Little rays of sunshine

The influence of local policy instruments on the production of solar energy

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1. Introduction

Sustainability has become an increasingly more prominent subject on the political agenda of the Dutch policymakers. Therefore, the policymakers strive to make the Dutch society more sustainable. One of goals to be achieved is increasing the share renewable energy. To achieve this goal the national government implemented policies to stimulate the production of this type of energy among homeowners. With the realisation that cities and municipalities are powerful entities to stimulate this part of the population, this goal eventually percolated from the national level to the provincial and local level.[1] A significant portion of these municipalities identified solar power as one of the energy sources to increase the renewable energy share within their jurisdiction. Hence, these local governments use a number of policies and other instruments to stimulate the production of solar energy. These various policies categorise into two types of instruments: 'hard'- and 'soft' measures. 'Hard' measures are policies and regulations which entail granting loans or subsidies for the instalment of solar panels on residential buildings. 'Soft' measures are energy service-desks created by the municipalities to provide information to residents about the benefits of solar panels and the possibilities for funding.

However, not all municipalities provide these subsidies and those who do provide them, provide them in different forms and the amount of money available for the subsidy also differs.[2] Since, the national subsidies were quite successful in stimulating the generation of solar energy, I wonder if the change from this national scheme to the local schemes has a similar effect. Therefore, I focus the research on:

"What is the influence of local policy instruments on the production of solar energy?"

[1] Murphy, Lorraine , Frit Meijer, and Henk Visscher. 2012. "Governance Tools." In Sustainable Urban Environments, by Ellen Van Bueren, Hein Van Bohemen, Laure Itard and Henk Visscher, 341-360., page 348-349

[2] Subsidiezonnepanelen.net: https://www.offerteadviseur.nl/categorie/energie/zonnepanelen/subsidie-2016/

This questioned will be answered in a number of steps. Chapter two provides an introduction into the case of solar energy and the types of policies. The third chapter gives an overview of the theory on the influence of policies and the effect of other factors. Chapter four explains the research design and chapter five the analysis. Finally, chapter six and seven provide the conclusion and the implications for policy makers and further researcher.

2. Introduction to the case

2.1 Dutch solar energy

Sustainable energy consists of two sides: energy consumption and energy production. Governments can influence both of these sides by, either reducing the energy consumption or by stimulating the generation of renewables. Since I want to investigate the impact of regional policy instruments, it should be possible to account the changes in production or consumption to a local policy. Hereto, it must be clear what is and what is not part of the jurisdiction of the local authority. With this consideration in mind, I make a choice for either of the two sides. The widely used definition of energy consumption of Statistics Netherlands (CBS) is "the amount of energy used by companies, households and transport".[3] This definition immediately shows that the scope of power consumption is quite broad. Even when you choose one of the three aspects, what should be included in their energy consumption is entirely unclear. For example, do you only count the use of the house, or also the appliances and what to to do with the energy used during travel from home to work or the other way around? These couple of questions already show that the consumption side is quite a complex area in which it is hard not to compare apples and oranges. Consequently, it's hard to address any changes in energy consumption to local policy measures. In short, consumption is a too vague of a concept to analyse, and therefore I focus on power generation.

Within the concept of energy production I to focus on solar energy. There are many reasons to focus on this type energy. First of all, since I want to investigate the effect of local policy measures this layer should be involved. Therefore, the first criterion for selecting an energy source should be local involvement. Besides this criterion, I created other selection criteria. Since the scope of this research entails the Netherlands, it should be generated in the Netherlands. Furthermore, the energy sources should produce a sufficient amount of kilowatt hours to generate valid results. Moreover, to allow for a thorough investigation, the information on the amount of energy generated

[3] CBS: https://www.ensie.nl/cbs/energieverbruik

from the source should be available. To summarise, there are four criteria: (a) local involvement (b) domestic generation, (c) significant production, and (d) available information. The European Directive promoting the use of energy from renewable resource defines renewable energy as "energy generated from non-fossil resources, such as solar, wind, geothermal, biomass and tidal resources".[4]

The first energy source considered is tidal- and geothermal energy. These types of energy do not fulfil the first criterion; there are no local policy measures involved. The national government regulates tidal- and geothermal energy.[5] Since this means that I cannot investigate the influence of local policy measures, I leave the sources out of the equation. Then, energy generated from biomass. The national government regulates energy from biomass in comprehensive agreements.[6] However, there are no local policy measures involved in the regulatory process, and therefore these energy sources do not fulfil the first criteria. Therefore, this scope does not contain this type of renewables.

Eliminating these three sources leaves two sources left for assessment: solar and wind energy. All three layers of government regulate these sources.[7] The national government set the goals and the policy framework; the provinces determine the zoning, and the municipalities can assign some areas and grants licenses or have the freedom to complete the plan set by the provinces.[8] However, the responsibilities of these last two layers are intertwined and thus difficult to isolate the effect of the municipalities from that of the provinces.[9] Subsequently, drawing conclusions on the impact of the local authorities is troublesome. The allocation of tasks for solar energy is much more clear

[4] Richtlijn EU: http://eur-lex.europa.eu/legal-content/NL/TXT/?uri=LEGISSUM:en0009
[5] Rijksdienst voor ondernemend Nederland: http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/duurzame-energie-opwekken/bodemenergie/aardwarmte/beleid
[6] Rijksdienst voor ondernemend Nederland: http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/duurzame-energie-opwekken/bio-energie/beleid-bio-energie
[7] Rijksdienst voor ondernemend Nederland: http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/duurzame-energie-opwekken/windenergie-op-land/spelers/overheden
[8] Ibid
[9] Ibid

cut and therefore, addressing any changes in the production to local policies more accurate. Hence, this research focuses on solar energy.

The share of solar energy as part of the total energy supply in the Netherlands has been increasing. The amount of solar energy generated within the Netherlands has grown, and since 2012 the rate at which this has been increasing has progressed.[10] Over the last couple of years, the capacity of solar power increased with approximately 300 Megawatt per year and is now at around 1.5 Gigawatt per year. Installing solar panels has become increasingly popular among homeowners. "Milieu Centraal", a Dutch public information organisation, estimated that at the end of 2015 there were 400.000 houses with solar panels on their roof.[11] That is a tenfold increase compared to 2010.

Although the total amount of solar energy increased, there are substantial differences between the municipalities. Using the data by Rijksdienst Ondernemend Nederland, a Dutch agency for the entrepreneurs, the difference between the area with the highest and the lowest installed capacity is a factor 200.[12] Therefore, it is interesting to see what causes these differences.

2.2 Local policies

In The Netherlands, there are multiple layers of government. There is a national level, a municipal and an intermediate, provincial level. All of these levels of government write and implement policies, rules and regulations regarding solar energy. Nonetheless, I choose to local policy measures as the independent variable. The reason for this focus lays in the manner in which the policies on solar energy are implemented.

