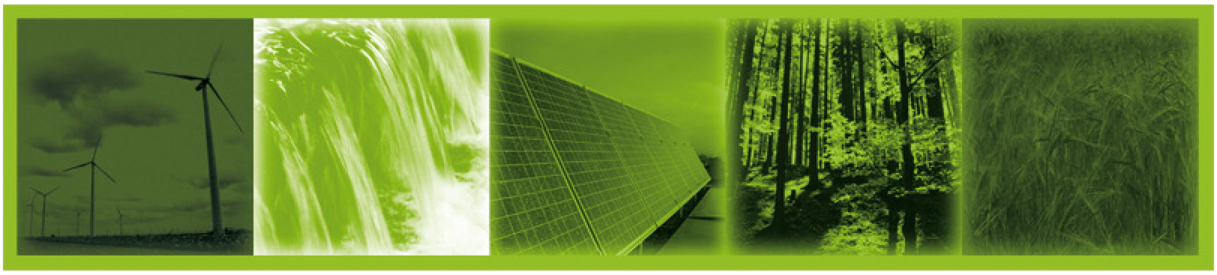
REPAP 2020

Renewable Energy Policy Action Paving the Way towards 2020



# *Renewable Energy Industry Roadmap for the Netherlands*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# Table of Contents

## Introduction

The European Renewable Energy Directive has put the transition towards a renewable energy society high on the political agenda of the EU member states.

The binding targets for 2020 and the "roadmap" (Actionplan) to achieve these targets are a true stimulance for national governments to develop effective programs for the wide deployment of renewables.

The Netherlands have set a 20% (of prime energy consumption) target for 2020, which is even a bit higher than the 14% target of the EU set for the Netherlands.

These targets are ambitious, but realistic, provided that the right policy measures are taken. It will require a different approach towards renewables as the Dutch position lags behind in the EU and a continuation of current policies is not an option to meet the targets.

The DE Koepel has clear views on how to increase the use of renewables by an effective mix of consistent legislation and stimulation programs. Many lessons have been learned and successful examples from other countries show the way.

It will built on the valuable elements we have today, but will require an extension to boost the deployment of the renewables towards the target levels. The outline of these policies are summarized in this Roadmap. It also shows the positive effects on the macro economic situation, the employment and the best use of Dutch industrial capacities and research talents.

This REPAP study provides the outline how to achieve our goals. It was developed in a team of high experienced experts from EREC (European Renewable Energy Counsil), Fraunhofer Institute (ISI), the University of Vienna and Ecofys Netherlands. We highly appreciate and thank them for the contribution of these organizations and the team members to develop this Roadmap.

We trust this Roadmap will contribute to a large extent to the development of consistent and effective Dutch policies to reach our goals.

*Teun Bokhoven*
*Chairman DE Koepel*
*(Dutch Renewable Energy Council)*

# 1 The case of the Netherlands

## 1.1 Current situation

### 1.1.1 Background

The Netherlands have a modern energy market with sound energy policies in place. The country has a significant production of fossil fuels, especially of natural gas, and has a large oil-refining industry. Because of its strategic location, it is an important transit and trade hub for natural gas, oil and electricity.[1]

The electricity market in the Netherlands is liberalized. The three largest electricity generators are Essent with a capacity of 4,760 MW, Electrabel with 4,710 MWh, and Nuon with 4,307 MW, which together have about 60% of the market share. In 1998, TenneT was established. It is a fully state-owned company and the transmission system operator in charge of managing and monitoring the electricity grid in the Netherlands. In the fully liberalized retail market, 39 companies have a retail and distribution license. The three largest companies Essent, Nuon and Eneco together had a market share of 80% in July 2007.[2]

The lead entity for energy policy of the Netherlands is the Ministry of Economic Affairs. The Ministry of Agriculture, Nature and Food Quality; the Ministry of Transport, Public Works and Water Management; and the Ministry of Housing, Spatial Planning and the Environment are also closely involved in the energy policy making process. The Office of Energy Regulation (Energiekamer) is in charge of regulation based on the Electricity Act. The duties cover the issue of electricity supply licenses and the determination of tariff structures and conditions for the transmission of the network. The agency Agentschap.NL (previously SenterNovem) of the Ministry of Economic Affairs promotes sustainable development and innovation and grants subsidies based on certificates issued by CertiQ, a subsidiary of TenneT that is responsible for certifying sustainable electricity by issuing “guarantees of origin”. The Energy Research Centre of the Netherlands (ECN) is the main institute providing the Dutch government with forecasts of the developments in energy demand and supply, $CO_2$ emissions and energy efficiency.[3]

[1] IEA/OECD (2009), pag. 9, 15

[2] IEA/OECD (2009), pag. 15, 19, 91 and 92

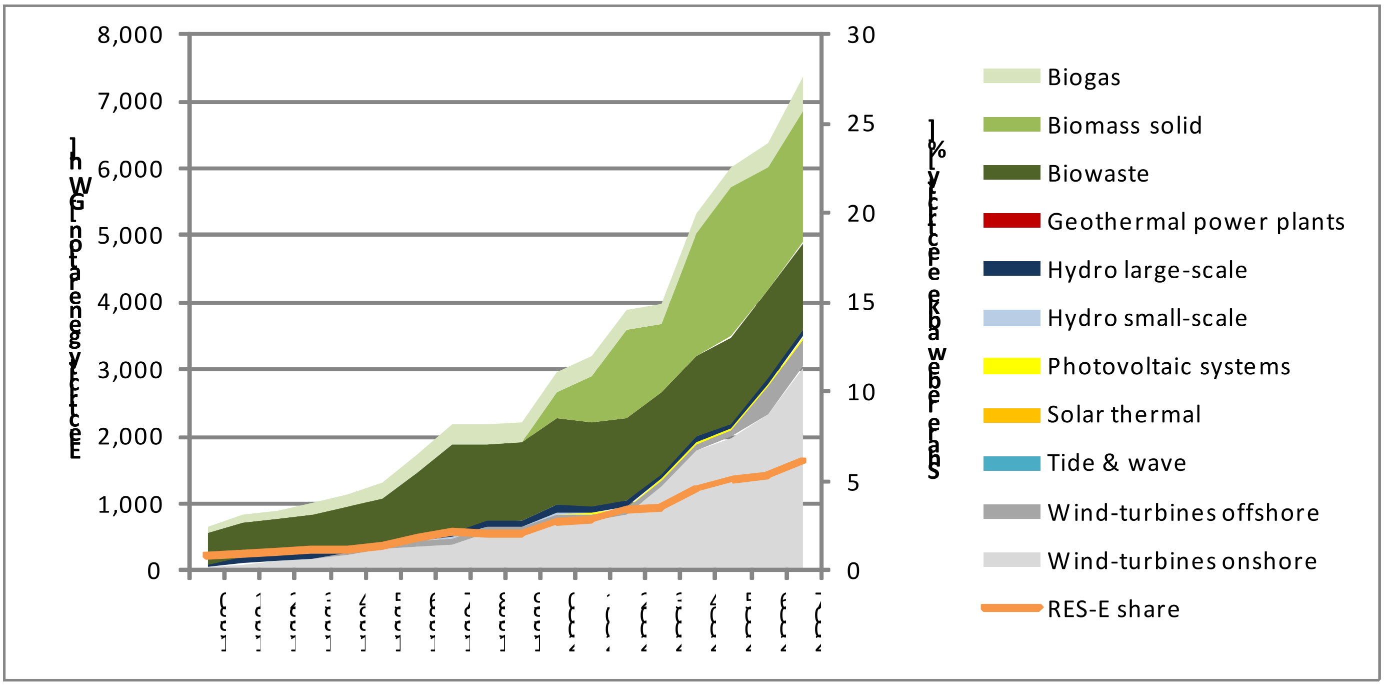
[3] IEA/OECD (2009), pag. 18-20

### 1.1.2 Current status of renewable energies

**Electricity:**

In 2007, the renewable electricity generation was with 7,372 GWh more than 11 times higher than in 1990 with 643 GWh. This corresponds to a Compound Annual Growth Rate (CAGR) of 15%. Meanwhile, the share of renewable electricity increased from 1% to 6.1%. An overview is given by **Figure 1-1**.[4]

**Figure 1-1:** Development of RES-Electricity generation in the Netherlands 1990 – 2007




**Source:** Eurostat (2009)

The renewable electricity generation in 2007 was dominated by biomass and wind, each having about half of the market share. In detail, wind-turbines onshore accounted for 42% while wind-turbines offshore accounted for 6%, but still the very high potential of wind-turbines offshore is only recently being exploited. Solid biomass[5] with its annual capacity growth of 26% could reach a share of 26% followed by biowaste (18%) and biogas (7%). Detailed renewable electricity generation data can be seen in **Table 1-1**.

The installed capacity of hydro large-scale remained constant from 1990 to 2007, which is similar to biowaste that has a small CAGR of 4%. In the same time period, the installed

[4] Eurostat (2009)

[5] Also includes to a large extent liquid biomass from imported palm oil.

capacity of photovoltaic systems showed an average annual growth of 26%, biomass solid (26%), wind-turbines onshore (22%) and biogas (11%). Wind-turbines offshore entered the market later, but the capacity increased as well strongly with a CAGR of 24% from 2000 to 2007 as shown in **Table 1-2**.

**Table 1-1:** Development of RES-Electricity generation in the Netherlands 1990 – 2007

| Technology | Electricity generation | | | | CAGR | | |
|---|---|---|---|---|---|---|---|
| | 1990 [GWh] | 2000 [GWh] | 2007 [GWh] | Share 2007 [%] | 1990-2007 [%] | 1990-2000 [%] | 2000-2007 [%] |
| **Biogas** | 82 | 299 | 511 | 6.9 | 11.4 | 13.8 | 8.0 |
| **Biomass solid** | 0 | 378 | 1,970 | 26.7 | : | : | 26.6 |
| **Biowaste** | 467 | 1,292 | 1,310 | 17.8 | 6.3 | 10.7 | 0.2 |
| **Geothermal power plants** | 0 | 0 | 0 | 0.0 | : | : | : |
| **Hydro large-scale** | 37 | 142 | 107 | 1.5 | 6.4 | 14.4 | -4.0 |
| **Hydro small-scale** | 1 | 1 | 0 | 0.0 | -100.0 | 0.0 | -100.0 |
| **Photovoltaic systems** | 0 | 8 | 36 | 0.5 | : | : | 24.0 |
| **Solar thermal** | 0 | 0 | 0 | 0.0 | : | : | : |
| **Tide & wave** | 0 | 0 | 0 | 0.0 | : | : | : |
| **Wind-turbines onshore** | 56 | 738 | 3,023 | 41.0 | 26.4 | 29.4 | 22.3 |
| **Wind-turbines offshore** | 0 | 91 | 415 | 5.6 | : | : | 24.3 |
| **RES-E total** | 643 | 2,949 | 7,372 | 100.0 | 15.4 | 16.5 | 14.0 |

**Source:** Eurostat (2009)

**Table 1-2:** Development of RES-Electricity capacities in the Netherlands 1990 – 2007

| Technology | Capacity | | | | CAGR | | |
|---|---|---|---|---|---|---|---|
| | 1990 [MW] | 2000 [MW] | 2007 [MW] | Share 2007 [%] | 1990-2007 [%] | 1990-2000 [%] | 2000-2007 [%] |
| **Biogas** | 22 | 81 | 138 | 5.5 | 11.4 | 13.8 | 8.0 |
| **Biomass solid** | 6 | 72 | 324 | 12.9 | 26.4 | 28.2 | 24.0 |
| **Biowaste** | 108 | 228 | 202 | 8.1 | 3.8 | 7.8 | -1.7 |
| **Geothermal power plants** | 0 | 0 | 0 | 0.0 | : | : | : |
| **Hydro large-scale** | 37 | 37 | 37 | 1.5 | 0.0 | 0.0 | 0.0 |
| **Hydro small-scale** | 2 | 2 | 0 | 0.0 | -100.0 | 0.0 | -100.0 |
| **Photovoltaic systems** | 1 | 13 | 53 | 2.1 | 26.3 | 29.2 | 22.2 |
| **Solar thermal** | 0 | 0 | 0 | 0.0 | : | : | : |
| **Tide & wave** | 0 | 0 | 0 | 0.0 | : | : | : |
| **Wind-turbines onshore** | 57 | 412 | 1,610 | 64.3 | 21.7 | 21.9 | 21.5 |
| **Wind-turbines offshore** | 0 | 30 | 138 | 5.5 | : | : | 24.3 |
| **RES-E total** | 233 | 875 | 2,502 | 100.0 | 15.0 | 14.1 | 16.2 |

**Source:** Eurostat (2009)

## Heat:

The CAGR of renewable heat production was more than four times higher since 2000 compared to the nineties. The market is dominated by solid biomass non-grid heat generation having more than 60% market share in 2007 followed by solid biomass grid (22%) and biogas grid (10%). The newer technologies, solar thermal heating and heat pumps, have a market share of 3% and 4%. The highest CAGR were achieved by these newer technologies. Heat pumps grew by 55% and solar thermal heating by 9% annually between 2000 and 2007 as can be seen in **Table 1-3**. It is worth mentioning the strong absolute growth of grid connected biomass technologies in the Netherlands.

