case of OWPs) or availability of better natural resources (e.g. steadier wind speeds) etc. Also in case of the MC shifting to the right very far, Q will increase to Q" (Fig. 2.15), and output increases strongly, then the FIT support cost per unit of output may decline. Although in this case FIT is also efficient in comparative statics terms, but it needs a huge state budget that may it is not expected by policy makers.

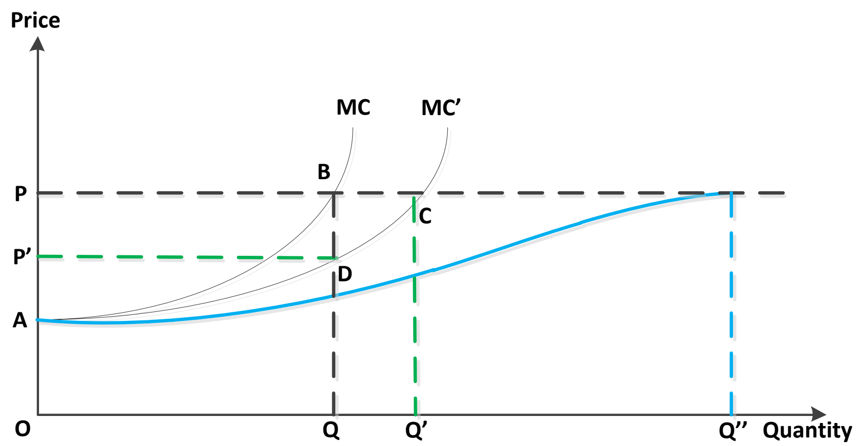

Fig. 2.15. Illustration of static efficiency: Price-driven and quantity-driven systems with lower than anticipate MC

Under price-driven systems, such as FiT, where policy-maker(s) fix a price P, and the quantity of electricity generated from RES increases from Q to Q', the cost paid by consumers is determined by OPCQ' and producer's surplus would increase by ABC (Fig. 2.15). In case of a quantity-based system, such as the TGC, predetermined quantity, Q, is reached while the price decreases to P'. In this situation the cost paid by consumers is OP'DQ, accordingly producer's surplus would be dropped to AP'D (Fig. 2.15). This demonstrates that in these circumstances the produce's surplus is higher in case of a price-based system such as the FiT. However under a quantity-driven system (e.g. TGC) support costs reduces from OPBQ to OP'DQ (Fig. 2.15). This results in higher saving for policy-makers (government) at the expense of the producer's surplus. It could be concluded that if generation costs are lower than anticipated costs by designers, quantity-based policies such as TGC not only are more efficient but also it leads to mitigate the risk of high output that leads to more burden on end-users.

In case of marginal costs higher than expected marginal costs of electricity generation from RESs (Fig. 2.16), under a quantity-driven support system, such as TGC, the targeted quantity (Q) would be generated at higher price (P') than what be expected by policy makers (P), therefore it leads to more cost for government (OP'BQ > OPCQ) and accordingly higher cost for end-users.

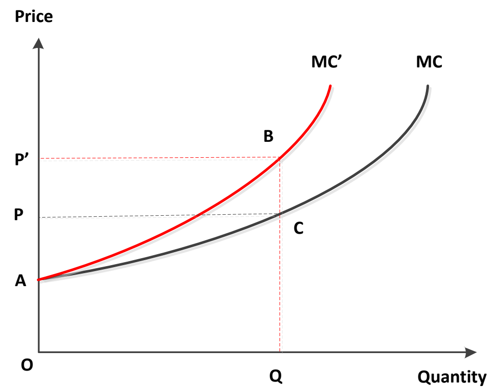

Fig. 2.16. Illustration of static efficiency: Price-driven and quantity-driven systems with higher than anticipate MC

Equally, under this situation, a price-based policy such as the FiT is more cost efficient compared to quantity-based policies such as TGC where the fixed price of the FiT (P) is imposed to set a cap for marginal costs (Fig. 2.16).

On the other side, in case of RES-E technologies with relatively flat marginal cost curve, a quantity-based policy, such as the TGC, is more efficient, due to this approach limits the risk of excessively high output and consequently in costs needed in form of subsidy. In addition, by applying a quantity-driven policy, RES-E technologies with a steep marginal cost curve likely leads to the risk of excessively high costs if predetermined targets are set too high. Hence, in this case a price-driven policy is more efficient.

As discussed during beforehand paragraphs, generation cost (MC curve) is not known in advance in real life. Therefore, by applying one economic policy instrument this likely leads to higher costs for supporters (government/consumers) or windfall profits for producers. To overcome these two challenges, policy-makers could set a penalty option during designing a TGC. This penalty provides a safety cap in order to limit the imposed costs when the cost of electricity generation from a given RES-E technology is higher than expected. In addition, under a price-driven support scheme such as FiT, in case that electricity generation costs are less than the anticipated costs, policy-makers could overcome windfall profit by designing a predetermined tariff mitigation option.

Dynamic efficiency

Dynamic efficiency would be assessed in terms of how successful was the given economic policy instrument to stimulate technological improvement and development of competition to reach cost reductions for the appointed novel technology such as RES-E technologies.

The major technological improvement regarding RES-E technologies is occurred by implementation of price-driven policies such as FiT (Finon, 2007). And accordingly this technological improvement leads to increasing of the producer's surplus (Fig. 2.14). As Finon (2007) describes, implementation of FiT results in the technological development through three different ways (Finon, 2007). As the first way, producer's surplus stimulates producers to install new capacity. Installation of new RES-E capacity accelerates technological learning[29] that results in lower marginal cost. Secondly, FiT stimulates R&D through allocation of the surplus profits between electricity producers and manufactures of RES-E technologies. As the last pathway, since FiT system has ability to adopt easier a technological diversification through stepped tariff, this system could promote both mature and immature RES-E technologies. This causes technological development of a wide range of RES-E technologies, and this technological progress consequentially leads to cost reduction of electricity generation from RESs. On the contrary, applying TGC system could not leads to promotion of technology innovation regarding all of RES-E technologies due to this system promote the most mature (the most static efficient) RES-E technologies over immature (less efficient) ones.

On the other side, implementation of quantity-based policies, such as TGC, results in cheaper RES-E technologies through acceleration of competitiveness. Under TGC system, competitiveness would be transferred from producers (usually as the main obligators) to manufacturers. Due to producers are forced to use the more efficient technologies to reduce generation cost, therefore they look for manufactures those develop and make the most efficient (innovative) RES-E technologies. Moreover, it is notable that depending on the obligator actor along the electricity supply chain, TGC could motivate the competition among other parties such as end-users.

2.3.2.3. Certainty for investors

The uncertainty is a huge barrier to investment, especially in innovative projects such as OWPs (Haas et al., 2004). Uncertainties are occasions when man (e.g. investors, consumers) is not in position to envisage the range of outcomes and accordingly all of their consequent impacts (Littler et al., 2006). Therefore, involved investigators assign only probabilities or chance of those occurrences (Littler & Melanthiou, 2006). In general, uncertainties are in terms of technologies, markets, and regulatory (Jacobsson et al., 2006).

Political uncertainty

Political certainty depends on the government commitment (in this case the Dutch government commitment) on promoting RES-Es. In addition, the number of revisions on policy instruments is another factor to determine the political risk.

Market uncertainty

Market uncertainty for investors and developers due to:

- The future payment levels are not known in advance (Couture & Gagnon, 2010).
- Difficulty regarding reliable prediction of the electricity retail prices in advance, particularly over a period of 10–20 years (Couture & Gagnon, 2010)

Those uncertain outcomes are considered as a component of risk, and the conversion (interpretation) of uncertainties into risks is a way to overcome challenges arisen by these uncertainties. Usually uncertainty and risk have been conflated, but in this sense, (unexpected occurrences) uncertainty is different from risk, risk is caused by uncertainty(ies). Risk is a

[29] "Technological learning refers to the phenomenon that the cost of a technology decreases as the cumulative installation of the technology increases" (Klassen et al., 2005).

perception by people that is often based on the assumption that involved actors (investors) have access to sufficient reliable and valid information to enable them to evaluate innovative offerings" (Littler & Melanthiou, 2006).

Since every investment contains certain risks, investors are forced to make a feasibility analysis in order to assess risks associated with investment (vanDijk et al., 2003). For investment in innovative projects/technologies (e.g. OWPs), associated risks are higher than for conventional (fossil-based) projects/technologies. Van Dijk et al (2003) mention that technological risks, market risks and political risks are three main associated risks arisen by development of innovative technologies such as OWP.

- *Technological risks* are related to uncertainties of the innovative nature of the RES-E technologies (vanDijk et al., 2003). *Technical risks* "indicate the uncertainty of investment, operating, maintenance and decommissioning costs" (Fagiani et al., 2013). In case of electricity generation from RES-E technologies such as OWP, *market risks* are related to the price and the demand for the electricity from RESs.
- *Market risks* also are accompanied by uncertainty of the fluctuation on the support (policy instrument) level.
- P*olitical risks* are accompanied by uncertainty of the continuity of policy instruments that determines financial support may or may not be available (vanDijk et al., 2003).

This implies that identification of uncertainties associated with support systems is crucial for creation of certainty needed for investment by investors. These uncertainties and risks lead to situations that investors do prefer to do not invest in this field. Therefore, policy instruments are provided to compensate those risks, and create a desirable level of security. In other words, an economic policy instrument with low risk for developers (investors) stimulates investors to invest in innovative renewable energy projects such as OWPs (delRio & Gual, 2007). This certainty allows them to convince financial agencies to loan them at lower interest rates due to the low associated risks in project. This leads to reduction of deployment cost. As a final word, well-functioning of a support system depends on a sufficient level of certainty that a support system creates for the development of renewable energy projects (VanDerLinden; et al., 2005).

- **Certainty under quantity-based policies**

Under a quota support system, such as TGCs systems, uncertainty about the current and the future price of certificates could increase the financial risks (Lesser et al., 2008). This reduces incentives of RES-E technology developers to invest in RES-E technologies. In addition, uncertainty about the wholesale electricity market price in future is another financial related risk. In addition, TGCs systems confront volume risk. Volume risk refers to situation that there is no guarantee to the RES-E generators that their output (generated power and certificates as well) will be bought (Mitchell et al., 2006). Frequent regulatory changing or policy revisions are some policy risks regarding TGCs. Changing the number of certificates or including new RES-E technologies to the renewable energy portfolio during revision phase of TGCs are considered as two of elements that lead in policy risks. This implies that although TGCs could be an efficient support system, but it does not necessarily lead to electricity generation from RESs at the lower cost due to implementation of TGC results in increasing relevant uncertainties.

- **Certainty under price-based policies**

Certainty for investors relatively is supported under price-driven policies such as Feed-in Tariff. Under FiT systems, certainty for investors is created by ensuring revenue stability to high initial capital investments (delRio & Gual, 2007). Price risks are in minimum level due to price paid does not depend on the market price (Mitchell et al., 2006). Political risks also are low. Under the FiT usually the duration of implementation of the given system is predetermined (e.g. for 10 years in the case of MEP in the Netherlands). However changing in the level of support could threaten this certainty, as observed under implementation of MEP in the Netherlands 2008 due to some unexpected problems and also lack of political commitment.

However certainty for the investors depends on the existence of an institutional commitment to development of electricity generation from RESs (delRio & Gual, 2007). Del Rio et al. (2007) describe that in the case of deployment of RES-E technologies in Spain, electricity generation from RESs has been a major policy priority since 1994 (delRio & Gual, 2007). This stability of policy caused that deployment of onshore and offshore wind parks experienced a remarkable growth by implementation of FIT in Spain for almost three decades. Wind installed capacity in 2003 was 5976 MW whiles it was only 1609 MW in 1999.

2.3.2.4. Equity

Economic policy instruments for the promotion of power generation from RESs have distributive impacts (delRio et al., 2010). The distributional impacts of those policies consist of fairness, justice and respect for the rights of indigenous people (Mitchell et al., 2011). Studies (van Dijk et al. 2003; van der Linden et al., 2005) show the importance of fair distribution of costs and benefits (associated with implementation of support schemes for promotion of RES-E technologies) over various stakeholders in a long-term success of the support systems.

The primary literature review identified the lack of social dimension in evaluation of economic policy instruments (Sovacool, 2014; Jenkins et al., 2015; Sovacool and Dowrkin 2015). Sovacool (2015) argues there is a need to move towards human-centered, social science exploration of energy systems development. Integration of social aspects does increase the reliability of energy systems (Sovacool & Dworkin, 2015). Usually energy systems are designed and developed based on economic assumptions, while the importance of other drivers of energy policy and behavior such as social equity, politics, and unforeseen technological advances is ignored (Sovacool & Dworkin, 2015). In addition, Sovacool et al., (2015) argue that the social aspects of energy systems determine "their acceptance and use, shape the risks they can present, and offer opportunities for achieving energy policy goals with existing technology" (Sovacool & Dworkin, 2015)

Among social issues (e.g. social responsibility, equity, social exclusion etc.) regarding support policy instruments for promotion renewable energy systems such as OWPs, *equity* is an important social-oriented criterion for evaluation of suggested/implemented economic policy instruments.

In this study, *effectiveness, efficiency, certainty for investors*, and *equity* are recognized and discussed as criteria for evaluation. The first three (effectiveness, efficiency, and certainty for investors) are economy-oriented criteria for evaluation of policy instruments, whilst the forth one (equity) concerns the importance of social dimension of the implementation of economic policy instruments for stimulating investment in OWPs in the Netherlands. Then equity of policy instruments would be addressed in the next section.

Equity could be evaluated either by looking at the distribution of costs and benefits of a policy instrument or by evaluating the extent to which a policy facilitates the participation of a wide range of different actors (Mitchell et al., 2011). With respect to equal distribution of costs and benefits, if a policy instrument leads to promotion of OWPs effectively and efficiently but it imposes costs on only some actors or communities, that support scheme exceeded (does not consider) equity. A policy instrument also could exceed equity whenever it causes that some companies (while own novel but expensive RES-E technologies) could not apply for grants.

2.4. Addressing equity in policy instruments

Equity is a multiple dimension issue. Pascual et al. (2014) suggest four dimensions of equity; procedure, distribution, recognition, and context (Pascula et al., 2014). At the same time, *energy justice* is suggested to address some justice principles regarding policies for promoting the development of electricity generation from renewable energy sources (RESs) (Jenkins et al., 2016). Jenkins et al. (2016) describe that energy justice includes three tenets; distributional justice, recognition justice, and procedural justice (Jenkins et al., 2016). *Procedural* dimension discusses "the degree of involvement and inclusiveness in rulemaking and decisions around land management or conservation programs" (Pascula et al., 2014). *Distributive* equity brings up the distribution of costs, benefits, burdens, and rights derived from programs or actions (in this case derived from implementation of policy instruments). *Recognition* dimension is about "the respect for knowledge systems, values, social norms, and the rights of all stakeholders in the design and implementation of conservation programs" (Pascula et al., 2014). And as the last dimension, *context* points out the surrounding social condition that influence the actor's ability to achieve recognition, participate in decision making, and lobby for fair distribution. To narrow down, it is noteworthy to mention that equity and energy justice include three common dimensions. Table 2.5 lists the evaluative and normative contributions of three dimensions those are common between equity and energy justice.

Table 2.5. The evaluative and normative contributions of energy justice (Jenkins et al., 2016)

Dimensions	Evaluative	Normative
Distributional	Where are the instances of injustice?	How should we solve them?
Recognition	Who is ignored but also, who has an interest at stake	How should we recognize?
Procedural	Is there fair process?	Which new processes? And which existing processes are fair?

In this research, for evaluating distributional justice issue at the current economic policy instruments, *evaluative* contributions of these tenets of justice is applied, and the *normative* one would be discussed at designing framework in Chapter 4 in order to recommend how distributional justice should be approached in future policy instruments. Among these three common dimensions, this study focuses on subject of distributive dimension to discuss directly the distribution of ills for electricity consumers. Distributive justice is selected because this study is an evaluative study to select one policy by assessment of outcomes resulted from implementation of some policies. In other words this study is going to discuss and evaluate issues regarding outcomes of policies and do not assess issues regarding the process of policy-making.

2.4.1. Distributive justice

Under distributive (energy) justice, researchers want to investigate location(s) of injustice associated with developing of (renewable) energy systems. Distributive (energy) justice discusses issues regarding not only the siting of energy systems but also about access to energy services (in this case, OWPs). A sense of distributive justice regarding energy systems would be enforced through two efforts; distribution of ills for electricity consumers or other involved actors, and redistribution of associate benefits. In the following paragraphs, distributive energy justice regarding those four appointed economic policy instruments for promoting the deployment of OWPs in the Netherlands would be discussed. It is notable to mention that, as van Dijk et al. (2003) mention, distributive justice (equity in general) aspects of support mechanisms are not inherent to the support schemes itself, but depend very much on its design (vanDijk et al., 2003). Policy-makers can design support systems to steer on the distribution of ills and benefits over different involved actors. In following paragraphs equity issue in four recognized policy instruments would be discussed.

- **Investment subsidy and distributive justice**

Under *investment subsidy* scheme, the costs of the support system cannot be allocated directly to market players, therefore funds must be assigned from government budgets (Socialized by tax) or by addition to electricity bills in the form of a special levy (vanDijk et al., 2003). By imposition of constant amount of levy, different households have different ability to bear that amount of levy. In other words this imposes unequal costs on households. In case of payment by tax[30], taxpayers, who finally have to pay the required expenditures of OWPs, are not necessarily people who consume electricity from OWPs. But from distributive justice point of view this is fair, and people pay taxes in order to fund societally important issues including OWP projects.

- **Feed-in tariff and distributive justice**

The associated costs and benefits of *Feed-in Tariff* is a crucial issue, and it depends on the design of the policy (Mitchell et al. 2011, van Dijk et al., 2003). Mitchell et al. (2011) explain while Feed-in Tariff leads to increase renewable energy capacity, even expensive technologies (e.g. PV and OWP), but this capacity boosting results in rising total electricity costs that causes increasing in the total cost of the promotion policy (FiT) (Mitchell et al., 2011). As the total cost of the policy grows, the distribution of these costs becomes a remarkable issue. The FiT is designed to subsidize producers of green electricity in order to compensate extra costs invested for generation of green electricity.

[30] By tax, we mean all types of taxes (e.g. income tax, property tax) which are collected by government to fund various public expenditures.

The cost of subsidizing producers of RES-E (through FiT) could be covered either through cross-subsidies among all electricity consumers or simply by those customers of the utility obliged to buy green electricity, or by the taxpayer, or a combination of both systems (Menanteau et al., 2003). However calling simply on customers of local companies to finance green power generation is considered unfair (Menanteau et al., 2003). This kind of cost distribution[31] brings up issues such as unequally and inequity. Unequal distribution of costs refers to imposition of costs on only some people (customer of obliged companies) but others benefit from electricity generation from RESs. Inequity refers to disproportionate distribution of associated costs within local customers, and disproportionate distribution of ills between local customers and other who benefit from electricity generation from RESs. In addition, in the case of implementation of FiT in Germany (1990), operators in areas with high power generation from RESs are obliged to buy renewable energy at premium price[32] (vanDijk et al., 2003). Those operators must tolerate more costs (more pay for obligations) compared to operators in areas with low power generation from renewable sources. Furthermore generators from cheap RES-E technologies earn more than other producers, and in some cases this leads to excess profits that it is another unfair distribution linked to FiT. Excess profits could be minimized by well-designed FiT when every RES-E technology gets the adapted remuneration (Verbruggen et al., 2012).

- **Tradable Green Certificates and distributive justice**

Literature study shows that overcompensation (windfall profits) to some electricity producers is a main concern regarding *Tradable Green Certificates* (TGCs). Overcompensation (windfall) is earned by technologies which does not determine the price of certificates (Agnolucci, 2007a). This include incumbent generators, also by cheaper technologies and even for the same technology, for example, wind at coastal and inland sites (Agnolucci, 2007a). This implies that TGCs create competition for those technologies that receive less reward. And there is not a competition between all of technologies fairly.

Overcompensation does lead to abnormal profits that electricity utilities benefit at the expense of consumers (Bergek et al., 2010). Moreover, there is another equity-related concern related to participation in the case of *TGCs*; since the transaction and administration costs of a TGC is relatively high, then it creates barriers for participation of small-scale new coming companies (Mitchell et al., 2011). It could leads to unequal distribution of benefits for some large-scale involved actors those could pay the relatively high costs for transaction and administration of a TGC.

- **Tendering system and distributive justice**

As mentioned earlier, in case of *tendering system*, there is the risk that the actual cost of realization of the project turns out to be higher than that predicted when drafting the bid. This leads to extra costs. The extra cost is either added to electricity bills in the form of a special levy, or the cost is covered through cross-subsidization among all electricity consumers (Menanteau et al., 2003). In both cases (a special levy or cross-subsidization) it leads to extra expenditures (costs). As discussed

[31] A constant annual or monthly levy on the electricity connections of every local household

[32] The *premium price is* a constant premium or bonus over and above the average retail price

earlier, extra costs have disproportionate distribution of burden on some group of consumers, especially on low-income households, who pay for a special levy added to electricity bills.

2.4.2. Measuring distributive energy justice

As the first step to measure the distributive justice regarding four recognized policy instruments, some relevant indicators would be identified for quantification of this criterion. Indicators would be useful to quantify and analyze performance of a policy, and they lead to improvement of communication. These indicators are not merely data, but they provide a deeper understanding of distributive energy justice, as main issue in this discussion (Nussbaumer et al., 2012). For measurement, the choice of indicator(s) depends on the exact political requirements (Speck, 1999). For instance, for measurement of unequal distribution of ills on consumers caused by policy instruments, the costs imposed on (paid by) consumers (households) would be a proper indicator. This payment would be assessed in term of absolute amount of money paid by people or in term of percentage (proportion) of income.

As discussed earlier, unequal and inequitable distribution of ills and benefits (associated with implementation of policy instruments) have potential impacts on minimum three involved actors along electricity supply chain; consumers, operators (obliged to buy renewable energy at premium price), and power companies (generators). Moreover, implementation of policy instruments and consequently deployment of OWPs imposes unequal costs on some other actors or communities such as fisheries and oil and gas industries. Measurement of this unequal distribution of costs and benefits would be discussed in the next paragraphs.

Since those unequal distributed ills and benefits are derived from either implementation of policy instruments (e.g. cost of policies) or from development of offshore wind projects (e.g. costs for some industries such as fishery, noise, transport and pollution for local people in the nearest harbor), then it is notable to elucidate that in this study, the focus is on unequal distribution of costs and benefits regarding design and implementation of policy instruments for stimulating investment in OWP projects in the Netherlands. For this reason, from the above mentioned associated ills and benefits, only measurement of unequal distribution of ills and benefits which imposed on power producers and power consumers would be discussed in this section.

Measurement of unequal distribution of costs

Costs regarding implementation of policy instruments usually are paid by two main manners; either reimbursement is done through state budget or by imposition of costs on electricity bills. In country such as the Netherlands, in every two cases, households should pay that imposed money either by tax (indirectly) or by electricity bill (indirectly). Therefore, in both cases distribution of costs on households should be measured.

- Negative impacts on households' budget

Implementation of those four discussed energy policy instruments leads to some costs. These costs lead to increasing of electricity price that affects households' budget. However if implementation of policy instruments results in increasing of electricity price, this will affects low-income household more than high-income households, because low-income households have to spend a larger fraction of their budget on electricity. Therefore, this (fraction of their budget) is an indicator to measure distribution of costs on households in the Netherlands.

- Excess profits

The occurrence and appropriation of extra profits is another theme regarding equity in policy support to promote RES-E technologies. As Verbruggen and Lauber (2012) argue when profits earned by RES-E investors are excessive, a significant of grant (Subsidy/support money) is deviated from its predetermined aim to enrich RES-E developers, while electricity end-users and taxpayers are unduly burdened (Verbruggen & Lauber, 2012). To find out if excess profit is obtained by RES-E developers or not, actual expenditures (including a normal[33] return on invested capital) must be subtracted from revenues of power generated by the given RES-E technology sold or substituted (Verbruggen & Lauber, 2012).

Briefly, justice principles regarding policy instruments for promoting the development of OWPs is recognized as a main social dimension to evaluate those policy instruments. Among three tenets of justice principles, distributive justice is discussed in this chapter. Distributive justice considers that design and implementation of policy instruments result in shifting economic wealth from some groups in society (e.g. taxpayers, households) to others (RE-E developers). This means a more wide range of relevant and involved actors are considered and also their interests and values will be respected. This will lead to more public acceptance of implementation of given policy instrument (Wüstenhagen et al., 2007). This implies it is very important to apply proper approach and framework for design and implementation of selected policy instrument.

2.5. Reflection

This chapter reflects the main points which are grasped during the literature study. This literature review is aimed to get an insight into evaluation of four already implemented economic policy instruments for stimulating of investment in development of offshore wind parks.

First, offshore wind park, as a socio-technical system, is investigated wherein several *actors* with their own values, interests and resources observe relevant *rules and regulation* to develop an offshore wind farm by applying available *technologies and materials*. Although at first sight it may seem that policy-makers could stimulate investors by only designing and implementation of some policy instruments. But in reality, a complex interaction between those three mentioned dimension (involved actors, institutions and regulations, and relevant technology) leads to design and implementation of a policy instrument in a very dynamic environment. Technology progress has a crucial role to propel policy-makers and investors to think about diffusion of a novel RES-E technology. In one side, technology progress implies that a given technology is enough mature to compete with existed alternatives, hence policy-makers consider that technology as feasible alternative and start to design policy to support its diffusion. On the other side, a mature technology has less associated risks, therefore investors would be motivated to invest in that technology. In case of OWP in the Netherlands, from policy-makers' perspective, OWP is considered as a relatively mature technology that could be an alternative for electricity generation. But from investors' point

[33] It is interpreted as a fair and safe compensation for investors to address climate change (Verbruggen & Lauber, 2012).

of view, this technology is not enough economic to invest in it. Therefore, policy-makers must use their resources (regulations and laws) to stimulate investors. This environment is very dynamic, and a given support policy necessarily is not proper for a long time and for any RES-E technology.

Price-based approaches (e.g. Feed-in Tariff, and Investment subsidies) and quantity-based approaches (e.g. Tradable Green Certificate, and Tendering System) are two fundamental types of economic policy instruments. Price-based policies increase certainty for investors to deploy RES-E technologies, such as OWPs, for electricity generation while quantity-based policies lead to development of more efficient RES-E technologies.

Among price-based support mechanisms, investment subsidy is studied in this literature review. Although the investment subsidy does increase certainty for investors to invest in this industry/market by reducing both technical risks and market risk, but in a liberalized market such as electricity market in the Netherlands it is a direct government intervention in the market. Feed-in Tariff is another price-driven policy instrument that decreases relevant risks for investors compared to other policy instruments. In addition, the FiT is a dynamic incentive that increases the total rent paid to investors in long-term by providing stimulant for investors to improve technology and consequently to decrease the long-term marginal cost. Nonetheless there is no guarantee for achieving those long-term objectives. FiT leads to some problem regarding budgeting. Sometimes FiT costs more than expected, and it also brings up unequal distribution of costs (tax-payers or consumers) and benefits (RES-E developers).

Tendering system and Tradable Green Certificates (TGCs) are two quantity based promotion strategies that are discussed in this literature review. By tendering system, policy makers aim to grant the lowest cost option by selection of the most cost-effective offers in each bidding round. But as every tendering system, there is the risk that the actual cost of realization of the project turns out to be higher than that predicted when drafting the bid. Tradable Green Certificate is a support system that relies on market mechanism for resource utilization, and technology choice. TGCs lead to promotion of more economic RES-E technologies therefore this policy instrument does not promote high cost RES-E technologies. Implementation of the TGCs results in competition between RES-E technologies, but this policy does not lead to technology improvement.

In real world, FiT and TGCs are implemented more than the other policy instruments. However there are three main issues regarding efficient functioning of these support schemes. The first notable point refers to understand that there is no single best policy instrument that works well universally to promote all of RES-E technologies. In addition, a mixed and tailored support mechanism works better to promote a particular RES-E technology. As the last, these policies would be more efficient when they set in a harmonized regulatory system while the other policies do not neutralized these policy instruments. The last issue implies that it is time to shifting economic paradigm from neoclassical economic to institutional economics.

During this literature review, thirty scientific articles are studied to identify criteria for evaluation of these four mentioned economic policy instruments. Eleven common criteria are identified. Among them the four most frequent criteria are recognized to discuss in this study; effectiveness, efficiency, certainty for investor, and equity. These four criteria not only have more frequency in these thirty studies but also those studies are conducted recently. Equity is discussed in term of distributive (energy) justice.

Albeit at the first sight, it seems these criteria are four separate criteria, but in reality these factors are interwoven and support each other. Certainty for investors does increase investment in construction of new capacity of OWPs that consequently leads to more effectiveness. More efficient policy instrument results in promotion of development of new capacity of OWPs (effectiveness). And policy instruments that consider equity lead to more acceptance by public. This higher acceptance stimulates development of new OWPs by reduction of potential public resistance.

Also, this literature study reflects that difficulty of selecting the proper support systems comes back to involved actors' perspectives. Those involved actors are different and sometimes conflictive interests and expectations regarding to designing and implementation of a given support systems. For instance, government prefers to implement the most efficient policy instrument in order to spends minimum budget for it and also observes liberal market principles (minimum governmental intervention into market). This (less intervention) is a value for the Dutch government. While making profit is one of main values for investors, and they expect that government supports these risky projects financially. And also equity and distributive justice are values for consumers. In other words consideration of public values (e.g. profit making, less governmental intervention, distributive justice) guarantees successful implementation of a policy instrument. This implies that public values must be considered during the design and implementation of a selected policy instrument. Therefore, it is crucial to apply an approach which considers public values.

As the last point, this literature study reflects that the degrees of success of implementation of the given policy instrument depends on stability of political environment. Stable political environment results in more certainty for investors which is desirable for investors to enter and invest in new OWP projects.

CHAPTER 3
Case study - Support Policy Instruments for OWPs in the Netherlands

Chapter 3 includes an extensive insight into the deployment of large-scale offshore wind power systems in the Netherlands, and the role of implemented economic policy instruments in this deployment. The chapter does begin with a description of offshore wind power deployment in the Netherlands. After that the role of support policy instruments in stimulating investment would be discussed. In addition, the role of equity in the Dutch support policy instruments regarding OWP development would be addressed. The reflecting on lesson(s) learned would be the third part of this chapter.

3.1. OWP in the Netherlands – Case description

The European Commission is looking at offshore wind energy technology as an alternative for moving to a competitive low carbon economy. They argue that in Europe is a large amount of potential. They expected 5800 GW is the technical potential of OWP in Europe, that 150 GW of OWP capacity could be realized up to 2030 (Wieczorek et al., 2013).

The Netherlands, as an EU member state, decided to follow European energy policy. According to expectations by the European Wind Energy Association (EWEA), it is anticipated that around 6000 MW of offshore wind capacity to be realized by 2030 in the Netherlands (EWEA, 2011). To achieve this objective, in 1995 they set a target of 1500 MW offshore wind capacity in 2010 up from 228 MW back then (CBS, 2008). Up to 2014, from 1500 MW planned electricity generation from offshore wind parks, only 357 MW is implemented and supplied to grid. It is 0.70% of total electricity generation in the Netherlands (CBS, 2015b). This shows a slow penetration of OWP in the Netherlands. A list of current installed and also under construction of offshore wind parks in the Netherlands is listed in the Table 3.1. In addition, Table 3.2 listed the social-environmental benefits of these six commissioned OWPs in the Netherlands.

Table 3.1. List of installed and under construction OWPs in the Netherlands

Wind park	Capacity	Turbines	Expected life	Km to shore	Depth (m)
Lely (1994)	2 MW	4 (Nedwind 500kW/41)	-	0	3-4
Irene Vorrink (1996)	17 MW	28 (Nordtank NTK600/43)	-	1	2-3
Egmond aan Zee (OWEZ) (2008)	108 MW	36 (Vestas V90-3MW)	20 years	13	15-18
Princess Amalia (2008)	120 MW	60 (Vestas V80-2MW)	-	26	19-24
Eneco Luchterduinen (2015)	129 MW	43 (Vestas V112/3000)	25 years	24	18-24
Gemini (Expected 2017)	600 MW	150 (Siemens SWT-4.0-130)	20 years	55	28-36

Table 3.2. Social-environmental benefits of OWPs in the Netherlands

Wind park	Homes powered annually	CO2 reduced per year	SO2 reduced per year
Lely	1417	2863 tones	67 tones
Irene Vorrink	11899	24047 tones	559 tones

Egmond aan Zee (OWEZ)	76492	154589 tones	3595 tones
Princess Amalia	84991	171766 tones	3995 tones
Eneco Luchterduinen	91365	184649 tones	4294 tones
Gemini	424953	858830 tones	19973 tones

The Dutch government also provides the roadmap[34] towards 4500 MW offshore wind power in 2013 for development and diffusion of OWPs in the Netherlands. Under this roadmap, they determine three wind farm zones in the North sea, Borssele (22.2 km from coast), South Holland coast (23 km from coast), and North Holland coast (24.8 km from coast), wherein those 4500 MW OWP are only allowed to be developed between 2015 and 2020.

Below, deployment of large-scale offshore wind power systems would be discussed. After that, a general explanation of the main technological characteristics of offshore wind parks that distinguish it from the other RES-E technologies is given.

3.1.1. Deployment of OWP in the Netherlands

A large-scale offshore wind power plant is not an isolated physical asset, but it is a socio-technological system (STS) wherein several actors by their own knowledge and resources are involved to develop a technological artifact (OWP) within relevant institutions. The socio-technical systems (STSs) are conceptualized as constellations of aligned elements, such as technical artifacts, knowledge, markets, regulation, policies, cultural meaning, rules (Markusson et al., 2012). In case of an offshore wind power system, a number of offshore wind turbines are installed, as technical artifacts, based on the current available knowledge to realize some socio-economic targets which are substantiated by some regulation such as EU Directive (e.g. RE Directive 2009/28/EC) and/or national rules (e.g. the Dutch Offshore Wind Energy Law). This subsection provides insights into the deployment of OWP in the Netherlands as a socio-technical system.

