Assignment 5

Energy Strategy 2050
The Netherlands

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Energy Policy & Transitions (GEO4-2311)
MSc Sustainable Development

Adam Mathews	3421503
Sanderine van Odijk	3073807
Jessica Yearwood	3492508

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1. INTRODUCTION

In this document, an energy policy plan will be developed for the Netherlands. Located in the northwest of Europe, a region characterized by a maritime climate with cool summers and mild winters, the Netherlands offers, on the one hand, good potentials for a variety of renewable energy sources. Wind is abundant, and space, which is a constraint, can be overcome by extending offshore. Other sources include geothermal, wave, biomass and solar. On the other hand, energy consumption savings will reduce demand, and therefore the amount of energy required. This paper will look at a number of possibilities within a system perspective, whereby many of the policies find reasoning within the field of Evolutionary Economics and its offshoots.

1.1. Problem analysis

The Dutch current energy supply, largely driven by oil and gas, requires a transition. Fossil fuel reserves are declining, which will result in higher and less predictable costs. Also, the dependence on gas and oil from countries with unstable political regimes can threaten the energy security of the country. Additionally, the environmental impact of fossil fuel burning, and especially the contribution of the greenhouse gas CO_2 to climate change, poses significant threats to the Netherlands, being a low lying country. The expected sea-level rise of around 1 meter in 2100 will have large consequences for the live-ability of the Netherlands. Immediate action is required now, for the Netherlands to retain a strong economy, with a reliable and independent energy supply and an innovative green technology sector. The current lock-in from fossil-fuel based resources for Dutch energy supply is a major obstacle to the development of a fully renewable-powered energy sector. This lock-in situation is best observed in the electricity supply, based on coal and gas, in the transport system, which relies on liquid fossil fuels as well as in the heating supply supplied (largely) by natural gas.

In order to unlock the energy system it is important to take a system approach, considering the existing, and potential, interactions among actors and institutions. In accordance with Evolutionary Economic theory, during the initial stage of system transition, special attention should be paid to fostering diversity in innovative energy supply, while at a later stage specific technologies should be selected to achieve optimal allocation of resources and use of conditions. At the same time, alignment of the different levels is needed to create windows of opportunity for the niche technologies to overcome the current, locked-in system, as described in the Multi-Level Perspective. Some of these new niches should be supported by the government in order to become market leaders and hence the dominant regime. When possible, building upon existing infrastructure, knowledge and policy, while using other instruments such as developing regional clusters the transition to a renewable energy based economy can be facilitated.

Based on a previous literature review, as part of the course 'Energy Policy and Transitions' at Utrecht University, it is important to base policy plans not only on a neoclassical perspective that seeks largely to correct market failures through financial incentives, but on different approaches aiming at correcting system failures. Another lesson learned is to align all existing policies under the transition policy umbrella to avoid conflicts between them.

1.2. Goal

The government of the Netherlands has made an ambitious goal of transforming its energy sector to 100% renewable in 2050.

To reach this goal, extensive policy measures have to be taken, which will be outlined in this plan. The focus of this transition policy plan is to present the tools necessary to transform the current energy system. In order to fulfil the transition goal, there is a need for a mix of strategies that take into account both demand-side and supply-side measures to unlock the current energy system. It is important to maintain the goal throughout the defined period of time to show the government's commitment, although it should be borne in mind that the target is 2050, and the route is not defined except through existing international commitments.

Setting an ambitious, clear, overall goal will trigger a virtuous cycle and provide legitimacy. By guiding the search, new resources are made available to reach these goals, which in turn, will lead to knowledge development and increasing expectations about technological options (Hekkert et al, 2007).

2. CURRENT SITUATION

2.1. Energy consumption

A breakdown of current primary energy consumption is given in the table below

	TWh/year	% of total supply
Solids	84,5	9,3
Oil	365,6	40,1
Natural gas	388,6	42,6
Nuclear	11,8	1,3
Electricity	16,2	1,8
Renewables	45,6	5,0
	912,3	

Table 1: Breakdown of 2010 sources of consumed energy (Data taken from NTUA, 2009)

2.1.1. Conventional Fuels (Fossil and Nuclear)

- **Gas:** At present, 42% of overall energy use, and over 55% of electricity in the Netherlands is produced by gas. The Netherlands became dependent on gas after large discoveries at the Groningen gas field. Current domestic supplies are estimated at 16 years (at present rates of use), while internationally reserves will last 60 years at current consumption (World Energy Council, 2007). Other large-scale uses of gas include domestic and greenhouse heating, industrial purposes and as a feeder in the petrochemical industry. (IEA – Gas)

- **Coal:** Coal and Lignite supply over 20% of current electricity demand in the Netherlands. As no coal is mined domestically, it is imported – largely through Rotterdam port. As well as producing electricity, 26,600TJ (7.4TWhTh) of power from coal was used in coke and blast furnaces. (IEA – Coal). CO_2 Emitted from Coal-fired power plants is a major contributor to Climate Change.

- **Oil:** While the Netherlands has only small reserves of oil, consumption in 2010 was 31.4Mtoe (365TWh), contributing around 40% of the primary energy consumption in that year. Oil is used for transport and as liquid petroleum gas (LPG) in industry (NTUA, 2009). Global oil reserves currently total 40 years at current consumption rates. (BP, 2011)

- **Nuclear:** The Borssele Nuclear Plant is currently the only Nuclear power station in the Netherlands, with a capacity of 485MW, and has been operational since 1973. The Dutch utility company, Delta, is currently constructing a new plant at the same site, which is due to go online in 2018, however the state of this construction has not been certified by this report.

2.1.2. Renewables

Currently (2010) only 5% of the total energy production of the Netherlands is from renewable sources, of which 80% is through incineration of biomass and waste, and 20% is from wind. Under Business as Usual conditions, the share of biomass in energy production is predicted to grow to 16% of overall production by 2030, with wind at 5%, solar 4% and geothermal 2%. This includes an anticipated decline in domestic Natural Gas production from 54900 Mtoe in 2010 to 32670 Mtoe in 2030, should reserves permit (NTUA, 2009).

2.2. Potentials

2.2.1. Reducing Demand

Energy, heat and the process of extracting raw materials, rely upon rapidly depleting non-renewable fossil resources. In almost all sectors, energy, heat and raw materials are essential. Based on data found in PRIMES 2009 (NTUA, 2009) and the EU Database on Energy Saving Potentials, different target sectors have been chosen that, according to present data and extrapolations and future projections, offer the highest demand reduction potential that can realistically be achieved. The potentials used are based on a high policy measures scenario in which a multitude of policy measures are used to move from the present business-as-usual scenario towards the technical potentials that can be achieved in the different sectors.

The following savings potentials through efficiency and technology improvements have been calculated using data provided in PRIMES 2009 and the EU Database on Energy Saving Potentials and extrapolated linearly to 2050.

