Socio-economic indicators of renewable energy in 2010

Update of data of turnover and employment of renewable energy companies in the Netherlands

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Acknowledgement/Preface

This scoping study focuses on the turnover and workforce of renewable energy companies in the Netherlands. The authors wish to express gratitude for co-reading by....., although the study's contents remain their responsibility. The study has been conducted in the framework of the European project EurObserv'ER (ECN project number 7.7903).

Abstract

This study focuses on the turnover and workforce of Dutch renewable energy companies, in particular for wind energy, photovoltaic electricity (PV), solar thermal energy, biofuels, solid biomass, biogas and municipal solid waste, small hydro and related technologies, and geothermal energy. As data of renewable energy companies is still scarce and incomplete, the figures presented in this study are generally estimates with some uncertainty (±20%). Still, the turnover of companies in this sector is tentatively estimated at € 3.32 billion and the direct employment at approximately 7,450 people in 2010. The data presented is inevitably incomplete and reflects the current views on this subject.

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Summary

This study presents an overview of Dutch companies engaged in wind energy, photovoltaic energy (PV), solar thermal energy, biofuels, solid biomass, biogas and municipal solid waste, small hydro and related technologies, and geothermal energy. This scoping study - although based on data that were available at the time of writing, but inevitably incomplete - has been conducted in the framework of the European IEE-funded project EurObserv'ER (www. eurobserv-er.org), which collects data on deployment of renewable energy (RE) in EU countries. The focus of the present study are *socio-economic data* such as turnover and employment of RE companies particularly in the Netherlands. As data of turnover and employment are scarce and incomplete, the figures presented are generally estimates with some uncertainty (±20%).

All in all, renewable energy sources considered in the present study represent a gross final energy equivalent of 86.2 PJ in 2010. The total turnover of RE companies in the Netherlands is estimated at € 3.32 billion in 2010 (€ 3.15 billion in 2009). The total workforce of these companies is estimated at approximately 7,450 employees in 2010 (approximately 7,130 in 2009), as elucidated by Table S.1. Based on a ratio between indirect and direct employment of 0.88, the total direct and indirect employment of companies engaged in renewable energy in the Netherlands may be estimated at 14,000. Several technologies or stages in a renewable energy sector were not covered in the present study. For instance, the study does not include storage of heat and cooling based on aquifers and geothermal heat pumps. With respect to solid biomass, this study does not include turnover and employment related to wood-fired furnaces and boilers in households and related to co-firing of biomass in power plants.

The total installed capacity of *wind energy* (onshore plus offshore) in the Netherlands stood at 2,230 MW by the end of 2010. The gross final energy equivalent of electricity generation was 16.2 PJ. With regard to the turnover of wind energy companies in the Netherlands, the present study gives an estimate of € 1,330 million in 2010. The total number of employees of wind energy (component) companies in the Netherlands is estimated at 2,400.

The installed capacity of *photovoltaic electricity* (PV) in the Netherlands stood at 88 MW by the end of 2010. The gross final energy equivalent of electricity generation was 0.22 PJ. A detailed overview of PV related companies and activities indicates that the turnover of PV companies may be estimated at € 1,000 million and the number of employees at 1,240 in 2010.

The installed capacity of *solar thermal energy* in the Netherlands stood at 563 MW_{th} by the end of 2010. The primary energy equivalent of solar thermal energy was 0.99 PJ. With regard to the turnover of solar thermal energy companies in the Netherlands, this study presents an estimate of € 53 million in 2010. The number of employees in the Netherlands is estimated at 960.

Approximately thirteen companies are active on *biofuel* production in the Netherlands. In 2010, the gross final energy equivalent of biofuel production amounted to 9.6 PJ. With regard to the turnover of biofuel companies in the Netherlands, this study presents a figure of € 170 million in 2010. The number of employees in the Netherlands is estimated at 300.

A number of companies are active on (conversion of) *solid biomass* in the Netherlands. In 2010, the gross final energy equivalent of solid biomass stood at 34.7 PJ. With regard to the turnover of companies in the Netherlands, this study presents a figure of € 65 million in 2010. The number of employees in the Netherlands is tentatively estimated at 250.

At least eight companies focus on production of equipment for *biogas* plants in the Netherlands. In 2010, the gross final energy equivalent of biogas was 8.3 PJ. With regard to the turnover of

companies in the Netherlands, this study presents a figure of € 100 million in 2010. The number of employees in the Netherlands is tentatively estimated at 1,000.

There are nine companies active in energy (electricity and/or heat) generation from *municipal solid waste* (MWS) in the Netherlands. In 2010, the gross final energy equivalent of the bio-genic fraction of MSW was 11.5 PJ. With regard to the turnover of companies in the Nether-lands, this study presents a figure of € 500 million. The number of employees is estimated at 890.

There are about eight companies active in hydro power or related technologies in the Nether-lands. In 2010, the total hydro capacity stood at 37 MW, and the electricity generated was equivalent to 0.38 PJ_e. The turnover of these companies is estimated at € 1.5 million and the number of employees is estimated at 30.

Finally, there are tens of companies engaged in (deep) geothermal energy, which is a relatively small but strongly growing renewable energy source in the Netherlands. Until this date, there is no official data of geothermal energy production, as geothermal heating projects started only very recently. With regard to the turnover of companies in the Netherlands, this study presents a figure of € 100 million in 2010. The number of employees is tentatively estimated at 380. For shallow geothermal energy - storage of heat and cooling based on shallow aquifers - and for geothermal heat pumps, it turned out to be impossible to collect data in the present study.

Table S.1 *Key data turnover and employees of companies engaged in RE in the Netherlands*

Renewable energy sector	Turnover 2007 [€ mln]	Employees 2007	Turnover 2008 [€ mln]	Employees 2008	Turnover 2009 [€ mln]	Employees 2009	Turnover 2010 [€ mln]	Employees 2010
Wind energy	840	1,500	1,100	2,000	1,220	2,200	1,330	2,400
Photovoltac energy	328	525	580	800	970	1,180	1,000	1,240
Solar thermal energy	30	580	35	670	60	1,090	53	960
Biofuels	40	70	130	220	140	260	170	300
Solid biomass	60	240	62	240	65	250	65	250
Biogas	60	240	62	240	95	1,000	100	1,000
Municipal solid waste	420	670	470	710	500	760	500	890
Small hydro & tidal	1.2	25	1.5	30	1.5	30	1.5	30
Geothermal energy	45	85	55	170	98	360	100	380
Geothermal heat pump	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	1,800	~3,900	~2,500	~ 5,080	~3,150	~ 7,130	~ 3,320	~ 7,450

1. Introduction

This scoping study presents an overview of the turnover and employment of Dutch companies engaged in wind energy, photovoltaic energy (PV), solar thermal energy, biofuels, solid biomass, biogas and municipal solid waste, small hydro and related technologies, geothermal energy and geothermal heat pumps. It has been conducted in the framework of 'EurObserv'ER', an EU-wide database of renewable energy data, to which ECN Policy Studies contributes.

The data conveyed refer to the year 2010 and cover:

- Number of companies engaged in each of the renewable energy technologies.
- Direct employment figures for each of the renewable energy technologies.
- Turnover of companies that are involved in renewable energy technology.
- Renewable energy produced (data from Statistics Netherlands, CBS).

The methodology applied was to convey data on turnover and employment of companies engaged in renewable energy in the Netherlands as far as publicly available data was accessible. Sometimes, data was readily available but in most cases more generic information had to be converted to the format used. For instance, some companies are engaged in several technologies, some of which are renewable. Alternatively, a company may be a subsidiary of a foreign company which produces and supplies renewable energy technologies in a number of countries, among which the Netherlands. Therefore, a lot of data has the character of a crude appraisal of renewable energy companies in the Netherlands. In 2011, Statistics Netherlands (CBS) published a study on turnover, added value, and employment in the 'renewable energy sector' in the Netherlands (Van Rossum et al, 2011). To some extent, this study uses a different definition of renewable energy, as it includes CO_2 capture and storage. This energy conversion technology is normally not denoted as renewable energy, as it is based on fossil fuels. The same holds for electric transport, hydrogen technology, and smart grids, which may be related to renewable energy but are not necessarily renewable. Also, the study includes energy efficiency in its definition of the renewable or sustainable energy sector. For these reasons, the data conveyed in the present study are only compared in their aggregated state (all renewables) in Chapter 12 with the results from (Van Rossum et al, 2010).

Van Rossum et al (2010) also make mention of a report of Ecorys 'Versterking van de Nederlandse duurzame Energiesector' (2010). However, no such report is publicly available. Therefore, it is impossible to compare the results of the present study with those of Ecorys.

Chapter 2 starts with a short overview of the methodology used in retrieving and analyzing data of turnover and employment of renewable energy technologies. After that, nine renewable energy technologies are covered followed by a chapter with conclusions:

- Wind energy (Chapter 3).
- Photovoltaic electricity (Chapter 4).
- Solar thermal energy (Chapter 5).
- Biofuels (Chapter 6).
- Solid biomass (Chapter 7).
- Biogas (Chapter 8).
- Municipal Solid Waste (Chapter 9).
- Small hydro power, tidal power, and 'Blue Energy' (Chapter 10).
- Geothermal energy (Chapter 11).
- Overview and conclusions (Chapter 12).

2. Methodology

The methodology used to retrieve and analyse data of turnover and employment of renewable energy technologies consisted of the following methods:

- Use of data provided by Statistics Netherlands (CBS) or data from companies in Municipal Solid Waste. In a similar way, data were provided for geothermal energy based on annual accounts or sector-specific information. It is assumed that the coverage of the sectors is almost complete, with an error of approximately 10%.
- Collection of data on a company-by-company base, for wind energy, photovoltaic energy, biofuels, and small hydro. The method is assumed to provide data of turnover and employment that are accurate with an uncertainty margin of 20%.
- Collection of scattered data on turnover and employment of a sector, i.e. for solar thermal energy, solid biomass, and biogas. The method is less accurate than the preceding methods, and the uncertainty margin may be 35%.

The uncertainty margins of the second (20%) and third (35%) categories are somewhat arbitrary. They are only used for illustration purposes. Also, several companies are not only active in the renewable energy sector but also in other businesses. For such companies, corrections have been applied.

3. Wind energy

Wind turbine companies which manufacture turbines or components, and produce related services (R&D, engineering and design) including companies engaged in offshore wind, constitute a growing industry with many representatives in the Netherlands. This chapter focuses on data of turnover and employment of these companies, as far as available. Based on a recent overview of Agentschap NL, a distinction is made between companies that are primarily engaged in onshore wind and those that are primarily engaged in offshore wind (Agentschap NL, 2011a).

3.1 Onshore wind

3.1.1 ABB

ABB bv, which has a subsidiary (ABB Benelux) in Rotterdam, is engaged in various activities in electricity generation and transport, among which generators for wind turbines, and engineering, and manufacturing of cables (High Voltage Direct Current, HVDC) for e.g. offshore wind farms (Agentschap NL, 2011a).

3.1.2 ABN AMRO

ABN AMRO is an international operating bank and is engaged in financing of industries, among which companies engaged in wind energy (Agentschap NL, 2011a).

3.1.3 ABT

ABT bv with offices in Belgium and the Netherlands is *inter alia* engaged in engineering of the foundation of onshore wind farms (Agentschap NL, 2011a; Internet Source 1).

3.1.4 Acrress

Acrress in Lelystad hosts the Wind Turbine Testing Services facility of Ecofys (Eneco) for wind turbines with a maximum tip height of 200 m (Internet Source 2).

3.1.5 Actiflow

Actiflow is an engineering company in Breda (a spin-off from Delft University of Technology) with a special focus on flow engineering. Services range from the building industry to medical services, from automotive to aerospace, and from oil and gas to wind energy (Internet Source 3). Its wind-related workforce is estimated at 5 people.

3.1.6 Advanced Tower Systems (ATS)

Advanced Tower Systems (ATS) in Enschede developed a new tower concept for large wind turbines as an economically and logistically attractive alternative to steel towers. ATS is a joint venture of MECAL, Hurks Group BV and Juwi Holding AG, established in May 2005 (REW, 2009; Internet Source 4). Its workforce stood at 64 people in 2009 (Internet Source 5) and 73 in 2010 (Internet Source 6).

3.1.7 Altenburg & Wyminga (A&W)

Altenburg & Wyminga ecologisch onderzoek bv (A&W) is engaged in research and consultancy with regard to e.g. bird collisions at wind farms. It is assumed that one of its 35 employees is engaged in wind related research and consultancy (Agentschap NL, 2011a; Internet Source 7).

3.1.8 Arcadis

Arcadis is an international engineering company in Amersfoort with a workforce of 15,000 people and a turnover of € 1.8 billion (Internet Source 8). One activity relates to searching for locations for onshore and offshore wind farms. Its wind-related workforce is estimated at 5 people.

3.1.9 Ascent Safety

Ascent Safety bv in Amersfoort has a subsidiary which is specialised in training in working on height for wind turbines (Agentschap NL, 2011a).

3.1.10 ASN Bank

ASN Bank is engaged in financing of e.g. on- and offshore wind farms. Until this date ASN Bank financed five onshore and three offshore wind farms in Belgium and Germany. Its wind energy related workforce is estimated at 5 people (Agentschap NL, 2011a; Internet Source 9).

3.1.11 Atlas Magnetics Europe

Atlas Magnetics Europe bv, a subsidiary of Atlas Magnetics Group in Schijndel, supplies *inter alia* permanent magnets and magnetic systems for automotive, energy (wind turbines), medical, semiconductor, industrial, and aerospace industries (Agentschap NL, 2011a; Internet Source 10).

3.1.12 ATO

ATO Sustainable Business Engineers in Den Helder is a non-profit organisation that is engaged in environmentally friendly and renewable energy start-ups (Agentschap NL, 2011a).

3.1.13 Bettink Service en Onderhoud

Bettink Service en Onderhoud in Barneveld is specialised in maintenance of (onshore) wind turbines. Its number of employees is reportedly 25 (Internet Source 11).

3.1.14 BLIX Consultancy

BLIX Consultancy bv in Utrecht supports its clients in realising renewable energy projects (e.g. offshore wind farms) with the lowest cost of energy and the highest return for shareholders. Its workforce is reportedly approximately 5 people (Agentschap NL, 2011a; Internet Source 12).

3.1.15 Bosch & Van Rijn

Bosch & Van Rijn bv in Utrecht is a consultant with respect to renewable energy and energy conservation, among which wind energy projects (Internet Source 13).

3.1.16 Bosch Rexroth

Bosch Rexroth bv in Boxtel, a subsidiary of Robert Bosch GmbH, is specialised in drive and control technologies, for instance for wind turbines (Agentschap NL, 2011a).

3.1.17 Bureau Waardenburg

Bureau Waardenburg is an independent research and consultancy agency in the field of ecology, environment and landscaping, with approximately 70 employees (Internet Source 14). The workforce involved in studies on the impacts of wind farms is estimated at 5 people.

3.1.18 Cofely GdF Suez

Since 2010, Cofely GdF Suez (France, with subsidiary in Bunnik) is *inter alia* engaged in maintenance of onshore wind farms in the Netherlands (Agentschap NL, 2011a; Internet Source 15).

3.1.19 Composite Technology Centre (CTC)

Composite Technology Centre (CTC) in Almelo is an engineering company established in 2001, with experience in composites and wind energy. In-house know-how and experience covers areas ranging from aerodynamic design, via structural design and material knowledge to production processes, such as Resin Infusion Molding (RIM). It believes in a strong cooperation and co-maker ship with its customers, to enforce the capacities of each other (Internet Source 16; Ter Laak, 2007). Its workforce is tentatively estimated at 15 employees.

3.1.20 Croon Electrotechniek

Croon Electrotechniek bv is part of TBI Holdings bv, a Dutch real estate, construction, and technology group. It is specialised in the design, installation, and maintenance of electrical installations for the wind industry (Internet Source 17). By the end of 2009, its workforce stood at 1,967 people (Internet Source 18). Its wind-related workforce is estimated at 85 people.

3.1.21 DELTA

The multi-utility company DELTA (partially) services six onshore wind farms with a combined capacity of 87 MW (DELTA, 2011; Internet Source 19). The wind-related workforce of DELTA was tentatively estimated at 20 people in 2009, and is estimated at 15 people in 2010.

3.1.22 ECN Wind Energy

ECN Wind Energy is part of ECN (Energy research Centre of the Netherlands) in Petten, and is involved in R&D on wind energy. Its workforce is approximately 50 FTE.

3.1.23 E-Connection Project

E-Connection Project bv in Bunnik develops mainly on- and offshore wind projects in the Netherlands. It operates seven relatively small onshore wind farms and two solitary wind turbines in the Netherlands with an aggregated capacity of 35 MW (Internet Source 20). It has an estimated workforce of 5 people.

3.1.24 Edelweiss Finance Advisors

Edelweiss Finance Advisors bv in Voorburg provides financial advice for consortia engaged in large energy and infrastructure investments, among which wind farms (Internet Source 21).

