Public and private energy RTD expenditures in Belgium, Luxembourg and the Netherlands

A pilot study on behalf of SenterNovem based on an IEA format

P. Lako

M.E. Ros

ECN-E--07-035 June 2007

Acknowledgement
This study on behalf of SenterNovem may be regarded as an effort to integrate existing databases on energy Research and Technological Development (RTD) of the IEA for Belgium, Luxembourg (data was non-existent), and the Netherlands. The focus of the study is on filling the gaps in the IEA database for Belgium with regard to public energy RTD, and retrieving first-hand public energy RTD data for Luxembourg. Another main effort in the framework of the study is to collect, retrieve, and analyse private energy RTD data for the Netherlands. The authors want to express their gratitude for valuable advice and comments from Prof. Dr. W.C. Sinke (ECN, Unit Solar Energy) with regard to the photovoltaic industry. The project is registered at ECN under project number 7.7807.

Abstract
This study aims to present a broad view of energy RTD expenditures of Belgium, Luxembourg, and the Netherlands, *in the public domain* and *by private enterprises*. Data is provided as much as possible by disaggregating into a format of the IEA (IEA code). IEA data serve as the starting point for data collection. The main task is to fill in the gaps in the database, viz.:
- Completing the IEA database for Belgium with regard to public energy RTD.
- Starting with a database of public energy RTD for Luxembourg.
- Collecting, retrieving, and analysing private energy RTD data for the Netherlands.

The latter data, based on a ‘bottom-up’ approach, are compared to recent data of SenterNovem based on an R&D subsidy scheme in the Netherlands. The private energy RTD expenditures from both sources (the bottom-up approach in this study and the data of SenterNovem) are combined to one database of private energy RTD that may be used for, e.g., the IEA.

Contents

List of tables

List of figures

Summary

This study aims to present a broad view of energy RTD - Research and Technological Development[1] - expenditures of Belgium, Luxembourg, and the Netherlands, *in the public domain* and *by private enterprises*. The timeframe is 1974-2005, as IEA's website and (IEA, 2006a) provide public energy RTD expenditures of IEA countries starting in 1974. Recent years receive more emphasis than the first decades. For various reasons, private energy RTD data is hardly accessible. As a matter of fact, the private sector is more dynamic than, e.g., the residential sector, which is why energy RTD data of the private sector will become quickly outdated. Therefore, the timeframe for *private sector RTD* data is 2000-2005. Data is provided as much as possible by disaggregating into a format of the IEA (IEA code). IEA data serve as the starting point for data collection. The main task is to fill in the gaps in the database. For practical reasons expenditures are presented in nominal €'s (if needed, converted from US$).

With respect to public energy RTD in Belgium, and Luxembourg and private energy RTD in the Netherlands, data is collected and analysed in the following way, and to the following extent:
- Data of RTD expenditures by country: Belgium and the Netherlands (and Luxembourg).
- Publicly versus privately financed RTD. Publicly financed RTD is retrieved in particular for Belgium based on interviews with representatives from governmental institutions and disaggregated in accordance with the IEA code. The same holds for Luxembourg (minor effort).
- Data of private energy RTD of companies (with R&D centres) in the Netherlands based on:
  - Annual reports
  - Websites
  - Other publications, e.g., articles in magazines
  - Interviews with key private companies or inter-firm organisations.

  As far as possible, data of private energy RTD is disaggregated according to IEA code. This bottom-up approach provides a dataset that is different from, but also complementary to, the database in (SenterNovem, 2007) based on the R&D subsidy scheme called WBSO (Paragraph 4.4).
- Due attention is paid to sources of uncertainty or lack of accuracy or completeness of energy RTD data, and the extent to which they may be disaggregated according to the IEA format.

In the period 2000-2005, industrial R&D expenditure increased by approximately 3% annually, ending up at nearly € 4 billion in 2005. The R&D expenditure of commercial and environmental services enterprises increased to € 0.9 billion in 2005 (CBS, 2007). Energy R&D is commonly only a fraction of total R&D, except for oil and gas industries and companies specialised in energy technology.

Technisch Weekblad (2007a) is another source of private R&D expenditure. This literature source shows the top-25 private companies ranked by R&D expenditure for the period 2002-2006. Comparison between the 'top-22' of the *industrial* companies and the corresponding total industrial R&D shows that the 22 largest industries in terms of R&D in the Netherlands represent between two-thirds and three-quarters of the total industrial R&D (CBS, 2007).

SenterNovem gives an update of private energy RTD expenditures in (SenterNovem, 2007) for the years 2003-2005, to the extent that the R&D was financed with WBSO subsidy - an R&D support scheme of the Ministry of Economic Affairs. The database starts with the total expenditures, i.e. the private expenditures and the subsidies. Then, the subsidies are subtracted, resulting

[1] According to (EC, 2005a), RTD includes fundamental research, socioeconomic research, industrial and applied research, and (pilot) demonstration activities.

in 'net' expenditures. (SenterNovem, 2007) shows that the latter range from approximately € 150 mln in 2000 to approximately € 220 mln annually for 2003-2005.

With regard to *public energy RTD*, data from the public domain, e.g., from the IEA and from governmental institutions in Belgium and Luxembourg (and marginally, the Netherlands) have been checked for completeness. Considering the lack of data of Belgium for several years and of Luxembourg in the total period considered, the focus has been on completing the database for Belgium and gathering first-hand data for Luxembourg. The Walloon and Flemish governments were able to provide more or less detailed data on their energy RTD expenditure. In 2003, the *public energy RTD expenditure* for Wallonia amounted to € 10 mln (with due disaggregation) and for Flanders to € 23 mln (without disaggregation). Besides, the federal government of Belgium spent some € 43 mln (with due disaggregation) on nuclear RTD in 2003. Similarly, data were obtained from Luxembourg on their public RTD expenditure, of which the energy RTD expenditure is a fraction of about 75%: energy RTD in Luxembourg is approximately € 2 mln.

Another main effort in the framework of this study is the collection, retrieval, and analysis of data of *private energy RTD expenditures* in the Netherlands. This effort was alleviated by the recent study (SenterNovem, 2007) which presents data of private energy RTD spending based on data from the so-called WBSO R&D subsidy scheme, for the years 2000 and 2003-2005. The authors used a methodology to retrieve and analyse private energy RTD data, viz. combination of search for data in annual reports, websites, etc. and interviews with representatives of the industry or inter-firm collaborative enterprises. This methodology (more or less bottom-up) proved to be complementary to energy RTD data from (SenterNovem, 2007) in two respects:
- For the years 2001 and 2002, the 'bottom-up' approach provided additional data.
- For two multinationals, Philips and Shell, crude estimates of their energy-related RTD by IEA category could be made, that turned out to be much higher than corresponding data from (SenterNovem, 2007), based on the WBSO subsidy scheme.

The rather large differences in the WBSO database and the data from the 'bottom-up' approach for energy RTD categories that are representative of Philips Netherlands and Shell Netherlands may be explained mainly on the following grounds:
- Due to lack of more details about the RTD expenditures of Shell Netherlands, all of these expenditures are assumed to be energy-related and disaggregated to IEA classes.
- Due to deficiency of data of RTD performed by Philips in the Netherlands, large 'chunks' of those expenditures are attributed to energy efficiency, notably reduced power consumption and stand-still losses and improved lighting efficiency. However, this may be an underestimation or an overestimation, depending on the deviation of the disaggregation of the Dutch RTD compared to the RTD of Philips Company.
- The comparison is between the 'bottom-up' estimates in this study and data of (SenterNovem, 2007), notably after deduction of the financial contribution from the WBSO scheme. However, in case of the 'bottom-up' approach such a distinction is not made (estimates of RTD expenditure may include subsidies of governments, albeit not quantified).

Private energy RTD expenditures in the Netherlands may be estimated at approximately € 500-560 mln per year, i.e. about 13% of the total industrial R&D or 10% of the R&D of private enterprises (CBS data). Most of the disaggregated data are based on (SenterNovem, 2007), except for the energy RTD expenditures of Shell Netherlands (of which the total is published by Shell) and of Philips Netherlands (which are a fraction of the total RTD expenditures of Philips Netherlands which published too). The synthesis of the data of SenterNovem and of data from the bottom-up analysis in this study provides a valuable dataset that may be used in the framework of, e.g., the IEA.

1. Introduction

This study aims to present a broad view of energy RTD - Research and Technological Development[2] - expenditures of Belgium, Luxembourg, and the Netherlands, *in the public domain* and *by private enterprises*. The timeframe is 1974-2005, as IEA's website and (IEA, 2006a) provide public energy RTD expenditures of IEA countries starting in 1974. Recent years receive more emphasis than the first decades. For various reasons, private energy RTD data is hardly accessible. As a matter of fact, the private sector is more dynamic than, e.g., the residential sector, which is why energy RTD data of the private sector will become quickly outdated. Therefore, the timeframe for *private sector RTD* data is 2000-2005. Data is provided as much as possible by disaggregating into a format of the IEA (IEA code). IEA data serve as the starting point for data collection[3]. The main task is to fill in the gaps in the database. Although it would have been possible to convert expenditures into a currency of *one reference year* (e.g., the Euro of 2005), for practical reasons expenditures are presented in nominal €'s (if needed, converted from US$).

The study should enable construction of commonly agreed indicators to help policy makers make well-weighted decisions regarding sustainable energy strategies. There is a complete IEA dataset of public RTD expenditures of the Netherlands, and (Ecorys-NEI, 2006) provides data for 2004. The IEA dataset for Belgium, however, is incomplete due to the split up in three regions (Flanders and Wallonia are of interest), and data for Luxembourg is non-existent. Therefore, the dataset for Belgium has to be updated and for Luxembourg first-hand data are needed.

Most countries that are setting benchmarks in energy efficiency improvement and renewable energy growth, such as Denmark, Germany, Finland, and the Netherlands, have strongly funded energy RTD programmes, which often aid development of emerging and new technologies (NEECS, 2006). The favourable position of public energy RTD in the Netherlands is confirmed by (Van Duin, 2006). She concludes that 'with regard to the per capita budgets for energy R&D, the Netherlands is leading together with Japan and the United States'.

Generally, *public energy RTD* has a long-term focus and involves both fundamental and applied research, development, and demonstration. The IEA provides data on energy RTD in the Netherlands for the years 1974-2005. IEA data is available for Belgium until 1999, except for 1990. For 2000 and beyond, (IEA, 2006b) and (EC, 2005c) provide data for Flanders and Wallonia. In the framework of this study, data for Belgium and Luxembourg is retrieved to the extent possible, based on literature search and interviews with representatives from the governments.

Private energy RTD generally has a shorter time horizon than publicly financed energy RTD. However, large companies may also be engaged in basic energy research with a long time horizon. All in all, the 'time to market' is an important indicator for private energy RTD. Data of private sector energy RTD expenditures can be obtained from two broad classes of data sources. The first source is a government or the EU. The second source is directly from the firms themselves or from inter-firm collaborative enterprises (Dooley, 2000). For Renewable Energy Sources (RES), the latter approach seems to be worthwhile as there are inter-firm organisations for, e.g., wind (EWEA[4]) and photovoltaic power, PV (EPIA).

Problems may arise due to the scale of private companies. Generally, companies in the Netherlands and Belgium operate on markets that are (much) larger than the country of origin itself. Private RTD expenditures should be attributed to the country in which the R&D is performed.

---

[2] According to (EC, 2005a), RTD includes fundamental research, socioeconomic research, industrial and applied research, and (pilot) demonstration activities.

[3] (EC, 2005b) proposes to revise the IEA questionnaire on energy R&D expenses including definitions of R&D.

[4] Appendix A provides a list of abbreviations and acronyms.

(Dooley, 2000) reports another source of uncertainty, viz. attribution of RTD expenses to, e.g., process improvement instead of energy saving. Interviews with stakeholders may solve this problem. Another phenomenon is that private RTD may be focused on technologies that are not considered energy-related, e.g., research on aircraft gas turbines from which stationary gas turbines may profit. Therefore, a technology has to be identified as energy-related.

For private companies, energy RTD data is practically absent. The study starts with reporting RTD data of companies that (partially) originate from the Netherlands, focusing on the energy RTD performed in this country. These preliminary data is completed by interviews with key enterprises in the Netherlands and with inter-firm collaborative enterprises that may provide useful data or insights. Private energy RTD data may be less reliable and/or accurate than for the public domain. Also, energy RTD cannot always be separated from non-energy R&D.

Almost all of the data pertains to public and private energy RTD expenditures in Belgium and the Netherlands, and not to EU contributions. It is evident that the EU has substantial energy RTD programmes, consisting of numerous projects. EU contributions to projects with research institutes and universities are included in the IEA database of public RTD expenditures. With regard to private-sector RTD and in case of co-financing by private enterprises, however, it would be elaborative to disentangle the EU contributions and the companies' own expenditures. The authors chose to quantify as much as possible energy RTD expenditures of industrial sectors or companies representative of those sectors, without undue attention for double counting. Although it is acknowledged that overestimation of private RTD spending is probable or at least possible, the methodology may be refined in the future. Also, a few companies publish gross RTD expenditures, including funds from the EU, as well as net expenditures in annual reports.

Chapter 2 presents a methodology to retrieve energy RTD data based on literature, articles in, e.g., magazines, and interviews with representatives from industry, governments, and inter-firm enterprises. Chapter 3 provides public energy RTD data found with this methodology for Belgium and Luxembourg. Chapter 4 summarises three publications, two of which address private *R&D expenditures* (timeframe 2002-2006), viz. (CBS, 2007) and (Technisch Weekblad, 2007a), and the third - (SenterNovem, 2007) - private *energy RTD expenditures* in the Netherlands, timeframe 2003-2005. The SenterNovem study is based on data of an R&D subsidy scheme, WBSO[5]. Chapter 4 also includes a section on public RTD expenditures on hydrogen and fuel cells, which may serve to refine IEA's dataset of the Netherlands. All in all, Chapter 4 provides insight in *R&D expenditures* of Dutch companies (including multinationals) by industrial sector, or ranked by expenditure (€ mln), and of *energy RTD spending* by IEA code (WBSO data).

Chapter 5 contrasts with Chapter 4 in methodology to infer energy RTD expenditures in private companies. The authors apply the aforementioned methodology of literature search and interviews with representatives from industry or inter-firm collaborative enterprises. For practical reasons, only private enterprises in the Netherlands are considered. Thus, Chapter 5 is a bottom-up approach of the quest to quantify energy RTD expenditures of companies (including multinationals) in the Netherlands. Finally, Chapter 6 presents a few conclusions and recommendations.

5 WBSO is the abbreviation for Wet Bevordering Speur- en Ontwikkelingswerk (see Appendix A).

2. Methodology

2.1 Introduction

In order to retrieve data of public and private energy RTD, several options exist. First of all, it is useful to make a clear distinction between public and private energy RTD. Public energy RTD is defined as follows, based on (Norway, 2005):

> *Public energy RTD expenditures are financial contributions from the (Dutch) government or the EU to research centres, universities, etc. - also private companies in, e.g., consortia - as well as contributions channelled by the government through, e.g., SenterNovem aimed at research, development, and demonstration of energy technologies. A small proportion comes from provincial or local administrations.*

The corresponding definition of private energy RTD is as follows:

> *Private energy RTD expenditures are financial contributions from industrial enterprises or other industrial activity, generally to energy RTD activities in the enterprise itself. Contributions to these private RTD activities from the Dutch government or the EU are considered as public energy RTD.*

Paragraph 2.2 describes the methodologies to retrieve and quantify public energy RTD data. In Paragraph 2.3, a corresponding overview is presented of the 'bottom-up' methodology applied to private energy RTD expenditures. Paragraph 2.4 shows how data of energy RTD expenditures are analysed and handled.

2.2 Public energy RTD data

With regard to *public energy RTD*, data from the public domain, e.g., from the IEA and governments in Belgium, Luxembourg, and the Netherlands are checked for completeness. Considering the different quality of the data, the focus is on completing the database for Belgium and finding data for Luxembourg. This is accomplished by interviewing representatives from governmental institutions (Table 2.1). To complete the IEA database for Belgium, lacking data on energy RTD expenditures (of Flanders and Wallonia) is retrieved (to a reasonable extent) and presented. In Flanders, RTD funds have to be distinguished from market development funds.

Table 2.1 *Data collection and analysis for public RTD expenditure*

	Belgium	Luxembourg	The Netherlands
Analysis of dataset	√	-	(Ecorys-NEI, 2006) and IEA
Completion of data	√	-	√ (H_2 and FC RTD)
Interview → data	√	√	-

For Luxembourg, an interview with a representative of the government that has experience in energy related RTD provides first-hand information and a preliminary view on energy RTD in Luxembourg. As this country does not have a large energy RTD budget and there are hardly any large companies engaged in energy RTD, the efforts are modest (information by telephone).

IEA data of public energy RTD expenditures in the Netherlands - including EU contributions to projects with participation from public institutions in the Netherlands (universities, research centres) - is fairly complete, except for data on hydrogen (H_2) and fuel cells RTD (Table 2.1).

2.3 Private energy RTD data

Data of *private energy RTD expenditure* is practically non-existent. Only companies in (originating from) the Netherlands - occasionally Belgium - are addressed. Data is searched based on:
1. Annual reports.
2. Websites.
3. Other publications, e.g., articles in magazines.
4. Interviews for verification and possibly additional information or data.

The latter interviews refer to companies or inter-firm enterprises in the Netherlands (Table 2.2).

Table 2.2 *Data collection and analysis for private RTD expenditure*

	Belgium	Luxembourg	The Netherlands
Analysis of dataset	-	-	√
Completion of data	-	-	√
Interview → data	-	-	√

Table 2.3 lists companies and inter-firm enterprises interviewed or contacted by telephone etc.

Table 2.3 *Companies and inter-firm enterprises in the Netherlands interviewed or contacted*

	Inter-firm enterprise or government institution	Private company
Belgium		
EPIA (PV, Brussels, EU), EWEA (wind)	√	
The Netherlands		
Shell Netherlands (the Hague)		P.M.
VNCI (Leidschendam)	√	
Akzo Nobel (Arnhem)		√
Dow Chemical (Terneuzen)		P.M.
DSM (Heerlen)		√
FME-CWM (Zoetermeer)	√	
Corus (IJmuiden)		√
DAF Trucks (Eindhoven)		P.M.
Philips (Eindhoven)		P.M.
Bouwend Nederland (Zoetermeer)	√	
BAM Groep (Bunnik)		√
UNETO-VNI (Zoetermeer)	√	
Van Dorp installaties Zoetermeer		√
KEMA (Arnhem)		√
Advanced Surface Technology (Bleiswijk)		√
Helianthos/Nuon (Arnhem)		√
OTB Solar (Eindhoven)		P.M.
Scheuten Solar (Venlo)		√
Siemens Solar Projects (the Hague)		√
Solland Solar Energy (Heerlen/Aachen)		√
Ubbink Solar Energy (Doesburg)		√
AE-Rotor Techniek (Hengelo)/Suzlon Energy		√
Darwind (Ecoventures, Utrecht/Den Helder)		P.M.
Emergya Wind Technologies (Schoondijke)		√
Harakosan Europe		P.M.
Home Energy (EnergyBall®, Schoondijke)		√
LM Glasfiber Holland		P.M.
Polymarin Composites (Hoorn)		√
Wind Energy Solutions (Zijdewind)		√
Agrotechn. and Food Innov. (Wageningen)		√
Biomass Technology Group (Enschede)		√
Nedalco/Cosun		P.M.

2.4 Data analysis and handling

Data for Luxembourg only pertains to the public domain. For practical reasons it was not deemed feasible to retrieve RTD data for private companies in Luxembourg: such data is hardly available. Public energy RTD data of Luxembourg is disaggregated according to the IEA code.

With respect to public energy RTD in Belgium and private energy RTD in the Netherlands, data is collected and analysed in the following way, and to the following extent:

- Data of RTD expenditures by country: Belgium and the Netherlands (and Luxembourg).
- Publicly versus privately financed RTD. Publicly financed RTD is retrieved in particular for Belgium based on interviews with representatives from governmental institutions and disaggregated in accordance with the IEA code. The same holds for Luxembourg (minor effort).
- Data of private energy RTD of companies (with R&D centres) in the Netherlands based on:
    - Annual reports
    - Websites
    - Other publications, e.g., articles in magazines
    - Interviews with key private companies or inter-firm organisations.

  As far as possible, data of private energy RTD is disaggregated according to IEA code. This bottom-up approach provides a dataset that is different from, but also complementary to, the database (SenterNovem, 2007) based on the R&D subsidy scheme called WBSO (Paragraph 4.4).
- Due attention is paid to sources of uncertainty or lack of accuracy or completeness of energy RTD data, and the extent to which they may be disaggregated according to the IEA format.

The authors acknowledge that methodologies to quantify energy RTD expenditures of private companies have advantages and disadvantages. On the one hand, the database of WBSO used in (SenterNovem, 2007) is accurate, but possibly incomplete. Some private R&D projects may not have qualified for a WBSO subsidy. On the other hand, literature search and interviews with key representatives from industries is a straightforward methodology, but RTD expenditures may be overestimated due to double counting (including subsidies from governments or EU) and/or underestimated due to (sub-)sectors overlooked or ill-conceived inferring of data. Combination of the two methodologies may possibly reduce each of the disadvantages signalled.

3. Public energy RTD expenditure in Belgium and Luxembourg

3.1 Introduction

There is a complete IEA dataset of public RTD expenditures of the Netherlands, and (Ecorys-NEI, 2006) provides data for 2004. However, for Belgium and Luxembourg data of public energy RTD is incomplete or lacking. Originally, public energy RTD expenditures of Belgium were coordinated by the government, but from 2000 onwards, a decentralised coordination on the level of Flanders and Wallonia was introduced. The Walloon and Flemish governments are responsible for the RTD expenditures in their own region. Only expenditures on nuclear RTD are still a matter of the federal government. Probably, this is why recent data on RTD expenditures in the IEA database are lacking.

In the case of Luxembourg, the situation is also difficult. The country is rather small and has only little RTD expenditure. For these small amounts it is not possible to make a distinction between the different categories distinguished by the IEA and used in this study. Therefore, the authors only present a concise overview of energy related RTD expenditures.

3.1.1 Belgium

General

In order to complete IEA's dataset of Belgium, representatives of the Walloon and Flemish governments have been interviewed. The focus was on energy RTD expenditures in general, except nuclear energy RTD which resorts to the national government. A representative of the federal government of Belgium was contacted for an overview of nuclear RTD expenditures.

Wallonia

For Wallonia, the authors contacted 'Direction générale des Technologies de la Recherche et de l'Energie' (Stephenne and Switten, 2007). Representatives from Wallonia were able to provide the data for the Walloon region from 1999 to 2003 (Table 3.1, Figure 3.1 and Figure 3.2).

The Walloon government has two kinds of support policies for RTD. Firstly, there is 50% support for projects encompassing a university and a private company. This support is managed in a programme that focuses on a special topic each year. In 2006, this was energy efficiency in buildings. In 2007, it is renewable energy. Projects under this umbrella have an average duration of 3-5 years and the average project subsidy is € 3-5 mln.

Secondly, there is a research and innovation policy. This supports SMEs (Small and Medium Enterprises) with a loan from a fund. The policy is that in general the loan has to be repaid after ten years. It is noticeable that this subsidy and loan scheme is not especially focused on energy technologies, but also on other innovative technologies.

It was hard to get insight into private energy RTD expenditures. Representatives of the ministries indicated that there are a few companies in the Walloon region of interest, viz.:

- Solvay
- Energie solaire (Seraing, Internet Source 1)[6]
- Electrabel.

[6] Flemish Photovoltech, a subsidiary of Total of France, evolved into a significant player on the market of PV cells: production capacity 20 MWp around 2005, envisaged to increase to 80 MWp before end 2008 (Internet Source 2).

It was decided to focus only on public energy RTD in Belgium.

Table 3.1 presents public energy RTD expenditures of Wallonia for the period 1999-2003.