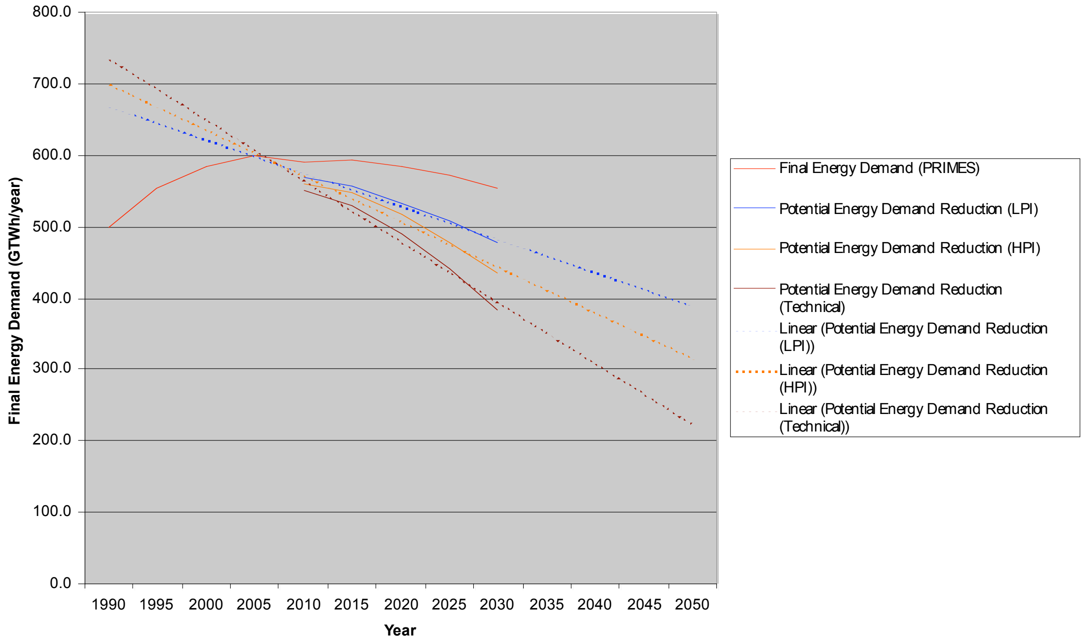


Figure 1. Graph of potentials for energy consumption against PRIMES baseline to 2030 and extrapolated to 2050 (data from NTUA, 2009 and EU Database)

The potentials are defined by the EU database as follows:

- **Low policy intensity potential (LPI)** corresponds to the energy savings obtained in the low policy intensity scenario in comparison to the autonomous scenario.
- **High policy intensity potential (HPI)** corresponds to the energy savings obtained in the high policy intensity scenario in comparison to the autonomous scenario.
- **Technical potential** corresponds to the energy savings obtained in the technical scenario in comparison to the autonomous scenario

(EU Database)

The graphs show potential energy savings across all four sectors. The data also include details for intrasectoral savings as shown below:

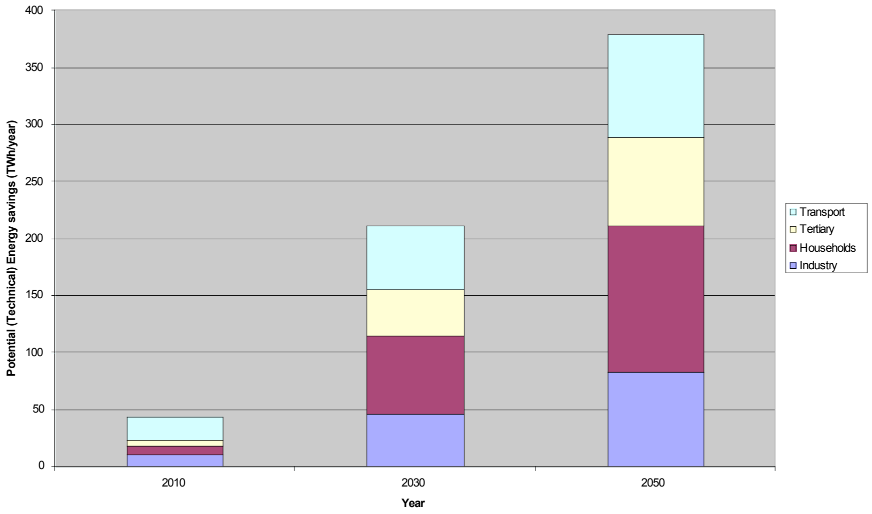


Figure 2. Energy savings by sector in the HPI scenario for the Netherlands, extrapolated to 2050 (EU Database)

Using these values, the target for total Dutch Energy Consumption in 2050 (HPI level) is 320TWh/year. It can, however, reasonably be predicted that the LPI level at least will be attained, that is 390TWh/year, as compared to total current demand of 590TWh/year. These targets are ambitious but also highly obtainable.

The following savings have been predicted by the EU Data Base on Energy Saving Potentials (and linearly extrapolated to 2050)

Based on the high policy potential data for the different sectors, the following high potentials have identified and the outline of policies will therefore focus on these areas (see section 3.3):
- chemical industry (12.2 TWh)
- transport sector, passenger and freight transport (65TWh)
- in tertiary sector heating of service buildings (10.6 TWh)
- heating in households (25,4 TWh)

A number of other sectors also show high potential for energy savings, although due to time constraints only the above will be investigated in depth.

2.2.2. Possibilities for Supply

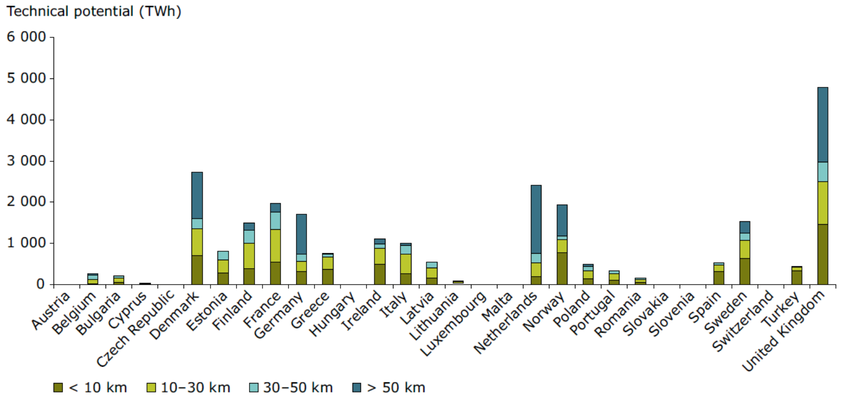
Wind

By 2012, the installed onshore wind energy capacity in the Netherlands should reach 4,000 MW. The total capacity of offshore wind in 2009 was 246.8MW, with an extra 2340MW planned to 2015. According to ENERCO, by 2020 the offshore wind energy capacity should amount to 6,000 MW. Together, these turbines will generate more than 30 TWh a year, to 2020, which equals the consumption of 8.8 million households or 30% of our total electricity consumption (households, industry, traffic, etc.). (ENERCO, 2011)

The offshore wind energy capacity in particular will continue to grow until 2050, possibly up to 20,000