**Table 1-3:** Development of RES-Heat generation in the Netherlands 1990 – 2007[6]

| Technology | Generation | | | | CAGR | | |
|---|---|---|---|---|---|---|---|
| | 1990 [ktoe] | 2000 [ktoe] | 2007 [ktoe] | Share 2007 [%] | 1990-2007 [%] | 1990-2000 [%] | 2000-2007 [%] |
| Biogas (grid) | 47 | 69 | 63 | 10.4 | 1.7 | 3.9 | -1.3 |
| Solid biomass (grid) | 49 | 82 | 130 | 21.5 | 5.9 | 5.3 | 6.8 |
| Biowaste (grid) | 0 | 0 | 0 | 0.0 | : | : | : |
| Geothermal heat (grid) | : | : | : | : | : | : | : |
| Solid biomass (non-grid) | 320 | 300 | 364 | 60.3 | 0.8 | -0.6 | 2.8 |
| Solar thermal | 2 | 11 | 20 | 3.3 | 14.5 | 18.6 | 8.9 |
| Heat pumps | : | 1 | 27 | 4.4 | : | : | 55.3 |
| RES-H total | 418 | 463 | 604 | 100.0 | 2.2 | 1.0 | 3.9 |

**Source:** Eurostat (2009)

## Transport:

According to Eurostat no biofuels were consumed in the Netherlands until 2005. In 2006, biofuels entered the market generating a total of 42 Ktoe, which corresponds to 0.3% of total consumption. The consumption of biofuels grew strongly to 311 Ktoe in 2007. The majority of the consumed biofuels was biodiesel with a share of more than 70%. Detailed information is given in **Table 1-4.**[7]

**Table 1-4:** Development of RES-Transport fuel consumption in the Netherlands

| Technology | Unit | 2005 | 2006 | 2007 |
|---|---|---|---|---|
| Biodiesel | [ktoe] | 0 | 23 | 223 |
| Bioethanol | [ktoe] | 0 | 19 | 88 |
| Biofuels, total | [ktoe] | 0 | 42 | 311 |
| Share Biofuels | [%] | 0.0 | 0.3 | 2.0 |

**Source:** Eurostat (2009)

[6] For the case of geothermal heat pumps not the Eurostat figure given in the table below is used for the modelling in the folowing chapers but instead the value of the national statistics of 171.7 ktoe in 2007. The national statistics also contain data for heat and cold storage, which have however not been considered in this report.
[7] Eurostat (2009) tables: Share of biofuels in fuel consumption of transport (tsdcc340) and supply, transformation, consumption - oil - annual data (nrg_102a)

### 1.1.3 Current renewable energy support policies

Under its Clean & Efficient Programme (Schoon & Zuinig), the Dutch government set ambitious climate targets. The nationally set target for the share of renewables is higher than the EU 2020 target of 14% renewables in total energy consumption. The emission of greenhouse gases will be reduced by 30% by 2020 compared to 1990. The level of energy efficiency was decided to increase by 2% annually with a current pace of growth of over 1%.[8]

All three sectors are eligible of a subsidy of approximately 40% for projects in R&D and marketing related to sustainable energy. The height depends on the duration and the aim of the specific project.[9] The limit for subsidies is set and yearly refreshed.[10]

#### Electricity and Heat:

In April 2008, the new support scheme Stimulering Duurzame Energieproductie (SDE: stimulation of sustainable energy production) was established. It replaced the previous Milieukwaliteit Van Elektriciteitsproductie (MEP: environmental quality of electricity production), which ran until August 2006. The scheme can be described as a feed-in premium scheme – producers have to sell the power production to the power market and receive a SDE premium on top. The premium level is adjusted according to the actual wholesale electricity price in order to keep the combined income from power sales and SDE premium stable. The SDE scheme covers electricity generated from wind onshore, solar photovoltaics, biogas, biomass and heat generated from biomass. Wind off-shore is planned to be included via a tender procedure of which the first round started early 2010. The duration of support is 15 years for wind and solar and 12 years for biogas and biomass. The available funding and installed power capacity under the SDE is capped annually for each of the technologies and faces an annual political review.

The premium levels are adjusted annually. During 2009 the premium levels as shown in the table below applied. For 2010 these are adjusted again.

[8] VROM (2007), pag. 8

[9] Staatsblad van het Koninkrijk der Nederlanden (2004), Art. 1, 2, 3

[10] For further information: Ministery of Economic Affairs (2008b)

**Table 1-5:** Feed-in tariffs

| Technology category | Base price 2009 in €/MWh | **Feed-in premium 2009 in €/MWh** (base price – price adjustment) |
|---|---|---|
| **Onshore wind** | 118 | 69 |
| **Small Solar-PV-installations (0.6 - 15 kWp)** | 526 | 324 |
| **Large Solar-PV installations (15-100 kWp)** | 459 | 406 |
| **Hydro power <5 meters** | 125 | 81 |
| **Hydro power >5 meters** | 73 | 29 |
| **Biomass electricity [1]** | | |
| **- Combustion (10-50 MW)** | 115-156 | 71-112 |
| **- Fermentation of bio-degradable waste** | 129-149 | 85-105 |
| **- Co-fermentation and small-scale combustion (top-up) (</= 10 MW)** | 152-177 | 108-133 |
| **- Other fermentation (liquid biomass)** | 158 | 114 |
| **Electricity production from landfills and sewage treatment (for power stations)** | 59 | 15 |
| **Electricity production in waste incineration plants (efficiency of the installation > 22%)** | 117-140 | 25-48 |

[1] The more heat per kWh is used effectively, the more subsidy installations receive.

**Source:** Ministerie van Economische Zaken, Netherlands (2009)

The Energy Investment Allowance (EIA) is a tax incentive allowing companies to deduct 44% of the investment amount for sustainable energy from the pre-tax profit and therefore to pay less corporate tax. EIA can be awarded over a maximum of € 110 million investments per installation and it can be combined with the SDE. The support will be yearly updated.[11] Supported technologies in the field of sustainable energy generation are shown in **Table 1-6**.

**Table 1-6:** Energy Investment Allowance – supported technologies

| Technology | Capacity restriction [kW] | Maximum promotion | Code |
|---|---|---|---|
| Photovoltaic solar energy system | >0.09 | 3000 €/kWp | 251102 |
| Wind turbines off-/onshore | ?25 | 3000 €/kW | 251103 |
| | >25 | 600-1,000 €/kW | |
| Boiler based on biomass | - | - | 251105 |
| Cogeneration plants based on biomass | - | - | 251106 |
| Hydropower | - | - | 251108 |
| Heat pumps | - | 200€/kWth | 211101 |
| Heat pump boiler | - | - | 211102 |
| Biofuel production installation | - | - | 251205 |

**Source:** SenterNovem (2009b)

In terms of renewable heating and cooling, two subsidy programmes were introduced in 2009, the “subsidieregeling Duurzame warmte” (subsidy program for renewable heat) and the “UKR” (Unieke Kansen Regling) both increasing the level of support strongly. The first

[11] SenterNovem (2009), pag. 2, 3

one subsidizes investments of solar thermal heat, heat pumps and micro-CHP installations while the second one aims at stimulating cooperation projects between private and non private parties.[12]

The production of gas is included in the feed-in premium SDE. Biogas quality needs to be enhanced, as it has to meet the quality standards of the natural gas network. Production of gas is eligible from: bio degradable waste and manure co-fermentation, landfills and sewage treatment and fermentation of (liquid) biomass from the food, drink and tobacco industry.

Due to sustainability concerns related to biomass and the non-existence of an established certification system, liquid biomass is not (yet) eligible. However, liquid biomass from the food, drink and tobacco industry is eligible.

**Table 1-7:** Biogas feed-in premiums

| Technology category | Base price 2009 in €/Nm$^3$ |
|---|---|
| **Fermentation of bio-degradable waste** | 0.465 |
| **Other fermentation (liquid biomass, mainly from the food and tobacco industry)** | 0.583 |
| **Biogas production from landfills and sewage treatment** | 0.218 |

**Source:** Ministerie van Economische Zaken, Netherlands (2009)

### Biofuels:

The government implemented a reduction in excise duty for mixing 2% biofuels with conventional fuels in 2006. In 2006, biofuels accounted for 0.3% of the road fuel market.[13]

Since 2007, a blend of biofuels in transport fuels is mandatory. The blending obligation was 2% in 2007 rising to 3.25% in 2008 and 4.5% and 5.75% in 2009 and 2010. In October 2008, the Act was modified and the 2009 and 2010 targets were changed to 3.75% and 5.75%. According to formal reports of oil companies and traders, the share of renewable fuels reached 2% in 2007.[14]

[12] See also http://www.senternovem.nl/duurzamewarmte/

[13] IEA/OECD (2009), pag. 116

[14] IEA (2008) and IEA/OECD (2009), pag. 117

# 2 Targets & trajectories

### 2.1.1 Overall renewable energy targets and trajectories

The 2020 target set by the EU with Directive 2009/28/EC for the Netherlands of 14% share of renewables in gross final energy consumption is challenging considering the low starting value of 2.4% in 2005. The trajectory up to 2020 is shown in **Table 1-8**.

**Table 1-8:** Overall renewable energy targets and trajectories in the Netherlands

| 2005 | Average 2011 - 2012 | Average 2013 - 2014 | Average 2015 - 2016 | Average 2017 - 2018 | 2020 |
|---|---|---|---|---|---|
| 2.40% | 4.72% | 5.88% | 7.62% | 9.94% | 14.00% |

**Source:** Directive 2009/28/EC

### 2.1.2 Sectoral targets and trajectories

Possible future developments of the renewable energy sector in the Netherlands until 2020 have been assessed based on two scenarios using the Green-X model, the NAT and the ACT scenario (defined in Appendix 1) and considering a moderate energy demand (based on PRIMES 20% case scenario). Increased energy efficiency efforts would lead to higher renewables shares as shown in Appendix 2.[15]

In both scenarios the 14% target as well as the mandatory target to reach a share of 10% of renewables in transport energy consumption in 2020 is achieved by inland production. The gross final energy consumption remains almost steady between 2005 and 2020.

The national target fulfillment scenario (NAT scenario) has a share of 15.1% of renewables in its final energy consumption exactly fulfilling the Directive's target. More than half of the renewables are consumed in the electricity sector. The share of renewables in electricity consumption is with 42% high compared to the share of renewables in heating and cooling consumption with just 9.8% (**Table 1-9** ).