3.1.25 EEE-Team

EEE-Team bv in Amersfoort is engaged in project development, interim management, and consulting with respect to *inter alia* wind energy (Internet Source 22).

3.1.26 Eneco (Ecofys and Evelop)

Ecofys and Evelop are subsidiaries of Eneco (Rotterdam) focused on energy conservation and renewable energy as well as operation of the (wind turbine) Test Site Lelystad (Ecofys), and the development, construction, and operation of on- and offshore wind farms (Evelop), respectively. Eneco and its subsidiaries are involved in the development and operation of onshore and offshore wind farms. Eneco owns 270 MW onshore wind (it has power purchase agreements, PPAs, for 452 MW) and 60 MW offshore wind (with PPAs for 90 MW). Furthermore, Eneco has 88 MW of onshore wind capacity under construction or permitted in the Netherlands, and about 1,420 MW of offshore capacity, most of which in the UK and Belgium (Eneco, 2011). Its wind-related workforce is estimated at 100 people in 2009, and 110 people in 2010.

3.1.27 Enercon Benelux

Enercon Benelux bv in Zwolle is a subsidiary of Enercon of Germany, one of the leading wind turbine manufacturers in the world. Its Dutch workforce is tentatively estimated at 50 people out of a total of 2,500 people engaged in maintenance (Agentschap NL, 2011a; Internet Source 23).

3.1.28 E.On Benelux

E.On Benelux N.V. is a subsidiary of E.On (Germany), which has interests in 21 on- and offshore wind farms with a combined capacity of 1,200 MW, including the offshore wind farms Robin Rigg in the Solway Firth in the UK (Agentschap NL, 2011a; Internet Source 24).

3.1.29 Essent (RWE)

Essent (subsidiary of RWE) operates a number of wind farms with an aggregate capacity of 201 MW (Internet Source 25). These wind farms, formerly owned by Essent Wind NL, are currently part of RWE Innogy Benelux. The wind-related workforce is tentatively estimated at 25 people.

3.1.30 EWT (Emergya Wind Technologies)

EWT (Emergya Wind Technologies) bv in Amersfoort is specialised in manufacturing and supply of direct drive (gearless) wind turbines from 500 to 900 kW. It started operations in February 2004, based on key assets of the former Lagerwey Wind company. From 2005 to 2006, turnover increased from € 7.3 mln to € 81 mln. EWT supplied wind turbines to China, North America, Brazil, and Europe (the Netherlands, UK, Poland, and Sweden). A prototype 2-MW turbine commissioned by the end of 2010 is due to be commercially available in 2011. Its global workforce is over 100, of which approximately 90 in the Netherlands (Internet Source 26).

3.1.31 GA-Finance

GA-Finance bv in Amsterdam provides financing solutions for aircraft and renewable energy projects, among which wind energy projects for project developers and asset owners (Internet Source 27).

3.1.32 GL Garrad Hassan Netherlands

GL Garrad Hassan (UK) is a renewable energy consultancy, focused on on- and offshore wind, wave energy, tidal energy, and solar energy (Internet Source 28). Its subsidiary in the Netherlands, with offices in Delft and Heerenveen, has a workforce of an estimated 8 people.

3.1.33 Global Blade Technology

Global Blade Technology bv in Wieringerwerf, founded in 2009, designs and produces state-of-the-art wind turbine blades and production molds. It produces *inter alia* wind turbine blades for WES bv (Wind Energy Solutions) and is developing blades for 1.5 MW wind turbines. Its workforce in the Netherlands is estimated at 25 people (Agentschap NL, 2011a; Internet Source 29).

3.1.34 Global Windpower

Global Wind Power bv (formerly Lagerwey Wind bv) in Amstelveen, focuses *inter alia* on the development and marketing of the Direct Drive PMG Class II 2000kW wind turbine (GWP82-2000kW) and the Class I 750kW Norwin wind turbine (GWP47-750kW). The company had a number of vacancies lately (Internet Source 30). Its workforce is estimated at 8 employees.

3.1.35 Green Giraffe

Green Giraffe Energy Bankers in Utrecht and Paris is specialised in financing of renewable energy projects. It has about six Dutch employees (Agentschap NL, 2011a; Internet Source 31).

3.1.36 Grontmij

Grontmij bv in de Bilt is an engineering and consultancy company, which is amongst others engaged in wind energy projects. Its wind-related work force is tentatively estimated at three people (Agentschap NL, 2011a; Internet Source 32).

3.1.37 Hodij Coatings

Hodij Coatings bv in Hoogeveen is specialised in (protective) coatings, among which for rotor blades and towers of wind turbines (Agentschap NL, 2011a; Internet Source 33).

3.1.38 Hoekstra Suwâld Installatie

Hoekstra Suwâld Installatie bv in Suawoude is *inter alia* specialised in maintenance of wind turbines (Agentschap NL, 2011a; Internet Source 34).

3.1.39 Home Energy and other small urban wind turbine manufacturers

Home Energy bv in Schoondijke *inter alia* develops and manufactures small urban wind turbines (product name Energy Ball®) with capacities of 500 W and 2,250 W (Internet Source 35), In 2009, the number of urban wind turbines in the Netherlands was put at 300. The work force

of Home Energy and other companies producing urban wind turbines is approximately 30 FTE, and the aggregate turnover approximately € 2.8 mln, according to (NWEA, 2009).

3.1.40 KEMA

KEMA N.V. in Arnhem is an international company with competence in energy technology, which has *inter alia* technical and economic expertise in wind energy. Its wind-related workforce in the Netherlands is estimated at 15 people (Agentschap NL, 2011; Internet Source 36).

3.1.41 Koninklijke Nooteboom trailers

Koninklijke Nooteboom trailers bv in Wijchen, is a leading company with respect to transport of e.g. wind turbines (blades, towers, etc) (Agentschap NL, 2011a; Internet Source 37).

3.1.42 Koninklijke Wagenborg

Koninklijke Wagenborg bv in Delfzijl is a leading company with respect to international transport, among which shipping and services related to offshore wind farms (Agentschap NL, 2011a; Internet Source 38).

3.1.43 Lloyd's Register Energy Nederland

Lloyd's Register Energy Nederland bv in Rotterdam is engaged in certification, training, and consultancy with respect to e.g. operation and risk management of wind farms (Agentschap NL, 2011a; Internet Source 39).

3.1.44 LM Wind Power (R&D) Holland

LM Wind Power (Denmark) is the world's leading supplier of wind turbines blades, besides supplying wind turbine brakes. LM Wind Power (R&D) Holland bv in Heerhugowaard is one of its centres for design and manufacturing of wind turbine blades. It also has an office in Amsterdam. In 2010, LM Wind Power employed 5,826 people, and its revenue stood at € 727 million (Internet Source 40). The workforce in the Netherlands is tentatively estimated at 25 employees.

3.1.45 Mecal

MECAL, founded in 1989 and with offices in the Netherlands (Enschede), the USA and Japan, focuses on wind energy, semiconductor equipment, and 'vision and optronics' (Internet Source 41). In wind energy, MECAL provides services in turbine design, due diligence, inspections, and consultancy. It is a partner in the joint venture Advanced Tower Systems (ATS). Its wind-related workforce is estimated at 25 employees (out of a worldwide workforce of over 100).

3.1.46 Meeuwind

The investment company 'Seawind Capital Partners' of Meewind in Heemstede (Internet Source 42) participates in the offshore wind farms Belwind (Belgium). It has 2 employees.

3.1.47 Mott MacDonald

Mott MacDonald bv (Arnhem) is specialised in financial advisory services for renewable energy projects, e.g. Princess Amalia offshore wind farm (Agentschap NL, 2011a; Internet Source 43).

3.1.48 Nexans

Nexans Netherlands is specialised in electrical cables and systems for power transmission, that are applicable for on- and offshore wind projects (Agentschap NL, 2011a; Internet Source 44).

3.1.49 Ngup

Ngup in Almelo and Nijverdal is active in repair, inspection, maintenance, and manufacturing of wind turbine rotor blades (Internet Source 45). Its workforce in the Netherlands is tentatively estimated at 30 people.

3.1.50 NIBC Bank

NIBC Bank in The Hague is one of the main financial organisations in the Netherlands that is involved in financing of on- and offshore wind (Agentschap NL, 2011a; Internet Source 46).

3.1.51 Nieuwhof

Nieuwhof bv in Groningen is an engineering company which has *inter alia* provided services for the wind turbine manufacturer EWT (Agentschap NL, 2011a; Internet Source 47).

3.1.52 Nuon (Vattenfall)

Nuon (Vattenfall) owns seven wind farms in the Netherlands, of which six onshore with a total capacity of 92 MW, and one offshore wind farm with an equivalent capacity of 54 MW (50% of the total capacity of 108 MW) in the joint venture 'Noordzeewind' with Shell at Egmond aan Zee (Internet Source 48). The wind-related workforce including Noordzeewind C.V. and Nuon Wind Development B.V., formerly WEOM, is tentatively estimated at 40 people.

3.1.53 OutSmart

OutSmart bv in Velp, founded in 2006, is involved in engineering, contracting, construction and operation of on- and offshore wind (Agentschap NL, 2011a; Internet Source 49).

3.1.54 PMSS

PMSS Benelux in The Hague, a subsidiary of PMSS in the UK, provides assistance in developing renewable energy projects including onshore wind, offshore wind, wave and tidal energy and biomass (Internet Source 50).

3.1.55 Polymarin Composites

Polymarin Composites, founded in 2004 and with a production plant in the Eemshaven, has developed and produced fibre-reinforced composite structures. In 2008, the workforce stood at approximately 55 employees, but in July 2009 Polymarin became bankrupt (Internet Source 51).

3.1.56 Pondera Consult

Pondera Consult bv in Hengelo is specialised in feasibility studies and environmental impact statements for on- and offshore wind farms (Agentschap NL, 2011a; Internet Source 52).

3.1.57 Pontis Engineering

Pontis Engineering bv in Amsterdam is specialised in logistics of wind energy (road, rail, and ocean transport of rotor blades) and yachting (Agentschap NL, 2011a; Internet Source 53).

3.1.58 Prodeon

Prodeon bv in Zwolle is specialised in feasibility studies for e.g. onshore wind farms as well as biogas and tip gas plants in the Netherlands (Agentschap NL, 2011a; Internet Source 54).

3.1.59 Profin Sustainable Energy Solutions

Profin Sustainable Energy Solutions bv in Amersfoort is specialised in risk analysis and Due Diligence of e.g. offshore wind farms (Agentschap NL, 2011a; Internet Source 55).

3.1.60 Promorfo

Promorfo bv in Heerenveen manufactures composite plastic plugs, one-offs and moulds for industries like the yacht building, wind energy, etc (Agentschap NL, 2011a; Internet Source 56).

3.1.61 PS Legal

PS Legal in Nijmegen is engaged in advice on (renewable) energy law (Internet Source 57).

3.1.62 Quality in wind

Quality in wind bv in Emst is specialised in wind-engineering consultancy, technical inspection, and Due Diligence for on- and offshore wind (Agentschap NL, 2011a; Internet Source 58).

3.1.63 Rabobank Nederland

Rabobank in Utrecht is one of the financial institutions that is involved in financing of renewable energy projects, among which wind farms (Agentschap NL, 2011a; Internet Source 59).

3.1.64 Raedthuys Groep

Raedthuys Groep in Enschede is involved in the development of onshore wind and bio-energy projects. The expertise of Raedthuys is in planning, acquisition of permits and project development (Internet Source 60). Its workforce related to wind projects is estimated at 20 people.

3.1.65 Royal Haskoning

Royal Haskoning bv (Nijmegen, 3300 employees) is an international engineering and consultancy group which is experienced in environmental, technical, and financial feasibility studies for on- and offshore wind farms (Agentschap NL, 2011a; Interne Source 61).

3.1.66 Sarens Wind

Sarens Wind bv, a subsidiary of Sarens Nederland bv in Amsterdam, is specialised in construction and site management of onshore wind farms (Agentschap NL, 2011a; Internet Source 62).

3.1.67 Shell Windenergy

Shell (formerly Shell Windenergy bv) is involved in eight wind projects in North America and three in Europe, among which 50% of the joint venture 'Noordzeewind' with Nuon at Egmond aan Zee (54 MW out of 108 MW) (Agentschap NL, 2011a; Internet Source 63).

3.1.68 Siemens Netherlands

Siemens (Germany) is a global manufacturer of power plants, and also of wind turbines. It has core competence centres for wind turbine R&D in Copenhagen (Denmark), Aachen (Germany), Delft (Netherlands), Keele (United Kingdom), and Boulder, Colorado (USA). Siemens is market leader with respect to offshore wind (Internet Source 64). Siemens continues to invest in wind energy R&D to reduce investment risks and improve project economics. Its relevant workforce in the Netherlands is estimated at 75 employees.

3.1.69 Suzlon Blade Technology (SBT)

Suzlon Blade Technology (SBT) in Hengelo – formerly AE-Rotor Techniek – is experienced in composites technology. Since a few years, it is part of the globally operating SBT, a 100% subsidiary of Suzlon Energy Ltd of India. SBT has subsidiaries in Denmark and the Netherlands (Hengelo). Suzlon, which acquired REpower, is the sixth largest wind turbine manufacturer (2010). In 2009-2010, Suzlon shipped wind turbines with an aggregate capacity of 1,460 MW (Suzlon, 2010). The 500-strong Technology Group, led from its R&D headquarters in Hamburg, derives its technological success from a close collaboration between the development teams in Germany, Netherlands, Denmark and India, and key technological partners such as Hansen Transmission (Belgium). The design, R&D and the standard project aspects of the rotor blades are represented in Hengelo and The Hague in The Netherlands, Pune and Baroda in India, and Århus in Denmark. Its workforce in the Netherlands is approximately 70 FTE (Schuring, 2009).

3.1.70 Ter Linden

Ter Linden Transport & Craning bv in Doetinchem is a company specialised in the exceptional transport and craning of wind turbine rotor blades (Agentschap NL, 2011a; Internet Source 65).

3.1.71 The Wind Factory

The Wind Factory bv in Amsterdam/Suwâld is involved in relatively small onshore wind farms in the Netherlands and abroad (see Hoekstra Suwâld Installatie bv) (Internet Source 66).

3.1.72 TJA

TJA (Timmermans Juridisch Advies) bv in Baexem is specialised in environmental law, *inter alia* with respect to wind energy (Internet Source 67).

3.1.73 Triodosbank

Triodosbank in Zeist is one of the financial institutions that is involved in financing of renewable energy projects, among which wind farms (Agentschap NL, 2011a; Internet Source 68).

3.1.74 TSWE

TSWE (Ter Schuur Wind Energie) bv in Heerenveen is engaged in advice and project development with respect to wind energy (Internet Source 69).

3.1.75 TU Delft

For the TU Delft (Technical University of Delft), the two major research areas are rotor aerodynamics and wind turbine design (Agentschap NL, 2011a; Internet Source 70).

3.1.76 Twentse kabelfabriek

Twentse kabelfabriek bv in Haaksbergen is a technologically leading supplier of cable solutions, among which cables for on- and offshore wind (Agentschap NL, 2011a; Internet Source 71).

3.1.77 Vestas Benelux

Vestas Wind Systems A/S, Randers (Denmark) is the world market leader in wind energy. In 2010, it realised a turnover of € 6,920 million, with 4,057 MW of wind turbines shipped. The revenue from Europe and Africa amounted to € 4,162 million (60%), based on 3,111 MW (53%) installed. The workforce in Europe and Africa is 15,126, i.e. 65% of the global workforce (Vestas, 2011). Its subsidiary for the Benelux in Arnhem has approximately 200 employees (Vestas Benelux, 2010).

3.1.78 Wind Energy Solutions (WES)

Wind Energy Solutions bv (WES) in Opmeer is manufacturer of two-bladed, passive pitch, wind turbines of 80 kW and 250 kW, and also of a three-bladed 2.5 kW Tulipo (WES5) wind turbine (Internet Source 72). Its workforce is estimated at 8 people (in 2006, 6 people).

3.1.79 Windunie

Windunie is a joint venture of owners of wind turbines in North Holland. The electricity generated by wind farms owned by Windunie is traded in the Netherlands (Internet Source 73). The employment related to Windunie is deemed to be very small.

3.1.80 Witteveen + Bos

Witteveen + Bos in Deventer is an international engineering and consultancy firm – services in the water, infrastructure, spatial development, environment and construction sectors. It is *inter alia* involved in permitting for energy projects (Agentschap NL, 2011a; Internet Source 74).