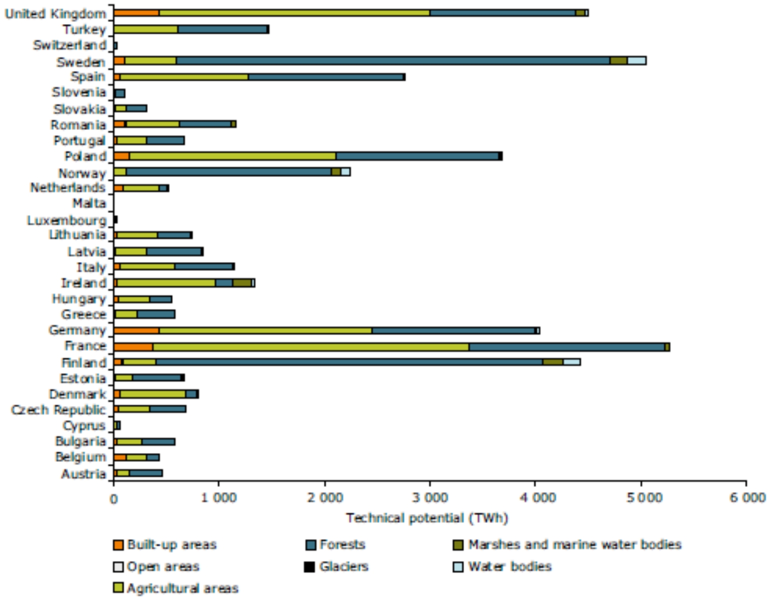
MW. By then, the wind energy capacity will be sufficient to meet 40 to 50% of the total electricity demand in the Netherlands (ENERCO, 2011).

That said, as the below two graphs show, the technical potential of wind power in the Netherlands could be around 3000TWh/year, with 500TWh/year for onshore wind projects and the remainder offshore (EEA 2009).



Note: A recent Norwegian study (NVE, 2008) estimates Norwegian offshore wind power capacity to be around 55 300 MW (at maximum depths of 50 m and minimum distances to the coast of 1 km).

Figure 3. Unrestricted technical potential for Offshore Wind Energy in 2030 based on average wind speed data (EEA 2009)



Source: EEA, 2008.

Figure 4. Unrestricted Technical Potential for onshore wind energy up to 2030, based on estimated 80m average wind speeds 2000-2005 (EEA 2009)

Geothermal

Roughly 40% of the total Dutch energy demand is in the form of 'low temperature' power for heating homes and offices (at the municipal level) and industrial greenhouses. This demand for low-temperature power could easily be supplied by geothermal energy in its various forms. (TNO 2009)

Whereas the implementation of seasonal heat and cold storage (including the use of shallow borehole heat exchangers) has become quite common on a local scale (roughly 600 installations), the number of deep low-enthalpy geothermal applications currently stands at zero. Many factors are holding back development in this area: namely, the wealth of Dutch gas resources, the tariff structure imposed on gas for agricultural application and the lack of a subsidiary instrument for the use of green heat. (TNO 2009)

The deep geothermal results show that the Netherlands has good subsurface conditions for the utilization of deep geothermal energy but that the current deep geothermal market is still in its infancy. The technology for the direct-use of deep geothermal energy is matured and is therefore not considered as a possible bottleneck for the deployment of deep geothermal energy in the Netherlands. (Mackaaij, 2010)

Biogas and Biomass

It has been calculated that 27.7million Kg of methane is produced by agricultural biomass every year (van Asselt et al, 2007). Not only is methane a major greenhouse gas, but harnessing this to produce energy would also cut down on the amount of gas required to fuel power stations or for home cooking (assuming heating is supplied by geothermal power). With an energy content of 55.7KJ/g, Dutch methane from agriculture alone would be able to provide 1.5PJ of primary energy. Taking a conversion factor of 30% for electricity production, this equates to 128.6GWh/year, which is small compared to total energy demand (less than 0.5%), but could be used for specific applications (preferably not electricity production, although possibly for peak-generation).

It is possible that biogas be produced from crops. Space and economics will be deciding factors in the decision as to whether crops are grown in NL for such purposes. Importing agricultural products for energy production may be worse than using Dutch natural gas as the supply would be dependant on harvests as well as the existing international competition for resources.

At present, biomass from waste is used to produce 4% of the Netherlands primary energy supply, and this is predicted to grow to 16% by 2030 (NTUA, 2009). Biogas production from green waste could impede this figure, although conversion rates to final energy are almost equal (around 30%)

Solar Power

a. Within the Netherlands

As of 2009, penetration of PV solar power in the Netherlands was very low. While Belgium had an installed capacity of 803MW, the Netherlands lags significantly – so much so that international statistics group the Netherlands with 'Rest of Europe' (total 333MW installed capacity 2009). (EPIA 2011a)

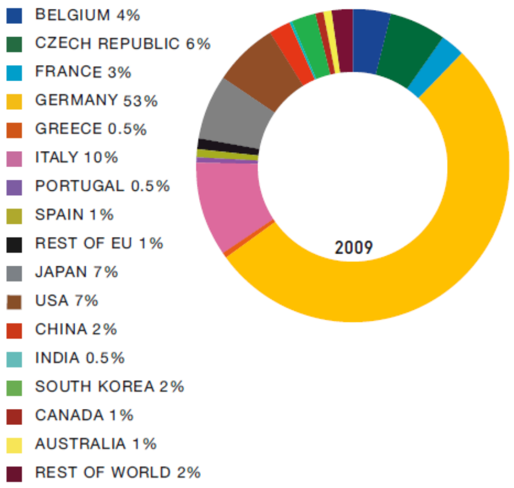
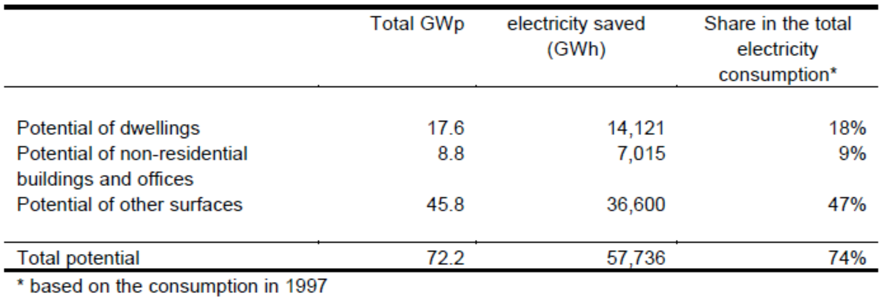


Figure 5. Breakdown of global installed capacity of wind power. The Netherlands is grouped with 'Rest of Europe' (EPIA 2011)

KPMG calculated that the technical potential for solar power in the Netherlands is around 57TWh/year, or some 15% of anticipated energy demand. With the correct market conditions and subsidies, this could easily be transformed into an economic potential too.



	Total GWp	electricity saved (GWh)	Share in the total electricity consumption*
Potential of dwellings	17.6	14,121	18%
Potential of non-residential buildings and offices	8.8	7,015	9%
Potential of other surfaces	45.8	36,600	47%
Total potential	72.2	57,736	74%

* based on the consumption in 1997

Figure 6. Total Potential for Solar Panels in the Netherlands (KPMG, 1999)

The PV sector has recently set an ambitious 12% target of total EU electricity consumption met by photovoltaic energy by 2020 (EC, 2008)

b. Solar Thermal

The below graphs show the division of the Dutch Market Potential of Solar thermal power. This would produce savings of some 70PJ/year, which is equivalent to 19TWh$_{Th}$/year.