[15] Results and figures for a low energy demand scenario (based on PRIMES high energy efficiency case scenario) are shown in Appendix 2.

**Table 1-9:** Sectoral targets and trajectories – NAT scenario the Netherlands

| Netherlands | | NAT (National target fulfillment) | | | | | |
|---|---|---|---|---|---|---|---|
| Indicator | Unit | 2005 | Average 2011 - 2012 | Average 2013 - 2014 | Average 2015 - 2016 | Average 2017 - 2018 | 2020 Targets |
| Expected Gross Final energy consumption | Ktoe | 52,984 | 54,783 | 54,392 | 54,094 | 54,059 | 54,030 |
| Total share of RES in final energy consumption | % | 2.0% | 5.9% | 7.6% | 9.5% | 12.2% | 15.1% |
| Gross Final Consumption of RES-E | Ktoe | 509 | 1,596 | 2,036 | 2,614 | 3,519 | 4,328 |
| Share of RES-E in gross final electricity consumption | % | 5.0% | 15.5% | 20.1% | 26.1% | 34.8% | 42.1% |
| Gross final energy consumption from RES-H | Ktoe | 544 | 1,141 | 1,448 | 1,810 | 2,212 | 2,739 |
| Share of RES-H in final Heating and Cooling consumption | % | 2.0% | 4.0% | 5.1% | 6.4% | 7.8% | 9.8% |
| Final energy from renewable sources consumed in transport | Ktoe | 0 | 498 | 666 | 740 | 848 | 1,097 |
| Share of RES in transport | % | 0.0% | 4.5% | 6.0% | 6.7% | 7.7% | 10.0% |

**Source:** Green-X Model (2009)

The proactive support – realizable deployment scenario (ACT scenario) has a share of RES in final energy consumption in 2020, which is with 15.8% above the set target. The higher share is reached because of the higher consumption of electricity and heat from renewable sources. The following table shows the deployment. In case of increased energy efficiency efforts 17% can be achieved as shown in Appendix 2. An even higher share – towards the higher domestic target – could be achieved by increasing the use of imported biomass. The *DE KOEPEL* likes to stress that they also see larger growth potentials compared to the NAT and ACT scenario particularly in solar thermal, photovoltaic's, the use of heat pumps and heat/cold storage (WKO).

**Table 1-10:** Sectoral targets and trajectories – ACT scenario the Netherlands

| Netherlands | | ACT (proactive support - realisable deployment) | | | | | |
|---|---|---|---|---|---|---|---|
| Indicator | Unit | 2005 | Average 2011 - 2012 | Average 2013 - 2014 | Average 2015 - 2016 | Average 2017 - 2018 | 2020 Targets |
| Expected Gross Final energy consumption | Ktoe | 52,984 | 54,783 | 54,392 | 54,094 | 54,059 | 54,030 |
| Total share of RES in final energy consumption | % | 2.0% | 5.9% | 7.8% | 9.8% | 12.4% | 15.8% |
| Gross Final Consumption of RES-E | Ktoe | 509 | 1,603 | 2,069 | 2,660 | 3,536 | 4,627 |
| Share of RES-E in gross final electricity consumption | % | 5.0% | 15.6% | 20.5% | 26.6% | 34.9% | 45.0% |
| Gross final energy consumption from RES-H | Ktoe | 544 | 1,153 | 1,485 | 1,887 | 2,313 | 2,829 |
| Share of RES-H in final Heating and Cooling consumption | % | 2.0% | 4.0% | 5.2% | 6.7% | 8.2% | 10.1% |
| Final energy from renewable sources consumed in transport | Ktoe | 0 | 498 | 666 | 740 | 848 | 1,097 |
| Share of RES in transport | % | 0.0% | 4.5% | 6.0% | 6.7% | 7.7% | 10.0% |

**Source:** Green-X Model (2009)

## 2.1.3 Contribution of renewables to electricity consumption

In 2005, wind offshore electricity consumption is only 95 GWh being 2% of total renewable electricity consumption but this relation changes strongly. Wind offshore is the most consumed renewable electricity source in 2020.

The share of wind offshore is 48% in 2020 in the NAT scenario showing an average growth of 45% between 2005 and 2020. Together with wind onshore having a share of 24%, wind alone has the dominating position in renewable electricity consumption. Biogas has a high average growth of 20% and can reach a market share of 9% in 2020.

In the scenarios the installed capacity for wind offshore exceeds the government target. A lower contribution of wind offshore – in line with the government target – could however be compensated by an increased use of imported biomass (compare section 3.1.3). The import of biomass for the purpose of co-firing in coal power plants is expected to exceed 50% of the total biomass use for co-firing. Already at this stage large imports of biomass take place from i.e. Canada, US and Australia.

**Table 1-11:** Contribution of renewables to electricity consumption– NAT scenario the Netherlands

| Netherlands | NAT (National target fulfillment) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Technology | 2,005 | | Average 2011 - 2012 | | Average 2013 - 2014 | | Average 2015 - 2016 | | Average 2017 - 2018 | | 2020 Targets | |
| | MW | GWh | MW | GWh | MW | GWh | MW | GWh | MW | GWh | MW | GWh |
| Biomass | 658 | 3,828 | 1,235 | 7,531 | 1,350 | 8,178 | 1,528 | 9,186 | 1,814 | 10,767 | 2,279 | 10,935 |
| Solid | 343 | 2,247 | 845 | 5,226 | 899 | 5,471 | 964 | 5,747 | 1,053 | 6,126 | 1,190 | 4,622 |
| Biogas | 79 | 294 | 114 | 621 | 164 | 942 | 264 | 1,588 | 446 | 2,696 | 768 | 4,295 |
| MSW | 236 | 1,287 | 275 | 1,683 | 287 | 1,765 | 300 | 1,851 | 315 | 1,945 | 321 | 2,019 |
| Liquid | : | : | : | : | : | : | : | : | : | : | : | : |
| Concentrated Solar Power | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Geothermal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hydro, total | 37 | 99 | 39 | 101 | 39 | 101 | 39 | 101 | 39 | 101 | 39 | 101 |
| >10MW | 37 | 99 | 37 | 100 | 37 | 100 | 37 | 100 | 37 | 100 | 37 | 100 |
| <10MW | 0 | 0 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 |
| Of which pumping | : | : | : | : | : | : | : | : | : | : | : | : |
| Photovoltaic | 51 | 34 | 349 | 268 | 772 | 583 | 1,669 | 1,240 | 3,401 | 2,505 | 4,146 | 3,050 |
| Ocean | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Wind | 1,224 | 1,957 | 4,445 | 10,659 | 6,072 | 14,818 | 7,697 | 19,879 | 10,122 | 27,554 | 12,818 | 36,254 |
| Onshore | 1,194 | 1,861 | 3,892 | 8,883 | 4,851 | 10,818 | 5,145 | 11,426 | 5,329 | 11,767 | 5,380 | 11,883 |
| Offshore | 30 | 95 | 553 | 1,776 | 1,221 | 4,000 | 2,551 | 8,454 | 4,793 | 15,787 | 7,438 | 24,370 |
| Gross Final Consumption of electricity from RES | 1,970 | 5,918 | 6,068 | 18,558 | 8,233 | 23,681 | 10,933 | 30,406 | 15,377 | 40,927 | 19,283 | 50,339 |

**Source:** Green-X Model (2009)

In 2020 the development in the ACT scenario is with 53,809 GWh stronger than the one in the NAT scenario. The main difference is the more than 2000 GWh higher deployment of photovoltaic electricity.

**Table 1-12:** Contribution of renewables to electricity consumption– ACT scenario the Netherlands

| Netherlands | ACT (proactive support - realisable deployment) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Technology | 2005 | | Average 2011 - 2012 | | Average 2013 - 2014 | | Average 2015 - 2016 | | Average 2017 - 2018 | | 2020 | |
| | MW | GWh | MW | GWh | MW | GWh | MW | GWh | MW | GWh | MW | GWh |
| Biomass | 658.4 | 3,828 | 1,247.1 | 7,602 | 1,369.4 | 8,292 | 1,555.3 | 9,348 | 1,798.2 | 10,748 | 2,128.2 | 10,340 |
| Solid | 343.0 | 2,247 | 858.0 | 5,298 | 916.0 | 5,573 | 986.1 | 5,881 | 1,030.2 | 6,068 | 1,032.9 | 3,995 |
| Biogas | 79.5 | 294 | 114.3 | 621 | 166.0 | 954 | 268.7 | 1,617 | 453.0 | 2,736 | 774.1 | 4,326 |
| MSW | 236.0 | 1,287 | 274.8 | 1,683 | 287.4 | 1,765 | 300.5 | 1,851 | 315.0 | 1,945 | 321.1 | 2,019 |
| Liquid | : | : | : | : | : | : | : | : | : | : | : | : |
| Concentrated Solar Power | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| Geothermal | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| Hydro, total | 37.0 | 99 | 39.5 | 101 | 39.8 | 102 | 40.3 | 104 | 40.8 | 106 | 40.9 | 106 |
| >10MW | 37.0 | 99 | 37.0 | 100 | 37.0 | 100 | 37.0 | 100 | 37.0 | 100 | 37.0 | 100 |
| <10MW | 0.0 | 0 | 2.5 | 1 | 2.8 | 2 | 3.3 | 4 | 3.8 | 6 | 3.9 | 6 |
| Of which pumping | : | : | : | : | : | : | : | : | : | : | : | : |
| Photovoltaic | 51.0 | 34 | 348.9 | 268 | 771.7 | 583 | 1,668.6 | 1,240 | 3,400.6 | 2,505 | 7,103.4 | 5,209 |
| Ocean | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| Wind | 1,224.0 | 1,957 | 4,453.8 | 10,673 | 6,243.4 | 15,090 | 7,931.9 | 20,246 | 10,263.8 | 27,766 | 13,442.0 | 38,154 |
| Onshore | 1,193.8 | 1,861 | 3,900.5 | 8,897 | 5,022.2 | 11,089 | 5,380.7 | 11,792 | 5,470.4 | 11,979 | 5,495.3 | 12,052 |
| Offshore | 30.2 | 95 | 553.3 | 1,776 | 1,221.2 | 4,000 | 2,551.2 | 8,454 | 4,793.5 | 15,787 | 7,946.7 | 26,102 |
| Gross Final Consumption of electricity from RES | 1,970.4 | 5,918 | 6,089.3 | 18,644 | 8,424.4 | 24,067 | 11,196.1 | 30,938 | 15,503.5 | 41,125 | 22,714.5 | 53,809 |

**Source:** Green-X Model (2009)

### 2.1.4 Contribution of renewables to heating & cooling consumption

In 2005, solid biomass was the main source of renewable heat. Although solid biomass is still the most consumed heat source in 2020, other renewable heat sources catch up.

In the NAT scenario, heat from solar thermal and heat pumps have high average growth rates of 22% and 27% between 2006 and 2020 and can reach a respective share of 17% and 28% (**Table 1-13**).