Table 3.1 *Public energy RTD expenditure Wallonia, 1999-2003*

[€ mln]	1999	2000	2001	2002	2003
Conservation					
Industry	0.744	0.748	0.726	0.768	3.757
Residential and commercial	0.678	2.003	0.775	0.744	0.685
Transportation	2.012	0.105	1.743	0.620	0.359
Others	0.059	0.401	0.204	0.248	0.729
Fossil fuels: Oil, gas, and coal					
Total oil and gas	*0.245*	*0*	*0*	*0.026*	*0*
Enhanced oil and gas	0	*0*	0	0	0
Refining, transportation and storage	0.245	0	0	0.026	0
Oil shale and tar sands	0	0	0	0	0
Other	0	0	0	0	0
Total coal	*0.574*	*0.418*	*0.164*	*0.168*	*0.370*
Production, preparation and transport of coal	0.076	0.013	0	0	0
Combustion of coal	0.133	0.215	0.081	0.087	0.245
Conversion of coal	0.141	0	0	0	0
Others (coal)	0.224	0.190	0.083	0.082	0.126
Renewable energy sources					
Total solar	0.686	0.620	1.249	1.388	1.849
Heating and cooling (solar)	0.636	0.556	0.251	0.297	1.433
Photo electric	0.050	0.050	0.050	1.090	0.416
Thermal electric	0	0.015	0.949	0	0
Wind	0.050	0.062	0.050	0.347	0.051
Ocean	0	0	0	0	0
Biomass	0.050	1.104	2.267	1.116	0.603
Geothermal energy	0	0	0	0	0
Total hydro	0.397	0.744	1.261	0.052	0.051
Large hydro (capacity of 10 MW and above)	0	0	0	0	0
Small hydro (less than 10 MW)	0.397	0.744	1.261	0.052	0.051
Power generation and storage technologies					
Electric power conversion	2.278	0.572	0	0.248	0
Electric transmission and distribution	0.497	0.415	0.114	0.372	0.133
Energy storage	0	0.409	0.952	0.496	0.761
Other cross-cutting technologies or research					
Energy system analysis	0.071	0	0	0	0.175
Others	0.338	1.352	0.376	0.855	0.609

Figure 3.1 shows public energy RTD of Wallonia by IEA category, and Figure 3.2 an in-depth view of the (public) Walloon RTD expenditure disaggregated by renewable energy source.

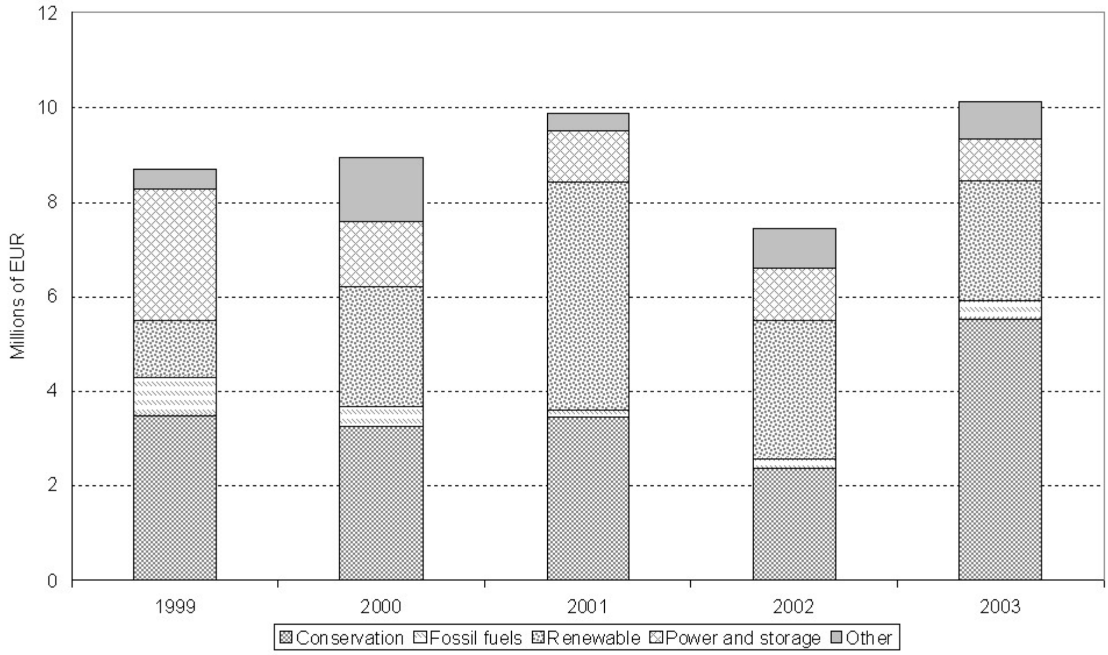

Figure 3.1 *Public energy RTD expenditure Wallonia by IEA category*
Source: Stephenne and Switten, 2007.

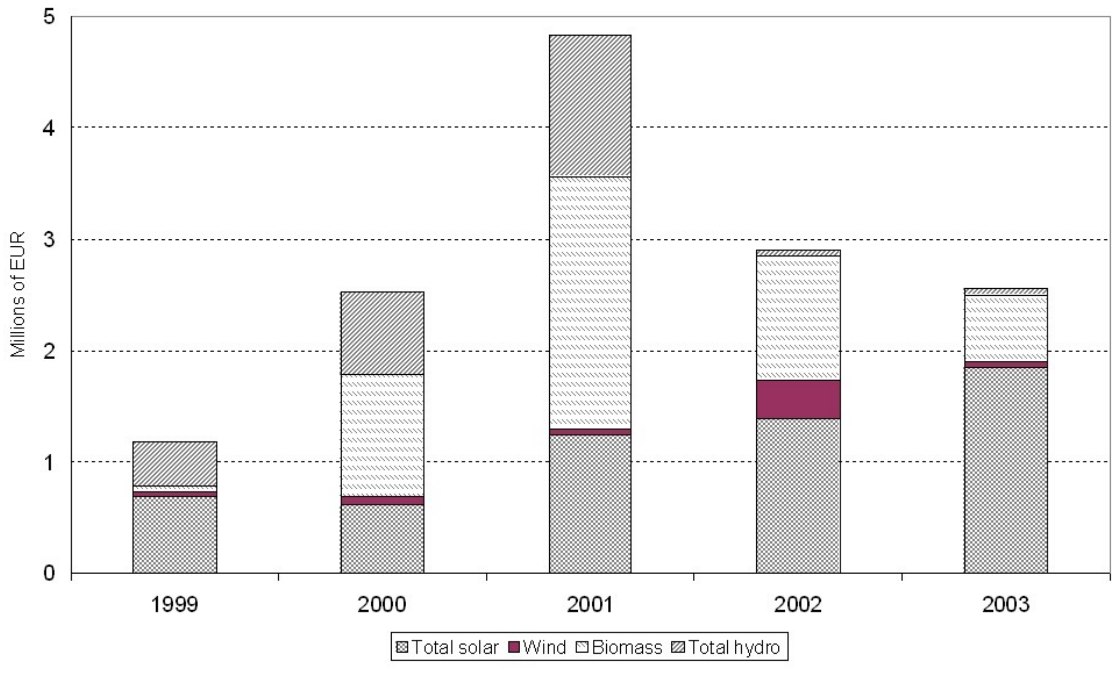

Figure 3.2 *Public RTD expenditure Wallonia disaggregated by renewable energy source*
Source: Stephenne and Switten, 2007.

Flanders

The Flemish region organises its energy-related RTD expenditure via multiple institutions (see Figure 3.3). Overall coordination resorts to the Administration for Science & Innovation. In Flanders, scientific research and innovation are distinguished, which is different from the distinction between basic and applied research that is common in other government organisations.

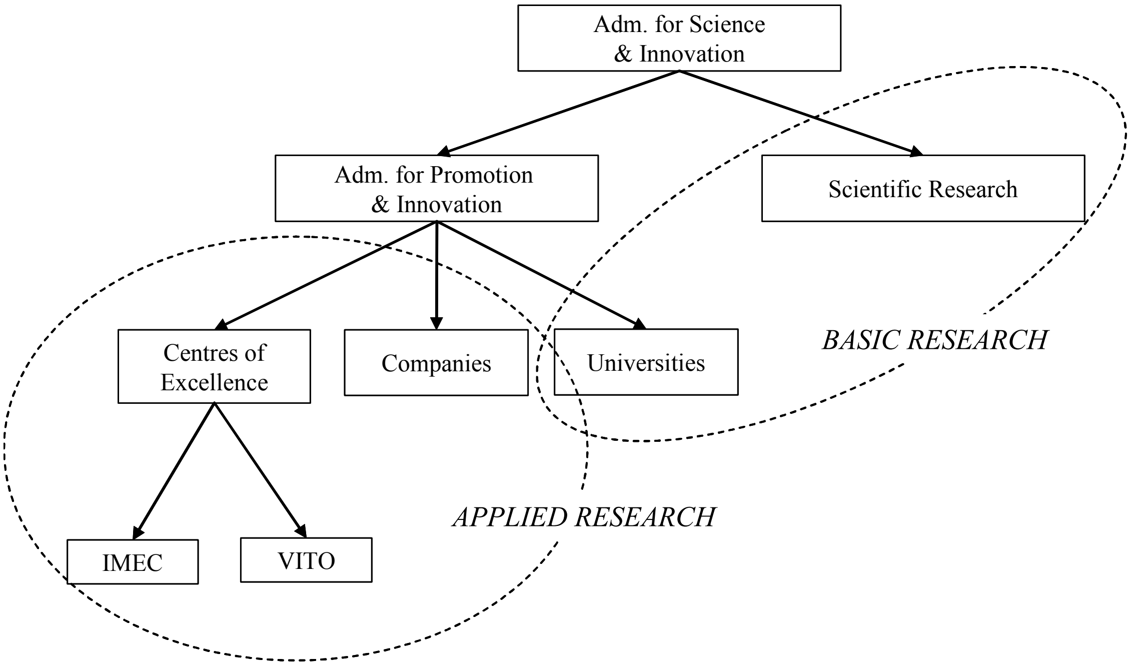

Figure 3.3 *Overview of the organisation of the Flemish region in relation to RTD expenditures*
Source: Bollen, 2007.

Due to a recent reorganisation within the Flemish government one can hardly get hold of recent energy RTD expenditure. Only the total expenditure of the Flemish government is available (Table 3.2).

Table 3.2 *Total public energy RTD expenditure of the Flemish government*

	Unit	1999	2000	2001	2002	2003
Public energy RTD expenditure	[€ mln]	8.437	10.574	11.897	16.017	23.351

Source: Bollen, 2007.

To get a better view of the share of basic and applied research, the expenditures may be disaggregated accordingly, but solely for 2003. The total expenditure for 2003 is € 23.4 million. IWT of Flanders (Instituut voor de Aanmoediging van Innovatie door Wetenschap en Technologie) has generic programmes to stimulate innovation and spent approximately € 13.8 mln on energy related research. Basic research expenditure for 2003 is estimated at € 2.1 mln, demonstration at € 0.3 mln (via the ANRE programme), and environmental projects at € 0.8 mln. Furthermore, two centres are funded especially based on their expertise, viz. IMEC (€ 2.2 mln for PV R&D) and VITO (€ 4.2 mln for hydrogen and fuel cells and policy support activities). It has been noted, that Photovoltech, a subsidiary of Total of France, has evolved into a significant player on the market of PV cells: production capacity 20 MWp around 2005 (Internet Source 2).

The federal government is responsible for expenditure on nuclear R&D. Table 3.3 gives an overview of nuclear energy RTD expenditure in Belgium (Michaux, 2005; Michaux, 2007).

Table 3.3 *Public energy RTD expenditure on nuclear energy of Belgium, 2002-2004*

[€ mln]	2002	2003	2004
Nuclear fission and fusion	42.742	43.195	48.033
IV.1 Total Nuclear Fission	37.387	37.656	42.287
IV.1.1 Light-Water Reactors (LWRs)	24.323	23.860	25.742
IV.1.2 Other Converter Reactors	-	-	-
IV.1.3 Fuel Cycle	1.960	2.418	5.435
IV.1.4 Nuclear Supporting Technology	11.103	11.379	11.109
IV.1.5 Nuclear Breeder	-	-	-
IV.1.6 Other Nuclear Fission	-	-	-
IV.2 Nuclear Fusion	5.355	5.538	5.747

3.1.2 Luxembourg

Due to its small size, and correspondingly small GDP and population, Luxembourg does not provide much support for energy RTD. Also, the structure of the economy - large numbers banks - does not make high RTD expenses desirable. By law, the government is required to provide some R&D funds. No distinction, however, is made between research areas. After contacting several ministries - 'Ministère de l' Environnement', 'Ministère d'Agriculture', and 'Ministère de la Justice' - the latter turned out to be responsible for coordination of energy RTD. According to (Mollen, 2007), some 75% of public RTD is energy-related. Table 3.4 and Figure 3.4 show RTD expenditures in general - increasing since 2005 - and energy RTD in particular.

Table 3.4 *Overview of total RTD and energy RTD expenditure of Luxembourg, 2000-2007*

[€ mln]	2000	2001	2002	2003	2004	2005	2006	2007
Total RTD expenditure	0.6	0.4	0.6	0.7	0.9	0.9	2.7	2.5
Energy-related RTD expenditure	0.45	0.3	0.45	0.53	0.68	0.68	2.03	1.88

Source: Mollen, 2007.

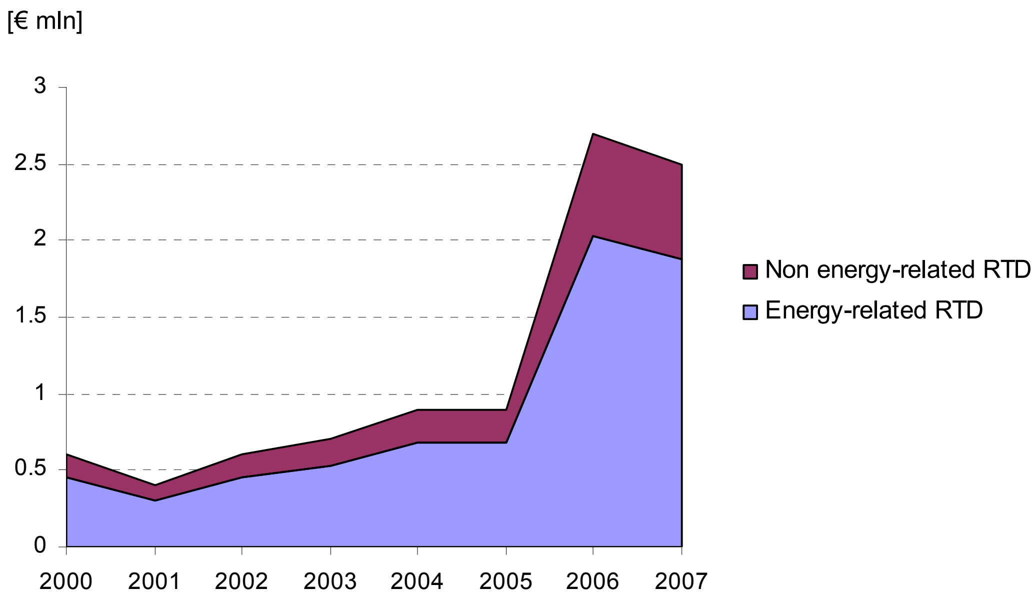

Figure 3.4 *Non-energy RTD vis-à-vis (estimated) energy RTD expenditure Luxembourg*
Source: Mollen, 2007.

4. Private R&D and energy RTD expenditure in the Netherlands

4.1 Introduction

Paragraph 4.2 presents private R&D expenditures based on (CBS, 2007) and (Technisch Weekblad, 2007a), Paragraph 4.3 private *energy* RTD data from (SenterNovem, 2007) - based on the WBSO database - and Paragraph 4.5 RTD expenditure on H_2 and fuel cells, that may be included in the IEA dataset.

4.2 Private R&D expenditure

Table 4.1 presents R&D expenditure in the Netherlands, timeframe 2000-2005 (CBS, 2007).

Table 4.1 *Research and development (R&D) expenditure in the Netherlands, 2000-2005*

[€ mln]	2000	2001	2002	2003	2004	2005
Industry						
Food and luxury foods	258	256	283	271	227	268
Textile and leather	14	16	12	13	21	27
Paper and board	12	14	11	9	24	19
Printing and publishing	8	9	24	11	24	12
Oil refining	30	17	9	5	5	8
Basic chemicals	268	305	284	316	528	548
Pharmaceutics	396	401	382	455	505	544
Other chemical final products	231	161	186	229	218	194
Rubber and plastics	30	32	39	44	38	47
Basic metal	62	68	83	57	51	57
Metal products	42	57	58	50	35	49
Machines	440	535	480	502	503	490
Electrical	1,432	1,509	1,414	1,597	1,491	1,509
Transport goods	118	147	132	143	182	176
Other	45	46	56	49	45	39
Subtotal Industry	3,386	3,573	3,453	3,751	3,897	3,987
Commercial & environmental services						
Wholesale	131	157	202	174	213	215
Retail trade	47	41	42	39	11	0
Transport & communication	109	99	28	27	40	36
Financial	97	54	43	45	142	98
Computer services	242	273	297	224	166	137
Research enterprises	110	183	113	180	165	189
Juridical & advice	29	19	30	19	48	30
Architecture & engineering	87	68	81	99	89	132
Renting & other commercial services	21	23	40	27	47	54
Environmental services	4	6	9	4	2	9
Subtotal Commercial & Env. Services	877	923	885	838	923	900
Total other enterprises	195	217	204	215	217	255
Total Enterprises	4,458	4,713	4,542	4,804	5,037	5,142
Other categories						
Agriculture, forestry and fishery	53	62	66	68	47	63
Minerals mining	86	88	83	95	83	99
Energy, gas and water	22	27	18	19	23	23
Building industry	35	40	33	29	65	70
Universities	2,120	2,184	2,312	2,356	2,430	N/A
Research institutes	N/A	N/A	994	978	1040	1007
Governmental services	N/A	N/A	89	110	97	85
Health care and public welfare	N/A	N/A	61	94	88	114
Other institutes	N/A	N/A	20	33	29	10
Total Semi-governmental Institutes	974	1,114	1,164	1,215	1,254	1,216

In the period 2000-2005, industrial R&D expenditure increased by approximately 3% annually, ending up at nearly € 4 billion in 2005. The R&D expenditure of commercial and environmental services enterprises increased to € 0.9 billion in 2005. Energy R&D is commonly only a fraction of total R&D, except for oil and gas industries and companies specialised in energy technology.

(Technisch Weekblad, 2007a) is another source of private R&D expenditure. Table 4.2 shows the top-25 private companies ranked by R&D expenditure for the period 2002-2006. Comparison between the 'top-22' of the *industrial* companies (Table 4.2) and the corresponding total industrial R&D in Table 4.1 shows that the 22 largest industries in terms of R&D in the Netherlands represent between two-thirds and three-quarters of the total industrial R&D (CBS, 2007).

Table 4.2 *Top-25 of private R&D expenditure in the Netherlands, 2002-2006*

Rank	Company	2002 [€ mln]	2003 [€ mln]	2004 [€ mln]	2005 [€ mln]	2006[b] [€ mln]
	Industry					
1	Philips, Eindhoven	1,050	1,001	1,024	1,001	955
2	ASML, Veldhoven	267	252	246	348	414
3	Akzo Nobel, Arnhem/Oss	286	291	293	425	~ 400
4	Shell, Amsterdam/Rijswijk	298	249	273	239	~ 260
5	DSM, Geleen/Delft	195	180	177	163	187
6	Océ, Venlo	140	140	132	130	155
7	Unilever, Vlaardingen	149	172	168	140	145
8	NXP, Nijmegen[a]	-	-	-	-	120
9	Stork, Naarden	32	71	69	61	67
10	Thales, Hengelo	84	69	63	63	66
11	Corus NL, IJmuiden	69	60	57	62	60
12	FEI Company, Eindhoven	-	21	24	25	27
13	Teijin Twaron, Arnhem	13	14	15	16	19
14	Gasunie, Groningen	10	11	12	17	14
15	ASMI, Bilthoven	19	10	10	11	12
16	Nefit, Deventer	-	-	7	8	10
17	Neopost, Drachten	5	6	7	9	10
18	Vanderlande, Veghel	-	7	8	8	10
19	Nutreco, Boxmeer	8	11	11	8	9
20	Vredestein, Enschede	4	5	5	5	6
21	IHC, Kinderdijk	6	7	6	5	6
25	Kuwait Petroleum, Europoort	-	2	5	2	2
Subtotal	Subtotal Industry	2,635	2,579	2,612	2,746	2,294
	Commercial & environmental Services					
22	DHV, Leusden	5	5	5	4	6
23	Tauw, Deventer	-	-	3	3	3
24	Movares, Utrecht	-	-	-	2	2
Subtotal	Subtotal Commercial & Env. Services	5	5	8	9	11
Total		2,640	2,584	2,620	2,755	2,305

[a] NXP de-merged from Philips on October 1, 2006.
[b] R&D expenditures of Akzo Nobel and Shell Netherlands in 2006 are estimates.
Source: Technisch Weekblad, 2007a.

4.3 Private energy RTD expenditure based on WBSO database

SenterNovem gives an update of private energy RTD expenditures in (SenterNovem, 2007) for the years 2003-2005, to the extent that the R&D was financed with WBSO subsidy - an R&D support scheme of the Ministry of Economic Affairs. The database starts with the total expenditures, i.e. the private expenditures and the subsidies. Then, the subsidies are subtracted, resulting in 'net' expenditures. Table 4.3, based on (SenterNovem, 2007), shows that the latter range from approximately € 150 mln in 2000 to approximately € 220 mln annually for 2003-2005.

Table 4.3 *Net private energy RTD expenditures disaggregated by IEA code, 2000-2005*

IEA code	Subject	2000 [€ mln]	2003 [€ mln]	2004 [€ mln]	2005 [€ mln]
	ENERGY EFFICIENCY (1)	94.1	117.3	119.8	118.6
1.1.1	Industry	62.5	65.2	61.4	57.1
1.1.2	Residential and commercial	14.2	27.3	28.8	30.8
1.1.3	Transport	10.9	15.5	12.8	15.5
1.1.4	Other	6.6	9.2	17.0	15.3
	FOSSIL FUELS (2)	14.4	55.0	53.4	53.4
	Oil and gas				
2.1.1	Production	9.7	8.9	13.4	11.4
2.1.2	Refining, transport & storage	4.5	27.8	18.9	25.4
2.1.3	Oil shale and tar sands	0.0	0.3	0.0	0.2
2.1.4	Combustion	0.0	8.3	10.7	10.9
2.1.5	Conversion		0.2	0.2	0.4
2.1.6	Other		5.8	5.9	2.2
	Coal				
2.2.1	Production, treatment & transport	0.0	0.2	0.6	0.2
2.2.2	Combustion	0.0	0.2	1.8	0.6
2.2.3	Conversion	0.2	1.5	0.4	1.0
2.2.4	Other	0.0	0.5	0.2	0.0
	CO_2 and storage				
2.3.1	CO_2 capture		0.7	0.8	0.0
2.3.2	CO_2 transport		0.3	0.2	0.0
2.3.3	CO_2 storage		0.3	0.4	1.0
	RENEWABLE ENERGY (3)	18.2	22.5	24.0	25.6
	Solar energy (3.1)				
3.1.1	Solar thermal	1.4	0.8	3.5	2.6
3.1.2	Solar photovoltaic	6.9	6.6	6.9	5.4
3.1.3	Solar thermal power	0.0	0.0	0.0	0.0
3.2	*Wind energy*	2.8	3.7	4.7	4.2
3.3	*Ocean energy*	0.7	0.7	0.4	0.2
	Biomass (3.4)	6.2	10.6	8.1	11.0
3.4.1	Production of transport biofuel		1.3	0.4	1.0
3.4.2	Production of other biofuel		3.4	2.0	1.7
3.4.3	Heating and power generation		3.2	1.5	4.1
3.4.4	Other		2.7	4.2	4.2
3.5	*Geothermal energy*	0.2	0.0	0.0	0.4
	Hydro power (3.6)		0.0	0.4	0.4
3.6.1	> 10 MW		0.0	0.2	0.0
3.6.2	< 10 MW		0.0	0.2	0.4
3.7	*Other renewable energy*		0.2	0.0	1.2
	ENERGY GENERATION (4)	20.3	26.4	25.9	23.2
	Nuclear energy				
	Fission energy (4.1)				
4.1.1	Light Water Reactor (LWR)	0.0	0.0	2.0	0.0
4.1.2	Other reactors	0.0	0.2	0.0	0.0
4.1.3	Fuel cycle	0.2	0.0	0.0	0.0
4.1.4	Support technology	0.2	2.1	0.0	0.6
4.1.5	Generation	0.0	0.3	0.2	0.2
4.2	*Fusion energy*	0.2	0.0	0.2	0.2
	HYDROGEN & FUEL CELLS (5)				
	Hydrogen (5.1)				
5.1.1	Production		1.8	2.4	2.0
5.1.2	Storage		0.3	1.2	0.4
5.1.3	Transport and distribution		0.3	0.2	0.4
5.1.4	Other infrastructure & systems		0.2	0.0	0.0
	Fuel cells (5.2)				
5.2.1	Stationary		0.5	1.3	2.6
5.2.2	Mobile		0.3	0.8	0.8
5.2.3	Other		1.2	1.2	0.4
	OTHER ELECTR. & STORAGE				
6.1.1	Electricity generation	16.3	5.4	3.8	2.6
6.1.2	Electricity transm., distr., storage	1.3	10.2	10.7	10.0
6.1.3	Energy storage	2.2	0.3	0.4	2.2
	OTHER ENERGY TECHN. (7)				
7.1.1	System analysis	0.0	0.0	0.0	0.0
7.1.2	Other energy technology research	0.0	2.2	1.5	1.0
	TOTAL	147.0	221.1	223.1	220.8

Source: SenterNovem, 2007.