3.1.81 WMC / EWTW

The Knowledge Centre WMC in Wieringerwerf is a research institute for materials, components and structures. The major activities are fundamental and applied research on Fibre Reinforced Plastics (FRP) and wind turbine structures (Internet Source 75). In close proximity to WMC, the wind turbine test site EWTW (ECN Wind Energy Facilities bv, subsidiary of ECN) facilitates the measurement and development programs of ECN by testing wind turbines of up to 6 MW. It generates income from operating a small wind farm at the same site to offset the costs of operation of the test site. EWTW is in negotiation with the municipality to increase the test facility and simultaneously increase the number of wind turbines in the commercial wind farm at the site (Internet Source 76). The number of employees of WMC and EWTW is estimated at 24.

3.1.82 Summary onshore wind

At the end of 2010, the onshore wind capacity in the Netherlands stood at 2,002 MW (1,993 MW in 2009) (CBS, 2011). The electricity generated by onshore wind farms was 3,728 GWh, or 13.4 PJ of final energy. Table 3.1 summarises the turnover and employment of companies

that are assumed to be primarily engaged in onshore wind in 2008-2010. The employment is estimated at approximately 1,440 employees in 2010 (approximately 1,360 in 2009), and the turnover at approximately € 780 million in 2010 (approximately € 740 million in 2009). These numbers refer to ‘onshore wind companies’ which is a somewhat arbitrary distinction. Reference is made of paragraph 3.3 on turnover and employment of on- and offshore wind.

Table 3.1 *Turnover and employees of companies related to onshore wind in the Netherlands*

Company	Turnover 2008 [€ mln]	Employees 2008	Turnover 2009 [€ mln]	Employees 2009	Turnover 2010 [€ mln]	Employees 2010
ABB	N/A	15	N/A	15	N/A	15
ABN AMRO	N/A	N/A	N/A	N/A	N/A	N/A
ABT	N/A	4	N/A	4	N/A	4
Acrress	N/A	-	N/A	1	N/A	1
Actiflow	-	-	N/A	5	N/A	5
Advanced Tower Systems (ATS)	-	55	N/A	64	N/A	73
Altenburg & Wyminga (A&W)	N/A	N/A	N/A	1	N/A	1
Arcadis	N/A	N/A	N/A	5	N/A	5
Ascent Safety	N/A	1	N/A	1	N/A	1
ASN Bank	N/A	5	N/A	5	N/A	5
Atlas Magnetics Europe	N/A	8	N/A	9	N/A	10
ATO	N/A	N/A	N/A	N/A	N/A	N/A
Bettink Service en Onderhoud	N/A	N/A	N/A	25	N/A	25
BLIX Consultancy	N/A	4	N/A	5	N/A	5
Bosch & van Rijn	N/A	1	N/A	1	N/A	1
Bosch Rexroth	N/A	N/A	N/A	N/A	N/A	N/A
Bureau Waardenburg	N/A	N/A	N/A	5	N/A	5
Cofely GdF Suez	N/A	N/A	N/A	N/A	N/A	N/A
Composite Technology Centre (CTC)	N/A	15	N/A	15	N/A	15
Croon Electrotechniek	N/A	75	N/A	80	N/A	85
DELTA	N/A	15	N/A	15	N/A	15
ECN Wind Energy	N/A	40	N/A	45	N/A	50
E-Connection Project	-	5	N/A	5	N/A	5
Edelweiss Finance Advisors	N/A	1	N/A	1	N/A	1
EEE-Team	N/A	1	N/A	1	N/A	1
Eneco (Ecofys and Evelop)	N/A	90	N/A	100	N/A	110
Enercon Benelux	N/A	40	N/A	45	N/A	50
E.On Benelux	N/A	N/A	N/A	N/A	N/A	N/A
Essent (RWE)	N/A	25	N/A	25	N/A	25
EWT	~70	90	N/A	90	N/A	90
GA-Finance	N/A	2	N/A	2	N/A	2
GL Garrad Hassan Netherlands	N/A	N/A	N/A	8	N/A	8
Global Blade Technology	-	-	N/A	15	N/A	25
Global Wind Power (Lagerwey)	N/A	7	N/A	8	N/A	8
Green Giraffe	N/A	N/A	N/A	4	N/A	5
Grontmij	N/A	N/A	N/A	3	N/A	3
Hodij Coatings	N/A	N/A	N/A	N/A	N/A	N/A
Hoekstra Suwâld Installatie	N/A	4	N/A	5	N/A	5
HomeEnergy & other urban WT Co's	2.8	30	N/A	30	N/A	30
KEMA	N/A	N/A	N/A	15	N/A	15
Koninklijke Nooteboom trailers	N/A	N/A	N/A	N/A	N/A	N/A
Koninklijke Wagenborg	N/A	N/A	N/A	N/A	N/A	N/A
Lloyd's Register Energy Nederland	N/A	N/A	N/A	N/A	N/A	N/A
LM Wind Power (R&D) Holland	N/A	25	N/A	25	N/A	25
Mecal	N/A	25	N/A	25	N/A	25
Meewind	N/A	N/A	N/A	2	N/A	2
Mott MacDonald	N/A	N/A	N/A	N/A	N/A	N/A
Nexans	N/A	N/A	N/A	N/A	N/A	N/A

Company	Turnover 2008 [€ mln]	Employees 2008	Turnover 2009 [€ mln]	Employees 2009	Turnover 2010 [€ mln]	Employees 2010
Ngup	N/A	20	N/A	30	N/A	30
NIBC Bank	N/A	N/A	N/A	N/A	N/A	N/A
Nieuwhof	N/A	N/A	N/A	N/A	N/A	N/A
Nuon (Vattenfall)	N/A	35	N/A	40	N/A	40
OutSmart	N/A	N/A	N/A	N/A	N/A	N/A
PMSS	N/A	1	N/A	1	N/A	1
Polymarin Composites	N/A	55	-	-	-	-
Pondera Consult	N/A	4	N/A	4	N/A	4
Pontis Engineering	N/A	N/A	N/A	N/A	N/A	N/A
PS Legal	N/A	3	N/A	3	N/A	3
Prodeon	N/A	3	N/A	3	N/A	3
Profin Sustainable Energy Solutions	N/A	N/A	N/A	N/A	N/A	N/A
Promorfo	N/A	N/A	N/A	N/A	N/A	N/A
Quality in wind	N/A	N/A	N/A	N/A	N/A	N/A
Rabobank Nederland	N/A	N/A	N/A	N/A	N/A	N/A
Raedthuys Groep	N/A	20	N/A	20	N/A	20
Royal Haskoning	N/A	N/A	N/A	N/A	N/A	N/A
Sarens Wind	N/A	5	N/A	5	N/A	5
Shell Windenergy	N/A	N/A	N/A	N/A	-	-
Siemens Netherlands	N/A	75	N/A	75	N/A	75
Suzlon Blade Technology (SBT)	N/A	70	N/A	70	N/A	70
Ter Linden	N/A	N/A	N/A	N/A	N/A	N/A
The Wind Factory		N/A	N/A	N/A	N/A	N/A
TJA	N/A	1	N/A	1	N/A	1
Triodosbank	N/A	N/A	N/A	N/A	N/A	N/A
TSWE	N/A	1	N/A	1	N/A	1
TU Delft	N/A	N/A	N/A	N/A	N/A	N/A
Twentse kabelfabriek	N/A	N/A	N/A	N/A	N/A	N/A
Vestas Benelux	N/A	150	N/A	200	N/A	200
Wind Energy Solutions (WES)	1.5	8	N/A	8	N/A	8
Windunie	-	-	-	-	-	-
Witteveen + Bos	N/A	N/A	N/A	N/A	N/A	N/A
WMC / EWTW	N/A	22	N/A	24	N/A	24
Total onshore wind companies	~ 710	1,300	~ 740	1,360	~ 780	1,440

Note: Some wind turbine companies also produce other components or services, which have been excluded.
Sources: Agentschap NL, 2011a; REW, 2009; Ter Laak, 2007; DELTA, 2011; Eneco, 2011; NWEA, 2009; Suzlon, 2010; Schuring, 2009; Vestas, 2011; Internet Sources 1-76.

3.2 Offshore wind

3.2.1 Alstom Power Netherlands

Alstom Power Nederland bv in Barendrecht is a subsidiary of Alstom (France), which has over 30 years of experience in development, planning and construction and maintenance of wind turbines, with a 6-MW turbine in the design stage (Agentschap NL, 2011a; Internet Source 77).

3.2.2 Ampelmann

The Ampelmann company in Delft (a spin-off from Delft University of Technology) focuses on the development, construction, lease and sale of offshore access solutions. The Ampelmann is a ship-based self-stabilizing platform that actively compensates all vessel motions to make off-

shore access safe, easy and fast. The system has proven itself successfully in the offshore wind industry (Internet Source 78). Its wind-related workforce is estimated at 5 people.

3.2.3 Amsterdam IJmuiden Offshore Port

Amsterdam IJmuiden Offshore Port is the Alliance of Port & Offshore related industries and regional authorities in the Amsterdam-IJmuiden Seaports area (Agentschap NL, 2011a).

3.2.4 Atlantic Marine Services (AMS)

Atlantic Marine Services bv in Ouderkerk aan de Amstel, a subsidiary of Atlantic Marine Services Ltd (AMS), is specialised in logistic marine services for the marine, oil, gas and petrochemical industries (Agentschap NL, 2011a; Internet Source 79).

3.2.5 Ballast Nedam

Ballast Nedam NV in Nieuwegein offers a wide range of products and services related to construction of houses, buildings, and infrastructure. With activities in building, infrastructure, and engineering, it employs 3,870 people and has a turnover of € 1.36 billion. It is *inter alia* engaged in design and construction of offshore wind farms. Ballast Nedam has performed design and/or installation activities for the offshore wind farms 'Noordzeewind' (Netherlands), Baltic 1 (Germany), the second stage of Belwind (Belgium), and Gunfleet Sands and Rhylflats (UK) (Ballast Nedam, 2011; Internet Source 80). Its wind-related workforce is estimated at 40 people.

3.2.6 Bard Group

The BARD Group with its subsidiary BARD Engineering GmbH (Bremen) engineers, procures, constructs, and operates offshore wind farms on a turn-key basis. Typhoon capital (Amsterdam) and HVC, the Alkmaar-based company active in power generation based on municipal solid waste, acquired from the BARD Group the 600-MW wind farm that will be constructed in the North Sea, 55 km North East of Schiermonnikoog (Agentschap NL, 2011a; Internet Source 81).

3.2.7 2-B Energy

2-B Energy was founded in 2007 and is active in the field of offshore wind energy. The company is currently developing a new concept for offshore wind power plants together with a network of partners in the industry. The 2-B concept includes differentiating designs for the rotor, nacelle, support structure and electrical system. This holistic approach, covering the full life cycle of all components, is claimed to result in significant cost savings compared to current technologies (Internet Source 82). The number of employees is estimated at 10.

3.2.8 Blue H Technologies

Blue H Technologies bv in Oosterhout focused on the development of a floating structure for offshore wind turbines (Internet Source 83). Blue H USA is furthering the so-called Submerged Deepwater Platform (SDP), developed by Blue H Technologies, primarily for the US market (Internet Source 84). Since 2009, no wind-related workforce is assumed for the Netherlands.

3.2.9 Bluestream Offshore

Bluestream Offshore bv in Den Helder owns and operates a fleet of ROV's (Remotely Operated underwater Vehicle) for oil and gas, renewables, and onshore. It is *inter alia* involved in the Greater Gabbard offshore wind farm in the UK (Agentschap NL, 2011a; Internet Source 85).

3.2.10 BMO Offshore

BMO Offshore in Rotterdam is a dedicated partner for ECN, Workships Contractors b.v and the company Ulstein Sea of Solutions with respect to data in offshore wind power. BMO Offshore applies re-deployable foundation types supporting state-of-art meteorological mast designs. The turnover and workforce of this start-up company are as yet unknown (Internet Source 86).

3.2.11 BMT ARGOSS

BMT ARGOSS (subsidiary of BMT Group Ltd) in Marknesse is leading in the field of marine environmental information. BMT Group is an international multi-disciplinary engineering, science and technology consultancy, with a staff of 1,300, offering a broad range of services, particularly in the defence, energy, environment, shipping and ports and logistics sectors. (Internet Sources 87-88). The wind-related workforce of BMT ARGOSS is estimated at 10 people.

3.2.12 Breakbulk & Offshore Wind Terminal (BOW)

Breakbulk & Offshore Wind Terminal (BOW) terminal in Vlissingen focuses on offshore (wind) industry, breakbulk handling, heavy lift cargoes, and the non-ferrous metals market (Agentschap NL, 2011a; Internet Source 89).

3.2.13 Corrosion & Water Control

Corrosion & Water Control bv in Moerkapelle, with subsidiaries in China and Vietman is *inter alia* engaged in ICCP protection (Impressed Current Cathodic Protection) of offshore wind farms (for the Greater Gabbard wind farm in the UK) (Agentschap NL, 2011a; Internet Source 90).

3.2.14 Damen

Damen Shipyards Group in Gorinchem, with 5600 employees of which 2300 in the Netherlands, is *inter alia* involved in construction and maintenance of special ships for offshore wind farms (Agentschap NL, 2011a; Internet Source 91).

3.2.15 Deep Hydrography & Geophysics

Deep Hydrography & Geophysics in Amsterdam is specialised in offshore hydrographic survey and geophysics, e.g. with respect to the seabed (Agentschap NL, 2011a; Internet Source 92).

3.2.16 Deltares

Research institute and specialist consultancy Deltares (Delft) is *inter alia* engaged in offshore wind from the perspective of interaction between waves, currents and wind. It is also involved in the Kaderrichtlijn Mariene Strategie (KRM) (Directive on Marine Strategy) (Agentschap NL, 2011a; Internet Source 93).

3.2.17 DHTC

DHTC bv in Den Helder is specialised in safety training, e.g. for peopled employed in maintenance and installation of offshore wind farms (Offshore Wind Energy Basic Safety) (Agentschap NL, 2011a; Internet Source 94).

3.2.18 Dutch Offshore Innovators

Dutch Offshore Innovators bv in Rotterdam is a naval architects studio specializing in innovative solutions for the offshore installation industry (e.g. offshore wind) (Internet Source 95).

3.2.19 Dynamar

Dynamar bv in Alkmaar is specialised in credit and marketing reports in the maritime sector (Internet Source 96). Its wind-related workforce is estimated at 2 people.

3.2.20 Energy Solutions (Ensol)

Energy Solutions (Ensol) in Delft is a high-voltage engineering and consultancy company. It has *inter alia* been involved in engineering and design of the electrical cable system for the Princess Amalia (formerly Q7) offshore wind farm (Agentschap NL, 2011a; Internet Source 97).

3.2.21 ENERPAC

ENERPAC, with its subsidiary ENERPAC bv in Ede, produces *inter alia* bolting solutions for joint assembly, controlled tightening and separation, which may be applied to offshore wind turbines (Agentschap NL, 2011a; Internet Source 98).

3.2.22 2EQ

2EQ bv provides technical and managerial consultancy services for the offshore wind industry (Internet Source 99).

3.2.23 Fugro

Fugro is an international engineering company, with activities in three divisions, geotechnical, survey, and geoscience. By the end of 2009, Fugro employed some 13,500 staff in more than 50 countries. Fugro offers *inter alia* services related to sustainable energy, among which on- and offshore wind. The latter activities are localised in the UK (Internet Source 100). An estimated 15 employees are engaged in services for on- and offshore wind in the Netherlands.

3.2.24 Geo Plus

Geo Plus bv in Scheemda is specialised in surveying and hydrography. Recently, it ordered a hybrid survey / ROV (Remotely Operated underwater Vehicle) support vessel for offshore activities which is due for 2012 (Agentschap NL, 2011a; Internet Source 101).

3.2.25 Groningen Seaports

Groningen Seaports supports economic activities in the ports, industrial complexes, and other logistic centres under its management or control (Agentschap NL, 2011a; Internet Source 102).

3.2.26 GustoMSC

GustoMSC is an alliance of experienced specialists offering a range of design, engineering, construction, and installation services to offshore markets, including offshore wind (Internet Source 103). GustoMSC was *inter alia* involved in the construction of the offshore wind farm Kentish Flats in the UK. Its wind-related workforce is estimated at 30 people.

3.2.27 Heerema Group

The Heerema Group (with offices in the Netherlands, Luxembourg and Switzerland) designs, fabricates, transports, installs, and removes facilities for the exploitation of oil and gas at sea. The company has experience in offshore wind substructures, substations (topsides and substructures), etc (Internet Source 104). Its wind-related workforce is estimated at 30 people.

3.2.28 HSM Offshore

HSM Offshore and HSM Steel Structures in Schiedam are subsidiaries of the Andus Group. HSM Offshore is specialised in production, compression and wellhead platforms, jackets and other types of substructures, mooring buoys and transformer stations. Some offshore constructions may be used for offshore wind farms (Agentschap NL, 2011a; Internet Source 105).

3.2.29 Huisman Equipment

Huisman Equipment bv in Schiedam, active in Brazil, China, Czech Republic, Singapore, and the USA, is specialised in the design and manufacturing of heavy construction equipment for onshore and offshore companies (Agentschap NL, 2011a; Internet Source 106).