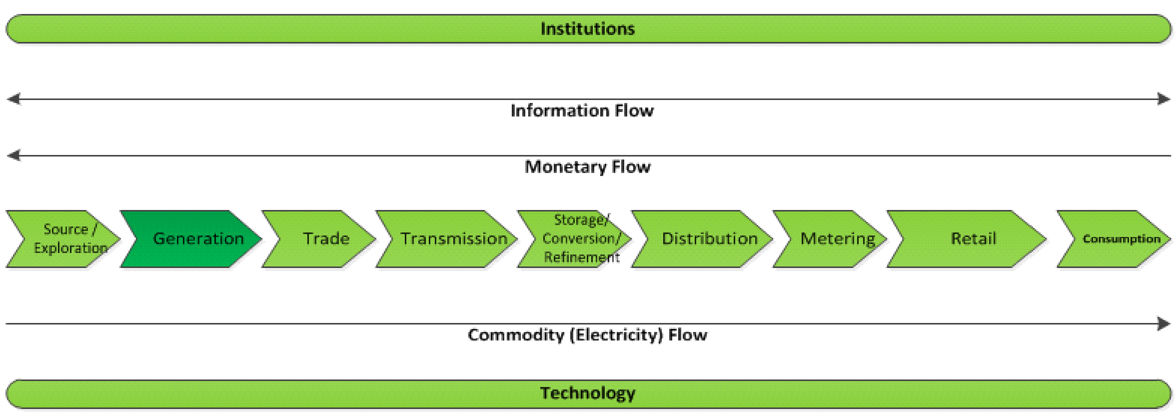

Fig. 3.1. Electricity infrastructures as complex adaptive socio-technical systems (Adapted from Scholten et al., 2016)

34 A roadmap for moving to a competitive low carbon economy in 2050 - http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52011DC0112

From an engineering point of view, an offshore wind power plant relates to the assets (generation plant and cables for connection) that generate electricity in the supply chain of energy system (Fig. 3.1). An offshore wind energy system consists of the meteorological, the support system foundation (Number 1, Fig. 3.2), the wind turbine (Numbers 2&3, Fig. 3.2), the electricity collection and transmission (Numbers 4&5, Fig. 3.2), the offshore substation (Number 6, Fig. 3.2), and commissioning as the phase between installation phase and commercial operation phase (M.J. Kaiser et al., 2012). Following paragraphs illustrate these components in regard to deployment of OWPs in the Netherlands.

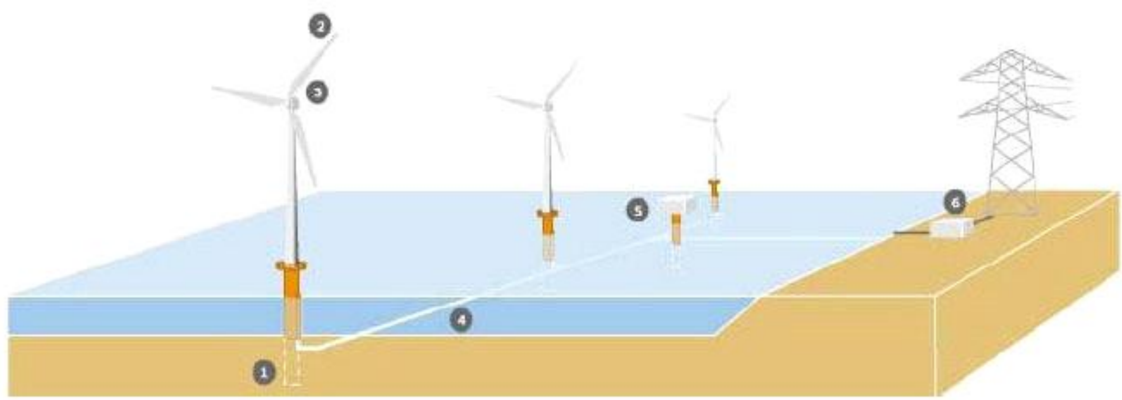

Fig. 3.2. Schematic of offshore wind park facilities (adapted from (OCS Renewable Energy EIS, 2006))

The electricity supply chain is composed by several actors such as energy utilities, Transmission System Operator (TSO), financial agency, the ministries. These involved actors contributing to deployment of OWP directly (e.g. power companies), or indirectly such as regulators or financer (Wieczorek et al., 2013). These actors have own interests and resources to pursue their own relevant objectives lonely or through cooperation with other involved actors. Table 3.3 provides an overview of involved actors and their own interests, resources and objectives regarding development of offshore wind energy in the Netherlands.

Table 3.3. Involved actors to develop OWPs in the Netherlands ant their own interest(s), resource(s), and objective(s)

Actor	Role(s)	Interest(s)	Resource(s)	Objective
European Commission	Regulatory	Sustainable development	Policy making (e.g. Directive 2009/28/EC)	Moving toward a low carbon economy
The Dutch Parliament	Provision regulation regarding subsidies,	Sustainable development	Policy making (SDE+)	Create large scale offshore wind farms in the next decades (4450 MW electricity from OWPs)
Ministry of Economic Affairs	Regulatory, support OWP projects	Clean, reliable energy (sustainable economic growth)	Energy policy making (e.g. wind farm site decisions; “kavelbesluiten”) Allocate budget	
Ministry of Finance	Monitoring	Responsible and effective spending of government	Implementation of fiscal instruments Perform a control	

		resources	function in the green certificates system	
Ministry of Infrastructure and the Environment	Support development of OWP projects (Handles permits, advisory role)	Increase green energy for improving sustainable environment	Energy policy making (e.g. wind farm site decisions; “kavelbesluiten”) Commissioned to perform EIA	
Regional governments (e.g. Nord Holland Provinces)	Regulatory	Increase the usage of renewable energy with what the area has to offer	Excellent base for assembly, transportation and construction of windmills	
Dienst Noordzee	Supportive and investigative role	Safety for shipping and living sea	Handle permits	Safety and environmental concerns in the North Sea
Energy sector	Multi-functional	Reputation (green image) and long-term profits through investment in RE-E	Energy facilities, access to relevant actors and infrastructures	Increase his market share, and long-term profits
Wind turbine manufacturers (e.g. Lagerwey Wind, Vestas)	Manufacturing	Long-term profits	Knowledge, technology and skills	Sell more wind turbines
Project developers/Investors (e.g. NUON, Eneco)	Investment, deployment and generation	Reaching at least a minimum market volume Market profit	Technology, knowledge and skills Provide equity for new OWP projects (financial resources)	Have a more share in deployment of OWPs Reputation (green image)
Financial agents (e.g. Typhoon)	Provision financial resources	Planning security Reputation	Providing project finance bank loans for OWP projects	Providing more loan for deployment of OWPs with minimum risks
Environmental NGOs (e.g. Waddenvereniging)	Regulatory (Indirectly)	Environmental issues	Lobby, campaign and media	Realization OWP projects in sustainable way
TSO (TenneT)	Transmission and monitor the balance between the demand for and provision of power	Expend grid connection	Infrastructure (grid), investment	High degree of grid reliability
Consumers	Consumption	Low energy price	Media and voting	Paying less for energy

Construction of an offshore wind park does need the physical space which other users, such as industries (e.g. fishing, oil and gas etc.) and military organizations have competing claims on it (Künneke et al., 2015). Especially this is considerable in the Dutch North Sea Coast wherein already is full of the busy shipping routes, and outflow of fresh fluvial water into the sea (Healey, 2004).

This implies that some regulations, as rules of the game, are needed to streamline those activities. For instance there are several national regulations regarding environmental protection, military exercises, deployment of offshore wind farms, etc. These all regulations form the legal and regulatory frameworks for the activities in the Dutch North Sea Coast. This regulatory framework shapes institutional context which includes not only the rules of game but also determines relevant responsibilities and leads to interaction and interrelation between involved actors. Following paragraphs include socio-economic and institutional aspects regarding development of OWPs in the Netherlands.

Next paragraphs provide an extensive description about involved actors, their activities, and utilized assets for development of OWP in the Netherlands. In addition, finance affairs and regulatory issues would be discussed at the end. This discussion lists actors per step in the electricity infrastructure supply chain. Since offshore wind energy source, as the first ring in the chain, is free and there are almost no involved actors and utilized assets, therefore this step is not included in this discussion.

3.1.1.1 Technological aspects

Development and generation

In the Netherlands, energy (electricity) companies invest, build, own and operate OWP projects (Negro et al., 2012). Nuon, Eneco, and Van Oord are three of main energy companies that own OWPs in the Netherlands. Generation of electricity from OWPs is realized through three phases; development, construction, and Operations and Maintenance (O&M) (Wieczorek et al., 2013). Several Dutch companies (actors) are involved in the Netherlands and foreign countries in these three phases (Fig. 3.3). Ballast Nedam, Van Oord, and Mamomoet are three of the most famous Dutch companies that are specialize in offshore wind parks construction (Fig. 3.3).

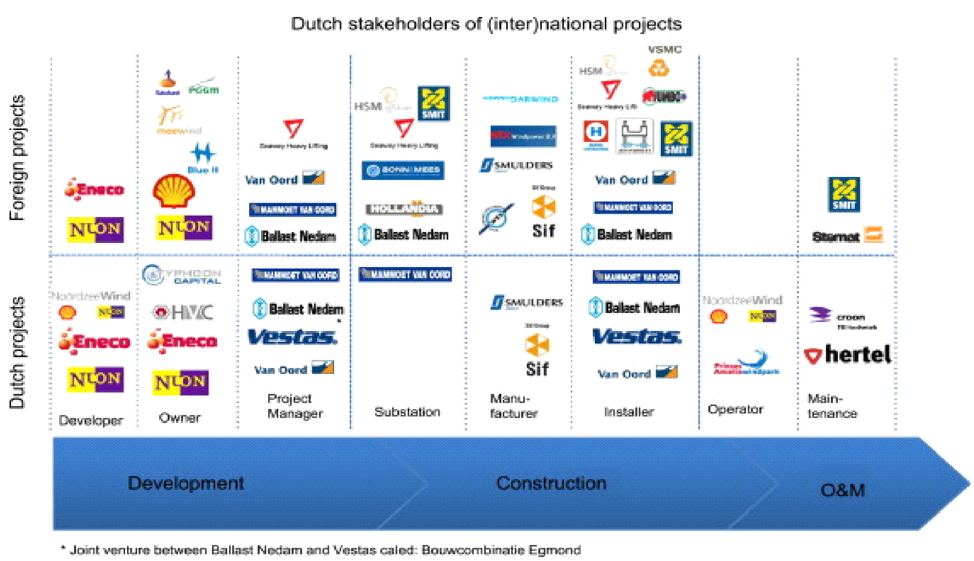

Fig. 3.3. Dutch stakeholders of (inter)national OWP projects (Wieczorek et al., 2013).

Electricity generation by offshore wind park is realized by utilization of some technological assets which would be discussed in the next paragraphs.

Support system foundation

The support foundation includes the foundation, transition piece, and scour protection. The foundation is aimed at support the turbine (Number 1, Fig. 3.2). The site condition, size and weight of turbine determine the type and design of foundation technology. The site condition is a function of maximum wind speed, water depth, wave heights currents, and surf properties. Therefore, each foundation within a wind park is customized to its particular location and the water depth. Monopiles, jackets, tripods, gravity, and floating foundation are the five basic types of foundation. Fig. 3.4 illustrates the level of technology maturity of these different support foundations and their (planed) suitable location.

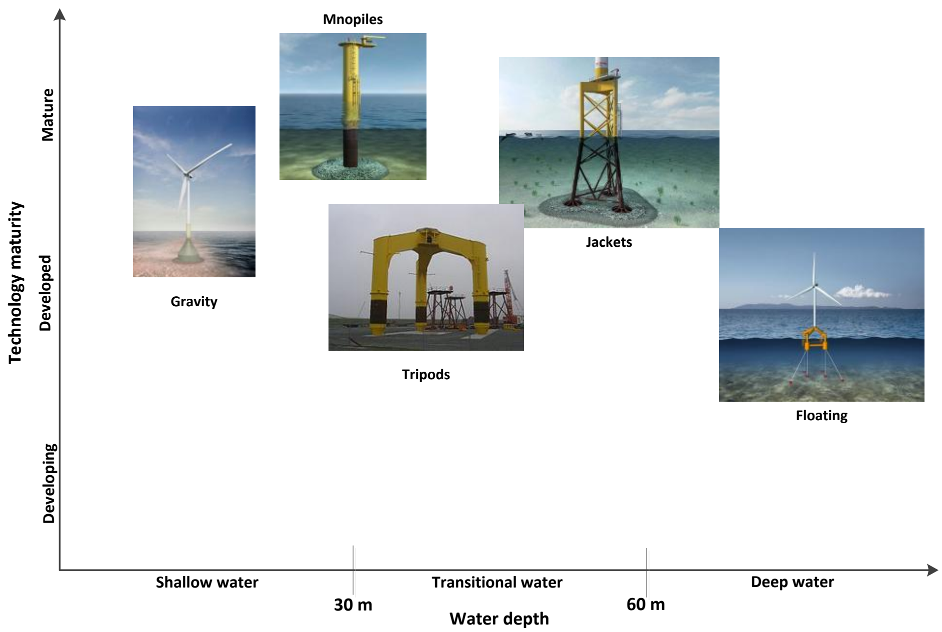

Fig. 3.4. Support system foundations regarding water depth (Adapted from (Kaldellis & Kapsali, 2013))

Transition piece is installed on top of the foundation and it forms a base upon which the wind turbine stands. And source protection is created to protect support system against the removal of sediment from the area around the base of support structure (M.J. Kaiser & Snyder, 2012).

In the Netherlands, the type of foundations is monopole in all of six commissioned OWPs, but with different sizes (Table 3.4).

Table 3.4. Foundations of OWPs in the Netherlands

OWP	Grounded	Diameter (meter)	Length (meter)	Weigh (ton)
Lely (1994)	Monopile	-	-	-
Irene Vorrink (1996)	Monopile	-	-	-
Princess Amalia (2008)	Monopile	-	-	-
OWEZ (2008)	Monopile	4.6	-	-
Eneco Luchterduinen (2015)	Monopile	5	70	525
Gemini	Monopile	7m at base, 5.5m at top	59-73	670-916

The power output from offshore wind turbines is higher in deep water and as mentioned in introduction, it increases with distance from the coast. Because the power output is theoretically a function of the cube of the wind speed, and the wind speed is higher and steadier wind speeds in the open sea (Kaldellis & Kapsali, 2013). Hence, it is important which support system foundation is used by the Dutch developers. Up to now, in the Netherlands, they apply monopile support foundations which are enough mature technically but it could not be installed in deep water where greater resource potential is existed. While installation of advanced support foundations (e.g. floating) could lead to more efficiency for one offshore wind park, but these technologies are relatively commercial immature then brings up risks that threaten OWPs' investors to apply these risky and expensive technologies. To overcome these barrier some support mechanisms is needed to stimulate investors to use these innovative technologies in development of OWPs in the Netherlands.

Wind turbine

Wind turbine is the electricity generating component of an onshore/offshore wind power plant that converts kinetic energy from the wind into electrical power. The wind turbine consists of a tower, nacelle, hub, and blades (Number 2 and 3, Fig. 3.2). The tower is installed on the transition piece of support system, and nacelle is placed on the tower. The hub and blade form the rotor which is attached to the nacelle.

Fixed-speed wind turbines and variable-speed wind turbines are two main available designs of wind turbine technologies in the market. Variable-speed technology enables wind turbines operate in variable wind speed and capture optimize energy from the wind (Carrasco et al., 2006). Although it needs more complex control system, but it causes 5% more energy capturing compared to energy capturing in case of the fixed-speed wind turbines. By this technology, the grid voltage would be controlled in more comfortable way due to variability of the reactive-power generation (Carrasco et al., 2006). Furthermore there are no flicker problems with variable-speed turbines. The generated energy is rectified to "dc" connecting cable, and then it is converted to suitable "ac" electricity for the network.

At offshore sites, the size of wind turbines, in terms of height and rotor diameter, is not restricted what is observed in case of onshore sites due to negative visual impacts. This causes wind turbine capacity has been increasing steadily (Kaldellis & Kapsali, 2013). Offshore wind turbines range from 2 to 5 MW (M.J. Kaiser & Snyder, 2012). This growth of wind turbine capacity leads to increasing of offshore wind parks' total capacity, as it is observed in the Netherlands. Some information about installed turbines in OWPs in the Netherlands are listed in Table 3.5. As Table 3.5 shows, capacity of recently developed OWPs' is increased by applying huge wind turbines.

Table 3.5. Turbine model installed in OWPs in the Netherlands

OWP	Capacity (MW)	Turbine Name	Rated power	Turbine type
Lely (1994)	2	NedWind 40/500	0.5 MW	-
Irene Vorrink (1996)	17	NTK 600/43	0.6 MW	-

Princess Amalia (2008)	120	V80-2.0 MW	2 MW	Variable speed
OWEZ (2008)	108	V90-3.0 MW Offshore	3 MW	Variable speed
Luchterduinen (2015)	129	V112-3.0 MW Offshore	3 MW	Variable speed
Gemini	600	SWT-4.0-130	4 MW	Variable speed

In the Netherlands, installed wind turbines usually are manufactured by Danish companies such as Nordtank or Vestas, and in the last case, Gemini, turbines are manufactured by Siemens. Turbines range from 2 to 4 MW (Table 3.5).

In addition, realization of stronger offshore wind turbines results in greater productivity that could compensate higher installation and operation costs (Esteban et al., 2011). This not only enforces policy-makers to think seriously about offshore wind as proper option but also this stimulates investors to come and invest in new capacity of OWPs.

Transmission

Transmission Operator System is a key player in the electricity supply chain (Fig. 3.1). TenneT (The Dutch TSO) does own high-voltage grid (220 and 380 kV) that transforms high-voltage electricity from generation to regional and local distribution grids or directly to large industrial consumers (Fig. 3.5). Moreover, TenneT is responsible for maintaining the interconnectors, and balancing supply and demand on the high voltage Network in the Netherlands. By developing large-scale OWPs that generate intermittent power, electricity generated by OWPs is not fully predictable. For this reason system operators lose some unpredicted extra electricity or they must export it to abroad. In addition, Wind park units have to pay a balancing cost if there is less wind than predicted. Hence, the cross border interconnection and balancing supply and demand would be more required in case of development of large-scale OWPs. Therefore, TenneT has a crucial role while OWPs will be developed in the Netherlands.

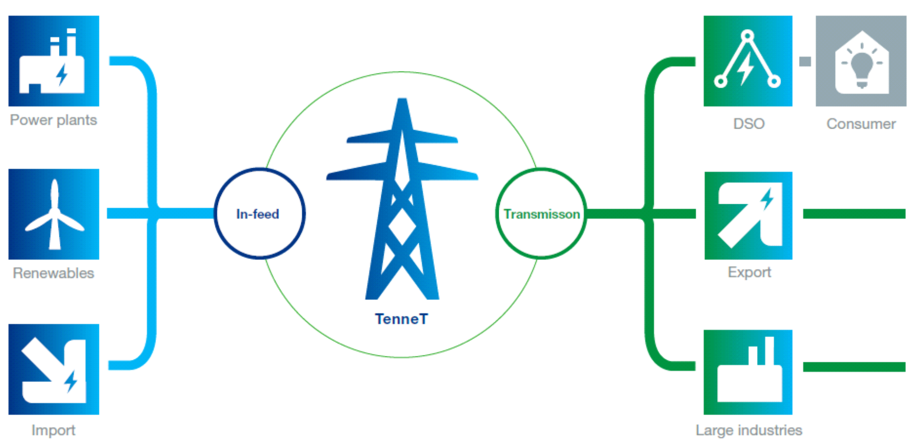

Fig. 3.5. TenneT in the electricity supply chain (TenneT Annual report 2015)

In The Netherlands, TenneT continually invests in grid connections for offshore wind farms. In 2015, TenneT invested €1.46 billion in grid connections for offshore wind farms. This investment by TenneT provides excellent connection between OWPs and the national grid. An excellent connection is very crucial for investors to decide on investment in new capacity of OWPs. It ensures that their generated electricity would be supplied through already prepared grid connection. Investment on grid connection by TenneT implies that OWPs' investors do not need to invest in connection.

Electricity infrastructure

Electricity collection and transmission, substation, and grid connection are three main elements compose electricity infrastructure regarding offshore wind farms.

Electricity collection and transmission

The electricity collection and transmission is composed of cables which connect the offshore turbines and the offshore wind park to the electrical grid (Number 4 and 5, Fig. 3.2). These cables are combined at a common collection point or substation for transmission the output of turbines to coast. There are two kinds of cables; the inner-array cables, and export cables. The wind turbines within the array would be connected to each other by the inner-array cables, in addition, the inner-array cables connect the wind turbines in the offshore wind farm to an offshore substation (M. J. Kaiser et al., 2010). And the wind park would be connected to the onshore transmission system by the export cables. Typically this is installed in one continuous operation (M.J. Kaiser & Snyder, 2012). Electricity collection and transmission facilities in six already developed OWPs, in the Netherlands, are listed in the Table 3.6.

Table 3.6. Connection facilities in 6 OWPs in the Netherlands

OWP	Array cable length	Transmission type	Nominal voltage
Lely (1994)	0.6 km	-	-
Irene Vorrink (1996)	-	-	-
Princess Amalia (2008)	45 km	MVAC	24 kV
OWEZ (2008)	20.4 km	MVAC	34kV
Luchterduinen (2015)	32 km	MVAC	33 kV
Gemini	105 km	MVAC	33kV

Offshore substation

The offshore substation is installed in order to increase the voltage of the electricity generated at the offshore wind turbine to minimize the transmission losses (M.J. Kaiser & Snyder, 2012). Offshore substation is necessary for all of OWPs, and could be installed on water or on Land (Number 6, Fig. 3.2). The size of substation depends on power rating for the project capacity.

Table 3.7. OWPs' substations in the Netherlands

OWP	Transformer ratio	Transformer power	Topside dimension (LxWxH)	Switchgear
Lely (1994)	-	-	-	-

Irene Vorrink (1996)		-	-	-	-
Princess Amalia (2008)		-	-	-	-
OWEZ (2008)		34/150 kV	-	-	-
Luchterduinen (2015)		33/150 kV	80 MVA	24x23x16 m	155 kV and 33 kV GIS
Gemini	**Buitengaats**	33/220 kV	170 MVA	26.4x31.65x23.8 m	22 MV GIS Nxplus bays and 4 HV GIS 8DN9 bays
	ZeeEnergie	33/220 kV	170 MVA	26.4x31.65x23.8 m	22 MV GIS Nxplus bays and 4 HV GIS 8DN9 bays

Grid connection

Albeit wind turbines generate intermittent power, wind parks should be stable like conventional power plants, and also turbines should be connected and contribute to the network continuously. They must supply active and reactive powers for frequency and voltage recovery (Carrasco et al., 2006). Therefore, wind farm developers do apply several special gird-connection codes to cover reactive-power controlling and to respond frequently. In the Netherlands, Transmission System Operator (TenneT) is responsible to connect offshore wind turbines directly to the national grid by construction of platforms. Directly connection implies that investors (developers) do not need to invest for grid connection when they want to invest in OWP projects. This leads to capital cost reduction for OWP construction.

The other components (trade, distribution etc.) in the supply chain of electricity infrastructure are common in the Netherlands. Power generated by offshore wind farms has to be sold into the electricity market like any other power generated by other generating units. Electricity generated by OWPs, the same as power generated from other resources, is distributed through distribution power grid (110 and 150 kV)) owned by some companies such as Stedin and Liander, as the distribution system operators (DSOs), in the Netherlands.

3.1.1.3. Financial resources

Financial resources are necessary for all activities in above mentioned phases (development, construction and O&M) during development of OWPs. In the Netherlands, Typhoon Capital is one of important incumbent to realize offshore wind projects in the North Sea by acquiring permitted North Sea offshore wind projects and to arrange the contracting, structuring and financing.

3.1.1.4. Institutional aspects

Construction of an offshore wind park does need the physical space which other users, such as industries (e.g. fishing, oil and gas etc.) and military organizations have competing claims on it (Künneke et al., 2015). Especially this is considerable in the Dutch North Sea Coast wherein already is full of the busy shipping routes, and outflow of fresh fluvial water into the sea (Healey, 2004).

This implies that some regulations, as rules of the game, are needed to streamline those activities. For instance there are several national regulations regarding environmental protection, military exercises, deployment of offshore wind farms, etc. These all regulations form the legal and regulatory frameworks for the activities in the Dutch North Sea Coast. This regulatory framework shapes institutional context which includes not only the rules of the game but also determines relevant responsibilities and leads to interaction and interrelation between involved actors. Following paragraphs include socio-economic and institutional aspects regarding development of OWPs in the Netherlands.

European Commission started moving toward a low carbon economy by establishment of Renewable Energy Directive 2009/28/EC. This Directive aims to promote power generation from renewable sources in the European Union. It requires the EU member states to fulfill at least 20% of their total energy needs from renewable resources by 2020 (EU 2016). Member states have to achieve this objective through the attainment of individual national targets. Therefore, in the Netherlands *the Dutch government* provided the Offshore Wind Energy Law (Wet Windenergie op Zee), in order to realize objectives set by the RE Directive 2009/28/EC. The Dutch Parliament (Tweede Kamer) initiates it by performing the cost and benefit analysis regarding development of OWP and determining the budget is needed for subsidy. Among these actors *the Ministry of Economic Affairs* plays the predominant role in shaping all renewable energy policies such as wind farm site decisions (kavelbesluiten) (Gan et al., 2007). In addition, the ministry of Infrastructure and the Environment cooperates to plan some relevant regulations such as wind farm site decisions (kavelbesluiten), or has developed a proposal for revision of the shipping lanes of the Dutch coast to ensure the safety for shipping around OWPs in the North Sea. The ministry of I&E also advises for bundling of infrastructure for wind parks (Mast, 2009). The Service in North Sea (Dienst Noordzee) is another stakeholder that has high impact in process of development of OWPs in the Dutch part of the North Sea. This governmental organization is a part of Rijkswaterstaat (an organization under the Ministry of I&E) and handles permits to guard living sea and safety for shipping in the Dutch part of the North Sea. Therefore, this organization has role to determine the location of OWPs in the North Sea.

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 provides an overall policy for the generation and promotion of energy generated from renewable energy sources in the EU[35]. Under this directive, the EU wants to fulfill 20% of its total energy needs must be produced from RESs. This objective will be gained through the attainment of individual national targets. The Directive also specifies national RE targets for each member state, by consideration of their starting points and overall potential for energy from RESs. The Netherlands must fulfill 14% of its total energy needs from renewable resources in 2020.

Within this Directive, the Netherlands, as an EU member state, must draw up a national energy action plan in order to describe how they intend to reach the RE Directive targets in the Netherlands. The Dutch government believes, at the first step, they must provide a stable investment climate with long-term prospect for market players in order to achieve sufficient energy from RESs[36]. Therefore, they started to provide support schemes to promote the use of electricity generated from RESs.

[35] EUR- Les - http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32009L0028

[36] National renewable energy action plan

Those regulations (e.g. Renewable Energy Directive 2009/28/EC, the Offshore Wind Energy Law) frame the conditions and rules are needed to promote OWP in the Netherlands. In addition, the National Water Plan (developed by the Dutch government), as a complementary rule, determines wind farm zones. The construction of offshore wind park would be allowed only in sites within those determined zones. Finally the Dutch government grants funds such as the Stimulation of Sustainable Energy Production (SED+) to compensates producers for this unprofitable component for a fixed number of years, depending on the technology used (Netherlands Enterprise Agency, 2016).

Those relevant rules and standards often are influenced by the development of offshore wind parks mutually. For instance the type of substructures determines the distance from the seacoast. The monopole, gravity-based, and floating foundations are three types of substructures for offshore wind turbines. While the monopole, and gravity-based are utilized in shallow waters, the floating one is developed for deeper and further from the land (Leung et al., 2012). After developing of the floating substructures, the Dutch policy-makers determined three wind farm zones in the deeper water and further from the land in the North Sea.

Rules enable and constraint actors in the market. Renewable Energy Directive 2009/28/EC requires EU member states to create the attractive environment for relevant actors (investors). Therefore, the Dutch government provided SDE+ to stimulate investors to enter and invest in developing of renewable energy technologies such as large-scale offshore wind parks in the Netherlands. On the other side, national and international economic and political situation has role in rule definition by involved actors. For instance some (conservative) policy-makers after financial crisis (2008) favor realizing emissions targets in the cheapest possible way (Verhees et al., 2015), then they prefer to socialize those costs as much as possible.

3.1.1.5 Integration of aspects

The last three paragraphs imply that there is an interrelationship between those three dimensions (technical, actors/socio-economic and institutional) of a large-scale OWP system, as a socio-technological system (Fig.3.6).

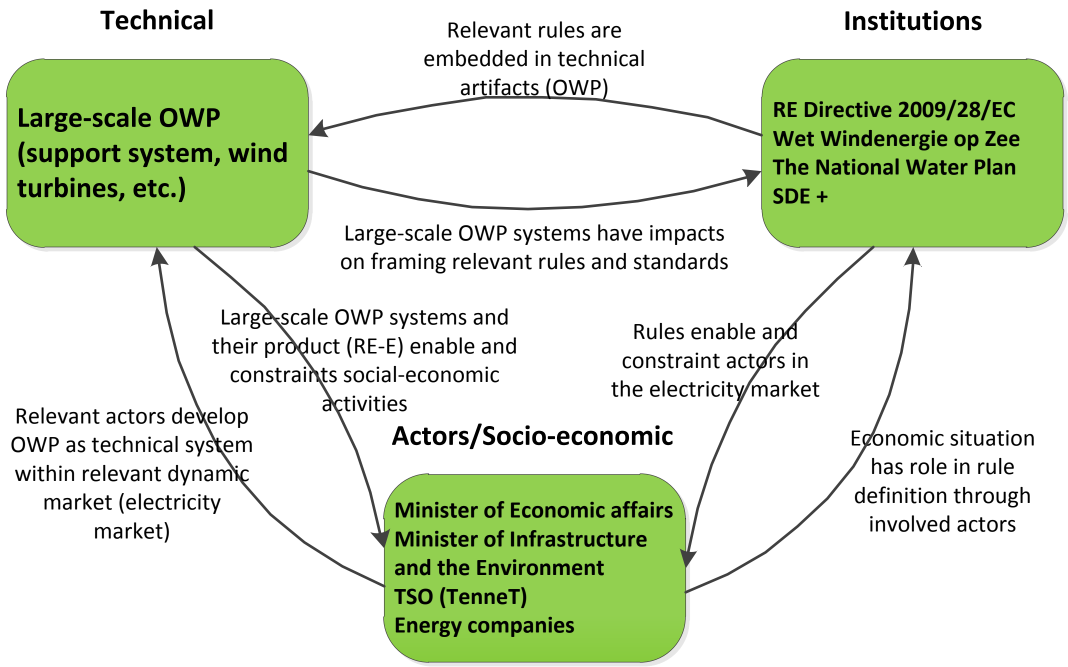

Fig. 3.6 Three interrelated analytic dimensions regarding OWP in the Netherlands

In general, deployment of an offshore wind park depends on the current state of offshore wind energy technology development (the level of commercial maturity of technology). The current state enables and constraints social-economic activities. In this case, development of OWPs in the Netherlands, for instance the size and power of vertical axis wind turbine get much bigger compared to horizontal axis technology, and thereby produce electricity at lower cost. Hence, it is economic that investors want to apply vertical axis wind turbine and accordingly these results in higher efficiency (Wind power, 2016[37]). On the other side, energy companies prefer to invest and develop OWPs to generate green electricity in order to make a good reputation for being sustainable in electricity sector.

Institutional and technological aspects also interrelate with each other in developing process of OWP projects. Development of OWPs in the Netherlands is considered as an option to realize objectives planed by RE Directive 2009/28/EC. Therefore, the Dutch policy-makers provide relevant regulations, such as the National Water Plan or SDE, to promote the development of OWPs. Reciprocally large-scale OWPs have impacts on framing some rules and standards (e.g. kavelbesluiten).

In addition, interaction between policy-makers and developers or investors could lead to discuss about recent progress in the sector (relevant technologies), and recent relevant regulation. According to the National Energy Agreement, the Dutch government is responsible for some primary tasks (e.g. consents, electrical infrastructure etc.), and OWP developers (energy companies) must to do Front End Engineering Design (FEED) studies before they register for one of

[37] http://www.windpowerengineering.com/featured/business-news-projects/is-the-vertical-axis-turbine-key-to-offshore-success/

selected sites for OWP construction. If those developers have a good interaction with policy-makers (the Dutch government) they could base their FEED studies on those primary works in an efficient way to save time and money.

Moreover, national and international economic situation has role to determine the support policy regarding OWP development in the Netherlands. In economic crisis, policy makers prefer to apply more efficient policies such as TGCs that focus to promote most efficient (mature) RES-E technologies. Reciprocally, by implementation of market-oriented policy instruments, such as SDE+, the RES-E's developers have not enough stimulation to develop OWPs as one commercial immature RES-E technology.

It is remarkable to mention that those relevant institutions coordinate all of those activities needed during construction, operation and maintenance of an offshore wind park. This coordination leads to avoid confusion between institutions and relevant organizations and actors (Geels, 2004).