Although the WBSO database provides very valuable insight in the extent to which private companies invest in different categories of energy RTD, the actual energy RTD expenses of private companies are inevitably underestimated, for the following reasons:

- Private R&D projects may not have qualified for a WBSO subsidy. If the industry still decides to go ahead with an R&D project, it is not accounted for in the WBSO database.
- Some private R&D projects may not qualify for WBSO subsidy, e.g., because the time horizon of a technology is too distant for WBSO. Long-term energy RTD may better fit in other national (or EU) R&D programs: the energy-related EOS programme or the generic BSIK programme (see Appendix A for abbreviations). As this study is a pilot study for SenterNovem, and not an in-depth study of all R&D programs, private energy RTD expenditure in the framework of EOS and BSIK has not been taken into account.
- Private companies may regard energy RTD as strategic. Disclosure of details necessary in order to qualify for subsidy from a specific R&D support scheme may conflict with commercial interests. Therefore, such R&D remains outside the scope of the WBSO.

4.4 Public energy RTD expenditure on hydrogen and fuel cells

Although IEA data on public energy RTD expenditures in the Netherlands is fairly complete, an effort was made to complete it with data of public RTD on hydrogen and fuel cells. Because this is a rather new RTD area, only data for the period 1997-2001 could be retrieved. Expenditure is rather limited and it seemed impossible to distinguish different categories of fuel cell RTD, viz. for stationary or mobile applications. Table 4.4 presents data from SenterNovem (Denys, 2007).

Table 4.4 *Public RTD expenditure on hydrogen and fuel cells in the Netherlands, 1997-2001*

Hydrogen and Fuel cells [€ mln]	1997	1998	1999	2000	2001
Total Hydrogen					
Hydrogen production	0.28	0.33	2.49	2.74	0.88
Hydrogen storage	0.01	0.02	0.01	2.57	0.05
Hydrogen transport and distribution	0.04	0.01	1.77	0.00	3.64
Other infrastructure and systems R&D	0.02	0.03	0.04	0.05	0.16
Hydrogen end uses incl. comb; excl. fuel cells	-	-	-	-	-
Total fuel cells applications	0.14	0.68	2.15	0.75	0.59
Stationary applications					
Mobile applications					
Other applications					

Source: Denys, 2007.

5. Energy RTD expenditures of private companies in the Netherlands

5.1 Introduction

In the framework of this study, the authors looked for data of private energy RTD expenditures. In the past, (Luiten and Blok, 1999) published data but these proved to be hardly useful as the year of reference was 1997. Due to limitations inherent to this study, only private enterprises in the Netherlands are considered. The methodology applied here is a combination of literature search and interviews with representatives from industry or inter-firm collaborative enterprises.

Data with regard to company profile, turnover (sales), number of employees, and - last but not least - numbers of R&D employees and/or RTD expenditure are contained in Appendices, viz.:

- Shell (Appendix D)
- Chemical companies (Appendix E)
- Corus (Appendix F)
- Philips (Appendix G)
- Automotive system suppliers (Appendix H)
- Construction and installation (Appendix I)
- KEMA (Appendix J)
- Photovoltaic industry (Appendix K)
- Wind industry (Appendix L)
- Bio-energy industry (Appendix M).

Table 5.1 shows the extent to which industrial companies or sub-sectors are analysed. It is noteworthy that the analysis does not include all industrial sectors/sub-sectors or commercial and environmental services companies (compare Paragraph 4.2). Also, the quest for data did not always result in concrete energy RTD data for the companies or sub-sectors analysed. Many industries do not regularly publish (energy-related) RTD, or only on the level of the global company. Another complication is that RTD data of a lot of industries does not disclose the fraction that is energy-related. If energy-related RTD may be distinguished from non-energy RTD, a straightforward allocation to energy RTD categories of the IEA (IEA code) often poses problems.

This Chapter starts with a closer look at the methodology used (Paragraph 5.2). Then, the most relevant data of industrial companies or sub-sectors from Appendix D through M is summarised in subsections of Paragraph 5.3. In each subsection, RTD expenditure is allocated to IEA categories (IEA code), to a reasonable extent. Also, sources of uncertainty pertaining to the RTD expenditures or the level of detail (disaggregation) are reported. Finally, data of these subsections is summarised and commented in Paragraph 5.4, and Paragraph 5.5 gives a synthesis of the private energy RTD landscape, integrating data of energy RTD expenditures from (SenterNovem, 2007) - the WBSO dataset.

Table 5.1 *Depth of analysis of (energy) RTD of companies and industrial subsectors*

Company/Sector	Company	Annual Report	Other data sources	Interview/ contact
Shell		√	√	P.M.
Chemical industry	Air Products	√		
	Akzo Nobel	√	√	√
	Dow Chemical	√		P.M.
	DSM	√	√	√
Corus		√	√	√
Philips		√	√	P.M.
Automotive s.s.	PACCAR Inc.	√		P.M.
	Scania AB	√		
	Nedcar	√	√	
Constr. & Install.	BAM Groep	√	√	√
	Oskomera Groep		√	
	Van Dorp Installatie		√	√
KEMA		√	√	√
Photovoltaic industry	Advanced Surface Technology (AST)		√	√
	Helianthos (NUON)	√	√	√
	Mastervolt		√	
	OTB Solar		√	
	Scheuten Solar		√	√
	Siemens Solar Projects		√	√
	Solland Solar Energy		√	√
	Ubbink Solar Modules		√	√
Wind industry	AE-Rotor Techniek (AERT)	√	√	√
	Composite Technology Centre (CTC)		√	
	Darwind		√	
	Emergya Wind Technology (EWT)		√	√
	Harakosan Europe		√	
	Home Energy		√	√
	Lagerwey Wind		√	
	LM Glasfiber Holland	√	√	
	Mecal		√	
	Polymarin Composites		√	
	Rheden Steel		√	
	Wind Energy Solutions (WES)		√	√
Bio-energy	A&F (Wageningen)		√	
	BTG		√	√
	HoSt		√	
	Nedalco	√	√	

5.2 Methodology

As noted in Chapter 2, data of private energy RTD expenditure is practically non-existent. Only companies in - or originating from - the Netherlands are addressed. Data is searched based on:

1. Annual reports.
2. Websites.
3. Other publications, e.g., articles in magazines.
4. Interviews for verification and possibly additional information or data.

Interviews were organised with industrial or commercial and environmental services companies, but most of the verification was based on telephone call and/or email contact. An interview, telephone call, or email contact generally is the concluding peace of the process of collecting and retrieving energy RTD data. Figure 5.1 serves as an (idealised) frame for data collection.

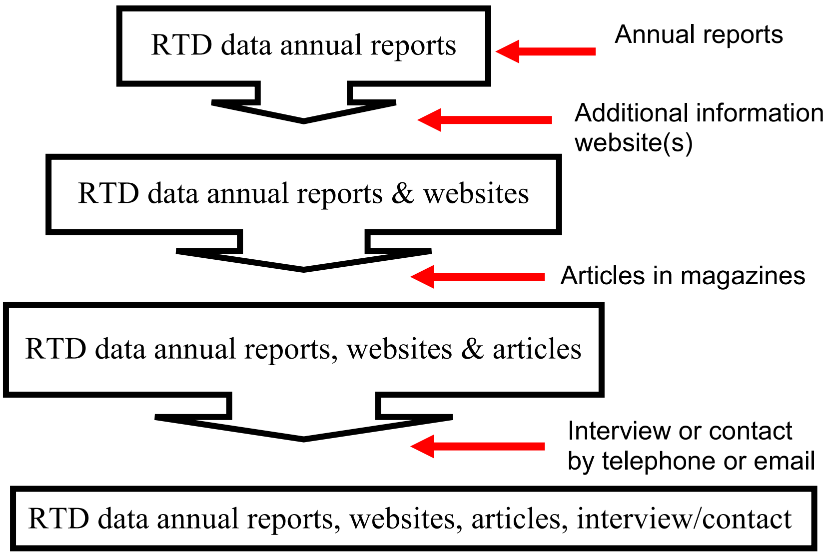

Figure 5.1 *(Idealised) frame for staged collection of data of energy RTD expenditure*

5.3 Energy RTD and other key data by company or subsector

5.3.1 Introduction

In the next subsections, data is presented of salient parameters and (energy) RTD expenditures other of companies and sub-sectors that have been analysed in Appendix D through M, viz.:

- Shell (Paragraph 5.3.2)
- Chemical companies (Paragraph 5.3.3)
- Corus (Paragraph 5.3.4)
- Philips (Paragraph 5.3.5)
- Automotive system suppliers (Paragraph 5.3.6)
- Construction and installation (Paragraph 5.3.7)
- KEMA (Paragraph 5.3.8)
- Photovoltaic industry (Paragraph 5.3.9)
- Wind industry (Paragraph 5.3.10)
- Bio-energy industry (Paragraph 5.3.11).

5.3.2 Shell

Shell is a multinational company - ‘oil and gas major’ - as well as an icon of Anglo/Dutch corporations. In 2006, Shell’s net revenue amounted to US$ 319 billion, and the RTD expenditure was US$ 885 mln (Appendix D), i.e. merely 0.3 percent of net revenue. RTD expenditure, however, tends to increase with rising revenues. Shell’s R&D budget is huge compared to that of other companies, except oil and gas majors. Shell’s RTD is possibly 100% energy-related.

In 2005, the number of employees of Shell Netherlands was 10,723 (10,737 in 2004), of which - according to (Technisch Weekblad, 2007a) - R&D personnel approximately 1,500. R&D centres of Shell Netherlands are located in Rijswijk (mainly Exploration and Production, E&P), and

Amsterdam (Global Solutions, and Renewables, Hydrogen and CO_2) - the names between brackets referring to divisions of Shell Netherlands. Appendix D describes the way in which RTD expenditures of Shell Netherlands are allocated to Shell divisions and successively to IEA's energy RTD categories (IEA code). Table 5.2 and Figure 5.2 show the distribution of RTD, presumed that the assumptions made are right (which is highly improbable of course).

Table 5.2 *Crude estimates RTD expenditure of Shell Netherlands by IEA category, 2000-2006*

[€ mln]		2000	2001	2002	2003	2004	2005	2006
IEA code	RTD category							
II.1.1	Enhanced oil & gas production	*173*	*173*	*195*	*163*	*179*	*157*	*157*
II.1.2	Refining Transport & Storage of Oil and Gas	*58*	*58*	*65*	*53*	*57*	*47*	*60*
II.1.3	Non-conventional oil & gas production	*29*	*29*	*32*	*26*	*28*	*24*	*30*
III.4	Total bio-energy	*3*	*3*	*4*	*5*	*6*	*8*	*10*
II.3	CO_2 capture and storage	*1*	*1*	*2*	*2*	*3*	*3*	*4*
	Total	*264*	*264*	298	249	273	239	~ 260

Note: Data of Shell Netherlands RTD for 2000-2001 is not available. Possibly, expenditure in 2000 and 2001 was equal to the average of 2002-2006. Figures refer to €'s of the year. Figures in italics are estimates: energy RTD data by IEA code, based on disaggregation, is denoted as 'poor', although total RTD is 'excellent'.
Source: Internet Source 3; Shell, 2004; Technisch Weekblad, 2007a.

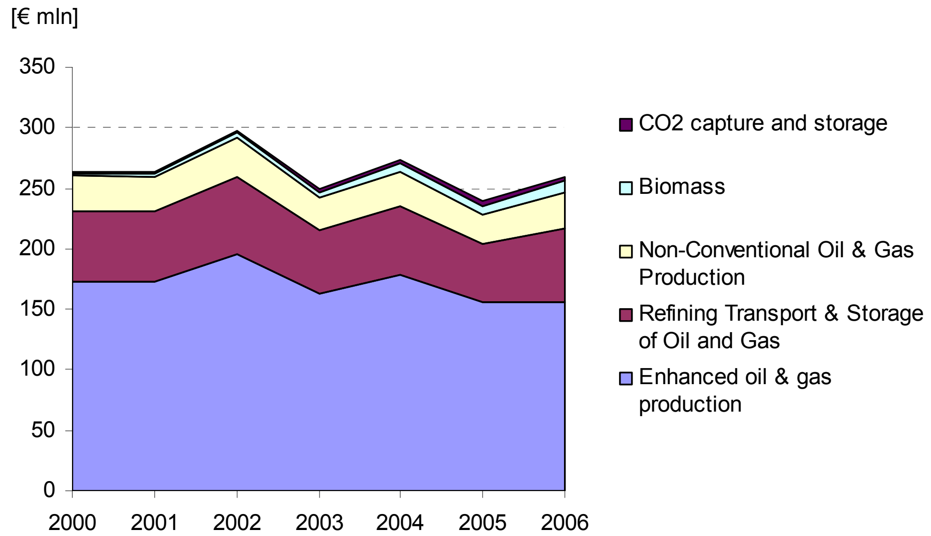

Figure 5.2 *Crude estimates RTD expenditure Shell Netherlands allocated by IEA category*
Note: As there is only scattered evidence of the way in RTD expenditures of Shell Netherlands may be allocated among IEA categories, the disaggregated data is denoted as 'poor', although total RTD is 'excellent'.

Although total RTD expenditure is precisely known, the allocation is fraught with substantial uncertainty. Expenditures on 'biomass' and 'CO_2 Capture and Storage' are increasing. Growth in these areas may be at the expense of 'Enhanced oil & gas production'. 'Refining, Transport, and Storage of Oil and Gas' and 'Non-Conventional Oil and Gas Production' may be stable.

5.3.3 Chemical companies

Appendix E presents net sales, employees, and RTD expenditures of four chemical companies, viz. (in alphabetical order): Air Products (US based), Akzo Nobel, Dow Chemical (US based), and DSM. In 2005, their cumulative net sales amounted to € 64.7 billion, and RTD expenditure was € 2.1 billion. Thus, RTD is equal to slightly more than 3% of net sales (Table 5.3). Chemical companies are not used to publish energy RTD information. Data provided anonymously by one company is assumed to be representative of the chemical industry sector. Therefore, total energy RTD of the chemical industry in the Netherlands could amount to € 24 mln (Table 5.3, Figure 5.3). Energy-related RTD is mainly related to energy conservation or energy efficiency of processes - e.g., membranes (IEA Code I.1). Inferred data of energy RTD expenditure of chemical companies in the Netherlands is fraught with substantial uncertainty ('acceptable').

Table 5.3 *Summary (energy) RTD expenditure of four chemical companies in the Netherlands*

		2004[b]	2005[b]
Global net sales	[€ mln]	58,605	64,660
RTD[a]			
Air Products	[€ mln]	102	107
Akzo Nobel	[€ mln]	816	843
Dow Chemical	[€ mln]	822	862
DSM	[€ mln]	286	290
Subtotal 'four'	[€ mln]	2,026	2,102
RTD, % of net sales	[%]	2.8	2.8
Energy RTD[a]			
I.1 Energy end-use efficiency industry	[€ mln]	*23*	*24*

[a] RTD expenditure refers to the global amounts of RTD, but energy-related RTD refers to the Netherlands.
[b] The amounts of RTD refer to €'s of the corresponding year. Figures in italics are 'acceptable' estimates.
Source: Air Products, 2007; Akzo Nobel, 2006; Dow Chemical 2004-2006; DSM, 2006a; Internet Sources 8-9.

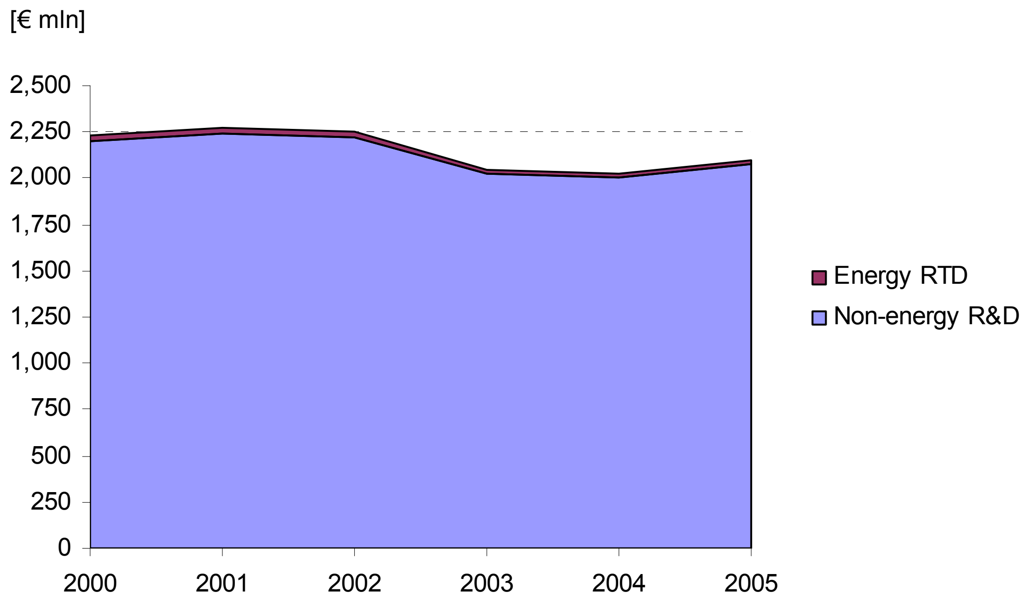

Figure 5.3 *RTD and estimated energy RTD expenditure chemical industry Netherlands*
Note: RTD expenditure refers to the global amounts of RTD, but energy-related RTD refers to the Netherlands. As data of net sales and RTD for the period 2000-2005 is only available for Dow Chemical, energy RTD expenditure can only be inferred with substantial uncertainty (data is denoted as 'acceptable').

5.3.4 Corus

Appendix F provides key data of Corus - today part of Tata Steel of India - with regard to turnover, employees, and RTD expenditure. Table 5.4 summarises the main data of Corus, distinguishing between Corus Company and Corus Netherlands. Data of turnover, employees, and RTD is based on annual reports. Corus is not used to publish energy-related RTD data. However, in an interview with a representative of Corus IJmuiden (Hoppesteyn, 2007)[7] data of en-

[7] Mr. P. Hoppesteyn, Knowledge Group Leader Reheating & Annealing, Corus Research Development & Technology, RDT, Corus IJmuiden.

ergy-related RTD in 2005 has been provided - presumably, expenditure in 2004 was comparable. Energy RTD is related to energy efficiency improvement (IEA code I.1).

Table 5.4 *Key data of turnover, employees, and RTD expenditure Corus (Netherlands)*

		Unit	2000	2001	2002	2003	2004	2005
Turnover	Total	[€ mln]	15,458	12,428	11,456	11,555	13,700	14,796
Employees	UK	[fte]	N/A	28,800	25,900	25,100	24,500	24,300
	Netherlands	[fte]	N/A	12,400	11,900	11,600	11,300	11,300
	Germany	[fte]	N/A	6,700	6,450	6,200	5,900	5,700
	Other areas	[fte]	N/A	7,700	7,350	7,400	6,900	6,900
	Total	[fte]	64,700	55,600	51,600	50,300	48,600	48,200
RTD	Gross expenditure	[€ mln]	138	107	113	100	104	109
	Less: Recoveries	[€ mln]	-10	-10	-10	-10	-9	-13
	Net expenditure	[€ mln]	128	97	104	90	95	96
	Net RTD as % of turnover	[%]	0.8	0.8	0.9	0.8	0.7	0.6
Netherlands	Energy-related RTD							
IEA code	Employees	[fte]	N/A	N/A	N/A	N/A	*20*	*22*
I.1	Expenditure	[€ mln]	N/A	N/A	N/A	N/A	*2.0*	*2.2*

Note: RTD spending refers to €'s of the corresponding year. Energy RTD expenditure is based on an assumed expenditure of 100 k€ per employee per year. Data for 2000-2003 is not available. Energy RTD figures for 2004 and 2005 are approximate numbers based on (Hoppesteyn, 2007), and denoted as 'acceptable'.
Source: Corus, 2001-2004a, 2005-2006.

5.3.5 Philips

With sales of € 30.4 billion (2005) Philips is a market leader in medical diagnostic imaging and patient monitoring systems, energy efficient lighting solutions, Domestic Appliances and Personal Care (DAPC), and consumer electronics. By the-end of 2005, the number of employees was 159,226. Table 5.5 shows key data of sales, employees, and RTD of Philips, as well as ('poor') estimates of energy RTD expenditures in the Netherlands - for details, see Appendix G.

Table 5.5 *Data of turnover, employees, RTD expenditure Philips (Philips Netherlands)*

[€ mln]		Unit[a]	2000	2001	2002	2003	2004	2005
Sales (GAAP)	Total	[€ mln]	32,339	31,725	30,983	27,937	29,346	30,395
RTD	Medical systems	[€ mln]	*554*	*652*	603	515	447	526
	DAPC	[€ mln]	*139*	*163*	151	129	134	139
	Consumer Electronics	[€ mln]	*581*	*684*	632	540	475	419
	Lighting	[€ mln]	*162*	*191*	177	151	175	212
	Semiconductors	[€ mln]	*971*	*1,144*	1,058	903	900	957
	Other activities	[€ mln]	*699*	*823*	761	650	654	587
	Elimination	[€ mln]	*-341*	*-402*	-371	-317	-301	-281
	Total	[€ mln]	2,766	3,257	3,011	2,571	2,484	2,559
	RTD as % of sales	[%]	8.6	10.3	9.7	9.2	8.5	8.4
Netherlands								
	Total RTD	[€ mln]	1,060	1,055	1,050	1,001	1,024	1,001
	Energy-related RTD							
	DAPC	[€ mln]	*53*	*53*	*53*	*50*	*55*	*54*
	Lighting	[€ mln]	*62*	*62*	*62*	*59*	*72*	*83*
IEA code I.4	Total energy-related	[€ mln]	*115*	*115*	*114*	*109*	*127*	*137*

[a] Figures refer to €'s of the year. Figures in italics are estimates: data of energy RTD is denoted as 'poor'.
Source: Philips, 2001-2006.

5.3.6 Automotive system suppliers

There are many companies - small, medium-scale, and large - involved in supplying materials and parts and manufacturing of cars, trucks, and buses in the Netherlands. The focus is on automotive system suppliers that are relatively technology and R&D intensive (FIER/NEVAT, 2003). Production of cars, trucks, and buses is rather important for the Netherlands: notably NedCar in Sittard-Geleen, DAF Trucks in Eindhoven, and Scania in Zwolle are well-known production centres. Table 5.6 summarises data of these main automotive system suppliers.

Table 5.6 *Sales, employees, RTD expenditure PACCAR, Scania and NedCar, 2004-2006*

Company	Key variables	Unit	2004	2005	2006
PACCAR Inc.	Truck and other net sales	[€ mln]	8,709	10,689	12,347
	Employees	(year-end)	20,500	22,000	22,000
	RTD expenditure[a]	[€ mln]	83	95	120
	RTD expenditure, % of sales	[%]	0.9	0.9	1.0
Scania AB	Truck and other net sales	[€ mln]	6,224	6,823	7,816
	Employees	(year-end)	29,993	30,765	32,820
	RTD expenditure	[€ mln]	218	268	334
	RTD expenditure, % of sales	[%]	3.5	3.9	4.3
NedCar bv	Net sales	[€ mln]	2,174	1,356	
	Employees	(year-end)	3,875	3,126	
	RTD expenditure	[€ mln]	P.M.[b]	P.M.[b]	
	RTD expenditure, % of sales	[%]	-	-	

[a] RTD costs are expensed as incurred and included as a component of cost of sales in the accompanying consolidated statements of income. Amounts in Table 5.5 represent costs charged against income.
[b] Development costs (including running-in production costs) are invoiced directly to the customers.
Source: PACCAR, 2005-2007; Scania, 2007; NedCar, 2006; Internet Source 12.

Unfortunately, it was impossible to distinguish between general RTD and energy-related RTD. Appendix H provides more background to the main automotive system suppliers.