In 2008 the national government introduced the national subsidy scheme “Encouraging Sustainable Energy Production” (SDE). This grant consisted of a fixed

[10] CBS: http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=82610ned&D1=6-7&D2=5&D3=18-26&HDR=T&STB=G1%2cG2&VW=D
[11] Milieu Centraal: https://www.milieucentraal.nl/nieuwsbrieven/professionals/juli-2016/400000-huizen-met-zonnepanelen-hoe-kom-je-er-bij/
[12] Rijksdienst ondernemend Nederland, Memo 2010

amount of money per generated kilowatt hour (kWh). This national subsidy scheme went viral, and due to this overwhelming popularity, the government changed it in 2011.[13] The government changed the applicability criteria to exclude households from the subsidy, while at the same time lowering the amount of money paid per kWh generated.[14] Still, many people applied for the grant, and therefore in 2012, the plan was changed again. With the implementation of this change, households could once again apply for the subsidy, but instead of receiving an amount of money per kWh generated, households that purchased solar panels would receive 15% of their purchase back (up to a maximum of €650,-).[15] Just as with the first scheme, the number of applications was very high, such that it was terminated halfway through 2013.[16]

Although the Dutch government terminated the national subsidy schemes, the local authorities continued subsidising solar panels. From 2014 onwards, the municipalities introduced a loan aimed at stimulating sustainable measures.[17] This loan is called the "Sustainability-loan". Homeowners who want to reduce the energy use within their homes or want to increase the generation of renewables can apply for this loan. Among other things, owners can buy solar panels with this loan. Alongside this loan, the municipalities created energy service desks at which residents can receive information on solar energy and even created some additional subsidy schemes. These subsidies, loans and service desks are extensively used by citizens. The exact impact of these policy instruments will be examined in the following chapters.

[13] Cees van der Werken: http://www.allesoverzonnepanelen.nl/
[14] Ibid
[15] Rijksoverheid subsidie voor zonnepanelen 08-06-2012
[16] Subsidie-zonnepanelen2017; rijksoverheid 2446 toezeggingen subsidie zonnepanelen
[17] SVN: https://svn.nl/particulieren/lening/duurzaamheidslening

3. Theoretical model and causal mechanisms

3.1 Local policy instruments

This year, it is twenty years ago that the idea that for climate change interventions to be effective, they need to be context specific, became increasingly popular.[18] Context specific entails that environmental policies need to take the environmental, social, economic and political interactions and complexities into consideration.[19] The analyses on the local dimension of climate change, among other things, focus on the influence of local policies on climate issues.[20] More specifically, it concentrates on where and how local governments can increase their environmental sustainability.[21]

The research on mitigating climate change at the local level comes to the general conclusion that local governments are an important aspect in solving environmental issues.[22] According to the researchers, these governments have critical knowledge of the situation 'on the ground' and can, therefore, bring valuable insights into how to address these issues.[23] Moreover, they can implement policies, regulations and deploy other tools to steer towards a more sustainable environment.

The scientific inquiry into the influence of the local level has made municipalities more aware of what role they could play in making this world more sustainable.[24] As a result, environmental sustainability is a prominent and recurring subject on the political

[18] Betsill, Michele, en Harriet Bulkeley. 2007. „Looking Back and Thinking Ahead: A Decade of Looking Back and Thinking Ahead: A Decade of." ***Local Environment*** 447-456, page 447
[19] Culotta, Daniel, Arnim Wiek, and Nigel Forrest. 2016. „Selecting and Coordinating Local and Regional Climate Change Interventions." ***Environment and Planning C: Government and Policy*** 1241-1266, page 1247
[20] DeAngelo, Benjamin and L.D.Danny Harvey. 1998. „The Jurisdictional Framework for Municipal Action." ***Local*** 111–136, page 125
[21] Agyeman, Julian, Bob Evans and Robert W. Kates. 1998. „Greenhouse Gases Special: Thinking locally in." ***Local Environment*** 245–46; Easterling, William E., Colin Polsky, Doug Goodin, Michael W. Mayfield, William A. Muraco and Brent. 1998. „Changing Places, Changing Emissions: The cross-scale reliability of greenhouse gas." ***Local Environment*** 247–62; Kates, Robert W., Michael W. Mayfield, Ralph D. Torrie and Brian Witcher. 1998. „Methods for Estimating Greenhouse Gases from Local Places." ***Local Environment*** 279–298.
[22] Betsill & Burkeley, 2007, page 448
[23] Angel, David P. Samuel Attoh, David Kromm, Jennifer DeHart, Rachel Slocum and Stephen White. 1998. „The Drivers of Greenhouse Gas Emissions: What do we learn from local case studies?" ***Local Environment*** 263–78.
[24] K Plus V. 2014. ***Een analyse van bestuursakkoorden van Nederlandse gemeenten voor de periode 2014-2018,*** page 5

agendas of these local governments.[25] Furthermore, the local policymakers have become to regard themselves as the Spurs on this topic.[26] Therefore, they have started to stimulate their citizens to contribute towards achieving their sustainable goals.

These stimuli encourage the use or production of products and services deemed to aid the public good.[27] Helping the public good regarding environmentally sustainable development could mean three things: [28]

1. The product or service reduces the energy use
2. The product of service changes the energy use
3. The product or service makes the use of energy as efficient as possible.

The research question of this thesis investigates the relationship between local policy measures and the production of solar energy. The step that relates to the generation of solar power is the second step; switching the use of energy from fossil to renewable sources. In other words, the production of energy needs to change from fossil fuels like oil, coals and gas, to sources of production like wind, geothermal or solar.

There are multiple ways in which the local policymakers can encourage their citizens to switch towards the use of more environmentally friendly energy sources. There are direct ways to influence the citizens and indirect measures.[29]Direct policy measures are rules, regulations and standards which directly determine or affect the use of particular products or services.[30] Indirect policies are more flexible arrangements that try to steer behaviour by changing the preferences of the citizens.[31] These indirect means include multiple tools, economic- and noneconomic incentives.[32] The financial resources consist of e.g. taxes, charges, tax benefits and subsidies and the noneconomic tools can, among other things, include media and other instruments to provide information.[33] The following section explains the theoretical ideas and causal mechanisms of these last financial and non-financial incentives.