3.1.2. Important OWP technical features for investment

Some technological features of offshore wind parks distinguish this RES-E technology from other RES-E technologies. These distinctive technological features would be discussed in following paragraphs. Insight into technological aspects of offshore wind power system would elucidate the (level of) commercial maturity of the OWP technology. The level of commercial maturity of a technology determines whether given technology could compete with existing technologies or not (Menanteau et al., 2003). If one RES-E technology has an adequate level of economic performance, then there are enough reasons that policy-makers consider it as an option for electricity generation from RESs and add it in the list of RES-E technologies for supporting. Furthermore the level of commercial maturity of one RES-E technology has crucial role in choosing and designing economic policy instrument. For instance some policies are designed to support more mature technologies while some others are designed to support all of RES-E technologies that have an adequate level of economic performance. Therefore, in this part, the technical aspects of OWP in the Netherlands would be discussed in order to give an insight into the level of commercial maturity of this RES-E technology.

The main features of wind energy (onshore and offshore as well) in comparison with other types of RES-E technologies could be described due to the combination of two factors: the availability of resources and the commercial maturity of the technology (Esteban et al., 2011). Regarding the availability of resources, it is clear the huge availability of wind energy in the Netherlands. The Netherlands has almost 2700 TW unrestricted technical potential for offshore wind energy in 2030 (EEA Technical report - 2009). As the second factor, the commercial maturity of offshore wind energy is relatively low (Fig. 3.7). The commercial maturity of onshore wind energy is relatively higher than offshore wind technology (Fig. 3.7). This implies that onshore and offshore wind parks are different in many characteristics such as commercial maturity.

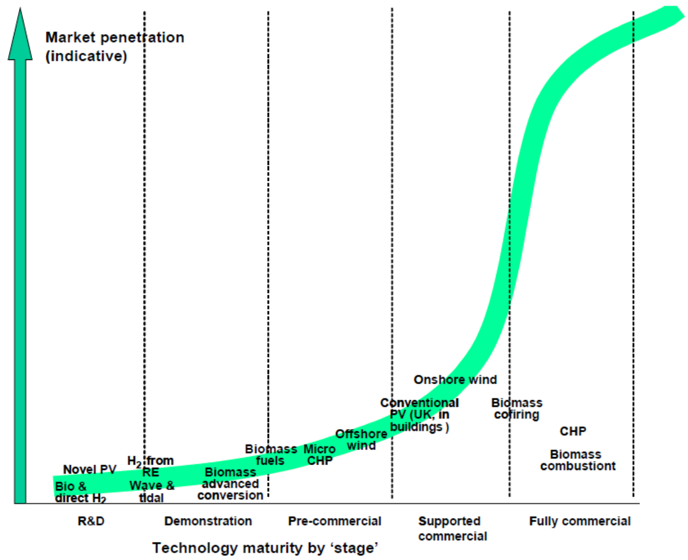

Fig. 3.7. The commercial maturity of RE-E technologies relative to market penetration (Adopted from Foxon et al., 2005)

In fact offshore wind power, as a whole RES-E technology, is immature but some of its components that are common with onshore wind technology are enough commercial mature (Table 3.8).

Table 3.8. Commercial maturity level of offshore wind farms' components and their regarding costs

Component	Commercial maturity level	Cost (% of total)
Support structure	Depends on technology	23
Wind turbine	High	43
Electricity infrastructure (e.g. collection and transmission, substation)	Low	22
Others (e.g. design, permits, etc.)	High	12

High capital cost, long lead time, extensiveness of scale, relatively less availability, and the volatility of electricity price, are recognized as the main distinguished technical characteristics of offshore wind technology that have determinant role in designing and choosing of economic policy instrument to stimulate investment in developing of OWPs in the Netherlands.

Capital cost

Development of offshore wind farms leads to relatively high costs, mainly because of commercial immaturity of construction and installation techniques (Esteban et al., 2011). Capital costs of deployment of offshore wind farm projects can be categorized into: cost of wind turbines, cost of electrical infrastructure, cost of support structure, cost of logistics and installation, deployment and engineering costs (Kaldellis & Kapsali, 2013). In addition, the costs regarding the deployment of offshore wind farms are much more diverse than those of most other RES-E technologies. As Kaldellis and Kapsali (2013) describe those costs depend on a variety of factors such as distance from the shore, water depth, foundation technology employed (Kaldellis & Kapsali, 2013). As offshore wind farms are located in long distance from shore and in deep water, installation and connection (e.g. larger cabling system, offshore substation) costs would be high. These cause a high capital cost for development of OWPs (Table 3.9).

Table 3.9. Estimated capital costs ($/kW) regarding deployment of OWP (Adapted from Gernaat et al., 2014)

Sea depth	Distance to shore		
	Near (23 km)	Intermediate (65 km)	Far (140 km)
Shallow (15 m)	1760	2090	2480
Transitional (45 m)	2330	2660	3050
Deep (80 m)	3000	3330	3720

For comparison between offshore and other alternatives, the average capital cost per kW of offshore wind in shallow sea depth is $1760, it is $1500/kW for onshore wind farms, and around $1400/kW for conventional coal power stations, and $800/kW for conventional natural gas power stations (Gernaat et al., 2014).

Variable costs

Variable costs are not as well-known as capital costs, and they depends on countries, regions and sites (Blanco, 2009). Fuel costs, Operation and Maintenance (O&M) costs, insurance and tax, and management and administration costs (e.g. management activities, forecasting services etc.) are the most important of variable costs regarding offshore wind parks. Offshore wind farms fuel cost is zero, whilst in a natural gas power plant almost 74% of variable costs is related to fuel cost (Greenblatt et al., 2007). This is the substantial difference between power generation by offshore wind technology and other conventional electricity generation alternatives. However this feature results in the predictable generation cost of electricity in case of the wind measurements have been calculated correctly. This leads to overall risk reduction of a company's or country's power portfolio (Blanco, 2009).

The operation and maintenance (O&M) costs are the main variable costs regarding offshore wind technology. The O&M costs would be increased with increasing distance to shore and sea depth, however these costs are around 21% of total life-cycle costs of a typical offshore wind park (Fig. 2.14).

The overall variable costs over operational life of 25 years are estimated by 32% of total life-cycle costs of a typical offshore wind park (Fig. 3.8). However variable costs of offshore wind technology are determined by a quite high degree of uncertainty, mainly due to different policy measures and support mechanisms adopted in several countries (Kaldellis & Kapsali, 2013).

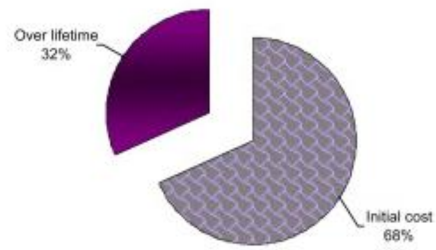

Fig. 3.8. Life-cycle cost breakdown for a typical offshore wind farm (Adapted from Kaldellis and kapsali, 2013)

Long lead-time

Long lead-time is the third feature that distinguishes offshore wind technology from the other RES-E alternatives. Harsher wind and wave conditions while moving deeper in the sea results in a possible time-delay of the installation. This time-delay may leads to around 20-30% additional time for installation. It is clear that the time-delay affects significantly installation costs (Kaldellis & Kapsali, 2013).

Extensiveness of scale

Integration of large-scale offshore wind power into the grid creates potential technical challenges. Due to the intermittent nature of wind power technology, it affects power quality of the system including: voltage fluctuation due to variations of wind speed, long transmission lines, synchronization of grid frequency, voltage and phase to control power quality, low power factor, storage system to ensure the reliability of electricity delivery, load management, and forecasting and scheduling (Shafiullah et al., 2013). Therefore, reduction of these potential technical challenges is needed for successful integration of large-scale offshore wind energy into the network. Overcoming these challenges clearly leads to more expensive integration into the power grid, and in some cases there is a necessary to increase the capacity of weak coastal network. However this feature of OWPs (Extensiveness of scale) increases the cost of OWPs' development that has influences on investors' perception about investment in new capacities of OWPs.

Relatively less availability

Restricted technical availability is another distinct feature of offshore wind technology in comparison with other types of RES-E technologies. For example, land-based wind technology reaches availability level of 98% or even more, whilst the average availability of offshore wind parks in UK is around 80% (Kaldellis & Kapsali, 2013). This limited availability is due to restricted accessibility of offshore wind turbines. The accessibility to offshore wind parks depends on parameters such as the distance from the shore, local climate conditions and the type and availability of the maintenance strategy adopted. The restricted availability of OWPs lead to a low level of energy and economic performance that increase risk associated with the development of OWPs.

Volatility of electricity price

Offshore wind technology is an intermittent power generation technology that follows mandatory sales approach, therefore this leads to large supply fluctuations. In case of a market-based mechanism, like the electricity market in the Netherlands, this results in lower electricity prices or price volatility. Price volatility (low electricity price) causes a considerable revenue risk when this causes that output is sold at a lower price than the reference value (Gatzert et al., 2016). Revenue risk could be mitigated by support policies, such as guaranteed Feed-in Tariff for a period of 20 years that we see is implemented in Germany in order to ensure investors their revenue is guaranteed by that policy instrument in case of low electricity price (Gatzert & Kosub, 2016).

As wrap up, it should be mentioned although offshore wind technology leads to achieve objectives regarding mitigation consumption of conventional fossil fuels, but its distinct technical features such as current commercial immaturity, and its intrinsic characteristics (e.g. low availability, intermittency, long lead time, extensiveness of scale, etc.) result in increasing of a quite high degree of uncertainties and consequently technical uncertainties (risks) that brings up some market risks. Therefore, investors have no enough motivation to invest in this field. In fact deployment of offshore wind power is not an economically feasible option yet. Then, it still requires support (the technical and financial support) by governments.

3.2. The role of support policy instruments in stimulating investment

3.2.1. Implemented support systems in the Netherlands

Earlier discussion implies that under current (normal) market condition electricity generation from renewable energy sources, such as offshore wind, creates more uncertainties and costs than power generation from fossil energy resources under current (normal) market condition. Therefore, policy instruments (e.g. subsidies, tax rebate) are designed to support electricity generation from renewable energy sources in order to compensate those extra costs or (market) barriers (failures).

In the Netherlands, promoting the green power policy is launched by the Dutch government directly after the first oil crisis in 1973. They started to promote research and development (R&D) in the 1970's, and providing subsidies during the 1980's (vanRooijen et al., 2006). This long-standing experience brought limited share of RESs, only 0.9% electricity consumption was generated by RES-Es in 1990 (vanRooijen & vanWees, 2006).

After that experience, the main effort by the Dutch government started by designing support policies in the early 1990's (vanRooijen & vanWees, 2006).These economic policies has been characterized by three main phases (Fig. 3.9).

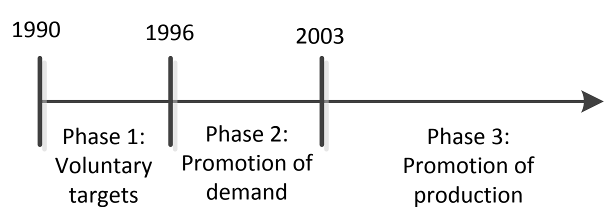

Fig. 3.9. Three phases of renewable energy policies in the Netherlands (adapted from N.M. van Rooijen et al., 2006)

In these three phases, the Dutch government decided to focus on one actor (e.g. the energy distribution companies (EDCs) in the first phase) by applying one or some policy instruments. Table 3.10 includes all of those three phases, their main features, and main policy instrument(s).

Table 3.10. Phases in the Dutch green electricity policy; key characteristics and instruments

Policy Phase	Period	Key characteristics	Policy instrument(s)
1st phase: Voluntary targets	**1990 - 1995**	Voluntary agreement with power distribution sector (EDCs). Financing investment in RES-E.	A general environmental **levy.**
2nd phase: Promotion of demand	**1996 – 2002** (ecotax) tax exemption for RES-E consumption	Stimulation of demand (and partly supply/production) by means of price incentives.	**Energy tax** for small- and medium-scale energy users, Voluntary **green label** system (FiT), Voluntary **Tradable Green Certificates** system
3rd phase: Promotion of production	**2003– 2008** MEP (Environmental Quality of Electricity Production)	The amount of budget varied between technologies. Reduce investment risk and to improve the cost-effectiveness of renewable electricity.	**Feed-in tariff**, combined with a partial exemption from the ecotax
	2009 – 2010 SDE (*Renewable Energy Production Incentive Scheme*)	Each technology had a separate tariff. Subsidy ceiling is determined each year.	**Feed-in Tariff,**
	2011 – ongoing SDE+	No separate subsidy budget per technology.	**Premium Feed-in Tariff**

3.2.1.1. The first Dutch policy phase (1990-1995)

In 1990, the Dutch government negotiated with the energy distribution sector about voluntary sales target. At that time, this sector includes the energy distribution companies (EDCs), such as Nuon, Essent, Eneco, and Delta. The Dutch government guaranteed to finance investment in renewable energy by a general environmental levy (Gan et al., 2007).

The target was to voluntary sale of renewable electricity amount to 3.2% of electricity sales by the 2000 (vanRooijen & vanWees, 2006). After three years, statistics demonstrated that the policy was not able to meet quantitative targets (Table 3.11).

Table 3.11. Share of green electricity consumption in the Netherlands (adapted from van Rooijen et al., 2006)

Year	% Energy consumption	% Electricity consumption
1990	0.6	0.9
1995	0.7	1.3
2000	1.2	2.5
2001	1.3	2.8

To measure effectiveness of this policy, the equation 1 is applied;
$E_t = C_t / T_t \times 100\%$

E_{2000} = (2.5 / 3.2) x 100% = 0.78 x 100% = 78%

According to this definition of effectiveness, effectiveness of this policy instrument was 78% up to 2000. In other words, this policy was not effective. Gan and colleagues (2007) argue that since the target was not compulsory and the compliance system was not enough strong, therefore the targets were never met (Gan et al., 2007). Policy uncertainty is recognized as one of main reasons for this failure. The liberalization of electricity market happened in this period, and this resulted in no realization of the targets. The liberalization of electricity market forced changes in the economic support system. Since this support system was financed through a general environmental levy and "it was feared that reallocation of tax revenues to cover the cost of green energy would disturb the market" (vanRooijen & vanWees, 2006).

This policy could be recognized as a direct subsidy investment. Although in theory investment subsidy increases certainty for industry by reducing both technical risks and market risks (vanDijk et al., 2003), but in this case it seems it did not work due to two main reasons; as the first, that subsidy was granted to distributors and not to investors/developers, and the policy uncertainty caused by liberalization of electricity market was the second reason of that failure. Policy uncertainty caused not only political risk but also market risk (by cutting subsidies) that led to uncertainty for investors at that time. This lack of certainty for investors resulted in no new investment by investors to develop new capacity of OWPs in the Netherlands. Moreover, this demonstrated that the Dutch government had not enough commitment to development of electricity generation from RESs at that time. And they preferred to liberalize the electricity market in place of development of electricity generation from RESs.

3.2.1.2. The second Dutch policy phase (1996-2002)

The second Dutch policy phase began with provision of *regulatory energy tax* (ecotax) in 1996. By this policy, policy-makers aimed at stimulating small- and medium-scale consumers to consume green electricity by exemption from the energy tax. Consumers of green electricity received six Euro Cents per kWh. In addition, the ecotax supported green electricity suppliers by paying them two Euro Cents per kWh for green electricity supplying (Gan et al., 2007).

After that, in 1998, the Dutch government introduced *voluntary green label system*. A small feed-in tariff, the green label price, and a production subsidy were three components that structured the renewable electricity price under this support system (Dinica et al., 2003). In the first two years of implementation of this policy, the largest part of the traded green labels was for electricity generation from wind energy (Fig. 3.10).

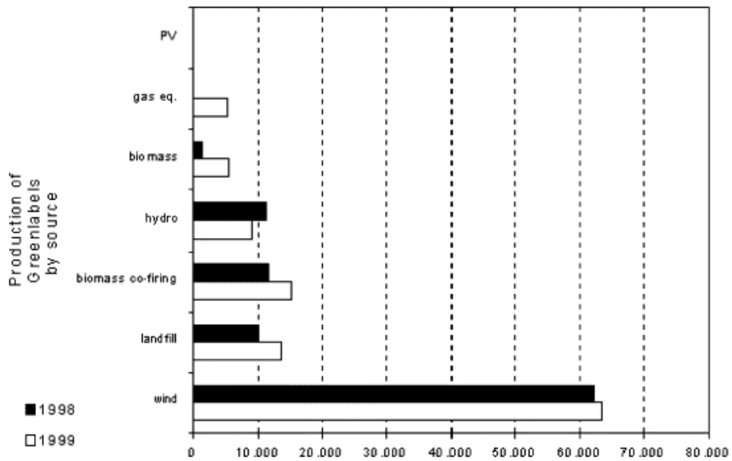

Fig. 3.10. Results of the green label system in 1998 and 1999 (Dinica & Arentsen, 2003)

Since statistics are not clear, therefore the evaluation of this policy in order to determine its role in growth of installation of new capacity (effectiveness) for electricity generation from renewable energy is very difficult (Dinica & Arentsen, 2003).

In 2001, by liberalization of electricity market in the Netherlands, the Dutch government introduced voluntary *tradable green certificate (TGC)* system. The Dutch governments aimed to stimulate the domestic production of renewable electricity (Gan et al., 2007). Inasmuch as this policy instrument was voluntary and did not entail obligation on supply-side or demand-side, therefore this policy did lead not to deployment of new RES-Es in the Netherlands. This implies that the effectiveness of this policy was limited in the Netherlands (Dinica & Arentsen, 2003).

It is notable that this demand-oriented support system resulted in rapid increasing of green electricity consumers from 16,000 in 1996 to 1.4 million in 2001. Despite the fact that green electricity consumers increased during that period, but this did not lead to new capacity of green electricity generation in the Netherlands. Because the granted subsidy also applied to green electricity generated abroad, and this caused rapid increasing of imports of electricity generated from RESs. Therefore, it can be concluded that the subsidy application to green electricity imported from abroad was one of reasons that this policy system did not met its targets. The lack of development of new capacities of RES-Es in the Netherlands implies that this policy was not effective. The leakage of grant to abroad confirms that implementation of this policy was not effective and efficient for policy-makers to develop new capacity of RES-Es in the Netherlands.

During this phase, three sorts of economic policy instruments were introduced; investment subsidy (ecotax), Feed-in Tariff (green lable), and Tradable Green Certificate. Although investment subsidy is aimed to create certainty for investors, but in this case that subsidy was granted to consumers not to investors. Therefore, it did not lead to new capacity of RES-Es and OWPs in the Netherlands. The second policy (FiT) is expected to provide lower risk to investors compared to other support mechanisms, and also to ensure long-term return for investors, and at the same time it is relatively simple to implement. These properties of FiT caused that implementation of green label relatively led to deployment of new capacities of RES-Es in the Netherlands (Fig. 3.10). The third implemented support system in this phase was TGC. In theory, TGC mechanism relies on market mechanism for resource utilization, and technology choice, therefore the TGC does not work for high cost RES-E technologies such as OWP at that time. And it is not strange that implementation of this policy instrument did not lead to new capacity of green electricity generation in the Netherlands.

Moreover, introducing of three policies within a period of six years could not provide political certainty for investors. In other words rapid policy changing could not lead to enough certainty for investors. Implementation of these policies also demonstrated that it is crucial to distinguish between development of new capacities of RES-Es or increasing of consumption of green electricity. In addition, again as it is observed in the first phase, it is important to oblige actors to implement policies, and if the compliance system is not enough strong, the targets will not be met.

3.2.1.3. The third Dutch policy phase (2003-ongoing)

Among these three phases, in the third phase (Promotion of production) the Dutch policy-makers decided to focus on stimulation of producers, among all of involved actors (e.g. suppliers or consumers), in order to promote electricity generation from RESs. In other words, the Dutch government wants to stimulate investors (developers) to enter and develop RES-E projects.

As Table 3.10 indicates, the third phase includes three periods; 2003-2008; 2008- 2011; 2011-ongoing. The Dutch government has introduced one (dominant) policy instrument in every period. Stimulating investors (to invest in OWP) by these three policy instruments would be discussed in following paragraphs. In addition, those policy implemented in every period would be evaluated by 4 already identified indicators; effectiveness, efficiency, certainty for investors, and equity.

First period (2003-2007); MEP (Environmental Quality of Electricity Production)

The Dutch government implemented the MEP subsidy (*Milieukwaliteit Elektriciteitsproductie subsidie*) in July 2003. By this policy they aimed at reducing associated investment risk, and also at improving the efficiency of green electricity generation. Feed-in tariff (as main policy instrument) and a reduced ecotax[38] exemption were two policy instruments that formed the MEP (vanSambeek & vanThuijl, 2003).

By reduced ecotax (from 6 to 2.0 €cent/kWh), policy-makers aimed to decrease tax losses due to imports. While it does help to stimulate consumers to use green electricity and consequently it leads to motivate the retail market for electricity from RESs such as OWP. In addition, policy-makers will to decrease the level of imports by implementation of reduced ecotax exemption. The ecotax exemption was 2.9 Euro Cent per KW electricity from OWP.

[38] The Dutch government introduced the regulatory energy tax or ecotax (Regulerende Energie Belasting, REB) in 1996. It was an amendment to the Law on Environmental Taxes (Wet Belastingen op Milieugrondslag, Wbm). It is collected by the energy supply companies and finally passed on to the tax authorities. By the ecotax, the Dutch government established a partial shift in taxation from income taxes to taxes on environmentally damaging activities (vanSambeek et al., 2003).

The Feed-in Tariff is set to increase certainty for investors (vanSambeek & vanThuijl, 2003).The Feed-in tariff system is financed through an annual levy on electricity connections of every household (vanRooijen & vanWees, 2006). The annual levy started with €34 per connected household in 2003. It was increased to €37 (2004), €39 (2005) and €40 per household in 2006. According to the MEP framework, the Dutch Transmission System Operator (TenneT) must disburse the MEP Feed-in Tariff. The level of the FiT was fixed and it was determined annually by the Ministry of Economic Affairs. The level of the MEP tariff was at the level of the tariff in the first year. That tariff is requested for a duration of 10 years. And the Dutch government guaranteed it for a period of ten years after one plant (e.g. an offshore wind park) starts to generate electricity. The tariffs varied between RES-E technologies. By implementation of the MEP Feed-in Tariff, investors receive 6.8 €cent/kWh electricity generated from offshore wind power. Fig. 3.11 illustrates the architecture of the MEP framework.

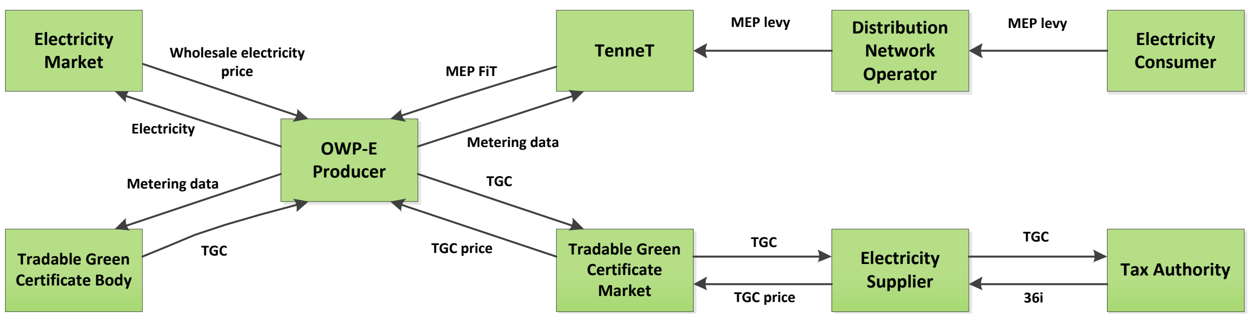

Fig. 3.11. Architecture of the MEP framework (adapted from van Sambeek et al., 2003)

As Figure 3.11 shows, also Tradable Green Certificates (TGCs) are presented in the MEP framework. Electricity utilities (Dutch producers and foreign green electricity producers/imported) received those green certificates from TGC Body, when they delivered green electricity to grid. Those companies could trade those green certificates on the TGC market. Electricity suppliers those had TGCs could claim the ecotax exemption. The market price of TGC does depend on the level of the ecotax exemption and the competition from imported green electricity.

Under this framework (MEP), green electricity producers had three main sources of income; selling electricity in the electricity market, trading TGCs in the TGC market, and receiving the MEP Feed-in Tariff from TenneT (Fig. 3.11).

- *Effectiveness of the MEP FiT regarding OWP*

By implementation of the MEP framework, the Dutch government aimed to increase electricity generation from RESs to 9% of total electricity consumption in 2010. Thus implemented policy instrument (MEP Feed-in Tariff) would be evaluated to assess if this policy provide a sufficiently high incentive to attract new investments in order to achieve that target (9% of total electricity consumption in 2010).

Table 3.12. Electricity generation by offshore wind parks in the Netherlands

Year	2003	2004	2005	2006	2007
Gross RE-E production (MWh)	-	-	-	63,000	303,000

Table 3.13. Electricity generation by RES-E technologies in the Netherlands

Year	2003	2004	2005	2006	2007	2008	2009	2010
% RE-E generation	-	5.9	7.7	7.5	-	9.0	10.7[39]	
Target (%)	-	-	-	-	-	-	-	9
OWP generation [mln kWh]			-	108	-	120	-	-

To measure effectiveness of this policy, the equation 1 is applied;

$E_t = C_t / T_t \times 100\%$

$E_{2008} = (9 / 9) \times 100\% = 1 \times 100\% = 100\%$

According to this definition of effectiveness, effectiveness of this policy instrument was 100% up to 2008. This statistics is about the electricity generation from the all of renewable energy sources such as aerothermal[40], biomass, geothermal, hydro, solar, and wind (onshore and offshore as well). This implies that this support policy system led to targets effectively. About offshore wind power, under MEP framework, 228MW was awarded for development of OWPs, and it was realized.

- *Efficiency of the MEP FiT regarding OWP*

The MEP Feed-in Tariff also is assessed to determine if this policy instrument caused electricity generation from OWP be within a narrow range of the cost of electricity generation. The highest level of subsidy through the MEP Feed-in Tariff was set for the offshore wind (6.8 €cent/kWh). But the financial gap between the cost of renewable electricity generation and the value of the electricity on the wholesale market was 9.7 €cent/kWh. The rest (2.9 €cent/kWh) was financed through ecotax exemption (van Sambeek). This amount of support per unit was constant during those five years (2003-3007). Since this policy did not lead to decreasing of the amount of support, this implies that the MEP Feed-in Tariff was not efficient generally. The costs needed for the policy instrument (FiT) got out of hand, thus it was closed to start new projects in August 2006 (CBS, 2012).

This inefficiency is due to, in general, Feed-in Tariff schemes are relatively non efficient (van dijk et al, 2003). Maybe developers try to minimize costs of projects in order to maximize their benefits, but a cost decreasing on the supply side does not lead necessarily to a decreasing of costs of the implemented policy instrument to society. In this case a constant fee (9.7 €cent/kWh) for support led to ensure developers that there is enough money to compensate their costs.

- *Certainty for investors by the MEP FiT regarding OWP*

Generally, the Feed-in Tariff creates certainty for investors by making sure the long-term return for investors (Gan et al. 2006). But in this case, because the Feed-in Tariff was financed through the ecotax, the uncertainty surrounding the continuity of the ecotax exemption reduced incentive for investments in domestic production (vanSambeek & vanThuijl, 2003). In other words, as the Dutch Ministry of Economic affairs recognized “the outflow of tax revenues and the lack of long-term price

[39] https://en.wikipedia.org/wiki/Electricity_sector_in_the_Netherlands

[40] It utilizes the calories present in the air to generate heat.

certainty for domestic investors as an obstacle to achieving its long-term targets" (Agnolucci, 2007b).

Since the marginal cost of electricity generated from OWPs and other RES-Es is almost zero (relatively flat MC), hence the (gradual) adding of electricity generated from OWPs to the wholesale electricity market will decrease the wholesale market prices of electricity (deMiera et al., 2008). As Fig. 3.12 illustrates by increasing of electricity generated from wind, the prices will decline (Fig. 3.12). This decreasing of electricity price leads to a considerable revenue risk as a sort of market risk regarding the electricity market that threatens investors to invest in new capacities of OWPs. In the Netherlands, electricity price increased from 0.18 €/kWh in 2003 to 0.22 €/kWh in 2007[41]. This electricity price rise started since 1991 due to increasing of electricity basic price, and imposing higher levies and value-added tax in the Netherlands. Thus this price increase was not unexpected at that time, and this reduced the chance that implementation of MEP lead to revenue risk.

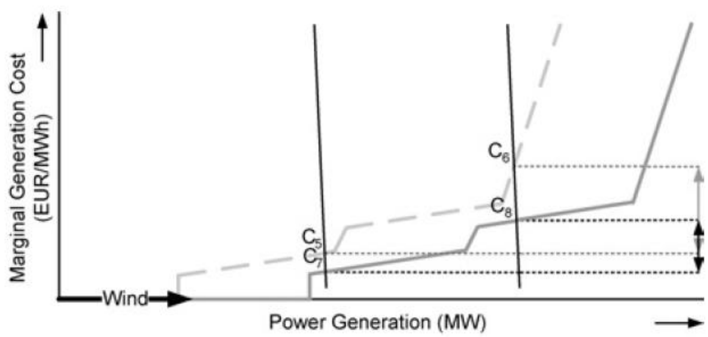

Fig. 3.12. Short-term marginal cost curve and the impact of wind power (Ummels et al., 2008)

The second period (2008-2011) – SDE (Sustainable Energy Production Incentive)

The Dutch government found out the MEP scheme was effective, and they achieve their intended targets, but it cost too much for government. For that reason, they decided to replace the MEP with a new option in order to increase the development of renewable energy projects with less associated costs. They designed and implemented the Sustainable Energy Production Incentive (Stimulating Duurzame Energieproductie, SDE) in 2008. The SDE was a premium Feed-in Tariff system, each RES-E technology had a separate tariff, and the grant rate level was adjusted annually. The amount of subsidy depended on the market price of conventional electricity or natural gas. It does cover the gap between generation cost and the actual electricity price. In this scheme, once an application for subsidy had been approved, the price differential was paid for a period of 12-15 years (depending on RES-E technology is used)[42]. Furthermore this subsidy scheme is available not only for production of green electricity, but also for production of green gas and renewable heat. However the available SDE budget for subsidy has been underspent over the period 2005 – 2011 (EEA, 2014).

[41] Dutch gas and electricity prices among the highest in Europe - https://www.cbs.nl/en-gb/news/2007/18/dutch-gas-and-electricity-prices-among-the-highest-in-europe

[42] http://iepd.iipnetwork.org/policy/incentive-scheme-sustainable-energy-production-sde

- *Effectiveness of the SDE premium regarding OWP*

By implementation of the SDE (Feed-in Premium), the Dutch government intends to develop at least 450 MW of OWP before 2011. After SDE introduction by the Dutch government, three applications are submitted for three offshore wind parks in 2009. Two wind farms, Gemini, are planned and will be constructed in north of Schiermonnikoog with a total capacity of 600 MW. And one wind park, Luchterduinen, with a total capacity of 129 MW. It was in the planning stages and is under construction on the North Sea (NetherlandsEnterpriseAgency, 2014). Since there is a time (lead-time) between the submission of an application and the realization of a project, thus the closing of the SDE only become visible in 2011, when a substantial expansion of OWP capacity is visible (CBS, 2012). However Table 3.14 indicates the electricity generation by offshore wind parks in the Netherlands within period of SDE implementation.

Table 3.14. Electricity generation by offshore wind parks in the Netherlands

Year	2008	2009	2010	2011
Promised to install new capacity through MEP (MW)	-	-	228	228
Installed through MEP (MW)	-	-	228	228
Promised to install new capacity through SDE (MW)	-	-	600	719
Installed new OWPs through SDE (MW)	-	-	-	-
Gross OWP-E production through MEP(MWh)	549,000	719,000	678,631	801,741
Gross OWP-E production through SDE (MWh)	-	-	-	-

To measure effectiveness of this policy, the equation 1 is applied;

$E_t = C_t / T_t \times 100\%$

$E_{2011} = (0 / 450) \times 100\% = 0.0 \times 100\% = 0.0\%$

According to this definition of effectiveness, effectiveness of this policy instrument was 0.0% up to 2011. This shows the Dutch government could not stimulate investors to come and install 450 MW new capacity by 2012, therefore SDE does not seem to been effective. Study by Rabobank shows that despite the fact that there were enough budget (€9 billion) the Dutch government supposed OWP projects are expensive, and they did not support projects for development of OWPs, therefore those projects have been sidelined in the SDE system (Rabobank, 2012).

- *Efficiency of the SDE premium regarding OWP*

As discussed in the last paragraph, the SDE (Feed-in Premium) did not lead to installation of new capacities of OWP. Table 3.15 shows the subsidy payment increased from 6.9 to 7.4 per unit. Thus could be concluded that this policy instrument is not efficient. Moreover, although this policy instrument pays for electricity generation from OWP (Table 3.15), but when nothing is generated then it does not sense to discuss efficiency of this economic instrument.

Table 3.15. SDE annual available budget and determined subsidy per kWh

Year	2008	2009	2010	2011
Total available budget (€ billion)	1.5	2.5 + 1.3	2.1	-
Available budget (€ billion) for OWP	0	0	0.068 (MEP) + 0 (SDE)	0.0723 (MEP) + 0 (SDE)

Subsidy (€cent/kWh)	-	-	6.9	7.4

- *Certainty for investors by the SDE premium regarding OWP*

Since SDE includes a specific category regarding OWP and there is enough budget (€9 billion), then investors decided to enter and invest over the long-term (Gemini and Luchterduinen). Accordingly could be concluded that this policy created enough certainty for investors to enter and invest over the long-term projects.

The third period (2011-ongoing) – SDE+ premium

SDE was replaced by SDE+ in 2011. It is an operating premium Feed-in Tariff, and it does not bid a fixed tariff per technology and separately for each technology. The auction is being announced in a number of rounds. The amount of the grant does increase gradually with each phase (Table 3.16). The subsidy is made available in 6 rounds and it would be allocated on a 'first come, first serve' approach. The premium would be paid for a period of up to fifteen years.