**Table 1-13:** Contribution of renewables to heating and cooling consumption– NAT scenario the Netherlands

| Netherlands | NAT (National target fulfillment) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Technology | 2005 | | Average 2011 - 2012 | | Average 2013 - 2014 | | Average 2015 - 2016 | | Average 2017 - 2018 | | 2020 | |
| | MWth | Ktoe | MWth | Ktoe | MWth | Ktoe | MWth | Ktoe | MWth | Ktoe | MWth | Ktoe |
| Biomass | 0 | 508 | 4,034 | 700 | 4,384 | 782 | 4,808 | 874 | 5,481 | 1,000 | 6,717 | 1,198 |
| Solid | 0 | 445 | 3,431 | 503 | 3,712 | 570 | 4,043 | 646 | 4,581 | 751 | 5,441 | 910 |
| Biogas | : | 63 | 171 | 67 | 191 | 69 | 234 | 74 | 315 | 80 | 448 | 88 |
| Biowaste | : | 0 | 432 | 131 | 481 | 142 | 531 | 155 | 586 | 168 | 828 | 200 |
| Geothermal | : | 0 | 19 | 5 | 37 | 11 | 93 | 20 | 125 | 25 | 212 | 43 |
| Solar Thermal | : | 19 | 1,924 | 76 | 2,966 | 118 | 4,281 | 170 | 6,079 | 241 | 9,102 | 361 |
| Heat pumps | : | 17 | 2,902 | 359 | 4,343 | 538 | 6,023 | 746 | 7,648 | 947 | 9,189 | 1,138 |
| Gross final energy consumption from RES in heating and cooling | 0 | 544 | 8,879 | 1,141 | 11,729 | 1,448 | 15,205 | 1,810 | 19,333 | 2,212 | 25,220 | 2,739 |

**Source:** Green-X Model (2009)

The consumption of renewable heat is higher in the ACT scenario than in the NAT scenario, because of a 69 Ktoe higher consumption of solid biomass. More detailed data is depicted in **Table 1-14**.

**Table 1-14:** Contribution of renewables to heating and cooling consumption– ACT scenario the Netherlands[16]

| Netherlands | ACT (proactive support - realisable deployment) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Technology | 2005 | | Average 2011 - 2012 | | Average 2013 - 2014 | | Average 2015 - 2016 | | Average 2017 - 2018 | | 2020 | |
| | MWth | Ktoe | MWth | Ktoe | MWth | Ktoe | MWth | Ktoe | MWth | Ktoe | MWth | Ktoe |
| Biomass | 0 | 508 | 4,034 | 712 | 4,384 | 819 | 4,808 | 951 | 5,481 | 1,090 | 6,717 | 1,267 |
| Solid | 0 | 445 | 3,431 | 515 | 3,712 | 607 | 4,043 | 722 | 4,581 | 841 | 5,441 | 979 |
| Biogas | : | 63 | 171 | 67 | 191 | 69 | 234 | 74 | 315 | 80 | 448 | 88 |
| Biowaste | : | 0 | 432 | 131 | 481 | 142 | 531 | 155 | 586 | 168 | 828 | 200 |
| Geothermal | : | 0 | 19 | 5 | 37 | 11 | 94 | 20 | 178 | 36 | 316 | 64 |
| Solar Thermal | : | 19 | 1,924 | 76 | 2,966 | 118 | 4,281 | 170 | 6,079 | 241 | 9,102 | 361 |
| Heat pumps | : | 17 | 2,902 | 359 | 4,343 | 538 | 6,023 | 746 | 7,648 | 947 | 9,189 | 1,138 |
| Gross final energy consumption from RES in heating and cooling | 0 | 544 | 8,879 | 1,153 | 11,729 | 1,485 | 15,206 | 1,887 | 19,386 | 2,313 | 25,324 | 2,829 |

**Source:** Green-X Model (2009)

[16] Holland Solar (one of the Associations under the DE Koepel) sees larger growth potentials for solar thermal in case of more active support policy then presented in the ACT scenario. They consider a heat production of 12-30 PJ feasible in 2020. This corresponds to roughly 300 to 750 ktoe, compared to 361 Ktoe in the ACT scenario.

### 2.1.5 Contribution of renewables to transport fuel consumption

The domestic production of biofuels is almost exclusively in form of bioethanol and only to a small amount biodiesel. Second generation biofuels are firstly consumed in 2020. But the national production is not dominating the market. 87% of the total consumed transport fuels from renewable sources are imported in 2020. The mandatory target of 10% renewables in transport energy consumption is exactly fulfilled in the scenarios.

**Table 1-15:** Contribution of renewables to transport consumption– NAT scenario the Netherlands

| Netherlands | | NAT | | | ACT | | |
|---|---|---|---|---|---|---|---|
| **Technology** | **Unit** | **2005** | **Average 2011 - 2012** | **Average 2013 - 2014** | **Average 2015 - 2016** | **Average 2017 - 2018** | **2020** |
| **Bioethanol** | **Ktoe** | 0.0 | 88.7 | 118.1 | 107.4 | 130.2 | 138.2 |
| **Of which imported** | **Ktoe** | : | : | : | : | : | : |
| **Biodiesel** | **Ktoe** | 0.0 | 2.0 | 3.9 | 0.0 | 0.0 | 3.9 |
| **Of which imported** | **Ktoe** | : | : | : | : | : | : |
| **Biofuels from wastes, residues, non-food cellulosic material, and ligno-cellulosic material** | **Ktoe** | : | 0.0 | 0.0 | 0.0 | 0.0 | 5.1 |
| **Of which imported** | **Ktoe** | : | : | : | : | : | : |
| **Hydrogen from RES** | **Ktoe** | : | : | : | : | : | : |
| **Renewable electricity** | **Ktoe** | : | : | : | : | : | : |
| **Biofuel import** | **Ktoe** | : | 407.3 | 543.7 | 632.2 | 717.7 | 950.1 |
| **Final energy from renewable sources consumed in transport** | **Ktoe** | 0.0 | 498.0 | 665.7 | 739.6 | 848.0 | 1,097.3 |

**Source:** Green-X Model (2009)

# 3 Measures for achieving the target

## 3.1.1 Policy measures

**Measures on administrative procedures, regulations and codes:**

- **Position of renewable energy potential in spatial planning?**

Generally RES, and their respective potential, are insufficiently taken into account in spatial planning. In many countries and regions future development of RES projects are not taken into account at the moment of drawing up spatial planning programs. This means that spatial planning programs have to be adopted in order to allow for the implementation of a RES project in a specific area (e.g. RES-E), especially when there is a high RES potential involved in that particular area. This process can take a very long time. Often the acquirement of permits related to spatial planning is the longest trajectory of the overall period needed for development of the project. This is especially the case for projects in the field of wind and biomass. Responsible authorities should be stimulated to anticipate the development of future RES projects in their region, by allocating suitable areas.

Surveys show that spatial planning, construction permits and EIA (environmental impact assessment) procedures are key problems for regulators. In the RES-E sector to obtain the necessary permits can take years in countries where the authorities take into account the opinion of many stakeholders that are hard to harmonize. Since RES-E development is not taken into consideration in the spatial planning, every project and project variants have to be evaluated on an individual basis.

The number of the often long lasting appeal procedures could be effectively decreased by including RES-E development plans in local and regional spatial planning. In Germany for example these problems have been solved to a large extent. In the case of onshore wind projects the administrative barriers regarding spatial planning are low thanks to the Building Code (1996), which made states designate areas for onshore wind parks. Thanks to this, a wind farm can be established within 1 year. A similar approach is being followed for offshore wind parks. The federal states and the Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency) are responsible for designating areas and issuing permits for offshore wind installations.

*The DE KOEPEL* is in favor of establishing a pre-planning scheme with designated areas for renewables. It should be made obligatory for provinces or communities to designate a minimum amount of areas for renewables projects. A similar approach is considered to be necessary for geothermal and heat & cold storage (ruimtelijke ordening ondergrond).

- **Timetables for processing applications to be communicated in advance**

Usually long lead times are needed to obtain necessary permits. Time needed to obtain all necessary permits for the construction of a RES plant can take many years. Also it can be unclear what the exact length of a procedure will be. Clear guidelines and time caps for authorization procedures are highly recommended together with obligatory response periods for authorities involved in such procedures. The *DE KOEPEL* advocates the implementation of special legislation to speed authorization processes similar to processes relating to maritime and water safety procedures ("zwaarwegend maatschappelijk belang").

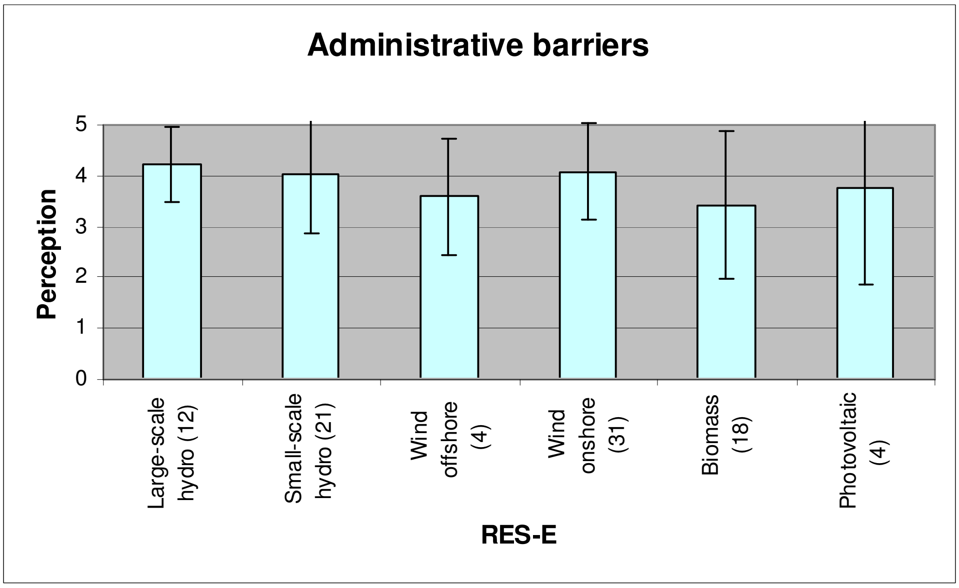
- **Limiting the steps in order to obtain the final authorization. A one-stop shop for coordinating all the steps.**

Generally, a high number of authorities are involved to obtain the final authorization. Often many authorities are involved in both permitting as well as support related procedures for renewable energy projects. Responsible authorities usually comprise several administrative bodies at national, regional and local level. An important improvement would be to reduce the number of local, regional and national administrations involved in the authorization processes for permits and financial support. Project developers are much more positive in situations where a single administrative body has been made responsible for co-ordination of several administrative procedures, such as the Bundesamt for off-shore wind in Germany.

Furthermore, there is a lack of co-ordination between different authorities. In many cases project developers need to submit similar information multiple times to different authorities. A suggestion to reduce the administrative burden for RES development would be to standardize procedures, such as standardized administrative requirements and application forms between different authorities and to appoint a coordinating authority to deal with the administrative issues.

In **Figure 1-2** we present the perception of administrative barriers per renewable energy source, as identified by a stakeholder consultation conducted in the past.[17]

**Figure 1-2:** Perception of administrative barriers




**Source:** OPTRES (2007)

[17] OPTRES (2007).

Perception from 0 (no perceived barrier) to 5 (high perceived barrier). Number of received answers per source is provided in brackets, while standard deviation is marked by bars. Only those RES-E types with at least 4 answers have been depicted.

**Figure 1-2** shows that the respondents of the stakeholder consultation perceived the administrative problems to be highest for hydropower projects and on-shore wind. However, also for the other renewable energy sources the administrative barriers are perceived an important obstacle in the development of renewable energy projects.

Detailed implementation aspects with respect to how many steps should be needed to obtain the final authorization for the case of the Netherlands are to be discussed during the workshop.

**Measures concerning Buildings:**

- **Measures recommended for inclusion into the building codes to ensure the share of renewable energy used in the building sector will increase.**

Policy instruments should be introduced that provide incentives for integrating a RES-H/C device into the heating/cooling system. But since RES-H/C applications operate only effectively if they are fitted to the overall system design, the chosen policy instrument should create incentives for a good overall system performance. Hence, it should also support the reduction of a building's energy consumption (e.g. by improving its insulation) and motivate for an efficient use of the RES-H/C equipment.

As far a possible the policy instrument should motivate the utilization of high efficiency equipment, e.g. through linking the financial incentives to quality standards of a determined minimum rate of efficiency.