[25] K Plus V, page 5
[26] Ibid, page 5
[27] Murphy, Lorraine , Frit Meijer, and Henk Visscher, Governance Tools, page 352
[28] Ibid, page 171
[29] Ibid, page 350
[30] Ibid, page 350
[31] Ibid, page 350
[32] Ibid, page 351
[33] Ibid, page 352

3.1.1 'Hard' policy measures

The first types of tools that local governments can deploy involve economic incentives. These financial incentives include tools that influence the citizen economically. The basis for these instruments is the idea of the self-interested, rational actors.[34] These types of agents are expected to react rationally to price changes.[35] Based on this assumption, local governments try to incentivize their citizens by changing the price of certain goods and services. They can either do this by increasing the rate by taxes or by appending additional charges to the good or service. Or they can decrease the price by subsidising the product or offering tax benefits to the buyer. [36]

These incentives can also be deployed to stimulate the generation of solar power. [37] This active involvement of local governments is especially useful in the production of renewable energy in and on the already existing buildings.[38] Since the price of renewables is still higher than the price of fossil fuels, subsidies can help to make the purchase of solar panels more attractive to citizens.[39] For example, the cities producing the most solar energy were the places where the municipality provides subsidies to help the citizens to invest in solar panels.[40]

To sum up, lack of financial means for the investment in solar panels is one of the most significant barriers for people to refrain from buying solar panels.[41] From this finding, it can be derived that removing these obstacles makes citizens more keen to install solar panels. Therefore, I expect that 'hard' policy measures, in the form of subsidies or loans will increase the solar energy production. This expectation leads to the following hypothesis:

$$\boldsymbol{H_1: \beta_1 > 0}$$

[34] A, Dobson. 2009. „Citizens, citizenship and governance for sustainability." In ***Governing sustainability***, door Jordan A Adger WN, 125–141. Cambridge: Cambridge University Press.
[35] Ibid, page 130
[36] EEA. 2005. ***Market-based instruments for environmental policy in Europe.*** Copenhagen.
[37] Rapportage evaluatie Klimaatakkoorden, page 46
[38] Ibid, page 51
[39] Statistics Netherlands. 2015. ***Hernieuwbare Energie in Nederland 2015.***, page 33
[40] Rapportage evaluatie Klimaatakkoorden, page 52
[41] TenBült. 2012, page V

'Hard'-stimuli, i.e. subsidies and loans, increase the solar energy production per capita compared to the year before.

3.1.2 'Soft' policy measures

Complementary to the economic incentives, local governments use non-economic tools.[42] The reasoning behind deploying these means is the assumption that information can help citizens help to better understand sustainable forms of energy production and help them to take action themselves.[43] In short, these tools are used to address the information problem surrounding renewable energy solutions.[44] Furthermore, research indicates that the attitude towards solar energy strongly influences willingness to install solar panels.[45] The measures can steer behaviour in the direction of sustainable solutions.[46] However, research does point out that this is most effective for people who are already aware of the possibility of producing renewable energy themselves and are interested in purchasing the products to do so.[47] In other words, these types of tools do not completely alter preferences, but can reduce barriers which withhold people from buying the solar panels.

$$H_2: \beta_2 > 0$$

'Soft'-stimuli, i.e. energy service desks increase the solar energy production per capita compared to the year before.

3.1.3 Combined policy measures

Besides, the individual influence of each of the policies, researchers also expect that the combination of the two types of measures will affect the production of solar energy.

[42] Murphy, Lorraine , Frit Meijer, en Henk Visscher. 2012. Governance Tools, page 356
[43] Ibid, page 356
[44] Sunnika, M M. 2006. ***Policies for improving energy efficiency in the European housing stock.*** As cited by Murphy, Lorraine , Frit Meijer, en Henk Visscher. 2012. Governance Tools, page 353
[45] TenBült. 2012, page V
[46] Welch, E W, en A Hibiki. 2002. „Japanese voluntary environmental agreements: bargaining power and reciprocity as contributors to effectiveness." ***Policy Sci*** 401-424, page 418
[47] O'Riordan, T. 2009. „Reflections on the pathways to sustainability." In Governing sustainability, door Jordan A Adger WN, 307–328. As cited by Murphy, Lorraine , Frit Meijer, en Henk Visscher. 2012. Governance Tools, page 356

Their analyses indicate that the combination of the two tools will complement each other.[48] Both needs of financial means and information are important barriers to purchasing solar panels. Therefore, addressing both of these problems, could be more effective than solely addressing one of the aspects.[49] However, the results of the analyses are inconclusive, so it not entirely sure if the combined effect is indeed stronger than the individual effects. These expectations are expressed formally, in the following hypothesis:

$$H_3: \beta_3 < 0 \mid \beta_3 > 0$$

The influence of the combination of 'hard'- and 'soft' stimuli is not immediately clear. The combination could either enforce the individual influence and subsequently increase the t*he solar energy production per capita compared to the year before, more than each of the policies implemented individually. In that case the expectation is $\beta_3 > 0$. On the other hand, it could also be the case that the impact of the combination of the stimuli is smaller than the influence of 'hard' and 'soft' alone. That would mean that $\beta_3 < 0$.

3.2 Other influential factors

Besides the influence of financial means and information, other factors affect the willingness of people buying solar panels. For example, the demographic factors are important determinants.[50] Demographic factors consist of the size of the population, the average age of the people and the average income in the municipality. Calculating the difference in the generated kilowatt hours solar energy per capita controls for the size of the population. The rest of the factors do need to be incorporated by the control variables. The three age group variables account for the age of the population. The first group is the percentage of the population under the age of 21. This young group of people has a low income and, therefore, they cannot be expected to invest in solar panels. Moreover, since they often do not own a house, they are not eligible for the solar panels subsidies or loans. As a result, a larger share of this young individuals is expected

[48] TenBült. 2012, page V
[49] TenBült. 2012 page V
[50] Steg, L. Verspilde energie? Wat doen en laten Nederlanders voor het milieu?

to decrease the kilowatt hours. The same result is projected to happen when the share of people over the age of 65 is significant. Given their age, this group of individuals is likely not to invest in solar panels, because these panels have a long return on investment. The people in between these groups, on the other hand, are expected to increase the production of solar power. This group of individuals has a relatively high income, as compared to the other two groups and are often owners of homes.[51] Subsequently, they can invest in solar panels and are eligible for the subsidies and loans.

$$H_4: \beta_4 < 0$$

A younger population, under the age of 21, will decrease the solar energy production per capita compared to the year before.

$$H_5: \beta_5 > 0$$

A population between 20 and 45 years of age will increase the solar energy production per capita compared to the year before.

$$H_6: \beta_6 < 0$$

A older population, with an average age above 65 years old, will decrease the solar energy production per capita compared to the year before.

4. Research design

The goal of this thesis is to examine if local policy measures increase the production of solar energy. In other words, I want to know if local policy measures are effective in influencing solar power generation. To achieve this goal, I drafted the central question:

"What is the influence of local policy instruments on the production of solar energy?"

This question identifies local policy instruments as the independent variable and the production of solar energy as the dependent variable. Before the relation between these two variables can be analysed, these concepts require an explicit conceptualization,

[51] TenBült. 2012, page 2

definition and operationalisation. The following chapter contains these steps. First, this section provides the conceptualisation of the independent variable. Second, this variable is split up into its two parts, the 'hard' policy measures and the 'soft' measures. Third, I will provide the concept of solar energy production. Fourth, the paragraph "scope", defines the place and time for investigating the relation between the two variables. Fifth, the section "Research approach" describes the operationalisation of both the independent variable, local policy measures, its two forms, and the dependent variable, solar energy production. Furthermore, this section operationalizes the control variables, and finally, I formalise these variables in a fixed effects regression model.