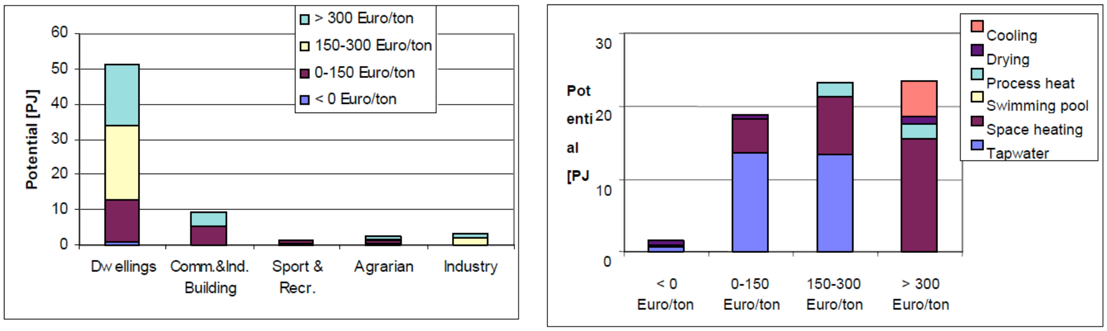


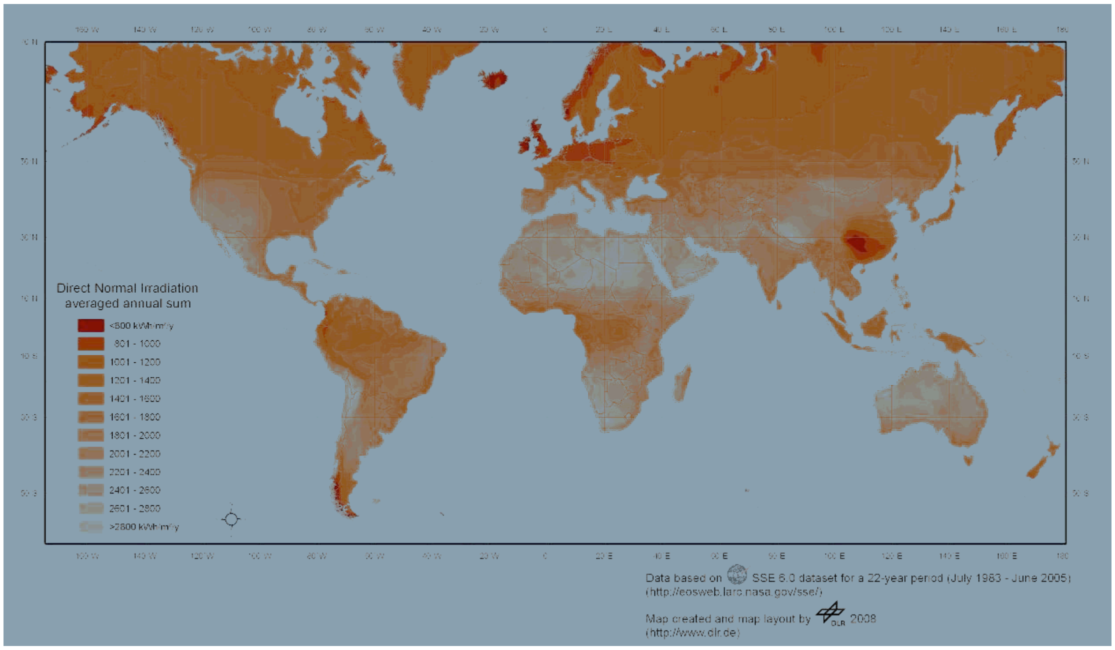
Figure 7. Potentials for solar thermal power in the Netherlands by sector (left) and by application (right) for various cost scenarios

c. International

The Netherlands is a member of the Solar Industry Initiative. They will invest €1.2billion in PV research and will seek to

- Advance manufacturing processes for all solar PV technologies, aiming at reducing costs and improving output;
- Develop Building Integrated PV (BIPV) products and applications for the easier and lower cost building integration; and
- The demonstration of concentrated solar PV (CPV) technology in the field.

Research into the Desertec plan to create electricity through concentrating solar power continues. Through an integrated international grid, this will be able to provide an enormous amount of power. Global potentials for Solar electricity production reach 3,000,000TWh/year, many times higher than current demand. That said, as the below map shows, sunlight in unevenly spread across the world.



Data based on SSE 6.0 dataset for a 22-year period (July 1983 - June 2005) (http://eosweb.larc.nasa.gov/sse/)

Map created and map layout by DLR 2008 (http://www.dlr.de)

Figure 8. World wide annual direct normal irradiation in kWh/m²/y (NASA)

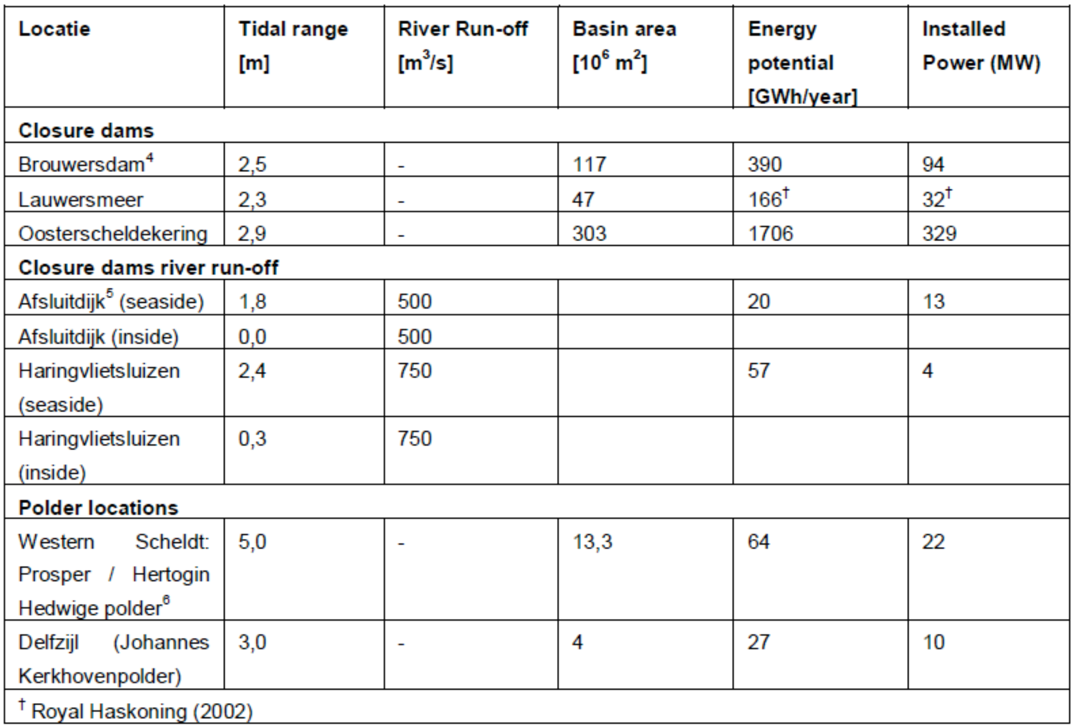
Wave Power

Wave power is, unlike wind, a predictable resource. The global, economically exploitable resource varies from 140-750 TWh/yr for current designs of devices when fully mature (Wavenet, 2003) and could rise as high as 2 000 TWh/yr (Thorpe, 1999), if all the potential improvements to existing devices are realised.