5.3.7 Construction and installation

Companies engaged in construction and installation are analysed to some extent in Appendix I. Three companies have been analysed, two of which construction companies and one installation company:

- *BAM Groep*
  BAM Groep in Bunnik is a construction company with a turnover of € 8.6 billion in 2006, and approximately 30,000 employees. Energy-related RTD in *BAM Groep* is mainly performed by the division ‘Installation technology’, particularly in the knowledge centre ‘Energy Systems’. This business unit initiates new energy systems, and related activities in design, implementation, monitoring, consultancy, and project development. RTD expenditure may be of the order of magnitude of 100,000’s rather than M€’s (Uiterweerd, 2007).
- *Oskomera Groep*
  Oskomera Groep in Uden is specialist in the field of façade technology and steel structuresA subsidiary, Oskomera Solar Power Solutions, supplies complete solar power systems for building integrated solutions. Besides, Oskomera supplies system technology from a wholesale perspective, and produces and supplies components for solar power systems. Oskomera has a turnover of approximately € 55 mln and 220 employees (Internet Source 17). RTD is focused on smart integrated solutions, sustainability, etc.

- *Van Dorp Installaties*
  Van Dorp Installaties in Zoetermeer is a medium-scale installation firm with 550 employees (Remmerswaal, 2007). Despite its modest scale in comparison to some of the larger firms in the sector (e.g., GTI), it is strongly involved in development and implementation of new heating, cooling and ventilation technologies for housing and building projects. *Van Dorp Installaties* does not perform RTD itself, but investigates engineering problems and the economic feasibility -sometimes assisted by technical advisors- of technologies to be applied.

Detailed data of energy RTD expenditure of (Dutch) construction and installation companies are not available (IEA code I.2). Probably, RTD expenditure is in excess of € 1 mln per year.

5.3.8 KEMA

KEMA is an internationally operating company whose shares are hold by electricity generating and distributing companies. Activities range from solutions for high-quality business and technical consultancy to the inspection, testing and certification of equipment of any voltage. KEMA's headquarter is in Arnhem, and it has subsidiaries in the USA, Germany, and China (Appendix J). In 2006, its turnover was € 180.5 mln (a growth of 9% compared to 2005) and the number of employees stood at 1,363 FTE by year-end 2005 (KEMA, 2006; Internet Source 18).

While consultancy, e.g., with regard to environmental issues, inspection, testing and certification are its main activities, there is also significant RTD activity (Rienstra, 2007). In 2005, 3% of KEMA's turnover consisted of RTD activities, according to (KEMA, 2006). Table 5.7 shows the turnover of KEMA in the period 2000-2006, as well as the estimated RTD expenditure based on this 'rule-of-thumb'. It is assumed that expenses are evenly distributed among IEA categories Electric Power Conversion (VI.1) and Electricity Transmission & Distribution (VI.2).

Table 5.7 *(Estimated) turnover and RTD expenditure of KEMA by (IEA) category, 2000-2006*

[€ mln]	2000	2001	2002	2003	2004	2005	2006
Turnover	N/A	182.0	183.7	167.9	173.1	167.9	180.5
Energy RTD (estimate)	N/A	*5.5*	*5.5*	*5.0*	*5.2*	5.0	*5.4*
VI.1 Electric Power Conversion	N/A	*2.75*	*2.75*	*2.5*	*2.6*	*2.5*	*2.7*
VI.2 Electricity Transmission & Distribution	N/A	*2.75*	*2.75*	*2.5*	*2.6*	*2.5*	*2.7*

Note: KEMA does not publish RTD expenditure in more detail. The figure of 3% RTD as a function of turnover for 2005 has been used for the total period 2000-2006. Figures in italics are 'acceptable' estimates.
Source: KEMA, 2006; Internet Source 18.

5.3.9 Photovoltaic (PV) industry

The photovoltaic (PV) industry, producing solar modules (based on solar cells), solar panels and components is a nascent industry with a number of production facilities in the Netherlands. An overview of key data is presented in Appendix K for the start-ups/companies Advanced Surface Technology (ASP), Helianthos (NUON), Mastervolt, OTB Solar, Scheuten Solar, Siemens Solar Projects, Solland Solar Energy, and Ubbink Solar Modules. In this subsection, key data of turnover and employees as well as (estimates of) RTD expenditure is summarised (Table 5.8).

RTD expenditure data of PV (component) companies is not available. However, figures for a large German PV company, SolarWorld AG, are available (SolarWorld, 2005-2007). The RTD expenditure turns out to be between 2.5 and 4.5% of turnover. As the combined turnover of the PV (component) companies in the Netherlands is about € 200 mln (2006), their RTD expenditure may be estimated at approximately € 7 mln annually (IEA code III.1.2). In 2005, the RTD expenditure could be approximately € 6 mln. Both estimates are denoted as 'acceptable'.

Table 5.8 *Key data of turnover and employees of PV (component) companies Netherlands*

Company (Netherlands[8])	Turnover 2005 [€ mln]	Turnover 2006 [€ mln]	Capacity 2006 [MWp/yr]	Employees 2006
Advanced Surface Technology (AST)	N/A	N/A	-	N/A
Helianthos (Nuon)	N/A	N/A	-	~ 35
Mastervolt	35	N/A	(inverters)	115
OTB Solar	16	~ 30	N/A	~ 55
Scheuten Solar[a]	N/A	100	65	300
Siemens Solar Projects (the Hague)	N/A	N/A	-	N/A
Solland Solar Energy[b]	N/A	40	60	150
Ubbink Solar Energy	N/A	~ 5	6	36
Total PV companies		~ 200	~ 125	~ 700

[a] Scheuten Solar announced to build a new factory for PV cells based on a new technology in Venlo, with a capacity of 250 MW_p/year and due to be put in operation in 2009 (Internet Source 27).
[b] Objectives of Solland Solar for 2010 are: capacity of 500 MW_p/year, turnover € 1 bln; employees 1,000. An investment programme of € 200 mln is foreseen, excluding R&D facilities (Ploumen, 2007).
Source: Schoonman 2005; Schlatmann, 2005; SIGN, 2006; Jongerden, 2007; Ploumen, 2007; FD, 2006; ED, 2006; Internet Sources 20-30.

5.3.10 Wind industry

The wind industry, producing wind turbines, components and related services (RTD, engineering and design) is a relatively new industry with several production plants in the Netherlands. In Appendix L, key data is presented of AE-Rotor Techniek (AERT), Composite Technology Centre (CTC), DarwinD, Emergya Wind Technology (EWT), Harakosan Europe, Home Energy, Lagerwey Wind, LM Glasfiber Holland, Mecal, Polymarin Composites, Rheden Steel, and Wind Energy Solutions (WES). Table 5.9 summarises data and estimates based on Appendix L. Although only data of (turnover and) employees is published or referable for six out of twelve companies, employees engaged in wind turbine (components) manufacturing, engineering, design, etc. amount to approximately 250 (2006). AE-Rotor Techniek and LM Glasfiber Holland are R&D centres of Suzlon Energy and LM Glasfiber, respectively. As a lot of employees are engaged in R&D, RTD expenditure (IEA code III.2) is estimated at € 6 mln per year in 2006.

8 Flemish Photovoltech, a subsidiary of Total of France, evolved into a significant player on the market of PV cells: production capacity 20 MWp around 2005, envisaged to increase to 80 MWp before end 2008 (Internet Source 2).

Table 5.9 *Key data turnover and employees of wind (component) companies Netherlands*

	Turnover 2005 [€ mln]	Turnover 2006 [€ mln]	Employees 2006
AE-Rotor Techniek (AERT), Suzlon Energy Ltd.	N/A	N/A	~ 125
Composite Technology Centre (CTC)	N/A	N/A	12
DarwinD	N/A	N/A	N/A
Emergya Wind Technologies (EWT)	7.3	81	25
Harakosan Europe	N/A	N/A	30-35
HomeEnergy (Wind and Water Technology)	N/A	N/A	N/A
Lagerwey Wind	N/A	N/A	4
LM Glasfiber Holland	N/A	N/A	~ 20
Mecal	N/A	N/A	~ 25
Polymarin Composites	1.1	1.5	15
Rheden Steel	N/A	N/A	N/A
Wind Energy Solutions (WES)	0.5	1.1	6
Total wind turbine (component) companies	N/A	N/A	~ 250[a]

[a] Numbers of employees refer to people engaged in turbine (component) manufacture, engineering, design, and RTD.
Sources: Verheij, 2007; Ter Laak, 2007; WindNieuws, 2007a and b; Bolleman, 2007; Grauznis, 2007; Bijleveld, 2007; Internet Sources 31-46.

5.3.11 Bio-energy industry

The bio-energy industry, producing biomass-based technologies and fuels (e.g., for the transportation sector) is a new industry with several representatives in the Netherlands. In the following, data of turnover, employees, and RTD expenditure - if available - is presented of Agrotechnology and Food Innovations (A&F), BiogaS International Project, Biomass Technology Group (BTG), Brouwers BioEnergy, Certified-Energy, W.K. Crone, Dordtech Engineering, HoSt, Nedalco, OGIN Biogasinstallaties Nederland, Orgaworld, Polow Energy Systems, Thecogas PlanET Biogastechniek, and Unica Ecopower. An overview of key data of the bio-energy companies or R&D centres is presented in Appendix M.

Table 5.10 summarises data of bio-energy companies (research centres) in the Netherlands from Appendix M. The Table also includes (estimates of) turnover and number of researchers of Shell Netherlands in the area of bio-energy. Possibly, private RTD expenditure (IEA code III.4) in the Netherlands - including that of Shell Netherlands - is approximately € 10 mln (2005).

Table 5.10 *Key data of turnover & employees of bio-energy companies in the Netherlands*

	Turnover 2005 [€ mln]	Turnover 2006 [€ mln]	Employees 2006
Agrotechnology and Food innovations (Wageningen)	N/A	N/A	N/A
BiogaS International Project	N/A	N/A	N/A
Biomass Technology Group	2	2	30
Brouwers BioEnergy	N/A	N/A	N/A
Certified-Energy	N/A	N/A	N/A
W.K. Crone	N/A	N/A	N/A
Dordtech Engineering	N/A	N/A	N/A
HoSt	N/A	N/A	N/A
Nedalco (Cosun) [a]	N/A	N/A	N/A
OGIN Biogasinstallaties Nederland	N/A	N/A	N/A
Orgaworld	N/A	N/A	N/A
Polow Energy Systems	N/A	N/A	N/A
Thecogas PlanET Biogastechniek	N/A	N/A	40
Unica Ecopower	N/A	N/A	N/A
Subtotal Dutch companies and research centres	5	6	~ 75
Shell Netherlands, division biomass (Global Solutions) [b]	8	10	~ 50
Total bio-energy companies	13	16	~ 125

[a] Nedalco is reported to have about 5 R&D employees.
[b] Data of Shell Netherlands is based on a disaggregation of its RTD expenditures in Appendix D. It is reiterated that this disaggregation is fraught with considerable uncertainty: 'poor' data. Therefore, the quality of the inferred total RTD expenditure on bio-energy in the Netherlands - € 12 mln in 2006 - is 'poor' too.
Sources: Van de Beld, 2007; Cosun, 2006; Internet Sources 47-51; Leveranciersgids 1-4, 2006.

5.4 Summary of private energy RTD

The estimated energy RTD expenditures of enterprises in the Netherlands in Table 5.11 are fraught with considerable uncertainty. Figures are approximations of the real numbers, numbers that are unknown as they have not been published or are considered confidential. Just like preceding paragraphs, numbers are presented in '*italics*' if based on approximation or estimation.

Data of Fossil Fuel RTD - Oil & Gas, CO_2 Capture and Storage - refer to Shell Netherlands. Although total RTD of Shell Netherlands is published ('excellent'), the disaggregation is fraught with considerable uncertainty: data by category is considered as 'poor'. RTD on Electric Power Conversion and Electricity Transmission & Distribution refers to KEMA. The quality of disaggregated data is considered as 'acceptable'.

Data of RTD on photovoltaics refers to the analysis in Appendix K. The total figure for 2005 is considered as 'acceptable'. Data of RTD on wind energy refers to Appendix L. The total figure for 2005 is considered as 'acceptable'. Data of RTD on bio-energy refers to Appendix M. The total figure for 2005 is considered as 'poor'.

RTD on industrial energy end-use efficiency refers to estimates of the chemical industry and Corus, which are both considered as 'acceptable'. The quality of the total is considered as 'poor'. RTD on energy end-use efficiency in the residential and commercial sectors refers to the company NEFIT (Paragraph 4.3) plus an estimated € 1 mln for construction companies ('excellent' for NEFIT and 'acceptable' for construction companies). The total RTD figure is 'poor' due to absence of many companies. RTD on 'Other Conservation' (IEA code I.4) refers to energy RTD of Philips (quality of data: 'poor').

Table 5.11 *Summary estimated energy RTD of enterprises in the Netherlands, IEA format*

IEA Code	[€ mln]	2000	2001	2002	2003	2004	2005
II	*Fossil fuels*						
II.1	Total Oil & Gas						
II.1.1	Enhanced Oil & Gas Production	*173*	*173*	*195*	*163*	*179*	*157*
II.1.2	Refining Transport & Storage of Oil and Gas	*58*	*58*	*65*	*53*	*57*	*47*
II.1.3	Non-Conventional Oil and Gas Production	*29*	*29*	*32*	*26*	*28*	*24*
II.1.4	Oil and Gas Combustion						
II.1.5	Oil and Gas Conversion						
II.1.6	Other Oil & Gas						
II.2	Total Coal						
II.2.1	Coal Production Preparation & Transport						
II.2.2	Coal Combustion						
II.2.3	Coal Conversion (excl. IGCC)						
II.2.4	Other Coal						
II.3	Total CO_2 Capture and Storage	*1*	*1*	*2*	*2*	*3*	*3*
II.3.1	CO_2 Capture/Separation						
II.3.2	CO_2 Transport						
II.3.3	CO_2 Storage						
IV	*Nuclear fission and fusion*						
V	*Hydrogen and fuel cells*						
VI	*Other power and storage technologies*						
VI.1	Electric Power Conversion		*3*	*3*	*3*	*3*	*3*
VI.2	Electricity Transmission & Distribution		*3*	*3*	*3*	*3*	*3*
VI.3	Energy Storage						
III	*Renewable energy sources*						
III.1	Total Solar Energy						
III.1.1	Solar Heating & Cooling (incl. daylighting)						
III.1.2	Photovoltaics						*6*
III.1.3	Solar Thermal Power and High Temp. Apps.						
III.2	Wind Energy						*5*
III.3	Ocean Energy (tidal and wave)						
III.4	Total Bio-Energy						*10*
III.4.1	Prod. of Transport Biofuels incl. from Wastes						
III.4.2	Prod. Other Biomass-Derived Fuels incl. from waste						
III.4.3	Applications for Heat and Electricity						
III.4.4	Other bio-energy						
III.5	Geothermal Energy						
III.6	Total Hydropower						
III.7	Other Renewables						
VII	*Total other tech./research*						
VII.1	Energy System Analysis						
VII.2	Other						
I	*Energy end-use efficiency*						
I.1	Industry	*27*	*28*	*28*	*25*	*25*	*26*
I.2	Total Residential Commercial (IEA)					*8*	*9*
I.3	Transportation						
I.4	Other Conservation	*115*	*115*	*114*	*109*	*127*	*137*
	Socio-economic & horizontal						
	Total	*404*	*409*	*442*	*383*	*433*	*430*

Note: Only data from the 'bottom-up' approach are presented.

Private energy RTD expenditures in the Netherlands may be estimated at € 400-450 mln per year. The 'oscillations' around approximately € 425 mln per year do not signal a specific trend. Most of the variation is due to complex derivations of energy-related RTD of Philips and Shell, and the balance is due to discontinuity in data of 'renewables' and energy end-use efficiency.

5.5 Synthesis of different esimtates of private energy RTD

Comparison between the total energy RTD expenditures of Table 5.11 -this study- and Table 4.3 (SenterNovem, 2007) shows that the former are about two times higher than the latter. This may be explained mainly on the following grounds:

- Due to lack of more details about the RTD expenditures of Shell Netherlands, all of these expenditures are assumed to be energy-related and disaggregated to IEA classes.
- Due to deficiency of data of RTD performed by Philips in the Netherlands, large 'chunks' of those expenditures are attributed to energy efficiency, notably reduced power consumption and stand-still losses (DAPC) and improved lighting efficiency. However, this may be an underestimation or an overestimation, depending on the deviation of the disaggregation of the Dutch RTD compared to the RTD of Philips Company.
- Data of (SenterNovem, 2007) presented n Table 4.3 is 'net' energy RTD expenditure, i.e. after deduction of the financial contribution from the WBSO scheme. However, Table 5.11 does not make such a distinction: generally, financial contributions of governments are included (although not quantified).

Chapter 4 shows that the private R&D expenditures of the 'top-22' industrial companies in the Netherlands total € 2.7 billion, and those of all industries approximately € 4 billion. Therefore, private energy RTD expenditures in the Netherlands based on a bottom-up methodology could be about 10-11% of the total industrial R&D expenditures. Including R&D of commercial and environmental services (Table 4.1), would reduce this number to about 8%. This underscores that energy RTD is generally only a fraction of all R&D performed in the industry.

Finally, Table 5.12 presents a synthesis of private energy RTD expenditures. On the one hand, Table 5.12 largely draws on data of (SenterNovem, 2007) - the WBSO data excluding subsidies. On the other hand, data for 2001 and 2002 that are lacking in (SenterNovem, 2007), may be based on the bottom-up analysis in this study. For fossil fuel RTD and energy efficiency RTD, subcategory 'other conservation', the (crude) estimates in this study have been used, as they are considerably higher than those from the WBSO database. It turns out that total private energy RTD is approximately € 500-560 mln per year, i.e. about 13% of the total industrial R&D or 10% of the R&D of private enterprises (Table 4.1, based on CBS data).

Table 5.12 *Synthesis of energy RTD of enterprises in the Netherlands, IEA format*

IEA Code	[€ mln]	2000	2001	2002	2003	2004	2005
II	*Fossil fuels*						
II.1	Total Oil & Gas						
II.1.1	Enhanced Oil & Gas Production	173	173	195	163	179	157
II.1.2	Refining Transport & Storage of Oil and Gas	58	58	65	53	57	47
II.1.3	Non-Conventional Oil and Gas Production	29	29	32	26	28	24
II.1.4	Oil and Gas Combustion						
II.1.5	Oil and Gas Conversion						
II.1.6	Other Oil & Gas						
II.2	Total Coal	0.2			2.4	3	1.8
II.2.1	Coal Production Preparation & Transport						
II.2.2	Coal Combustion						
II.2.3	Coal Conversion (excl. IGCC)						
II.2.4	Other Coal						
II.3	Total CO_2 Capture and Storage	1	1	2	2.4	3	1.8
II.3.1	CO_2 Capture/Separation						
II.3.2	CO_2 Transport						
II.3.3	CO_2 Storage						
IV	*Nuclear fission and fusion*	0.6			2.6	2.4	1
V	*Hydrogen and fuel cells*	0			5.6	9.4	9.2
VI	*Other power and storage technologies*	19.8	6	6	15.9	14.9	14.8
III	*Renewable energy source*						
III.1	Total Solar Energy						
III.1.1	Solar Heating & Cooling (incl. daylighting)	1.4			0.8	3.5	2.6
III.1.2	Photovoltaics	6.9			6.6	6.9	5.4
III.1.3	Solar Thermal Power and High Temp. Apps.						
III.2	Wind Energy	2.8			3.7	4.7	4.2
III.3	Ocean Energy (tidal and wave)	0.7			0.7	0.4	0.2
III.4	Total Bio-Energy	6.2			10.6	8.1	11
III.4.1	Prod. of Transport Biofuels incl. from Wastes				1.3	0.4	1
III.4.2	Prod. Other Biomass-Derived Fuels incl. from waste				3.4	2	1.7
III.4.3	Applications for Heat and Electricity				3.2	1.5	4.1
III.4.4	Other bio-energy				2.7	4.2	4.2
III.5	Geothermal Energy	0.2			0	0	0.4
III.6	Total Hydropower	0			0	0.4	0.4
III.7	Other Renewables	0			0.2	0	1.2
VII	*Total other tech./research*						
VII.1	Energy System Analysis						
VII.2	Other						
I	*Energy end-use efficiency*						
I.1	Industry	63	28	28	65	61	57
I.2	Total Residential Commercial (IEA)	14.2			27.3	28.8	30.8
I.3	Transportation	10.9			15.5	12.8	15.5
I.4	Other Conservation	115	115	114	109	127	137
	Socio-economic & horizontal						
	Total	503	409	442	521	559	534

Note: In this Table, data of SenterNovem (WBSO) have been used integrally, and data of the 'bottom-up' approach if they seemed to have been overlooked by the WBSO database.

6. Conclusions and recommendations

With regard to *public energy RTD*, data from the public domain, e.g., from the IEA and from governmental institutions in Belgium and Luxembourg (and marginally, the Netherlands) have been checked for completeness. Considering the lack of data of Belgium for several years and of Luxembourg in the total period considered, the focus has been on completing the database for Belgium and gathering first-hand data for Luxembourg. The Walloon and Flemish governments were able to provide more or less detailed data on their energy RTD expenditure. In 2003, the *public energy RTD expenditure* for Wallonia amounted to € 10 mln (with due disaggregation) and for Flanders to € 23 mln (without disaggregation). Besides, the federal government of Belgium spent some € 43 mln (with due disaggregation) on nuclear RTD in 2003. Similarly, data were obtained from Luxembourg on their public RTD expenditure, of which the energy RTD expenditure is a fraction of about 75%: energy RTD in Luxembourg is approximately € 2 mln.

Another main effort in the framework of this study is the collection, retrieval, and analysis of data of *private energy RTD expenditures* in the Netherlands. This effort was alleviated by the recent study (SenterNovem, 2007) which presents data of private energy RTD spending based on data from the so-called WBSO R&D subsidy scheme, for the years 2000 and 2003-2005. The authors used a methodology to retrieve and analyse private energy RTD data, viz. combination of search for data in annual reports, websites, etc. and interviews with representatives of the industry or inter-firm collaborative enterprises. This methodology (more or less bottom-up) proved to be complementary to energy RTD data from (SenterNovem, 2007) in two respects:

- For the years 2001 and 2002, the 'bottom-up' approach provided additional data.
- For two multinationals, Philips and Shell, crude estimates of their energy-related RTD by IEA category could be made, that turned out to be much higher than corresponding data from (SenterNovem, 2007), based on the WBSO subsidy scheme.

The rather large differences in the WBSO database and the data from the 'bottom-up' approach for energy RTD categories that are representative of Philips Netherlands and Shell Netherlands may be explained mainly on the following grounds:

- Due to lack of more details about the RTD expenditures of Shell Netherlands, all of these expenditures are assumed to be energy-related and disaggregated to IEA classes.
- Due to deficiency of data of RTD performed by Philips in the Netherlands, large 'chunks' of those expenditures are attributed to energy efficiency, notably reduced power consumption and stand-still losses and improved lighting efficiency. However, this may be an underestimation or an overestimation, depending on the deviation of the disaggregation of the Dutch RTD compared to the RTD of Philips Company.
- The comparison is between the 'bottom-up' estimates in this study and data of (SenterNovem, 2007), notably after deduction of the financial contribution from the WBSO scheme. However, in case of the 'bottom-up' approach such a distinction is not made (estimates of RTD expenditure may include subsidies of governments, albeit not quantified).

Private energy RTD expenditures in the Netherlands may be estimated at approximately € 500-560 mln per year, i.e. about 13% of the total industrial R&D or 10% of the R&D of private enterprises (CBS data). Most of the disaggregated data are based on (SenterNovem, 2007), except for the energy RTD expenditures of Shell Netherlands (of which the total is published by Shell) and of Philips Netherlands (which are a fraction of the total RTD expenditures of Philips Netherlands which published too). The synthesis of the data of SenterNovem and of data from the bottom-up analysis in this study provides a valuable dataset that may be used in the framework of, e.g., the IEA.

References

Air Products (2007): *2006 Annual Report - Financials*. Air Products and Chemicals Inc, Allentown, PA, USA, 2007.

Air Products (2006): *Corporate Responsibility Annual Report*. Air Products and Chemicals Inc, Allentown, PA, USA, 2006.

Akzo Nobel (2006): *Annual Report 2005*. Akzo Nobel, Arnhem, the Netherlands, 2006.

BAM Groep (2006): Verkort jaarrapport 2005. Koninklijke BAM Groep nv, Bunnik, the Netherlands, 2006.

BAM Groep (2005): Jaarrapport 2004. Koninklijke BAM Groep nv, Bunnik, the Netherlands, 2005.

Beld, B., van de (2007): Personal communication Mr. B. van de Beld (BTG bv), Enschede, the Netherlands, May 2, 2007.