3.2.30 Hytorc Nederland

Hytorc Nederland bv in Beuningen is specialised in industrial bolted connections, inter alia for Ballast Nedam (Agentschap NL, 2011a; Internet Source 107).

3.2.31 IHC Merwede

IHC Merwede in Sliedrecht is *inter alia* engaged in services and expertise for the construction, operation and maintenance of offshore wind farms. Recently, W3G Marine (W3GM) and IHC Merwede have agreed to collaborate on the development of W3GM's patented design for an offshore wind turbine installation ship (OWTIS) (Agentschap NL, 2011a; Internet Source 108).

3.2.32 Imares Wageningen UR

Imares Wageningen UR in Wageningen is *inter alia* engaged in ecological research related to marine living resource management (Agentschap NL, 2011a; Internet Source 109).

3.2.33 IMT

IMT bv in Culemborg is specialised in lighting systems which are inter alia applied to offshore wind farms (Internet Source 110).

3.2.34 Jack-Up Barge

Jack-up barge bv in Sliedrecht provides services based on self-elevating platforms, pontoons and crane barges, e.g. for offshore wind farms (Agentschap NL, 2011a; Internet Source 111).

3.2.35 Jumbo Offshore

Jumbo Offshore and Jumbo Shipping, subsidiaries of Jumbo bv in Rotterdam, are specialised in services related to e.g. offshore wind. Jumbo Offshore has been awarded by MT Højgaard the transport and installation contract for the 111 Transition Pieces (TP's) for the 400-MW Anholt Offshore Wind Farm in Denmark (Agentschap NL, 2011a; Internet Source 112).

3.2.36 KCI

KCI (Korndörffer Contracting International) bv in Schiedam is specialised in oil and gas extraction concepts. It is also engaged in design and construction of renewable energy concepts, e.g. installation of cables for offshore wind farms (Agentschap NL, 2011a; Internet Source 113).

3.2.37 Keppel Verolme

Keppel Verolme bv in Rotterdam is a leading shipyard which is specialised in offshore and marine services (Agentschap NL, 2011a; Internet Source 114).

3.2.38 KOCH Consultancy Group

KOCH Consultancy Group in Goes and Terneuzen builds on specialists like consulting engineers and architects. Koch Consultancy Group is *inter alia* engaged in research, engineering, and implementation of onshore wind farms (Agentschap NL, 2011a; Internet Source 115).

3.2.39 Mammoet Europe

Mammoet Europe bv in Schiedam is an international company active in integrated heavy lifting and transportation services (Agentschap NL, 2011a; Internet Source 116).

3.2.40 MARIN

MARIN (Maritime Research Institute Netherlands) has expertise in the field of wave impacts against ships and offshore structures, which is of interest for offshore wind farms (Agentschap NL, 2011a; Internet Source 117).

3.2.41 Marine Construct International

Marine Construct International bv in Zevenaar is a marine equipment supplier company, providing marine equipment and related contracting services to the marine civil market, offshore oil & gas, marine salvage, and offshore renewables (Agentschap NL, 2011a; Internet Source 118).

3.2.42 Mercon Steel Structures

Mercon Steel Structures, a subsidiary of Mercon Holding bv in Gorinchem, is a company serving the offshore oil & gas and offshore wind industry. Onshore the focus is on the petrochemical and infrastructural sector. Currently, projects range from topsides and substructures to storage tanks and steel bridges (Agentschap NL, 2011a; Internet Source 119).

3.2.43 Meteo Consult

Meteo Consult bv in Wageningen, a subsidiary of MeteoGroup in the UK, provides weather-related data for offshore wind projects (Agentschap NL, 2011a; Internet Source 120).

3.2.44 MeteoVista

MeteoVista bv in Zeist, formerly ‘WeerOnLine’, provides – just like Meteo Consult – weather-related data for offshore wind projects (Agentschap NL, 2011a; Internet Source 121).

3.2.45 Ned Marine Services

Ned Marine Services bv in Ridderkerk provides *inter alia* ultrasonic thickness measurements for ships and for substructures of offshore wind (Agentschap NL, 2011a; Internet Source 122).

3.2.46 N-Sea

N-Sea bv (formerly Noordhoek Survey) in Zierikzee is an offshore contractor specialised in a range of activities involving diving, ROV (Remotely Operated underwater Vehicle), subsea repair, and survey operations related to *inter alia* the offshore wind industry (Internet Source 123).

3.2.47 Oceanteam Shipping

Oceanteam Shipping bv with a registered office in Amsterdam provides a number of services like service ships for the installation of cables and engineering of offshore installations related to offshore wind (Agentschap NL, 2011a; Internet Source 124).

3.2.48 Offshore Solutions

Offshore Solutions bv in IJmuiden is inter alia specialised in marine access systems and related services to be used for offshore wind farms (Agentschap NL, 2011a; Internet Source 125).

3.2.49 Port of Den Helder

The port of Den Helder is a key link in the logistic chain for the offshore oil and gas industry, as well as for activities related to offshore wind (Agentschap NL, 2011a; Internet Source 126).

3.2.50 PriceWaterhouseCoopers

PriceWaterhouseCoopers bv with a registered office in Amsterdam provides consultancy services for renewable energy projects like on- and offshore wind farms (Agentschap NL, 2011a; Internet Source 127).

3.2.51 Primo Marine

Primo Marine bv is in Rotterdam an independent, globally operating consultancy, engineering and project management house, which offers services such as environmental impact statements for offshore wind farms (Agentschap NL, 2011a; Internet Source 128).

3.2.52 Ravestein

Ravestein bv, Shipyard and Construction Company, in Deest builds dedicated jack-up vessels for the offshore wind industry (Agentschap NL, 2011a; Internet Source 129).

3.2.53 Seafox Contractors

Seafox Contractors bv with a registered office in Hoofddorp (owns and) operates jack-up vessels that may be used for offshore wind farms (Agentschap NL, 2011a; Internet Source 130).

3.2.54 7Seas Project Services

7Seas Project Services bv in Houten is specialised in project and operational crew for Jack-up rigs in the oilfield and wind turbine industry (Internet Source 131).

3.2.55 Seaway Heavy Lifting

Seaway Heavy Lifting bv in Zoetermeer provides *inter alia* services such as installation of platforms and substructures of offshore wind farms (Agentschap NL, 2011a; Internet Source 132).

3.2.56 SeaZip Offshore Service

SeaZip Offshore Service bv in Harlingen provides service vessels and ship management for safe access to *inter alia* offshore wind farms (Agentschap NL, 2011a; Internet Source 133).

3.2.57 SIF Group

SIF Group bv in Roermond is specialised in the manufacture of tubular structures, such as offshore wind farms (Internet Source 135). An estimated 30 out of its 150 employees are assumed to be engaged in manufacturing of monopoles (diameter up to 4 m) for offshore wind farms.

3.2.58 Smit Transport & Heavy Lift

Smit Transport & Heavy Lift bv in Rotterdam provides several services *inter alia* for installation of offshore wind turbines (Agentschap NL, 2011a; Internet Source 136).

3.2.59 Smulder wind turbine constructions

Smulders wind turbine constructions is a subsidiary of Smulder Group bv in Helmond. 'Wind turbine constructions' is engaged in the production of steel towers for onshore wind turbines and monopoles for offshore wind farms in the Netherlands and Denmark (Internet Source 136). The relevant workforce in the Netherlands is estimated at 50 employees.

3.2.60 SPT Offshore

SPT Offshore bv in Woerden is an independent offshore contractor specialised in *inter alia* suction pile foundations for offshore wind farms (Agentschap NL, 2011a; Internet Source 137).

3.2.61 SSE Renewables & Dong Energy

SSE plc (formerly Scottish and Southern Energy) has entered into an agreement with Dong Energy (Denmark) to develop offshore wind farms in the Netherlands (Agentschap NL, 2011a; Internet Source 138). Dong Energy has a subsidiary in the Netherlands in 's-Hertogenbosch.

3.2.62 Synergy Marine

Synergy Marine bv in Haarlem provides *inter alia* complete setup and organisation of offshore project operations related to offshore wind farms (Agentschap NL, 2011a; Internet Source 139).

3.2.63 TenneT

TenneT Holding bv in Arnhem is the transmission system operator (TSO) for the high-voltage grid in the Netherlands and a part of Germany. TenneT is engaged in connection of offshore wind farms in the Netherlands and Germany (Agentschap NL, 2011a; Internet Source 140).

3.2.64 Tideway

Tideway bv in Breda is *inter alia* specialised in offshore ballasting and landfall works related to offshore wind farms (Agentschap NL, 2011a; Internet Source 140).

3.2.65 TNO Underwater Technology

TNO Underwater Technology in Delft has *inter alia* expertise with respect to pile-driving noise in case of monopiles for offshore wind farms (Agentschap NL, 2011a; Internet Source 142).

3.2.66 Trelleborg

Trelleborg Ridderkerk bv, a subsidiary the Trelleborg Group, *inter alia* supplies grout seals and grout hoses for transition pieces applied to offshore wind monopoles (Internet Source 143).

3.2.67 Typhoon capital

Typhoon capital is a privately owned independent investment company in Amsterdam focused on investing in renewable technology and energy infrastructure, i.e. on- and offshore wind, solar PV, and Concentrating Solar Power (CSP). In 2011, it acquired a 15% share (recently raised to 85%) in two offshore wind farms of 300 MW each to be built by Bard on the Dutch continental shelf. It is assumed that 10 employees are engaged in wind energy (Internet Source 144-145).

3.2.68 Ulstein Sea of Solutions

Ulstein Sea of Solutions in Vlaardingen (subsidiary of Ulstein Group) is specialised in designing complex offshore construction vessels (Internet Source 146). Recently, Ulstein developed a wind turbine installation vessel called the Windlifter, The workforce of the Ulstein Group is approximately 700-800 people of which an estimated 10 people are engaged in wind-related work.

3.2.69 Van Oord

Van Oord Groep in Rotterdam is a marine contractor, active in dredging, offshore, and marine engineering projects, with a workforce of more than 4,000 people (Internet Source 147). Initially, Van Oord focused on construction activities such as export and inter-array cable installation. Later on, Van Oord expanded into foundation and topside installation and transport. In 2009, Van Oord signed a contract for the engineering, procurement, and construction of the first stage of the Belwind offshore wind farm. Its wind-related workforce is estimated at 30 people.

3.2.70 Verbrugge Terminals

Verbrugge Terminals in the ports of Vlissingen (Flushing) and Terneuzen, is specialised in logistic services for the offshore wind sector (Agentschap NL, 2011a; Internet Source 148).

3.2.71 Visser & Smit Marine Contracting

Visser & Smit Marine Contracting (VSMC), a subsidiary of Koninklijke Volker Wessels Stevin NV, is specialised in installation of cables for offshore wind farms. In 2011, it secured several contracts for cables for offshore wind farms with an aggregate value of €400 million (Internet Source 149). Its wind-related workforce is estimated at 40 people.

3.2.72 Vroon Offshore Services

Vroon Offshore Services in Breskens is *inter alia* specialised in offshore support vessels for offshore wind farms (Agentschap NL, 2011a; Internet Source 150).

3.2.73 Vryhof Anchors

Vryhof Anchors bv in Capelle a/d IJssel is *inter alia* specialised in engineering and construction of mooring systems to be used for offshore wind (Agentschap NL, 2011a; Internet Source 151).

3.2.74 Vuyk Engineering

Vuyk Engineering Rotterdam bv provides *inter alia* services such as consultancy with respect to installation of offshore wind turbines (Agentschap NL, 2011a; Internet Source 152).

3.2.75 Wals Diving & Marine Service

Wals Diving & Marine Service in IJmuiden is specialised in diving and wet welding related to offshore wind farms (Agentschap NL, 2011a; Internet Source 153).

3.2.76 WindCat Workboats

WindCat Workboats bv in Ijmuiden is specialised in crew transfer vessels for the offshore wind industry (Agentschap NL, 2011a; Internet Source 154).

3.2.77 Windpowercentre

Windpowercentre bv in Harlingen has a dedicated workshop facilitating the (offshore) wind power industry (Agentschap NL, 2011a; Internet Source 155).

3.2.78 XEMC Darwind

XEMC Darwind in Hilversum, established in 2005, was acquired by XEMC Windpower Co., Ltd, in Xiangtan, China, in 2009. It develops a 5-MW wind turbine based on its Direct Drive Permanent Magnet Generator technology for offshore application. Its workforce was 45 people in 2008 and is estimated at 72 people in 2010 (Internet Source 156; De Ingenieur, 2008).

3.2.79 XEMC VWEC

XEMC VWEC (formerly STX Windpower/Harakosan Europe) is a subsidiary of XEMC Windpower Co. (China). It produces large wind turbines of 2.5 MW (originally the 2-MW Zephyros wind turbine), designed for near-shore and offshore applications. The headquarter of Wind Turbine Service is Dronten, the Netherlands. The XV90 wind turbine will be deployed at three sites in Ireland (Internet Source 157-158). Its workforce is estimated at 20 employees.

3.2.80 Zeehaven IJmuiden

Zeehaven IJmuiden N.V. (port of IJmuiden) is a link in the logistic chain for the offshore industry, among which the offshore wind industry (Agentschap NL, 2011a; Internet Source 159).

3.2.81 Zeeland Seaports

Zeeland Seaports N.V. in Terneuzen operates the two sea ports of Vlissingen (Flushing) and Terneuzen and provides services to the offshore wind industry (Agentschap NL, 2011a; Internet Source 160).

3.2.82 Z Technologies

Z Technologies bv in IJmuiden provides safe and cost effective solutions for the offshore industries, among which the offshore wind industry (Agentschap NL, 2011a; Internet Source 161).

3.2.83 Summary offshore wind

At the end of 2010, the offshore wind capacity in the Netherlands stood at 228 MW (CBS, 2011). The electricity generated by the two offshore wind farms was 766 GWh, or 2.75 PJ of final energy. Table 3.2summarises the turnover and employment of companies that are assumed to be primarily engaged in offshore wind in 2008-2010. The employment is estimated at approximately 990 employees in 2010 (approximately 860 in 2009), and the turnover at approximately € 550 million in 2010 (approximately € 480 million in 2009). These numbers refer to 'offshore wind companies' which is a somewhat arbitrary distinction. Reference is made of paragraph 3.3 on turnover and employment of on- and offshore wind.

Table 3.2 *Turnover and employees of companies related to offshore wind in the Netherlands*

Company	Turnover 2008 [€ mln]	Employees 2008	Turnover 2009 [€ mln]	Employees 2009	Turnover 2010 [€ mln]	Employees 2010
Alstom Power Netherlands	N/A	N/A	N/A	N/A	N/A	N/A
Ampelmann	-	-	N/A	5	N/A	5
Amsterdam IJmuiden Offshore Port	N/A	N/A	N/A	N/A	N/A	N/A
Atlantic Marine Services (AMS)	N/A	N/A	N/A	N/A	N/A	N/A
Ballast Nedam	N/A	N/A	N/A	25	N/A	40
Bard Group	-	-	-	-	N/A	N/A
2-B Energy	-	-	N/A	10	N/A	10
Blue H Technologies	N/A	~10	-	-	-	-
Bluestream Offshore	N/A	N/A	N/A	N/A	N/A	N/A
BMO Offshore	N/A	N/A	N/A	N/A	N/A	N/A
BMT ARGOSS	N/A	N/A	N/A	10	N/A	10
Breakbulk & Offshore Wind Terminal (BOW)	N/A	N/A	N/A	N/A	N/A	N/A
Corrosion & Water Control	N/A	N/A	N/A	N/A	N/A	N/A
Damen	N/A	N/A	N/A	N/A	N/A	N/A
Deep Hydrography & Geophysics	N/A	N/A	N/A	N/A	N/A	N/A
Deltares	N/A	N/A	N/A	N/A	N/A	N/A
DHTC	N/A	N/A	N/A	N/A	N/A	N/A
Dutch Offshore Innovators	N/A	N/A	N/A	N/A	N/A	N/A
Dynamar	N/A	N/A	N/A	2	N/A	2
Energy Solutions (EnSol)	N/A	N/A	N/A	N/A	N/A	N/A
ENERPAC	N/A	N/A	N/A	N/A	N/A	N/A
2EQ	N/A	N/A	N/A	N/A	N/A	N/A
Fugro	N/A	N/A	N/A	15	N/A	15
Geo Plus	N/A	N/A	N/A	N/A	N/A	N/A
Groningen Seaports	N/A	N/A	N/A	N/A	N/A	N/A
GustoMSC	N/A	N/A	N/A	30	N/A	30
Heerema Group	N/A	N/A	N/A	30	N/A	30
HSM Offshore	N/A	N/A	N/A	N/A	N/A	N/A
Huisman Equipment	N/A	N/A	N/A	N/A	N/A	N/A
Hytorc Nederland	N/A	N/A	N/A	N/A	N/A	N/A
IHC Merwede	N/A	N/A	N/A	N/A	N/A	N/A
Imares Wageningen UR	N/A	N/A	N/A	N/A	N/A	N/A
IMT	N/A	N/A	N/A	N/A	N/A	N/A
Jack-Up Barge	N/A	N/A	N/A	N/A	N/A	N/A
Jumbo Offshore	N/A	N/A	N/A	N/A	N/A	N/A
KCI	N/A	N/A	N/A	N/A	N/A	N/A
Keppel Verolme	N/A	N/A	N/A	N/A	N/A	N/A
KOCH Consultancy Group	N/A	N/A	N/A	N/A	N/A	N/A
Mammoet Europe	N/A	N/A	N/A	N/A	N/A	N/A
MARIN	N/A	N/A	N/A	N/A	N/A	N/A
Marine Construct International	N/A	N/A	N/A	N/A	N/A	N/A
Mercon Steel Structures	N/A	N/A	N/A	N/A	N/A	N/A
Meteo Consult	N/A	N/A	N/A	N/A	N/A	N/A
MeteoVista	N/A	N/A	N/A	N/A	N/A	N/A
Ned Marine Services	N/A	N/A	N/A	N/A	N/A	N/A
N-Sea	N/A	N/A	N/A	N/A	N/A	N/A
Oceanteam Shipping	N/A	N/A	N/A	N/A	N/A	N/A
Offshore Solutions	N/A	N/A	N/A	N/A	N/A	N/A
Port of Den Helder	N/A	N/A	N/A	N/A	N/A	N/A
PriceWaterhouseCoopers	N/A	N/A	N/A	N/A	N/A	N/A