The Resource of wave power off the Dutch Continental shelf has been measured at between 7-17kW/m. Although this is not as high as the Atlantic coast of Portugal, for instance, waves in this part of the North sea are generally less destructive than in the ocean. An actual potential for Dutch wave power has yet to be calculated, although the possibilities are considerable.

Tidal

In the Netherlands, various barrages/dams already exist which were built several decades ago with the goal of reducing flood risk behind the barrage. Presently, approximately 30 to 80 years after construction, problems occur in the water quality and ecology as a result of closing off the estuaries. As part of the goal to re-open these estuaries (and therefore improve the water quality at various locations in the estuaries), implementing a tidal power plant can become attractive. (Cooper et al, 2009) The following table gives the potentials in a number of dam sites in the Netherlands.



Locatie	**Tidal range [m]**	**River Run-off [m^3/s]**	**Basin area [10^6 m^2]**	**Energy potential [GWh/year]**	**Installed Power (MW)**
Closure dams					
Brouwersdam[4]	2,5	-	117	390	94
Lauwersmeer	2,3	-	47	166[†]	32[†]
Oosterscheldekering	2,9	-	303	1706	329
Closure dams river run-off					
Afsluitdijk[5] (seaside)	1,8	500		20	13
Afsluitdijk (inside)	0,0	500			
Haringvlietsluizen (seaside)	2,4	750		57	4
Haringvlietsluizen (inside)	0,3	750			
Polder locations					
Western Scheldt: Prosper / Hertogin Hedwige polder[6]	5,0	-	13,3	64	22
Delfzijl (Johannes Kerkhovenpolder)	3,0	-	4	27	10

[†] Royal Haskoning (2002)

Table 2. Relevant indicators for tidal energy for identified areas of tidal potential (Cooper et al, 2009)

2.3. Current Policy: Energy Transition Program

The Netherlands adopted a transitions approach aiming at 'system innovation' in 2001. Using transition management, the policy model 'was developed to tackle persistent, structural problems of unsustainability unsolved by traditional short-term policy approaches in systems such as energy' (Kern and Smith, 2008). In order to overcome locked-in technologies, the model proposes the creation of transition arenas, which are public–private networks that engage diverse societal actors in a reflexive and deliberative learning process. The Energy Transition Program (ETP) is based on the following platforms:

- *Chain efficiency*: Save energy while producing goods.
- *Green resources*: Energy savings, recycling, use of bio-based raw materials.
- *New gas*: Clean use of fossil resources, carbon capture and storage.
- *Sustainable mobility*: Biofuels.
- *Sustainable electricity*: Wind.
- *Build environment*: Neighborhood development.

3. POLICY MEASURES

3.1. General policy measures

3.1.1. Creating new centres of knowledge: the Offshore Institute

The Netherlands is in desperate need of local knowledge and personnel to make the transition to a 100% renewable energy scenario. As the target of 2050 is still almost 40 years away, this time period allows for long-term planning to take place. Education will be key in providing on-hand expertise in the field of all Offshore Technologies and in the creation of networks amongst academics and businesses.

Most Offshore Technology relies upon mechanical harnessing of energy. Therefore significant knowledge spillover could occur amongst diverse groups working on turbines or materials technology, for example. A major role of the Offshore Institute will be to encourage the exchange of knowledge amongst scientists, engineers and business, and also with the general public. The exhibition hall of the new institute will be an important resource for education on where the Netherlands will receive much of its future energy supply. This will be one of the tools available for *changing the landscape* (section 3.1.4)

The creation and funding of an offshore institute will promote research in the different existing offshore technologies, such as wave, tidal and offshore wind power. It will not only establish the existing potentials for such technologies, but will encourage knowledge creation amongst University students and the wider public to create a world-leading Institute of Offshore energy technology. It will also encourage innovation through incentives and support to entrepreneurs in the field.

What is more, the private sector development of many of the ideas and technologies emanating from the Institute will be encouraged by the establishment of a free trade zone in a 10 kilometre radius of the headquarters for offshore renewable technologies, offering zero corporate tax for the first 5 years for all start-ups. A number of other tax reductions and streamlining activities will empower entrepreneurs and experts to collaborate and help build a world-class region of entrepreneurial activity and innovation in sustainable offshore technologies in the Netherlands. This allows for knowledge to be used commercially to produce market-ready technologies through the Free Trade zone located around the Institute. An incubator such as this will provide seed capital for entrepreneurs and protect developing markets, such as offshore technologies. The creation of (semi-) protected niches outside of current market selection is important to stimulate alternative technologies.

While the Netherlands will obviously have to take precedent in the use of this knowledge base, international expansion will be encouraged by making available existing contact networks through the Agency for International Business and Cooperation (NL EVD International), creating a fertile climate for sustainable energy production globally.

There are many examples of how innovation occurs in Regional Clusters - Silicon Valley being a classic case in point. Even in a globalised world, geographical location appears to be important in the dissemination of information and thus innovation across sectors (Baptista and Swann, 1998). What is more, Debresson and Amesse (1991), quoted in Baptista and Swann (1998) show that these channels are more durable when "social, cultural and symbolic bonds … resulting in a kind of 'social solidarity'" are in existence, and, as they also state, this is more likely to occur among regionally-based groups than disparate groupings. The Offshore Institute will seek to build such bonds amongst classmates, and later in the commercial world.

By not selecting a single technology for this centre, but instead focussing on a huge variety of projects and ideas, the regional cluster around the Offshore Institute will seek to breed ideas and facilitate experimentation according to the basics of Evolutionary Economics.

3.1.2. Maintaining support for existing centres of research

The government will foster diversity and promote innovation, research and development in the energy field, taking into account the transition policy goal. By promoting R&D the different actors in the system will broaden their knowledge base, which is the first step for innovation and will facilitate the unlocking of the energy system. It is important to take into account that, from a neoclassical perspective, governmental support should concentrate on a restricted number of technologies, in order to allocate the resources in a more efficient and effective manner. However, from an evolutionary economics approach, diversity is also key; therefore, in a first stage government should foster diversity and in a second stage there should be a selection of the fitter technologies to be supported further.

In order to develop diverse knowledge in both the renewable energy and energy efficiency fields, and to stimulate innovation, the government will continue investing in existing centres of research such as the following:

National Energy Research Strategy (EOS)

The EOS provides funding for renewable energy research, stimulating successful innovators, as well as existing research centres and universities. However, it is important that the funding provided is aimed towards the transition goal.