4.1 Conceptualisation

4.1.1 Local policy instruments

First, the independent variable, local policy measures, will be conceptualised. The definition came about via various steps. The starting point was the straightforward definition of local policy measures: policy measures implemented at the local level. However, this interpretation does not explain what policy measures are nor does it clarify what the definition of local is. Therefore, the second step is defining governance and local. The widely accepted definition of governance by Stoker and Heffen et al. forms the basis for the conceptualization of governance. According to these authors, policy measures are part of the actions of a governmental body.[52] These efforts include drafting policies, offering grants and implementing regulations.

Then, the conceptualisation of the second part of the independent variable. The term "local" is tight to a physical context. The physical context of this research is The Netherlands. Therefore, I define "local" within the Dutch context. In The Netherlands, there are multiple layers of governance; the national government, the provinces and the municipalities. The first layer refers to the national government, which consists of the King and the Minister. As the term, "national" implies, this layer is not a form of local

[52] Stoker. 1998. "Governance as Theory: Five Propositions"; Heffen, O. Van, and Kickert, Walter J.M. 2000. ***Governance in Modern Society".*** As cited by Geurtz, Casper, and Ted Van De Wijdeven. 2010. "Making Citizen Participation Work",

policy measures and is, therefore, not included in the conceptualisation. That leaves two layers of governance left for consideration: the provinces and municipalities. The provinces are the governmental body consisting of representatives that govern the 12 largest regions in The Netherlands.[53] In this capacity, they are the 'middle management' between the national government and the municipalities.[54] The municipalities are 'lowest' layer of government and govern anything that directly affects the citizens. This governmental layer consists of the Mayor, the aldermen and the city council.[55]

Looking at the tasks of both the provinces and municipalities, each of the layers is responsible for policies on energy generation.[56] More specifically, each of the governmental layers has measures in place to stimulate the production of solar energy.[57] However, the provinces have a different role than the municipalities. While these regions, in combination with the Dutch Municipal Stimulation fund for Housing (DMSH), provide the capital for the funding, the municipalities offer these grants and loans to citizens.[58] That means that when a homeowner decides to install solar panels on the roofs of their houses, it has to request the loan with its municipality. In short, the municipalities are responsible for the implementation of the policies regarding solar energy.

For the analyses, I want to focus on the relationship between the policy measures of the municipalities and the production of solar energy. More specifically, I want to know if these plans are effective in achieving their goal to enhance the generation of solar power. With this type of focus, it makes more sense to look at the executive body, rather than the government agency that merely provides the funds. In this case, the administrative bodies are the municipalities. Therefore, the definition of local is

[53] Rijksoverheid: https://www.rijksoverheid.nl/onderwerpen/provincies
[54] Ibid
[55] Rijksoverheid: https://www.rijksoverheid.nl/onderwerpen/gemeenten/inhoud/raadsleden
[56] Ibid
[57] Blok, S A. 2013. „Beantwoording kamervragen over oprichting stichting nationaal energiebespaarfonds."
[58] Ibid

municipal. With this consideration in mind, the final definition of local policy measures is:

Policies, funding and other policy instruments from a municipality

'Hard'- & 'soft' measures

The definition of local policy measures consists of two parts, 'hard' policy measures and 'soft' policy measures. Here, 'hard' policies represent stimuli that entail hard, real materials, 'hard' cash, so to speak.[59] These financial incentives include government grants and loans. Therefore, the definition of hard policy measures is:

Funding and loans from municipalities

Soft policy measures are an alternative to or complementary tool for these hard policy measures. These incentives consist of intangible resources that shape the preferences of the citizens through appeal and attraction. In this case, information about the benefits of solar panels, but also information about the possibilities for government funding. The local energy service desks provide this information. The municipalities create these offices to stimulate the installation of solar panels on residential buildings within their jurisdiction. Hence, the definition of soft policy measures is:

Energy service desks created by the municipality

The local administrative bodies create these two measures as separate policies. However, some of the municipalities offer both of these incentives at the same time. That means that within these municipalities there is a possibility of these two measures interacting with each other. It is not directly evident what the consequence of this interaction is. The policies could be stronger together, or it could be the case that the policies are better off alone. The conceptualisation of this additional independent variable is the product of the other variables. In other words, the definition of this interaction variable is:

[59] Investopedia: http://www.investopedia.com/terms/h/hardmoney.asp.

The interaction between funding or loans with energy service desks

4.1.2 Solar energy production

The third step is defining the dependent variable. The research question identifies this variable as the production of solar energy. Solar power is the energy generated by the radiation of the sun.[60] There are two ways of converting this radiation into energy, photovoltaic technology and thermal technology. The installations for thermal energy harvest the heat of the sun and the photovoltaic plants convert sunlight into electricity. The Netherlands deploys both these technologies, however, contrary to photovoltaic energy, there have been far less and far less durable subsidies and other policy measures for thermal solar energy.[61] The lack of planning for solar heat is the result of the lack of strategic objectives for this type of renewables.[62] As a result, there have been fewer peaks and troughs in the generation of thermal solar energy.[63] Since I want to examine the influence of local policy measures on the generation of solar energy, I will exclude the production from thermal installations and include the power generation from photovoltaic systems. With this further specification, the definition of the dependent variable is:

Production of photovoltaic solar energy

More specifically, I will focus on photovoltaic solar energy generated from solar panels ***on residential buildings***. Solar panels produce this photovoltaic solar power. These devices can be placed e.g. in fields, deserts and urban areas. However, since the focus of this thesis is on municipalities, I will concentrate on those panels installed in urban areas. Broadly speaking, within these cities there are developed- and undeveloped areas.

[60] CBS: https://www.ensie.nl/peter-timofeeff/zonne-energie
[61] Statistics Netherlands. 2015. Hernieuwbare Energie in Nederland 2015., page 21 & 51
[62] Ibid, page 21 & 51
[63] Ibid, page 21

[64] Within the developed regions, again grosso modo, there are two types of areas for the installation of solar panels: industrial zones and residential areas.[65]

Policy-wise, these areas are also divided. Policies are intended for business ór for households.[66] For example, subsidies can either be requested by business owners ór by home owners.[67] So, policy instruments responsible for changes in the solar energy production of companies cannot be responsible for the production from households, and the other way around. Therefore, I have to choose between either the generation of solar energy in industrial areas, ór focus on the production in residential areas. Since the data on solar power generation of residential buildings is far more precise than the production of industrial properties, I make the decision to focus on residential solar energy. The power generated from houses and other small private buildings. This way, the only local policy measures that will be analysed are the policies, regulations and financial incentives aimed at households small private housing. To summarise, the dependent variable is:

Photovoltaic solar energy generated from solar panels on residential buildings

4.1.3 Other influential factors

Alongside the independent variables, the model also contains other factors that influence the production of solar energy; these are the demographic variables and the yearly trends. The conceptualisation of the demographic variables is the percentage of a particular age group the population in a municipality. Alongside the demographic factors, other annual trends are influencing the production of solar power. These yearly trends entail some aspects that could affect solar energy generation, such as the changes in energy prices, the decrease in the price of solar panels and the spillover-effect of subsidies. This carry-over effect entails that a grant implemented in one year does affect

[64] Rijkswaterstaat: http://www.infomil.nl/onderwerpen/ruimte/ruimtelijke/wet-ruimtelijke/bestemmingsplan/uitleg/
[65] Ibid
[66] Energie subsidie: http://www.energiesubsidiewijzer.nl/; Zonnepanelen: https://www.zonnepanelen.net/subsidie-zakelijk/
[67] Ibid

not only the production of the year of implementation but also the generation in subsequent years. The decrease in the price of solar panels affects the affordability of the panels. The more affordable the systems are, the more people can buy the panels and thus the higher solar energy production. Also, the price of energy itself affects the production. The higher the energy cost, the more attractive it is to generate renewables. A higher price does not only mean, you will save more money, but also increases the profitability of feeding excess solar energy into the grid.

4.2 Scope

To ensure a reliable and feasible research, I define the appropriate scope of analysis. To use a cliche, everything in life has its place and time, and research is no exception to this rule. Therefore, I need to demarcate what places and which years this thesis investigates. In short, where and when is the research taking place.

First, the question 'where'. The answer to this question defines the spatial scope of the research. For this analysis, I focus on the Dutch municipalities. The Association of Dutch Municipalities (Vereniging van Nederlandse Gemeenten) defined the boundaries of these districts. Except for the towns of the province Zeeland, I examine all the municipalities. Omitting the cities in this region is due to lack of available information on Zeeland.[68] The initiators of the database are the Dutch transmission system operators.[69] However, the operator of Zeeland did not join the initiative, and therefore there is no data available in this area.[70]

The second interrogative pronoun "when" refers to the temporal scope of the research. Given the combination of availability of information, and the reliability and relevance of the data, plus the feasibility of the study, the scope entails 2008 until 2015. 2008 is the oldest year of which the database 'Energy View' has data on energy production. Furthermore, this is the year in which the first major national funding scheme for sustainable measures started. Moreover, 2015 is the final year for which

[68] Enexis; Liander; Stedin: http://www.energieinbeeld.nl/.
[69] Ibid
[70] Ibid

adequate information is available. Therefore this is the upper limit of the research. To summarise the scope is:

Dutch municipalities from 2008 until 2015

4.3 Operationalisation

The fifth step in the research design is the operationalization of the variables. In the following paragraphs, I will explain where I found the information on each of the variables and explain how each of the variables is measured.

4.3.1 'Hard' measures & 'soft' measures

To measure the influence of the local policy instruments, the information about these tools is collected. The definition of local policy measures is ***policies, funding and other policy instruments by municipalities.*** Therefore, I collect the data on both the 'hard'- and soft tools for each of the communes. To gather the information on the 'hard' measures, I looked for the subsidies and loan intended for the installation of solar panels on residential buildings. Multiple sources provided this information. The primary sources of information were the websites of the municipalities and provinces and the website of the Dutch government 'overheid.nl', which publishes all the local laws and regulations, and the sites on the funding and loans for sustainable measures.[71] The data of the 'soft' policy instruments, the energy service desks, was gathered using the same sources, with additional information collected from the national, regional and local sites about the energy service offices.[72]

After collecting the information, I entered the data on into an excel file, creating an overview of the different types of local policy measures for each of the municipalities. The two types of local instruments, 'hard' stimuli and 'soft' stimuli, divide this summary into two. To analyse the effect of these two categories, I coded them as dummy variables.

[71] https://zoek.overheid.nl/lokale_wet_en_regelgeving, see appendix for overview of all the sources.
[72] http://www.energieloket.nl/; https://regionaalenergieloket.nl/; see appendix for overview of all the sources.

The ‘hard’ stimulus variable is coded dichotomous because not all the information about the loans is known. Although the height of subsidy is known for many municipalities, this grant is intended for multiple purposes, and only partly destined for solar panels. However, which part of the subsidy the cities reserved for this purpose, it is often not clear.

Furthermore, the height of the loan is also known, but the exact amount paid to the citizens for the installation of solar panels is unknown. To circumvent this problem, I decided to code the local policy measures using a dummy variable: 1 there is a subsidy or loan, 0 there is no subsidy or loan. The coding for the ‘soft’ stimuli uses the same principle. Whenever there is an energy service desk specifically designed to provide information to homeowners about solar energy and panels, it is coded with a 1, if not it receives a 0. Moreover, some municipalities implemented both ‘hard’- and ‘soft’ policy measures. To analyse the effect of the combination of the two policies, I created an interaction variable. This variable multiplies the dummy values of the 'hard' and 'soft' stimuli to form a new interaction variable.

4.3.2 Solar energy

Solar energy can be produced in a lot of different places and measured in multiple ways. Therefore, before the effect of the policy instruments on the generation of solar power can be analysed a clear operationalization is needed. In section 4.1.2 the dependent variable is defined as ***Photovoltaic solar energy generated from solar panels on residential buildings.*** More specifically, the kilowatt hours (kWh) of photovoltaic solar power generated by solar panels on residential buildings. Within the category residential buildings, there are high-volume consumers, which are customers such as businesses, industries and other users with a power connection above 3x80 ampere and small consumers. These consumers are mainly households and some other users who have a power connection with a maximum of 3x80 ampere. The analysis focuses on this last category, the small consumers.

How much solar energy these consumers produce is collected by many institutions and organisations. However, there are differences in the way they collect this data and to what level of detail they receive this information. Since I want to analyse the relationship between local policy instruments and the domestic production of solar energy, not all databases are suitable. After all, this type of research requires that the output is specified for homeowners and collected on the municipal level. The database that fulfilled these criteria and allowed for the easiest collection was Energy View.[73] Within this database, the numbers on the production of 'small consumers' comprise solar power generation of homes and small companies.[74] The part of the companies is virtually negligible, and therefore I can perform the analysis using these numbers.[75]

The initiators created the data bank with the goal of aiding municipalities and provinces to keep track of the effect of their climate policies. The initiators of the database are the Dutch transmission system operators, Enexis, Liander, Stedin, Cogas and Westland Infra. The transmission operator for the Province Zeeland did not participate, and as a result, there is no data of this province. Furthermore, the companies want to secure the privacy of individual households and ensure that the information remains anonymous. Hereto, they take two measures. First, they collect the data on energy generation in clusters on postcode- and neighbourhood level. Second, these clusters must have a minimum of 6 connections.[76] However, the smaller regions often have too little sections to fulfil this criterion, which means that their privacy would no longer be guaranteed. Therefore the operators excluded these areas. As a result, some data is missing, mainly of the smaller municipalities.