The *DE KOEPEL* is in favor of an obligation for building owners to utilize a minimum of 20% renewable energy generation in buildings, gradually increasing this percentage over time. This should also apply for existing buildings when economically justified to start with major renovations and at the moment of replacement of the heating system.

- **Obligation for minimum levels of renewable energy in new and newly refurbished buildings to be drafted to best ensure renewable energy integration in buildings.**

The obligation should take the different target groups and their different needs into account and might be different for each of these groups. The target groups are private homeowners living in their own home, homeowners renting to others as well as private, municipal and social housing organizations. As such companies often own and manage a large number of buildings they can become a key driver (but also key barrier) for switching buildings to RES-H/C as well as RES-E.

Whereas housing companies often have sufficient technical skills to handle even innovative RES- technologies they generally base their economic calculation on shorter pay back times compared to e.g. private building owners in the domestic sector. In addition, the level of willingness to pay might generally be lower than with small scale investors. These circumstances should be considered in the setting of minimum levels for RES and in the corresponding support schemes.

From the perspective of the building owner (investor) apart from the level of support one of the main indicators is the share of the investment costs he can and/or legally is allowed to allocate to the tenants (by increasing the rent). From the perspective of tenants the crucial question concerns the relationship between the financial burden that might derive from an allocation of the investment costs on the rent and potentially reduced costs for heating/cooling due to the reduced use of conventional fuel.

The chosen obligation should ensure that investment is still effectively motivated. Costs for building owners and tenants shall not be too high to discourage investments (e.g. by postponing the reconstruction of heating systems as long as possible).The DE Koepel is in favor of combining the obligation with stimulating measures as currently introduced in the UK for the large scale introduction of micro generation by RES E+H/C through a feed-in mechanism in order to make RES- technologies assessable for larger numbers of building owners and renters.

**Measures on information:**

The *DE KOEPEL* likes to stress the need for improvements in qualification of personnel and certification of technology. Both are needed to ensure the quality of renewable energy installations and thus its long-term support among stakeholders. The knowledge of staff in public authorities responsible in the permitting process about (new) renewable technologies needs to be improved too.

The *DE KOEPEL* stresses the role of the government in establishing a positive image of renewable energy and support within the society. A consistent picture of all benefits of renewable energy (including the non-economic benefits like health and security of supply) has to be presented. Enabling more local participation in for example wind energy projects is also important in this respect.

- **Information to be targeted at different groups, as end consumers, builders, property managers, property agents, installers, architects, farmers, suppliers of equipment using renewable energy sources, public administration**

The question is basically about information sharing to all stakeholders. General information for example about support mechanisms for renewable technologies needs to be broadcasted to all stakeholders. As the internet offers 24 hours access to information and can be updated easily, a base for general information would be a web page. A best practice examples is given in Luxembourg, where Subsidies for heat in households are communicated with the information paper “Förderprogramm zur Energieeinsparung und Nutzung erneuerbarer Energien im Wohnbereich” of the Ministère de l'Environnement of Luxembourg in an easy manner. Thereby, the paper targets not only public administration, but also especially end consumers, property managers and agents, installers and architects and is kept in an understandable and clear style.

End users can be informed by customer information brochures about the possibility to make use of support for renewables. The information brochures can be shared among installers, property managers and suppliers of equipment to hand them over to the end consumers.

Furthermore, there could be a subsidy for consultancy on renewable energy and energy efficiency related topics for end consumers. This would give the advantage, that consumers would choose the most appropriate efficiency and renewable energy option according to an energy expert. This approach is demonstrated in the “Meer met Minder” program and is effective.

Renewable energy and energy efficiency exhibitions are a great possibility to get to know information physically and are therefore for energy experts as well as for technology end consumers adequate. With expositions, it is possible to share specific information as well. For instance, the SOLTEC exhibition in Germany is mainly focusing in solar technologies and through this focus, information can be shared in more detail.[18]

Workshops and speeches provide the possibility to share specific information only of major interest for a small target group. Workshops and speeches can be integrated to exhibitions as well.

Experts and public administration members need the most up to date information having a higher degree of details than the ones for example for end users. Regularly reports published by the responsible administrative bodies keep the legal framework up-to-date. A best practice example is the German “Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit”, which published a brochure of the environment policy from 2005 to 2009 in July 2009 being detailed and giving an overview of the topic as well.19 With published articles in RES journals, the dynamics of the market can be analyzed in detail.

Specific information for a smaller target group can be shared via internet as well. It would be possible to establish a work group in a small field of work being responsible for specific field publishing news on their own internet platform.

- **Guidance for planners and architects to be provided to help them consider the optimal combination of renewable energy sources, high efficiency technologies and district heating and cooling when planning, designing, building and renovating industrial or residential areas.**

Planners and architects should be provided with an internet platform that holds information on possible options of including renewable energy, high efficiency technologies and districts heating and cooling into new or existing buildings. It should not only contain up-to-date information on technology, how it can be installed and how profitable such investments are on the long run. It should also include detailed information on successfully completed

[18] Information about the exhibition is given on the web page: http://www.soltec.de/s

[19] Document available on http://www.bmu.de/ministerium/aufgaben/aufgaben/doc/44214.php

exemplary projects, legislation and events related to the topic. Local information on the applicability of solar technology and the availability of district heating and cooling is desirable. Furthermore it should be possible to order printed copies of the contained information as well as publications explaining the various concerns in greater detail. Contact information to all relevant professional associations and their local members would complete the web page's content.

The information should be gathered in consultation with experts in energy, technology, construction and installation and be updated continuously to secure a high level of relevance and actuality. The web page should be supervised with the help of the chambers of architects as well as planners associations respectively consumers advice centers to secure that the target groups are addressed properly. These organizations could also contact their members and customers to raise the web page's awareness level within the target groups.

RES sector stakeholders mentioned, that detailed implementation aspects require the continuation and stronger role of the Dutch National Expertise Centre for Heat and Cold (NEW), operated by AgentschapNL with respect to how increased guidance for planners, architects and developers be provided to help them consider the optimal combination of renewable energy sources, high efficiency technologies and district heating and cooling when planning, designing, building and renovating industrial or residential areas to increased deployment of RES-H/C.

**Measures on electricity infrastructure development:**

- **Priority connection rights and reserved connection capacities for new installations producing electricity from renewable energy sources.**

Introduction of positive discrimination of RES-E as regards the guarantee of grid access or transmission and distribution of RES-E, may become an additional motivating factor for reasons of investment security, low transaction costs and the acknowledgement of RES-E system benefits.

**Priority/Guaranteed Access to the grid:**

The *DE KOEPEL* stresses that priority transmission should be granted to RES-E. The cost of congestion management should be covered by the producers of conventional electricity. This has been covered by the law "Voorrang voor duurzaam" which has only recently been agreed by the First chamber of Parliament. The main issues with regard to the priority access to the grid have been covered in this law.

### 3.1.2 Financial support

**Table 1-16** gives an indication on the necessary financial support by illustrating the weighted average (2011 to 2020) levelised (to a period of 15 years) total remuneration per MWh of RES generation for new installations in the investigated cases (NAT and ACT). This shows the gross support requirements as besides the financial premium offered by a RES support scheme also default revenues from the selling of the produced energy on the related energy market are included.[20] Gross figures were selected here as net expenditures largely depend on the future development of energy and carbon prices at European as well as at global scale.[21]

A comparison of the technology- or sector-specific figures by scenario shows significant differences between both cases. This illustrates the need to increase support levels if an ambitious and accelerated RES deployment is targeted. However, the figures of the ACT case represent the upper limit of such support requirements, where a fine tuning of the EU-wide equally conditioned technology-specific support levels to the Dutch circumstances offers a significant potential for cost reduction.[22]

Consequently, if The Netherlands follows the NAT policy track the support requirements would decrease significantly. An important precondition for that is however that the implemented RES policy needs to be classified as stable and the investor's risk is reduced to a low level (e.g. by offering a guaranteed duration of support (incl. support levels)).

The remuneration shown in the table cannot be directly compared to the current SDE base price levels for two reasons: (a) The support value of the investment deduction EIA has to be considered in addition; (b) the remuneration shown is an average value for new installations between 2011 and 2020.

Remuneration levels are based on expected learning rates and globally cumulated installed capacity. The latter is based on the Green-X results for the EU and the IEA World Energy Outlook for the rest of the world.

The *DE KOEPEL* likes to stress that the growth rates for photovoltaic's in the latter publication are far too low compared to currently observable and widely expected global market developments and expected grid parity on consumer level by the second half of the

20 For the case of small-scale RES heating systems this shall mean the price of heat supply based on a typical conventional reference technology.

21 Obviously, also gross figures are not independent from the future development of energy prices. As the price development for energy related equipment in the years before the financial crisis (2008) has shown, prices (and largely also cost) for most types of power plants coincided to a large extent with rising energy and raw material prices.

The overall impact of energy prices on support cost is however seen larger on net compared to gross figures.

22 Compare e.g. total remuneration for RES in the heat sector: Although support is significantly higher in the ACT case differences in terms of resulting RES deployment are comparatively small.

coming decade. Assuming higher growth rates for photovoltaic's would lead to considerably reduced remuneration levels due to increased learning effects.

**Table 1-16:** Weighted average (2011 to 2020) total remuneration for yearly new RES installation in the Netherlands – NAT and ACT scenario

| *RES policy indicator (i.e. required total remuneration)* | Weighted average (2011 to 2020) total remuneration for yearly new RES installations [€/$MWh_{RES}$] | |
|---|---|---|
| | NAT (National target fulfillment) | ACT (proactive support - realisable deployment) |
| Biogas | 139.1 | 147.6 |
| (Solid) Biomass | 107.0 | 125.2 |
| Biowaste | 96.6 | 106.1 |
| Geothermal electricity | 0.0 | 0.0 |
| Hydro large-scale | 0.0 | 0.0 |
| Hydro small-scale | 0.0 | 125.2 |
| Photovoltaics | 314.3 | 364.7 |
| Solar thermal electricity | 0.0 | 0.0 |
| Tide & Wave | 0.0 | 0.0 |
| Wind onshore | 98.5 | 105.5 |
| Wind offshore | 110.3 | 118.6 |
| RES-E (average) | 125.6 | 148.0 |
| RES heat (district heat) | 61.5 | 81.8 |
| RES heat (decentral) | 106.3 | 129.1 |
| Biofuel (average) | 106.8 | 106.8 |

**Source:** Green-X Model (2009)

### The *DE KOEPEL* suggestions to improve financial support measures

The DE Koepel supports a fundamental choice towards a broad and decentralized energy infrastructure (using all the technologies ranging from large scale offshore wind parks to decentralized domestic PV systems and heat/cold storage systems). Key for the support system is stability and good design of details. Consistent policies are essential to develop market trust and investment security. Therefore abolishing the SDE and replacing it by a completely new scheme is strongly discouraged. Instead the SDE should evolve based on lessons learnt domestically and abroad. The following detail improvements are considered essential by the *DE KOEPEL*:

1. The SDE should not rely on the government budget. Instead the SDE support cost should be covered by all electricity consumers (including companies) via a surcharge per kWh. This surcharge on fossil fuel cost should be calculated based on the actually occurring support cost, not based on a long-term forecast as foreseen in the government proposals. Imbalances can be corrected in the calculation of next year's surcharge level. That way income from surcharges and expenses for SDE support always match, and there is always sufficient budget for all new projects. The government can avoid political discussions around insufficient or excess SDE

budgets. In fact such an approach reduces the government involvement and administrative burden.

2. Financing the SDE via a surcharge on electricity consumption as described above allows abolishing the limited SDE budgets per technology. If budget limits cease to apply, the application procedure will be easier and shorter and project developers have certainty that their projects can be realized. This reduces risk during the project development phase and will thus increase the number of projects and reduce cost.