The Solar Academy at the Energy Research Centre of the Netherlands (ECN)

The ECN carries out technological research, working closely with Dutch and foreign universities, as well as research institutes, facilitating the implementation of such technologies. At the same time, the ECN should partner industry in the development and implementation of processes, products and technologies important to the transition to sustainable energy management.

3.1.3. Green FastTrack: Enabling Renewables

In order to increase pressure on locked-in technologies, support should be given to renewables by providing fast track procurement of planning permission for such projects. The current planning application procedure of the Netherlands is both unwieldy and bureaucratic. The misalignment of time-frames, from securing funding to operation of a unit can result in delays of many years. The Green FastTrack will streamline the process to ensure that investments to be made in the renewable energy sector receive priority in planning applications. Existing bureaucracy will be unable to cope with such increased demand; therefore this initiative will be overseen by a new sub-department in the Interdepartmental Directorate Energietransitie (IPE) (see section 3.1.5 for more details). Decisions will be made centrally, but with due consideration for local concerns.

In a democracy, it is important that local citizens be allowed to express concerns about new building projects in their area. Therefore all decisions will be fully participatory and will have a target of six months from initial submission of a plan to final decision. These quick decisions, whether they turn out in favour or against the investors, will benefit both the local population and business by giving a fast, unambiguous decision to work from.

3.1.4. Changing the landscape

Creating legitimacy

It is important to focus not only on technological innovation but also on social and institutional changes at a landscape level in order to influence the transition. Public opinion of the energy transition is far from guaranteed to be welcoming towards renewable energy technologies. This will require a large change throughout a society which has been lulled into a feeling of security by cheap and plentiful fuel supplies. The halcyon days of eternal expansion would appear to be behind us now. This should be explained thoroughly through education programmes, televised documentaries, action group meetings, newspaper articles and a host of other ways via advocacy groups, civil society movements and NGOs. This policy framework should not appear to be a top-down one, but rather one which takes into account projected real-world issues both globally (in the procurement of oil) and locally (the situating of wind farms), thus legitimising the process.

Involvement of local citizens throughout the process will be essential. For example, local initiatives will be devised, whereby residents will be encouraged to participate in decision-making in planning processes, and to invest in infrastructure which will return year-on-year dividends, to allow local citizens to feel personal responsibility in the transition. Short-term loans for consumers to invest in these niche technologies will be provided.

Securing a dynamic electricity supply

Under the current regime of energy production, coal-fired and nuclear power plants have been the mainstays in providing consistent 'base load' electricity to the grid. Both technologies are highly reliable energy producers, but by their nature they are also unwieldy and unable to apart to a dynamic energy system.

The new energy regime will not be like the previous one. Relying largely on intermittent wind power, there will be no scope for traditional baseload generation. Therefore a different way of thinking is required. Increased internationalisation will help to secure the supply of electricity to consumers through a Europe-wide electricity grid. This will enable both unused electricity produced to be sold on an open European market, as well as utilising power from elsewhere during peak hours or during lulls in local wind conditions, promoting a competitive market for renewable energies. It will also give access to existing energy storage present in Scandinavia, but will likewise require investment into alternative energy storage techniques in the Netherlands – a task which the EOS will be responsible for overseeing.

Much of this infrastructure already exists and plans to increase integration are well-developed. The recently opened BritNed link between the UK and the Netherlands is one such example, as is the existing agreement and infrastructure linking the Netherlands and Norway. Further investment will be made as necessary, although the private-sector can be reasonably expected to take charge of much of this construction, as was seen in the Amsterdam Power Exchange (APEX) participation in the BritNed link. The Netherlands government will use its influence to encourage further growth in this field.

3.1.5. Integrated energy planning

A whole-of-government approach to energy planning is needed in order to address this complex and dynamic transition; by involving and coordinating the different energy-related organisations and institutions, a clear framework can be developed to promote renewable alternatives in the energy system. This, in turn, will provide legitimacy and will lead to increased entrepreneurial activity, which will help create and foster a market for new technologies. It is important that the policy portfolio focuses on all the phases of the innovation process, from R&D to large-scale market diffusion, and that it is connected across governmental departments and institutions. Core energy policy issues such as security of supply, liberalisation and affordable prices, should be re-framed according to the transition goal, in order to emphasise governmental commitment.

Periodic review of energy institutions under a coherent umbrella

It is important for new entrants to have a stable, predictable investment climate that allows them to reduce risk. Political uncertainty in energy policy has dominated for the last few years, hindering development of renewable technologies in the Netherlands. Therefore, it is important periodically to review the existing financial and regulatory instruments in place in light of the transition goal. The Interdepartmental Directorate Energietransitie (IPE) was created because of stakeholder pressure to re-organise policies (Kern and Smith, 2008). It is important that such an organisation is maintained and periodically revises and coordinates the existing institutions in the light of the transition goal. These decision should not be subject to political whim.

Koplopersloket or 'Front runner desk'

The Koplopersloket was established to aid entrepreneurs to identify and channel the existing barriers to innovation, as well as supporting them on various issues (Kern and Smith, 2008). This initiative will be kept in place and promoted widely, and the findings will be channelled towards the IPE for them to set or modify policy instruments to overcome the barriers.

3.2. Supply-led policy measures

The government must level the playing field and put pressure on locked-in technologies by reviewing the existing institutions, supporting entrepreneurship and protecting niches. Temporary niche market formation can also develop expectations, essential in guidance of the search; and it can be created by favourable tax regimes or minimal consumption quotas (Hekkert et al., 2007).

3.2.1. Developing the wind energy sector

Wind power should become one of the mainstays of Dutch energy production. As such, policy is drawn-up to support the industry. The growth required in wind turbine installation in the Netherlands will be constrained by the increase globally as supplies and expertise will be in short supply. Therefore efforts will be made to encourage domestic production of windmills for both onshore and offshore wind.

Onshore wind power technology is relatively well advanced, so efforts will be made to encourage entrepreneurs to produce and collaborate domestically. This will be done through the existing Nederlandse Wind Energie Associatie (Netherlands Wind Energy Association), which will receive funding for network creation, start-up aid and provide windfarm planning advice. What is more, the Green FastTrack programme will simplify planning applications for wind-farms, within a centrally planned strategy and tender framework.

Offshore wind is a much less developed technology, and so presents an opportunity for the Netherlands to create a local knowledge base through the Offshore Institute, and thus take a lead in this burgeoning market. It is considered that incentives emanating from the Free Trade Zone around the Offshore Institute will be sufficient to drive this sector. Therefore there will be no immediate installation of market-based policies such as wind feed-in tarrifs or green certificates. The situation will be periodically reviewed as necessary.

TARGET: wind energy is to provide 50% of Dutch electricity by 2050

3.2.2. Geothermal

Geothermal energy has the potential to heat all the households and offices in the Netherlands. This should be encouraged through a number of steps. This policy, more than any, should be supported throughout political cycles while, in the initial stage at least, the new Green FastTrack planning procedure will be implemented to allow for easier planning permission acquisition.