Before performing this analysis, I performed some calculations. The first addition is that the energy will be measured not only per municipality but also within a particular year. More specifically, the difference in the production between two years will be measured. n other words, the dependent variable is the production of the current year minus the generation of the previous year. By doing so, I measure the in- or decrease in

[73] Enexis; Liander; Stedin: http://www.energieinbeeld.nl/
[74] Ibid
[75] Ibid
[76] Enexis; Liander; Stedin: http://www.energieinbeeld.nl/faq/

production rather than the total production in that year. This way I can see if a policy instrument in one year altered solar energy generation compared to the year before. By calculating the difference in the generation of solar power, the formula for dependent variable is:

$$DiffkWh_{i,t} = kWh_{i,t} - kWh_{i,t-1}$$

The second addition helps to account for the differences in population size between the municipalities. The population size likely matters because smaller districts have fewer homeowners and thus fewer homes. Therefore, these areas have fewer roofs to place solar panels on and thus a lower energy production. In other words, just by having a larger population, it could be the case that larger municipalities have a higher rate of solar power than smaller regions. Not controlling for this factor could lead to wrongfully addressing greater energy production to a policy measure. The solar output of the municipalities divided by the population size controls for the different sizes. Which is why I adjust the formula in the following way:

$$DiffkWh\_per\ capita_{i,t} = (kWh_{i,t} - kWh_{i,t-1}) / population_{i,t}$$

4.3.3 Control variables

Besides the effect of the explanatory variables, other factors also influence the production of solar energy within a municipality. Therefore, I add these elements to the model in the form of control variables. These variables control for the demographic factors and other yearly trends in the municipalities. There are three variables for the different age groups for which the model controls. One variable is the percentage under the age of 21, the second is the percentage between 20 and 45 years old, and the third variable represents the percentage of the population over 65 years of age. The factor income is not added as a separate variable because this is linked to age and therefore will probably correlate with the age variables. Moreover, due to the linkage, any effect of income will probably show up in the age variables. The share of the population is gathered using the numbers from Statistics Netherlands.[77] The use of the percentage of

[77] See appendix for full list of sources

people allows for measuring the effect of having a larger or a smaller share of the age group within a municipality. In other words, I do not expect that having twenty more people under the age of 21 or over 65 makes a difference, but I do think it is likely that having 20% more people of a particular age group affects the results.

Alongside the demographic factors, the yearly trends are represented by the year dummies. Grouping these annual factors into one variable for each year makes the model less complex. Furthermore, separating this variable could result in collinearity with other variables. Or wrongfully addressing effects to a factor, while in reality, the causes are more complex. For example, adding the gross price of solar panels as a separate variable shows that the higher the price, the higher the energy production. While in reality this, of course, is not the case. The gross cost of the systems is not the price that affects the purchase of solar panels; it is the net price. These costs consist of the cost of solar panels, the energy price and subsidies. So, if you only include the gross price, the model is inaccurate, but combining it with the grants and energy price leads to collinearity.

4.3.4 Model

I will use cross-sectional time-series data. In this case, that means I collected the difference of generated kilowatt hours solar energy from the municipalities from all the provinces (except for Zeeland) over the years 2008 until 2015. The upside is that it ensures a more in-depth analysis and a broader perspective on time. First of all, reviewing these many municipalities and years assures that any conclusion about the effect of local policy measures on the generation is representative of a vast number of places. Second, it guarantees a broader look at the influence of local policy measures on solar energy over time. The conclusions about the impact of the policies are not isolated, but rather an effect that is visible over the course of many years.

The data to analyse the effect of subsidies, loans and energy service desks on the production of solar power contains both data points across different municipalities, as well as points across multiple years. This type of cross-sectional, cross time series data is

best analysed using a fixed effects regression model. To run this kind of regression, I create a model containing all the variables mentioned above. Into this model, I will formalise the dependent variable, the set of explanatory variables and the control variables. The section below presents and explains this model step by step.

Combining these theories, I form the following model:

$$\boldsymbol{DiffkWh_{i,t}} = \boldsymbol{C} + \beta_1 \boldsymbol{Hard_{i,t}} + \beta_2 \boldsymbol{Soft_{i,t}} + \beta_3 \boldsymbol{Int_{i,t}} + \beta_4 \boldsymbol{Perc{<}21_{i,t}} + \beta_5 \boldsymbol{Perc20\text{-}45_{i,t}} + \beta_6 \boldsymbol{Perc{>}65_{i,t}} + \varepsilon_{i,t}$$

- $\boldsymbol{DiffkWh_{i,t}}$ is the dependent variable, which is the difference in the amount of kilowatt hours generated per capita, between $year_t$ and $year_{t-1}$. The $\boldsymbol{i}$ represents the municipality and $\boldsymbol{t}$ represents the time. This leads to the full definition of $\boldsymbol{DiffkWh_{i,t}}$ the difference in the amount of kilowatt hours generated per capita per municipality over the course of one year.

- $\boldsymbol{Hard_{i,t}}$ is the first independent variable, which is the 'hard' stimulus. The 'hard' stimulus encompasses the subsidies and loans provided by the municipality and provinces in a year.

- $\boldsymbol{Soft_{i,t}}$ represents the second independent variable, the 'soft' stimulus. This variable captures the effect of the presence of an energy service desk in a municipality.

- $\boldsymbol{Int_{i,t}}$ is the variable that represents the interaction between the 'hard' and the 'soft' variable.

- $\boldsymbol{Perc{<}21_{i,t}}$ is the percentage of the population under 21

- $\boldsymbol{Perc20\text{-}45_{i,t}}$ is the percentage of the population between 20 and 45 years old.

- $\boldsymbol{Perc{>}65_{i,t}}$ is the percentage of the population above 65

5. Analysis

From 2008 until 2015 many municipalities have offered subsidies and loans as well as created energy service-desks. To get an idea which regions implemented these grants and created these desks, let's start with some general statistics. In all of the municipalities divided over the course of the eight years, 1309 subsidies and loans were offered, with most of these grants implemented between 2013 and 2015. Of course, these statistics merely provide a shallow inside of what is going on. To get a deeper understanding of the effects at play, I performed a fixed effects regression analysis.

5.1 Analysis of the influence of local policy measures

In the following sections, I will explain the model and its variables and repeat the expected effects of these variables. After that, I will analyse the results of the regression to examine if these anticipated effects are indeed happening. Then, I will check the robustness of the model and finally draw conclusions about the influence of local policy measures on the generation of solar energy.

5.1.1 The variables in the model

The effect of local policy measures on the generation of solar energy is analysed using a fixed effects regression model. Here, the dependent variable is the change in kilowatt hours of generated solar power per capita. Using the difference in the production of energy allows the model to show if the local policy measures deployed in a particular year, increased or decreased the amount of solar energy as compared to the previous year. These local policy measures are the independent variable of the model. This variable is divided into a dummy variable ‘hard’ stimulus, representing the subsidies and loans for solar panels and the dummy variable ‘soft’ stimulus, entailing the energy service desks. Furthermore, a third independent variable is added to capture the combined effect of the ‘hard’ and ‘soft’ stimuli. This interaction variable multiplies the value of the ‘hard’ stimulus with that of the ‘soft’ stimulus.