3. In the current SDE premium system, project operators are responsible to sell the electricity to the market and they receive a premium (onrendabele top) on top of the income from electricity sales. This responsibility for selling electricity introduces risk, transaction cost and can make it difficult to receive bank loans for projects. This is especially relevant for small scale projects and/or independent project operators (independent of incumbent utilities, thus not having own power production and sales structures where the RES production can easily be integrated). Therefore at least for small projects and/or independent project operators the option should be introduced to choose between the current SDE premium tariff and a fixed feed-in tariff (which is one price paid for both the electricity and the premium). In case the transaction cost and risk for a certain kind of project are prohibitively high within the SDE premium tariff, the project can be realized within the feed-in tariff option. The feed-in tariff option can be part of the SDE. The feed-in tariff option should at least apply for PV, small wind onshore and small biomass stand-alone projects.

4. PV: The annual growth rate of installed PV capacity should be increased in order to gradually prepare the domestic market and its actors for the likely strong growth in future years once grid parity at consumer level is reached. In order to avoid extremely high growth rates and expenses and the related risk of stop-and-go policies, a target corridor could be applied: Such a corridor would describe the envisaged annual market growth (for example 30-50% for the next years) and the change in support tariffs in case the growth in a year is higher or lower than envisaged. In case of extreme growth in one year, the tariff for new installations in the next year will automatically decrease faster than envisaged, thus leading to less market growth in that year.

5. Wind onshore: Support tariffs should be differentiated according to wind speed in order to also allow development of sites further inland.

6. Wind offshore: The rules of the tendering system should evolve based on lessons learnt in this year’s first round and in foreign systems.

7. Biomass co-combustion: Coal power plants could be obliged to have a certain share of biomass co-combustion. That way premium tariffs do not have to be adjusted continually to fluctuating world market prizes for biomass. Alternatively a tendering system and a SDE premium with a bonus for use of heat could be applied. The share of imported biomass for this purpose is expected to exceed 50%.

8. Heat and cold options should be supported via a "SDW" (Subsidieregeling Duurzame Warmte), which should be financed and budgeted like described for the SDE in points 1 and 2 above. The SDW need to assure the deployment of large scale RES-H/C through small to medium scale projects, which are currently in practice blocked out through the introduction of the recent Heat Law (warmtewet).

9. In the transport sector establishment of a distribution network for the use of biogas should be supported.

10. The green regulation (groenregeling) allowing soft loans for renewables projects should apply to all renewable energy projects, without further limitations.

The DE Koepel observes that any of the financial support mechanisms are expected to be reduced drastically as soon as CO2 prices for conventional production increase to a level that reflects either their external cost (maatschappelijke kosten) or ambitious long-term emission reduction targets. As soon as serious policies are underway to charge such higher CO2 prices in conventional energy sources, the longer term development of the support policy scheme described above can be redesigned.

### 3.1.3 Increasing biomass availability

In the Netherlands, the total availability of biomass is about 5,400 Ktoe and the biomass imports are about 1500 Ktoe in both scenarios in 2020. The biomass mix is very similar in both scenarios and therefore analyzed together. As mentioned earlier, the use of biomass can be increased by further increasing biomass imports for which the Netherlands have already a good infrastructure.

Biowaste has the highest domestic usage from the considered feedstock categories with about 1,210 Ktoe followed by agricultural residues (1,160 Ktoe) in 2020, but other sources have as well notable availabilities. Imports of agricultural products and forestry residues are high. The next tables depict the availability of biomass in the Netherlands.

**Table 1-17:** Availability of biomass in the Netherlands – NAT scenario

| Netherlands | | NAT (National target fulfillment) | | | |
|---|---|---|---|---|---|
| Feedstock category | Unit | Total 2015 | Imports 2015 | Total 2020 | Imports 2020 |
| Agricultural products | [ktoe] | 414 | 468 | 498 | 796 |
| Agricultural residues | [ktoe] | 410 | : | 1,160 | : |
| Forestry products | [ktoe] | 359 | : | 370 | : |
| Forestry residues | [ktoe] | 537 | 639 | 551 | 820 |
| Biowaste | [ktoe] | 1,076 | : | 1,208 | : |
| Total biomass availibility | [ktoe] | 3,902 | | 5,403 | |

**Source:** Green-X Model (2009)

**Table 1-18:** Availability of biomass in the Netherlands – ACT scenario

| Netherlands | | ACT (proactive support - realisable deployment) | | | |
|---|---|---|---|---|---|
| Feedstock category | Unit | Total 2015 | Imports 2015 | Total 2020 | Imports 2020 |
| Agricultural products | [ktoe] | 426 | 468 | 498 | 796 |
| Agricultural residues | [ktoe] | 410 | : | 1,160 | : |
| Forestry products | [ktoe] | 359 | : | 370 | : |
| Forestry residues | [ktoe] | 537 | 639 | 551 | 820 |
| Biowaste | [ktoe] | 1,083 | : | 1,216 | : |
| Total biomass availibility | [ktoe] | 3,921 | | 5,412 | |

**Source:** Green-X Model (2009)

### 3.1.4 Flexibility / cooperation mechanisms

#### Excess and deficit production of renewable energy compared to the indicative trajectory

The Directive sets not only a binding target for 2020 but also indicative trajectories up to 2020. This section compares the usage of renewables in the scenarios shown above plus an additional scenario analyzing a target fulfillment from a purely European perspective (defined in Annex 1) with these trajectories.

The two scenarios NAT and ACT shown in the section above result in an excess production of renewable energies for the entire period under review as compared to the indicative trajectory for the entire period until 2020, provided that the recommended measures are implemented. At the beginning of the period the EU scenario results in an excess production as well. The over fulfillment can be used for flexibility mechanisms in form of exports. However from 2015 the indicative scenario shows that the Netherlands produces less renewables than required and needs to use the flexibility mechanisms for imports especially in order to reach the 2020 target. The next tables show the development. **(Table 1-19)**

**Table 1-19:** Excess and deficit production of renewables compared to the indicative trajectory in the Netherlands – EU scenario

| Netherlands | | NAT (National target fulfillment) vs. Indicative trajectory | | | | |
|---|---|---|---|---|---|---|
| Sector | Unit | Average 2011 - 2012 | Average 2013 - 2014 | Average 2015 - 2016 | Average 2017 - 2018 | 2020 |
| Excess | [ktoe] | 649 | 952 | 1,042 | 1,206 | 601 |
| Deficit | [ktoe] | : | : | : | : | : |

| Netherlands | | EU (European perspercitve) vs. Indicative trajectory | | | | |
|---|---|---|---|---|---|---|
| Sector | Unit | Average 2011 - 2012 | Average 2013 - 2014 | Average 2015 - 2016 | Average 2017 - 2018 | 2020 |
| Excess | [ktoe] | 303 | 356 | : | : | : |
| Deficit | [ktoe] | : | : | 90 | 568 | 2,025 |

| Netherlands | | ACT (proactive support) vs. Indicative trajectory | | | | |
|---|---|---|---|---|---|---|
| Sector | Unit | Average 2011 - 2012 | Average 2013 - 2014 | Average 2015 - 2016 | Average 2017 - 2018 | 2020 |
| Excess | [ktoe] | 669 | 1,022 | 1,165 | 1,324 | 989 |
| Deficit | [ktoe] | : | : | : | : | : |

**Source:** Green-X Model (2009)

# 4 Estimated costs & benefits of RES policy support measures

## Expected renewable energy use

The consumption of renewables is 8,165 Ktoe in the NAT and 8,553 Ktoe in the ACT scenario. In both scenarios, the renewable energy was mostly consumed in the RES-E sector in 2020.

The development in the NAT and ACT scenario is quite similar. While in 2005 a bit more than 1,000 Ktoe are consumed from renewable sources, this value grows to more than 7,000 in 2020. In 2020, almost 60% of renewables are consumed in the electricity sector as well as almost 30% and 14% in the heat and transport sector.

## Expected GHG reduction

The cumulative avoided $CO_2$ emissions from 2006 to 2020 are 190 $MtCO_2$ in the NAT and 196 $MtCO_2$ in the ACT scenario. As the deployment of renewable energy is similar in the NAT and ACT scenario, the savings of $CO_2$ emissions are comparable as well. The majority of the $CO_2$ is avoided in the electricity sector. Roughly 150 $MtCO_2$ are saved cumulative from 2006 to 2020 in the electricity sector.

## Expected job creation[23]

The effects on the job market are based on the study EmployRES published by Fraunhofer ISI, EEG, Rütter + Partner, ECOFYS LEI and SEURECO. In this study, the total gross employees due to the renewable energy field are analyzed in different scenarios. The first scenario is a business as usual scenario (BAU scenario) assuming the current renewable energy policy will be retained. The second scenario assumes a stronger RES policy (advanced policy scenario) and is comparable to the EU scenario of Green-X.

The efforts to achieve the target to produce 14% of the Netherlands' energy from renewable sources will add in the BAU and advanced policy scenario the following total gross jobs figures:

**Table 1-20:** Additional employees in the renewable energy sector of the Netherlands

| Indicator | Unit | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| BAU scenario | 1000 employees | 20.1 | 25.3 | 31.3 |
| Advanced policy scenario | 1000 employees | 23.6 | 36.8 | 53.2 |

**Source:** Fraunhofer ISI; EEG; Rütter + Partner; ECOFYS ; LEI; SEURECO (2009)

[23] This paragraph is based on Fraunhofer ISI; EEG; Rütter + Partner; LEI; SEURECO (2009)

## Avoided fossil fuel imports

***Avoided fossil fuel imports in energy terms:***

In energy terms, 73 Mtoe are cumulatively avoided in the NAT and 74 Mtoe in the ACT scenario from 2006 to 2020. More than three-fourths of the imports are avoided because of the usage of renewables in the electricity sector in both scenarios, while the heat and transport sectors are minor contributors.

***Avoided fossil fuel imports in monetary terms:***

The cumulated avoided fossil fuel costs from 2006 to 2020 are M€ 27,532 in the NAT and M€ 28,323 in ACT scenario. Although the absolute avoided costs are different, the sectoral share is quite similar in the scenarios and therefore analyzed together. More than two thirds are avoided in the electricity sector, a bit less than 15% in the heat and almost 20% in the transport sector.

## Avoided external costs

The highest cumulative avoidance between 2006 and 2020 is reached in the ACT scenario with M€ 5,526. In the NAT scenario M€ 5,699 are reached.

The vast majority of the avoidance is due to the electricity sector, which contributes roughly four-fifths. This result was foreseeable as the electricity sector is by far the main source of renewable energy in the Netherlands.

## Expected capital expenditures

The cumulative capital expenditures are M€ 49,625 in the NAT and M€ 56,778 in the ACT scenario between 2006 and 2020.

As the contribution of the electricity sector to renewables in the Netherlands is the highest, this sector as well has the highest cumulative investments in all sectors. In the scenarios, the share is about 80% of this sector followed by about 20% of investments in the heat sector.

## Expected costs of achieving the 2020 target

***Policy costs:***

The policy costs in the NAT and ACT scenario are M€ 22,959 and M€ 30,209, respectively. Furthermore, the yearly expenditures grow steadily in both scenarios.

The consumer expenditures rise from M€ 360 in 2007 to M€ 3,242 in 2020 in the NAT scenario. About two thirds of the cumulated expenditures up to 2020 are spent on the electricity sector, one fourth on the heat sector and 10% on the transport sector. The average yearly support costs during the period 2006-2020 for all sectors are M€ 1,537.

The ACT scenario causes the highest costs but can achieve the highest renewables consumption as well. The expenditures rise up to M€ 5,035 in 2020. Most money is spent on the electricity sector (63%). The annual average costs during the period 2006-2020 in this scenario are M€ 2,015.

***Additional generation costs:***

The additional generation costs cumulated from 2006 to 2020 are M€ 7,022 in the NAT and M€ 7,613 in the ACT scenario.