Building on the existing knowledge base which has grown up around the gas and oil industry, a complete survey will be performed of geothermal potentials across the country before 2015. Once this has been completed, the first tenders should be offered; the deadline for tendering is 2015. Government will take the role of insurer of last resort to offset some of the inherent financial risk in geothermal energy.

That said, the Geothermal industry will be expected to be a profit-making one – especially as experience increases. Governmental support through subsidies will be focussed on creation of initial market conditions and will be gradually phased out as the industry becomes more competitive.

What is more, to make optimal use of geothermal energy, infrastructure will be invested in to facilitate district heating. This could potentially use parts of the existing gas or other network, while the storage of low enthalpy heat will be encouraged by re-aligning the existing tariff structure for heating in agriculture and encouraged through R&D subsidies. This will be an expensive measure, and sufficient funds will be made available to ensure success of the policy.

TARGET: Complete Surveillance of Netherlands potential leading to 100% low enthalpy heat provision to buildings and greenhouses by 2050.

3.2.3. Solar

The Netherlands currently suffers from a lack of incentives in PV installation. Belgium has a much higher penetration rate. Therefore the re-installation of feed-in tariffs will occur with immediate effect.

Research should be encouraged to produce PV solar panels suitable for the Netherlands. ECN's Solar Academy will receive additional funding along these lines.

Membership of the Solar Industry Initiative will continue, and the Netherlands will use its position there and internationally to support the realization of the Desertec project, which offers large predictable potential for electricity production. It will also take advantage of the investments made in the development of infrastructure for international electricity grids.

TARGET: 15% of Electricity production from Solar power by 2050

3.2.4. Biogas and Biomass

As with many other renewable technologies, planning applications for anaerobic digesters to produce methane gas have been difficult to obtain. The new Green FastTrack will allow for easier procurement of licenses.

The input to digesters is currently limited to agricultural waste. Input materials could be widened to include a number of green waste items. This will necessitate a health and safety study and financial incentives to create a viable green waste recycling system, but it also increases the potential for biogas production dramatically, while reducing waste to incineration. Furthermore, feed-in tariffs will be applied to biogas from waste. Unsustainable biogas production from crops will be discouraged by only extending these tariffs to production from waste.

Existing waste disposal in the Netherlands makes use of municipal waste to create electricity through incineration. Care must be taken to ensure both the infant biogas industry and the existing incineration sector benefit from increased separation at point of organic waste for biogas production.

The collection of biogas remains an issue. The existing gas network, however, has the potential for incorporating inputs from various sources, and work will commence to integrate biogas production and the natural gas network. Hence, the Dutch Government will invest in the necessary adaptation of the existing gas infrastructure. It is envisioned that biogas will go towards the production of electricity and heat in district CHP plants, or to specific industrial processes.

TARGET: Biogas and biomass to provide 20% of final use energy by 2050

3.2.5. Wave and Tidal

As a technology for energy production, wave power is still in its infancy. The Offshore Institute will provide a location for knowledge sharing and room for experiment, as well as easy access to funds. It will also create an atmosphere whereby entrepreneurship is actively supported, and the nearby 'Offshore Technology Zone' will continue this work into the private sector.

Conversion of existing dikes and sluices to enable a harnessing of tidal power by allowing water to pass through in a controlled manner will be undertaken nationwide. This will also help to alleviate some of the environmental issues stemming from stagnant water behind the dikes.

TARGET: 15% of Electricity Production

3.3. Demand side measures

3.3.1. Chemical industry

The Dutch chemical industry is a large provider of employment, as well as a large contributor to the economy. It consists of around 400 companies, of which there are around 3 large incumbent firms which dominate. The chemical industry also uses large amounts of energy and heating, and is still able to improve its energy efficiency significantly, as appears from statistics shown in section 2.2.1.

A new policy cycle of voluntary agreements will be introduced, based on previous experiences with this type of self-regulation. Also, benchmarking of best-practices in the chemical industry will be supported. This will be organised under the auspices of the Collaborative Chemical Industry Association (VNCI) which will receive a top-priority budget to bring about long-term energy efficiency improvements in this sector. The creation of a strong alliance in the chemical industry will promote collaboration and synergies amongst the different actors (academia, private and public organisations, international cooperation, etc.), facilitating knowledge exchange between them and allowing innovation to take place.

TARGET: 12.2 TWh/year savings to be achieved by 2030, in line with EU Data Base predictions for the HPI scenario, and ongoing target setting to 2050.

3.3.2. Transport sector

The Dutch transport sector is heavily reliant on fossil fuels, although a wide range of alternative means of transportation is already in use. This transition must build upon previous policies that stimulate alternative means of transport, such as bicycle facilities and public transport which have been important policy aims of the past. It is unlikely that personal car ownership will increase further given the limited space in cities and on roads as constraints.

In order to avoid economic collapse from inflated fuel prices or shortages, it is important that a transition is made towards vehicles that run on renewable energy. Currently, the transport sector is highly locked-in by fossil fuelled cars, mainly because of the existing infrastructure and knowledge base. In order to move away from this locked-in situation, a parliamentary commission will be formed with the specific task of deciding upon technology for non-fossil vehicles, for which currently both the electric and hydrogen power vehicle are major candidates. The decision will be made within the coming 5 to 10 years. It is expected that the knowledge created through research institutes and diffusion of R&D funds by the energy research centre (ECN) and the energy transition program (EOS) will by then have formed a solid foundation from which the 'winning technology' will be chosen and further developed, whereby the period of 2020-2050 will be largely devoted to actually transform into an electric or hydrogen vehicle system.

From 2020, infrastructure for the 'winning technology' will be implemented by the government, in cooperation with large firms. Innovative exploitation models will be developed in order to have a cost-effective transport system by 2050. In order to stimulate the growth of the emerging market, obligatory public procurement of new technology vehicles will in place by 2030.

When an alternative vehicle technology has been decided upon and sufficient infrastructure has been developed, a tax escalator will be placed on fossil fuels for transportation. Road tax for fossil fuelled cars will also increase as currently planned, while zero direct emission vehicles will not be taxed. These measures will apply pressure on the current regime to create a window of opportunity for the alternative technology to become dominant. What is more, all bus transport will be converted to the winning technology to give the new market an initial boost.

TARGET: 25% of cars in 2025 should be non-fossil fuel 2050, 100% of the vehicles should drive on renewable energy by 2050

3.3.3. Heating in buildings and houses

The provision of heat in both service (tertiary sector) buildings and domestic buildings offers large potential to reduce the Dutch heat demand. As presented before in section 2.2.2, geothermal has excellent potential as a renewable source for low enthalpy heating. Additionally, innovations to recover heat and cold from lakes, aquifers and sewage system also offer a large potential for reducing heat demand. The industry of geothermal energy is still a niche market; therefore, it is important for the Dutch government to intervene in order to create a market. Specific policies will be geared towards the creation of a virtuous cycle that will foster the growth of thermal energy recovery to become greater embedded in the future energy system.