Company	Turnover 2008 [€ mln]	Employees 2008	Turnover 2009 [€ mln]	Employees 2009	Turnover 2010 [€ mln]	Employees 2010
Primo Marine	N/A	N/A	N/A	N/A	N/A	N/A
Ravestein	N/A	N/A	N/A	N/A	N/A	N/A
Seafox Contractors	N/A	N/A	N/A	N/A	N/A	N/A
7Seas Project Services	N/A	N/A	N/A	N/A	N/A	N/A
Seaway Heavy Lifting	N/A	N/A	N/A	N/A	N/A	N/A
SeaZip Offshore Service	N/A	N/A	N/A	N/A	N/A	N/A
SIF Group	N/A	N/A	N/A	30	N/A	30
Smit Transport & Heavy Lift	N/A	N/A	N/A	N/A	N/A	N/A
Smulders wind turbine construct.	N/A	50	N/A	50	N/A	50
SPT Offshore	N/A	N/A	N/A	N/A	N/A	N/A
SSE Renewables & Dong Energy	N/A	N/A	N/A	N/A	N/A	N/A
Synergy Marine	N/A	N/A	N/A	N/A	N/A	N/A
TenneT	N/A	N/A	N/A	N/A	N/A	N/A
Tideway	N/A	N/A	N/A	N/A	N/A	N/A
TNO Underwater Technology	N/A	N/A	N/A	N/A	N/A	N/A
Trelleborg	N/A	N/A	N/A	N/A	N/A	N/A
Typhoon capital	N/A	N/A	N/A	7	N/A	10
Ulstein Sea of Solutions	N/A	N/A	N/A	10	N/A	10
Van Oord	N/A	N/A	N/A	30	N/A	30
Verbrugge Terminals	N/A	N/A	N/A	N/A	N/A	N/A
Visser & Smit Marine Contracting	N/A	N/A	N/A	25	N/A	40
Vroon Offshore Services	N/A	N/A	N/A	N/A	N/A	N/A
Vryhof Achors	N/A	N/A	N/A	N/A	N/A	N/A
Vuyk Engineering	N/A	N/A	N/A	N/A	N/A	N/A
Wals Diving & Marine Services	N/A	N/A	N/A	N/A	N/A	N/A
WindCat Workboats	N/A	N/A	N/A	N/A	N/A	N/A
Windpowercentre	N/A	N/A	N/A	N/A	N/A	N/A
XEMC DarwinD	N/A	45	N/A	72	N/A	72
XEMC VWEC	N/A	20	N/A	20	N/A	20
Zeehaven IJmuiden	N/A	N/A	N/A	N/A	N/A	N/A
Zeeland Seaports	N/A	N/A	N/A	N/A	N/A	N/A
Z Technologies	N/A	N/A	N/A	N/A	N/A	N/A
Total offshore wind companies	~ 390	~ 690	~ 480	~ 860	~ 550	~ 990

Note: Some wind turbine companies also produce other components or services, which have been excluded.
Sources: Agentschap NL, 2011a; Ballast Nedam, 2011; De Ingenieur, 2008; Internet Sources 77-161.

3.3 Summary

In 2010, the wind capacity in the Netherlands amounted to 2,230 MW (2,002 MW onshore and 228 MW offshore wind) (CBS, 2011). The electricity generated was 4,494 GWh, or 16.2 PJ of final energy. According to the European Wind Energy Association (EWEA, 2009), 108,600 people were employed in wind energy in Europe in 2009, of which 2,000 in the Netherlands. The present study presents an estimate of about 2,400 employees in 2010 and 2,200 in 2009 (Table 3.1 and Table 3.2), which is in agreement with EWEA's estimate for 2009. In the present study the turnover is estimated at about € 1,330 million in 2010, and € 1,220 million in 2009.

These figures may be compared to data from a recent survey for offshore wind in the Netherlands (Agentschap NL, 2011b), which gives an estimate of the employment in offshore wind of 2,000 FTE and a turnover in excess of € 1,000 million. However, the number of offshore wind companies is as high as 153 – the corresponding number in (Agentschap NL, 2011a) is 138. The latter number may be an overestimation, as equal numbers of companies may be labelled 'onshore wind companies' as 'offshore wind companies'. The present study distinguishes 81 'onshore wind companies' and 82 'offshore wind companies'. Therefore, the employment and

turnover in the present study may be compared to corresponding figures for ‘offshore wind’ in (Agentschap NL, 2011b). This comparison shows that the number of employees in the present study is about 10% higher and the turnover about 20% higher than in (Agentschap NL, 2011b).

4. Photovoltaic electricity

Photovoltaic (PV) electricity companies, producing solar cells or modules, panels and components represent a nascent industry with several representatives in the Netherlands. This chapter focuses on data of turnover and employment, as far as available. The companies are subdivided in four categories, which are reviewed in the order presented below:

- Companies producing equipment and materials for PV cells/modules.
- Companies producing (components for) PV cells and/or modules.
- Companies developing technology or providing services.
- PV system suppliers.
-

4.1 Equipment and materials companies for PV cells/modules

4.1.1 Cedova

Cedova bv, based at the High Tech Campus in Eindhoven, is a leading edge supplier of serviced foundry facilities to the opto-electronics industry (Internet Source 162). Its specialty is the growth and processing of III-V compounds. Its workforce is tentatively estimated at 5 people.

4.1.2 DHV

DHV bv in Amersfoort is a consultancy and engineering company. It is also active in the design of photovoltaic cells plants, e.g. for Arise Technologies of Canada in Bischofswerda, Germany (Internet Source 163). Its workforce related to design of PV cells plants is estimated at 15 people.

4.1.3 Enthone

Enthone Inc. Is a Cookson Electronics company, a division of Cookson Group plc, London. It is a leading supplier of high performance specialty chemicals and coatings used in the electronics and surface finishing industries. One of its subsidiaries is Enthone Benelux bv in ‘s Hertogenbosch. Enthone PV electroplating chemistries for solar cell manufacturing increase cell efficiency while lowering production costs and increasing throughput and yield (Internet Source 164). The workforce related to such materials for the PV industry is estimated at 30 people.

4.1.4 Eurotron

Eurotron in Bleskensgraaf offers a complete solution for the PV module manufacturing process for backside contact cells (Internet Source 165). As it is a rather new company (in 2009, it was selected as supplier by Canadian Solar), its workforce is estimated at 15 people.

4.1.5 Lamers High Tech Systems

Lamers High Tech Systems bv in Nijmegen – a subsidiary of Air Liquide (present in over 75 countries with 42,300 employees) – is a leading supplier in the semi-conductor market. It offers *inter alia* clean rooms for manufacturing of PV cells (Internet Source 166). The workforce in the Netherlands related to equipment (clean rooms) for the PV industry is estimated at 30 people.

4.1.6 Levitech

Levitech is a global player in semiconductor production solutions for the IC and solar industry. A spin-off of ASM International, it was established (in 2009) around its core product, the Levitor™ system, used in the semiconductor industry for Rapid Thermal Processing (RTP) As Levitech originated as a divesture from ASM International in the course of 2009, its 'PV related' workforce is tentatively estimated at 20 people (Internet Source 167).

4.1.7 Mallinckrodt Baker

Mallinckrodt Baker (USA), with a subsidiary in Deventer, produces *inter alia* chemicals for PV cell manufacturing (Internet Source 168). About 15% of its workforce of 200 people in the Netherlands is assumed to be related to the PV industry, i.e. 30 people.

4.1.8 Meco

Meco in Drunen – division of BE Semiconductor Industries NV in Duiven – manufactures and supplies plating systems to suit a wide variety of products, *inter alia* for the PV cell industry. After introduction of its the Cell Plating Line (CPL) in 2009, Meco launched its Direct Plating Line (DPL) for metallization directly onto silicon, which can be used together with the CPL platform, fitting into advanced metallization routes developed by the PV industry. The PV related turnover is estimated at € 10 million and the workforce at 45 people (Internet Source 169).

4.1.9 NTS-Group

NTS-Group with several manufacturing plants in Bergeijk, Deurne, Eindhoven, and Nijmegen, has extensive knowledge in the field of optical and mechatronic systems. Its turnover in the Netherlands is reportedly € 95 million and its workforce in the Netherlands is about 500 people (Internet Source 170). An estimated 10% of its turnover and workforce in the Netherlands is assumed to be PV related', i.e. a turnover of € 10 million and a workforce of 50 people.

4.1.10 Rimas

Rimas Group bv in Beringe is specialised in PV module manufacturing equipment. Since 2005, the company has grown from 12 to 30 employees (2009) and has been able to more than double its turnover (Internet Source 171). Its number of employees is estimated at 30.

4.1.11 Smit Ovens

Smit Ovens in Eindhoven (Son) is specialised in thermal processes (ovens) for the display, glass and electronics industries with a workforce of 50 people (Internet Source 172). One of its products is a thermal process for thin-film solar panels. In 2010, it completed a project to specify, design, test, and build a selenium deposition and crystallization oven for production of CIGS (Copper Indium Gallium Selenide) PV panels. In 2011, turnover will reportedly double to €17 million (Internet Source 173). Therefore, its turnover is put at €8.5 million and its PV related workforce is put at 30 people in 2010.

4.1.12 SolayTec

SolayTec is a spin-off company from TNO and focuses on Atomic Layer Deposition (ALD) on solar cells. ALD machines are intended for industrial production in the solar market. The start-up dates from 2010. Due to lack of data no turnover or workforce is attributed to the company (Internet Sources 174).

4.1.13 Stork Prints Group

Stork Prints Group (SPG) bv in Boxmeer – a subsidiary of Bencis Capital Partners (60%) and Stork (40%) – is a leading company in the textile and graphics printing market. Most of the processes applying conductor paste to silicon solar cells require screen printing. An alternative to the standard wire mesh screen is the metal stencil (Internet Source 175). Its workforce in the Netherlands related to the PV cell industry is tentatively estimated at 35 people.

4.1.14 Sunlab

Sunlab bv in Petten is a subsidiary of ECN offering three instruments, (Internet Source 176). The turnover and workforce are relatively small and are consolidated in ECN's unit Solar Energy.

4.1.15 Tempress Systems

Tempress Systems, in Vaassen since 2007 (subsidiary of Amtech Systems, Inc.), develops and manufactures furnaces for the semiconductor, MEMS, Nano and solar industries. Its workforce related to the PV industry is estimated at 100 people in 2009 (Jong, 2011) and 125 in 2010 (Internet Source 177).

4.1.16 The Silicon Mine

The Silicon Mine at the Chemelot production site of DSM (Beek, Limburg) is a start-up for the production of TriChloroSilane (TCS) for the production of polysilicon. The construction of the TCS plant will start in 2012 and the plant will be commissioned in 2013 (Internet Source 178).

4.1.17 VDL ETG

VDL Enabling Technologies Group (ETG) in Eindhoven supplies to the Original Equipment Manufacturing industry related to the automotive sector, but is also specialised in vacuum deposition systems for PV cells, based on crystalline silicon and thin-film technology (Internet Source 179). Its workforce related to the PV industry is tentatively estimated at 15 people.

4.2 Companies producing (components for) PV cells and/or modules

4.2.1 Alrack

Alrack in Eindhoven, a mechatronics specialist at Veldhoven, develops a new electric connection between the solar panel and the grid in cooperation with six other innovative companies in the provinces North Brabant and Limburg (Internet Source 180). As a start-up with 9 employees it received a subsidy of nearly € 1 mln from the government and the province North Brabant. The number of employees is put at 5.

4.2.2 Mastervolt

Mastervolt was founded in 1991, and offers AC and DC solutions for customers in the global marine, mobile and renewable energy markets, among which inverters for PV. In 2005, Mastervolt had 115 employees in the Netherlands and abroad, and its global turnover was € 35 mln. It is assumed that Mastervolt has a turnover of € 25 million and 75 employees in the Netherlands in 2010, based on a global workforce of 115 (Internet Source 181).

4.2.3 Nuon Helianthos

In 2000, Akzo Nobel entered into cooperation with Shell Solar to bring Helianthos products to the market. In 2004, this cooperation was terminated. In 2006, Akzo Nobel sold Helianthos to NUON. Various projects co-financed by SenterNovem to bring the technology from lab to pilot plant level have been carried out over the past years (Schlatmann, 2005). In 2007, Helianthos (Arnhem) had about 35 employees (Jongerden, 2007). In September 2011, Nuon decided to terminate its activities in Helianthos. Its workforce is 75 employees (Internet Source 182).

4.2.4 OM&T

OM&T (Optical Media & Technology) bv in Eindhoven, a Dutch subsidiary of Moser Baer India Ltd, is an optical media technology company offering an extensive range of specialised test discs, for use by optical disc drive and player and associated component producers (Internet Source 183). The number of employees related to the PV industry is tentatively estimated at 10.

4.2.5 Scheuten Solar

Scheuten Solar bv in Venlo is an innovative and leading solar company that develops, produces, designs and sells PV solar modules and total PV solar solutions. It is categorised as a company producing PV cells or modules, although it also supplies complete PV systems. PV production facilities are in Gelsenkirchen (Germany) and Venlo. The parent company Scheuten employs a staff of about 1,800. Scheuten Solar's turnover is estimated at € 175 mln and its Dutch workforce at 128 people in 2008 (Internet Source 184), € 190 million and 135 people, respectively, in 2009, and € 113 million and 270 people, respectively, in 2010.

4.2.6 SolarExcel

In February 2011, SolarExcel announced to build a pilot plant (investment cost €5 million) for thin-film PV based on specific foils in Venray (Limburg), due for 2012 (Internet Source 185).

4.2.7 Solar Modules Nederland

Solar Modules Nederland bv in Kerkrade manufactures solar modules with 25 employees. It originated in 2009, and production started in the first half of 2010. In May 2010, the production capacity of PV modules reached the level of 25 MW_p/year. (Internet Source 186). The workforce is probably approximately 5 people.

4.2.8 Solland Solar

Solland Solar bv is a polysilicon solar cell producer in Heerlen/Aachen on the border between Germany and the Netherlands and is a subsidiary of DELTA. After initially high growth rates – in 2007, Solland Solar had 200 employees, and in 2008 approximately 400 (Internet Source 187). It was forced to lay off 86 people (temporary contracts) in 2009 (DELTA, 2010). DELTA intends to unwind its interest in Solland Solar (DELTA, 2011). The turnover of Solland Solar was estimated at € 70 million and the Dutch workforce at 135 people in 2009, and € 70 million and 140 people, respectively, in 2010 (Internet Source 188).

4.2.9 Suncycle

Suncycle in Eindhoven, which originates from 2005, is specialised in concentrating panels for PV systems (CPV). In 2011, a CPV system will be installed in Deurne (Internet Sources 189-190). Its workforce is estimated at approximately 5 people.

4.2.10 Ubbink Solar

Ubbink Solar bv in Doesburg – subsidiary of Ubbink Groep (originally Centrosolar and Econcern) – supplies PV systems consisting of PV modules, mounting systems, cabling and converters (Internet Source 191). Its turnover is estimated at € 4 mln and its workforce at 20 people.

4.3 Companies developing technology or providing services

4.3.1 Advanced Surface Technology (AST)

Advanced Surface Technology (AST) bv in Leeuwarden is mainly focused on R&D and installation of solar PV (systems). The workforce of AST stood at 23 people in 2009 (Kruithof, 2010; Internet Source 192) and is estimated at 20 people in 2010.