Almost 90% of the additional costs are caused by the electricity sector in the NAT and ACT scenario. The rest of the costs are due to the transport sector while the heat sector causes only marginal costs.

The reason of this additional generation costs structure is the high deployment in the electricity sector in the Netherlands. The renewable heat consumption increases strongly despite no additional costs.

The *DE KOEPEL* likes to stress that the scenario results on expenditures would be lower if more appropriate growth rates for photovoltaic's would be assumed in the IEA World Energy Outlook – compare the comment in 1.3.2. Further they emphasize that higher CO2 cost will reduce the supporting funding for renewables.

# 5 Outline of RES industry

The RES industry of the Netherlands covers the various elements in the supply – and value chain for the various technologies. In total approximately 350 companies and industries are active in the supply site and project development. This number is without the typical installation companies which are currently estimated at 200-300 additional companies who deal with renewable energy technologies alongside their more traditional activities. In the table below is indicated where the relative strong positions are in the value chain of the various technologies (based on information provided by *DE KOEPEL*).

| | Wind | Solar PV | Solar Th | Heat Pumps | Heat/cold undergr. | Bio-gas | Bio-masse | Bio Fuel | Maritime / Hydro |
|---|---|---|---|---|---|---|---|---|---|
| Research | +++ | +++ | + | + | + | + | +++ | ++ | + |
| Engineering | +++ | + | ++ | + | +++ | + | ++ | + | + |
| Production | + | ++ | + | + | + | + | + | + | + |
| Installation | +++ | + | + | + | +++ | + | + | + | + |
| O&M | ++ | + | + | + | ++ | + | ++ | + | + |

There is a strong focus on innovations in RES -R&D as is also illustrated by the relatively strong research position of a number of Dutch technological institutes on i.e. wind, solar PV and biomass. The *DE Koepel* advocates an additional focus on the implementation stage of innovations to allow the RES industry to anticipate on the opportunities arising. There is no innovation without implementation and it is recommended that this will become an additional focus area in the “innovation agenda”.

# 6 References


EEG. (2005). The Green-X Model.

Eurostat. (2009). Eurostat. Retrieved 2009, from http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home

Fraunhofer ISI; EEG; Rütter + Partner; LEI; SEURECO. (2009). EmployRES - The impact of renewable energy policy on economic growth and employment in the European Union. Retrieved July 2009, 17, from http://ec.europa.eu/energy/renewables/studies/renewables_en.htm

IEA. (2008). Global Renewable Energy - Policies and Measures. Retrieved May 18, 2009, from Biofuels sales requirement: Transport Biofuels Act 2007: http://www.iea.org/textbase/pm/?mode=cc&id=4301&action=detail

IEA/OECD. (2009). Energy Policies of IEA Countries - The Netherlands 2008 Review. Paris.

Ministry of Economic Affairs. (2008a). Regeling aanwijzing categorieën duurzame energieproductie 2008. Retrieved May 15, 2009, from http://www.senternovem.nl/mmfiles/Regeling%20aanwijzing%20categorie%C3%ABn%20duurzame%20energieproductie%20-%2028-02-08_tcm24-254253.pdf

Ministery of Economic Affairs. (2008b). Regeling vaststelling subsidieplafonds en aanvraagperiodes EOS nieuw energieonderzoek 2008. Retrieved May 15, 2009, from http://wetten.overheid.nl/BWBR0023560/geldigheidsdatum_08-04-2009

Ragwitz, M., Resch, G., Morthorst, P.E., Coenraads, R., Konstantinaviciute, I., Heyder, B. (2007). OPTRES – "Assessment and optimization of renewable energy support schemes in the European electricity market". http://ec.europa.eu/energy/renewables/studies/doc/renewables/2007_02_optres.pdf

SenterNovem. (2009). Energy Investment Allowance. Retrieved May 2009, 15, from http://www.senternovem.nl/eia/publicaties/energy_investment_allowance_2009_(leaflet).asp

Staatsblad van het Koninkrijk der Nederlanden. (2004). Besluit van 20 oktober 2004, houdende regels inzake de verstrekking van subsidies ten behoeve van energiedemonstratieprojecten en energietransitie-experimenten. Retrieved May 15, 2009, from http://www.senternovem.nl/mmfiles/AMVB%20EOS%20Demo%20en%20Unieke%20Kansen%20regeling%20STB89421_tcm24-123237.pdf

VROM. (2007). New Energy for Climate Policy. Retrieved May 15, 2009, from http://www.senternovem.nl/robinternational/publications/the_clean_and_efficient_programme_of_the_dutch_government.asp

# 7 Appendix 1 - Overview on investigated cases

Within this project we have calculated three different scenarios of the future renewable energy development up to 2020. These scenarios are meant to form a basis for establishing the 27 national energy roadmaps. The following gives an overview of the three aims of the scenarios. Generally, in all scenarios it is preconditioned to pursue the overall 20% RES by 2020 on EU scale. All results of the scenario calculations are depicted in terms of RES deployment as well as the associated costs and benefits.

NAT – National target fulfillment:

Within the NAT scenario each Member States tries to fulfil its national RES target by its own. The use of cooperation mechanisms as agreed in the RES Directive is reduced to necessary minimum: For the exceptional case that a member state would not possess sufficient RES potentials, cooperation mechanisms would serve as a complementary option. Additionally, if a member state possesses barely sufficient RES potentials, but their exploitation would cause significantly higher consumer expenditures compared to the EU average, cooperation would serve as complementary tool to assure target achievement. As a consequence of above, the required RES support will differ comparatively large among the countries.

EU – European perspective:

In contrast to the NAT case, within the EU scenario the use of cooperation mechanisms does not represent the exceptional case: If a member state would not possess sufficient potentials that can be economically exploited, cooperation mechanisms as defined in the RES directive would serve as a complementary option. Consequently, the prior aim of the EU scenario is to fulfil the 20% RES target on EU level, rather than fulfilling each national RES target purely domestically. Generally, it reflects a "least cost" strategy in terms of consumer expenditures (due to RES support). In contrast to simple short-term least cost policy approaches, the applied technology-specification of RES support does however still allow an EU-wide well balanced RES portfolio.

ACT – proactive support – realizable deployment:

Finally, the ACT scenario depicts an optimistic future with respect to RES exploitation. The assumption is taken that all EU member states apply proactive RES support whereby EU-wide equal incentives are preconditioned for individual RES technologies (e.g. by applying a harmonised but technology-specific premium feed-in system to support RES-E). With EU-wide effective and efficient RES support this scenario ends up with a higher RES exploitation as foreseen in the RES directive.

# 8 Appendix 2 - Results and figures for a low energy demand

<u>Based on PRIMES high energy efficiency case scenario</u>

Sectoral targets and trajectories – NAT scenario the Netherlands

| Netherlands | | NAT (National target fulfillment) | | | | | |
|---|---|---|---|---|---|---|---|
| Indicator | Unit | 2005 | Average 2011 - 2012 | Average 2013 - 2014 | Average 2015 - 2016 | Average 2017 - 2018 | 2020 Targets |
| Expected Gross Final energy consumption | Ktoe | 52,984 | 55,263 | 53,564 | 52,093 | 51,153 | 50,028 |
| Total share of RES in final energy consumption | % | 2.0% | 5.8% | 7.7% | 9.8% | 12.4% | 15.4% |
| Gross Final Consumption of RES-E | Ktoe | 509 | 1,596 | 2,036 | 2,607 | 3,384 | 4,022 |
| Share of RES-E in gross final electricity consumption | % | 5.0% | 14.5% | 19.1% | 24.9% | 31.9% | 37.3% |
| Gross final energy consumption RES-H | Ktoe | 544 | 1,131 | 1,414 | 1,751 | 2,132 | 2,620 |
| Share of RES-H in final Heating and Cooling consumption | % | 2.0% | 4.0% | 5.2% | 6.7% | 8.3% | 10.4% |
| Final energy from renewable sources consumed in transport | Ktoe | 0 | 501 | 668 | 732 | 824 | 1,043 |
| Share of RES in gross final transport energy consumption | % | 0.0% | 4.4% | 6.0% | 6.7% | 7.7% | 10.0% |

**Source:** Green-X Model (2009)

Sectoral targets and trajectories – ACT scenario the Netherlands

| Netherlands | | ACT (proactive support - realisable deployment) | | | | | |
|---|---|---|---|---|---|---|---|
| Indicator | Unit | 2005 | Average 2011 - 2012 | Average 2013 - 2014 | Average 2015 - 2016 | Average 2017 - 2018 | 2020 Targets |
| Expected Gross Final energy consumption | Ktoe | 52,984 | 55,263 | 53,564 | 52,093 | 51,153 | 50,028 |
| Total share of RES in final energy consumption | % | 2.0% | 5.9% | 7.9% | 10.1% | 13.0% | 17.0% |
| Gross Final Consumption of RES-E | Ktoe | 509 | 1,603 | 2,069 | 2,660 | 3,536 | 4,626 |
| Share of RES-E in gross final electricity consumption | % | 5.0% | 14.6% | 19.4% | 25.4% | 33.4% | 42.9% |
| Gross final energy consumption RES-H | Ktoe | 544 | 1,153 | 1,485 | 1,887 | 2,313 | 2,829 |
| Share of RES-H in final Heating and Cooling consumption | % | 2.0% | 4.1% | 5.4% | 7.2% | 9.0% | 11.2% |
| Final energy from renewable sources consumed in transport | Ktoe | 0 | 501 | 668 | 732 | 824 | 1,043 |
| Share of RES in gross final transport energy consumption | % | 0.0% | 4.4% | 6.0% | 6.7% | 7.7% | 10.0% |

**Source:** Green-X Model (2009)

## Contribution of renewables to electricity consumption – NAT scenario the Netherlands

| Netherlands | NAT (National target fulfillment) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Technology | 2005 | | Average 2011 - 2012 | | Average 2013 - 2014 | | Average 2015 - 2016 | | Average 2017 - 2018 | | 2020 Targets | |
| | MW | GWh | MW | GWh | MW | GWh | MW | GWh | MW | GWh | MW | GWh |
| Biomass | 658.4 | 3,828 | 1,234.9 | 7,533 | 1,350.0 | 8,178 | 1,528.4 | 9,188 | 1,814.0 | 10,767 | 2,220.5 | 10,693 |
| Solid | 343.0 | 2,247 | 845.8 | 5,228 | 898.5 | 5,470 | 964.1 | 5,749 | 1,053.1 | 6,126 | 1,182.4 | 4,588 |
| Biogas | 79.5 | 294 | 114.3 | 621 | 164.1 | 942 | 263.7 | 1,588 | 445.9 | 2,696 | 717.0 | 4,086 |
| MSW | 236.0 | 1,287 | 274.8 | 1,683 | 287.4 | 1,765 | 300.5 | 1,851 | 315.0 | 1,945 | 321.1 | 2,019 |
| Liquid | : | : | : | : | : | : | : | : | : | : | : | : |
| Concentrated Solar | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| Geothermal | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| Hydro, total | 37.0 | 99 | 39.3 | 101 | 39.3 | 101 | 39.3 | 101 | 39.3 | 101 | 39.3 | 101 |
| >10MW | 37.0 | 99 | 37.0 | 100 | 37.0 | 100 | 37.0 | 100 | 37.0 | 100 | 37.0 | 100 |
| <10MW | 0.0 | 0 | 2.3 | 1 | 2.3 | 1 | 2.3 | 1 | 2.3 | 1 | 2.3 | 1 |
| Of which pumping | : | : | : | : | : | : | : | : | : | : | : | : |
| Photovoltaic | 51.0 | 34 | 348.9 | 268 | 771.7 | 583 | 1,668.6 | 1,240 | 2,458.5 | 1,818 | 2,738.9 | 2,023 |
| Ocean | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| Wind | 1,224.0 | 1,957 | 4,445.0 | 10,659 | 6,071.8 | 14,818 | 7,641.5 | 19,790 | 9,808.1 | 26,668 | 12,129.8 | 33,960 |
| Onshore | 1,193.8 | 1,861 | 3,891.7 | 8,883 | 4,850.6 | 10,818 | 5,090.3 | 11,337 | 5,205.3 | 11,567 | 5,359.4 | 11,852 |
| Offshore | 30.2 | 95 | 553.3 | 1,776 | 1,221.2 | 4,000 | 2,551.2 | 8,454 | 4,602.8 | 15,101 | 6,770.4 | 22,108 |
| Gross Final Consumption of electricity from RES | 1,970.4 | 5,918 | 6,068.1 | 18,560 | 8,232.9 | 23,680 | 10,877.8 | 30,318 | 14,119.9 | 39,353 | 17,128.5 | 46,776 |