Bijleveld, M. (2007): Personal communication Mr. M. Bijleveld (Director Wind Energy Solutions bv), Zijdewind, the Netherlands, April 17, 2007.

Bolleman, N.C.F. (2007): Personal communication Mr. N.C.F. Bolleman (Emergya Wind Technologies bv), Schoondijke, the Netherlands, April 13, 2007.

Bollen, L. (2007): Personal communication Mr. L. Bollen (Department of Economy, Science and Innovation of the Flemish government), Brussels, Belgium, April 2007.

Cornet, M., M. Rensman (2001): *The location of R&D in the Netherlands - trends, determinants and policy*. CPB Document no 14, CPB, the Hague, the Netherlands, November 29, 2001.

Corus (2006): *Report & Accounts and Form 20-F 2005*. Corus Group plc, London, UK, 2006.

Corus (2005): *Report & Accounts 2004*. Corus Group plc, London, UK, 2005.

Corus (2004a): *Report & Accounts 2003*. Corus Group plc, London, UK, 2004.

Corus (2004b): *Corus Research, Development & Technology - Continuous innovation*. Corus Research, Development & Technology, Communication & Publicity IJmuiden Technology Centre, the Netherlands, 2004. Http://www.corusgroup.com/en/design_and_innovation/research_and_development/

Corus (2003): *Report & Accounts 2002*. Corus Group plc, London, UK, 2003.

Corus (2002): *Report & Accounts 2001*. Corus Group plc, London, UK, 2002.

Corus (2001): *Report & Accounts 2000*. Corus Group plc, London, UK, 2001.

Cosun (2006): *Annual Report 2005*. Royal Cosun, Breda, the Netherlands, 15 March 2006.

Denys, F. (2007): Personal communication Mr. F Denys (SenterNovem), Utrecht, the Netherlands, March 15, 2007.

Dooley, J.J. (2000): *A Short Primer on Collecting and Analyzing Energy R&D Statistics*. PNNL, USA. PNNL-13158, February 2000.

Dow Chemical (2006): *The Dow Chemical Company 2005 Corporate Report*. The Dow Chemical Company, Midland, MI, USA, 2006.

Dow Chemical (2005): *The Dow Chemical Company 2004 Corporate Report*. The Dow Chemical Company, Midland, MI, USA, 2005.

Dow Chemical (2004): *The Dow Chemical Company 2003 Corporate Report*. The Dow Chemical Company, Midland, MI, USA, 2004.

DSM (2006a): *Annual Report 2005*. Royal DSM N.V., Heerlen, Netherlands, 2006.

DSM (2006b): *Triple P Report 2006*. Royal DSM N.V., Heerlen, Netherlands, 2006.

Duin, A.M., van (2006): *Nederland als producent van energiekennis*. ECN, Petten, April 2006, ECN-C--06-008.

EC (2005a): *Energy RTD Information Systems in the ERA*. European Commission, Directorate-General for Research, Sustainable Energy Systems, Brussels, EUR21613, May 2005.

EC (2005b): *Energy Statistics in the European Research Area*. European Commission, Directorate-General for Research, Sustainable Energy Systems, Brussels, EUR21453, 2005.

EC (2005c): *Non-Nuclear Energy Research in Europe - A comparative study*. Volume 2, European Commission, Directorate-General for Research, Sustainable Energy Systems, Brussels, EUR21614/2, 2005, pp. 30-40.

ED (2006): Eindhovens Dagblad, May 30, 2006.

Ecorys-NEI (2006): *Kwantitatief monitoren Publiek Gefinancierd Energieonderzoek 2004 - Samenvatting*. Ecorys-NEI, Rotterdam, the Netherlands, 24 January 2006.

FD (2006): Financieel Dagblad, November 15, 2006, p. 12.

FIER/NEVAT (2003): *De Nederlandse automotive industrie - een inventarisatie van de sector*. FIER/NEVAT, Zoetermeer, the Netherlands, April 15, 2003.

Grauzinis, D. (2007): Personal communication Ms. D. Grauzinis (Home Energy), Schoondijke, the Netherlands, April 27, 2007.

Hoppesteyn, P. (2007): Personal communication Mr. P. Hoppesteyn (Knowledge Group Leader Reheating & Annealing, Corus Research Development & Technology, RDT), IJmuiden, the Netherlands, March 15, 2007.

IEA (2006a): *Energy Policies of IEA Countries - 2006 Review*. IEA, Paris, 2006.

IEA (2006b): *Energy Policies of IEA Countries - Belgium 2005 Review*. IEA, Paris, 2006.

IEA (2006c): *Trends in Photovoltaic Applications - Survey report of selected IEA countries between 1992 and 2005*. IEA Photovoltaic Power Systems Programme (PVPS), IEA, Paris, 2006, Report IEA-PVPS T1-15:2006.

Jongerden, G.J. (2007): Personal communication Mr. G.J. Jongerden (Managing Director Helianthos bv), Nuon, Arnhem, the Netherlands, April 19, 2007.

KEMA (2006): *Annual Report 2005*. NV KEMA, Arnhem, the Netherlands, 2006.

Leveranciersgids 1 (2006): *Leveranciers van vergistinginstallaties voor biomassa en afval*. September 2006.

Leveranciergids 2 (2006): *Leveranciers van vergassingsinstallaties voor biomassa en afval*. September 2006.

Leveranciersgids 3 (2006): *Leveranciers van verbrandingsinstallaties voor bio-olie*. December 2006.

Leveranciersgids 4 (2006): *Leveranciers van verbrandingsinstallaties voor biomassa en afval*. September 2006.

Michaux, G. (2007): Personal communication Mr. G. Michaux (Service Public Fédéral Economie, P.M.E., Classes moyennes et Énergie, Federal government of Belgium), Brussels, Belgium, April 2007.

Michaux, G. et al. (2005): *R&D Technology Assessment - Belgium*. CERT - 1 March 2005.

Mollen, V. (2007): Personal communication Mr. V. Mollen (Société de l'information, science-technologie-innovation, tourisme, environnement), Luxembourg, February 26, 2007.

NedCar (2006): *Financieel Jaarverslag 2005/Annual Report 2005*. Nedcar, Sittard-Geleen, the Netherlands, 2006.

NEECS (2006): *Situation Assessment Report on the National Energy Efficiency and Conservation Strategy*. National Energy Efficiency and Conservation Strategy (NEECS) of New Zealand, March 2006.

PACCAR (2007): *PACCAR Annual Report 2006*. PACCAR Inc., Bellevue, Washington, USA, February 16, 2007.

PACCAR (2006): *PACCAR Annual Report 2005*. PACCAR Inc., Bellevue, Washington, USA, February 20, 2006.

PACCAR (2005): *PACCAR Annual Report 2004*. PACCAR Inc., Bellevue, Washington, USA, February 25, 2005.

Philips (2006): *Innovating to grow - Annual Report 2005*. Philips, Amsterdam, the Netherlands, 2006.

Philips (2005a): Password - Philips Research technology magazine, Issue 25, November 2005, p 4. Http://www.research.philips.com/password/archive/25/downloads/password25.pdf.

Philips (2005b): Password - Philips Research technology magazine, Issue 24, September 2005, pp. 22-23.

Philips (2003): Password - Philips Research technology magazine, Issue 16, July 2003, pp. 4-5.

Ploumen (2007): Personal communication Ms. J. Ploumen (Solland Solar), Heerlen/Aachen, the Netherlands/Germany, May 29, 2007.

Remmerswaal, J.P.M. (2007): Personal communication Mr. J.P.M. Remmerswaal (Vestigingsdirecteur Zoetermeer, Van Dorp Installaties), Zoetermeer, the Netherlands, March 27, 2007.

Rienstra, F. (2007): Personal communication Mr. F. Rienstra (Strategic Development Manager), KEMA, Arnhem, May 1, 2007.

Scania (2007): *Year-end report 2006*. Scania, Södertälje, Sweden, 25 January 2007.

Schlatmann, R. (2005): *Helianthos zonnefolie, roll to roll pilot line en tweede generatie technologie*. Akzo Nobel Chemicals bv, the Netherlands, June 2005.

Schoonman, J. (2005): Duurzame energie: een zonnige toekomst. 40e Woudschoten-conferentie, Noordwijkerhout, Netherlands, December 16-17, 2005. http:://www.cdbeta.uu.nl/natdid/woudschoten/archief/2005/parl_schoonman.htm.

SenterNovem (2007): *Energieonderzoek in Nederland - Energietechnologie projecten in de WBSO 2003 tot en met 2005*. SenterNovem, Utrecht/Sittard/Zwolle, the Netherlands, January 2007.

Shell (2007): *Annual Report and Accounts Royal Dutch Shell 2006*. Shell, UK, 2007

Shell (2006a): *Annual Report and Accounts Royal Dutch Shell 2005*. Shell, UK, 2006.

Shell (2006b): *Van koolwaterstof naar koolhydraat*. Shell Venster, March/April 2006, pp. 18-21.

Shell (2006c): *CO_2 gaat ondergronds*. Shell Venster, May/June 2006, pp. 4-9.

Shell (2006d): Shell Venster, September/October 2006, p. 23.

Shell (2005a): *Annual Report and Accounts Royal Dutch Shell 2004.* Shell, UK, 2005.

Shell (2005b): *Wat zit er nog onder het basalt?* Shell Venster, September/October 2005, pp. 10-13.

Shell (2005c): *Iogen levert groene borrel in de tank*. Shell Venster, March/April 2005, pp. 4-7.

Shell (2005d): *Tot stof kan CO_2 wederkeren*. Shell Venster, July/August 2005, pp. 23-25.

Shell (2005e): *Pernis als 'kunstmestfabriek'*. Shell Venster, January/February 2005, pp. 9-13.

Shell (2005f): *Wind aan zee*. Shell Venster, September/October 2005, pp. 6-9.

Shell (2004): *Shell in Nederland, 2003 - Enkele hoogtepunten uit de bedrijfsactiviteiten*. Shell Nederland, Public Affairs, 5 februari 2004.

SIGN (2006): *Helianthos-zonnecellen in de landbouw. De economie van een Doorbraaktechnologie*. Stichting Innovatie Glastuinbouw Nederland (SIGN) en Innovatienetwerk Nederland, Utrecht, October 2006. http:://www.energiek2020.nu/ener2020/resources/attachments/download/true/im/false/id/4236/Helianthos-zonnecellen.pdf.

Sinke, W.C. (2007): Personal communication Prof. Dr. W.C. Sinke (ECN, Solar Energy), Petten, June 20, 2007.

SolarWorld (2007): *Konzernbericht 2006*. SolarWorld AG, Bonn, Germany, May 20, 2007.

SolarWorld (2006): *Konzernbericht 2005*. SolarWorld AG, Bonn, Germany, 2006.

SolarWorld (2005): *Konzernbericht 2004*. SolarWorld AG, Bonn, Germany, 2005.

Stephenne, A., F. Switten (2007): Personal communication Mr. A. Stephenne and Mr. F. Switten (Direction générale des Technologies de la Recherche et de l'Energie), Namur, Wallonia, Belgium, March 2007.

Technisch Weekblad (2007a): *Top 25 bedrijfs-R&D in Nederland 2006*. Technisch Weekblad, March 31 2007, Special R&D, p. 11.

Technisch Weekblad (2007b): *Vermalen rots neemt CO_2 op*. Technisch Weekblad, April 7 2007, p. 3.

Technisch Weekblad (2007b): *Kema leidt project membranen CO_2 afvang*. Technisch Weekblad, 10 maart 2007, p. 9.

Ter Laak, J. (2007): Personal communication Mr. J. ter Laak (Managing Director CTC), Almelo, the Netherlands, June 1, 2007.

Uiterweerd, A. (2007): Personal communication Mr. A. Uiterweerd (Manager BAM Techniek bv, Regio Oost), Apeldoorn, the Netherlands, March 21, 2007.

Varin, Ph. (2005): *Becoming a Value Player in Steel*. CRU World Steel Conference, Luxembourg, March 7, 2005. Http://www.corusgroup.com/file_source/StaticFiles/Becoming%20a%20value%20player%20in%20steel.pdf.

Verheij, W. (2007): Personal communication Mr. W. Verheij (AE-Rotor Techniek, Suzlon Energy Ltd.), Hengelo, the Netherlands, April 20 and 24, 2007.

Windnieuws (2007a): Windnieuws, February 2007, p. 3-4. ODE, Utrecht, ISSN 0922-4041.

Windnieuws (2007b): Windnieuws, April 2007, p. 4. ODE, Utrecht, ISSN 0922-4041.

Internet Sources

1. Http://www.seraing.be/ville/energie.htm.
2. Http://www.be.total.com/content/nl/Hernieuwbare-energie/Hernieuwbare-energie-Photovoltech.aspx.
3. Http://www.shell-in-nederland.nl/2005/shell_in_nederland/kerncijfers_in_2005/6.
4. Http://www.srtca.shell.com/nl_openbaar_vgwm_jaarverslag.pdf.
5. Http://www2.nrcan.gc.ca/ES/OERD/English/view.asp?x=1569&mid=519.
6. Http://www.shell-in-nederland.nl/2005/personeel/hr_cijfers_2005/16.
7. Http://www.shell.com/home/Framework?siteId=shellsolar.
8. Http://www.dsm.com/en_US/html/about/interactive_graphs_2006.htm.
9. Http://www.dsm.com/en_US/html/about/rnd_trends.htm.
10. Http://www.dsm.com/en_US/html/science/sustainability_2006.htm.
11. Http://www.corusgroup.com/en/design_and_innovation/research_and_development/organisation/
12. Http://www.scania.com/ir/Statistics/
13. Http://www.rabobankgroep.nl/download/KB-geheel0307.pdf (March 2007, p. 24).
14. Http://www.daf.com/
15. Http://www.scaniaproductionzwolle.com/site/p_content.asp?intStyleitID=10029&intStyleitIDmainmenu=10004.
16. Http://www.bam.nl/baminternet/baminternet/portalen/koninklijkebam_nl/modules/nieuws_v2/Persberichten/bamsluit2006sterkaf/Jaarcijfers_2006.pdf (March, 22, 2007).
17. Http://www.oskomera.nl/index.php.
18. Http://www.kema.com/corporate/news/corporate/2007/q1/annual_results.asp.
19. Http://www.kema.com/corporate/news/products_systems/2006/q4/wenzhou.asp.
20. Http://www.pwl.nl/project2.html.
21. Http://www.senternovem.nl/mmfiles/EOS%20Lijnen%20naar%20de%20toekomst_tcm24-172585.pdf.
22. Http://www.astbv.nl.
23. Http://nuon.com.
24. Http://www.mastervolt.com/nl/303/over.html.
25. Http://www.otb-solar.com/files/otb_release_20070328.pdf.
26. Http://www.scheutensolar.com/
27. Http://www.scheutensolar.com/media/raw/PersberichtSunrise130607_EN_proofread.pdf
28. Http://www.siemens.nl/sunit
29. Http://www.siemens.nl/onderneming/siemens_netherlands.asp.
30. Http://www.delta.nl/web/show/id=42807/contentid=2646.
31. Http://www.centrosolar.de/.
32. Http://www.aerotor.nl/

33. Http://www.suzlon.com/global_locator.htm
34. Http://www.ctcgroup.nl/
35. Http://www.directwind.nl/art-uk.html.
36. Http://www.directwind.nl/Persbericht%20Delta(EdV)%208-2-06.pdf.
37. Http://www.harakosan.nl/company/
38. Http://www.zondirect.com/pdf/energyballzondirect.pdf
39. Http://www.homeenergy.nl
40. Http://www.lagerweywind.nl/php/aboutus_1company.php.
41. Http://www.lmglasfiber.com/
42. Http://www.mecal.nl/index.php?action=home&parent=home.
43. Http://www.polymarin.com/htm-uk/polymarinuk.htm.
44. Http://www.zibb.nl/industrie/nieuwsbericht/asp/artnr/1140865/index.html.
45. Http://www.rheden-steel.com.
46. Http://www.smuldersgroep.com.
47. Http://www.windenergysolutions.nl/company.htm.
48. Http://tmp.agrotechnologyandfood.wur.nl/Base/BaseFrames.asp?lan=nl&BuId=0.
49. Http://www.btgworld.com.
50. Http://www.host.nl/home.php.
51. Http://www.nedalco.nl/persb/pers17UK.pdf.
52. Http://www.nedalco.nl/persb/pers18UK.pdf.

Appendix A Abbreviations and acronyms

AERT	AE-Rotor Techniek
AST	Advanced Surface Technologies
BSIK	Besluit Subsidies Investeringen Kennisinfrastructuur (SenterNovem)
BTG	Biomass Technology Group
CBS	Central Bureau of Statistics (Netherlands)
CDM	Clean Development Mechanism
CRM	Centre de Recherches Metallurgiques
CTC	Composite Technology Centre
DAPC	Domestic Appliances and Personal Care (Philips)
ELV	End of Live (directive)
EMVT	Elektromagnetische Vermogenstechniek
EOR	Enhanced Oil Recovery
EOS	Energie Onderzoek Subsidie (SenterNovem subsidy scheme)
E&P	Exploration and Production
EPIA	European Photovoltaic Industry Association
EWEA	European Wind Energy Association
EWT	Emergya Wind Technologies
FC	Fuel Cell
FME-CWM	(Merged) inter-firm enterprise of Metal and Electro-technical industry
FTE	Full-Time Equivalent
GAAP	Generally Accepted Accounting Principles
H_2	Hydrogen
IEA	International Energy Agency
IFRS	International Financial Reporting Standards
IMMPETUS	Institute for Microstructural and Mechanical Process Engineering of the University of Sheffield
IOM3	Institute of Materials, Minerals and Mining
JI	Joint Implementation
LED	Light Emitting Diode
NIMR	Netherlands Institute for Metals Research
OLED	Organic Light Emitting Diode
OLLA	Organic LEDs for ICT and Lighting Applications
PV	Photovoltaic (energy)
R&D	Research and Development
RD&T	Research, Development & Technology (Corus)
RES	Renewable Energy Sources
RTD	Research and Technological Development
SME	Small and Medium Enterprise
TDT	Transmission & Distribution Testing (KEMA)
TSA	Technical Service Agreement (KEMA)
TWI	The Welding Institute
UNETO-VNI	Inter-firm enterprise of installation and technical retail companies
VNCI	Vereniging Nederlandse Chemische Industrie (chemical industry)
WBSO	Wet Bevordering Speur- en Ontwikkelingswerk
WES	Wind Energy Solutions

Appendix B Country fact sheet Belgium

	Format Country Reports for public and private ERTD expenditures			
	Approach used	**Sources available**	**Data quality**	**Comments**
Public	Flanders	Personal communication Mr. L. Bollen, Department of Economy, Science and Innovation of the Flemish government	Acceptable	Only total expenditures 1999-2003
	Wallonia	Personal communication Mr. A. Stephenne and Mr. F. Switten, Direction générale des Technologies de la Recherche et de l'Energie	Excellent	Complete dataset for 1999-2003
	Federal government Belgium	Personal communication Mr. G. Michaux, Service Public Fédéral Economie, P.M.E., Classes moyennes et Énergie, Federal government of Belgium	Excellent	Complete data of nuclear RTD for 2002-2004
Private				

Report for public (and private) ERTD expenditures Belgium				
	Approach used	**Sources available**	**Data quality**	**Comments**
Public	***1. Search into international organizations*** Data for public ERTD for the period through 1999 was available from the official IEA website.	www.iea.org	IEA study	Official data through 1999
	2. In personal contacts At the quest for public ERTD data for elapsed years 2000 to 2004, personal contacts were made with representatives of the governments of Flanders, Wallonia (interview March 2007), and the Federal government of Belgium.	Administrations of Flanders, Wallonia, and Federal government of Belgium	Partially Excellent (Wallonia, Federal government), partially Acceptable (Flanders)	- Data disaggregation of ERTD data Wallonia and Federal government (nuclear RTD) - For Flanders, no disaggregation occurred in categories of the IEA
Private	***Search for collaborative ERTD projects***	Not applicable	Not applicable	Not applicable

Appendix C Country fact sheet Luxembourg

Format Country Reports for public and private ERTD expenditures				
	Approach used	**Sources available**	**Data quality**	**Comments**
Public	Personal contacts with representatives of the government of Luxembourg	Personal communication Mr. V. Mollen, Société de l'information, science-technologie-innovation, tourisme, environnement	Acceptable	Only total expenditures 2000-2007
Private	Not applicable			

Report for public (and private) ERTD expenditures Luxembourg				
	Approach used	**Sources available**	**Data quality**	**Comments**
Public	***3. Search into international organizations*** Data for public ERTD was not available from the official IEA website.	(www.iea.org)	(IEA study)	No IEA data available so far
Public	***4. In personal contacts*** At the quest for public ERTD data, personal contacts were made with Mr. V. Mollen, Société de l'information, science-technologie-innovation, tourisme, environnement, Luxembourg, February 26, 2007.	Administration of Luxembourg	Acceptable	No disaggregation occurred in categories of the IEA
Private	***Search for collaborative ERTD projects***	Not applicable	Not applicable	Not applicable

Appendix D Shell

Profile

Shell (UK/the Netherlands) is a large integrated oil and gas company, with large R&D facilities, e.g., for Exploration and Production (E&P) at Rijswijk (the Netherlands) and Houston (USA). Table D.1 shows key data of Shell's global sales, number employees, and RTD expenditure.

Table D.1 *Key data revenues, employees, and RTD expenditure of Shell, 2002-2006*

	Unit	2002	2003	2004	2005	2006
Revenue by business segment						
Exploration & Production	[$ mln]	26,320	32,468	37,295	45,674	54,956
Gas & Power	[$ mln]	4,874	8,227	10,835	15,624	17,190
Oil Products	[$ mln]	135,761	162,491	222,348	253,853	251,309
Chemicals	[$ mln]	15,207	20,817	29,497	34,996	40,750
Other industry & Corporate	[$ mln]	770	872	1,070	767	162
Gross revenue	[$ mln]	182,932	224,875	301,045	350,914	364,367
Elimination	[$ mln]	22,135	29,639	34,659	44,183	45,522
Net revenue (IFRS)	[$ mln]	160,797	195,236	266,386	306,731	318,845
Employees (year-end)						
Exploration & Production	[1000]	17	17	16	18	19
Gas & Power	[1000]	2	2	2	2	3
Oil Products	[1000]	75	82	78	71	67
Chemicals	[1000]	9	9	8	8	6
Other industry & Corporate	[1000]	8	9	9	10	13
Total Employees	[1000]	111	119	113	109	108
RTD expenditure	[$ mln]	472	584	553	588	885
RTD as percentage of revenue	[%]	0.3	0.3	0.2	0.2	0.3

Source: Shell, 2007, 2006a, 2005a.

Table D.2 provides key data of RTD expenditure and employees of Shell Netherlands. The number of employees of Shell Netherlands was 10,723 in 2005 compared to 10,737 in 2004 (Internet Source 3). The number of employees of SRTCA in Amsterdam was 1,167 at the end of 2003 (Internet Source 4). Shell International E&P at Rijswijk performs research, development, and implementation of integrated technological solutions for E&P activities and locations around the world. In 2005, construction of the new Learning Centre at Rijswijk was finished. The New Technology Centre (NTC) in Amsterdam is due to replace the present research centre at Amsterdam by the end of 2007. According to (Cornet and Rensman, 2001), the number of research employees of Shell Netherlands was 2,100 (FTE) in 1998, and according to (Technisch Weekblad, 2007a) it has been approximately 1,500 FTE in the period 2003-2006 (Table D.2).

Table D.2 *Key data employees and RTD expenditure of Shell Netherlands, 2002-2006*

	Unit	1998	2002	2003	2004	2005	2006
Employees	(year-end)	N/A	10,300	10,900	10,737	10,723	N/A
R&D employees		2,100	N/A	1,500	1,500	1,500	~ 1,550
RTD expenditure	[$ mln]	N/A	283	284	340	297	~ 325
	[€ mln]	N/A	298	249	273	239	~ 260

Source: Cornet and Rensman, 2001; Shell, 2004; Internet Source 3; Technisch Weekblad, 2007a.

Energy RTD
In 2005, RTD expenditure in the Netherlands amounted to € 239 mln, or $297 mln (Table D.2). According to (Technisch Weekblad, 2007a), this amount increased to approximately € 260 mln (about $ 325 mln) in 2006. It is difficult to estimate the distribution of RTD expenditure among different categories of energy research. According to (Technisch Weekblad, 2007b), the number of researchers on CO_2 sequestration could be of the order of magnitude of 10 or possibly 20.