Besides these explanatory variables, the model contains control variables. These variables control for trends over time and for demographic factors. The year variables mirror the trends over time. Furthermore, the age variables reflect the effect of demographic factors. These variables control for the percentage of the population within the municipality under the age of 21, the percentage between 20 and 45 years old and the percentage over the age 65.

5.1.2 Expected results of the independent and control variables

Each of the variables mentioned in the formula is expected to have an implication for the generation of solar power. Building upon the ideas from the theories and the results from the reports, I formed hypotheses on the effect of these three variables. I expect that both 'hard'- and 'soft' stimuli would have a positive effect on the generation of solar energy. The expectation is that subsidies or loans will increase the amount of solar energy generated within the municipality. The presence of energy service-desks is likely to have the same effect. The reasoning behind these hypotheses is: subsidies and loans make the purchase of solar panels more profitable and the information at the desks help to create a more positive attitude towards solar panels. Both these policies are expected to increases the likelihood of people buying solar panels and therefore increase the solar energy production within the municipality. Furthermore, the combination of the two stimuli is likely to have an effect as well. However, a priori it is not clear what this effect will be. It could be that the combination enforces the individual policies, but it could also be the case that there is no difference between implementing one measure and applying both.

Moreover, I expect that the control variables will have an impact as well. Although the dependent variable itself controls for the difference in size of the populations, the age of the people and the yearly trends could influence the results. The reasoning behind this conclusion is as follows. A very young municipality probably has fewer homeowners and thus fewer people that can install solar panels on their roofs. An old population, on the other hand, is less likely to invest in solar panels, because of the long return on investment. The expectation is that the people in between these two

groups increase the production because they highly represented among the homeowners and have the financial means to invest in solar panels.

5.1.3 Results

‘Hard’, ‘soft’ and interaction variables

In this section, I will explain the influence of the explanatory variables and afterwards the impact of the control variables. The regression shows that ‘hard’ and the ‘soft’ stimulus have a significant positive effect on the difference in generation of solar power. The results of the ‘hard’ stimulus imply that when a municipality has made a subsidy or loan available, the number of kilowatt hours of solar energy increases with 3.17, as compared to the previous year. In other words, local grants or loans increase the generation of solar power. The same effect is visible for the ‘soft’ stimulus. A municipality opening an energy service desk enhances the difference in solar energy significantly with 8.28 kWh. Specifically, the availability of an energy service desk improves the solar power generation opposed to the year before.

These results are in line with the hypothesised effects of the variables. However, it is noteworthy to mention that the effect of the ‘soft’ variable is stronger than the effect of the ‘hard’ variable. In other words, the energy service desks increase the production of solar power more, than the subsidies and loans do. Apparently, information about the benefits of solar panels and the options for funding are more important than the funding itself. However, some caution should be taken when interpreting this result. The difference in the impact of ‘hard’ and ‘soft’, could be due to the couple of years in which municipalities implemented energy service desks, but did not offer any subsidies or loans. When the production of solar energy, coincidentally has relatively increased, compared to the years before, it may look if the ‘soft’ variable has a strong effect. While, in reality, this effect might be equal to the impact of ‘hard’ policy instruments or even be slightly less. To further support this argument, let us look at the results of the year 2011. The year 2011 shows a dip in the increase of solar power. Although, the difference is not significant, the effect of the change in policies is noticeable. At the start of the year 2011,

the government changed the applicability criteria to exclude households. The decrease in the data indicates that this affected the purchasing behaviour of citizens. In other words, the energy service desks are useful in removing or lowering the barriers to purchase solar power, but subsidies and loans also have a positive effect in making the purchase more affordable. In short, both the measures contribute to an increase in the difference in the production of solar energy.

Then, the interpretation of the interaction variable. Contrary to the other two independent variables, this interpretation is less straightforward. At first sight, the results show a negative correlation between the combination of the 'hard'- and 'soft' stimuli and the generation of solar energy. More specifically, the mixture of the two policies creates a significant negative coefficient of -2.86. However, it is incorrect to conclude that therefore the interaction decreases the generation of solar energy. Rather, the opposite is true. Combining the two policies is more beneficial to the production than implementing the policies individually. Understanding the interaction between the two instruments requires a little calculation. As mentioned above, the coefficient of subsidies and loans is 3.17, the ratio of the service desks is 8.28, and the combination of the two measures generates a coefficient of -2.86. Adding these numbers together. 3.17 + 8.28 - 2.86, results in a positive coefficient of 8.67. This value is higher than the coefficients of the 'hard' policy measures, but not (notably) greater than the impact of 'soft' instruments. In plain English, the combination of both subsidies or loans ánd an energy service desk increases the number of kilowatt hours solar energy more than just having a 'hard' stimulus in place. To sum up, all three of the independent variables have a significant effect. Furthermore, the effect of both the energy service desks and financial incentives together is more beneficial than implementing the subsidies and loans on their own.

Difference in kWh solar energy	
Hard stimulus	3.165**
	(-1)
Soft stimulus	8.280***
	(1.15)
Interaction variable	-2.864*
	(1.22)
D2009	8.228***
	(2.37)
D2010	6.507**
	(2.13)
D2011	3.688
	(1.88)
D2012	10.058***
	(1.56)
D2013	16.570***
	(1.3)
D2014	11.430***
	(1.11)
D2015	15.350***
	(0.95)
Perc<21	-1.871*
	(0.78)
Perc20-45	-0.464
	(0.6)
Perc>65	2.559***
	(0.64)
Constant	9.217
	(36.57)
R-squared	0.464
dfres	1985
* p<0.05, ** p<0.01, *** p<0.001	

Control variables

Alongside, the independent variables, the model also contains control variables. These control variables come in two types, year- and the age variables. The year variables control for fixed factors within a year, and the age variables control for the demographic impact of certain age groups. In this section, I will examine the effect of these yearly trends and demographic factors.

First, the year variables. Except for 2011, all of the coefficients of the year dummies have a significant positive effect on the dependent variable. That means that the yearly trends lead to significantly more solar energy as compared to the year before. Second, the age variables. The results indicate that the age groups have different effects. The population aged up to 21 years has a decreasing effect on the difference in production of solar energy, whereas the older population, the percentage aged over 65, increases the gap in the number of kilowatt hours. The group aged 20 to 45 years old does not have a significant effect as compared to the control group of 45 to 65. The coefficient of the younger proportion of the population is -1.87 and the older part of the population has a value of 2.56. In summary, as expected, the lack of income and fewer homeowners of the percentage of the population under 21, decreases the difference in production. However, the hypothesis that the older population would have a diminishing effect turn out not to be true. An explanation for this phenomenon is that this group, contrary to the expectation, view the purchase of solar panels as a substantial investment. Due to the small interests, these group of people rather invests in their homes, than leaving the money in their savings account.