Table 3.16. The SDE+ support levels for OWP

Stage	Basic amount (€cent/kWh)
1	8.75
2	10.00
3	11.25
4	13.75
5	16.25
6	18.75

The Dutch government designed SDE+ to support projects that require the lowest subsidy per unit of energy generated in order to achieve the intended targets with the minimum possible subsidy (CBS, 2012). Since in the SDE+ system, offshore wind projects must compete with other (cheaper) RES-E technologies equally for support, therefore there is little chance of success for OWP projects to be granted under this support system. Since this leads to unfair competition between OWP projects and cheaper RES-E technologies, the Dutch government decided to introduce a separate tendering scheme for offshore wind energy in the SDE+ 2015. This implies that the category of offshore wind energy does not form a part of the SDE+ 2015. However in following paragraphs, the SDE+ would be assessed on three indicators; effectiveness, efficiency, and certainty for investors.

- *Effectiveness of the SDE+ premium regarding OWP*

As Table 3.17 indicates, there is not installed new OWP since the announcement of SDE+ (2012). In 2015, Eneco Luchterduinen[43] wind park was fully commissioned. It is granted by SDE in 2010. Therefore, we could conclude that SDE+ premium was not effective to stimulate investors to invest in new OWP projects.

Table 3.17. Electricity generation by offshore wind parks in the Netherlands

Year	2011	2012	2013	2014	2015
Promised to install new capacity through MEP (MW)	228	228			

[43] http://projecten.eneco.nl/eneco-luchterduinen/

Installed through MEP (MW)	228	228			
Promised to install new capacity through SDE (MW)	729	729	700	700	700 (2 x 350)
Installed through SDE (MW)	-	-	-	-	129
OWP-E production through MEP(MWh)	801,741	789,257			
OWP-E production through SDE (MWh)	-	-			

To measure effectiveness of this policy, the equation 1 is applied;

$E_t = C_t / T_t \times 100\%$

$E_{2015} = (129 / 719) \times 100\% = 0.177 \times 100\% = 17.7\%$

According to this definition of effectiveness, effectiveness of the SDE was 17.9% up to 2011. Effectiveness regarding SDE+ would be assessed in two different time-periods; 2012 – 2015 and 2015-ongoing. Up to 2014 (2012-2014), any OWP project was realized in the Netherlands (Table 3.17). Also there were no permit applications for development of OWPs. But in 2015 two applications closed for Borssele Wind Farm Zone 700 MW, sites I and II (Table 3.17). It is expected that these two sites would be fully commissioned in 2019. Therefore, it is too early to evaluate it on effectiveness criterion before 2019.

- *Efficiency of the SDE+ premium regarding OWP*

As discussed earlier, in the SDE+ mechanism, all renewable energy technologies compete together for one (limited) budget. Electricity generation from offshore wind costs on average 18 €cent/kWh, and it is more than the upper limit (15 €cent/kWh) in the usual SDE+ scheme. Therefore, in the SDE+, OWPs are eligible under the free category[44], where offshore wind projects has to compete with some RES-E technologies such as osmosis, mono-fermentation of manure, and biomass gasification.

Table 3.18. SDE+ annual available budget and determined subsidy per kWh

Year	2011	2012	2013	2014	2015
Total available budget (€ billion)			3.0	3.5	3.5
Budget (€ billion) for OWP	0.8 (MEP) 5.384 (SDE)	0.79 (MEP) 5.384 (SDE)	Free category	Free category	A separate tendering system

This FiT premium system, as mentioned beforehand, in essence, could not lead to a decreasing of costs of the implemented policy instrument to society. Because policy-makers, by designing and implementation of FiT, aim to ensure investors and developers to enter and invest in this field while this necessarily does not result in cost reduction to society.

- *Certainty for investors by the SDE+ premium regarding OWP*

The implemented SDE+ premium has not offered enough stimulants to investors for investment in new OWP capacities, as a relatively expensive renewable energy technology. Because of the SDE+

[44] The "free category" is a category in the SDE+ system. This category is open for bidding to all technologies that do not have a specific category and threshold allocated to them. Under the "free category", all of RE technologies expected will cost more than the upper limit (15 €cent/kWh), and they must compete together equally for allocated grants.

offers grant to the cheapest RES-E technology via a competition between RES-Es. Then Developers of OWP projects, as relatively expensive RES-E projects, perceive there is no chance to win grants offered through the SDE+.

3.2.2. The role of equity in the Dutch support policy instruments

In this part, the three phases in Dutch green electricity policy would be evaluated on equity as a non-economic oriented criterion.

As mentioned in the second chapter, unequal distributed ills and benefits are derived from either policy instruments (e.g. cost of policies) or from development of offshore wind projects (costs for some industries such as fishery). In this study, only unequal distribution of costs and benefits regarding design and implementation of policy instruments for stimulating investment in OWPs projects in the Netherlands will be investigated. In respect to this presumption, only three actors are directly involved, consumers (Dutch households), developers, and he Dutch government as policy-makers. Then for the evaluation of discussed economic policy instruments on equity criterion, two indicators are elected which are related to those actors directly. Those two indicators are: (negative) impacts on households' budget, and excess profits.

3.2.2.1. Impacts on households' budget

In following paragraphs, the three phases of Dutch green electricity policy would be evaluated on negative impacts of electricity costs on households' budget. Since this study is going to evaluate policy instruments regarding stimulating investment in OWPs, the costs associated with implementation of those policies should be measured.

The first Dutch policy phase impacts on households' budget (1990-1995)

In 1990, the Dutch government started to negotiate with the energy distribution sector in order to realize voluntary sales target through financing renewable energy projects by a general environmental levy. Financing these projects (electricity generation from renewable energy sources) by environmental levy implies that those investments were compensated by polluters (companies). In other words investors benefit, and all of companies (polluters) compensate that benefit. From equity perspective, the implementation of this economic policy instrument had not potential distributional impacts whatsoever on households' budget due to that levy was not imposed on households. As mentioned earlier, implementation of this policy did not lead to diffusion of not only OWPs but also other RES-E technologies. Hence, there was no further development of new RES-E projects which needed subsidy by general environmental levy.

The Second Dutch policy phase impacts on households' budget (1996-2002)

The second Dutch policy phase consists of three policies focused on the stimulation of demand by means of price incentives. *Regulatory energy tax* (ecotax) in 1996, *voluntary green label system* (1998) as a small Feed-in Tariff mechanism, and voluntary *tradable green certificate* system (2001) are implemented in this interval. All of these three policy instruments are guaranteed by the Dutch government through the state budget. It means Dutch people (households) paid associated costs through tax payment to implement these three support schemes.

Table 3.19. Associated costs of implementation of the second phase of the Dutch green policy (vanRooijen & vanWees, 2006)

Year	Production	Import	Total	Fiscal support €/MWh	Fiscal support €	Cost per household[45] €/household
	MWh					
1996	1569		1569	26000	40,794,000	6,57
1997	1699		1699	26000	44,174,000	7.07
1998	1982		1982	26000	51,532,000	8.15
1999	2116		2116	37000	78,292,000	12.35
2000	2580	1500	4080	54000	220,320,000	34.58
2001	2937	7645	10582	78000	825,396,000	132.28
2002	3627	10350	13977	80000	1,118,160,000	173.01

Table 3.19 shows the annual budget allocated (paid) to support these three policy instruments during the second phase (seven years). Since these support schemes are financed through tax then it means people paid tax according to a taxation system in the country that uses different tax brackets. In other words, people do not pay directly for costs of financing those subsidies. Therefore, discussion about distribution of costs is not relevant in this situation. Accordingly, policy-makers did not confront challenges regarding equity issues during design of those three support systems.

The Third Dutch policy phase impacts on households' budget (2003-ongoing)

This phase included three periods. In the next paragraph their negative impacts on households' budget is evaluated.

- *MEP system and its impacts on households' budget (2003-2007)*

The MEP subsidy consists of two major support systems; Feed-in tariff (as main policy instrument) and a reduced ecotax. As mentioned earlier, under the MEP framework, 228MW was awarded for development of OWPs, and it was completely realized. Ecotax was imposed on consumers who consumed electricity generated from conventional resources, collected by the energy supply companies and finally passed on to the tax authorities. The Feed-in Tariff was financed through an annual levy on electricity connections of every household, collected by Distribution Network Operator.

The annual levy started with €34 per connected household in 2003. It was increased to €37 (2004), €39 (2005) and €40 per household in 2006. Households had to pay to finance Ecotax and Feed-in Tariff as well. Table 3.18 indicates the amount of money households paid for ecotax. It is noteworthy to mention that the average of power consumption by households in the Netherlands is almost 3500 kWh per year in 2006 (TNO 2008). It is less than 10,000 kWh per year, then every Dutch household had to pay €0.06 per kWh, totally €238 per year (Table 3.20).

Table 3.20. MEP costs imposed on Dutch households (vanRooijen & vanWees, 2006)

Power	Ecotax	Average consumption	Total payment	Annual levy	Total

[45] It is assumed that the household size is 2.5 persons per household. https://en.wikipedia.org/wiki/List_of_countries_by_number_of_households

consumption [kwh/year]	[€/kWh]	[kwh/year/household]	for ecotax[€/year]	[€/year]	payment [€/year]
up to 10,000	0.06	3300[46]	198	40	238
10,000 – 50,000	0.02	N/A	N/A	N/A	N/A
10,000 – 10 million	0.01	N/A	N/A	N/A	N/A

Fraction of households' budget paid for electricity is one indicator to measure distributional of costs on households in the Netherlands. Fraction of households' budget could be translated to the households' capacity to tolerate some costs. And as mentioned earlier, people have different capacities to tolerate the same imposed amount of payment. In this case, certainly this amount of money (€238 per year) is a larger fraction of low-income households' budget those have less capacity to tolerate costs compared to other households. It means the MEP led to inequity distribution of costs. Again, the same issue has brought up; renewable energy companies benefit from this support scheme but all of people (tax-payers) pay for it.

- *SDE system and its impacts on households' budget (2008-2011)*

The SDE system was a premium Feed-in Tariff, each technology had a separate tariff and the grant rate level was adjusted annually. This premium feed-in tariff was financed through state budget. The total cumulative budget for this system amounts to €9 billion to support development of all of available RES-E technologies in the Netherlands (Rabobank, 2012). But there was any realization of new capacity of OWP projects, thus nothing is spent in this year on OWPs project (Table 3.14). Although no money is spent for development of OWPs under SDE, but considering that implementation of the SDE cost €9 billion in an interval of four years, this is a huge amount of money that is paid by households (through tax) in the Netherlands. Thus there are no direct ills on some relevant actors (e.g. end consumers) for financing of this policy. It implies that policy-makers considered equity in design phase of policy.

- *SDE+ system and its impacts on households' budget (2011-ongoing)*

Since in the SDE+ system, offshore wind power projects must equally compete with other (more mature and cheaper) renewable energy technologies for grant, therefore there is little chance of success for OWP projects to be granted under this support system. Table 3.16 indicates, there is not installed new OWP since the announcement of SDE+ (2011). Although under the SDE+ any new capacity of OWP is developed, but the budget (the state budget) for it is already allocated. Therefore, there is the same question regarding equitable distribution of associated costs. Moreover, this system results in some unequal distribution of benefits (excess profits) for developers of cheaper RES-E technologies (e.g. biomass, and onshore wind power) compared to developers of more expensive RES-E technologies such as OWP.

According to this study, up to now in some cases (financing through direct imposition such as annual levy) implementation of economic policy instruments for diffusion of OWPs in the Netherlands have led to unequal distribution of costs be imposed on low-income households, while they have resulted in some excess profits for utilities that generate electricity by cheaper RES-E technologies in compared to OWP. It means that equity depends on the way is designed to collect

[46] https://www.milieucentraal.nl/energie-besparen/snel-besparen/grip-op-je-energierekening/gemiddeld-energieverbruik/

money for financing of those policies. Financing policy instruments through state budget do not lead to some new ills on end-users. But direct payment (through electricity bill) causes new costs on households. Since financing of those support systems is the main reason of inequity distribution of costs, therefore policy-makers, during designing those support systems, should be aware of equity, as a non-economic oriented criterion, and its negative (costly) impacts on low-income households.

Also it is notable to say that inequity distribution of costs on a group of people could leads to decreasing the acceptance of those policy instruments. And accordingly, as Wüstenhagen et al. (2007) say, the high degree of public acceptance could guarantee successful implementation of a support system (Wüstenhagen et al., 2007). This confirms that consideration of social aspects (equity) is needed for successful implementation of given policy instrument.

3.3. Lesson learned - reflection from case study

Getting an insight into main distinct characteristics of offshore wind parks as socio-technological systems was the first part of this section. Huge capital cost and long lead-time and some other features are identified as distinct features of OWP systems. Those features cause that development of OWPs is not feasible without attendance of big utilities/power companies. To stimulate them to enter and invest, support by government is needed; support mechanisms such as policy instruments.

This case study also brings up some noteworthy issues those prove why implemented policy instruments have not met targets to promote OWPs in the Netherlands. As the first, political uncertainty led to some risks and barriers. Those risks and barriers are recognized as reasons of that failure. Political uncertainty could be categorized in tow levels; uncertain political environment, and risky policy making. As uncertain political environment, we observed a high risky political environment due to regulatory uncertainty such as the situation in which the liberalization of electricity market is happened that forced new changes in the economic support systems. This demonstrates that the Dutch government has not a commitment to develop RES-Es in the Netherlands as observed in Spain up to 2012 for almost three decades. Because of such uncertain environment, big changing in design and implementation of policy instruments (risky policy-making) is occurred. This sort of political risk is observed with cabinet changing. For instance conservative governments prefer to promote RES-Es and in particular case the OWP, with minimum costs, therefore they change policy instruments in a desirable way. In Spain, it is observed that since 1980s when Spanish government committed to diffuse power generation from RESs, all of governments have committed to promote RES-E technologies.

The second detection was trial and error approach used in the Netherlands for implementation of policy instruments. This case study covers an interval of twenty five years, but following the track is very difficult. It is not clear why they changed a support scheme and implement the new one. For instance, it is obscure that policy-makers did not consider that the green electricity subsidy imported from abroad can absorb the subsidy to green electricity. Even it is remarkable that they set policies but they did not entail obligation on supply-side or demand-side, hence the effectiveness of those policies was limited in the Netherlands.

As the last finding, it is remarkable that there is a necessity to improve policy instruments by applying social dimension such as equity. Equity discusses equal regarding relevant costs and benefits. It is crucial to consider this issue during designing and implementation of policy instruments for promotion OWPs in the Netherlands. This increases acceptance of OWP developments by public and involved actors and communities.

As the last word in this part, it is noteworthy that the priority by the SDE+ is with cheaper RES-E technologies. Since offshore wind is more expensive (0.18 €/kWh) than the SDE+ maximum cost price of 0.15 €/kWh, therefore there is challenge to guarantee OWPs projects by the SDE+.

These historical findings confirm that in a very dynamic environment, such as electricity market in the Netherlands, it is very complex to suggest the proper economic policy instrument that can stimulate investment in OWP projects efficiently and effectively whilst not compromising equity considerations.

As the first challenge to overcome, it is remarkable that although certainty for investors is a very crucial to achieve targets regarding stimulating investment in OWP projects, but this certainty could not be realized efficiently under liberalized market condition. Specifically, FiT brings up certainty for investors but it is costly way for policy-makers and it is considered as direct government intervention to free market. This would be analyzed in the next chapter in detail in order to overcome this paradoxical issue.

In addition, there are multiple dimensions (e.g. social, economic, technical dimensions), wherein several actors are involved that have their own perspectives, values, interests and objectives. Sometimes those interests are conflictive interests, such as it is observed regarding interest to develop OWP as a relatively expensive RES-E technology under liberalized market condition and consideration of equity as a social dimension.

Unexpected events, such as new technological improvements or implementation of new regulations (e.g. liberalization of electricity market in 1990s) are real challenges to anticipate results of implementation of a new support system.

There are a number of options (four discussed support schemes), which would be evaluated by four recognized evaluation criteria. Multi-Criteria Decision Analysis (MCDA) and Multi-criteria Analysis (MCA) are two suggested methods for integration of several (conflictive) interests, perspectives and conflicting objectives as we observed in case of planning policy instrument to stimulate investment in OWP projects in the Netherlands. These techniques offer an algorithm to systematically aggregate multi-dimensional information and, therefore, reducing the information complexity in a transparent way (Kowalski et al., 2009).

All of findings in Chapter 2 and Chapter 3 would be analyzed in the next chapter to propose an evaluation framework in order to support the Dutch policy-makers to plan proper economic policy instrument to stimulate investment in developing of offshore wind parks in the Netherlands.

CHAPTER 4
Analysis and policy-making for OWP in the Netherlands

The two last chapters include discussion about economic policy instruments for stimulating investment in offshore wind park projects in general, and in specific case in the Netherlands. In this chapter we continue by conducting a multi-criteria analysis to support decision-making on the promotion of offshore wind power in the Netherlands. It is aimed at establishing the most promising instrument(s) for stimulating investment in OWP projects in the Netherlands. Also underlying theory would be discussed.

The point of view taken in the analysis is that of the policy-maker or regulator, whose target is the development of renewable energy technologies efficiently and effectively while considering fairly distribution of associated costs and profit on producers and consumers who eventually pay for it. Considering fairly distribution of associated costs implies that in new policy-making approach, beside economic aspects (effectiveness and efficiency) social dimension (equity) also have been considered.

The next subsections include methodology, analysis of the case (future stimulating policies) based on the method, and putting forward recommendation(s). Under methodology the Multi-criteria Analysis, as a method for evaluation, and the underlying reasons for choosing the MCA would be discussed. After that, under analysis of the case, it is aimed to elucidate policy instruments' features for assessment of those support systems by using Multi-Criteria Analysis (MCA). This leads to understand which policy or policies would be likely more efficient and effective policy instrument for future in the Netherlands. Also the Means and Map Causal Relations diagram as a method will be applied to get insight into dynamics of causal relations those help to detect and anticipate relevant activities and events in future. At the end, the designated policy instrument(s) would be addressed to figure out the policy instrument(s) that offers the best combination between stimulating investment and distributive justice.

4.1. Multi-Criteria Analysis

Decision-making for choosing policy instruments to stimulate investment in OWP projects in the Netherlands is a complex evaluative decision process. In the next paragraph an evaluation method for assessment of suggested alternatives will be discussed.

4.1.1. Multi-criteria analysis (MCA) as method for selecting policy instrument

Sustainable development of OWP projects in the Netherlands depends on selected support system and the way that policy instrument will be implemented. *Investment subsidies, Feed-in Tariff (FiT), Tradable Green Certificates (TGCs),* and *Tendering system* are four alternatives those will be assessed in this study. And *effectiveness, (dynamic and static) efficiency, certainty for investors*, and *equity* are four identified criteria for evaluation. Although the notion of static efficiency has no meaning when the market is not perfect, however in this study both, dynamic and static efficiency are considered as criteria for evaluation. It is noteworthy to mention that the importance (assigned weights) of these four criteria is up to policy-makers. In other words, policy-makers themselves will assign weights to the criteria if they want, but we will treat them as equal weighted criteria in this research. By this study, evaluating of four policy instruments is aimed in order to assess the extent to which the given criterion has been achieved by implementation of the given support system (alternative).

The policy instrument choosing, in this case, is characterized by four alternatives, four criteria, several involved actors and different factors that influencing functionality of those four support systems. Multi-criteria Decision Analysis and Multi-criteria Analysis are suggested as two methods in order to evaluate alternatives (policy instruments in this case) on some criteria to determine one alternative as suggested alternative for policy-makers. These two methods for decision-making are a combination of rationality[47] and intuition[48] regarding issues which different policies would be assessed on several criteria (Table 4.1), where X_{11} is the rating of alternative 1 with respect to criterion 1 (e.g. effectiveness) , see Table 4.1.

Table 4.1. Structure of the alternative performance matrix (Lotfi et al., 2011)

Alternatives	**Criteria**			
	Criterion 1	**Criterion 2**	**Criterion 3**	**Criterion 4**
Alternative 1	X_{11}	X_{12}	X_{13}	X_{14}
Alternative 2	X_{21}	X_{22}	X_{23}	X_{24}
Alternative 3	X_{31}	X_{32}	X_{33}	X_{34}
Alternative 4	X_{41}	X_{42}	X_{43}	X_{44}

The basic principles of MCDA have been outlined in the late 1960s and early 1970s. The main purpose of the MCDA is to develop a method to evaluate and choose among alternatives based on multiple criteria using systematic analysis that overcomes the observed limitations of unstructured individual and group decision-making (Linkov et al., 2004). Multiple Attribute Utility Theory (MAUT), outranking methods, interactive multi-objective optimization, and Evolutionary Multi-objective Optimization (EMO) are four main available methods of MCDA (Sheppard et al., 2005). The spectrum of applications covers a wide range with particular emphasis on very complex problems such as environmental projects.

Multi-criteria Analysis, as the second method, "establishes preferences between options by reference to an explicit set of objectives that the decision-making body has identified, and for which it has established measurable criteria to assess the extent to which the objectives have been achieved" (Janssen, 2001). As Janssen (2001) mentions, the MCA provides a systematic, transparent

[47] Under rational decision-making, it is assumed that a rational decision-maker(s) has enough data and information, and enough time for assessment of all available alternatives in order to make decision completely rational (Simon 1959).

[48] The intuitive decision-making means decision is made based on intuitive process. Intuition is defined as a gut feeling based on unconscious past knowledge and experience without reasoning (Dijksterhuis and Nordgren, 2006).

approach that increases objectivity and generates results that can be reproduced (Janssen, 2001). This method works for comparison of very different alternatives at the strategic level in the experimental applications and also for comparison of relatively similar alternatives at the project level (Janssen, 2001). But as every method, this method has some weaknesses such as it is prone to manipulation, and also this method provides a false sense of accuracy (Janssen, 2001).

The MCDA method is a comparison method base on the pairwise comparison of decision criteria (AHP tool) or ranking criteria (outranking technique), or it is used to choose the most preferred solution from the generated set wherein solution space is continuous (EMO technique). Because of the related solution space is not continuous therefore the MCDA is not proper method to evaluate alternatives (policy instruments).

Based on the findings from literature study and experiences in the Netherlands and other EU member states, policy-makers realized that in this case (selecting policy), all four recognized criteria have the same preference for them in order to choose a more sustainable policy instrument. In detail, sustainable decision-making is realized by consideration of social, environmental, and economic aspects equally as much as possible. These four criteria, as addressed earlier, include social and economic aspects without compromise on one dimension, and consequently could lead to selecting of a more sustainable support system. Then the MCA is suggested as the method for assessment of for support systems in this study. This is due to some specific features of this method, those cope with nature of this case;

- A method for mainly used on strategic level
- Provide a tool for quantification of qualitative parameter and criteria
- Systematic approach to anticipate and react to requests from all interested parties
- Criteria have the same level of importance
- The list of criteria includes requests from all relevant parties rather than the outcomes of a systematic value tree (Janssen, 2001)

In this case, decision-making about choosing and implementation of one proper policy instrument is happened in a strategic level not in a project level. Hence, the MCA could be the suitable method to evaluate alternatives in a strategic level. Also, evaluation of qualitative criteria such as, equity is a challenge that could be solved by MCA technique that has ability for quantification of qualitative criteria. Since, in the Netherlands, request of relevant stakeholders must be consider during policy-making, the MCA method provides a systematic approach to anticipate and react to requests from all interested parties (Janssen, 2001).

Several tools are developed for applying of the MCA method, such as *weighted summation,* and *the Evamix method*. *The Evamix technique* is developed in the Netherlands that has ability to provide qualitative and quantitative scores. But it has some important weaknesses (Janssen, 2001). As the first disadvantage of this tool, it is very complex. It is very difficult to relate input to output. And moreover, *the Evamix technique* is not a transparent tool. By the *weighted summation* method "a linear function is used to standardize the quantitative scores and the overall score is calculated as the weighted average of the standardized scores" (Janssen, 2001). Contrary to complexity of the

Evamix technique, the *weighted summation* is a relatively simple technique. Moreover, the *weighted summation* tool is easy to explain and enough transparent and limited interest in sensitivity analysis. Therefore, in this study the *weighted summation* is selected as the tool for applying the MCA method for consistent evaluation of identified alternatives.

How does the weighted summation work?

In the *weighted summation*, recognized criteria and qualitative scores are measured on a plus and minus (−−−/+++) scale. This scale is used as a representation of an underlying classification of quantitative scores. (Janssen, 2001). As Janssen describes the number of plusses and minuses reflects the size of the impact from policy-makers' point of view in this evaluation (Janssen, 2001). In the next paragraphs the four suggested policy instruments (alternatives) would be evaluated by using the *weighted summation* technique.

4.1.2. Conceptual evaluation of four policy instruments on four criteria

Next paragraphs describe the evaluation of four recognized policy instruments on four identified criteria based on findings resulted from literature study, experiences in some EU member states, and in the Netherlands, as the case study (during the Chapter 2 and Chapter 3).

4.1.2.1. Literature study

In Chapter 2 of this MSc Thesis Project, thirty academic articles and books are reviewed to get an insight into evaluation of four predefined support systems for stimulating OWPs in theory. This literature study shows that eleven criteria are the most frequent criteria which those four policy instruments are evaluated on them theoretically (Table 2.3). Among those eleven criteria, four criteria (efficiency, effectiveness, certainty for investors, and equity) recently are used more than others. Therefore, those four criteria are selected for evaluation of policy instruments in Chapter 2 of this research. Following paragraphs include analysis of those theoretical findings to investigate why and how those four criteria determine the degrees of success of implementation of the given policy instrument.

- Evaluation of Investment Subsidies,

Effectiveness by implementation of this subsidy is (in theory) relatively high. This support system provide certain budget to compensate extra costs which is associated with power generation not only from commercial mature RES-E technologies, but also from relatively commercial immature RES-E technologies. Investment subsidy causes low static efficiency from policy-makers' perspective, especially if this grant is offered to investors during deployment phase. But this could improve technology and accordingly increases dynamic efficiency. Also, implementation of this support system provides high certainty for investors. Providing certainty for investors is recognized as the main reason of relatively high effectiveness provided by this policy instrument. Depends on the source of the allocated budget to finance this subsidy system, the equity differently is impacted by implementation of this policy instruments. But case study demonstrates it has no clear impact on equity (Table 4.2).

In analysis, we should consider that providing money maybe leads to certainty for investors, but it does not necessarily results in more capacity (effectiveness). Because of some other factors have role to persuade investors for investment. And also it is noteworthy to mention that this subsidy is allocated for construction and deployment of one RES-E project. While during operation phase this subsidy is not allocated, wherein the most market risks (regarding expensive and uncompetitive generated power) are existed and accordingly (financial) support is needed to save the given RES-E technology.

- Evaluation of Feed-in Tariff,

By implementation of the *FiT* system, effectiveness is high. Developers know this support system will compensate associated extra costs for a certain period of time. This policy instrument leads to dynamic efficiency by providing technical improvement through acceleration of technological learning, stimulation of R&D through allocation of the surplus profits, and easiness technological diversification. Budget could be control relatively by applying the *FiT* premium system (Table 4.2). But theoretically this policy could not bring up static efficiency. Certainty for investors could be guaranteed by this support system. Again regarding equity, it depends on the source of the allocated budget, and the way of its gathering (e.g. direct payment through electricity bill or not).

- Evaluation of Tradable Green Certificates,

This policy instrument fits on the market system, wherein the most efficient (the most commercial mature) RES-E technologies will be supported. This leads to static efficiency (in theory), but not to dynamic efficiency. These imply that the implementation of this support scheme does not lead to installation of new capacities of the less commercial mature RES-E technologies. Implementation of the TGCs does not guarantee to compensate associated extra costs (Market risks) for RES-E technologies that are not enough commercial mature. This means the TGC does not lead to certainty for investors in commercial immature RES-E projects. Also impacts of the implementation of the TGC on equity depends on the approach is performed to provide the needed budget for the *TGC* (Table 4.2).

- Evaluation of Tendering System,

As the last alternative, the *tendering system* does not lead to promote electricity generation by RES-E technologies. It implies that the implementation of the *tendering system* has a poor effectiveness. Since the *tendering system* leads to the lowest cost option by selection of the most cost-effective offers in each bidding round, hence regarding OWP projects (immature RES-E technology), dynamic efficiency is low in this support system. This policy instrument provides low certainty for investors due to the actual cost of development of the project turns out to be higher than that anticipated when drafting the bid. The way is applied to provide needed budget to finance this policy instrument determines its impact on equity (Table 4.2).

Table 4.2. Structure of the alternative performance matrix regarding the literature study of stimulating investments in OWPs

Alternatives (Policies)	Criteria				
	C1. Effectiveness	C2. Efficiency		C3. Certainty for investors	C4. Equity
		Dynamic	Static		
A1. Investment subsidy	+	++	_	++	0 (conditional)
A2. Feed-in Tariff	++	+++	_	++	0

					(conditional)
A3. TGCs	0	+	++	_ _	0 (conditional)
A4. Tendering system	––	+	+	––	0 (conditional)

4.1.2.2. Country experiences

According to the literature study in Chapter 2, and also experiences in EU countries, including the Netherlands, the *Feed-in Tariff* and the *Tradable Green Certificates* are two most implemented support schemes to stimulate investors for investing in OWP projects, and other RES-E technologies in the European Union (Table 4.3).

Table 4.3. Overview of the main economic policy instruments for RES-E in EU-27 (Adapted from Haas et al., 2011)

EU Member state	**Fixed FiT**	**Premium FiT**	**FiT combined with regional investment incentive**	**TGCs**	**Quota obligation system with TGCs**	**Energy tax exemption**
Austria						
Belgium						
Bulgaria						
Cyprus						
Czech Republic						
Denmark						
Estonia						
Finland						
France						
Germany						
Greece						
Hungary						
Ireland						
Italy						
Latvia						
Lithuania						
Luxembourg						
Malta						
Netherlands						
Poland						
Portugal						
Romania						
Slovak Republic						
Slovenia						
Spain						
Sweden						
UK						

In addition, evolution of the main policy support schemes in EU-27 Member States are illustrated (Fig. 4.1). As Fig. 4.1 illustrates there is a major policy shift during the period 1997-2005, wherein the majority of EU countries focus on the FIT and the TGC.

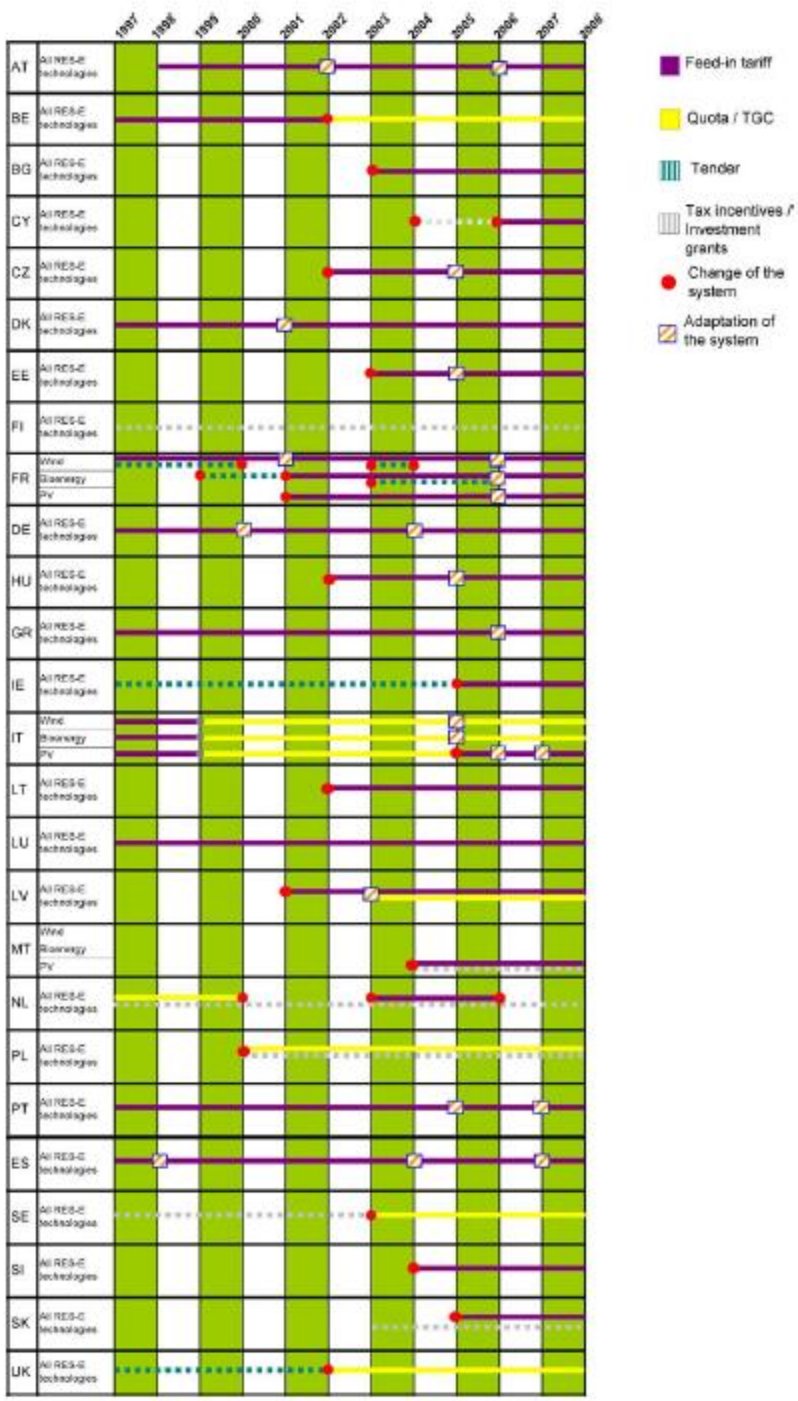

Fig. 4.1. Evolution of the most implemented policy instruments in EU-27 Member States (Haas, Panzer, et al., 2011)

Although it seems that it is more rational to focus on analysis of those two more implemented support schemes (FiT and TGCs), but in this study, as an evaluation study, it is tried to get a more comprehensive assessment as much as possible by evaluation of a large number of support systems. Therefore, the other two policies (investment subsidy and tendering system) also would be assessed to reach the most promising future instruments for promoting OWPs in the Netherlands. Then by this analysis, those four policy instruments would be analyzed in relation to the different criteria that distinguish price-based and quantity-based approaches by consideration of real adoption and innovation processes at the same time.