4.3.2 MiPlaza

MiPlaza (Microsystems Plaza) in Eindhoven (an activity of Philips research) offers expertise, service and infrastructure, enabling companies to carry out high-tech research in the most efficient way. One of its activities is the analysis of the composition and structure of materials and processes (Internet Source 193). Its 'PV related' workforce is estimated at 10 people.

4.3.3 OTB Solar

In February 2010, due to the takeover of OTB Group, OTB Solar bv in Eindhoven became a subsidiary of Roth & Rau AG of Germany. OTB's product portfolio consists of systems and technologies for the solar industry, especially antireflective coating systems and turnkey production lines for use in the manufacture of crystalline silicon solar cells. From 2005 to 2006, its turnover increased from € 16 mln to € 30 mln (ED, 2006). Its turnover is estimated at € 60 mln and the workforce at 125 people in 2008, € 30 million and 125 people, respectively, in 2009, and € 75 million and 150 people, respectively, in 2010 (Internet Sources 194-195).

4.3.4 Philips Applied Technologies

Philips Applied Technologies in Eindhoven is experienced in applying and integrating a wide range of technologies including software, electronics, robotics, precision motion and sensors (Internet Source 196). However, it appears that Philips Applied Technologies is no longer engaged in solar PV R&D.

4.3.5 RGS Development & Solar Electricity Development

RGS Development bv, based in Broek op Langedijk, worked on the completion of a pilot machine for PV cell manufacturing based on an innovative technology called Ribbon Growth on Substrate (RGS). This is an activity of Solwafer/Sunergy, which is covered hereafter. The number of employees of RGS Development is 15 (Internet Source 197). At the same location, Solar Electricity Development bv, subsidiary of Solar Electricity Holding bv, develops early stage projects in the field of solar PV (Internet Source 198). Solar Electricity Development intends to build a solar PV plant in Leeuwarden (Internet Source 199).

4.3.6 Solwafer/Sunergy

Solwafer/Sunergy in Broek op Langedijk is a start-up based on the RGS technology for manufacturing of PV cells. It is planning an industrial-scale production facility (Internet Source 200). Data on workforce is not available. The workforce is estimated at 5 people.

4.4 PV system suppliers

4.4.1 IBC Solar

IBC Solar bv in Amstenrade – a subsidiary of IBC Groep in Germany – focuses on engineering and installation of (turnkey) PV systems (Internet Source 201). Data on turnover or workforce is not available. Its workforce in the Netherlands is tentatively estimated at 20 people.

4.4.2 Oskomera Solar Power Solutions

Oskomera Solar Power Solutions bv in Deurne is a subsidiary of Oskomera Group, a group of companies that develop, engineer, manufacture and install windows, walls and load-bearing constructions. The solar division offers PV systems based on multi-crystalline silicon cells (Internet Source 202). The turnover is estimated at € 10 million and the workforce at 25 people in 2009, and € 15 million and 34 people, respectively, in 2010.

4.4.3 Siemens Netherlands

The subsidiary of Siemens in the Hague is *inter alia* engaged in inverter technology (Internet Source 203). Its 'PV related' workforce is estimated at 15 employees.

4.4.4 SolarTotal

SolarTotal Holding bv in Bemmel is active in distribution and installation of PV systems in Belgium, France, Spain, the Netherlands, Italy, and Germany. Since the start of its operations in 2006, revenues have increased to an expected € 40 million in 2008. Currently it has over 100 employees and franchisees (Internet Source 204). The turnover in the Netherlands is estimated at € 4 million, and the number of employees at 20.

4.5 Summary

At the end of 2010, the total installed PV capacity in the Netherlands stood at 88 MW (in 2009, 68 MW) (CBS, 2011), supplying 60 GWh or 0.22 PJ of gross final energy (CBS, 2011). Table 4.1 summarises the turnover and workforce of PV companies in 2010. Some 'PV related' companies also produce other components or services, which have been excluded. The turnover is estimated at € 1,000 mln in 2010 (€ 970 mln in 2009), and the workforce at 1,240 employees in 2010 (1,180 in 2009). These data may be compared to a turnover of € 491 mln, and a workforce of 622 people in (CBS, 2011). The datasets differ with respect to the coverage of the PV industry. The workforce in Table 4.1 may be slightly overestimated (persons vis-à-vis FTEs).

Table 4.1 *Key data turnover and employees of PV related companies, Netherlands*

Company	Turnover 2008 [€ mln]	Employees 2008	Turnover 2009 [€ mln]	Employees 2009	Turnover 2010 [€ mln]	Employees 2010
Equipment and materials companies						
Cedova	N/A	N/A	N/A	5	N/A	5
DHV	N/A	N/A	N/A	15	N/A	15
Enthone	N/A	N/A	N/A	30	N/A	30
Eurotron	N/A	N/A	N/A	15	N/A	15
Lamers High Tech Systems	N/A	N/A	N/A	30	N/A	30
Levitech	N/A	N/A	N/A	20	N/A	20
Mallinckrodt Baker	N/A	N/A	N/A	30	N/A	30
Meco	N/A	N/A	10	45	10	45
NTS-Group	N/A	N/A	10	50	10	50
Rimas Group	N/A	N/A	N/A	30	N/A	30
Smit Ovens	N/A	N/A	N/A	25	8.5	30
SolayTec	-	-	-	-	-	-
Stork Prints Group	N/A	N/A	N/A	35	N/A	35
Sunlab	-	-	-	-	-	-
Tempress	N/A	N/A	N/A	100	N/A	125
The Silicon Mine	-	-	-	N/A	-	N/A
VDL ETG	N/A	N/A	N/A	15	N/A	15
Subtotal	N/A	N/A	N/A	445	N/A	475
Industries producing PV cells/modules						
Alrack	N/A	N/A	N/A	5	N/A	5
Mastervolt	10	30	25	75	25	75
Nuon Helianthos	N/A	35	N/A	35	N/A	75
OM&T	N/A	N/A	N/A	10	N/A	10
Scheuten Solar	128	175	135	190	113	140
SolarExcel	-	-	-	-	-	-
Solar Modules Nederland	-	-	-	5	-	5
Solland Solar	50	70	70	135	70	140
Suncycle	-	-	-	5	-	5
Ubbink Solar	5	36	4	20	4	20
Subtotal	340	470	400	480	400	475
Companies developing technology or providing services						
Advanced Surface Technology	-	20	-	23	-	20
MiPlaza	N/A	N/A	N/A	10	N/A	10
OTB Solar	60	125	30	125	75	150
Philips Applied Technologies	N/A	N/A	N/A	N/A	N/A	N/A
RGS Development & Solar Electricity Development	N/A	5	N/A	10	N/A	15
Solwafer/Sunergy	-	-	N/A	5	N/A	5
PV system suppliers						
IBC Solar	N/A	N/A	N/A	20	N/A	20
Oskomera Solar Power Solutions	N/A	N/A	10	25	15	34
Siemens Netherlands	N/A	15	N/A	15	N/A	15
SolarTotal	N/A	N/A	4	20	4	20
Subtotal	135	300	150	253	130	289
Total PV related industries	580	800	970	1,180	1,000	1,240

Sources: Schlatmann, 2005; Jongerden, 2007; Delta, 2010; ED, 2006; CBS, 2010; Kruithof, 2010; Internet Sources 162-204.

5. Solar thermal energy

5.1 Installed capacity 2009

The solar thermal energy industry, producing, distributing and installing solar collectors for hot water and heating (if applicable) is a nascent business in the Netherlands, which is why data is relatively scarce. According to (CBS, 2010), the cumulative collector area in the Netherlands amounted to 755,000 m^2 in 2009 (in 2008, 704,000 m^2), which is equivalent to 539 MW_{th} (in 2008, 503 MW_{th}), based on the 'rule-of-thumb' of 1.4 m^2/kW_{th} from (Holland Solar, 2007).

5.2 Turnover 2009

Data of the turnover of solar thermal energy companies is scarce. Holland Solar uses € 1,000 per m^2 collector area as a rule-of-thumb for current solar thermal systems with glazed collectors (van Amerongen, 2010 and 2011). Based on this figure, the best estimate for systems with unglazed collectors is € 400 per m^2 collector area. Therefore, the 42,000 m^2 of glazed collector area and 27,000 m^2 of unglazed collectors installed in 2010 represent a turnover of € 53 million. Based on the same rules-of-thumb the turnover of solar thermal energy companies has been estimated at € 60 mln in 2009 (46,000 m^2 of glazed collector area and 34,000 m^2 of unglazed collectors installed) and at € 37 mln in 2008 (23,000 m^2 of glazed collector area and 28,000 m^2 of unglazed collectors).

5.3 Employment 2009

In (ESV, 2010), the turnover of thermal solar heating installations in Upper Austria is put at €125 million and the related workforce from production, sales, and installation at 1,800 people. If we use this relationship, the turnover of € 53 million in 2010 is equivalent to 760 employees, the turnover of € 60 mln in 2009 equivalent to 860 employees and the turnover of € 37 mln in 2008 equivalent to 530 employees. However, the employment in the Netherlands may be underestimated as the breakdown of the employment may differ from Upper Austria. Presumed that two-thirds of the employment is related to marketing, distribution, planning, installation, and maintenance and one-third to manufacturing (ESTTP, 2008), the workforce may be 960 people in 2010, 1,090 in 2009, and 670 in 2008. This estimate is significantly lower than in (Lako and Beurskens, 2010), because of a better view on the employment in the Netherlands.

5.4 Summary

According to (CBS, 2011), the cumulative collector area amounted to 804,000 m^2 in 2010, which is equivalent to 563 MW_{th}, supplying 0.99 PJ of gross final energy. Table 5.1 summarises the estimated turnover (approximately € 53 mln) and the number of employees (~960) of companies engaged in solar thermal energy in 2010.

Table 5.1 *Key data turnover and employees solar thermal energy companies the Netherlands*

Solar thermal energy sector	Turnover 2008 [€ mln]	Employees 2008	Turnover 2009 [€ mln]	Employees 2009	Turnover 2010 [€ mln]	Employees 2010
Total	~37	~670	~60	~1,090	~53	~960

Sources: Holland Solar, 2007; Holland Solar, 2009; Amerongen, 2010 and 2011; ESV, 2010; CBS, 2011.

6. Biofuels

In the Netherlands, several biofuel plants have been commissioned in the last few years. Most of them produce biodiesel and some other produce bioethanol of biomethanol. Furthermore, a number of biofuel production plants are being commissioned, under construction, or planned. These biofuel plants are addressed below. For an overview of biofuel plants see the website of Agentschap NL (Internet Source 205).

6.1 Abengoa Bioenergy Netherlands

Abengoa Bioenergy Netherlands bv (parent company Abengoa, Spain) commissioned a bio-ethanol plant in Rotterdam in 2009/2010. The plant has a capacity of 480 mln l (million litres) of bioethanol per year, based on 1.2 Mt of cereal per year as feedstock. The bioethanol plant has 75 employees (Abengoa Bioenergy, 2011).

6.2 Biodiesel Amsterdam (Greenmills)

In 2009, BioDiesel Amsterdam bv (Greenmills) built a biodiesel plant in Amsterdam. The plant is based on vegetable and organic waste materials and has a capacity of 110 mln l of biodiesel. In addition to biodiesel, electricity and heat are extracted from a biogas plant. The number of employees is estimated at 24 (Internet Sources 206-207).

6.3 Biodiesel Kampen

Biodiesel Kampen bv, established in 2006, produces biodiesel (FAME, Fatty Acid Methyl Ester) from used vegetable oils in a plant with a capacity of 125 mln l (Internet Source 208).

6.4 BioDsl

Since September 2008, BioDsl bv in Breda produced biodiesel from used vegetable oils in a plant with a capacity of 11.5 mln l. At the end of 2010, it filed for bankruptcy (Internet Sources 209-210).

6.5 BioMCN

In June 2009, BioMCN started up production of biomethanol in a plant in Delfzijl, consisting of a conversion unit in which glycerol – by-product of biodiesel (FAME) plants – is converted into syngas, that feeds into in a two-train, 200,000 t per year, methanol plant producing biomethanol. The number of employees is estimated at 30 (Internet Sources 211-212).

6.6 Biopetrol

By the end of 2008, Biopetrol Industries AG started up a biodiesel plant in Rotterdam, with a capacity of 400,000 t of biodiesel and 60,000 t of glycerine. The plant is primarily based on rapeseed oil as a feedstock. In February 2010, Biopetrol Industries commenced production. Simultaneously, Glencore, one of the world's largest suppliers of commodities and raw materials to industrial consumers, became majority shareholder of Biopetrol Industries AG (Internet Source 213).

6.7 DELTA Biovalue Nederland

In 2007, DELTA Biovalue Nederland bv started production of biodiesel in the Eemshaven in a 80,000 t per year plant based on rapeseed oil as a feedstock. The number of employees was 28 (Internet Source 214). In 2010, DELTA decided to close the biodiesel plant, and in December 2010 the plant filed for bankruptcy (Internet Source 215).

6.8 NExBTL (Neste Oil)

In May 2009, Neste Oil started construction of a biodiesel plant NExBTL, based on its proprietary technology, in Rotterdam, with a capacity of 800,000 t per year. The investment cost is approximately € 670 million. It will be commissioned in the third quarter of 2011, and will create 100 jobs. The feedstock is palm oil, rapeseed oil, waste animal fat, and waste palm oil (Internet Source 216).

6.9 Sime Darby CleanerG

In April 2008, a biodiesel plant of Sime Darby CleanerG bv started production in Zwijndrecht. Its production capacity is 200,000 t of biodiesel per year. The plant uses rapeseed oil, soybean oil, and palm oil as feedstock. Its number of employees is put at 12 (Internet Source 217).

6.10 Ecoson

In December 2007, Ecoson – parent company VION Food Group – started production in Son of refined fats (43,750 t per year), biodiesel (4,500 t) and electricity based on anaerobic digestion. The investment cost was € 10 million. The plant is based on processed animal fats and other 'waste' fats (Rietveld, 2007).

6.11 Vesta Biofuels

Vesta Biofuels bv, Utrecht, is due to construct a plant with a capacity of 200,000 t biodiesel per year in Amsterdam. The investment cost would be € 42.5 million, and its workforce would be 30 employees (Internet Source 218). The plant will be in operation in 2011.

6.12 Nedalco

Royal Nedalco (Bergen op Zoom) currently supplies 10 mln l/yr of bioethanol to the transport sector. A plan to build a dedicated bioethanol plant in Sas van Gent has not been realised (Nedalco, 2007).

6.13 Bio Rights

Bio Rights bv (N2 Energy) is due to build a so-called 2nd generation bioethanol production plant in Hardenberg. The plant would have a production capacity of 6.5 mln l/yr of bioethanol (Internet Sources 219-220). Alternatively, the plant would be used to supply biogas and/or electricity. No recent information on this project is available.

6.14 Rosendaal Energy

In 2008, Rosendaal Energy bv started producing biodiesel from rapeseed oil, soy oil, and palm oil in a plant in Sluiskil (investment cost € 40 million), with a capacity of 250,000 t biodiesel. In

2009, the plant was declared bankrupt and closed. In 2010, 30 employees remained on the payroll of Fortis Lease. As of January 2011, Rosendaal Energy bv operates as a subsidiary of Goes On Green Limited (Internet Sources 221-222).

6.15 Sunoil Biodiesel Emmen

In 2006, Sunoil Biodiesel bv started production of biodiesel in a plant of 80,000 l/yr based on waste and animal fats in Emmen. The number of employees is 13 (Internet Source 223).

6.16 Dutch Biodiesel

Dutch Biodiesel BV is a joint venture between Argos (40%) and Glencore (60%). Since 2009, Argos produces biodiesel in a plant of its subsidiary Dutch BioDiesel bv at Rotterdam with a capacity of 250,000 t. Biopetrol Industries AG will transfer current operations from Dutch Biodiesel to existing Biopetrol sites in Rotterdam. These actions will create opportunities for improved logistics and operational synergies, providing enhanced services to customers. The combined future use of all sites will continue to be evaluated (Internet Source 224).

6.17 LyondellBasell ETBE

In 2008, LyondellBasell in the Botlek started production of bio-ETBE (Ethyl Tertiary Butyl Ether) as an additive to gasoline with a capacity of 600,000 t ETBE per year (Internet Sources 205 and 225).

6.18 Sunoil ETBE

In 2006, Sabic Europe in Geleen started production of bio-ETBE as an additive to gasoline with a capacity of 140,000 t ETBE per year (Internet Source 226).

6.19 Summary

According to (Agentschap NL, 2011c) and (CBS, 2011), biofuels represented an energy equivalent of 9.6 PJ of final energy in 2010. Table 6.1 summarises the estimated turnover (~ € 170 mln) and estimated employment (~ 300 people) of biofuel companies in 2010.