Summarising, the combination of the independent and control variables adds up to a model with an R-squared of 0.46, with a significant F value. Overall, the results of the model help to support the rejection of the null-hypothesis and give no indication for rejecting the alternative hypotheses. So, what is the influence of local policy instruments on the production of solar energy? The local policies, in their ‘hard’, ‘soft’ and combined form, increase solar power generation. However, the impact of the yearly trends is high. In other words, factors such as the changes in energy prices, the decrease in the price of

solar panels and the spillover-effect of subsidies influence the difference in solar power generation within a municipality.

6. Conclusion

Over the course of eight years, there have been different types policies to stimulate the generation of solar power. It started out with a national subsidy scheme in 2008 and slowly changed to multiple local plans in 2014. Each of these systems has been successful in term of the number of applications for the grant, but was the influence of these policies on the production of solar energy? This thesis has tried to provide an answer to this question.

The switch from a national to a local system has made municipalities more aware of what role they could play in making this world more sustainable. Therefore, they have started to stimulate their citizens to contribute towards achieving their sustainable goals. There are multiple ways in which the local policymakers can encourage their citizens to switch towards the use of more environmentally friendly energy sources. These various policies categorise into two types of tools: ‘hard’- and ‘soft’ measures. ‘Hard’ tools are policies and regulations which entail granting loans or subsidies for the instalment of solar panels on residential buildings. ‘Soft’ instruments are energy service-desks created by the municipalities to provide information to residents about the benefits of solar panels and the possibilities for funding.

The expectation was that both 'hard'- and 'soft' stimuli would have a positive effect on the generation of solar power. Since subsidies and loans make the purchase of solar panels more profitable and the information at the desks would help to create a more positive attitude towards solar panels, it seemed likely that these policies would increase the production of solar energy. Furthermore, the expectation was that the combination of the two policies would have an effect as well. However, just by looking at the theory, it is not clear what this effect will be. It could be that the combination

enforces the individual policies, but it could also be the case that there is no difference between implementing one measure and applying both.

Moreover, the demographic factors and yearly trends had a hypothesised effect as well. A very young municipality probably has fewer homeowners and thus fewer people that can install solar panels on their roofs. An old population, on the other hand, is less likely to invest in solar panels, because of the long return on investment. The people in between these two groups are expected to increase the production because they highly represented among the homeowners and have the financial means to invest in solar panels.

The yearly trends entail some aspects that could affect the production of solar energy, such as the changes in energy prices, the decrease in the price of solar panels and the spillover-effect of subsidies. The price of energy itself affects the production because a higher price does not only mean, you will save more money, but also increases the profitability of feeding excess solar power into the grid. The decrease in the price of solar panels affects the affordability of the panels. The more affordable the systems are, the more people can buy the systems and thus the higher the solar energy production. Finally, the spillover-effect of a subsidy affects the production because the financial impulse carries over to the subsequent years.

The results of the regression analysis are in line with these expectations. The regression shows that ‘hard’ and the ‘soft’ stimulus have a significant positive effect on the difference in generation of solar power. Also, the combination of both subsidies or loans ánd an energy service desk increases the number of kilowatt hours solar energy more than just having a ‘hard’ stimulus in place. However, it is noteworthy to mention that the effect of the ‘soft’ variable is stronger than the effect of the ‘hard’ variable. However, some caution should be taken when interpreting this result. The difference in the impact of ‘hard’ and ‘soft’, could be due to the couple of years in which municipalities implemented energy service desks, but did not offer any subsidies or loans. When the production of solar energy, coincidentally has relatively increased, compared to the

years before, it may look if the 'soft' variable has a strong effect. While, in reality, this effect might be equal to the impact of 'hard' policy instruments or even be slightly less.

Furthermore, the yearly trends lead to significantly more solar energy as compared to the year before. Also, the population aged up to 21 years has a decreasing effect on the difference in production of solar power, whereas the older population, the percentage aged over 65, increases the gap in the number of kilowatt hours. The group aged 20 to 45 years old does not have a significant effect as compared to the control group of 45 to 65.

In summary, the subsidies, loans and energy service desks have managed to contribute to an increase in the difference in solar energy. However, although the analysis shows that 'soft' policy measures are effective in stimulating the production of solar energy, other research points out that these types of information rely on citizens that are already somewhat aware of renewable energy solutions.[78] Furthermore, the demographic and yearly trends do have a substantial effect. It is therefore fair to say that, although the local policies can contribute to generating more solar power, the factors beyond the control of the municipality play a substantial role.

Concluding, local policy instruments have a positive influence on the production of solar energy. So indeed, these tools might be little rays of sunshine in the path towards a more sustainable society. On that sunny note, let me conclude with a quote from the book The Hollow.

"Do you see that out there? The strange, unfamiliar light? It's called the sun. Let's go get us a little."

Nora Roberts, The Hollow

[78] O'Riordan, T. 2009. „Reflections on the pathways to sustainability." As cited by Murphy, Lorraine, Frit Meijer, en Henk Visscher. 2012. Governance Tools, page 356

7. Implications for further research and policy makers

Although I attempted to conduct an analysis that would be as accurate as possible in predicting the influence of local policy instruments, there is room for improvement and extension of the research. The first area of improvement is breaking down the ‘hard’ variable. Subdividing these variables could help to investigate if the different types of subsidies and loans have a different effect on the production of solar power. Furthermore, the research could be extended to encompass a cost effectiveness analysis. This type of analysis helps to examine if the impact of the subsidies, loans and energy service desks justifies the public spending.

Which is why I carefully offer some advice to local policy-makers that want to increase the renewable energy production within their jurisdiction. My analysis shows that both that 'hard' and 'soft' policies have a positive impact on the generation of solar power. Therefore, I would advise the local administrators to consider opening an energy service desk, offering a grant or provide the opportunity to citizens to apply for a loan. However, I cannot say anything about the cost effectiveness. Therefore, each of the policy makers should calculate the cost to society before implementing these tools.

Furthermore, the impact of the yearly trends indicates that the fixed factors, such as the price of solar panels and the spillover-effect of subsidies from one year into to following year, influence the number of kilowatt hours generated. That is why I think it is wise to track the solar energy production and the impact of these factors and then assess the impact of previous policies regarding solar panels.

In short, subsidies, loans and energy service desks are an effective way to increase the solar power production, but the cost effectiveness of these policies should be assessed case by case.

8. Appendix

Sources policy instruments
Duurzaam Energieloket
Energie Overheid
Friese Energiepremie
Gemeente Aalsmeer
Gemeente Almere
Gemeente Arnhem
Limburgse Energie Subsidie
Provincie Drenthe
Provincie Flevoland
Provincie Gelderland
Provincie Groningen
Regionaal Duurzaam Energieloket
Servicepunt Duurzame Energie Noord-Holland
Stimuleringsfonds Volkshuisvesting
Duurzaamheidslening
Zoek officiële bekendmakingen

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