One of the specific policy measures is strengthening the current regulation regarding energy performance of new and existing buildings to stimulate house owners and project developers to increase the buildings' efficiency. As most efficiency measures are cost-effective, but often require the right knowledge and initial investments, both financial as well as advisory support will be given through Agentschap NL. Another policy measure is the investment in the construction or adaptation of district heating infrastructure, as well as development of geothermal sources (as described in section 3.2.2). The Green FastTrack will help to streamline planning application processes for a variety of heat recovery projects to be implemented.

Public-private partnerships will be developed, aimed at knowledge creation through R&D and collecting experiences through demonstration of heat recovery such as from sewage systems and aquifers. Such partnerships will serve as innovation networks to bring together incumbent and emerging firms, civil society organisations and government actors. They aim to provide dynamic networks for coordination, experimentation and social learning across government and the different stakeholders.

TARGET: 25.4 TWh/year savings, to be achieved by 2030, in line with EU Data Base predictions for the HPI scenario, and ongoing target setting to 2050.

4. ALLOCATION OF RESOURCES

A full cost analysis would be required to produce an accurate assessment of costs, benefits and financial sourcing options. Due to time constraints in the compiling of this report it has not been possible to produce reliable estimations of these figures, therefore specific allocation of resources has not been included. Further investigation is recommended to provide the appropriate figures and analysis. Nevertheless, in section 7 an indication is given on the priority of policy measures.

5. TIME LINE OF THE TRANSITION

The target of this policy framework is 2050, and as such the specific timeline for transition is beyond the scope of this report. That said, a number of considerations must be taken into account during the transition. The most important of these is security of supply. The change can become unpopular very quickly if power outages become common place, therefore due care should be taken to ensure this does not occur. That will involve the phased closure of existing fossil-fuel plants only when sufficient installed capacity and related infrastructure exists to cope with the extra load (see Section 0 for further details of infrastructure requirements).

There is no immediate rush to make a transition, and this is beneficial in a number of ways. Large-scale investment should only take place when technologies are mature enough for reliable market penetration. Despite the hype, offshore wind, for instance, is not yet developed enough to provide value for money. While R&D money should be made available for such initiatives to develop their niche, this should not be confused with large-scale infrastructure investment which should only be forthcoming when a technology is economically feasible over the long-term.

Some initiatives can be started immediately. Demand-side efficiency savings will be a high priority to reduce overall demand. This is an ongoing process and must be initiated as soon as possible across sectors. Many of these initiatives (installing heat insulation and changing lightbulbs to LEDs) are cost beneficial over the short-term (one year), and these *easy pickings* should thus be the starting position for efficiency measures, although more expensive changes will also have to be dealt with when they are considered economically or politically viable. As such, a regulatory framework will be formed to steer the process, and investment will be forthcoming.

6. INDICATORS

100% Renewable by 2050 may appear to be a concrete and obvious target, however it will require efficient monitoring to ensure the economy is on-track to reach this goal and to inform the public and policy makers alike of such progress. As such, indicators are required to measure success of the transition policy. The mainstream indicator for such things would appear to be tonnes of CO_2 emitted, however this policy is not about CO_2 reduction per se, so this is a poor indicator (it would reward unsustainable processes such as Carbon Capture and Storage and Nuclear power in the same way as a windfarm). Therefore, a straightforward measuring of the renewable share in the energy supply and consumption will be the main indicator. Overall, indicators must be devised for all sectors, and may, in that way, be limited in scope.

7. DISCUSSION

7.1. Influence of Specific Policies

It is important that policy measures be taken by considering the system as a whole and not just the short-term effect of such instruments on the target. Efficiency savings are essential, for example, although when they serve to prolong the life-time of unsustainable technologies they may be a hindrance to the overall goal (the sailing ship effect). Transport is just such an example. Rising costs will encourage the market penetration of more efficient internal combustion engines in private cars. However, this can serve to deepen the existing lock-in of the transport system to petroleum, which is a rapidly depleting resource (BP, 2011). The Dutch Government is unable to influence car makers or the general public in many ways, but increased taxation for all petrol-powered vehicles, regardless of fuel efficiency, will endeavour to pin-point the problem and encourage uptake of alternatives. However, without the prior existence of viable alternatives this will be a deeply unpopular move, so infrastructure investment must be made in a considered manner and tax increases should occur to provide encouragement to make a transition rather than as a punishment to drivers.

The sectors involved in this policy are many and diverse. As such, different sectors require different approaches and support. An SME start up, for example, needs different innovation support than a large R&D research firm. The differences can be found across the board, and include approaches to advice, demonstration, problem-solving, training, capacity building and dissemination of information. This policy framework attempts, where possible, to create such targeted support; however it is vital that future, specific policies be made with this in mind.

As laid out in section 5, influence and overlap of transition policy on 'regular' energy policy must be considered at all times (Kern & Smith, p. 9). The overall motivation of this document is to create a sustainable and reliable energy system for the latter part of the 21st century, and the reliability of the system must be maintained through the transition.

7.2. Influence among the different policy instruments

Taking a system perspective, it is clear that the different policy measures will influence the energy system and will have an influence on the other policies as well. Therefore, an upfront analysis of what is expected is briefly presented.

According to Suurs et al (2009), for emerging sustainable energy technologies to takeoff, it is crucial that system functions reinforce each other over time. By setting these policies, we can foresee that knowledge creation and diffusion will influence and promote entrepreneurial activity that will be supported by market creation and niche protection measures. Also, by establishing an overall energy framework, structured under the transition umbrella, and investing and developing the necessary infrastructure, these niches will find the perfect window of opportunity to overcome the locked in technologies.

It is important to consider the importance of aligning innovation policies with this transition policy for it to be effective. Through such policy instruments, disruptive innovations should change the current regime in the long run, instead of focusing the resources in short term, cost-effective technologies which might strengthen the lock-in (Alkemade et al, 2011).

8. CONCLUSION

Having an all-renewable energy system by 2050 is a very ambitious target, but, as has been outlined above, it is certainly achievable. By implementing the afore-mentioned policy instruments, the energy system will be stimulated and there will be a general change in the current locked-in situation. By investing in R&D and promoting knowledge diffusion through networks, technological innovations will be stimulated. At the same time, by having an integrated energy strategy, framed in the transition, the government seeks to legitimise the paradigm shift. Finally, by promoting competitive markets and protecting developing technologies through the formation of niches, a window of opportunity will be open for these new technologies to replace the locked-in system.

Indeed, the paradigm shift will be huge. New ways of thinking are required to see the benefits of increased internationalisation which will become vital as coal is phased-out as the baseload provider and the system becomes more dynamic. The construction of district heating is not a new idea, but in the Netherlands it is. During the whole process, the Dutch public must be kept on-side by involving them and thus creating an atmosphere of involvement – legitimising the tough decisions made.

Through the implementation of these policy instruments the government will foster diversity by promoting R&D, creating niches and levelling the playing field for all technologies, but refrains from ‘picking winners’ prematurely, following the Evolutionary Economic approach.

Through carefully considered policies and citizen involvement, the Netherlands has the potential to steal a lead on the rest of the world in Renewable Energy Technologies. Not only will this provide a secure and sustainable energy system, it will also increase domestic GDP growth, stimulate employment and set the Netherlands up to face the many other, unpredictable challenges that the world will face over the next 100 years.

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