Table 6.1 *Key data turnover and employees of biofuel companies in the Netherlands*

Company / City	Biofuel/ product	Turnover 2008 [€ mln] [a]	Employees 2008	Turnover 2009 [€ mln] [a]	Employees 2009	Turnover 2010 [€ mln] [a]	Employees 2010
Abengoa / Rotterdam	Bioethanol		5		5		75
Bio Rights / Hardenberg	Bioethanol		-		-		-
Nedalco / Bergen op Zoom	Bioethanol		4		4		4
BioMCN / Delfzijl	Biomethanol		30		30		30
Biopetrol Industries / Rotterdam	Biodiesel		40		40		40
BioDiesel Amsterdam	Biodiesel		5		24		24
Biodiesel Kampen	Biodiesel		12		12		12
BioDsl / Breda	Biodiesel		4		4		-
DELTA Biovalue / Eemshaven	Biodiesel		28		26 [b]		-
Dutch Biodiesel / Rotterdam	Biodiesel				25		25
Ecoson / Son	Biodiesel		10		10		10
NExBTL (Neste Oil) / Rotterdam	Biodiesel		10		10		10
Rosendaal Energy / Sluiskil	Biodiesel		25		25		30
Sime Darby CleanerG / Zwijndrecht	Biodiesel		12		12		12
Sunoil Biodiesel / Emmen	Biodiesel		12		12		13
LyondellBasell ETBE / Rotterdam	Bio-ETBE		10		10		10
Sunoil ETBE / Geleen	Bio-ETBE		10		10		10
Total		~130	~220	~140	~260	~170	~300

a Data on turnover is hardly available by company.
b DELTA decided to close the biodiesel plant in July 2009.
Sources : Agentschap NL, 2011 ; Internet Sources 205-226.

7. Solid biomass

The industry producing biomass-based technologies has several representatives in the Netherlands. Data of turnover and employees is presented of Agrotechnology & Food Sciences Group (AFSG), Biomass Technology Group (BTG), W.K. Crone, Dahlman, Dordtech Engineering, HoSt, KARA Energy Systems, Polow Energy Systems, and Tebodin (SenterNovem, 2006). A separate paragraph refers to torrefaction, a pre-treatment technology for solid biomass to make it suitable for application in heat and power production. Not all activities related to solid biomass are covered. For instance, wood-fired furnaces and boilers for households are only mentioned. Also, turnover and employment in co-firing of biomass in power plants is not covered here.

7.1 Agrotechnology & Food Sciences Group (AFSG)

Agrotechnology and Food Sciences Group (AFSG) of Wageningen University entails *inter alia* bioprocess engineering and valorisation of plant production chains (Internet Source 227).

7.2 Biomass Technology Group (BTG)

Biomass Technology Group bv in Enschede is an independent, private firm which for the past 25 years has specialised in the process of conversion of biomass into biofuels and bio-energy. Production and use of bio-energy shall take place in an environmentally, socially, and economically sustainable manner. Fields of expertise include:

- Bioenergy conversion processes.
- Biomass based decentralised rural electrification.
- Production of solid and liquid biofuels.
- Biomass and biofuels logistics and pre-treatment.

7.3 W.K. Crone

W.K. Crone, in Nieuwerkerk a/d IJssel (Zuid Holland), supplies boilers and equipment for industrial, utility, and agricultural applications, in particular wood/coal combustors – Bubbling Fluidized Bed Boilers – and wood pellets stoves.

7.4 Dahlman

Dahlman Filter Technology in Maassluis is specialised in the cleaning of product gas in biomass gasification systems based on the OLGA technology developed by ECN (Internet Source 228).

7.5 Dordtech Engineering

Dordtech Engineering, Dordrecht, is a developer and producer of CHP and generator sets for alternative fuels, such as biogas, bio oil, and hydrocarbon vapours.

7.6 HoSt

HoSt in Hengelo is an engineering and contracting company, specialised in energy technology and processes. It builds wood-fired combined heat and power installations, based on the HoSt gasification and gas cleaning technology. HoSt is also engaged in biogas projects.

7.7 KARA Energy Systems

KARA Energy Systems bv is a developer, manufacturer and supplier of wood fired boiler systems for converting solid biomass fuels into energy up to 15 MW thermal input.

7.8 Polow Energy Systems

Polow Energy Systems, in the Hague, is specialised in process technology, and particularly in energy recovery (Torbed® technology) and heat processes in industry and agriculture.

7.9 Tebodin

Tebodin Consultants & Engineers in the Hague is an independent, multidisciplinary consultancy and engineering firm with a turnover of € 210 million (2010). One of its activities relates to logistics of biomass-fuelled power or CHP plants (Internet Source 229).

7.10 Initiatives with regard to pyrolysis oil and torrefaction

Recently, KEMA published on behalf of Agentschap NL (Kleinschmidt, 2010). Also, BTG announced a pyrolysis plant at the AkzoNobel plant in Hengelo (Commissie voor de mer, 2009). Table 7.1provides some key data of initiatives/start-ups related to pyrolysis oil and torrefaction.

Table 7.1 *Key data initiatives/startups with respect to pyrolysis oil and torrefaction in NL*

Initiative	Site	Development stage	Capacity (biocal) [t/year]	Stage of permitting	Expected date of start-up	Number of employees 2010
BTG Bioliquids bv	Hengelo	Permit	60,000 t clean wood [a]			
Biolake bv	Den Helder	N/A	N/A			
BO2GO	Delfzijl	Permit		Permit for Nature Conservation Act revoked [b]		
Eclair-E Energie nv	Lelystad	Planning	N/A			
FoxCoal bv	Groningen	Planning	35,000			
Qlyte bv (DSM)	Roermond	Permit	30,000			
Stramproy (SGI)	Steenwijk	Start-up	90,000 [c]		2010	< 6
Topell Energy bv	Duiven	Construction	60,000 [d]		2011	6-8
Torr-Coal bv		Construction	36,000		2010	6-8

a The demonstration pyrolysis plant will produce 20 million l of pyrolysis oil per year.
b A permit for the initiative BO2GO in Delfzijl has been declined in 2011 (Internet Source 230).
c In 2010, Stramproy (SGI) commissioned a plant for 90.000 t of BioCoal in Steenwijk (Internet Source 231).
d Topell Energy's torrefaction plant in Duiven (60,000 t) is due for the end of 2011 (Internet Source 232).

Sources : Commissie voor de mer, 2009 ; Kleinschmidt, 2010 ; Internet Sources 230-232.

7.11 Wood-fired furnaces and boilers for households

Wood-fired furnaces, boilers, etc. for households provided 12.2 PJ of final energy in 2010, based on 940,000 installations (CBS, 2011). If only wood-fired furnaces and boilers are considered and open fires are omitted, the number decreases to approximately 550,000 (CBS, 2011; Koppejan, 2010). The turnover and employment in this sector has not been estimated.

7.12 Summary

In 2010, the energy equivalent of solid biomass in the Netherlands was 34.7 PJ (final energy), of which 11.5 PJ co-firing in power plants, and 12.2 PJ wood-fired furnaces and boilers in households (CBS, 2011). The workforce of nine companies in solid biomass (R&D, engineering and design, manufacturing, and installation) and the initiatives/start-ups in pyrolysis and torrefaction is estimated at 250 people, and the turnover at € 65 mln (Table 7.2). These numbers are exclusive of wood-fired furnaces and boilers and co-firing of biomass in power plants.

Table 7.2 *Key data turnover and employees 'solid biomass companies' in the Netherlands*

Company	Turnover 2008 [€ mln] [a]	Employees 2008 [a]	Turnover 2009 [€ mln] [a]	Employees 2009 [a]	Turnover 2010 [€ mln] [a]	Employees 2010 [a]
Agrotechnology and Food Sciences						
Biomass Technology Group (BTG)						
W.K. Crone						
Dahlman Filter Technology						
Dordtech Engineering						
HoSt						
KARA Energy Systems						
Polow Energy Systems						
Tebodin						
BTG Bioliquids bv (pyrolysis)		-		-		-
Torrefaction initiatives		-		~ 20		~ 20
Wood-fired furnaces/boilers for households						
Total	~62	~240	~65	~250	~65	~250

a Data on turnover is generally not available on company level. Turnover and employment of wood-fired furnaces and boilers in households and of co-firing of biomass in power plants is excluded.

Sources : SenterNovem, 2006 ; Commissie voor de mer, 2009 ; Kleinschmidt, 2010 ; Internet Sources 227-232.

8. Biogas

The industry producing biogas plants and related technology is an industry with several representatives in the Netherlands. Estimates of the workforce and turnover is presented of Ballast Nedam IPM, BiogaS International Project, Brouwers BioEnergy, Certified-Energy, DMT Milieutechnologie, Gastreatment Services (GtS), OGIN Biogas, Orgaworld, Thecogas Biogastechniek, and Van der Wiel Stortgas (SenterNovem, 2006). Also, an approximation of workforce and turnover of operating and maintaining biogas plants in the Netherlands is presented.

8.1 Ballast Nedam IPM

Ballast Nedam IPM (subsidiary Ballast Nedam) designs and builds gas stations based on Compressed Natural Gas sourced from green gas (bio-CNG), e.g. for HTM (Internet Source 233).

8.2 BiogaS International Project

BiogaS International Project bv, in Klazienaveen (Drenthe), an installation group with 16 companies in the Netherlands, was declared bankrupt in 2009/2010 (Internet Source 234). Another company with a comparable name is still in business: Swedish Biogas International AB.

8.3 BioGast Sustainable Energy

BioGast Sustainable Energy bv in Haarlem develops and implements technology for green gas production based on R&D, (turnkey) supply, project management, etc (Internet Source 235).

8.4 Brouwers BioEnergy

Brouwers BioEnergy bv, Leeuwarden (Friesland), a subsidiary of Brouwers Equipment, supplies turnkey biogas plants at farm-scale (Internet Source 236).

8.5 Certified Energy

Certified Energy bv, Wanroij (Limburg), is an engineering and construction company specialised in biogas and ‘green gas’ plants, with a capacity of 350 kW and more. These biogas plants are built in the Benelux based on a license from Schmack Biogas AG, Germany (Internet Source 237). In December 2010, Certified Energy bv was declared bankrupt (Internet Source 238).

8.6 DMT Milieutechnologie

DMT Milieutechnologie bv, Joure (Friesland), is specialised in design and construction of installations for biogas, and air and water treatment. In case of biogas, DMT makes use of its proprietary DMT Carborex® PWS biogas upgrading system (Internet Source 239).

8.7 Gastreatment Services (TtS)

Gastreatment Services bv (GtS) in Bergambacht is an engineering firm engaged in gas treatment in the broadest sense of the word. GtS designs and builds purification systems for biogas, land-

fill gas and digester gas, e.g., biogas cleaning and upgrading and conversion to Compressed BioGas (CBG) or Liquid BioGas (LBG) (Internet Source 240).

8.8 OGIN Biogas

OGIN Biogas bv in Lelystad, is active in the design, development, engineering, and supply of farm-scale biogas reactors for the digestion of manure and co-substrate – biogas plants – for the agricultural sector and biogas plants for the industry (Internet Source 241).

8.9 Orgaworld Netherlands

Orgaworld Netherlands, Uden (Noord Brabant) focuses on supply and operation of organic waste treatment plants, and particularly on the processing of organic waste to produce the final products energy, fuels, and agricultural products. Technologies used are anaerobic digestion combined with CHP producing power and compost as residual product (Internet Source 242).

8.10 Thecogas Biogastechniek

Thecogas Biogastechniek bv (detached from PlanET, Germany, in 2009) in Lochem, is specialised in turnkey supply of biogas plants and components thereof (Internet Source 243).

8.11 Van der Wiel Stortgas

Van der Wiel Stortgas, subsidiary of Van der Wiel Holding bv in Drachten, is specialised in design, engineering, supply, and installation of plants for energy recovery (e.g. based on gas engine CHP) from tip gas (Internet Source 244).

8.12 Operation and maintenance of biogas plants

The workforce and turnover related to operation and maintenance of biogas plants in the Netherlands is estimated based on data of biogas-based power generation in (CBS, 2011) and operation and maintenance costs of biogas-based power in (Lensink et al, 2010) as elucidated in Table 8.1.

Table 8.1 *Employment and turnover related to biogas in the Netherlands based on statistics of biogas based electricity and operation and maintenance costs*

	Electricity generated [GWh]	Capacity [kW]	O&M costs [€/kW]	O&M employment [FTE]	O&M turnover [million €]
Tip gas	82	12,620	240	76	3.0
Biogas sewage plants	154	19,250	220	106	4.2
Biogas agricultural companies	553	69,130	240	416	16.6
Other biogas	135	16,880	210	89	3.5
Total biogas	924	117,865		~ 690	27

Sources : CBS, 2011 ; Lensink et al, 2010.

8.13 Summary

In 2010, the gross final energy equivalent of biogas in the Netherlands was 8.3 PJ (CBS, 2011). The workforce of the nine companies engaged in biogas plants and equipment (R&D, engineer-

ing and design, manufacturing, and installation) as well operation and maintenance of the biogas plants is estimated at approximately 1,000 people, and the turnover at € 100 million (Table 8.2).

Table 8.2 *Key data turnover and employees of biogas (component) companies in the Netherlands*

	Turnover 2008 [€ mln]	Employees 2008	Turnover 2009 [€ mln]	Employees 2009	Turnover 2010 [€ mln]	Employees 2010
Ballast Nedam IPM		N/A		N/A		N/A
BiogaS International Project		N/A		- [a]		-
Brouwers BioEnergy		N/A		N/A		N/A
Certified Energy		N/A		N/A		- [b]
DMT Milieutechnologie		N/A		N/A		N/A
Gastreatment Services		N/A		N/A		N/A
OGIN Biogas		N/A		N/A		N/A
Orgaworld Netherlands		N/A		N/A		N/A
Thecogas Biogastechniek		N/A		N/A		N/A
Van der Wiel Stortgas		N/A		N/A		N/A
Operation and maintenance	N/A	N/A		~ 730	27	~ 690
Total	~62	~240	~95	~1,000	~100	~1,000

a In 2009/2010, BiogaS International Project bv was declared bankrupt.
b In December 2010, Certified Energy bv was declared bankrupt
Sources: SenterNovem, 2006; CBS, 2011; Lensink et al, 2010 ; Internet Sources 233-244.

9. Municipal solid waste

There are nine companies active in power generation or combined heat and power (CHP) based on municipal solid waste (MSW) in the Netherlands, viz. ARN (Nijmegen), Afval Energie Bedrijf (Amsterdam), E.ON Energy from Waste (Delfzijl), Attero (Moerdijk and Wijster), HVC Groep, OMRIN (Harlingen), SITA ReEnergy, Twence, and Van Gansewinkel Groep. Data of these companies is presented below. The relevant turnover and workforce are related to the biogenic fraction of the MSW, equivalent to approximately 50% of the energy content. (Agentschap NL, 2010) provides an overview of MSW plants in operation and under construction.

9.1 Afval Energie Bedrijf Amsterdam

Afval Energie Bedrijf Amsterdam, owned by the municipality of Amsterdam, operates the largest complex of combustion of MSW for power (and heat) in the Netherlands. The capacity of the MSW plants is 80 MW_e (net) and 50 MW_{th} (district heating), based on 1,360 kt/a of MSW. The turnover related to energy was € 46.76 million in 2009 (and presumably the same in 2010), € 24.03 million in 2008, and € 32.35 million in 2007. For 2009, the workforce related to waste-to-power is based on the proportion of the turnover from energy to the total turnover times the workforce of 360 FTE, resulting in 48 FTE, assuming a renewable fraction of MSW of 50%. This number has also been used for 2008 and 2010 (AEB, 2010; Internet Sources 245-246).

9.2 ARN (Nijmegen)

ARN bv (Nijmegen) operates a combustion plant for MSW in Nijmegen of 23 MW_e, based on 280 kt/a of MWS. The turnover of waste to energy is estimated at € 10 million, based on the waste fraction used for energy times the turnover (€ 39.96 million in 2010, € 45.25 million in 2009), and assuming a biogenic fraction of MSW of 50%. The workforce, assuming a renewable fraction of MSW of 50%, is estimated at 25 in 2010 (ARN, 2011; ARN, 2010).

9.3 E.ON Energy from Waste (Delfzijl)

A subsidiary of E.ON Benelux, E.ON Energy from Waste, operates a new MSW plant at Delfzijl of 28 MW_e (net), based on 275 kt/a of MSW. Its turnover is estimated at € 14 million, and its workforce related to energy from waste at 30 in 2010 (Internet Source 247).

9.4 Attero (AEC Moerdijk, GAVI Wijster)

Attero – subsidiary of RWE – operates MSW plants in Wijster (GAVI) and Moerdijk (AEC Moerdijk). The aggregate generating capacity of the two waste-to-power plants is estimated at 153 MW_e (net), based on 1,630 kt/a of MSW. Its turnover related to the renewable fraction of energy from waste is estimated at € 145 million, and its workforce at 172 employees (Internet Source 248).