4.1.2.3. Findings by case study

In the last twenty years, development of OWPs in the Netherlands is supported by several policy instruments but the *Feed-in Tariff* (FiT) and the *Tradable Green Certificates* (TGC) are two main support schemes used to support deploying of OWPs in the Netherlands. The only significant deployment of OWPs is occurred by implementation of the FiT system under the MEP and the SDE schemes. Under the MEP 228 MW OWP, and by implementation of SDE 129 MW OWP are deployed. But up to now by implementation of the TGCs, any OWP is deployed in the Netherlands. Under the SDE+, offshore wind power projects compete with all of other RES-E technologies for obtain subsidy grants. Although the Dutch policy-makers aimed at achieve targets in the most economical way, but it does not results in OWP deployment in the Netherlands.

Generally the implementation of the *FiT* led to more new OWP capacities in comparison to the implementation of the *TGCs* in the Netherlands. This relatively higher effectiveness is caused due to some reasons such as more certainty that the *FiT* provided for investors. That provided certainty for investors results in reluctant to improve technology in order to generate green power in more efficient way. In other words, this support system also brings up more dynamic efficiency.

On the other side, despite to the *TGCs* were aimed to provide a more market-based support system in a liberalized electricity market, but it has not been led to deployment of new OWP capacities yet. As discussed earlier, the *TGCs* system provides limited sources (certificates) based on a competitive process wherein several RES-E technologies compete to get subsidy. Certainly more commercial mature RES-E technologies get more subsidy than OWP, as a pre-commercial mature RES-E technology (Figure 3.7). Therefore, OWPs' developers have no incentive to invest in risky projects which are not supported by public resources (support systems).

Investment subsidy and *tendering system* are two other suggested policies for stimulating of investment in OWP projects. Investment subsidy is implemented under the first Dutch policy phase (1990-1995) but it did not lead to new OWPs. And the tendering systems are never implemented in the Netherlands. But literature and experiences in other EU countries have demonstrated that implementation of these two has not led to significant deployment of new OWP capacities.

4.1.2.4. Expectations

Up to now, the evaluation of already implemented policy instruments is investigated theoretically and experimentally (ex-post study). Since this study is aimed at developing of an evaluation framework to help decision-makers to select policy instrument for implementation in near future (up to 2023), therefore it is needed to get an insight into the evaluation of those four policy instruments in future (context). The anticipated results of this ex-ante evaluation (study) are based on the findings in the previous two sections.

It is expected, in the Netherlands, as an almost stable and developed country, implementation of those four mentioned policy instruments leads to the same results as the past. In other words, it is assumed the current trends will continue. Table 4.2 illustrates the evaluation of four policy instruments on four recognized criteria by applying the MCA method.

According to this evaluation, the price-based approaches (FiT and Investment subsidy) provide needed certainty for investor which is needed for ensure investors to invest in new capacity of OWPs. Also implementation of these two methods leads to dynamic efficiency. But in theory these policy instruments do not result in static efficiency. Conversely, whiles in theory, the quantity-based approaches (TGC and Tendering system) are statically efficient but implementation of those two support systems does not result in significant dynamic efficiency through technology improvement. Also implementation of the quantity-based approaches does not result in certainty for investors and accordingly in new installation of OWPs (low effectiveness). Impacts of these four policy instruments on equity are neutral due to equity depends on the design (of the way to finance policy) of the given policy instrument (Table 4.2).

This shows FiT leads to relatively high certainty for investors, effectiveness and efficiency in comparison to other support systems. However there is no concrete approach (policy instrument) to stimulate investment in OWPs by consideration of social and economic aspects at the same time. Thus it is necessary to investigate implementation of support systems to reach the most proper policy instrument for stimulating investment in OWP projects in sustainable way by consideration of social and economic aspects. Next section includes analysis of evaluation of those four suggested support systems on four criteria in order to develop an evaluation framework helps to assist policy makers to select most promising policy instrument for stimulating investment in OWP projects in sustainable way.

4.2. Analysis of policy instruments for stimulating investments in OWPs

We now turn to the MCA method where the Dutch context, past lessons, and future expectations come into play and are likely to result in a different assessment of the policy instruments.

Due to specific (technical) characteristics of OWPs, deploying of offshore wind projects needs support by governments. Features, such as huge capital cost, long lead-time, relatively low availability, and volatility of electricity piece cause that (up to now) there were no enough motivation for investors to invest in OWP projects. Although implementation of support systems has resulted in some diffusions of OWPs in some countries such as Denmark, but in the Netherlands implementation of the *Dutch Green Policies* has not brought expected fruits regarding OWP development.

Stimulating investors to contribute to the deployment of OWP projects in future, as a real case, is the main concern in this study. In the following paragraphs, diffusion of OWPs in the Netherlands, and the role of implementation of policy instruments in that promotion will be analyzed.

4.2.1 Desired situation

In contrast to the current situation, mentioned in Chapter 3, next paragraphs describe situation(s) where policy-makers want to be in near-time (up to 2023). The last elaborated plan by the Dutch policy-makers targets total installation of 6450 MW up to 2023 (Fig. 4.2). It means more than 5400 MW OWPs must be developed in only six years. By the trend of OWP development in the Netherlands (Fig. 4.2), it does not seem the planed target (6450 MW up to 2023) will be met at predetermined time. Therefore, a new assessment of policy support for the promotion of OWPs can work to overcome related barriers.

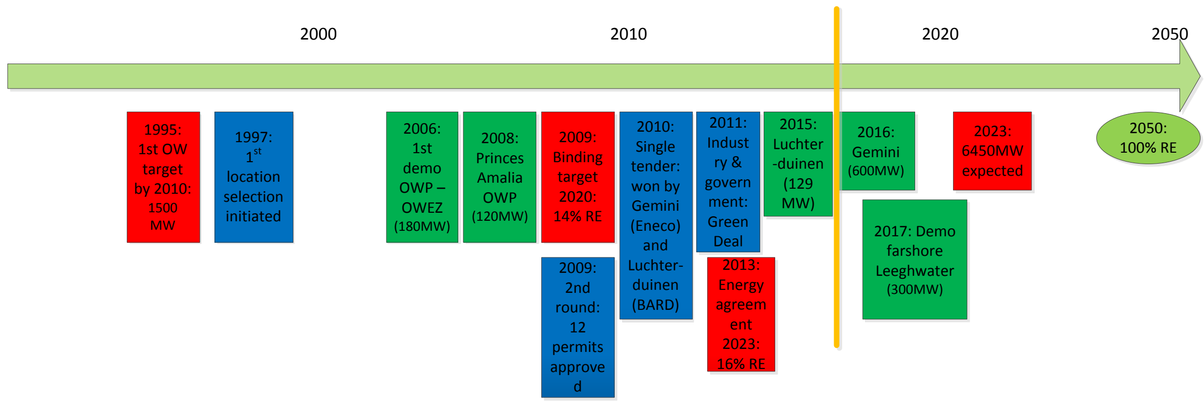

Fig. 4.2. Key events regarding OWP development in the Netherlands

Before than the new assessment, it is worthy to clarify the expectations and desirable situations and related context in near future (up to 2023) in the Netherlands, and specifically in the Dutch electricity market. Again, the expected or desirable situations regarding implementation of policy instruments for diffusion of large-scale OWPs, as social-technical systems (STS), will be investigated from three dimensions' point of view.

- **Technological aspects**

From *technological perspective*, there are two main barriers to develop new OWPs to meet targets (6450 MW OWP up to 2023). As the first, due to pre-commercial maturity of OWP technology, electricity generation from OWP is not efficient and accordingly power generator are not reluctant to invest in it. It implies a progress in this RES-E technology could work to overcome this challenge. However this is not related to this study. The second reason is caused by distinctive technical features of OWP that the development of OWP projects in the Netherlands needs support by public resources (financial support). This problem has a technological issue but has an institutional answer; proper policy support. This issue is related to this study. It is noteworthy to mention that it is desirable that the level of knowledge development be promoted from the strong level to the excellent level. In addition, it is expected that the TenneT, as the responsible actor for grid connection, continue his great commitment to connect new OWPs to national grid.

- **Social aspects**

From *social point of view*, the targets will be met if investors have enough motivation to involve and invest in deployment of new OWPs. This is the main issue of this MSc project; sustainable stimulating of investment in new OWPs in the Netherlands. As mentioned during this study, implementation of proper policy instruments is needed to stimulate investors (Dutch power companies). Beside this, it is expected the entrance of foreign rivals in order to increase competition in this field. This implies that some complementary regulations should be provided by regulators, but this issue is not related to this study. Changing public perception in order to motivate the Dutch people to be optimistic and supportive about power generation from OWP could be the second expectation which leads to support successful implementation of policy instruments. Increasing total costs for power production from conventional fossil fuels resources in the Netherlands is expected to increase stimulating investment in development of OWP projects. This could be realized by imposing more tax on electricity generation from conventional fossil fuels resources (as complementary regulations) however this issue is not directly related to subject of this study. The fourth and the last related issue (expectation) is that policy-makers, as responsible actor for designing and implementation of policy instruments, promote their commitment and intellectuality to design the most proper support systems to stimulate investors to invest in new OWPs as much as possible. Shortly, from actor perspective, committed and intellectual regulators have a crucial role to stimulate investors by designing and implementation of proper policy instrument. This shows the interaction between actor and institutional dimensions (Fig. 3.6).

- **Institutional aspects**

As the last dimension of Socio-technical Systems (STS), from *institutional perspective* it is expected that provision of some proper support systems causes stimulating of investment in new OWP projects to meet planned objective up to 2023. As mentioned earlier, for designing and implementation of more sustainable support systems a new assessment could work. Also as mentioned at above paragraphs, it is expected some complementary regulations (the second layer of the four-layer model of Williamson), as imposing more tax on electricity generation from conventional fossil fuels resources or *Wind Farm Site Decision*, are needed to increase the degrees of success of implementation of the given policy instruments. In addition, creation of public support environment (Optimistic about the OWPs) through education and campaigns, as new informal norms (the forth layer of the four-layer model of Williamson) is another expected progress in seven years forward. However, in theory, it is difficult or even impossible to create or to change (new) informal norms (Fourth layer) in short time.

Table 4.4 illustrates current and desired (expected) situations regarding the designing and implementation of policy instruments to develop new OWP projects, as a socio-technical system (STS), in the Netherlands.

Table 4.4. Socio-technical dimensions regarding OWPs in the Netherlands

STS components	Potential situation (resources)	Current situation	Desirable situation (objectives)
Technological	3000 Twh technical potential in 2030[49]	376 MW in Nov. 2016	6500 MW in 2030

[49] EEA Technical report, 2009 - Europe's onshore and offshore wind energy potential: An assessment of environmental and economic constraints – European Environment Agency

	Knowledge development		At strong level	At excellent level
	Commercial maturity of OWP technology		In progress	Enough (supported) commercial mature
	Grid connection		Guaranteed by TenneT	100% of OWPs connected to the national grid
Social	Developers/investors		Huge power companies are available without enough stimulating for development of the OWP projects	Stimulated power companies to invest in the OWP projects or entrance of foreign rivals
	Financial agents		Available	Available but depend on economic situation
	Regulators		Designed and implemented support systems, but not met targets (unsuccessful policy-making)	More commitment to design new or improve current policy instruments
	Public (the Dutch power consumers)		No enough optimistic of OWP, then no enough want and support from them	More optimistic and supportive
Institutional	Layer 4: Informal institutions (e.g. Norms, values, etc.)		Bad perception of the OWP as a RES-E technology	Optimistic about the OWPs
	Layer 3: Formal institutions	EU level regulation(s)	Renewable Energy Directive 2009/28/EC	The current RE Directive is transparent and accepted by EU member states
		National level regulation(s)	The Offshore Wind Energy Law	More effective and efficient policy instrument(s) with consideration of equity
			Support systems	
	Layer 2: Formal and informal institutional arrangements of STSs		Rules such as Wind farm site decisions	Streamline the development of OWP projects
			Contracts such as guarantee grid connection by TenneT	Secure contract terms Greater transparency of the remuneration scheme
	Layer 1: Actors and games in STSs		Hardly (ever) companies contract to deploy OWP	Contract to deploy OWPs

For new assessment, the most important issues those have role in implementation of support systems will be discussed. Performance of policy instruments to stimulate investment in OWP projects depends on relevant future prospects and (uncertain) events, related preconditions, and the design of policy instruments. This new assessment establishes evaluation frameworks to substantiate the main evaluation framework.

4.2.2. Analysis of findings

Description and analysis of all of findings during this study will be addressed in the next paragraphs. The qualitative information resulted from the assessment of every instrument on those four identified criteria will be analyzed and described separately.

4.2.2.1 Investment subsidy

The direct investment subsidy, as a price-based support system, is implemented in order to subsidize a part of investment in promotion of electricity generation from RES-E technologies. This is implemented in some EU member states such as Germany and Finland. In Germany, implementation of this policy support (combined with FiT) led to installation of PVs under *the German 1000 roofs and 100,000 roof-top PV program*.

In the Netherlands, the investment subsidy is implemented under *the first Dutch policy phase (1990-1995)*. This policy instrument did not lead to meet targets (installation of new RES-Es) because of two main reasons. Firstly, there was a mistake regarding to design of policy that the subsidy was granted to distributors and not to investors/developers. The political uncertainty (liberalization of electricity market) was the second reason of this failure. Liberalization of electricity market forced changes in the economic support system. After that there is limitation for direct intervention (e.g. financing OWP projects) by the Dutch government.

For analysis of this support system, we look at qualitative scores (−−−/+++) of the four recognized criteria regarding this alternative (Table 4.5). In theory, providing certainty for investors and relatively effectiveness are two strength points of investment subsidy according to the MCA measurement (Table 4.2). To understand the reason(s) of the lack of success of this policy to stimulate investing, it is crucial to look at this support system and its relevant issues from investors' point of view.

- Effectiveness

Although, theoretically, this policy instrument brings certainty for investors needed for increasing of effectiveness, but practically those are not realized in the Netherlands (Table 4.5). As mentioned earlier, political uncertainty was one of the reasons to fail this support system. This confirms that political uncertainties can counteract the support systems' inherent property. Therefore, it is considerable that policy makers provide political certainty beside efforts to increase the inherent certainty of economic policy instrument.

Table 4.5. Structure of Investment Subsidy's performance regarding the case of stimulating investments in OWPs in the Netherlands

Alternatives (Policies)	Criteria				
	C1. Effectiveness	C2. Efficiency		C3. Certainty for investors	C4. Equity
		Dynamic	Static		
A1. Investment subsidy	0	0	0	++	0 (conditional)

- Efficiency

Case study confirms that the implementation of the investment subsidy, in the Netherlands, does not lead to static and dynamic efficiency (Table 4.5). But it could result in dynamic efficiency in term of technology improvement, if developers' surplus be allocated for investment in R&D. Direct subsidy does not stimulate innovation especially in the deployment phase of OWP. The grant only helps investors to overcome the barrier of high initial investment in OWP projects. This subsidy usually covers a part of eligible investment costs in deployment step.

- Certainty for investors

Providing certainty for investors is one of main inherent features of investment subsidy, as policy instrument, to stimulate investment in non-economic projects such as deployment of OWPs in the Netherlands (Table 4.5). This is confirmed by under *the German 1000 roofs and 100,000 roof-top PV program.* Of course this certainty depends on the national (or global) political certainty as seen in the case of the Netherlands. Implementation of this policy failed due to the liberalization of the Dutch electricity market. It is expected, under a stable political environment, *investment subsidy* provides needed certainty for investors.

- Equity

There is any information to confirm that implementation of investment subsidy leads to some extra costs and ills or benefits to the given involved actor. But the way of payment to finance this support scheme could lead to some extra costs to some groups. In other words direct payment through the electricity bills results in some extra costs for low income families while financing this policy through tax (by tax-payers) does not cause this problem. Briefly, equity depends of the way of payment for financing this policy instrument. For this reason, this criterion is scored on "0", and it mean this policy has no inherent impact on equity (Table 4.5).

4.2.2.2 Feed-in Tariff

Feed-in Tariff is almost the most frequent support system investigated and implemented in EU countries and in the Netherlands (under MEP, SDE and SDE+). Following paragraphs include analysis of Feed-in Tariff in relation to effectiveness, efficiency, certainty for investors, and equity. For analysis of this support system, again we refer to qualitative scores (−−−/+++) of the four recognized criteria regarding this alternative (Table 4.6). Literature study shows that providing certainty for investors and effectiveness are two strength points of investment subsidy according to the MCA measurement (Table 4.2).

- Effectiveness

Implementation of Feed-in Tariff under MEP, SDE and SDE+ leads to relatively significant increase (From 19 MW in 1996 to 357 MW in 2015) in deployment of capacities from OWP in the Netherlands. But according to comprehensive definition of effectiveness[50], implementation of FiT under three programs was not effective. Because as mentioned earlier, it is expected that 6000 MW of offshore wind capacity to be realized by 2030 in the Netherlands (EWEA, 2011). It is almost

[50] "The effectiveness indicator measures the relation of the new generated electricity within a certain time period compared to the corresponding potential of the technologies" (Haas; et al., 2011).

twenty times bigger than new capacity of OWPs which is realized. It demonstrates that implementation of FiT in the Netherlands was not effective to increase the deployment of new capacity of OWPs in relation to the additional potential (6000 MW). Moreover, implementation of FiT did not realize the predetermined objectives by the Dutch government in 1995, to develop 1500 MW OWPs in 2010 (CBS, 2008). Therefore, it is scored by only "+" (Table 4.6).

Table 4.6. Structure of performance of FiT regarding the case of stimulating investments in OWPs in the Netherlands

Alternatives (Policies)	Criteria				
	C1. Effectiveness	C2. Efficiency		C3. Certainty for investors	C4. Equity
		Dynamic	Static		
A2. Feed-in Tariff	+	+	0	++	0 (conditional)

From a theoretical point of view sufficient compensation has role to determine the effectiveness of Feed-in Tariff. And from practical point of view, as Harmelink et al. (2006) says, availability of needed budget is the necessary preconditions for achieve the theoretical effectiveness (Table 4.7).

Table 4.7. Checklist on effectiveness of Feed-in Tariff

Type of instrument	Theoretical effectiveness	Actual effectiveness
Feed-in Tariff	• Sufficient compensation ✓	• Availability of needed budget ✓*In phase I (MEP) budget was finished after 3 years* ✓Enough and available budget under SDE (€ 9 billion) and SDE+

It is interesting to analyze this failure. Howbeit there was enough budget to support OWP projects, but developers did not invest in it. This demonstrates that investors' reluctance to invest in OWP projects is not because of policy instrument's features and (pre)conditions. Therefore, it is logical looking for exogenous parameters affected effectiveness of FiT during implementation of MEP, SDE and SDE+. Moreover, it is important to look at the issue from investors' point of view to investigate the reasons that cause to lack of desired effectiveness anticipated by implementation of those policy instruments.

Up to now, as mentioned above (Table 4.7), there were sufficient budget for compensation, but it did not lead to desirable results (high actual effectiveness). In other words, availability of needed budget does not lead to effectiveness necessarily. Maybe it is a necessary (pre)condition but it is not enough. Since main investors are the Dutch energy utilities (e.g. Eneco, Nuon, etc.), therefore it is useful to understand their perspective(s) upon investment in OWP projects, as one RES-E technology, and other projects. Although those energy companies try to show off their concern to develop green electricity projects, but more crucial is for them to sustain and to increase their market share. Therefore, they look for the most efficient power technologies to generate electricity in the most efficient way as much as possible. They generate electricity from cheaper sources such as natural gas and coal. It implies that they need long-term support that guarantees compensation of extra associate costs regarding generation power from OWP technology in order to sustain and improve their market share. Specifically, investors need support not only for deployment phase of the OWP but also need it during the operational phase. This support could be financial (guaranteed buying power) or technical (support grid connection). It shows that effectiveness from policy-makers' viewpoint is perceived efficiency and certainty from developers' perspective.

Therefore, *Long-term commitment for compensation extra costs* and also *availability of needed budget* by reliable actor (government) could be a way to ensure investors to invest in OWP projects. Developers need guarantee about selling generated power from OWPs which is more expensive than electricity from some other resources (e.g. fossil fuels). Hence, it is very crucial that the Dutch government provides relevant policies to ensure their long-term commitment for buying generated power from OWPs (RESs), and availability of enough budget for compensation for extra costs associated to electricity generation from OWP. In addition, *guaranteed connection to national grid* is necessary for developers to ensure them that they could supply their generated power at every time especially at peak wind energy generation. Briefly effectiveness depends on relevant certainty for investors.

Huge capacity of OWPs leads to decreasing of electricity price (according to merit order). Low electricity price results in drop of income needed to cover costs, especially fixed costs. This also threats power generation from usual resources such as natural gas and coal. Because these sort of usual plants do not drive for a lot of time at peak wind power generation, and they could not cover their costs (fixed costs). Then they hesitate to invest in OWP projects.

As conclusion, *Long-term commitment for compensation extra costs, availability of needed budget, guaranteed connection to national grid,* and *portfolio management* are four elements those determine the degrees of effectiveness of one given support system.

- Efficiency

In the Netherlands, implementation of Feed-in Tariff was neither dynamic efficient nor static. Under the MEP, a constant fee (9.7 €cent/kWh) was allocated for support OWP projects during those five years (2003-3007). This implies that this policy did not lead to decreasing of the amount of economic support during implementation. Hence, according to definition of dynamic efficiency, it is not relatively efficient because implementation of FiT did not lead to cost reduction. Cost reduction usually is achieved through technological improvement and innovation which lead to development of more efficient technologies (more efficient OWP). Dynamic efficiency regarding FiT is scored "+" (Table 4.6) due to some technological improvement through learning by doing. About static efficiency, since it is very difficult to determine the least possible cost for policy makers, therefore it is not possible to discuss about static efficiency of FiT under the MEP in the Netherlands. Therefore, static efficiency is scored "0" (Table 4.6). Moreover, as another undesired consequence of FiT implementation in this period, the costs needed for the FiT got out of hand (CBS, 2012).

Under the SDE, the subsidy payment increased from 6.9 to 7.4 per unit, thus could conclude that implementation of this policy instrument (Feed-in Premium) did not result in dynamic efficiency (cost reduction) regarding development of OWP projects in the Netherlands. Again, regarding static efficiency, lack of valid data and information (the least possible cost for policy makers) causes that determination of static efficiency is not possible.

In both cases (MEP and SDE), although technical innovations tends to raise the producers' surplus (Fig. 2.15), but due to availability of the constant grant, they are ensured that there is enough grant for electricity generation from OWP, as an expensive RES-E technology. Hence, this did not stimulate developers to be in quest of *technological innovations* (by invest in R&D) in order to reduce costs. This implies that the availability of budget (the availability of the constant grant), as a precondition, has a paradoxical role wherein it leads to certainty and accordingly to effectiveness but at the same time it reduces efficiency. A reduced rate of grant could be as a suggested way for stimulating developers to improve the technology while at the same time they are ensured that policy instrument supports them to cover extra associated costs. Briefly, it is expected that a reduced rate of FiT could lead to dynamic efficiency.

Regarding static efficiency, less efficiency of FiT in case of OWP projects is due to relatively flat shape of the wind energy cost curve at the present stage. Because of this distinctive feature of OWPs, a small variation in the FiT proposed results in substantial increase in the quantities of power generated and consequently in the amount of budget needed for grants. Therefore, the costs needed for the policy instrument (FiT) got out of hand (CBS, 2012). Applying policy cost control regarding Feed-in Tariff is almost impossible. Because of intermittent electricity generation from OWP (or other RES-Es) which cannot be anticipated for adjustment quantities, and consequently to control the costs.

It is noteworthy to mention that efficiency from policy-makers' perspective depends on commercial maturity of given technology, OWP in this case. Since usually the most improvement of the commercial maturity of given technology will be occurred in the R&D phase, therefore subsidy to R&D phase is more efficient than subsidy to deployment phase. Then the phase which subsidy be offered is determinant.

Briefly, a *reduced rate of allocated grant* is one suggested way *to* increase dynamics efficiency. Also it is important to consider the phase which subsidy is rewarded. Since support systems are implemented in the deployment phase, the awarded subsidy does not result in improvement or innovation of RES-E technology. Therefore, this does not lead to promote dynamic efficiency. Moreover, static efficiency is influenced by the flat shape of the wind energy cost curve.

- Certainty for investors

Theoretically, FiT provides high certainty for investors (Table 4.2). In the Netherlands, a constant fee (9.7 €cent/kWh) for support led to ensure developers there is enough money to compensate their costs (Table 4.6). This implies the implementation of the FiT reduced the relevant market risks. And also, as discussed earlier, in general the FiT brings political and market certainty for investors. Of course this depends directly on the existence of an institutional commitment by government (political risks' reduction) to development of electricity generation from OWPs. The commitment is needed for the duration of operational life of the technology. Then it is expected that under a long term commitment by the Dutch policy-makers FiT system could bring up a relatively high certainty for investors.

- Equity

Consideration of equity, as social dimension of support systems, depends on the way those policy instruments is financed. In other words, it is important that the financing of those policy instruments do not resulted in extra costs and ills for public. Then it is scored on "0" that implies the FiT has not impact on equity inherently (Tables 4.6). Up to now, in the Netherlands, the financing of the FiT has not led to extra (new) costs for the Dutch consumers. For this reason, it is important to recognize that the associated costs are passed on ratepayers or taxpayers.

4.2.2.3 Tradable Green Certificates as a "competition-based" system

The Tradable Green Certificates (TGCs), theoretically, has a number of advantages such as:

- It is compatible with the EU treaty rules
- It relies on market mechanism for resource utilization, and technology choice. This system provides a considerable level of security (depending on design)
- It ensures static efficiency that electricity is generated and sold at minimum cost
- It stimulates innovation as a result of the competition

In Europe, the TGC system is implemented for the promotion of RES-Es in general not only for the diffusion of OWPs. It is in force in Belgium, Italy, Poland, Romania, Sweden, and the UK (Haas et al., 2011). The actor who has to demonstrate the compliance with the obligation varies in these countries. In Italy the producers, in Sweden the end-users, and in four other countries suppliers have to demonstrate the compliance with the obligation. In all of these countries the most economic RES-E technologies are promoted by the implementation of this support system. In other words cheap RES-E technologies survive in this competitive based system. For instance, in the UK the cheap options biomass co-firing and hydro were among the dominant options.

The TGC is implemented in the Netherlands under SDE+ system. Following paragraphs include analysis of the TGC in relation to effectiveness, efficiency, certainty for investors, and social equity.

- Effectiveness

Up to now, by implementation of the TGC in the Netherlands, any new OWP capacity is deployed. For this reason, this criterion is scored by "_" (Table 4.8). From a theoretical point of view, enough demand for TGCs has role to determine the effectiveness of the TGC system. In addition, from practical point of view, trustworthy of certificates, and existence of penalties for non-compliance are two necessary preconditions for achieve the actual effectiveness (Table 4.9).

Table 4.8. Structure of the performance of TGCs regarding the case of stimulating investments in OWPs in the Netherlands

Alternatives (Policies)	Criteria			
	C1.	C2. Efficiency	C3. Certainty for	C4. Equity

	Effectiveness	Dynamic	Static	investors	
A3. TGCs	_	_	0	+	0 (conditional)

Table 4.9. Checklist on effectiveness of the Tradable Green Certificates

Type of instrument	Theoretical effectiveness	Actual effectiveness
Tradable Green Certificates	• Enough demand for TGCs *X*	• Trustworthy of certificates ✓ • Existence of penalties for non-compliance ✓

There were no enough demand for TGCs by developers for deployment of OWPs while two necessary preconditions for achievement of the actual effectiveness are existed (Table 4.9). Due to OWP projects must compete with cheaper RES-E technologies (e.g. biomass, onshore wind power) hence developers seemed reluctant to demand for TGCs in order to develop OWPs in the Netherlands. Of course, recently the Dutch authority decided to allocate separate budget for development of OWPs under SDE+. By this new approach, subsidies and permits for the deployment of the OWPs will be granted to the lowest bid that meets all criteria. Therefore, the competition is between developers of OWPs no between RES-E technologies.

- Efficiency

Theoretically, the main feature of this support system, as a quantity-based policy, is the stimulating of efficiency. But in the Netherlands, since implementation of the TGC did not lead to new OWPs, therefore there was no dynamic efficiency through learning by doing. Therefore, this criterion is scored by "_" (Table 4.9).

In general, TGC is a more market-based policy in comparison to other policy instruments such as the FiT, and it is compatible with the EU treaty rules. These recent mentioned features of the TGCs make it a proper option that does not exceed the EU regulations. The obliged stakeholder has role to determine the degree of success of this support policy. Determination of the quota target and deadline for it work to give horizon for implementation of the TGCs. Also involved RES-E technologies and determination of technology specific quota help to meet target. In other words some mature RES-E technologies do not allow less-matured RES-E technologies to be rewarded by subsidy, therefore it is better to introduce technology specific quota, as it is done recently in the Netherlands for OWP projects. In addition, designation of penalty (€/MWh) and yearly stepwise minimum limit (€/MWh) have role to lead to successful implementation of the TGCs.

- Certainty for investors

Implementation of TGCs could provide certainty for investors in the commercial mature RES-E technologies, while currently this policy instrument could not guarantee certainty for developers of OWPs in the Netherlands. Since there is no positive prospect for high progress in development of the OWP technology in near-term then it seems TGCs will not provide certainty for investors in short-term while the OWP must compete mature RES-E technologies for receiving grants. Unless the competition be between only OWP developers, as we see in the last years under SDE+ in the Netherlands. For this reason, this criterion is scored by "+" (Table 4.8).

- Equity

As discussed earlier, the same as other two policy instrument (FiT and Investment subsidy) equity depends on the approach used to finance the support system. TGC does not impact equity inherently and it is scored “0”. But it impacts equity if rate-payers pay for financing TGCs directly.

4.2.2.4 Tendering system

In EU, the tendering system is implemented in the 1990s in Denmark, France, Ireland, and the UK. Because of the poor effectiveness of this support system, those governments decided to change this policy instrument. The submission of unrealistic bid price, by developers, to secure a contract was recognized as the main reason for poor effectiveness and consequently lack of success to meet targets. In the Netherlands, this policy instrument is not implemented at all.

After this rephrasing of results from literature study and case study, as an overview of state of the art policy instruments for promotion of OWPs, the next paragraphs includes an effort to look at forward in order to identify one proper support system for diffusion of offshore wind farms in the Netherlands.

4.2.3. Future prospects and performance of support systems

The electricity market, as a dynamic, liberalized and competitive market, is really uncertain. It is full of uncertainties, unexpected events and consequently unexpected outcomes those affect implementation of policy instruments in future. Some of these events are illustrated under a Means and Map Causal Relations diagram depicted below (Figures 4.3; 4.4; 4.5; 4.6). These diagrams are developed to illustrate elaborated maps of causal chains in this system that connect means (four suggested policy instruments) to four identified criteria.

The causal map provides a good starting point for analysis to understand the contingent effects of means (policies) and/or external actors on other relevant actors and consequently on the four criteria. It is noteworthy to mention that some of external factors are recognized also as the institutional (internal) factors at the same time (e.g. Norms, Climate summit, etc.). These factors are distinguished by orange color. “+/-“ mean the effect(s) depends on specific situation of the factor. For instance, the effects of investment subsidy on technical innovation depend on the phase which grant is rewarded. If subsidy is granted in R&D it has positive effects on technical innovation. But in deployment phase it has negative effects on technical innovation. In this study, it is assumed that grant is awarded in the development phase, hence it has negative effect on technological innovation.

In this diagram the Dutch electricity market is assumed as the system boundary. As diagrams (Figures 4.3; 4.4; 4.5; 4.6) illustrate the factors, including future contingent events and uncertainties, decisions regarding the implementation of the given policy instrument are classified in two categories; external factors and socio-technical (internal) factors. The diagrams are clear, though it is noteworthy to say, the liberalized and integrated electricity market in EU is planned and almost all of EU member states follow it. Study by Moreno and her colleagues (2012) suggests that by liberalization and integration of EU electricity market the electricity price will increase in EU countries (Moreno et al., 2012). The price increasing is due to “the deployment of RES-E and with the expansion of greenhouse gas emissions produced by energy industries- as a European

Union CO_2 emission trading scheme exists" (Moreno et al., 2012). Next paragraphs include extensive description of causal relations regarding four policy instruments.

4.2.3.1. Investment subsidy

The four identified criteria are impacted by design and implementation of direct investment subsidy through a causal chain in the Dutch electricity market system (Fig. 4.3). Next paragraphs address the way investment subsidy impacts those four identified criteria.

- Effectiveness

As the diagram (Fig. 4.3) illustrates direct *investment subsidy* impacts on the degrees of effectiveness through two ways; increasing OWP developers' revenue and promotion of certainty for investors. Its impacts on certainty for investors will be quit now, and it would be discussed separately under certainty for investors, as a criterion, later.

By implementation of direct *investment subsidy*, financial grants will be offered. This results in increasing of developers' revenue. However electricity price also impacts on the level of developers' revenue. The level of developers' revenue has influence on the willingness of developers to invest in OWP projects. Investment in OWPs by developers is influenced by five factors directly. Three of them (green colored factors) are institutional factors (layers 1, 2 and 3) that could be elaborated during policy designing. *Bank interest rate* is an external factor and almost absolutely uncertain. The OWP developers' revenue is another factor that depends on three social factors. Developers' *green reputation* leads to attract more clients and consequently to more income. *Electricity price* is uncertain.