**Source:** Green-X Model (2009)

## Contribution of renewables to electricity consumption – ACT scenario the Netherlands

| Netherlands | ACT (proactive support - realisable deployment) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Technology | 2005 | | Average 2011 - 2012 | | Average 2013 - 2014 | | Average 2015 - 2016 | | Average 2017 - 2018 | | 2020 | |
| | MW | GWh | MW | GWh | MW | GWh | MW | GWh | MW | GWh | MW | GWh |
| Biomass | 658.4 | 3,828 | 1,247.1 | 7,602 | 1,369.4 | 8,292 | 1,555.3 | 9,348 | 1,798.2 | 10,748 | 2,126.7 | 10,331 |
| Solid | 343.0 | 2,247 | 858.0 | 5,298 | 916.0 | 5,573 | 986.1 | 5,881 | 1,030.2 | 6,068 | 1,031.5 | 3,986 |
| Biogas | 79.5 | 294 | 114.3 | 621 | 166.0 | 954 | 268.7 | 1,617 | 453.0 | 2,736 | 774.1 | 4,326 |
| MSW | 236.0 | 1,287 | 274.8 | 1,683 | 287.4 | 1,765 | 300.5 | 1,851 | 315.0 | 1,945 | 321.1 | 2,019 |
| Liquid | : | : | : | : | : | : | : | : | : | : | : | : |
| Concentrated Solar | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| Geothermal | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| Hydro, total | 37.0 | 99 | 39.5 | 101 | 39.8 | 102 | 40.3 | 104 | 40.8 | 106 | 40.9 | 106 |
| >10MW | 37.0 | 99 | 37.0 | 100 | 37.0 | 100 | 37.0 | 100 | 37.0 | 100 | 37.0 | 100 |
| <10MW | 0.0 | 0 | 2.5 | 1 | 2.8 | 2 | 3.3 | 4 | 3.8 | 6 | 3.9 | 6 |
| Of which pumping | : | : | : | : | : | : | : | : | : | : | : | : |
| Photovoltaic | 51.0 | 34 | 348.9 | 268 | 771.7 | 583 | 1,668.6 | 1,240 | 3,400.6 | 2,505 | 7,103.4 | 5,209 |
| Ocean | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| Wind | 1,224.0 | 1,957 | 4,453.8 | 10,673 | 6,243.4 | 15,090 | 7,931.9 | 20,246 | 10,263.8 | 27,766 | 13,442.0 | 38,154 |
| Onshore | 1,193.8 | 1,861 | 3,900.5 | 8,897 | 5,022.2 | 11,089 | 5,380.7 | 11,792 | 5,470.4 | 11,979 | 5,495.3 | 12,052 |
| Offshore | 30.2 | 95 | 553.3 | 1,776 | 1,221.2 | 4,000 | 2,551.2 | 8,454 | 4,793.5 | 15,787 | 7,946.7 | 26,102 |
| Gross Final Consumption of electricity from RES | 1,970.4 | 5,918 | 6,089.3 | 18,644 | 8,424.4 | 24,067 | 11,196.1 | 30,938 | 15,503.5 | 41,125 | 22,713.0 | 53,800 |

**Source:** Green-X Model (2009)

Contribution of renewables to heating and cooling consumption – NAT scenario the Netherlands

| Netherlands | NAT (National target fulfillment) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Technology | 2005 | | Average 2011 - 2012 | | Average 2013 - 2014 | | Average 2015 - 2016 | | Average 2017 - 2018 | | 2020 | |
| | MWth | Ktoe | MWth | Ktoe | MWth | Ktoe | MWth | Ktoe | MWth | Ktoe | MWth | Ktoe |
| Biomass | 0 | 508 | 4,010 | 691 | 4,274 | 748 | 4,650 | 824 | 5,254 | 932 | 6,358 | 1,099 |
| Solid | 0 | 445 | 3,407 | 493 | 3,602 | 536 | 3,885 | 595 | 4,353 | 683 | 5,081 | 811 |
| Biogas | : | 63 | 171 | 67 | 191 | 69 | 234 | 74 | 315 | 80 | 448 | 88 |
| Biowaste | : | 0 | 432 | 131 | 481 | 142 | 531 | 155 | 586 | 168 | 828 | 200 |
| Geothermal | : | 0 | 19 | 5 | 37 | 11 | 43 | 12 | 43 | 12 | 113 | 23 |
| Solar Thermal | : | 19 | 1,918 | 76 | 2,956 | 117 | 4,277 | 170 | 6,073 | 241 | 9,095 | 361 |
| Heat pumps | : | 17 | 2,902 | 359 | 4,343 | 538 | 6,023 | 746 | 7,648 | 947 | 9,189 | 1,138 |
| Gross final energy consumption from RES in heating and cooling | 0 | 544 | 8,847 | 1,131 | 11,610 | 1,414 | 14,992 | 1,751 | 19,018 | 2,132 | 24,754 | 2,620 |

**Source:** Green-X Model (2009)

Contribution of renewables to heating and cooling consumption – ACT scenario the Netherlands

| Netherlands | ACT (proactive support - realisable deployment) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Technology | 2005 | | Average 2011 - 2012 | | Average 2013 - 2014 | | Average 2015 - 2016 | | Average 2017 - 2018 | | 2020 | |
| | MWth | Ktoe | MWth | Ktoe | MWth | Ktoe | MWth | Ktoe | MWth | Ktoe | MWth | Ktoe |
| Biomass | 0 | 508 | 4,112 | 712 | 4,641 | 819 | 5,256 | 951 | 5,993 | 1,090 | 7,218 | 1,267 |
| Solid | 0 | 445 | 3,509 | 515 | 3,969 | 607 | 4,491 | 722 | 5,092 | 841 | 5,942 | 979 |
| Biogas | : | 63 | 171 | 67 | 191 | 69 | 234 | 74 | 315 | 80 | 448 | 88 |
| Biowaste | : | 0 | 432 | 131 | 481 | 142 | 531 | 155 | 586 | 168 | 828 | 200 |
| Geothermal | : | 0 | 19 | 5 | 37 | 11 | 94 | 20 | 178 | 36 | 316 | 64 |
| Solar Thermal | : | 19 | 1,924 | 76 | 2,966 | 118 | 4,281 | 170 | 6,079 | 241 | 9,102 | 361 |
| Heat pumps | : | 17 | 2,902 | 359 | 4,343 | 538 | 6,023 | 746 | 7,648 | 947 | 9,189 | 1,138 |
| Gross final energy consumption from RES in heating and cooling | 0 | 544 | 8,956 | 1,153 | 11,987 | 1,485 | 15,654 | 1,887 | 19,897 | 2,313 | 25,825 | 2,829 |

**Source:** Green-X Model (2009)

Contribution of renewables to transport consumption – all scenarios the Netherlands

| Netherlands | | NAT | | | ACT | | |
|---|---|---|---|---|---|---|---|
| Technology | Unit | 2005 | Average 2011 - 2012 | Average 2013 - 2014 | Average 2015 - 2016 | Average 2017 - 2018 | 2020 |
| Bioethanol | ktoe | 0.0 | 88.7 | 118.1 | 107.4 | 130.2 | 138.2 |
| Of which imported | ktoe | : | : | : | : | : | : |
| Biodiesel | ktoe | 0.0 | 2.0 | 3.9 | 0.0 | 0.0 | 0.0 |
| Of which imported | ktoe | : | : | : | : | : | : |
| Biofuels from wastes, residues, non-food cellulosic material, and ligno-cellulosic material | ktoe | : | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Of which imported | ktoe | : | : | : | : | : | : |
| Hydrogen from RES | ktoe | : | : | : | : | : | : |
| Renewable electricity | ktoe | : | : | : | : | : | : |
| Biofuel import | ktoe | : | 410.5 | 545.8 | 624.6 | 694.0 | 905.0 |
| Final energy from renewable sources consumed in transport | ktoe | 0.0 | 501.2 | 667.9 | 732.1 | 824.3 | 1,043.2 |

**Source:** Green-X Model (2009)

# 9 Appendix 3 - Short characterization of the Green-X model

As in previous projects such as FORRES 2020, OPTRES or PROGRESS the ***Green-X*** model was applied to again perform a detailed quantitative assessment of the future deployment of renewable energies on country-, sectoral- as well as technology level. The core strength of this tool lies on the detailed RES resource and technology representation accompanied by a thorough energy policy description, which allows assessing various policy options with respect to resulting costs and benefits. A short characterisation of the model is given below, whilst for a detailed description we refer to www.green-x.at.

*Short characterisation of the* ***Green-X*** *model*

*The model* ***Green-X*** *has been developed by the Energy Economics Group (EEG) at Vienna University of Technology in the research project "Green-X – Deriving optimal promotion strategies for increasing the share of RES-E in a dynamic European electricity market", a joint European research project funded within the 5th framework program of the European Commission, DG Research (Contract No. ENG2-CT-2002-00607). Initially focussed on the electricity sector, this tool and its database on RES potentials and costs have been extended within follow-up activities to incorporate renewable energy technologies within all energy sectors.*

***Green-X*** *covers geographically the EU-27, and can easily be extended to other countries such as Turkey, Croatia or Norway. It allows to investigate the future deployment of RES as well as accompanying cost – comprising capital expenditures, additional generation cost (of RES compared to conventional options), consumer expenditures due to applied supporting policies, etc. – and benefits – i.e. contribution to supply security (avoidance of fossil fuels) and corresponding carbon emission avoidance. Thereby, results are derived at country- and technology-level on a yearly basis. The time-horizon allows for in-depth assessments up to 2020, accompanied by concise out-looks for the period beyond 2020 (up to 2030).*

*Within the model, the most important RES-Electricity (i.e. biogas, biomass, biowaste, wind on- & offshore, hydropower large- & small-scale, solar thermal electricity, photovoltaics, tidal stream & wave power, geothermal electricity), RES-Heat technologies (i.e. biomass – subdivided into log wood, wood chips, pellets, grid-connected heat -, geothermal (grid-connected) heat, heat pumps and solar thermal heat) and RES-Transport options (e.g. first generation biofuels (biodiesel and bioethanol), second generation biofuels (lignocellulotic bioethanol, BtL) as well as the impact of biofuel imports) are described for each investigated country by means of dynamic cost-resource curves. This allows besides the formal description of potentials and costs a detailed representation of dynamic aspects such as technological learning and technology diffusion.*

*Besides the detailed RES technology representation the core strength of the model is the in-depth energy policy representation. Green-X is fully suitable to investigate the impact of applying (combinations of) different energy policy instruments (e.g. quota obligations based on tradable green certificates / guarantees of origin, (premium) feed-in tariffs, tax incentives, investment incentives, impact of emission trading on reference energy prices) at country- or at European level in a dynamic framework. Sensitivity investigations on key input parameters such as non-economic barriers (influencing the technology diffusion), conventional energy prices, energy demand developments or technological progress (technological learning) typically complement a policy assessment.*