9.5 HVC

N.V. HVC (52 municipalities) operates MSW plants at Alkmaar and Dordrecht, of which the one in Dordrecht is due for commissioning in May 2011[1]. The electric capacity was 56 MW_e

[1] Until this date, municipal solid waste is incinerated in a plant in Dordrecht without electricity generation. This plant will be closed after commissioning of the waste-to-power plant,

(net) in 2010 (both MSW plants also supply heat in Alkmaar and Dordrecht), and the capacity is 530 kt/a of MSW (885 kt/a in 2011 after commissioning of the MSW plant at Dordrecht). Its turnover (related to power and heat) is estimated at € 58 million, and its workforce at 217 employees out of a total of approximately 700 FTE (HVC, 2011; HVC, 2010; HVC, 2009).

9.6 Omrin (Harlingen)

Omrin (Afvalsturing Friesland N.V.), owned by 31 municipalities in Friesland, operates a 22 MW_e (net) MSW plant (REC, ReststoffenEnergieCentrale) at Harlingen, based on 228 kt/a of MSW. The plant is commissioned in 2011. The turnover related to the renewable energy fraction from waste is estimated at € 11 million, and its (relevant) workforce at 25 employees (Internet Source 249).

9.7 SITA ReEnergy (Roosendaal)

SITA ReEnergy in the Netherlands – a subsidiary of SITA Corporation which is active in seven European countries – owns an MWS plant in Roosendaal. The MSW plant with an electric capacity of 21 MW_e (net) and a capacity of 224 kt/a is due for commissioning in 2011. The current MSW plant, which will be decommissioned, only supplies about 4.5 MW_{th} of heat to a nearby greenhouse horticulture complex. The turnover in 2010 is estimated at € 21 million and the workforce at 77 (Internet Source 250).

9.8 Twence (Hengelo)

Twence bv operates two MSW plants in Hengelo with a combined capacity of 52 MW_e (net), based on 520 kt/a of MSW (Internet Source 251). Its turnover is estimated at € 74 million, and its workforce at 133 employees.

9.9 Van Gansewinkel Groep

Van Gansewinkel Groep operates MSW plants in Duiven and Rozenburg (the MSW plant in Rotterdam was closed in 2010). The total capacity stood at 146 MW_e (net), based on 1,550 kt/a of MSW (after closure of the MSW plant at Rotterdam). The turnover related to renewable energy from waste is € 139 million, and the workforce is estimated at 164 employees (Internet Source 252-253).

9.10 Summary

The gross final energy equivalent of the biogenic part of MSW amounted to 11.5 PJ in 2010 (CBS, 2011). Table 9.1 presents estimates of the turnover in renewable energy generation based on MSW, which is estimated at approximately € 500 million (in 2009, also € 500 million), and the relevant workforce at approximately 890 people (in 2009, approximately 760). In the present study, the estimate of the turnover and workforce of the MSW industry in the Netherlands is significantly lower than in (Lako and Beurskens, 2010), because in this study data have been used from annual accounts of the MSW industry, in which a much smaller share of the turnover and workforce has been attributed to ‘energy from waste’ than previously assumed.

Table 9.1 *Key data turnover and employees of companies in MSW power in the Netherlands*

Company	Turnover 2008 [€ mln]	Employees 2008	Turnover 2009 [€ mln]	Employees 2009	Turnover 2010 [€ mln]	Em-ployees 2010
Afval Energie Bedrijf (Amsterdam)	12	48	23	48	23	48
ARN (Nijmegen)	12	22	10	20	10	25
E.ON Energy from Waste (Delfzijl)	N/A	N/A	N/A	N/A	14	30
Attero (RWE) (Moerdijk & Wijster)	170	176	187	198	145	172
HVC (Alkmaar & Dordrecht)	62	202	51	183	58	217
Omrin (Harlingen)	N/A	N/A	N/A	N/A	11	25
SITA ReEnergy (Roosendaal)	5	16	5	16	21	77
Twence (Hengelo)	45	80	57	102	74	133
Van Gansewinkel Groep (Duiven and Rozenburg)	163	168	178	189	139	164
Total	~ 470	~ 710	~ 500	~ 760	~ 500	~ 890

a By the end of 2010, the Baviro plant of SITA ReEnergy was started up, with commissioning due for 2011.
Sources: AEB, 2010 ; ARN, 2011 ; ARN, 2010 ; HVC, 2011 ; HVC, 2010 ; HVC, 2009 ; Internet Sources 245-253.

10. Small hydro power, tidal power, and 'Blue Energy'

Eight companies and institutes are active in hydro power, tidal power, and 'Blue Energy'. The term 'Blue Energy' denotes saline gradient energy, making use of osmotic power due to difference in salt gradient between the North Sea and an estuary or lake. The companies and institutes that are active in conventional hydropower and tidal stream power are Bluewater, Tocordo, Ecofys/Eneco, and Entry Technology Support, whereas REDstack, Wetsus, and the Membrane Technology Group of the University of Twente are engaged in 'Blue Energy'.

Bluewater
Bluewater, an international company in offshore production systems (Internet Source 254), provides engineering and consultancy services to Tocardo for tidal energy devices (see below).

Tocardo
Tocardo International bv designs and develops tidal stream generators, ranging from 50 kW_e (currently in operation at the Afsluitdijk) to 150 kW_e and more (Internet source 255).

Ecofys/Eneco
Ecofys, currently a subsidiary of Eneco (Rotterdam), developed a pilot tidal stream power unit called C-Energy in the Westerschelde (Internet Source 256).

Entry Technology Support
Entry Technology Support bv (Rhenen) is a company that *inter alia* supports 'classical' hydro power and tidal stream energy with engineering and consultancy services (Internet Source 257).

REDstack
REDstack bv (Sneek) is a spin-off from Wetsus that is involved in 'Blue Energy', a technology that generates power from the saline gradient (Internet Source 258).

Wetsus
Wetsus is an R&D establishment in Leeuwarden that is *inter alia* supportive of the Blue Energy technology with development activities and pilot plants (Internet Source 259). Also the Membrane Technology group of the University of Twente is engaged in R&D on membranes for Blue Energy (Internet Source 260).

Summary
The electricity generated by hydropower was 0.38 PJ_e (105 GWh), based on 37 MW_e of conventional hydropower capacity (CBS, 2011). However, there is almost no relation between conventional hydropower generation and the aforementioned companies Table 10.1 provides estimates of turnover and employment of the companies engaged in unconventional hydro.

Table 10.1 *Key data turnover and employees hydropower related companies in the Netherlands*

	Turnover 2008 [€ mln]	Employees 2008	Turnover 2009 [€ mln]	Employees 2009	Turnover 2010 [€ mln]	Employees 2010
Aggregate	1.5	30	1.5	30	1.5	30

Sources: Internet Sources 254-260.

11. Geothermal energy

11.1 Deep geothermal energy

The Dutch association for deep geothermal energy 'Platform Geothermie' counts 65 members in 2011, and showed a steady increase in recent years. Members are companies engaged in deep geothermal energy, engineering firms, utilities, scientific institutes and municipalities (Internet Source 261). The investment cost of one doublet in a geothermal project is estimated at € 6.5 mln or more. A doublet consists of production well and an injection well, which is required to manage environmental effects. The injection well returns fluids from the production well at approximately the same depth, but – based on directional drilling – with a few kilometres distance from the production well, in order to delay cooling of the geothermal source. In addition to the investment in the doublet, the actual source of the energy, there may be a considerable investment in the district heating grid. According to (CBS, 2011), the gross final energy equivalent of deep geothermal energy stood at 0.32 PJ in 2010 (0.14 PJ in 2009). Table 11.1 provides data of turnover and employment in geothermal energy.

Table 11.1 *Key data turnover and employees geothermal energy companies in the Netherlands*

	Turnover 2008 [€ mln]	Employees 2008	Turnover 2009 [€ mln]	Employees 2009	Turnover 2010 [€ mln]	Employees 2010
Companies engaged in drilling (equipment)	13	15	25	40	25	40
Companies engaged in design, engineering, consultancy, etc.	20	45	40	110	40	115
Utilities (Eneco, E.On Benelux, Essent)	3	30	5	40	6	40
Suppliers	4	~30	8	90	9	95
Other, e.g., TU Delft, TNO, etc	15	50	20	80	20	90
Total	~55	~170	~98	~360	100	380

Source: Van Heekeren, 2009-2011; Platform Geothermie,2011.

11.2 Shallow geothermal energy: storage of heat and cooling based on aquifers

Menkveld and Beurskens (2009) pay attention to the widespread use of storage of heat and cooling based on shallow aquifers in the Netherlands. In the framework of this scoping study, it was not possible to collect data on employment and turnover of companies active in this field. The same holds for geothermal heat pumps. The gross final energy equivalent of shallow geothermal energy was 2.1 PJ (CBS, 2011).

12. Overview and conclusions

This study presents an overview of turnover and employment of Dutch companies engaged in wind energy, photovoltaic electricity (PV), solar thermal energy, biofuels, solid biomass, biogas, municipal solid waste (MSW), conventional and unconventional hydro technologies, and geothermal energy. As data on turnover and employment are scarce and incomplete, the figures presented are generally estimates that are fraught with some uncertainty.

The results and conclusions are presented by renewable energy source:

Wind energy
By the end of 2010, the combined on- and offshore wind capacity in the Netherlands stood at 2,230 MW, supplying 4,494 GWh or 16.2 PJ to the grid. The turnover of wind energy companies in the Netherlands is estimated at € 1,330 million and the number of employees at 2,400.

Photovoltaic power (PV)
The total installed capacity of PV in the Netherlands stood at 88 MW_e by the end of 2010, supplying 60 GWh or 0.22 PJ to the grid. Based on a detailed overview of PV related companies and activities, the turnover of PV companies is estimated at € 1,000 million, and the number of employees at 1,240.

Solar thermal energy
The total installed capacity of solar thermal energy in the Netherlands stood at 563 MW_{th} by the end of 2010, supplying the energy equivalent of 0.99 PJ. The turnover of companies in solar thermal energy is estimated at € 53 million, and the number of employees at 960 in 2010.

Biofuel production
Companies producing biodiesel, bioethanol, and biomethanol supplied the energy equivalent of 9.6 PJ in 2010. The turnover in 2010 is tentatively estimated at € 170 million, and the number of employees is estimated at 300.

Solid biomass
The gross final energy equivalent of solid biomass was 34.7 PJ in 2010. Based on fragmented data, the turnover is estimated at € 65 million, and the number of employees is put at 250.

Biogas
At least eight companies produce equipment for biogas plants. In 2010, the gross final energy equivalent of biogas was 8.3 PJ. The turnover is tentatively estimated at € 100 million, and the number of employees including operation and maintenance of biogas plants is put at 1,000.

Municipal Solid Waste (MSW)
Nine companies are engaged in energy generation from MSW, resulting in a gross final energy equivalent of the biogenic fraction of 11.5 PJ in 2010. The turnover of the renewable fraction of the energy from waste from these companies is estimated at € 500 million, and the number of employees at 890.

Hydro power and related technologies
There are about eight companies active in hydro power or related technologies. In 2010, the conventional hydro capacity stood at 37 MW, supplying 105 GWh or 0.38 PJ to the grid. The turnover is estimated at € 1.5 million and the number of employees is put at 30.

Geothermal energy
According to (CBS, 2011), the gross final energy equivalent of deep geothermal energy stood at 0.32 PJ in 2010. There are tens of companies engaged in (deep) geothermal energy in the Netherlands. The turnover of these companies is tentatively estimated at € 100 million, and the number of employees at 380 in 2010. For shallow geothermal energy – storage of heat and cooling based on shallow aquifers – and for geothermal heat pumps, no (reliable) data were retrieved.

All in all, renewable energy sources considered in the present study represent a gross final energy equivalent of 86.2 PJ in 2010. Table 12.1shows that the total turnover of RE companies in the Netherlands is estimated at € 3.32 billion in 2010 (€ 3.15 billion in 2009). The total workforce of RE companies in the Netherlands is estimated at approximately 7,450 employees in 2010 (approximately 7,130 in 2009). Based on (ADEME, 2009) the ratio between indirect and direct employment may be 0.88. Therefore, the total direct and indirect employment of companies engaged in renewable energy in the Netherlands may be estimated at 14,000 people. The numbers of turnover and workforce presented are not precise, and several technologies or stages in a renewable energy sector were not covered in the present study. For instance, the study does not include storage of heat and cooling based on aquifers and geothermal heat pumps. With respect to solid biomass, this study does not include turnover and employment related to wood-fired furnaces and boilers in households and related to co-firing of biomass in power plants.

In Chapter 1 (Introduction) it has been explained that the abovementioned aggregated results for turnover and employment in renewable energy in the Netherlands may be compared to some extent with those of (Van Rossum et al, 2011). One of the difficulties is that the definition of the 'sustainable energy sector' is different from 'renewable energy' in the following respect:

- Inclusion of Carbon Capture and Storage or CCS, a technology which is not renewable;
- Inclusion of electric transport, hydrogen technology, and smart grids, which may be related to renewable energy but are not necessarily renewable;
- Inclusion of energy conservation which is not renewable in itself;
- Inclusion of 'heat and geothermal' which is a mixture of renewable and not-renewable.

Another difficulty is that the study of Statistics Netherlands refers to the year 2008, whereas the present study focuses on the year 2010.

Nevertheless, the results of the present study may be translated into data for 2008. For 2008, the aggregate turnover is estimated at €2.5 billion and the employment at approximately 5,000 FTE. If the abovementioned categories CCS, electric transport, hydrogen technology, smart grids, energy efficiency, and 'heat and geothermal' are excluded, (Van Rossum et al, 2011) come up with an aggregated turnover of €3.2 billion and an employment of 8,200 people. Apparently, the employment estimate of Statistics Netherlands includes the indirect employment. If we include the indirect employment, the result for 2008 is approximately 9,475 FTE, and 9,150 FTE, exclusive of geothermal energy (for reasons of consistency). However, although the total (direct and indirect) employment estimates of the present study and Statistics Netherlands do not differ much (about 10%), the turnover estimates do. This needs to be addressed in future studies.

Table 12.1 *Key data turnover and employees of companies engaged in RE in the Netherlands*

Renewable energy sector	Turnover 2007 [€ mln]	Employees 2007	Turnover 2008 [€ mln]	Employees 2008	Turnover 2009 [€ mln]	Employees 2009	Turnover 2010 [€ mln]	Employees 2010
Wind energy	840	1,500	1,100	2,000	1,220	2,200	1,330	2,400
Photovoltaic energy	328	525	580	800	970	1,180	1,000	1,240
Solar thermal energy	30	580	35	670	60	1,090	53	960
Biofuels	40	70	130	220	140	260	170	300
Solid biomass	60	240	62	240	65	250	65	250
Biogas	60	240	62	240	95	1,000	100	1,000
Municipal solid waste	420	670	470	710	500	760	500	890
Small hydro & tidal	1.2	25	1.5	30	1.5	30	1.5	30
Geothermal energy	45	85	55	170	98	360	100	380
Geothermal heat pump	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	1,800	~3,900	~2,500	~ 5,080	~3,150	~ 7,130	~ 3,320	~ 7,450

Current energy and climate policies warrant a strong growth of renewable energy in Europe and in the Netherlands. For instance, the Netherlands has to increase the share of renewable energy to 14% of the gross final energy use in 2020 (compared to 3.8% in 2010). With regard to the turnover and the number of employees until 2020, it is to be expected that most renewable energy categories will show a healthy growth, except municipal solid waste. The latter energy source is already exploited to a very large extent. It remains to be awaited to which extent the Netherlands will succeed in grasp the benefits of technological development. However, it should be noticed that some renewable energy technologies are labour-intensive and others much less.

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Abbreviations

ALD	Atomic Layer Deposition
CBG	Compressed Biogas
CBS	Statistics Netherlands (Centraal Bureau voor de Statistiek)
CCS	Carbon Capture and Storage
CHP	Combined Heat and Power
CIGS	Copper Indium Gallium Selenide
CPL	Cell Plating Line
CPV	Concentrating Photovoltaic Power
CSP	Concentrating Solar Power
CTC	Composite Technology Centre
DPL	Direct Plating Line
ETBE	Ethyl Tertiary Butyl Ether
EWEA	European Wind Energy Association
FAME	Fatty Acid Methyl Ester
FRP	Fibre Reinforced Plastics
FTE	Full Time Equivalent
ICCP	Impressed Current Cathodic Protection
LBG	Liquid Biogas
MSW	Municipal Solid Waste
OEM	Original Equipment Manufacturer
PPA	Power Purchase Agreement
PV	Photovoltaic electricity
R&D	Research and Development
RE	Renewable Energy
RGS	Ribbon Growth on Substrate
RIM	Resin Infusion Molding
ROV	Remotely Operated underwater Vehicle
RTP	Rapid Thermal Processing
SDP	Submerged Deepwater Platform
TCS	TriChloroSilane
TP	Transition Piece
TSO	Transmission System Operator