OWP developers' revenue will be increased by giving financial grants for OWP projects offered by investment subsidy. Of course financial grants for OWP projects also depend on commercial maturity of other RES-E technologies, national economic situation, and liberalization of electricity market. Liberalization of the Dutch electricity market does not allow offering investment subsidy which is interpreted as government intervention. This is the crucial point that implies implementation of the direct investment subsidy has institutional constraints in future. These all cause despite of it is a price-based policy instrument, effectiveness of investment subsidy is limited, and therefore it is scored by "+" (Table 4.10).

Table 4.10. Structure of the expected performance of Investment Subsidy regarding the case of stimulating investments in OWPs in the Netherlands

Alternatives (Policies)	Criteria				
	C1. Effectiveness	C2. Efficiency		C3. Certainty for investors	C4. Equity
		Dynamic	Static		
A1. Investment subsidy	+	+	0	++	0 (conditional)

- Efficiency

In general, by implementation of price-based policy instruments, such as *investment subsidy*, technical innovation would not be happened even it is barrier to technical innovation needed for (dynamic) efficiency (Fig. 4.3). Efficient power production directly depends on the *commercial* *maturity level of OWP technology* (Fig. 4.3). *Learning by doing* and *technological innovation* are two technical (internal) factors that impact the *commercial maturity level of OWP*. If the current trend continues (no significant development of OWPs) the learning by doing would not be happened, it is a positive loop as vicious cycle. Thus it is expected investment subsidy leads to limited dynamic efficiency through learning by doing, then it is scored by "+" (Table 4.10).

- Certainty for investors

As discussed earlier, certainty for investors is provided by decreasing political and market uncertainties. The *investment subsidy* decreases market risks directly by providing financial grants. Political risks could be reduced by regulatory certainty, secure contract term, the greater transparency of the remuneration scheme and some complementary rules which could be considered in designing of all of these four support systems. In other words, well-designing of policy instruments can lead to reduction of policy uncertainties. Of course certainty for investors could be substantiated by guaranteed grid connection. Briefly, investment subsidy could guarantee certainty for investors by companion of some complementary rules. Therefore, it has an expected score of "++" (Table 4.10).

- Equity

Equity, as the social-oriented criterion, depends on the way or method of payment for the policy instruments. In other words merely implementation of investment subsidy could not impact on equity (distribution of associated costs and benefits). Its impacts depend on designing of investment subsidy, as policy instrument, not implementation of it. Since typically policy instrument are financed through tax. This typical method of payment has any negative impact on equity. But payment through electricity bill that has directive impact on ratepayers could provide negative impacts on equity wherein that forces costs unequally on poor people. Hence, this criterion has score of "0" (Table 4.10).

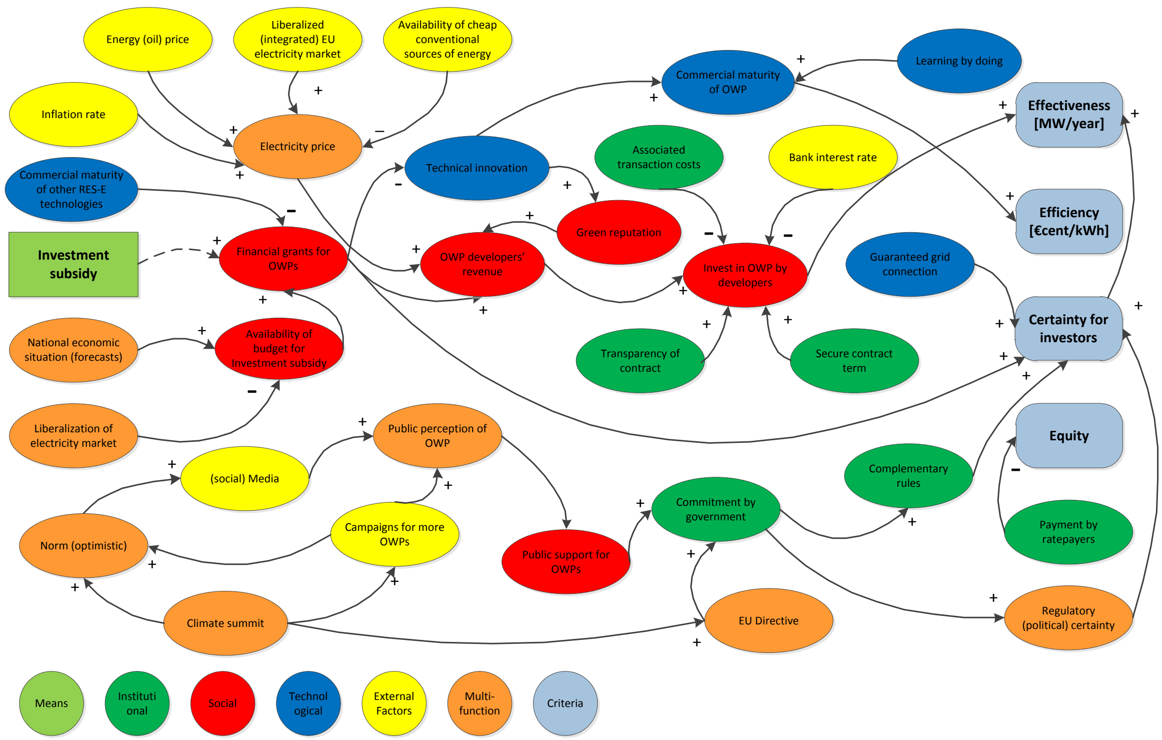

Fig. 4.3. Means and Map Causal Relations diagram regarding the "investment subsidy"

4.2.3.2. Feed-in Tariff

In next paragraphs, the anticipated performance of implementation of Feed-in Tariff in near future, in the Netherlands will be addressed.

- Effectiveness,

In theory and also from past experiences, it is expected that implementation of FiT, as a price-based support system, leads to relatively high installation of new OWPs even in short-term. But in reality, effectiveness depends on some other relatively uncertain events and activities (Fig. 4.4). Effectiveness is directly influenced by two factors; certainty for investors, and (willingness to) invest in OWP projects by developers. Certainty for investors would be discussed separately under certainty for investors, as a criterion, later.

Almost the same as discussed under investment subsidy, under implementation of FiT, investment in OWP projects by developers depends on five factors directly. Three of them (green colored factors) are institutional factors (layers 1, 2 and 3). Then it is expected that these factors could be elaborated during policy designing by policy-makers. *Bank interest rate* is an external factor and almost absolutely uncertain, influenced by some external factors (e.g. inflation rate, energy price etc.). Then it is almost impossible to anticipate it. Therefore, it is better that policy-makers use experts' opinion before designing new FiT. The OWP developers' revenue is another factor that depends on three social factors. By developers' *green reputation* it is expected those developers (power companies) attract more clients and consequently to more income. *Electricity price* is uncertain.

FiT increases OWP developers' revenue by rewarding financial grants for OWP projects. As Diagram (Fig. 4.4) illustrates financial grants for OWP projects depends on commercial maturity of other RES-E technologies and availability of allocated budget for FiT. And availability of budget depends on national economic situation, and liberalization of electricity market. In contrast to investment subsidy, offering grants through FiT is not interpreted as government intervention. Therefore, under the Dutch liberalized electricity market the Dutch government could implement FiT. This is the crucial point that leads to conclude that FiT is more effective policy instrument than investment subsidy to install new capacity of OWPs in the Netherlands. Therefore, it is expected it brings up high effectiveness and thus it is scored by "++" (Table 4.11).

Table 4.11. Structure of the expected performance of FiT regarding the case of stimulating investments in OWPs in the Netherlands

Alternatives (Policies)	Criteria				
	C1. Effectiveness	C2. Efficiency		C3. Certainty for investors	C4. Equity
		Dynamic	Static		
A2. Feed-in Tariff	++	+	0	++	0 (conditional)

- Efficiency

Efficiency, as the second identified criterion, directly depends on the *commercial maturity level of OWP technology*. *Technological innovation* and *earning by doing* are two technical (internal) factors that impact the *commercial maturity level of OWP* (Fig. 4.4). By implementation of FiT as a price-based policy instruments, technical innovation would not be happened, even it is barrier to technical innovation (Fig. 4.4).

If the current trend continues (no significant development of OWPs) the learning by doing would not be happened, consequently there is no technological improvement or innovation that leads to dynamic efficiency. It is a positive loop as vicious cycle. But it is noteworthy that fixed FiT, as a market-independent policy, could provide dynamic efficiency in near-term by promotion of learning by doing not through technological innovation. Fixed FiT provides lower market uncertainties and greater revenue certainty. Lower market uncertainties and greater revenue certainty encourage broader participation in OWP development and while providing a policy structure more conducive to leveraging large amounts of capital toward OWP deployment (Couture & Gagnon, 2010). Broader participation and leveraging capital lead to learning by doing as one of factors that increases commercial maturity of given RES-E. Therefore, FiT promotes efficiently power production by OWP, and gets score of "+" for bringing up dynamic efficiency (Table 4.10).

- Certainty for investors

Certainty for investors will be provided by decreasing of political and market uncertainties. Therefore, it is expected that by implementation of FiT, some associated market uncertainties arisen from development of OWPs, will be demolished. But political uncertainties could be reduced by some internal and external factors. Policy-makers could increase political certainty by well-designing of FiT (such as providing secure contract term) and also commitment to provide regulatory certainty, and some complementary rules. Of course certainty for investors could be substantiated by guaranteed grid connection. Thus it is expected FiT brings up relatively high certainty (++) for investors (Table 4.10).

- Equity

Equity is not impacted directly by implementation of FiT. However equity is influenced by the way or method of payment of the policy instruments. Typically FiT is financed through tax. This typical method of payment has any negative impact on equity. But payment through electricity bill that has directive impact on ratepayers could provide negative impacts on equity wherein that forces costs unequally on poor people. Hence, FiT gets score of "0" regarding equity (Table 4.10).

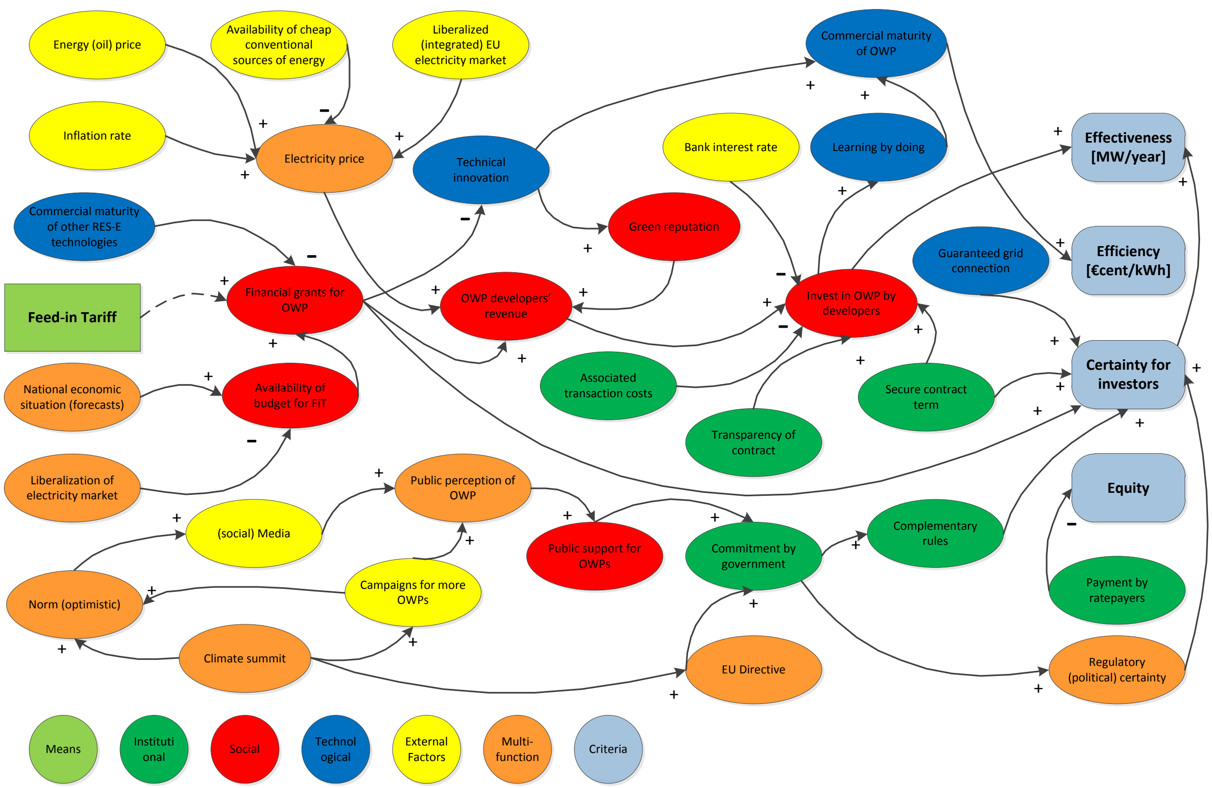

Fig. 4.4. Means and Map Causal Relations diagram regarding the "FiT system"

4.2.3.3. Tradable Green Certificates

As the main implemented quantity-based policy instrument, TGCs system is one main option to stimulate investment in OWP projects in the Netherlands. In following paragraphs, expected outcomes resulted by implementation of TGCs in the Netherlands will be addressed.

- Effectiveness

Under implementation of TGCs system, effectiveness, the same as the two mentioned price-based policy, depends on *certainty for investors* and the willingness of investors for *investment in OWPs*. The main difference is in the role of policy (TGCs) to increase developers' revenue. The increasing of OWP developers' revenue depends on commercial maturity of OWP and other RES-E technologies. Therefore, there is no guarantee that implementation of TGCs in future leads to more grants for OWP developers wherein OWP has to compete with other (mature) RES-E technologies for getting allocated subsidies. Accordingly there is no guarantee that implementation of TGCs results in new OWP capacities. But specific TGCs (competition for TGCs only between OWP developers) is one option to increase OWP by TGCs.

Table 4.12. Structure of the expected performance of TGCs regarding the case of stimulating investments in OWPs in the Netherlands

Alternatives (Policies)	Criteria				
	C1. Effectiveness	C2. Efficiency		C3. Certainty for investors	C4. Equity
		Dynamic	Static		
A3. TGCs	–	+	0	–	0 (conditional)

- Efficiency

Since dynamic efficiency depends on commercial maturity of the given RES-E technology (OWP in this study) implementation of TGCs does not increase the maturity level directly (Fig.4.5). It will increase maturity of OWP technology, if the OWP developers could receive grants in competition with other (mature) RES-E technologies. It implies, firstly OWP developers must increase OWP's maturity, if they want to receive subsidy. Therefore, the competition increases dynamic efficiency, not implementation of TGCs. In other words, implementation of TGCs promotes competition between RES-E technologies, and if OWP developers could win that competition, they could improve the OWP technology, and accordingly increases efficient power generation. For this reason, it gets score of "+" (Table 4.12).

- Certainty for investors

Theoretically and from experiences, it is expected that implementation of TGCs would not lead to increasing of market certainty. Therefore, this criterion gets score of "-" (Table 4.12). TGCs is a free market-oriented policy that does not commit to support developers. But policy risks associated with implementation of TGCs could be decreased by well-designing TGCs that provides secure contract terms. Also complementary regulations could decrease some associated political uncertainties. In addition, it is expected that commitment by governments leads to regulatory certainty which accordingly increase certainty for investors.

- Equity

As other earlier mentioned policy instruments, equity issues does not depend on merely implementation of TGCs, but equity could be influenced by designing of TGCs. If the budget needed for TGCs is provided by imposing associated costs on electricity bills, it leads to negative impacts on equity.

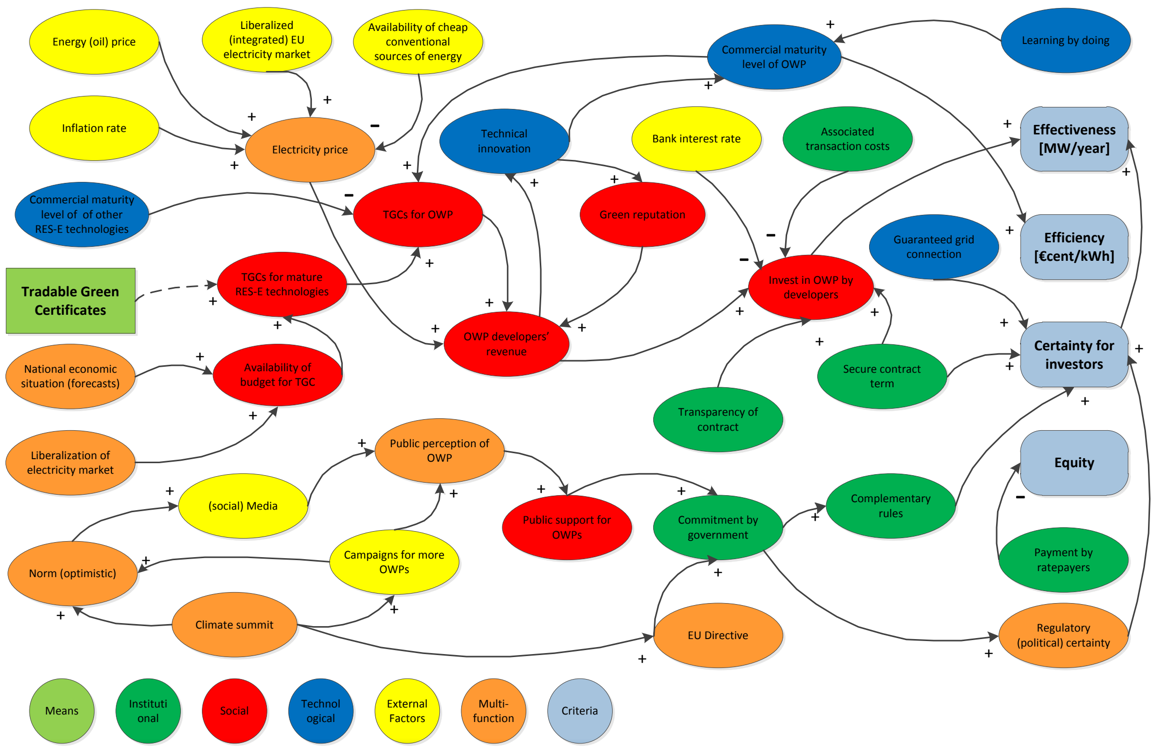

Fig. 4.5. Means and Map Causal Relations diagram regarding the "TGCs system"

4.2.3.3. Tendering system

- Effectiveness

The tendering system increases *investment in OWP* projects by *rewarded grants* that depends on *the commercial maturity of the OWP* (Fig. 4.6). Since it is not expected a huge progress in the OWP technology in the short term (up to 2023), hence this could not be proper option that leads to significant new capacities of the OWP in the Netherlands. Therefore, it has a score of "-" (table 4.13).

Table 4.13. Structure of the expected performance of Tendering System regarding the case of stimulating investments in OWPs in the Netherlands

Alternatives (Policies)	Criteria				
	C1. Effectiveness	C2. Efficiency		C3. Certainty for investors	C4. Equity
		Dynamic	Static		
A4. Tendering system	–	– –	0	–	0 (conditional)

- Efficiency

The *tendering system* is aimed at selecting the most cost-effective offers in each bidding round. Since it is not expected that OWP will be the most cost-effective RES-E technology in next near years, then it is almost impossible that OWP developers are awarded grants for investment for innovation or improve OWP technology (Fig. 4.6). Consequently those OWPs' developers could not generate power efficiently due to lack of improved OWP technology.

- Certainty for investors

As a quantity-based support system, it is expected there is no chance for OWPs' investors to win grants which is needed to cover associated market uncertainties. However political risks could be decreased by well-designed support system (tendering system) and by providing some relevant complimentary regulations.

- Equity

Implementation of tendering system threatens equity if needed budget would be imposed on electricity bills (payment by ratepayers). Then well-designed tendering system could overcome this challenge.

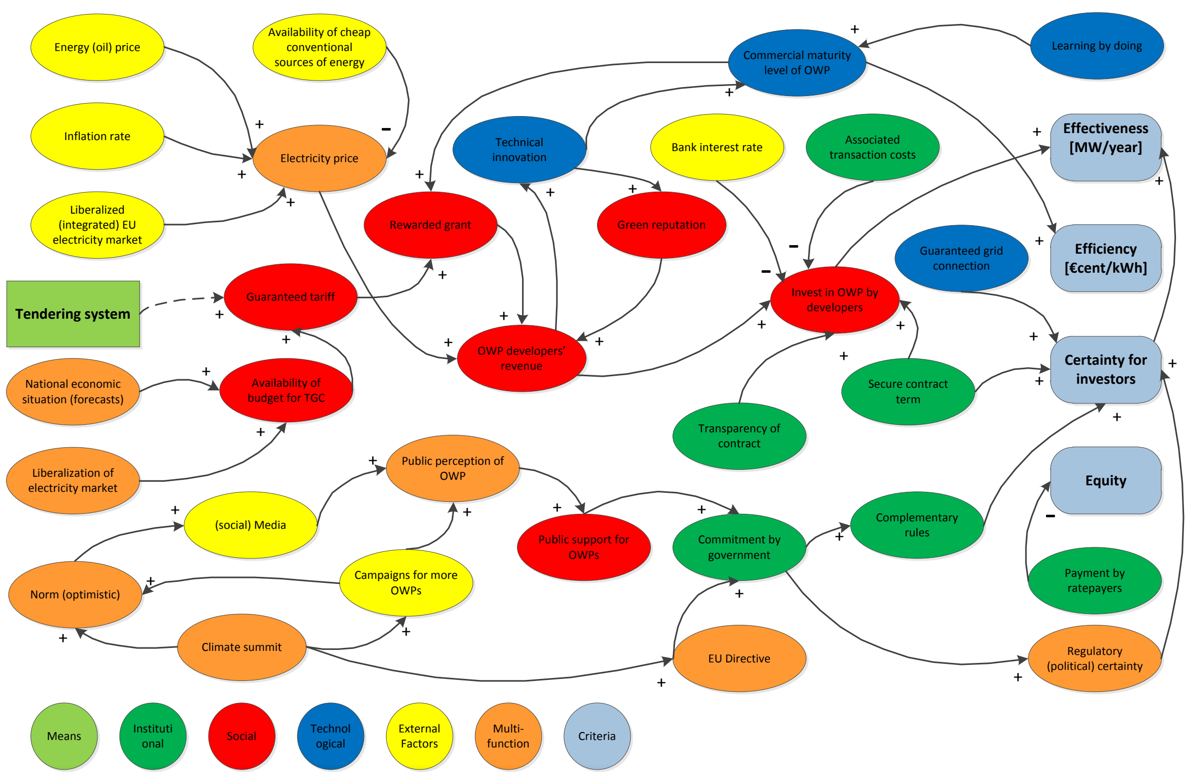

Fig. 4.6. Means and Map Causal Relations diagram regarding the "tendering system"

This discussion demonstrates that performance of policy instruments depends on some factors those could be influenced by support systems directly or indirectly. In other words policy instruments influencing criteria directly or indirectly through causal relations. Therefore, it is very crucial to address those related factor and consider them either during designing step or implementation phase of policy instruments. For this reason, it is suggested to consider those factors as (sub)criteria and then evaluate policy instruments on those sub-criteria beside the four main criteria.

Financial grants offered by policy instruments determine the ability of the given support scheme to stimulate investors to invest in OWP projects.

Commercial maturity of OWP technology is another factor that determines the degrees of success of implementation of the given support system. Especially by quantity-based (market oriented) policies, this factor is very definitive. Even by implementation of price-based policy instruments (e.g. FiT) the commercial maturity of OWP technology will be increased that consequently results in higher efficiency of the policy as one of the four main distinguished criteria.

Policy comfortability includes factors such as transparency of contract, secure contract term, and associated transaction costs. ***Policy comfortability*** could be elaborated during design of the given policy, whereas other two mentioned sub-criteria are intrinsic features of support systems.

Table 4.14: Structure of the expected performance of support systems regarding the case of stimulating investments in OWPs in the Netherlands

Alternatives (Policies)	**Criteria**		
	C2. Financial grants	**C3. Commercial maturity of OWP**	**C4. Policy comfortability**
A1. Investment subsidy	++	--	++
A2. Feed-in Tariff	++	_	++
A3. TGCs	0	+	+
A4. Tendering system	0	0	+

Table 4.14 illustrates that FiT has more ability compared to other three policy instruments to meet three recognized sub-criteria those have role in more successful implementation of policy instruments for stimulating of investment in OWP projects in the Netherlands in future. It is remarkable that these three sub-criteria are technological (Commercial maturity of OWP), social (financial grants) and institutional (policy comfortability) factors, as three aspects of a socio-technological system.

Moreover, it is considerable to note that the success of policy instruments' implementation depends on some external factors such as political certainty, (liberalized and integrated) EU/national electricity market, national economic situation, bank interest rate etc. All of them are almost uncertain and unexpected events. For these reasons, decision-making regarding selection of policy instruments becomes a task full of challenges.

Above discussion unfolds some important points. First of all, there is not one policy instruments to stimulate investment in OWPs while concern all of desired predefined criteria together.

As the second main recognized point, it is noteworthy to mention that the performance of policy instruments depends on designing of the policy. For instance fixed FiT and premium-in Fit, as two options of FiT, result in different outcomes and they match to different condition. It means that the selection of the appropriate support mechanism is not by itself sufficient and it must be supplemented by careful design phase and an appropriate implementation condition which will enable the given policy instrument to bring the maximum desired results.

Above analysis does not lead to a clear answer to our main research question; *the most proper policy instruments that stimulating investment in OWP projects in the Netherlands in effective and* *efficient and stable way while do not sacrifice equity*. Above analysis also shows that beside evaluation of policy instruments, it is important to consider relevant conditions and also implementation environment for selecting the most proper support system. In addition, well-designing of policy instrument has influential role for successful implementation of support systems.

4.2.3.4. Conditions

Also consideration of the role of conditions in performance of support systems is one subject matter that impacts the function of policy instruments. As mentioned earlier, existence of these conditions increases the success of support systems to meet objectives. The relevant preconditions are listed below in Table 4.15.

Table 4.15. Necessary preconditions for successful implementation of support systems

Policy instrument	Conditions
Investment subsidy	Availability of needed budget, Low interest rate
FiT	Sufficient compensation, Availability of needed budget
TGC	Enough demand for TGCs, Trustworthy of certificates, Existence of penalties for non-compliance
Tendering system	Favorable investment condition, Availability of enough bidders

The degrees of success of the implementation of a given support policy will be increased if there are as much as less external conditions which could not be managed by policy-makers. These factors (conditions) are not only more unexpected but also more uncontrollable therefore these could increase uncertainty. As Table 4.15 illustrates conditions for successful implementation of FiT are more internal factors those could be well-managed by decision-makers. While the other three policy instruments depend on some conditions those could not be handle (planed) by policy-makers easily. As table 4.15 presents, for instance in case of TGCs, enough demand for TGCs is determined by producers or suppliers within TGCs market. And TGCs market depends of some factors such as oil or coal price etc. These increase uncertainty that threaten achievement of objectives aimed by implementation of TGC.

4.2.3.5. Implementation environment

Implementation environment (in future) is another factor that determines the degrees of success of policy instrument to meet objectives. In this case, *political certainty, electricity market, bank interest rate, energy (oil) market*, and the *Dutch norms and perception regarding OWPs* shape socio-political environment that policy instrument has to be implemented in it. *Political certainty* could be guaranteed by the Dutch government commitment to the national and international environmental summits through diffusion of OWPs as one RES-E technology on time. *The liberalized (and integrated) EU and the Dutch electricity market* forces policy-makers to minimize their intervention. Therefore, the price-based policy instruments are not suggested while the quantity-based policies match the free market principles. TGCs system is the option could meet the free market objectives in case of implementation support systems for stimulating investments in OWPs in the Netherlands. *Bank interest rate* and *energy (oil) market* are uncertain and unexpected that lead to unpredictable revenue for investors. Fixed Fit is an option that has ability to ensure that investment in OWP projects will be profitable by creating a stable and reliable investment environment, one that provides predictable revenue streams over the course of the project's life. *The Dutch norms and perception regarding OWPs* could be well-managed by consideration of the Dutch concerns about OWP. For instance, the Dutch consumers think development of OWPs increases their annual electricity bill while by consideration of equity in policy instruments (tax-payers pay associated costs in place of rate-payers), policy-makers could rectify these concerns.

Based on the above discussion, from policy-makers' pint of view, in near future, the expected performance of those four suggested support system is weighed as illustrated in Table 4.16.

Table 4.16: Structure of the expected performance of support systems regarding the case of stimulating investments in OWPs in the Netherlands

Policies	Criteria					Stimulating invest in OWP by investors
	Effectiveness	Efficiency		Certainty for investors	Equity	
		Dynamic	Static			
Investment subsidy	+	+	0	++	0 (conditional)	+
Feed-in Tariff	++	+	0	++	0 (conditional)	++
TGCs	_	+	0	_	0 (conditional)	0
Tendering system	_	_ _	0	–	0 (conditional)	–

As Table 4.16 indicates all of four policy instruments have their own strength and weakness points. It implies that there is no one policy instrument to meet objectives in sustainable way. Then policy-makers not only must trade off between (contrary) criteria for selecting the more proper policy instrument but also they must consider implementation environment and necessary prepared conditions. Regarding static efficiency, since there is not perfect competition, and also transaction costs are not zero, therefore it is difficult to speak about static efficiency. Moreover, it is noteworthy to mention that equity is the only criterion that is not an intrinsic feature of policy instruments. Therefore, impact(s) of equity depend(s) on the design of implementation.

Since it is expected that OWP will not be enough commercial mature in near-time, thus policy-makers must know that by implementation of TGCs (SDE+), OWP would not win competition with more mature RES-E technologies. However the Dutch policy-makers solve this problem by a special TGCs that creates competition only between OWP developers. But even by this way, some OWP developers are excluded, then this decreases the number of OWP developers that accordingly leads to less development of OWPs. Consequently this causes that policy-makers do not meet their short-term objectives (6450 MW up to 2023).

If policy-makers prefer effectiveness, therefore it is suggested that they select Feed-in Tariff as policy instrument to stimulate investment in new OWP projects in sustainable way. Since the liberalized electricity market in the Netherlands is dynamic and is surrounded by an uncertain environment and context then one given FiT must be customized for its specific implementation environment and conditions.

It is expected, the Dutch government could promote performance of FiT by preparation of some desired environment and conditions such as (commitment to prepare) political certainty, sufficient compensation, availability of needed budget. It is noteworthy to repeat that conditions for successful implementation of FiT are more internal factors those could be well-managed by the Dutch decision-makers.

This qualitative analysis comes to end at the conclusion; evaluation of performance of suggested support systems on four criteria and three sub-criteria confirms that one improved and adjusted FiT system is more proper policy instruments that could stimulate investment in OWP projects in the Netherlands in next near-years if some conditions, such as political certainty, are existed. In other words, in the near-time in the Netherlands, among those four policies Feed-in Tariff is the only one could stimulate investors to invest in OWP projects in the Netherlands by providing enough certainty for investors at relatively effective and efficient approach from policy-makers' perspective while consider equity, as relevant, social aspect (Table 4.16).

4.3. Recommendations

Regarding the above discussion in this section, there is not one suitable support system to perform in sustainable way (considering social and economic concerns), but policy-makers could prepare some conditions to design proper policy instrument which will be implemented successfully in its expected specific implementation environment.

This study makes clear that among four suggested policy instruments, Feed-in Tariff (FiT) and Tradable Green Certificates (TGCs) were be implemented in EU and in the Netherlands more than others. But implementation of these two support systems did not meet objectives.

In the Netherlands, implementation of the all of implemented policy instruments has resulted in only 975 MW up to 2017. This implies it is almost impossible to meet the targets, 6450 MW in 2023. Therefore, the Dutch policy-makers must accelerate the process of OWP development by some new improved and/or adjusted policy instruments. It seems that high effectiveness of support systems is achievable at the expense of efficiency. In other words, price-based policies in comparison to the quantity-based policies are more effective to stimulate investment in new OWP projects in near-time (up to 2023), but not in high efficient way. Among price-based policy instruments, FiT is more effective than investment subsidy in such dynamic and uncertain environment that the Dutch liberalized electricity market works within. Briefly, if the Dutch government really wants to meet its objectives regarding OWPs in near time, this study recommends policy-makers to prefer FiT which has more ability than TGCs to stimulate investors to invest in new OWP projects in near-time.

By consideration of expected environment in the Dutch electricity market (up to 2023), policy-makers must prepare desired conditions such as (commitment to prepare) political certainty, sufficient compensation, availability of needed budget, and guaranteed grid connection. Beside this condition preparation, policy-makers should design a customized FiT.

Well-designed policy instrument is an important issue that impacts the performance of given support system. Well-designing depends on the time of implementation, specific RES-E technology and desired objective. Up to now, FiT meets most of desired criteria except it could not meet liberalized market conditions such as no intervention by government. During design phase, policy-makers could design the premium-in Feed, as a market-dependent FiT, that has a higher compatibility with the liberalized electricity markets than Feed-in Tariff. This compatibility is due to the remuneration changes with market demand. Moreover, the premium amount can be modified according to technology type and the level of commercial maturity of the given RES-E technology (e.g. OWP) during the implementation.

As recommendation, policy-makers can integrate the strengths of both methods of FiT (fixed and premium-in feed) within one dual support system that sets cap and floor values for premium amount. By implementation of this combined policy framework, investors could sell generated electricity from OWP into the spot market while benefiting from a variable premium payment which is limited by establishment of a cap and floor on the total premium amount. The premium could be adjusted each fifteen minutes depending on the spot market price and the cap and floor values. Introducing of the cap and floor also expands the predictability of future revenue streams for generators (investors). In addition, this combined approach increases the probability that the total remuneration will remain broadly cost-based over time. Moreover, it motivates OWP owners (developers) to produce electricity in times of high demand. Lack of proper cap values leads to overcompensation (when the electricity price rises quickly), that accordingly decreases the efficiency of policy. On the other side, an inappropriate floor value increases market risks for producers. This market risk threatens the certainty for investors and accordingly decreases effectiveness of policy.