Table D.3 presents crude estimates of RTD expenditure by category of energy research, i.e. the IEA categorisation (IEA code). The relation between the total number of employees and R&D employees is assumed to be twice as strong for 'Exploration and Production' (e.g., Shell, 2005b) than for 'Global Solutions' and 'Renewables, Hydrogen and CO_2'. The latter two divisions may have a stronger focus on implementation, next to RTD, than 'Exploration and Production'.

Shell Netherlands has specific bio-energy activities (Shell, 2006b; Shell 2005c). However, RTD expenditure may still be modest. It is assumed that 60% of the RTD in 'Global Solutions' is related to 'Refining, Transport, and Storage of Oil and Gas', 30% to 'Non-Conventional Oil and Gas Production', and the balance of 10% to bio-energy. Renewables, Hydrogen and CO_2' RTD could be mainly related to 'CO_2 Capture and Storage', an apparently prominent subject in Shell's R&D portfolio (Shell, 2006c, Shell 2005d and e; Internet Source 5). As noted above, the number of employees engaged in CO_2 sequestration RTD could be 10 or possibly 20. In 2006, Shell entered into cooperation with Statoil on construction of a gas-based power and methanol plant at Tjeldbergodden combined with CO_2 capture and EOR at Draugen and Heidrun.

Table D.3 *Crude estimates RTD expenditure of Shell Netherlands by IEA category, 2005*

Shell Netherlands division	Corresponding IEA category	Employees (year-end)		RTD expenditure
		Total	R&D	[€ mln]
Exploration and Production	Enhanced Oil & Gas Production	1,579	*980*	*157*
Global Solutions		1,602	*500*	*79*
	Refining Transp. & Stor. Oil & Gas		*300*	*47*
	Non-Conventional Oil & Gas Prod.		*150*	*24*
	Biomass		*50*	*8*
Renewables, H_2 & CO_2	CO_2 Capture and Storage	67	*20*	*3*
Subtotal		3,248	1,500	239

Note: Figures in italics are estimates. The RTD expenditure of € 239 in 2005 corresponds to Table D.2.
Source: Internet Source 6 (employees divisions Shell Netherlands 2005); Technisch Weekblad 2007a.

Shell's wind energy activities in the Netherlands appear to be focused mainly on demonstration and implementation (Shell, 2005f). The 108 MW offshore wind farm of Shell and Nuon at Egmond aan Zee entails an investment of more than € 200 mln. In 2006, Shell sold its production activities of photovoltaic (PV) panels to the German company SolarWorld (Shell, 2006d). A main thrust of Shell's PV RTD activities is the joint venture that Shell Erneuerbare Energien GmbH and Saint-Gobain Glass Deutschland GmbH started in 2006 (Internet Source 7).

Table D.4 and Figure D.1 show the estimated trend of RTD expenditures of Shell Netherlands by IEA category (IEA code).

Table D.4 *Crude estimates RTD expenditure of Shell Netherlands by IEA category, 2000-2006*

[€ mln]	2000	2001	2002	2003	2004	2005	2006
Enhanced oil & gas production	173	173	195	163	179	157	157
Refining Transport & Storage of Oil & Gas	58	58	65	53	57	47	60
Non-Conventional Oil & Gas Production	29	29	32	26	28	24	30
Biomass	3	3	4	5	6	8	10
CO_2 Capture and Storage	1	1	2	2	3	3	4
Total	*264*	*264*	298	249	273	239	~ 260

Note: The amounts of RTD refer to €'s of the corresponding year. For 2000 and 2001, RTD data of could not be retrieved. It is assumed that expenditure in 2000 and 2001 is equal to average of 2002-2006. RTD expenditure is allocated to five IEA categories, according to a few 'rules-of-thumb'. Firstly, for 2005 the distribution of expenditure among the categories is explained above. Secondly, it is assumed that RTD expenditure for 'biomass' and 'CO_2 Capture and Storage' in 2000 was 1/3rd of that in 2005. Thirdly, 'Enhanced oil & gas production' is assumed to be proportional to total RTD expenditure in the period 2000-2004. Fourthly, the ratio between 'Refining, Transport, and Storage of Oil & Gas' and 'Non-Conventional Oil & Gas Production' is put at 2:1 (2006 data are based on extrapolation).
Figures in italics are estimates: energy RTD data by IEA code, based on disaggregation, is denoted as 'poor', although total RTD is 'excellent'
Source: Internet Source 3; Shell, 2004; Technisch Weekblad, 2007a.

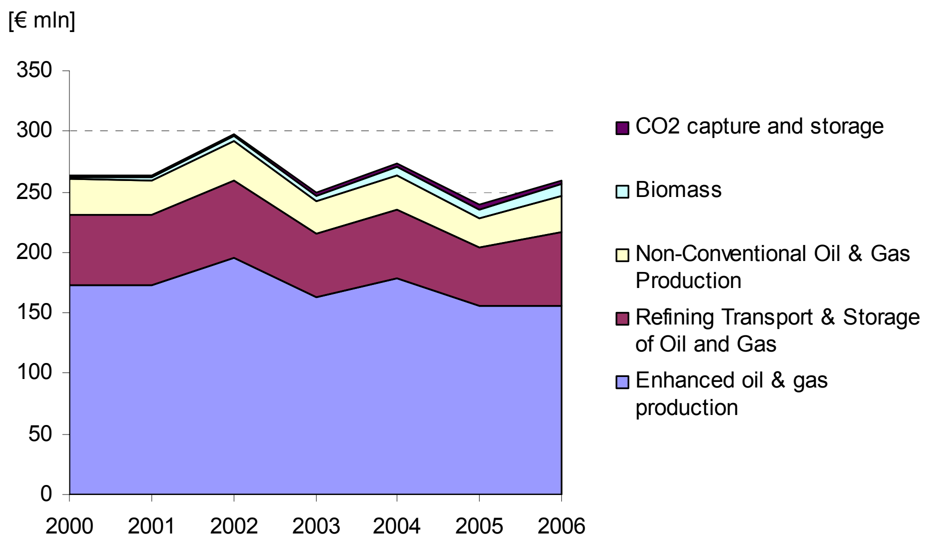

Figure D.1 *Crude estimates RTD expenditure Shell Netherlands allocated by IEA category*
Note: As there is only scattered evidence of the way in RTD expenditures of Shell Netherlands may be allocated among IEA categories, the disaggregated data is denoted as 'poor', although total RTD is 'excellent'.

Although total RTD expenditure is precisely known, the allocation is fraught with substantial uncertainty. Expenditures on 'biomass' and 'CO_2 Capture and Storage' are increasing. Growth in these areas may be at the expense of 'Enhanced oil & gas production'. 'Refining, Transport, and Storage of Oil and Gas' and 'Non-Conventional Oil and Gas Production' may be stable.

Appendix E Chemical companies

Introduction
In the Netherlands, many chemical companies are active, with chemical plants at several locations. The main companies in terms of turnover or RTD are *Air Products*, *Akzo Nobel*, *Dow Chemical*, and *DSM*. This is a first approximation of the chemical industry in the Netherlands. The chemical industry is not used to publish energy-related RTD. Also, according to (Cornet and Rensman, 2001), other chemical industries with significant RTD in the Netherlands are Avery Dennison, TotalFinaElf (Sigma Coatings), GE Plastics, Hercules, ICI, Suez Lyonnaise (Ondeo Nalco), and Vredestein. Key data and (estimates of) RTD expenditure are summarised.

Air Products
Air Products is a globally operating company from the USA with gases and chemicals as main products. In the period 2003-2005, the total sales were disaggregated as shown in Table E.1, based on (Air Products, 2007). The Table also shows Air Products' RTD expenditures.

Among the energy technologies commercialised by Air Products are:
- Hydrogen for desulphurisation
- LNG heat exchangers
- (Applications for the) hydrogen economy.

Between 2002 and 2004, Air Products reduced its global power consumption equivalent to the annual power consumed by 80,000 average U.S. homes and approximately 0.48 Mt of annual CO_2 emissions, and continued to improve on this effort in 2005 (Air Products, 2006).

Table E.1 *Key data net sales, employees, and R&D expenditure Air Products, 2004-2006*

[$ mln]	2004	2005	2006
Net sales			
Merchant gases	2,230	2,468	2,713
Tonnage gases	1,530	1,740	2,224
Electronics and performance materials	1,604	1,701	1,899
Equipment and energy	346	369	536
Healthcare	438	545	571
Chemicals	884	945	908
Total sales	7,032	7,768	8,850
Employees (year-end)	19,900	20,200	20,700
RTD expenditure	126.7	132.7	151.8
RTD as percentage of net sales	1.8%	1.7%	1.7%

Source: Air Products, 2007.

With regard to *Research and Development*, areas of expertise of Air Products are:
- Reaction Chemistry
- Materials Chemistry
- Engineering Fundamentals
- Applications Development
- Technology Support Services
- Process Engineering.

No specification of RTD or energy-related RTD for the Netherlands is publicly available.

Akzo Nobel
Akzo Nobel is an internationally operating company, specialised in the manufacture of human and animal healthcare products, coatings, and chemicals. Its revenues, employees (11,600 at year-end 2006), and RTD expenditure in 2004 and 2005 are shown in Table E.2.

Table E.2 *Key data net sales, employees, and RTD expenditure Akzo Nobel, 2004-2005*

		Unit	2004	2005
Net sales				
Division	Organon	[€ mln]	2,344	2,425
Division	Intervet	[€ mln]	1,024	1,094
Division	Coatings	[€ mln]	5,237	5,555
Division	Chemicals	[€ mln]	3,735	3,890
	Inter-company/divestment	[€ mln]	493	36
	Total	[€ mln]	12,833	13,000
Employees				
Division	Organon	(year-end)	14,090	14,100
Division	Intervet	(year-end)	5,270	5,260
Division	Coatings	(year-end)	28,860	29,200
Division	Chemicals	(year-end)	11,890	11,430
	Other	(year-end)	1,340	1,350
	Total	(year-end)	61,450	61,340
RTD	RTD expenditure	[€ mln]	816	843
	RTD as percentage of net sales	[%]	6.4	6.5

Source: Akzo Nobel, 2006.

In 2005, expenditures of Akzo Nobel on *Research and Development* amounted to € 843 mln (2004: € 816 mln). Within Akzo Nobel, *energy-related RTD* is not administrated separately.

Dow Chemical
Dow Chemical Company is a large company with chemicals and plastics as main products. Dow has annual sales of $ 46.3 billion and employs 42,410 people (2005). Global businesses include:
1. Performance Plastics:
   - Building and Construction
   - Dow Automotive
   - Engineering Plastics
   - Epoxy Products and Intermediates
   - Polyurethanes and Thermoset Systems
   - Technology Licensing and Catalyst
   - Wire and Cable Compounds
2. Performance Chemicals:
   - Acrylics and Oxide Derivatives
   - Dow Latex
   - Specialty Chemicals
   - Specialty Polymers
3. Agricultural Sciences
4. Plastics
   - Polyethylene
   - Polypropylene
   - Polystyrene
5. Chemicals
   - Core Chemicals
   - Ethylene Oxide/Ethylene Glycol
6. Hydrocarbons and energy.

Table E.3 shows the net sales, workforce, and RTD expenditure of Dow Chemical Company. In the Benelux, the number of employees stood at 2,656 at the end of 2005. Terneuzen is Dow's largest manufacturing site outside the USA, with 26 production plants for chemicals and plastics. Although the global expenditure for RTD is known (€ 1.073 billion in 2005), no specification for the Netherlands is publicly available, except the number of NLG 72 mln (€ 32.7 mln) for year 2000 (Cornet and Rensman, 2001). Also, data of energy-related RTD is not available.

Table E.3 *Key data net sales, employees, and RTD expenditure Dow Chemical, 2000-2005*

[$ mln]	2000	2001	2002	2003	2004	2005
Net sales						
Performance Plastics	7,667	7,321	7,095	7,770	9,493	11,388
Performance Chemicals	5,343	5,081	5,130	5,552	6,667	7,713
Agricultural Sciences	2,346	2,612	2,717	3,008	3,368	3,364
Plastics	7,118	6,452	6,476	7,760	10,041	11,815
Chemicals	4,109	3,552	3,361	4,369	5,454	5,660
Hydrocarbons and Energy	2,626	2,511	2,435	3,820	4,876	6,061
Unallocated and Others	589	528	395	353	262	306
Total net sales	29,798	28,057	27,609	32,632	40,161	46,307
Employees (year-end)	41,900	52,700	50,000	46,400	43,200	42,410
RTD expenditure	1,119	1,072	1,066	981	1,022	1,073
RTD as % of net sales	3.8%	3.8%	3.9%	3.0%	2.5%	2.3%

Source: Dow Chemical, 2004-2006.

DSM

DSM is an international company with originally a strong focus on commodity chemicals. In recent years, its portfolio became much broader by growth in life sciences and performance materials. Withdrawal from petrochemicals and accelerated growth of life science products and performance materials increased the share of the latter to approximately 80% of sales in 2005 (Table E.4). At year-end 2005, DSM had 21,820 employees. At the end of 2006, DSM's work force in the Netherlands stood at 7,061 (DSM, 2006b). Its profile as a mainly European company is changing: in 2005 about one out of every three employees was based outside Europe.

Table E.4 *Key data net sales and employees DSM, 2004-2006*

		Unit	2004	2005	2006
Net sales					
Division	Life Science Products	[€ mln]	1,484	1,479	
Division	DSM Nutritional Products	[€ mln]	1,899	1,914	
Division	Performance Materials	[€ mln]	2,007	2,447	
Division	Industrial Chemicals	[€ mln]	1,570	1,687	
	Other Activities	[€ mln]	474	485	
	Intra-group supplies	[€ mln]	-	-	
	Total, continuing operations	[€ mln]	7,434	8,012	
	Discontinued operations	[€ mln]	398	183	
	Total	[€ mln]	7,832	8,195	8,352
Employees		(year-end)	24,204	21,820	22,156

Source: DSM, 2006a; Internet Source 8.

With regard to renewables, (DSM, 2006b) states: 'If DSM were to use wind energy or biomass instead of fossil fuels, energy costs would rise from the current € 800 million to between € 2 and € 3 billion per year (based on today's cost levels). So apart from the aspect of limited availability, alternative energy sources are currently no realistic option from an economic point of view'.

In 2005, expenditure on *Research and Development* amounted to € 290 mln (2004: € 286 mln), see Table E.5. In 2006, RTD expenditure was € 327 mln, 3.9% of net sales (Internet Source 9). Examples of the contribution that DSM's technology can make to sustainability include:
- Green (i.e., bio-catalytic) routes for semi-synthetic antibiotics
- Dyneema®, the world's strongest fibre, now used in fishing ropes and nets to reduce fuel consumption
- Industrial chemicals based on renewable feedstocks, e.g. fermentatively produced Caprolactam.

Table E.5 *RTD expenditure DSM, 2004-2006*

[€ mln]		2004	2005	2006
Division	Life Science Products	98	93	
Division	DSM Nutritional Products	75	80	
Division	Performance Materials	78	94	
Division	Industrial Chemicals	16	14	
	Other	11	8	
	Discontinued operations	8	1	
	Total	286	290	327
	RTD as percentage of net sales	3.7%	3.5%	3.9%

Source: DSM, 2006a; Internet Source 9.

The broad integration of chemistry, physics, and biology may induce more breakthroughs (Internet Source 10). DSM also works closely with some of the world's most innovative R&D partners and exchanges scientific and technological knowledge with some 2,000 university departments. DSM participates in renowned research organisations and networks, such as Gene Alliance (Germany), the Bio-catalysis & Bio-processing of Macromolecules Consortium (USA), the Wageningen Center for Food Sciences and the Dutch Polymer Institute (The Netherlands). Although DSM's RTD data is quite detailed, no data of energy-related RTD is available.

Summary

One chemical company provided (anonymously) data of energy-related RTD. If these data are regarded as representative of the chemical industry that has been analysed above, energy-related RTD in the Netherlands could be € 23-24 mln (Table E.6). However, this is an approximation fraught with considerable uncertainty. Most of the energy-related RTD is related to energy conservation or energy efficiency improvement of processes, e.g., by application of membranes.

Table E.6 *Summary of (energy) RTD expenditure of four chemical companies Netherlands*

[€ mln]		2004[b]	2005[b]
Global net sales		58,605	64,660
RTD[a]	Air Products	102	107
	Akzo Nobel	816	843
	Dow Chemical	822	862
	DSM	286	290
	Subtotal	2,026	2,102
Energy RTD[a]	Subtotal	23	24

[a] RTD expenditure refers to the global amounts of RTD, but energy-related RTD refers to the Netherlands.
[b] The amounts of RTD refer to €'s of the corresponding year.

For the chemical companies data of net sales and RTD expenditure span a different period:
- Air Products: 2004-2006
- Akzo Nobel: 2004-2005
- Dow Chemical: 2000-2005
- DSM: 2004-2006.

For Dow Chemical, data of net sales and RTD expenditure over the timeframe 2000-2005 have been used. For Air Products, Akzo Nobel, and DSM, net sales and RTD expenditures have been extrapolated backwards from 2004, based on the change from 2004 to 2005. It is assumed that the ratio between energy RTD and total RTD expenditure of 2005 (€ 24 mln and € 2,102 mln, see Table E.6) is constant. Figure E.1 shows RTD and estimated energy RTD expenditure of the chemical industry in the Netherlands. The inferred energy RTD expenditure of chemical companies in the Netherlands is fraught with substantial uncertainty: data is denoted as ‘acceptable’.

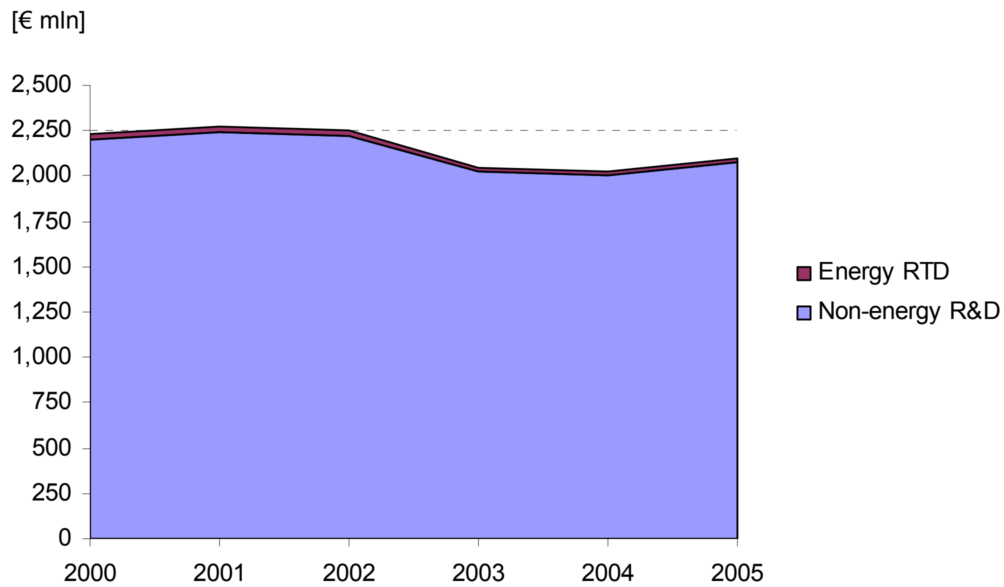

Figure E.1 *R&D and estimated RTD expenditure of chemical companies (2000-2005)*

Appendix F Corus

Profile
Corus Group (UK) originated in October 1999 from steel companies in the UK and the Netherlands. It has steel and aluminium activities across Europe and abroad. Recently, Tata Steel of India acquired Corus Group, which will become effective at April 2, 2007. Table F.1 shows key data of Corus' turnover, employees, and RTD expenditure.

Table F.1 *Key data of turnover, employees, and RTD expenditure Corus, 2000-2005*

		Unit[a]	2000	2001	2002	2003	2004	2005
Turnover								
Division	Strip products	[€ mln]			5,506	5,690	6,935	7,500
Division	Long products	[€ mln]			3,191	3,122	3,824	3,909
Division	Distr.&Build. Syst.	[€ mln]			3,100	3,301	3,826	4,408
Division	Aluminium	[€ mln]			1,629	1,494	1,603	1,620
	Central & Other	[€ mln]			124	92	98	112
	Eliminations	[€ mln]			-2,094	-2,143	-2,587	-2,753
	Total	[€ mln]	15,458	12,428	11,456	11,555	13,700	14,796
Turnover	UK	[€ mln]	4,284	3,683	3,301	3,120	3,838	3,949
	Other European	[€ mln]	7,265	6,208	5,830	6,034	7,315	7,906
	North America	[€ mln]	2,159	1,416	1,404	1,135	1,355	1,269
	Other areas	[€ mln]	1,751	991	921	1,266	1,192	1,672
	Discontinued oper.	[€ mln]	-	130	-	-	-	-
	Total	[€ mln]	15,458	12,428	11,456	11,555	13,700	14,796
Employees	UK			28,800	25,900	25,100	24,500	24,300
	Netherlands			12,400	11,900	11,600	11,300	11,300
	Germany			6,700	6,450	6,200	5,900	5,700
	Other areas			7,700	7,350	7,400	6,900	6,900
	Total		64,700	55,600	51,600	50,300	48,600	48,200
RTD	Gross expenditure	[€ mln]	138	107	113	100	104	109
	Less: Recoveries[b]	[€ mln]	-10	-10	-10	-10	-9	-13
	Net expenditure	[€ mln]	128	97	104	90	95	96
	Net RTD as percentage of turnover	[%]	0.8	0.8	0.9	0.8	0.7	0.6

[a] Turnover and RTD expenditures are converted from £ to € if necessary. Figures refer to €'s of the year.
[b] Recoveries comprise fees received from other steel and engineering companies and funding from the EU.
Source: Corus, 2001-2004a, 2005-2006 (Annual Accounts).

In 2005, the turnover of Corus was approximately € 14.8 billion, and the number of employees 48,200. Corus has four Divisions, each with a number of business units. At least 10% of the total capital investment of € 617 mln of Corus in 2005 were related to improved energy efficiency or reduced environmental impact.

Research and Development
Since January 2000, three technology centres in the UK and one in the Netherlands have been integrated into Corus Research, Development & Technology (RD&T), with multi-site departments (Corus, 2001). Following a reconsideration of the future of R&D operations in the UK, Corus decided to retain Swinden and Teesside Technology Centres (Corus, 2004a). Today, Corus has three R&D centres, two in the UK and one in the Netherlands, with 950 researchers - approximately 500 FTE in the Netherlands, and 400 FTE in the UK (Hoppesteyn, 2007).

Corus has a policy of collaborative product development with key customers in its principal markets. For more fundamental research, Corus collaborates with leading research institutes, e.g., the Netherlands Institute for Metals Research (NIMR), the Institute for Microstructural and Mechanical Process Engineering of the University of Sheffield (IMMPETUS), The Welding Institute (TWI) at Cambridge, the Institute of Materials, Minerals and Mining (IOM3) at London and the Centre de Recherches Metallurgiques (CRM) at Liège, Belgium (Corus, 2004b).

For the automotive market, Corus developed a unique adhesive coated material, Envirobond™ that is free from hexavalent chromium. It will help carmakers to avoid the use of environmentally undesirable hexavalent chromium and meet the requirements of the End of Life Vehicle (ELV) directive (Corus, 2006). The amount of iron and steel used is declining (Figure F.1).

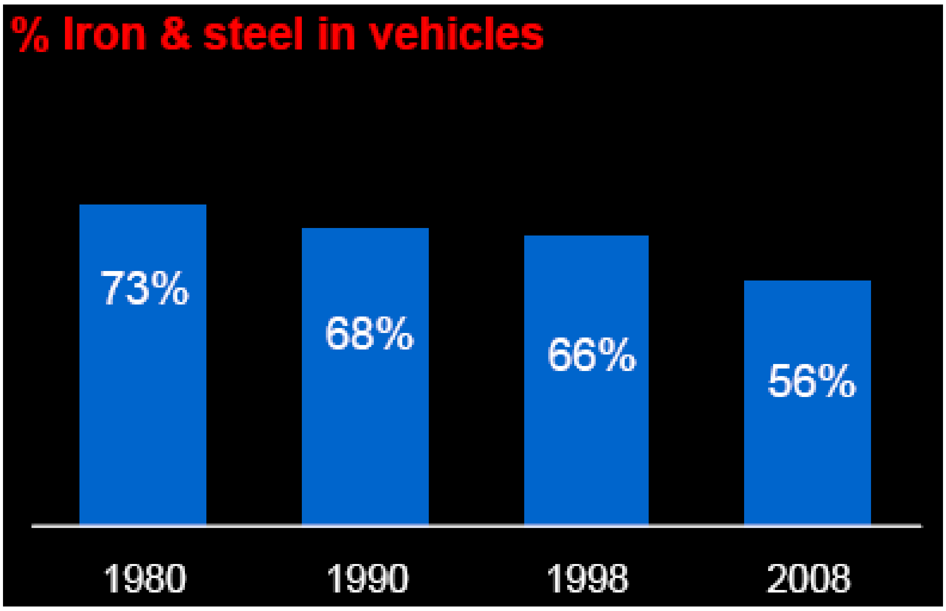

Figure F.2 *Percentage iron & steel in vehicles*
Note: Figure for 2008 (56%) is an estimate.
Source: Varin, 2005.