Since it is expected that over time, OWP technology will become mature from the market and also technology point of view, therefore a gradual change from the dual system to only a premium FiT is suggested in this transition period. In addition, premium value will be decreased gradually in order to minimize the cost of implementation (efficient implementation). If policy-makers could determine a proper value for the premium then this system also results in high efficiency.

As the last point, it is recommended for equal distribution of associated costs, reimbursement be done through state budget in place of cost imposition on electricity bills. This leads to consideration of relevant social dimension regarding implementation of support systems for stimulating of investment in development of new OWP projects.

Next chapter includes the sustainable way for implementation of the already recommended policy instrument.

CHAPTER 5
The design of new policy instruments to enable "Responsible Innovation" in OWP

In Chapter 4, the analysis of policy instruments' performance was conducted, taking also into account other exogenous parameters apart from the four performance evaluation criteria. The conducted analysis confirms that one improved and adjusted (dual) FiT system (digression and stepped tariff) could meet expected objectives. The way to implement the recommended policy instrument will be discussed in this chapter. Also in Chapter 2 (literature study) and Chapter 3 (case study) it was confirmed that the proper way for design and implementation of given policy instrument depends on consideration and involvement of relevant stakeholders. This increases public acceptance of policy instrument. Public acceptance will guarantee the successful implementation of the given support system.

In a democratic and culturally pluralist country, such as the Netherlands the better attuning of technological (policy) development to societal needs and values is one of the main objectives of technological (relevant policy) implementation. The introduction of OWP in the Netherlands can be expected to lead to significant, often unforeseen and sometimes negative consequences – in terms of the cost of electricity, the loss of environmental value, the ills for other sectors (e.g. Fishary) etc. The negative consequences lead to negative impacts on some stakeholders which will result in conflicts. Negative impacts could be classified in two main classes; "primary" impacts and "secondary" impacts. Some of those impacts are;

- Primary negative impacts:
  - Environmental damages
  - High capital costs (installation costs)
  - Navigational difficulties
- Secondary negative impacts:
  - Higher electricity costs
  - Inconsistent power generation
  - State subsidy in terms of policy instruments (governmental intervention)

"Responsible Innovation" is a proper approach to discuss and anticipate consequences of the action (policy-making in this study). The anticipation gives insight for the better attuning of technological (policy) development to societal needs and values. This works for policy-makers to promote development of OWPs in more sustainable way by consideration of relevant societal needs and values. Therefore, in this chapter, "Responsible Innovation" will be integrated in the process of policy-making pertaining to the promotion of OWPs.

5.1. Responsible innovation as an approach

The term "responsible innovation" has a history stretching back over fifteen years (Owen et al., 2012). This term "responsible innovation" is aimed at addressing the wider dimensions of science, technology and innovation and calls for greater public engagement with science and technology

(Owen et al., 2012).   Since 2010, “responsible innovation” has also emerged in EU policy discourse (Owen et al., 2012).

The literature suggests several definitions of responsible innovation. Von Schomberg defines responsible innovation as a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society) (Stilgoe et al., 2013). Moreover, in responsible innovation, possible impacts (consequences) of the proposed (or current) action (e.g. novel policy-making or new RES-E technology) will be identified. Owen et al. (2012) mention that “responsible development of a technology can be characterized as the balancing of efforts to maximize the technology’s positive contributions and minimize its negative consequences" (Owen et al., 2012). Those impacts include first order and higher order impacts. Those identified impacts have to be assessed by several methods. Environmental Impact Assessment (EIA), Social Impact Assessment (SIA), Health Impact Assessment (HIA), Gender Impact Assessment (GIA), and Risk Assessment are some of methods developed to identify and assess the future consequences of proposed action (vandePoel, 2014).

5.2. New support systems and responsible innovation

Von Schomberg (2012) argues the successful adoption of major public policies increasingly depends on how the anticipated impacts are perceived by the various stakeholders (Schomberg, 2012). Von Schomberg also mentions that a systematic use of impact assessments and foresight will pave the way for a framework for responsible research and innovation (Schomberg, 2012). In other words, early impact assessment of ethical and societal issues could either foster responsible innovation or even lead to rejection of a project.

Based on the earlier introduction, and referred to that sort of responsibility which tries to anticipate and mitigate adverse implications or unintended consequences, design and implementation of an improved and adjusted (dual) FiT system, means the balancing of efforts to maximize positive contributions of the policy (technology) and minimize its negative consequences. This implies a commitment to develop and use technology for helping to meet the most desirable human and societal needs. This leads to illustrate these concerns in a new situation or questions; "How can the implementation of a new support system (for instance: an improved and adjusted (dual) FiT system) result in the maximum positive social impacts and minimum negative social impacts?"

The impacts of an improved and adjusted (dual) FiT system could be categorized in two main categories; ”primary” impacts and “secondary” impacts.

- Primary Impacts:
    - Increasing certainty for investors
    - Increasing of electricity costs

- Secondary Impacts:
    - Stimulating new investment in new OWP projects (increasing effectiveness and dynamic efficiency)
    - Deployment of new capacity of OW Ps (increasing effectiveness)
    - Increasing (potential) unfair distribution of associated ills and benefits such as inequity (disproportionate distribution of ills on (low-income) households), overcompensation and under-compensation for OWP developers.

All of these above listed impacts are social-oriented impacts, therefore among the methods for impact assessment the method of "Social Impact Assessment" (SIA) is selected in this study.

5.2.1. Social Impact Assessment (SIA)

"Social impact assessment is defined as the process of identifying the future consequences of a current or proposed action which are related to individuals, organizations and social macro- (Becker, 2001). Becker (2001) identifies three types of SIA: micro, meso, and macro. These three types are analyzing impacts on individual and their behavior (the micro-level), organization and social networks (the meso-level), and national and international social systems (the macro-level) (Becker, 2001).

The design and implementation of an improved and adjusted (dual) FiT system is a proposed action at the social-macro level, hence the type of macro-social impact assessment is suggested for identifying and analyzing of future consequences/impacts. Adopting scientific procedures is needed to help the Dutch government (policy-makers) for designing and implementation of that support system more efficiently.

Those above mentioned consequences (primary and secondary impacts) of new FiT implementation impact public values of different involved actors, such as end users of electricity (Dutch consumers), investors, and the Dutch governments. This makes necessary to get an insight into public values pertain to design and implementation of a new dual FiT system.

5.2.2. Public values

Public values have an individual nature (Correlje. et al., 2015). As Correlje et al. (2015) say "public values reflect preferences of different, sometimes competing, groups in society regarding welfare, well-being, safety, equity, etc. in a given society and at a given time" (Correlje. et al., 2015). Distributional justice, procedural justice, security of supply, sustainability, environmental values, safety, profit making are some public values associated with OWPs (Correlije et al., 2015, Kunneke et al., 2015). Some of those relevant values and needs are addressed in this study as criteria for evaluation of support systems. These values are suitable for normative evaluation of OWPs (technical design) and policy instrument (institutional design). Table 5.1 indicates the consequences of FiT implementation and their impacted values.

Table 5.1: List of consequences, impacted values and criteria related to implementation of future Fit

Consequences	Impacted value	Source of values	Criteria (Norm)	Impacted actors
Huge budget	No market intervention	Law	Efficiency	Government
More certainty	profit making	Stakeholder	Certainty for investors	Investors
Unfair distribution of ills and benefits	Distributional justice	Ethics	Equity	Public

5.2.3. Stakeholders Involvement

The successful implementation of the new policy instrument depends on public acceptance. Responsible innovation not only demonstrates the social responsibility of innovators but also does enlarge acceptance of innovation by users, governments, public and other directly and indirectly involved stakeholders. Also responsible innovation refers to the acceptability of innovations according to some normative standards such as public values, law, ethical theories, law etc. Responsible innovation discusses procedural issues and product issues. Procedural issues include transparency, accountability and stakeholders' involvement. Product issues reflect deeply held public values such as human welfare, human safety, honesty, etc.

New designed Fit and its impacts on stakeholders and their values

Table 5.1 indicates that implementation of new designed and suggested FiT system brings up three main consequences; huge budget, more certainty for investors, and unfair distribution of ills and benefits (Table 5.1). In next paragraphs these three expected consequences are discussed in detail.

- **Huge budget**

As the first, it is expected that implementation of a dual FiT system needs a huge state budget. This causes that the Dutch government overlooks one of his important values (no market intervention) and intervenes in the Dutch liberalized electricity market. Stakeholder involvement could convince the Dutch government to overlook his value and allocate budget for implementation of FiT. The Dutch government will be stimulated to overlook this value if he/she understands that public (the Dutch people) want to develop OWPs and accordingly they support market intervention. Also positive reaction from developers motivates the Dutch government intervene liberalized electricity market.

- **More certainty**

Also by stakeholder involvement, policy-makers find out main feasible value for investors, and how they could guarantee that value. Profit making as one of main values for investors will be guarantee by implementation of a priced-based support system, as FiT, that brings up high level of certainty for investors.

- **Unfair distribution of ills and benefits**

Moreover, stakeholder involvement in primary steps causes that public have chance to discuss about their concerns, such as unfair imposed costs, which are impacted by implementation of new designed FiT system. They could discuss and argue that imposed associated costs on electricity bills bring up inequity in term of disproportionate distribution of ills on (low-income) households.

5.3. Political Technology Assessment (PTA) as method for responsible policy making

Since this study investigates the process of designing and implementation of the given support systems, procedural issues are the focal issue in this study. Among procedural issues, mentioned earlier, stakeholder involvement (engagement) will be the central issue. Several tools and approaches are suggested for early involvement of stakeholders including Socio-Technical Integration Research (STIR), Network Approach for Moral Evaluation, Value Sensitive Design (VSD), Constructive Technology Assessment (CTA), Political Technology Assessment (PTA), etc. (Doorn et al., 2013).

These methods and approaches might be applied at five different levels; the individual, the project, the organization, the technological sector, and the society (Figure 5.1). Also those approaches could be distinguished between various phases of development including fundamental research, research and development (R&D), innovation, and design (Figure 5.1).

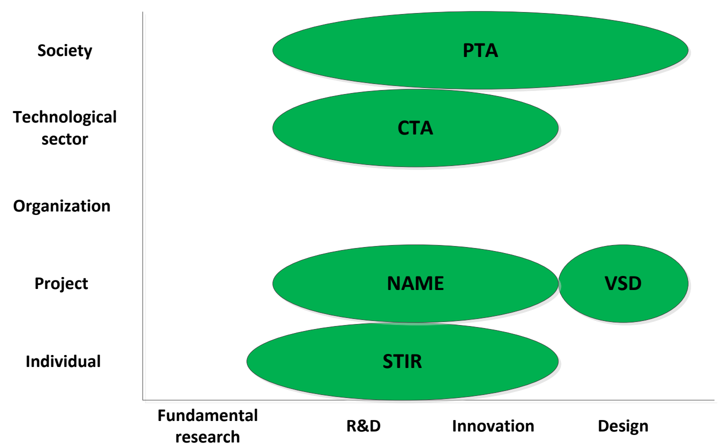

Figure 5.1. Levels and phases of institutional and technological development (Adapted from Lecture Responsible innovation)

This study discusses policy-making at the level of society. Therefore, Political Technology Assessment is selected as the appropriate approach in this study (Figure 5.1). PTA approach suggests political actors should be involved in some phases of technology development, such as R&D phase or design phases (Doorn et al., 2013). And this method mentions that political actors (government) will not intervene in technological development, but they aim at engaging more with technological issues, therefore they will not focus on one specific phase of technological development (Doorn et al., 2013). PTA suggests that communicative skills and the capacity to create an atmosphere of trust are very important (Doorn et al., 2013).

It is noteworthy to mention that PTA is originally an approach for technology assessment, but in this case this approach is applied analog for policy regarding one RES-E technology. In other words, design of a policy instrument, as a formal rule, is an institutional design and will be addressed by the PTA that is an analog with technological design.

As we mentioned beforehand, potential unfair distribution of costs and benefits is one of anticipated problems from the development of a new FiT. Thus the Dutch government in the first step should prepare an atmosphere full of trust, and invite involved actors (e.g. developers, local residents, NGOs) to come and discuss about development of this technology. The Dutch governments also should communicate with industry in order to understand what happens in (renewable) energy sector regarding this issue. It helps the government to anticipate relevant impacts, and to provide standards and regulations during design or for implementation phase. This helps to identify the main values concerned by involved actors.

5.4. The design of a new FiT system (institutional design)

The challenge is to design policy instruments in ways to bridge the diversity in involved actors' values. An ex-ante investigation helps anticipating (un)expected public values and perceptions and also social, environmental and technological impacts. For this, Political Technology Assessment approach is applied for designing of new support system in context of new institutional design for OWP-promotion. The next paragraphs include the institutional design in detail.

5.4.1. Current Institution (situation and problem)

As a learning and also preparation field for several participants in the (renewable) energy sector, a foundation for the Promotion of OWP will be established. Installing 6450 MW OWPs is one of the most important goals of this foundation OWP-Promotion. It will support the installation of new OWPs by realizing new national support systems (FiT) aligned with current national and EU regulations, ethical and economic regulations.

Current situation

Up to 2017, only 975 MW OWP is developed in the Netherlands using the TGCs as the support policy. This is far from the planned objective, which is the development of 6450 MW OWPs by 2023. The Dutch Ministry Economic Affairs plans and implements support systems almost without collaboration with other stakeholders. Therefore, the Dutch policy-makers could establish the OWP-Promotion.

By the OWP-Promotion, it is aimed at announce the collaborative policy-making. The most important thing for OWP-Promotion is to utilise the dependencies of the strategic players in the network and create a "win-win" situation between them. By this, policy-makers apply PTA approach and try to create an atmosphere full of trust, and invite involved actors to come and discuss about providing new support system for increasing development of OWPs. They could create an atmosphere of trust by cooperation with involved actors; due to "trust lubricates cooperation and cooperation builds trust" (Walker et al., 2010). Hence, the Ministry announces the invitation, and involved parties could come and discuss about the new proposed policy instrument. Energy companies, (social and environmental) NGOs will be the main stakeholders come into discussion. Besides that gathering for discussion, it is suggested that the OWP-promoter meets those stakeholders one by one separately. By these private sessions, stakeholders have opportunities to discuss what they could not in public gathering (due to privacy). This create environment for collaboration and accordingly leads to creation of an environment full of trust. Also these meetings and negotiation help to have a more clear insight into current situation and also leads to anticipation of potential future consequences. Beforehand, under social impact assessment, those likely impacts are discussed (Table 5.1).

After discussion, policy-makers analyze their findings from the discussion, and start to revise and redesign proposed new policy instrument. From social impact assessment and also from the investigation during this study, it is expected that policy-makers design an improved and adjusted (dual) Feed-in Tariff system, as new ambition.

5.4.2. The desired new institution design

The preparation sessions leads to identification of main actors, their values and interests, and future consequences of proposed policy instrument. Among new findings, it seems risk allocation of OWP development is necessary. The risk allocation of OWP development causes policy-makers to allocate the subsidy for most risky part of project. The most risky parts of projects are parts which are either commercial immature, such as support structure, collection and transmission (Table 3.8). Therefore, developers of these parts needs more certainty for support their activities. In addition, this decreases technical and market risks for investors, and this causes that the new institution encourages safeguarding profit making of investors. Based on this finding, the Ministry of Finance or a new actor (OWP-Promoter) could prepare knowledge for risk definition and analysis, and also monitor the allocated subsidy (as feedback). All phases of development must be controlled by this new actor (as feedback).

Moreover, a fair distribution of costs and benefits would be considered seriously by a check and balance mechanism by The Netherlands Authority for Consumers and Markets during implementation of new FiT. In addition, an actor, Environmental NGOs (e.g. Waddenvereniging) controls environmental concerns and Noordzee Dienst supports and investigates safety for shipping and living sea. All of identified and involved actors and their interactions are indicated in Figure 5.2.

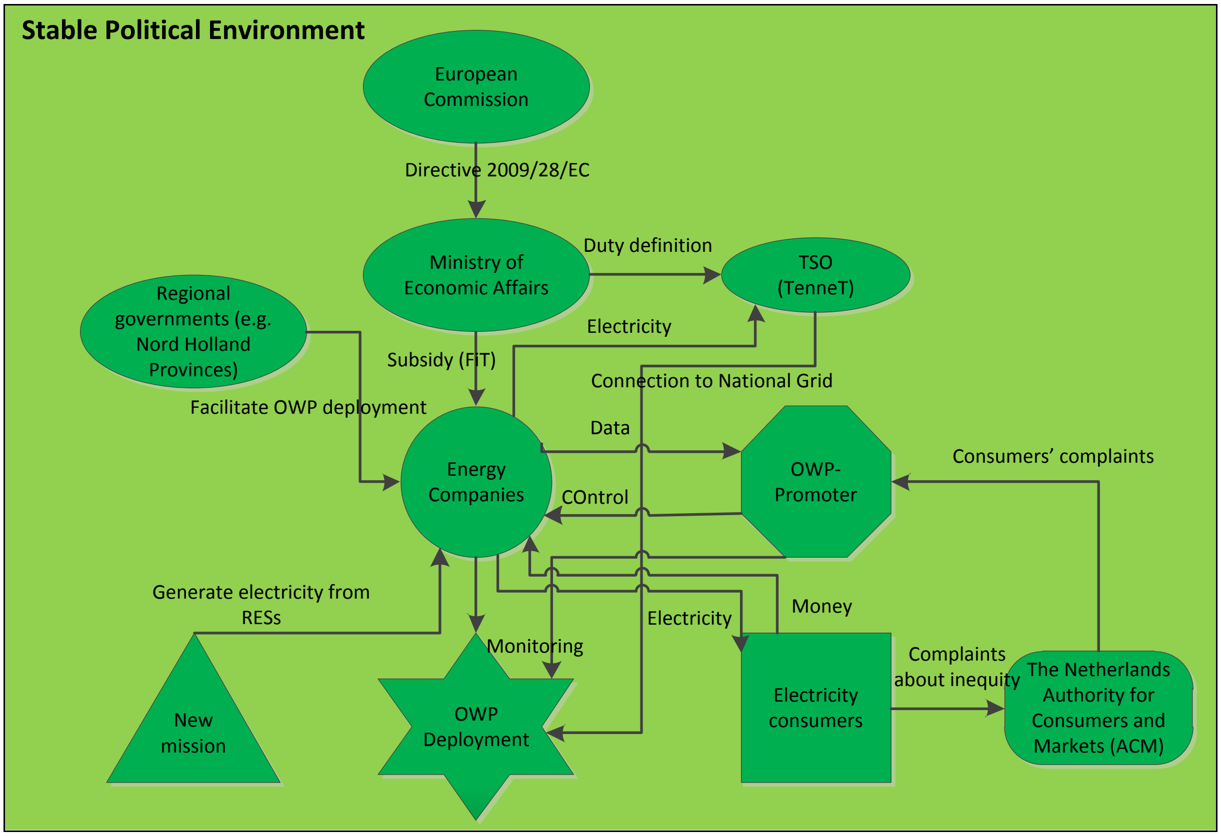

Figure 5.2. New Institutional Design for promotion deployment of OWPs in the Netherlands

Benefits and challenges new institutional design

By this new institution some benefits are expected;

- For investors
  - Safeguarding profit making by investors
  - Long term decreasing of electricity generation costs due to learning by doing
  - Reputation for companies because of power generation from RESs
- For Public (society)
  - More fair distribution of costs and benefits
  - More power generation from RESs
  - Job creation
- For regulators
  - Efficient spending of subsidy
  - More OWP development
  - Local development
  - Following EU Directives

Due to the new organization (OWP-Promoter), different challenges might rise. By acknowledging those, they can be taken into account in the process. The challenges are:

- A reinforcement of a hierarchical structure because of the extra actor

    - This actor should be acknowledged as important and in common interest
- Need for clear risk allocation:
    - Need for monitoring
    - Technical Control Mechanism should be set up for all phases of installation
- Coupling of actors for the setup of a single actor could be a challenge
    - Need for process approach and prioritizing actors influence
- Who pays for the new actor?
    - The government through the Ministry of Economic Affairs.

Network and process strategy for desired institution

In order to achieve the desired institutional design a network and process approach is applied. This approach leads to the identification of actors with Blocking power and Production power (de Bruijn et al., 2010): European Commission, The Dutch Ministry of Economic Affairs, Energy companies, and Consumers. For this reason, OWP-Promoter is established to invite them for discussion before finalization and implementation of a new support system (an improved and adjusted (dual) FiT). Under an atmosphere full of trust, those actors could collaborate for successful implementation of new FiT. This also helps to understand that there is room for communication, trade-off and finally "win-win" situation.

Optimizing design

For optimizing the design should meet desirable principles of institutional design according to Goodin's (1996) design requirements:

- **Revisability**: As the first requirement, deign must make sure that the policy (like the OWP technology development) is implemented incrementally. In that way the policy can be ***revisable*** (Goodin, 1996). OWP technology evolved gradually over time not only by innovations, but also through learning by doing. Subsidy should spend for more risky (immature) parts. Maturity of phases (technology) is evolved, then it is controllable and revisable to spend money for more risky (immature) parts.
- **Goodness in fit**: Goodness in fit is the second requirement. The new FiT should be adapted to the current EU regulations, and also liberalization of electricity market. For this reason, dual system is selected which is more compatible with liberalized market by applying premium-in Feed, as a market-dependent FiT.
- **Robustness**: New FiT, as a new institutional design must be capable of adapting to new situation. For example there will be a financial buffer to support OWP developers against financial crisis or natural disasters.
- **Sensitivity to motivational complexity**: Goodin suggests designs are desirable when they respect the admixture of motives that moves most people and be publicity defensible. For this reason, before finalizing of design (public gathering for preparation by OWP-Promoter) and before launching (by public announcement through mega and social media), the new FiT will be announced for public.

From responsible innovation point of view, the conclusion is that a successful design and also implementation of the proposed improved and adjusted Feed-in Tariff system depends on public engagement from early phases. Public involvement unfolds the bottlenecks which could make barriers or even block implementation. Public involvement leads to identification of (un)expected consequences which impact public values. Therefore, social impact assessment (SIA) is suggested to identify those expected impacts. And for a better design, Political Technology Assessment (PTA) is applied for creation of an environment full of trust to encourage involved stakeholders for collaborative institutional design.

CHAPTER 6
Conclusion

This chapter summarizes the key results of this thesis outlined in the previous chapters and discusses opportunities for future research.

6.1. Summary

This section presents the main conclusions of this study through addressing the research sub-questions pertinent to the research objective of this work.

Chapter 2 includes a literature study on economic policy instruments. It addresses this question: "*What are the most widely implemented economic policy instruments regarding renewable energies such as offshore wind power?*"

Why Support systems?

Deployment of offshore wind parks (OWPs) is one of the options for realizing renewable energy targets in the Netherlands. But since development of offshore wind parks requires snuck costs, therefore power utilities, as main power developers in the Netherlands, do not invest in new OWP projects. High investment requirements, as a barrier to electricity market, are a kind of market failure, and then governmental intervention is suggested to overcome this barrier. Government uses economic policy instruments (as public resources) to stimulate investors for investment in new OWP projects, as a RES-E technology. Economic policy instruments are used to overcome market barriers by supporting OWP technology financially in order to be competitive with more commercial mature technologies such as conventional technologies.

Which support systems, and how they work?

These support frameworks are based on two main approaches: price-based approaches (e.g. investment subsidy, Feed-in Tariff) and quantity-based approaches (e.g. Tradable Green Certificates). In price-based mechanisms, the authority sets the price (tariffs in FiT) and the quantity is determined by the market, while the quantity is set by authority and the price is decided by the market in quantity-driven schemes. In practice, FiT and TGCs are the most widely implemented policy instruments especially in the EU member states, such as Denmark, Germany, Spain, Sweden, and the UK. For a more comprehensive research, this study recommends investigation of *investment subsidies, Feed-in Tariff (FiT), Tradable Green Certificates (TGCs),* and *tendering system* to determine a proper support system for stimulating investments in OWP projects in the Netherlands.

Investment subsidy and Feed-in Tariff are two of the price-based frameworks. Investment subsidy is a price-driven support system, implemented to help overcome the obstacles of high initial investment by stimulating investment in less economical renewable energy technologies with long-term horizons for investment returns. Feed-in Tariff involves an obligation on the part of power companies to buy the electricity generated by renewable energy producers in their service area at a tariff determined by the public authorities and guaranteed for a specified period of time, typically 15-20 years. Tradable Green Certificates is a quantity-driven support mechanism which is a fixed quota of the electricity sold by operators on the market has to be generated from RESs, such as OWP. Tendering or bidding system, as another quantity-based economic instrument, calls for tenders to acquire specific amounts of capacity or generation from specified types of RESs.

Evaluation framework for selection of proper policy

Theoretically, each approach or policy has its own strengths and weaknesses (Table 6.1). Thus, an evaluation framework is needed for selecting a proper support system for investment stimulation. For designing a more comprehensive evaluation framework, thirty scholarly articles and books are reviewed in order to determine the most commonly applied criteria for assessment of policy instruments all over the world. Efficiency, effectiveness, certainty for investors and equity are not only the most used criteria, but also almost the most recently applied criteria for evaluation of both price-based and quantity-based support systems.

Table 6.1. The theoretical pros and cons of the four recommended instruments

Policy instruments	Strengths	Weaknesses
Investment subsidy	• Reduces market risks • Easy to understand and implement	• Leads to high administrative costs
Feed-in Tariff	• Decreases market risks	• Needs a good monitoring mechanism
Tradable Green Certificates	• Encourage competition • Relies on market mechanism for resource utilization, and technology choice	• Does not work for high cost RES-E technologies • High transaction costs associated with TGCs
Tendering systems	• Leads to the lowest cost option • The level of subsidies is controllable	• Actual cost may be higher than predicted

Equity as societal dimension of policy instruments

This study demonstrates that addressing equity, as a societal issue, allows for improving the current policy instrument in a more sustainable manner. Equity, consists of four dimensions: procedure, distribution, recognition and context dimensions. The procedural dimension addresses the degree of involvement and inclusiveness in decision making. Distributive equity discusses on the distribution of costs, benefits, burdens and rights derived from programs or actions. Recognition dimension considers the respect for values, societal norms and the rights of all involved actors in the design and implementation phases of conservation programs. Lastly, context encompasses the surrounding societal conditions that influence the actors' ability to achieve recognition, participate in decision making and lobby for fair distribution. This study focuses only on the distribution dimension of equity that pertains to design and implementation of policy instruments. The literature indicates that the equity aspects of policy instruments are not inherent to the support schemes, but largely dependent on its design. Therefore, it is possible for policy-makers to design support systems in such a way to adjust distribution of ills and benefits over different involved actors. Consideration of equity in terms of distributive justice into support systems leads to public acceptance and accordingly results in softly implementation of policy instruments.

In summary, the literature study in Chapter 2 demonstrates that high investment requirements disincentivize developers to invest in the development of offshore power park projects. These high investment requirements are recognized as market barriers or market failures. Therefore, governments should intervene in electricity market to overcome market barriers/failures pertinent to the development of RES-E technologies such as OWP. Among several price-based and quantity-driven support systems, FiT and TGCs are the most widely implemented support mechanisms all over the world. The theoretical debate between price-based and quantity-base policy instruments shows that policy instruments have their own strengths and weaknesses; thus, selecting a support system depends on policy-makers' priorities and implementation time and situation. This review demonstrates that the success of policies depends on political stability. In addition, as a remarkable point in this review, it is necessary to consider societal issues such as equity if policy-makers aim to promote OWPs in a more sustainable manner.

In Chapter 3, practical experiences in the Netherlands are discussed as a case study. In this Chapter the following question is addressed: "*What is the current state of policy instruments pertaining to OWP in the Netherlands*?".

The first part of this section addresses distinct features of offshore wind technology in comparison with other types of RES-E technologies. Relatively low commercial maturity, high capital costs and long lead-time are three of those distinct features. Those distinct features discourage power utilities, as main power developers in the Netherlands, to invest in OWP projects. Those features are recognized as market barriers or market failures, hence governmental intervention is needed. The Dutch government has started to design and implement policy instruments to promote RES-E technologies since 1990s seriously.

Although the Dutch policy-makers have designed and implemented several policy instruments for the promotion of RES-E technologies in the recent 25 years, but none of them has met the predefined objectives. FiT and TGCs are the two main policy instruments used in the Netherlands. Even though high effectiveness is one of the main inherent features of FiT system, implementation of FiT in the Netherlands has not led to effective development of OWPs. 1500 MW OWPs by 2010, only 957 MW has been implemented and supplied to the grid by 2017. Subsequently, policy-makers attempted to implement TGCs. General TGCs have not resulted in new OWPs in the Netherlands since OWP has been competing with more commercial mature RES-E technologies. Then they decided to improve that general TGCs by design and implementation of specific TGCs for only OWP projects. Although this improved policy has been applied recently, even though it is expected even this support system would not lead to efficient and effective development of new OWPs. In addition, some of OWPs' developers will be excluded as a result of implementation of specific TGCs, which can lead to less implementation of new OWPs.

This research demonstrates that equity is considered in the implementation of nearly all of the policy instruments in the Netherlands. The required budget for financing FiT and TGCs is allocated from the state budget. Hence, this policy would not impose unequal distribution of electricity costs on low income end-users.

To summarize, this case study leads to results that are aligned with the theory discussed in the Chapter 2 of this thesis. The case study also confirms that FiT is more effective than TGCs for promotion of an *immature* commercial RES-E technology (e.g. OWP), while in theory TGCs are more efficient than FiT, they could not stimulate investors to invest in OWPs. In addition, equity is a societal issue that must be considered in the design step.

Chapter 4 analyzes the results from the earlier. The four recommended policy instruments are evaluated in order to determine a proper support system. To this end, we asked the question "*Which policy instrument(s) could be promising future instruments for stimulating investment in OWPs in the Netherlands*?".

The Multi-criteria analysis (MCA) is applied to evaluate four alternatives (support systems) on four identified criteria. The evaluation elucidates that there is no single concrete policy instrument for meeting all of the four criteria. In addition, the analysis of outcomes demonstrates that some internal and external factors and elements can play a role in determining the performance of support systems. Moreover, the analysis illustrates that for successful implementation of policy instruments, policy-makers have to prepare some necessary conditions and also consider expected implementation environment (Table 6.2).

Table 6.2. The list of some necessary conditions and implementation environment for implementation of support systems

Policy Instrument	Necessary condition(s)	Implementation environment
Investment subsidy	• Low interest rate	• Guaranteed political certainty • Unexpected bank interest rate and energy (oil) market
Feed-in Tariff (FiT)	• Sufficient compensation,	
Tradable Green Certificates (TGCs)	• Enough demand for TGCs, • Existence of penalties for non-compliance	
Tendering systems	• Availability of enough bidders	

This analysis illustrates that *the amount of financial grants*, *the level of commercial maturity of OWP technology* and *policy comfortability* are the three key factors that determine the performance of policy instruments. Among the four support mechanisms, price-based support systems (investment subsidy and Feed-in Tariff) provide relatively higher financial grants and policy comfortability. Also, price-based policies can increase dynamic efficiency through learning by doing. On the other hand, Tradable Green Certificates can increase the level of commercial maturity of RES-E technologies through promoting competition between RES-E technologies. The analysis demonstrates that price-based policy instruments lead to increased market certainty, which in turn increases the certainty needed for encouraging the investors to invest in new OWP projects and consequently results in high effectiveness. Conversely, quantity-driven mechanisms offer financial grants to more mature and efficient RES-E technologies. This leads to exclusion of some immature RES-E technologies. In other words, quantity-based policies do not incentivize investors to invest in new immature RES-E technologies such as OWP at this moment.

This analysis also illustrates that Dutch policy-makers must realize that the high effectiveness of support systems is achieved at the expense of high efficiency. Therefore, FiT is more suitable for stimulating investment in the OWP projects. For illustrating the impacts of relevant elements on the performance of support systems, the Means and Map Causal Relations diagram is applied.

In conclusion, the analytical evaluation of the four recommended policy instruments suggests that an improved and adjusted FiT system is proper policy instrument that can stimulate investment in OWP projects in near-term (up to 2023) in the Netherlands. Clearly, the FiT system will be successful if policy-makers commit themselves to provide long-term political certainty (by creating regulatory certainty) in favor of promotion of RES-E technologies. Beside, policy-makers should prepare necessary conditions and consider expected implementation environment.

Ultimately, Chapter 5, addresses the last sub-question: *How could the responsible innovation be enabled in OWP development by implementation of the recommended policy instrument?*

Responsible innovation is advocated as an approach for sustainable and soft implementation of the recommended policy. It is expected that the implementation of the recommended policy instrument would result in some expected and unexpected consequences. Responsible innovation involves a trade-off between maximizing the technology's positive contributions and minimizing its negative consequences/impacts. In this approach, impacts would be evaluated by the Societal Impact Assessment (SIA) method. Consequences impact some people and their public values. Therefore, impacted actors and their public values related to the implementation of support systems are discussed in this chapter. This implies that the involvement of stakeholders is necessary for increasing the public acceptance of the technology, which is key to sustainable and successful implementation of policy instruments.

In the next step, stakeholder involvement is promoted by applying the Political Technology Assessment (PTA) method. This method suggests that communication skills and the capacity to create an atmosphere of trust are very important for responsible development of policies and technologies. The last part of Chapter 5 presents the design of a new dual FiT system, as an institutional design, by applying responsible innovation approach.

All of the above discussions laid the groundwork for tackling the main research question of this study: "*What economic policy instrument is the efficient, effective, and certain (providing certainty for investment) in stimulating investment in offshore wind power whilst not compromising equity considerations?*"

The major conclusion of this study is that there is not a single promotional scheme that can stimulate investment in OWP projects effectively and efficiently at the same time. However, proper design of the support system within a stable political framework will offer long-term investment continuity. In this case, an integrated FiT (fixed and premium-in feed) is recommended as an option for promoting OWP projects. This dual system starts with a fixed-FiT. A fixed FiT system creates great investment security for investors in OWP projects (relatively low mature RES-E technology). In addition, OWP deploying by fixed-FiT is cheaper than deployment by premium model. This lower cost is because of two reasons. Firstly, fixed-FiT creates lower risk investment condition. Also, fixed-FiT creates greater predictability of future cash flows. After some time, fixed-FiT will be replaced by premium system. Premium payment is offered on top of the electricity market price.

The premium will be adjusted every fifteen minutes (depending on the spot market price). The premium value will be decreased gradually. In addition, in case of a fixed premium, a cap and floor value will be set to overcome overcompensation and under-compensation. Premium FiT model can lead to a more harmonized electricity market. Also, a primary FiT system has the ability to remove effectively the difference between OWP and other mature RES-E technologies. This dual system can create market certainty in an efficient manner. Consequently, the created market certainty stimulates investors to invest in new OWP projects. This implies that a dual system can lead to high effectiveness (developing of new OWPs) in an efficient way.

This dual system not only increases investment in OWP projects, but also has a higher compatibility with the liberalized electricity markets due to the remuneration changes with market demand. Furthermore, the premium amount can be modified according to the technology type and the level of commercial maturity of OWP during the implementation.

For implementation of this dual system, as the first step, the Dutch policy-makers should determine the total lifetime of that dual system. Policy guarantees the support for the whole life cycle of the OWP. Typically, the life cycle of offshore wind park is 20 years in the Netherlands. Once the policy-makers determine the lifetime of the fixed-FiT and the value of fix tariff, they start to estimate and propose the value of cap and floor for premium. The premium value will fall yearly by x% for X (e.g. 5) years. This value drops to x+y% below the initial tariff up to the end of the lifetime of support.

This implementation will be sustainable by applying the responsible innovation approach. Responsible innovation creates trust (through cooperation) between involved actors in order to develop a policy that can maximize positive consequences while minimizing negative impacts.

6.2. Discussion and reflection

6.2.1. Discussion of results

In this part, results will be discussed in light of theories used, in order to clarify to what extend practical results/experiences are aligned with theory discussed in Chapter 2.

Discussion of findings by literature study

Four suggested policy instruments are characterized in relation to the classic discussion of price-based approaches versus quantity-based approaches. An investigation of the support systems implemented in the EU member states over the last 25 years for promotion of the deployment of RES-E technologies shows that the question of efficiency and effectiveness in the prices versus quantities are the main concerns. Theoretically Feed-in Tariff and investment subsidy, as price-driven policies, leads to more effectiveness by providing relatively high market certainty. Conversely, in general, quantity-based policies (e.g. TGCs and tendering system) result in higher efficiency through stimulating competition between RES-E technologies. These results are consistent with Menanteau et al. (2003) and Haas et al. (2004). These findings also imply that there is no policy instrument that could promote development of new OWPs effectively while brings up high efficiency. These results depend on regulatory certainty. Uncertain regulatory environment destroys the expected results from implementation of support systems. Therefore, long-term commitment by governments to develop RES-E technologies is the crucial point. This was demonstrated in case of Spain. Long term commitment by the Spanish government to RES-E technologies development led to significant deployment of RES-E technologies in Spain up to 2012 when they changed their policy. This result is supported by findings made by Couture and Gagnon (2010) that argue that a policy instrument is successful if governments commit to prepare and keep a stable and reliable policy framework. As the last noticeable point, it is noteworthy to mention that equity issue is not an inherent feature of support systems, but it relates to the way of designing one policy instrument. In other words, implementation of every policy instrument could lead to unequal distribution of associated costs and benefits. This is consistent with findings by van Dijk and his colleagues (2003). The literature demonstrates that FiT was (is) appropriate policy to promote RES-E technologies under long-term commitment of governments which leads to certain environment for investment in development of these renewable technologies. In Germany, implementation of FiT led to increasing of power generation from solar panels. Also in case of Spain, power generation from wind was promoted by implementation of a dual FiT system. Study shows implementation of that dual system brings up high effectiveness, high certainty for investors, and dynamic efficiency. Since the main research question of this study concerns stimulating of investment, FiT as a price-based instrument results in dropping of market risks (uncertainties) which is one of the most important elements that has negative impact on investors' decision about investment in novel technologies such as OWP. The financial support awarded by new recommended FiT system would be decreasing gradually over time to reflect cost reductions. This is in line with Sawin (2004), who argues that declining of fixed pays over time is needed to reflect cost reductions.

Discussion on results of case study

An examination of the policy instruments implemented in the Netherlands over the last 25 years to promote the development of OWPs demonstrates that practical results relatively aligns with theory. The case study indicates that inherent features of support systems are not the only factors that determine the performance of given policy instrument. The performance of policy instruments depends on some factors such as stability of the renewable energy policy. This is consistent with the study by Haas and his colleagues (2011) that mention "Continuity and stability of the renewable energy policy even under changing governments have contributed significantly to the success of this policy instrument" (Haas, Resch, et al., 2011). Effectiveness of price-based policy (investment subsidy) is destroyed due to uncertain political environment; liberalization of the Dutch electricity market in 1990s. The implemented FiT under the MEP and SDE did not lead to remarkable development of new OWPs (effectiveness) because of the Dutch utilities rely on huge availability of cheap natural gas resources in the Netherlands. In other words, effectiveness of policy instrument depends on energy (oil and gas) price. These findings are surprising in light of others' findings (Menanteau et al., 2003; Haas et al., 2004) and conventional logic that price-based policies increase effectiveness.

Regarding TGCs, implemented under SDE+, it was almost foreseeable that OWP, as a relatively immature RES-E technology, could not compete with more commercial mature RES-E technologies in the Netherlands. This finding is consistent with the study by Bergek et al. (2010) that mention commercial maturity of RES-E technology, as an external factor, has impact on performance of policy instruments (Bergek & Jacobsson, 2010).

Regarding consideration of equity, the case study results align with theory very well. If associated costs are imposed on electricity bill, it led to unequal distribution of costs on low income households. Otherwise (financing support systems via state budget) implementation of policy instruments did not result in unequal distribution of costs and benefits. It is consistent with van Dijk and his colleagues that argue equity aspects of support systems depend very much on their design, and they are not inherent to the support scheme itself (vanDijk et al., 2003).

This discussion highlights that certain environment and main-driver of policy-makers are two main points that have impacts on successful implementation of policy instruments. Liberalization of electricity market in early 1990s disrupted certainty environment which led to failure of implementation of the policy instrument at that time. In addition, efficiency from neoclassical economic was the main driver of the liberalization of electricity market, and it did not concern sustainability and environmental issues. These demonstrated that governmental long-term commitment to sustainable development of electricity market is needed for successful implementations of support systems to promote RES-E technologies. Moreover, study of implementation of policy instruments in the Netherlands illustrated that implementation of price-based support systems resulted in more deployment of OWPs than quantity-based policy instruments. This is due to (market) certainty which is guaranteed by price-based policies. Market certainty is needed to stimulate investors to invest in OWP projects as novel and immature RES-E technologies.

Discussion on results of analysis

The results of the analysis indicate that there is no single policy instrument to promote OWPs effectively and efficiently at the same time. This is consistent with study by Haas and his colleagues (Haas et al., 2004). However, the analysis demonstrates that although generally price-driven support systems leads to higher effectiveness (development of new OWP projects) than quantity-based support systems (Menanteau et al., 2003; Haas et al., 2004), willingness of investors to invest in OWP projects is crucial element that determines the effectiveness of given policy instrument.

The analysis is finalized by suggestion that a well-designed (improved and adjusted) dual FiT (combination of fixed FiT and premium FiT) under continuity of supportive political environment results in the most stimulating working environment for investment in new OWPs in near-term in the Netherlands. This is also mentioned by Haas et al. (2011) that promotional instruments which are properly designed within a stable framework and offer long-term investment continuity create better results.

The current implemented support system (especial TGC for OWPs) should be replaced by a dual FiT system. This new support system will be started by a fixed FiT for first five year after that premium tariff will support electricity generation from OWPs in the Netherlands. It is noteworthy to emphasize that governmental long-term commitment to sustainable development of electricity market is a decisive (pre)condition for successful implementation of this dual FiT system.

Sustainable development of electricity market implies that a paradigm shift is needed from neoclassical economics to institutional economics. In this paradigm shift, economic efficiency is not the focal concern. From an institutional point of view, informal and formal institutions must be considered or be elaborated for objective achievement. This consideration of institutions could help to find an appropriate way to stimulate "willingness of investors" to invest in OWP projects. This could be realized by some awareness campaigns to create social pressure to aware investors' willingness for investment in new OWP projects. Also provision of some complimentary regulations could stimulate investors to invest in OWP projects.

Discussion on sustainable way for new support system implementation

In analysis, it was clarified that a sustainable implementation of new suggested economic policy instrument depends on involvement of relevant stakeholders. For this reason, *responsible Innovation*, as an approach, is suggested to overcome that challenge. This stakeholder involvement increases public acceptance as one of the major reasons for successful implementation that was argued by Schomberg (2012). Therefore, it is suggested to establish a group (OWP-promoter) to invite those involved actors to gather and communicate for discussion about expected and unexpected consequences. By this gathering and communication actors with *Blocking power* and *Production powe*r will be identified. This aligns with network and process strategy for institutional design which is suggested by de Bruin and his colleagues (2010).

6.2.2. Reflection

In the course of conducting this MSc Thesis Project, some decisions have been made on how to advance this study. This part of Thesis reflects my opinion, as an external observer, on the discussed theory, the applied method and the gained practical results.

Reflection on theory

In general, this study was a contribution to wide controversial debate between two mainstreams of support mechanisms for promotion RES-E technologies; price-based and (vs.) quantity-based. The main focus was to assist the Dutch policy-makers (as problem owner) in finding a way (implementation of a support system) to stimulate investment in OWP projects in the Netherlands in the most sustainable way. For this, four policy instruments are suggested for investigation in order to identify the most common evaluation criteria. The conducted review confirms that in theory price-based policies lead to more effectiveness through providing more market certainty for investors, while quantity-based instruments are more efficient from policy-makers' point of view. These outcomes depend on the extent to which the long-term continuity of policy certainty is committed by governments. Therefore, it is important to include *long-term political stability*, as an extrinsic feature, in new evaluation frameworks. This implies that proper institutional regulation has influence on the performance of policy instruments. Furthermore, consideration of implementation environment and preparation of some conditions (complimentary regulations) is needed for gaining predefined objectives through implementation of policy instruments. In other words, consideration of factors such as efficiency and effectiveness aligns with neoclassical economics, but for more comprehensive investigation of policy instruments, it is suggested to consider institutional economics as the underlying theory. Under institutional economics, we will consider involved actors, their interests and interaction between them and the institutional context which fold all of those activities and interactions. This stakeholders' involvement and consideration of public values during policy implementation also support responsible development of OWPs.

Moreover, the literature study shows, equity is not an intrinsic feature of policy instruments, but in design phase must be considered if policy-makers want to provide sustainable policy instruments. This gives confidence to me to say that the degrees of success of implementation of the given policy instrument depend on not only intrinsic features of that policy but also the design of the policy determines the degrees of success of that policy. Therefore, distinguishing intrinsic and extrinsic features must be considered in future studies.

Reflection on methods

During this study, three methods were applied in order to answer the main research question: literature study, case study, and multi-criteria analysis. Literature study and case study are used to investigate policy instruments used for promotion of RES-E technologies in general, and specifically for OWPs. Also, multi-criteria analysis (MCA) is applied to conduct evaluation of suggested policy instruments on some identified criteria. Moreover, responsible innovation was considered as an approach for sustainable implementation of suggested new support system and accordingly for development of OWPs in a sustainable way.

Literature study was an appropriate way to get insight into discussion on support systems from a theoretical point of view. Through literature study, practical experiences in other countries were reviewed. This lightened the strengths and weaknesses of implemented support systems. Overview of Spanish case was a starting point for formulation of suggested dual FiT system in this study. Also, case study was very useful to elucidate the main reasons of unsuccessful implementation of policy instruments in the Netherlands. Combination of literature study and case study demonstrated that successful implementation of support system is not forever. Therefore, monitoring and evaluation systems are needed for diagnosing of potential or actual defects.

Multi-criteria analysis (MCA) is used to evaluate performance of policy instruments through quantification of qualitative criteria. This method is used due to all of four identified criteria have the same level of importance. There were other methods, such as Multi-criteria decision analysis (MCDA) for evaluation of several options. From a government point of view and for the long term sustainability of renewable energy support system, all economic, environmental and social dimensions of support systems have the same level of importance. Then we could not prefer one dimension at the expense of other one. With the MCA method, all evaluation criteria have the same level of importance (Janssen, 2001). Also by applying the MCA method, quantification of one qualitative criterion such as equity was possible. Therefore, this method was preferred to quantitative ranking for determining policy-makers' preferences for selecting policy instruments. The weighted summation is selected as the tool for applying MCA method for consistent assessment of four identified alternatives.

Briefly, multi-criteria analysis (MCA) is an appropriate method for evaluation of performance of policy instruments (alternative) across a range of four economic and social criteria. This method was used because it was important to participate policy-makers to meet criteria which have the equal weights. For this reason although this method is criticized that is prone to manipulation, but it is the proper method for assessment in strategic level. Therefore, in future studies that limitation of quantitative data is existed. However this method is the option could be used for participatory evaluation of alternatives in strategic level.

Responsible innovation is appropriate approach to increase public acceptance as a main factor for successful implementation of new support system. Public acceptance means new policy and new developments take public values including economic, social and environmental concerns which make three main dimensions of sustainability into account.

Reflection on practical results

This study implies that the Dutch policy-makers should change the current implemented support system, specifically SDE+ for OWPs. FiT is addressed as the most proper support system that is expected to bring anticipated outcomes. Before implementation, they have to get a comprehensive insight into relevant environment (context) in future short-term and necessary conditions for successful implementation of policy instruments.

In addition, this study demonstrates that the policy-makers' priority has role in determination of proper policy. If they prefer efficiency to effectiveness, selected policy will change totally. Also mutual interactions between actors and factors and also existing causal impacts demonstrate the complexity of work. For instance, actors' perspective determines the given weight to given policy instrument while actors' point of view is influenced by past results (of already implemented policies), implemented environment, etc. These remind us that neoclassical economic is not a proper underlying theory for looking at policy instruments in energetic societies, as the Dutch society. Instead institutional economics is the worthy underlying theory to discuss this issue.

As the last point, this study illuminates that "political stability" and "willingness of investors to invest" must be considered as the main and crucial point for stimulating investment in new OWP projects. Therefore, it is helpful to ask policy-makers to commit themselves to stability of regulatory environment. And also, it is necessary to invite investors to participate in evaluation process, this would be a new issue which should be investigated in future studies.

Results of this evaluation (by using new developed evaluation framework), will be elaborated in the next paragraphs to share with responsible policy-makers, under recommendations.

6.3. Recommendations and future studies

6.3.1. Policy Recommendations

Up to now, although implemented support systems were price-based and quantity-based, they have not met planned objectives. The reasons and also causes of these failures come back to the inherent features of implemented policies and also the exogenous factors and/or events. For instance, the lack of consideration of implementation environment or preparation of necessary conditions, and also political uncertainty are identified as three reasons of this failure. For these reasons, an evaluation framework is developed in order to improve the process of selecting policy instruments.

Under new developed performance evaluation framework, evaluation of suggested policy instruments demonstrates that the current implemented policy instrument (specific TGCs for

OWPs) does not lead to near-term objectives regarding development of OWPs in the Netherlands (6450 MW up to 2023). This new evaluation framework shows although there is no one concrete support system to achieve objectives in sustainable way, it is expected that by preparation of some necessary conditions, and with consideration of expected implementation environment a combination of Feed-in Tariff and premium FiT will work better than other options to meet near-time objectives regarding development of OWPs in the Netherlands in a sustainable way. Sustainable way means consideration of economic, environmental, and social aspects at the same time without compromising one aspect over another aspect. The main objectives of a future support system are addressed in the following paragraphs:

Systematic increasing of investment in development of OWPs: As mentioned earlier the lack of investment in OWP projects results in no significant development of OWPs in the Netherlands. The current unfavorable investment environment (market failure) will not change unless governments intervenes and adequate stimulants are given to investors (financial support). This financial support leads to market certainty which is needed during deployment phase and operation (selling) phase. By this governmental intervention, the government will ensure that the introduced policy instrument creates the needed market certainty.

Control the support costs in moderate level (efficiency): Sustaining the total costs to achieve the targets as low as possible is very crucial for policy-makers and tax-payers/end users who pay the needed budget. This could be realized by fine tuning and adjustment according the evolution of technology cost or by a gradual change from the dual system to only a premium FiT.

Investment certainty: This could be created by reducing market and political uncertainties. Reducing market uncertainties is discussed earlier. The political certainty will be created by long-term commitment to diffuse OWPs, as one RES-E technology, and also by some complimentary regulations (eg. wind farm site decisions (kavelbesluiten)). Moreover, guaranteed grid connection increases the needed certainty for investment.

Considering equity in policy instruments: For sustainable development of OWPs, it is important to consider social issues such as equity. Under equity in term of distributive justice, policy-makers should consider that implementation of policy instrument does not lead to unequal costs on some people.

Beside aforementioned issues, policy-makers must design the given policy instrument in simple and transparent way as much as possible.

According to this study, theoretically if policy-makers' priority is increasing deployment of new OWP projects (quantitative targets) then they must choose a price-based policy instruments. In other words, price-based policies gain effectiveness at expense of efficiency. Conversely quantity-based policies gain efficiency at expense of effectiveness. Based on this general theory, if the Dutch policy-makers want to realize the near-term objectives (6450 MW up to 2023), they must choose FiT (a customized FiT) in order to increase OWPs by stimulating investors to invest in new OWP projects. There are several reasons that demonstrate that FiT is a proper instrument to help policy-makers to meet their objective regarding diffusion of OWPs in short-term:

Stimulating investors to invest in OWPs (Market certainty): The proposed FiT system has enough ability to increase the needed market certainty in order to convince and accordingly encourage investors to invest in new OWP projects. The new adjusted FiT persuades financial agencies to support deployment of OWP projects (development phase). Also this support system ensures investors by covering extra generation costs (operation phase).

Promote commercial maturity through learning by doing (dynamic efficiency): In theory, the FiT system does not lead to promotion of commercial maturity through enhance competition in comparison to quantity-based policy such as TGCs. But the suggested FiT system promotes commercial maturity through learning by doing. Learning by doing will be promoted by broader participation and leveraging capital. This leads to dynamic efficiency.

Design flexibility to minimize costs (dynamic efficiency): Although quantity-based policy instruments (e.g. TGCs) cause cost-effectiveness, these support systems may limit RES-E technology variation and promote only the most cost-effective RES-E technologies. This leads to exclusion of less mature RES-E technologies such as OWP that could realize objectives regarding RES promotion. Therefore, the FiT is suggested that although it does not lead to cost reduction through competition, it has design flexibility (e.g. digression and stepped tariff) that realizes dynamic efficiency.

Market principles: In the Dutch liberalized electricity market, the premium-in Feed, as a market-dependent FiT, has a higher compatibility with the liberalized electricity market due to the remuneration changes with market demand.

Sustainable OWP development: Since implementation of support systems is a part (phase) of development of OWPs, sustainable development of OWP depends on sustainable implementation of policy instrument which is designed to support the development of OWP. For sustainable implementation of the given support system, responsible innovation approach is suggested. In other words, responsible innovation is appropriate approach for sustainable implementation of support systems and consequently for sustainable deployment of OWPs.

Also, it is noteworthy to mention that selecting one proper policy instrument is answering the question (dilemma) of whether policy-makers want to promote developing OWPs in the Netherlands or they prefer economic effectiveness. It seems, if those policy-makers want to meet their objectives, they should sacrifice efficiency for rapid diffusion of OWPs. Beside this painful decision, it is necessary that those policy-makers consider expected implementation environment and prepare needed conditions.

To conclude, current situation (implementations of specific SDE+) could not lead to gaining objectives regarding development of OWPs. Then, it is important that involved policy-makers to look at this issue through improving and adjusting support systems which accelerate development of new OWP capacities. Experiences in EU member states, such as Germany and Spain, confirm that adjusted and improved FiT has ability to realize RES-E objectives even in liberalized markets.

6.3.2. Recommendation for further research

In this study, despite the fact that some parts and subjects are treated adequately but a number of limitations caused that some parts and issues are investigated at a lower degree or not at all. These limitations are well worth studying therefore we leave a number of avenues for further research.

First, during conduction of this MSc Project Thesis, we find out that almost all of already investigations into policy instruments are based on neoclassical economics, whiles for comprehensive investigation **institutional economics** is a more appropriate underlying theory. Therefore, it is time to move from the world of rational finance into institutional approaches. A number of contributions in this issue is needed to shed light on real-world decision processes of policy-makers under real situations.

A second area for further research is to further investigate the **environmental aspects** regarding implementation of economic policy instruments. This means environmental criteria should be included in new evaluation frameworks. By consideration of environmental aspects, we come one step closer to sustainable implementation of support systems.

As it is addressed in this study, increasing the degrees of successful implementation of policy instruments depends on “political certainty” and “willingness of investors for investment”. This implies it is useful to look at this issue (successful implementation of policy instruments) from **investors’ point of view**. This could be the third area for future studies. This also could result in finding some ways for more involvement of investors, and consequently this leads to more democratizing of policy-making by participation of more involved actors.

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Appendix

List of thirty studies on policy instruments evaluation

	Author	Criteria	RE Technology	Policy	Reason(s)
1	Kuhn 1999	Efficiency	RES-E technologies	Fixed Fit vs. Bidding	Bidding exerts downward pressure on prices
		Technical improvement (innovation)	RES-E technologies	Fixed Fit vs. Bidding	Bidding sets incentives for technological improvements
		Flexibility	RES-E technologies	TGC vs. Bidding	Green Certificates trading is flexible. It might be more easily extended to other energy sectors or merged with the European bubble approach to CO2 reductions and emissions trading.
2	Menanteau et al. 2001	Effectiveness	Wind power	Fixed FiT vs. Bidding	FiT results in more additional capacity (3095 MW in 2000 in Germany, Denmark, and Spain) compared to 154 MW in the UK, Ireland and France.
		Efficiency	Wind power	Quantity-based vs. Price-based	The quantity-based approach is the most effective in controlling the cost of incentive policies, since by inviting tenders for successive quotas it is possible to maintain indirect control over the marginal production cost and thus the overall cost
			RES-E technologies	Bidding vs. FiT	A competitive bidding system creates more incentive to lower prices and costs of REs, compared to FiT.
3	Enzensberger et al. 2002	Effectiveness	Wind power	Fit and Bidding	
		Efficiency	Wind power	Fit and Bidding	
		System conformity	Wind power	Fit and Bidding	
		Practicibility	Wind power	Fit and Bidding	
4	Jansen et al. 2002	Efficiency	NA (RE technologies)	TGC	TGC does not increase the consumer price
5	Finnon et al. 2003	Effectiveness	NA (RE technologies	FiT	Effective
				Bidding	Weak
				TGC	Effective
		Efficiency	NA (RE technologies)	FiT	Overall costs are high
				Bidding	Overall costs are controlled
				TGC	Overall costs are controlled
6	Van dijk et al. 2003	Effectiveness	NA (RE technologies)	FiT	Weak
				Bidding	Can be very effective in stimulating new capacity as the amount of capacity to be tendered is set at forehand.
				TGC	Is the most effective in reaching policy

					targets for RESE.
		Efficiency	NA (RE technologies)	FiT	FiT is relatively non cost-effective
				Investment subsidy	Investment subsidies and fiscal measures stimulating investment do not create competition among market players, and do not form an incentive to reduce costs.
				Bidding	Bidding mechanisms drive down the price of projects, making this a very cost effective instrument
				TGC	Has the potential to reach cost-effective outcomes in case there is a supply surplus relative to the quota obligation.
		Certainty for investors	NA (RE technologies)	FiT	FiT provides almost absolute market certainty with respect to the tariff revenue stream to investors.
				Investment subsidy	Both technical risks and market risks are reduced. However, policy uncertainty is commonly high- as investment support schemes are prone to adaptations
				TGC	Uncertainties for investors arise from possible fluctuations in market prices.
		Equity	NA (RE technologies)	Quantity-based and price-based policies	Equity aspects of policy instruments are not inherent to the policy instrument itself, but depend very much on its design.
7	Menanteau et al. 2003	Effectiveness	Wind power	FiT vs. Bidding	More installed capacity of RE-E by FiT (10812 vs. 606 [MW in 2000])
		Efficiency	Wind power	FiT vs. Bidding	Bidding leads to lower purchase prices compared to FiT system
		Certainty for investors	Wind power	Bidding system	The allocation of subsidies after a competitive tendering procedure introduces an element of uncertainty and a new risk, with the unsuccessful bidders remaining fully responsible for the costs of preparing their proposals
		Technical improvement	Wind power	FiT vs. Bidding	The incentive to reduce costs in the competitive bidding system is much stronger than in FiT
		Practicability		FiT	It is extremely simple to implement from an administrative point of view.

8	Haas et al. 2004	Effectiveness	RES technologies	price-driven and capacity-driven	FITs are the prevailing instrument, followed by rebates, tax incentives, tendering systems, and green tariffs.
		Efficiency			
9	Van der Linden et al. 2005	Effectiveness	RES technologies	TGC	The effectiveness of an TGC can be high and compliance levels can be reached under long-term agreements
		Efficiency	RES technologies	TGC	the certainty of a long-term contract will lower the cost of compliance with the TGC and thereby increase efficiency.
		Certainty for investors	RES technologies	TGC	A sufficient level of certainty for the renewable energy industry is imperative for a well-functioning TGC system.
		Equity	RES technologies	TGC	Equity aspects should be duly taken into account when designing a quota obligation system to ensure sufficient long-term support from the main stakeholders.
10	Harmelink et al. 2006	Effectiveness	RES technologies	FiT and bidding system	Up to now, they do not meet targets
11	Held et al. 2006	Effectiveness	Wind onshore for 1998-2005 for EU-25 countries	FiT, TGC, Bidding, Investment subsidy	The highest effectiveness is for fixed feed-in tariffs during
		Efficiency	Wind onshore for 1998-2005 for EU-25 countries	FiT, TGC, Bidding, Investment subsidy	Expected profitability is significantly lower for FITs. It is directly linked with a higher efficiency of this strategy because additional costs for consumers are lower.
12	Regwitz et al. 2006	Effectiveness	NA (RE technologies)	FiT	It is effective
				TGC	Effectiveness is not high, however it could become more efficient as markets mature.
		Efficiency	NA (RE technologies)	FiT	It is efficient policy to promote RES technologies
				TGC	It leads in theory to minimal total RES-E system costs in the short term due to the concentration on the lowest cost technologies
13	Contaldi et al. 2007	Effectiveness	RES-E technologies	FiT	FiT is very effective in promoting RE technologies in different stages of development
				TGC	TGC becomes more effective in the medium term
		Efficiency	RES-E technologies	FiT in Italy	Fit leads to a low allocative efficiency
				TGC in Italy	High efficiency. It leads to predefined targets at maximum economic allocative

					efficiency
14	Del Rio et al. 2007	Effectiveness	wind power	FiT in Spain	Very effective (e.g. in 2003 wind power installed capacity reached 5976 MW, compared to 1609 MW in 1999)
		Efficiency	RES-E technologies	FiT in Spain	It is an efficient policy. It leaded to a reduction in the investment per k. This resulted in 1.197 €/kW in 2002, compared to 1.53 €/kW in 1998.
		Certainty for investors	RES-E technologies	FiT in Spain	It results in uncertainty for investors by creation of high risk and low/medium profitability (especially regarding investment in biomass an PV)
		Contribution to job creation	Data availability only for wind	FiT in Spain	In 2003, 17,000 employees worked in the wind sector
15	Held et al. 2007	Effectiveness	RES-E technologies	FiT in Germany, Spain and Slovenia	FiT is an effective system in triggering a considerable increase of RES-E technologies in all three countries.
		Efficiency	RES-E technologies	FiT in Germany, Spain and Slovenia	FiT has relatively a high (Static and dynamic) efficiency.
		Costs for society	RES-E technologies	FiT in Germany, Spain and Slovenia	Leads to a minimization of costs for society but not necessarily
16	Gan et al. 2007	Effectiveness	wind, solar PV, and biomass	FiT	High effectiveness in Germany (due to applying the high FiT levels)
		Efficiency	wind, solar PV, and biomass	TGC in EU	High efficiency
		Certainty for investors	wind, solar PV, and biomass	TGC vs. FiT	TGC provides less market certainty than feed-in tariff
		Flexibility	wind, solar PV, and biomass	FiT in EU	Transparent and flexible (This instrument allows different technologies to be given different tariffs.)

			wind, solar PV, and biomass	Investment subsidy	It is enough flexible to receive and channel funds from different sources, and using the resources according to public interest and policy objectives.
17	Klein et al. 2007	Efficiency	RES-E technologies	FiT	Efficiency is relatively high, and it depends on technology-specific, and location
18	De Jager 2008	Effectiveness	RES-E technologies	Investment subsidy	This policy is more effective at the demonstration and market introduction phase, than during the deployment phase
19	Haas et al. 2008	Efficiency	Wind	FiT vs. Tendering n Europa (1990 – 2001)	FiT is more efficient than bidding system
		Effectiveness	Wind	FiT, TGC, Tendering, and Investment subsidy in EU, USA, and Japan (199-2005)	FiT is more effective than other three policy instruments
20	Fouquet et al. 2008	Effectiveness	RES-E technologies	FiT vs. TGC in some EU member states	FiT deliver larger and faster penetration of RE than TGC
		Efficiency	RES-E technologies	FiT vs. TGC in some EU member states	FiT delivers power from RESs at lower cost. compared to TGC
		Certainty for investors	RES-E technologies	TGC	With TGC markets the value of the certificate is uncertain, and may change considerably over time. Would there be an oversupply of certificates the price would become very low. This could significantly affect the financial situation of investors.
21	Cory et al. 2009	Efficiency		FiT	FiT creates the guaranteed contract terms, and it also leads to a stable investment environment. These results in high efficiency.
		Certainty for investors		FiT	FIT policies generally provide preapproved guarantees of payments to the developer and investors
22	Burer et al. 2009	Effectiveness	RES-E technologies	Various price-based and quantity-based policies	It is effective. It provides lower risk to investors compared to other support mechanisms
		Efficiency			Quantity-based systems are more efficient

					than price-based systems
23	Bergek et al. 2010	Effectiveness	RES-E technologies	TGC in Sweden	It is effective, especially for plants that were already in operation (from 6.5 TWh in 2002 to 15 TWh in 2008)
		Efficiency	RES-E technologies	TGC in Sweden	It is efficient (from both a social and a consumer perspective)
		Equity	RES-E technologies	TGC in Sweden	TGC scheme does not pass on the Swedish Government criteria of equity.
		Technical improvement (innovation	RES-E technologies	TGC in Sweden	TGC system gives rise to a market dynamic that create the conditions for cost efficiency and technical change
24	Couture et al. 2010	Effectiveness	RES-E technologies	FiT in Germany and Denmark	It is effective, and it plays an important role in advancing the deployment of RE technologies.
		Efficiency	RES-E technologies	FiT	It is efficient. FITs allow efficiently operated projects to earn a reliable rate of return on renewable energy investments, which makes it possible for entrepreneurs, investors, and homeowners to invest in RE projects.
		Practibility	RES-E technologies	FiT	FiT is a transparent policy structure that creates an open and straightforward framework that residents, businesses and investors can understand. This helps both local project developers as well as investors from around the world evaluate the posted FIT prices when making their investment decisions.
25	Fischer et al. 2010	Effectiveness	Onshore Wind power	FiT vs. TGC,	FiT is more effective policy than TGC
		Efficiency	RES technologies	FiT vs. TGC	TGC is more efficient than TGC
26	Haas et al. 2011	Effectiveness	RES-E technologies	Various price-based and quantity-based policy instruments in the EU-15 member states 1998-2005	Countries with feed-in tariff as support scheme achieved higher effectiveness compared to countries with a quota/TGC system or other incentives. In other words FIT systems are effective at relatively low additional costs for final customers.
				Tendering in the UK (NFFO)	Low effectiveness

		Efficiency	RES-E technologies	Various price-based and quantity-based policy instruments in the EU-15 member states 1998-2005	Quantity-based systems (TGC) are more efficient (in term of Magnitude of absolute support level) than price-based systems
		Certainty for investors		FiT vs. TGC	Due to the intrinsic stability of feed-in systems appears to be a key element for success, therefore FiT creates more certainty compared to short term trading in renewable certificate markets.
27	Haas et al 2011	Effectiveness	RES-E technologies	FiT	FIT systems are effective at a relatively low producer profit.
		Efficiency	RES-E technologies	FiT	FIT which are implemented in a technology-specific manner and involve rather modest costs for European citizens. The main reason for this observation is the long-term price security of the system combined with technology diversification of support.
28	Mitchell et al. 2011	Effectiveness	RES-E technologies	Price-based and quantity-based policies	Among the different types of policy tools available, fiscal incentives and particularly public finance, such as loans and loan guarantees are generally thought to promote deployment most effectively when linked to production rather than investment.
		Efficiency	RES-E technologies	Price-based and quantity-based policies	FITs are highly efficient
		Equity	RES-E technologies	Price-based and quantity-based policies	
		System conformity	RES-E technologies	Price-based and quantity-based policies	
29	Del Rio 214	Effectiveness	RES-E technologies	FiT	FiT has promoted renewable energy technologies with different maturity levels and costs

			RES-E technologies	TGC	TGC does promote the deployment of the most mature, low-cost renewable energy technologies
		Efficiency			
		Equity			
		Sociopolitical acceptance			
30	Kilinc-Ata 2016	Effectiveness	RES-E technologies	Price-based and quantity-based policies	FiTs, tenders and tax incentives are effective mechanisms for stimulating deployment capacity of RES-E