Corus RD&T operates a matrix structure with separate management lines for people and equipment and for programmes and research projects (Corus, 2004b; Internet Source 11):

- Processes
  Research into Processes is organised according to Ironmaking, Steelmaking & Casting, Ceramics Research Centre, Rolling Metal Strip, Measurement Integration and Engineering, Environment and Long Product Rolling.
- Products and applications
  Research into products and applications is organised according to Steel Metallurgy, Aluminium Metallurgy and Materials Characterisation, Coated Products, Automotive applications, Construction Applications, Transport Applications and Packaging Applications.
- Programme management
  For each business unit, an RD&T Programme Manager is in charge of its research programme. This ensures that all business units have equal access to RD&T resources.

Energy RTD
Firstly, energy related RTD at Corus RD&T (Research, Development & Technology) IJmuiden is performed in the Directorate Processes, Department Rolling Metal Strip, Knowledge group Reheating & Annealing (Hoppesteyn, 2007). Reheating and annealing of steel are particularly energy-intensive processes in the iron and steel industry.

The knowledge group Reheating & Annealing covers *inter alia* the following topics of RTD:

- Combustion technology (including design of burners)
- Energy technology
- Furnace technology
- Digital control of furnace processes
- CFD (Computational Fluid Dynamics)
- Temperature and pressure measurement of gases.

Besides, the knowledge group gives consultancy to business units with regard to application of proven technology and identification of new technology. The knowledge group has some 14 (FTE) employees engaged in energy RTD, two (FTE) of which are detached to Corus UK[9].

Secondly, Corus is engaged in the EU project 'ULCOS', just like a number of other iron and steel companies, Statoil, research institutes (among which ECN), etc. This long-term research project aims to research and ultimately develop technology enabling a CO_2 emissions reduction of approximately 50% in 2050 compared to current steelmaking technology. At IJmuiden, R&D for this EU-wide project is performed in the Department of Ironmaking. In the Netherlands, approximately 8 FTE are engaged in this long-term research.

Summary of energy RTD employees and expenditure

Table F.2 summarises the aforementioned numbers of employees of Corus RD&T IJmuiden that are engaged in energy RTD, as well the (approximate) annual expenditure on energy RTD.

Table F.2 *(Approximate) energy RTD workforce and expenditure of CorusIJmuiden*

	Unit	2000	2001	2002	2003	2004	2005
Employees	[fte]	N/A	N/A	N/A	N/A	20	22
Energy RTD expenditure	[€ mln]	N/A	N/A	N/A	N/A	2.0	2.2

Note: The amounts of RTD refer to €'s of the corresponding year. The energy RTD expenditure is based on an assumed expenditure of 100 k€ per employee per year. Data for the years 2000-2003 is not available, whereas figures for 2004 and 2005 are approximate numbers based on (Hoppesteyn, 2007).

9 Corus UK has a number of some 15 FTE engaged in energy (related) RTD, viz. in knowledge group Reheating Technology (Hoppesteyn, 2007).

Appendix G Philips

Profile

With sales of € 30.4 billion in 2005 (€ 27 billion in 2006), Philips is a market leader in medical diagnostic imaging and patient monitoring systems, energy efficient lighting solutions, personal care and home appliances, as well as consumer electronics. At the end of 2005, the number of employees stood at 159,226. In recent years, Philips fundamentally redesigned its R&D efforts, directing resources towards growth markets -e.g., healthcare and wellness- and emerging applications. Philips' philosophy of 'open innovation' also implies a commitment to alliances (e.g., with a number of leading universities) as a means of leveraging its innovative capabilities.

One of Philips' divisions, Philips Lighting, employs 45,649 people, which is some 29% of the total workforce (Philips, 2006). Although there have been many innovations in lighting, few have made it to the market and many of those that did enter the product stage are variations of existing lighting concepts. An exception is solid-state lighting which over the last few years has opened new opportunities for lighting design. Advances in LED (Light Emitting Diode) technology based on fundamental research into both inorganic and organic LEDs have opened new possibilities in lighting. Originally, LEDs were just used to display information, e.g., on mobile phones. However, their energy efficiency makes them ideal for wider uses. LEDs convert 90% of the incoming electrical charge into a luminous energy and use only one-eighth of the power of traditional bulbs and less than half that for fluorescent lights. Other benefits are small size, low heat generation and flexibility. New concepts based on LEDs are likely to be translated into new products over the next few years across Philips' entire healthcare, lifestyle and technology portfolio (Philips, 2005a; Philips, 2003). High-brightness Organic LEDs (OLEDs) are a candidate for this new light source (Philips, 2005b). The EU is supporting OLED development by an initiative 'Organic LEDs for ICT and Lighting Applications' (OLLA) funded with € 12 mln.

Given their energy saving potential, LEDs provide enormous environmental benefits compared to current lighting technologies. An assessment of the benefits of replacing most of the current lighting by solid-state lighting in the USA reveals that these benefits include a 50% reduction in electricity use for lighting and a 10% reduction in total electricity consumption (Philips, 2003).

Research and Development

Philips Research, with establishments in the Netherlands, Belgium, the UK, Germany, the USA, China, and India, employs approximately 2,100 people. Its RTD expenditures totaled € 2.56 billion or 8.4% of sales in 2005. Table G.1 shows key data of Philips for the period 2000-2005.

Table G.1 *Sales and RTD expenditure Philips by category (estimates for 2000-2001)*

[mln €]	2000	2001	2002	2003	2004	2005
Sales (GAAP)	32,339	31,725	30,983	27,937	29,346	30,395
RTD expenditure by division						
Medical systems	*554*	*652*	*603*	515	447	526
Domestic Appliances and Personal Care	*139*	*163*	*151*	129	134	139
Consumer Electronics	*581*	*684*	*632*	540	475	419
Lighting	*162*	*191*	*177*	151	175	212
Semiconductors	*971*	*1,144*	*1,058*	903	900	957
Other activities	*699*	*823*	*761*	650	654	587
Inter-sector eliminations	*-341*	*-402*	*-371*	-317	-301	-281
Total RTD	2,766	3,257	3,011	2,571	2,484	2,559
RTD as percentage of net sales	8.6%	10.3%	9.7%	9.2%	8.5%	8.4%

Note: Figures refer to €'s of the year. For 2000-2002, only total RTD expenditure is available. The expenditure is assumed to be distributed proportionally to the segmentation of 2003. Figures in italics are estimates.
Source: Philips, 2001-2006 (Annual Accounts).

Over the past few years, total expenditure on RTD has remained relatively stable, while sales have shown consistent year-on-year growth. Consequently, R&D expenditure as a percentage of sales has fallen to a low in 2005 of 8.4%. The stabilisation of the research and development expenditure reflects actions taken to balance the overall Philips portfolio, such as the outsourcing of the monitor and low-end fl at TV activities to TPV, as well as the pro-active re-balancing of research and development expenditures in line with the company's healthcare, lifestyle and technology focus areas.

Table G.2 shows the employment of Philips by geographic area, based on Annual Accounts.

Table G.2 *(Estimated) employment of Philips by geographic area, 2000-2005*

	2000[a]	2001	2002	2003	2004	2005
Netherlands	*36,038*	30,982	29,260	27,688	26,772	26,110
Europe, excl. Netherlands	*66,419*	57,100	48,267	46,174	42,470	41,932
USA and Canada	*42,353*	36,411	34,196	28,111	27,144	27,175
Latin America	*17,726*	15,239	13,424	14,714	14,084	13,702
Africa	*603*	518	450	409	411	406
Asia Pacific	*56,291*	48,393	44,490	47,342	50,750	49,901
Total	219,429	188,643	170,087	164,438	161,631	159,226

[a] For 2000, only the total number of employees is available. Employment is allocated according to the segmentation of year 2001. Figures in italics are estimates.
Source: Philips, 2001-2006 (Annual Accounts).

Energy RTD

Finally, Table G.3 shows the estimated RTD expenditure in the Netherlands that may be related to energy efficiency of products. The expenditure has been estimated in the following way:

- For 2000, (Cornet and Rensman, 2001) present an estimate of the RTD expenditure of NLG 2,336 mln, which is approximately € 1,060 mln.
- For the period 2000-2005, the RTD expenditure of Philips Netherlands is derived from (Technisch Weekblad, 2007a), which is summarised in Chapter 4, Table 4.2.
- It is assumed that the disaggregation of the total RTD expenditure of Philips Company is also reflected in that of Philips Netherlands.
- Furthermore, it is assumed that RTD on 'Domestic Appliances and Personal Care' (DAPC) and 'Lighting' is energy-related, viz. aimed at reduced power consumption and stand-still losses (DAPC) and improved lighting efficiency (Lighting), respectively.
- Therefore, the disaggregation of global RTD is projected at RTD of Philips Netherlands, of which the estimated expenditures on DAPC and 'Lighting' RTD are deemed energy-related.

Energy-related RTD expenditure is assumed attributable to IEA code I.4, 'other conservation'.

Table G.3 *Estimated (energy) RTD expenditure of Philips Netherlands by (IEA) category*

[€ mln]	2000	2001	2002	2003	2004	2005
Total RTD expenditure	1,060	1,055	1,050	1,001	1,024	1,001
Domestic Appliances and Personal Care	*53*	*53*	*53*	*50*	*55*	*54*
Lighting	*62*	*62*	*62*	*59*	*72*	*83*
Subtotal IEA's code I.4 ('other conservation')	*115*	*115*	*114*	*109*	*127*	*137*

Note: Figures refer to €'s of the year. Figures in italics are estimates.

Appendix H Automotive system suppliers

Introduction
There are many companies -small, medium-scale, and large- involved in supplying materials and parts as well as manufacturing of cars, trucks, and buses in the Netherlands. Here, the focus is on so-called automotive system suppliers, which are relatively technology and R&D intensive (FIER/NEVAT, 2003). Production of cars, trucks, and buses is rather important for the Netherlands: notably NedCar in Sittard-Geleen, DAF Trucks in Eindhoven, and Scania in Zwolle are well-known production centres. NedCar bv was acquired by Mitsubishi Motors Corporation (Japan) and DaimlerChrysler (Germany/USA) in 1999. DAF Trucks N.V. is a wholly owned subsidiary of the North-American company PACCAR Inc. Scania AB (Sweden) has a production facility for trucks in Zwolle. In the following, presents key data is presented of the parent companies PACCAR and Scania and car manufacturer NedCar with regard to sales, employees, and RTD expenditure (and employees of production facilities in the Netherlands, if applicable).

Key data PACCAR Inc., Scania AB and NedCar bv
In March 2001, NedCar became wholly owned by Mitsubishi Motors Corporation (Japan) and Mitsubishi Motors Europe. In November 1996, DAF Trucks was acquired by PACCAR Inc. (Pacific Car & Foundry). The company is one of the largest and most successful manufacturers of heavy-duty trucks in the world. DAF Trucks has production facilities in Eindhoven, the Netherlands, and in Westerlo, Belgium. Scania AB from Sweden (Södertälje) is a leading manufacturer of heavy trucks and buses as well as industrial and marine engines. Table H.1 provides key data of the parent companies PACCAR and Scania, as well as car manufacturer NedCar.

Table H.1 *Sales, employees, RTD expenditure PACCAR, Scania and NedCar, 2004-2006*

Company	Key variables	Unit	2004	2005	2006
PACCAR Inc.	Truck and other net sales	[€ mln]	8,709	10,689	12,347
	Employees	(year-end)	20,500	22,000	22,000
	RTD expenditure[a]	[€ mln]	83	95	120
	RTD expenditure, % of sales	[%]	0.9	0.9	1.0
Scania AB	Truck and other net sales	[€ mln]	6,224	6,823	7,816
	Employees	(year-end)	29,993	30,765	32,820
	RTD expenditure	[€ mln]	218	268	334
	RTD expenditure, % of sales	[%]	3.5	3.9	4.3
NedCar bv	Net sales	[€ mln]	2,174	1,356	
	Employees	(year-end)	3,875	3,126	
	RTD expenditure	[€ mln]	P.M.[b]	P.M.[b]	
	RTD expenditure, % of sales	[%]	-	-	

[a] RTD costs are expensed as incurred and included as a component of cost of sales in the accompanying consolidated statements of income. Amounts in Table F.1 represent costs charged against income.
[b] Development costs (including running-in production costs) are invoiced directly to the customers.
Source: PACCAR, 2005-2007; Scania, 2007; NedCar, 2006; Internet Source 12.

Worldwide, Scania has somewhat higher RTD expenditures than PACCAR, but in other respects -turnover, number of employees- the companies are quite comparable. DAF Trucks is the third largest manufacturer of heavy-duty trucks in Europe (Internet Source 13). At the end of 2006, the number of employees of DAF Trucks Eindhoven stood at 5,113 (Internet Source 14). (Cornet and Rensman, 2001) put DAF Trucks' RTD expenditure in 2000 at NLG 71 mln (€ 32 mln). The number of employees of Scania Zwolle is 1,350 (Internet Source 15).

No specification of energy-related RTD for the Netherlands is publicly available.

Appendix I Construction and installation

Introduction
The construction industry and installation companies are strongly involved in new concepts and technologies for energy-efficient and sustainable building and installation. Around 40% of total energy use in the Netherlands is related to houses and buildings. Therefore, without doubt significant energy RTD is performed in this industry sector. However, data on energy RTD expenditures is generally lacking. The inter-firm collaborative enterprise Bouwend Nederland suggested an interview with a representative of the construction company BAM Groep nv. Similarly, inter-firm collaborative enterprise UNETO-VNI suggested an interview with a representative of installation company Van Dorp Installaties. In the following, key information of BAM Groep, Oskomera Groep, and Van Dorp Installaties is presented.

BAM Groep
Koninklijke BAM Groep nv in Bunnik (the Netherlands) is a construction company with a turnover of approximately € 8.6 billion and a workforce of approximately 30,000 people (2006). It is the leading construction company in the Netherlands. Within the EU, it ranks among the top-five of construction companies. Data on energy-related RTD is not routinely published by Dutch companies. Table I.1 provides key data of turnover and employees of Koninklijke BAM Groep.

Table I.1 *Key data turnover and employees BAM Groep, 2003-2006*

Turnover		Unit	2003	2004	2005	2006
Division	Building & real estate	[€ mln]	3,578	3,734	3,605	4,415
Division	Civil engineering	[€ mln]	3,347	3,418	3,511	3,847
Division	Public Private Partnership	[€ mln]	-	-	40	70
Division	Mechanical and electrical engineering	[€ mln]	201	193	182	191
Division	Consultancy & engineering	[€ mln]	165	143	166	204
Division	Dredging	[€ mln]	526	-	10	20
	Other	[€ mln]	37	55	24	-
	Eliminations	[€ mln]	-84	-75	-113	-101
	Total	[€ mln]	7,770	7,468	7,425	8,646
Employees		(year-end)	26,837	26,651	27,190	~ 30,000

Source: BAM Groep 2005-2006; Internet Source 16.

Energy-related activities in Koninklijke BAM Groep are mainly developed by the division 'Installation technology', particularly in the knowledge centre 'Energy Systems'. This business unit initiates new energy systems, and related activities in design, implementation, monitoring, consultancy, and project development. The unit focuses on efficiency improvement and reduction of the consumption of fossil fuels. Sustainability, efficient energy conversion and renewable energy are key notions. Much emphasis is on tracking new energy technologies and concepts. New technologies are researched, developed and implemented in the framework of projects, both in housing and buildings. An example is combined heating and cooling in conjunction with shallow aquifers for housing and building projects. As the relation between RTD on the one side and implementation in projects on the other side is intimate, it is difficult to discern between the RTD effort and the project properly. Also, other types of RTD are performed in other divisions or units of BAM, e.g., related to safety in buildings and fire prevention.

As BAM is evolving from a straightforward building company to a more technology-intensive company, RTD in a unit such as 'Energy Systems' (part of Installation Technology) is growing. There is a close cooperation with technical universities, polytechnic schools, and entrepreneurs in the Netherlands. Also, a few employees are working on a doctoral thesis in conjunction with their work for BAM. As RTD is not separately administrated, only a tentative estimate is possible. Probably, energy-related RTD within the company concerns 1-10 FTE. Therefore, RTD expenditure may be of the order of magnitude of 100,000’s rather than M€’s (Uiterweerd, 2007).

Oskomera Groep
Oskomera Groep bv in Uden (Netherlands) is specialist in the field of façade technology and steel structures. The Oskomera Group consists of self-supporting subsidiary companies which execute the projects independently but also in close cooperation with other group members. One of the strengths of Oskomera is its capacity to provide total solutions, whereby the façade system and the supporting steel structure are developed jointly. The total building process, from design to a perfect execution, is realised within the company. One of the subsidiaries is Oskomera Solar Power Solutions bv. This subsidiary supplies complete solar power systems for building integrated solutions. Besides, Oskomera supplies system technology from a wholesale perspective, and produces and supplies components for solar power systems. Oskomera Groep has a turnover of approximately € 55 mln and a staff of 220 people (Internet Source 17).

Research and development
According to the vision of Oskomera Groep, designing beyond the established boundaries is a speciality of Oskomera. RTD is focused on smart integrated solutions, sustainability, etc.

Van Dorp Installaties
Van Dorp Installaties bv (Zoetermeer) is a medium-scale installation firm with 550 employees (Remmerswaal, 2007). Despite its modest scale in comparison to some of the larger firms in the sector (e.g., GTI), it is strongly involved in development and implementation of new heating, cooling and ventilation technologies for housing and building projects. Just like in case of BAM Groep, one of the mostly applied technologies is combined heating and cooling in conjunction with shallow aquifers for housing and building projects. Also, technologies such as low-temperature heating, heat pumps, and heat regeneration (and humidification) from ventilation air are generally applied.

The concept of ‘total cost of ownership’ -often including project financing and exploitation by an installation company- is more and more applied, not only in hospitals, commercial buildings, etc., but also in renovation of buildings. Also, the current high price of fossil fuels (natural gas) encourages the uptake of energy-efficient technologies for heating and cooling. Installation firms work in an environment in which new technologies are presented and promoted by technology suppliers, SenterNovem, technical advisors, and market-pull. Within this framework, Van Dorp Installaties endorses energy-efficient or sustainable options, provided that they are cost-effective. It does not perform RTD itself, but investigates engineering problems and the economic feasibility -sometimes assisted by technical advisors- of technologies to be applied.

Appendix J KEMA

Profile

KEMA's headquarter is in Arnhem, the Netherlands, and it has subsidiaries in the USA, Germany, and China. In 2006, KEMA's turnover amounted to € 180.5 mln (a growth of 9% compared to 2005) and the number of employees stood at 1,363 FTE by the end of 2005 (KEMA, 2006; Internet Source 18). KEMA is an internationally operating company whose shares are hold by electricity generating and distributing companies. Activities range from high-quality business and technical consultancy to the inspection, testing and certification of equipment of any voltage. While consultancy, e.g., with regard to environmental issues, inspection, testing and certification are its main activities, there is also significant RTD activity.

In the 1990s, RTD by KEMA amounted to NLG 60-80 mln, or € 27-36 mln per year (Rienstra, 2007). However, due to the liberalisation of energy markets, interest and incentives for RTD declined. Today, electricity supply companies are more focused on reducing costs than on selecting and investing in advanced (power generation/transmission/distribution) technology. Therefore, it is difficult to define a generic RTD policy. However, KEMA succeeded in nurturing areas of high-quality RTD from which the electricity companies engaged may profit, as well the shareholders in general.

The areas of expertise of KEMA include:

- Markets & Regulation
- Power Generation
- Power Exchange/Energy trading
- Transmission & Distribution
- Retail & Demand Side Management
- Public Infrastructure, Transportation & Safety
- Testing & Certification - Low Voltage
- Testing & Certification - Medium & High Voltage.

KEMA has four business units, viz.:

1. Testing & Certification - Low Voltage
   This unit addresses electrical safety issues of consumer appliances. Certification not only pertains to electrical appliances in the EU, but also in China: KEMA has four testing and certification laboratories in China for testing of products intended for export to Europe (Internet Source 19).
2. Testing & Certification - Medium & High Voltage
   This unit performs Medium and High Voltage (M&HV) testing: Transmission & Distribution Testing group (TDT). KEMA is acknowledged internationally for its expertise on M&HV testing.
3. Consulting Services
   KEMA provides the full scope of services and resources required to take a project from analysis to timely and effective implementation. Consulting service areas include:
   - Management Consulting
   - Asset Management
   - KEMA Market Research and Knowledge Base
   - Energy Systems Consulting
4. Technical & Operational Services
   This business unit focuses on, e.g., power generation technologies, advice and engineering in this respect, measurements of emissions and efficiencies, optimisation, etc.

There are three areas of RTD for which electricity supply companies - not only KEMA's shareholders - expressed interest and that they are willing to support, and one other area of RTD:

1. Membrane technology
   RTD activities of KEMA concern *inter alia* membrane separation of CO_2 from flue gas of coal or gas-fired power plants (Technisch Weekblad, 2007c).
2. Power Electronics (EMPT, in Dutch: Elektromagnetische Vermogens Techniek, EMCT)
   KEMA has an association with - among others - technical universities (Eindhoven, Delft, Twente) aiming to develop and exploit a laboratory for Electromagnetic Power Technology at the KEMA premises.
3. Cable diagnostics
   Most power network faults are due to defective distribution cables. Therefore, power companies and network owners try to identify weak spots in cables and replace defective sections before short circuits occur. New KEMA technology will enable power companies to monitor the quality of vital cables continuously while remaining in use.
4. Technical Service Agreement (TSA)
   In the framework of the Technical Service Agreement (TSA), each year an RTD area is defined - in 2007, 'Clean Fossil Power' - that coincides with the demand from key electricity generation companies and which they are willing to support financially.

In 2005, 3% of KEMA's turnover consisted of RTD activities, according to (KEMA, 2006). In Table J.1, the turnover of KEMA in the period 2000-2006 is displayed, as well as the estimated RTD expenditure based on this 'rule-of-thumb'. It is assumed that the RTD expenses are evenly distributed among the categories Electric Power Conversion (code VI.1) and Electricity Transmission & Distribution (VI.2) of the IEA. Resulting RTD figures are denoted as 'acceptable'.

Table J.1 *(Estimated) turnover and RTD expenditure of KEMA by (IEA) category, 2000-2006*

[€ mln]	2000	2001	2002	2003	2004	2005	2006
Turnover	N/A	182.0	183.7	167.9	173.1	167.9	180.5
Energy RTD (estimate)	N/A	*5.5*	*5.5*	*5.0*	*5.2*	5.0	*5.4*
VI.1 Electric Power Conversion	N/A	*2.75*	*2.75*	*2.5*	*2.6*	*2.5*	*2.7*
VI.2 Electricity Transmission & Distribution	N/A	*2.75*	*2.75*	*2.5*	*2.6*	*2.5*	*2.7*

Notes: KEMA does not publish RTD expenditure in more detail. The figure of 3% RTD as a function of turnover for 2005 has been used for the total period 2000-2006. Figures in italics are 'acceptable' estimates.
Source: KEMA, 2006; Internet Source 18.

Appendix K Photovoltaic (PV) industry

Introduction
The photovoltaic (PV) industry, producing solar modules (based on solar cells), solar panels and components is a nascent industry with a number of production facilities in the Netherlands. Data is presented of the start-ups/companies Advanced Surface Technology (ASP), Helianthos (NUON), Mastervolt, OTB Solar, Scheuten Solar, Siemens Solar Projects, Solland Solar Energy, and Ubbink Solar Modules. Key data and (estimates of) RTD expenditure are summarised.

Advanced Surface Technology (AST)
Advanced Surface Technology (AST) bv, Bleiswijk (Zuid Holland), is a start-up of the Technical University Delft, to which is referred in, e.g., (Schoonman, 2005). The small company, that aims to develop and commercialise innovative solar cells and modules, profited from the aforementioned WBSO subsidy scheme (Internet Sources 20-21). As its website (Internet Source 22) is under construction, no data on turnover, workforce, etc. of this company is available.

Helianthos (NUON)
The mission that the new company Helianthos has formulated is: ‘Helianthos wants to provide customers with the means to generate clean electricity through innovative photovoltaic (PV) products at a price competitive with that of conventional electricity. With our range of thin-film, durable flexible PV solutions we enable our customers around the world to generate electricity in a sustainable and economical way’.

Helianthos started in 1997 developing an innovative process for the manufacturing of cost competitive flexible solar cell laminates. Initially, Helianthos was a joint venture between the Technical Universities of Delft and Eindhoven, University Utrecht, TNO, and Akzo Nobel. Later also ECN was involved in the development of specific parts of the technology.

In 2000, Akzo Nobel entered into cooperation with Shell Solar with the aim that the latter would bring Helianthos products to the market. However, the cooperation ended in 2004 and Akzo Nobel agreed in 2006 (SIGN, 2006) to sell Helianthos to NUON. Various cooperative projects cofinanced by SenterNovem to bring the patented Helianthos technology from lab to pilot have been carried out over the past years (Schlatmann, 2005). Currently, Helianthos has a staff of about 35 people. It is piloting its innovative production process and preparing commercialisation of its flexible solar cell laminates (SIGN, 2006; Internet Source 23; Jongerden, 2007).

Mastervolt
Mastervolt was founded in 1991, and offers AC and DC solutions for customers in the global marine, mobile and renewable energy markets, e.g. inverters for PV. The turnover was € 35 mln in 2005. Mastervolt has 115 employees in the EU (headquarter Amsterdam) and abroad. Investing in RTD and closely anticipating market demands are key pillars to Mastervolt’s approach (Internet Source 24).

OTB Solar
In 2005, OTB Solar bv originated as a spin-off of OTB Groep bv at Eindhoven. The latter has 200 employees and a turnover of € 64.3 mln in 2005 compared to € 57.4 mln in 2004 (FD, 2006). OTB Solar, a 100% subsidiary of OTB Groep, is a leading company in the design, engineering, development and manufacturing of tailor made inline production equipment. OTB Solar’s core activity is the development and marketing of state-of-the art production machinery for solar cell manufacturing facilities. OTB Solar, headquartered in Eindhoven, has regional offices in the United States, Singapore and India. In May 2006, it announced the successful installation of a 30 MWp production line for the South-Korean solar cell manufacturing company KPE. In

March 2007, OTB reported that it will design, deliver and commission manufacturing and handling equipment for the initial production line of ARISE's planned 80 MWp photovoltaic (PV) cell production facility in Bischofswerda, Germany (Internet Source 25). OTB Solar's turnover increased from € 16 mln in 2005 to approximately € 30 mln in 2006, and its number of personnel stood at 55 in mid 2006 (ED, 2006).

Scheuten Solar
Solar/glass Scheuten is a leading and fast-growing industrial producer of complete solutions for glass and solar energy systems. Solar/glass Scheuten headquarters are located in Venlo in the Netherlands and currently employs approximately 1,200 people, with an annual turnover of approximately € 200 mln (Internet Source 26).

The division Scheuten Solar is active in the field of PV production and the supply of complete PV system solutions. The division Solar has offices in the Netherlands, Belgium, Germany, Spain, Italy and Korea. The Solar division employs worldwide more than 300 people with an estimated turnover of more than € 100 mln (2006). The 65 MWp module production plant is located in Gelsenkirchen (Germany). Furthermore, Scheuten Solar acquired the former cell production plant in Gelsenkirchen from SolarWorld AG (Germany), which also included an agreement to buy silicon wafers form SolarWorld AG. This transaction adds another dimension to Scheuten Solar enabling them to be actively involved in nearly the whole value chain.

Scheuten Solar also develops its own thin-film CIS (copper indium sulphide) technology, and is currently building a pilot plant in Venlo with a capacity of 10 MW_p/year. Furthermore, on June 13 2007 the company announced plans to upscale this technology in a new factory with a capacity of 250 MW_p/year, due to be put in operation in 2009. The Scheuten Solar thin film CIS technology is unique in the sense that it employs small (0.2 mm) glass beads, which are covered with an active layer and subsequently embedded in a perforated metal foil to make a solar cell. These solar cells are then assembled to form a solar module. By using this approach, thin film deposition itself does not have to take place on large areas, as with other thin-film approaches. This technology can thus easily be scaled up to large surfaces, flexible dimensions and produces considerable synergies with existing glass technology (Internet Source 27).

Siemens Solar Projects
The subsidiary of Siemens in the Hague, Netherlands, has a Centre of Competence (CoC) for solar projects. CoC Solar Projects supplies grid-connected and autonomous energy supply with photovoltaic power. Siemens has its own inverter techniques. The SINVERT is used as a central inverter for large scale solar systems. A SITOP inverter is developed for residential and functional architecture. Four areas of business related to PV are distinguished (Internet Source 28):
- Large scale grid connected energy supply with PV
- Building integrated PV systems
- Energy supply for residential and functional architecture
- Autonomous energy supply.

Siemens has a number of Centres of Competence in the Netherlands, offering customers international expertise, products and solutions, ranging from harbour transhipment systems to solar energy systems. The consolidated sales of all Siemens companies in the Netherlands amounted to € 1,511 million in fiscal 2006, and the number of employees is 3,188 (Internet Sources 29). Further data on turnover with regard to PV services and related workforce is not available.

Solland Solar Energy
Solland Solar Energy holding bv is a German/Dutch solar cell producer -70% shareholder DELTA of the Netherlands and 20% shareholder Sunergy[10]- with a production facility at Heerlen/Aachen, at the border of both countries. In October 2005, Solland Solar started its first pro-

[10] Sunergy is active in silicon and solar wafer technologies and owns a system house.

duction line with a capacity of 20 MWp/year. A second line of 40 MWp became operational by the end of 2006. Solland Solar employs 150 people. A new technology developed by ECN is the Back-contact Solar Cell technology, which will be applied in new production facilities. In 2006, the turnover of Solland Solar was approximately € 40 mln. The objective of Solland Solar is 500 MWp/year, capacity 2010 (€ 1 bln turnover; 1,000 employees). An investment programme of € 200 mln is foreseen, excluding R&D facilities (Ploumen, 2007).

Ubbink Solar Modules

The production plant for PV modules of Ubbink Solar Modules bv in Doesburg is a joint venture of Econcern (30%, Utrecht) and Centrosolar AG (70%, Munich, Germany). The plant opened in 2006, and has currently an output of 6 MWp. The solar cells are from Solland Solar Energy. Centrosolar AG has a turnover of € 172 mln and 364 employees (2006). The plant at Doesburg has 36 employees, and the turnover could be some € 5 mln (Internet Source 31).

Key data and (estimates of) RTD expenditures

Table K.1 summarises key data presented above of PV companies, component suppliers, etc.

Table K.1 *Key data of turnover and employees of PV (component) companies Netherlands*

Company (Netherlands[11])	Turnover 2005 [€ mln]	Turnover 2006 [€ mln]	Capacity 2006 [MWp/yr]	Employees 2006
Advanced Surface Technology (AST)	N/A	N/A	-	N/A
Helianthos (Nuon)	N/A	N/A	-	~ 35
Mastervolt	35	N/A	(inverters)	115
OTB Solar	16	~ 30	N/A	~ 55
Scheuten Solar	N/A	100	65	300
Siemens Solar Projects (the Hague)	N/A	N/A	-	N/A
Solland Solar Energy	N/A	40	60	150
Ubbink Solar Energy	N/A	~ 5	6	36
Total PV companies		~ 200	~ 125	~ 700

In order to put their production capacities in perspective, Table K.2 presents an overview of the global PV industry in 2005.

Table K.2 *PV cell and module production in 2005 by world region - IEA PVPS countries*

[MW/yr]	Japan	USA	Europe	Balance	Total
Cell production 2005					
Cell production	824	156	479	41	1,500
Cell production capacity	1,071	207	811	63	2,152
Module production 2005					
sc-Ci	159	58	118	1	336
mc-Si	461	50	116	33	660
a-Si	33	22	2	-	57
Undefined Si	120	42	270	11	443
Other	-	26	99	<1	36
Total module production	773	198	515	46	1,532
Module production capacity	1,286	257	791	193	2,527

Source: IEA, 2006c.

[11] Flemish Photovoltech, a subsidiary of Total of France, evolved into a significant player on the market of PV cells: production capacity 20 MWp around 2005, envisaged to increase to 80 MWp before end 2008 (Internet Source 2).

Data of RTD expenditure of the PV companies is not available. However, data of, e.g., RTD expenditure of a large German PV company, SolarWorld AG, is publicly available (Table K.3).

Table K.3 *Key data turnover, employees, and RTD expenditure of SolarWorld AG (Germany)*

	Unit	2003	2004	2005	2006
Turnover	[€ mln]	98.5	199.9	356.0	512.2
Employees	(end-of-year)	525	616	759	1,348
RTD expenditure	[€ mln]	4.5	8.5	8.33	12.4
RTD as percentage of turnover	[%]	4.6	2.4	2.3	4.3

Source: SolarWorld, 2005-2007.

For SolarWorld AG, RTD expenditure turns out to be between 2.5 and 4.5% of its turnover. As the combined turnover of the PV (component) companies in the Netherlands is about € 200 mln, their RTD expenditure may be estimated at approximately € 7 mln annually (2006). In 2005, RTD expenditure could be approximately € 6 mln. Both estimates are denoted as 'acceptable'.

Appendix L Wind industry

Introduction
The wind industry, producing wind turbines, components and related services (RTD, engineering and design) is a relatively new industry with several production plants in the Netherlands. In the following, data is presented of the companies AE-Rotor Techniek (AERT), Composite Technology Centre (CTC), DarwinD, Emergya Wind Technology (EWT), Harakosan Europe, Home Energy, Lagerwey Wind, LM Glasfiber Holland, Mecal, Polymarin Composites, Rheden Steel, and Wind Energy Solutions (WES). Key data of - if available or applicable - turnover, employees, and (estimates of) RTD expenditure is summarised.

AE-Rotor Techniek (AERT)
AE-Rotor Techniek (AERT) in Hengelo was founded in 2001, and has wide experience in the field of composites technology. As a 100% subsidiary of Suzlon Energy Ltd (India), and because of its specialisation in aerodynamics, Suzlon's R&D centre in Hengelo is responsible for design and development of rotor blades. The centre works closely with various universities on the development of new blade designs and engineering solutions, based on latest Resin Infusion Moulding (RIM) techniques. This results in enhanced aerodynamic efficiency, by making the blades lighter in weight while increasing their strength, which in turn reduces the load on the wind turbine and results in higher returns on investment for our customers. In Europe, Suzlon Energy Ltd has its corporate head office in Amsterdam, a marketing branch office in Aarhus, Denmark, and an R&D facility for turbines in Berlin and Rostock, Germany. The number of employees of AERT (Hengelo) and Suzlon Energy Ltd. Amsterdam is 125 - first quarter 2007 (Internet Sources 32-33; Verheij, 2007).

Composite Technology Centre (CTC)
Composite Technology Centre (CTC) in Almelo is an engineering company established in 2001, with experience in composites and wind energy. At this moment VTC has a team of 14 employees working in different fields of interests. The in house know how and experience covers the fields from aerodynamic design, via structural design and material knowledge towards production processes, such as Resin Infusion Molding (RIM). As a company CTC believes in a strong cooperation and co-makership with its customers, to enforce the capacities of each other. Therefore CTC aims for turn key projects, from design till production support on site (Internet Source 34). Currently, the number of employees of CTC is 12 (Ter Laak, 2007).

Darwind
Darwind was established in 2005 by ATO-NH (Stichting Associatie Technologieoverdracht Noord Holland). The province of Noord Holland granted subsidies for Darwind. Darwind (headquarter Utrecht, manufacturing plant Den Helder), focuses on the development of large offshore wind turbines of 4.5 MW (rotor diameter 115 m). These will probably be tested in 2008 at the wind turbine test location in Wieringermeer (Noord Holland). In June 2006, Econcern bv (Utrecht), viz. its subsidiary Ecoventures, became major shareholder of Darwind (WindNieuws, 2007a).

Emergya Wind Technologies (EWT)
Emergya Wind Technologies bv (EWT) is a wind energy company, based in Schoondijke (headquarter and operations centre, Zeeland) and Barneveld (engineering, Gelderland), that started operations in February 2004, based on key assets including Intellectual Property of Lagerwey Windturbine bv for production of its *DIRECTWIND* 750 kW and 900 kW direct drive wind turbines derived from the 750 kW base model. Based on this technology, EWT has a rich history of innovation, technological breakthroughs, producing cost-effective high yielding wind turbines.

The core activities of EWT are:

- Marketing and sales of wind farms on a full turnkey basis, as well as installation and service of wind turbines.
- Development and manufacturing of technologically advanced, state-of the-art direct drive wind turbines.

EWT is forecasting cumulative orders to the tune of 350 MW by 2008. It also forecasts to have installed 70 MW of wind capacity by 2008. In 2006, construction started on a 16-turbine wind farm for Delta Energy at Reimerswaal with estimated annual output of 32 mln kWh (Internet Sources 35-36). It also delivered *DIRECTWIND* 900 turbines to Friesland, the Netherlands, and Nova Scotia, Canada. From 2005 to 2006, its turnover increased from € 7.3 to € 81 mln, and its number of employees is 25 (Bolleman, 2007).

Harakosan Europe

In January 2005, Harakosan Europe bv, a subsidiary of Harakosan Japan Co. Ltd., acquired the technology of Zephyros bv, a Dutch developer and manufacturer of multi-MW gearless wind turbines. Harakosan Europe bv, headquartered at Lelystad (Flevoland) and with a production facility at den Helder (Noord Holland), focuses on four areas of business related to the wind energy market:

- Designing leading technology concepts for future wind turbine developments.
- Sales and marketing of wind turbine projects.
- Sales of production licenses.
- Service engineering / upgrading advice / retrofit.

Its main product is a 2 MW permanent magnet direct drive wind turbine, designed for near-shore and offshore applications. In 2005 and 2006, Harakosan supplied the hubs and nacelles for twenty-five 2 MW turbines, 22 of which for Taiwan (Windnieuws, 2007a; Internet Source 37). The number of employees is estimated at 30-35 (Ter Laak, 2007).

Home Energy

Home Energy bv, Schoondijke (Zeeland), is a subsidiary of Wind and Water Technology (WWT), a fast growing company producing and marketing products in the area of clean technology. Home Energy develops and manufactures small urban wind turbines with the product name Energy Ball®, and with a rated capacity of 500 W (Internet Sources 38-39).

Home Energy has an extended product range in renewable energy, viz. (Grauzinis, 2007):

- The aforementioned Energy Ball®, a small urban wind turbine.
- Pellets (wood chips) for central heating systems of consumers.
- PV panels.
- Evacuated solar collectors.

All products of Home Energy are specifically designed for the consumer market.

Home Energy is expanding its market throughout the Benelux and beyond. It focuses on promoting renewable energy by the Home Energy brand name and informing consumers about options to generate renewable energy - both thermal energy and electricity - for their own use.

Lagerwey Wind

Lagerwey Wind, established in 2006 in Barneveld, focuses on the development of innovative wind turbine concepts, particularly with direct drive technology. It aims to provide designs that can be adapted to the special needs of customers. The expertise in design, engineering, and consultancy spans the range from very small to MW turbines (Internet Source 40; WindNieuws, 2005b). The number of employees is estimated at 4 (Ter Laak, 2007).

LM Glasfiber Holland
LM Glasfiber (Denmark) is the world's leading supplier of blades for wind turbines. LM's production capacity measured in MW is the largest in the industry, and it has factories in four major regions: Northern Europe, Southern Europe, North America and Asia. LM has the largest R&D department in this specialist field enabling it to be at the forefront of technological development. LM Glasfiber Holland in Heerhugowaard, a 100% subsidiary of LM Glasfiber, is one of three R&D centres, the other two being located in Denmark and Balgalore, India (Internet Source 41).

Mecal
Mecal, founded in 1989, is leading in applied engineering (e.g. applied mechanics) and product development. Over time Mecal's activities concentrated on the two major areas: wind energy and semiconductor equipment manufacturing. Therefore, global customers are the wind turbine industry and the semiconductor industry. Mecal employs 50 people and has offices in Enschede, Veldhoven, and Groningen (Internet Source 42). It has increased its role in Wind Turbine Inspections and Assessments and services offered to wind farm investors, project developers and other stakeholders. MECAL Turbine Assessments are typically performed at the end of a turbine test run, at the end of the warranty period or whenever a Due Diligence is required.

Polymarin Composites
Polymarin Composites is a leading company in the field of developing and producing fibre-reinforced composite structures. Its production site is (temporarily) in Hoorn (Noord Holland). Since 1982, it is active development of rotor blades for wind turbines. These rotor blades vary from 5 to 80 m in diameter and are applied on turbines, ranging from 2.5 kW to 2.0 MW. Until recently, Polymarin Composites aimed for a share in the production of rotor blades of 5 to 10% of the world market within a period of 3 to 5 years (Internet Source 43). Although a fire at the production site at Medemblik was a serious setback, an order from Emergya Wind Technologies (EWT) for 48 rotor blades to be produced for the 16-turbine wind farm of Delta Energy at Reimerswaal meant a boost in the viability of Polymarin Composites (Internet Source 44). From 2005 to 2006, Polymarin's turnover increased from € 1.1 to € 1.5 mln, and it has approximately 15 employees (Bolleman, 2007).

Rheden Steel
Rheden Steel bv in Rheden (Gelderland), is a subsidiary of Smulders Group bv in Helmond (Brabant), which employs over 1,000 employees, spread over different European establishments. Smulders Group realises large and quite complicated steel constructions. The various companies of the Group are cooperating closely in many projects. Owing to experience of many years, Rheden Steel has developed into a leading manufacturer of steel wind turbine towers (Internet Sources 45-46).

Wind Energy Solutions (WES)
Wind Energy Solutions bv (WES) was established in 2003 as the manufacturer of the well-known two-bladed, passive pitch, wind turbines with 80 (WES18) and 250kW (WES30) capacities, and also of the three bladed 2.5 kW (WES5) Tulipo model (WindNieuws, 2005b).

WES of Zijdewind (Noord Holland) has recently developed a new control cabinet that enables the WES18 and WES30 models to be used as wind/diesel hybrid systems, with a 100% wind penetration. This feature, in combination with the logistics-friendly, two-bladed design, makes the WES products ideal for applications in remote areas, in weak grids, or in combination with a generator of some kind. Another recent development is that of the stand-alone wind turbine that works without the use of an outside power source like a grid or generator.

WES targets its products at electricity consumers that:

- Are grid connected, but want to reduce their electricity bills.
- Are connected to a weak grid that needs stabilising support.
- Do not have grid connection and need a Wind/Diesel system for stand-alone (island) configurations.

The company also performs comprehensive wind studies and project engineering and consultancy. It works together with ECN, WMC (Test Laboratories for Blade Materials) and Technical University Delft, has agents in North America and Asia, and resellers in many other countries (Bijleveld, 2007; Internet Source 47).

Key data and (estimates of) RTD expenditures

Table L.1 summarises key data presented above of wind turbine companies or component manufacturers in the Netherlands.

Table L.1 *Key data turnover and employees of wind (component) companies Netherlands*

	Turnover 2005 [€ mln]	Turnover 2006 [€ mln]	Employees 2006
AE-Rotor Techniek (AERT), Suzlon Energy Ltd.	N/A	N/A	~ 125
Composite Technology Centre (CTC)	N/A	N/A	12
DarwinD	N/A	N/A	N/A
Emergya Wind Technologies (EWT)	7.3	81	25
Harakosan Europe	N/A	N/A	30-35
HomeEnergy (Wind and Water Technology)	N/A	N/A	N/A
Lagerwey Wind	N/A	N/A	4
LM Glasfiber Holland	N/A	N/A	~ 20
Mecal	N/A	N/A	~ 25
Polymarin Composites	1.1	1.5	15
Rheden Steel	N/A	N/A	N/A
Wind Energy Solutions (WES)	0.5	1.1	6
Total wind turbine (component) companies	N/A	N/A	~ 250[a]

[a] For some companies, wind turbines (components) are not the only product. The total number of employees refers to people engaged in turbine (component) manufacture, engineering, design, and RTD.

Although only data of turnover and employees is published or referable for AE-Rotor Techniek (AERT, Hengelo), Emergya Wind Technologies (EWT, Schoondijke), LM Glasfiber Holland (Heerhugowaard), Mecal (Enschede, Veldhoven en Groningen), Polymarin Composites (Hoorn), and Wind Energy Solutions (WES, Zijdewind), employees engaged in wind turbine manufacturing (including components), engineering, design, etc. amount to approximately 250 (year-end 2006). AE-Rotor Techniek and LM Glasfiber Holland are R&D centres of Suzlon Energy and LM Glasfiber, respectively. So, a lot of employees are engaged in R&D. Therefore, the RTD expenditure is estimated at € 6 mln per year in 2006, and slightly less in preceding years.

Appendix M Bio-energy industry

Introduction

The bio-energy industry, producing biomass-based technologies and fuels (e.g., for the transportation sector) is a new industry with several representatives in the Netherlands. In the following, data of turnover, employees, and RTD expenditure - if available - is presented of Agrotechnology and Food Innovations (A&F), BiogaS International Project, Biomass Technology Group (BTG), Brouwers BioEnergy, Certified-Energy, W.K. Crone, Dordtech Engineering, HoSt, Nedalco, OGIN Biogasinstallaties Nederland, Orgaworld, Polow Energy Systems, Thecogas PlanET Biogastechniek, and Unica Ecopower.

Agrotechnology and Food innovations (A&F)

Agrotechnology and Food innovations (A&F) constitute an R&D department of Wageningen University and Research Centre (Wageningen, the Netherlands). There are four research areas (Internet Source 48), viz.:

- Sustainable biomass production
- Biomass logistics and pre-treatment
- Bioconversion and biofuels
- Biomass-to-energy and products chain aspects.

BiogaS International Project

BiogaS International Project bv, in Klazienaveen (Drente), is an installation group with 16 companies in the Netherlands, a turnover of around € 200 mln, and some 1,600 employees (Leveranciersgids 1, 2006). BiogaS International is a company that supplies tailor-made biogas plants, including maintenance contracts, project financing or leasing, guarantees, etc.

Biomass Technology Group (BTG)

Biomass Technology Group, BTG, in Enschede (Overijssel) has as its mission to contribute significantly to increasing the share of bio-energy in the primary energy supply. Production and use of bio-energy shall take place in an environmentally, socially, and economically sustainable manner. BTG has two business units, Consultancy & Project Development and R&D. Important activity of project development is CO_2 emission trading under JI and CDM mechanisms. Actual trading is carried out by BTG's subsidiary Bioheat International bv (Van de Beld, 2007).

The current R&D activities of BTG include (Internet Source 49):

- Bio-oil production: development of a fast pyrolysis process for the production of a liquid fuel (bio-oil) from biomass and bio-waste.
- Bio-oil applications: combustion in boilers for industrial and district heat generation and in engines for power, gasification of bio-oil for the production of chemicals.
- Upgrading of pyrolysis oil to transportation fuel.
- Torrefaction of biomass and waste streams.
- Two-step catalytic gasification: tar-free producer gas production
- Reforming or wet and/or liquid biomass in supercritical water: production of a hydrogen-rich gas and high-pressure syngas.

Brouwers BioEnergy

Brouwers BioEnergy, in Leeuwarden (Friesland), is supplier of turnkey biogas plants at farm-scale. Brouwers cooperates with a number of partners with experience in the agricultural sector. The biogas installations are modular, which enables contracting from different suppliers of components (Leveranciersgids 1, 2006).

Certified-Energy
Certified-Energy, in Wanroij (Limburg), is an engineering and construction company specialised in renewable energy technology (in particular biogas installations), including preparation of building permits, consultancy, maintenance, and R&D. Certified-Energy is a licence partner of Schmack Biogas AG, Germany (Leveranciersgids 1, 2006).

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 (Leveranciersgids 2, 2006).

Dordtech Engineering
Dordtech Engineering, in Dordrecht (Zuid Holland), is a developer and producer of CHP and gensets for alternative fuels, such as biogas, bio oil, and hydrocarbon vapours (Leveranciersgids 3, 2006).

HoSt
HoSt in Hengelo (Overijssel) is an engineering and contracting company, specialised in energy technology and processes. It realises cost reductions for her clients by custom-made solutions, based on proven technology. HoSt builds wood-fired combined heat and power installations, based on the HoSt gasification and gas cleaning technology. The expertise of HoSt is related to:
- Biomass combustion
- Biomass gasification
- Digestion
- Gas Cleaning.

Alternatively, biomass processes and systems of well-known suppliers can be installed (Internet Source 50).

Nedalco
Nedalco is a subsidiary of Cosun[12], which produces and sells natural ingredients and foodstuffs for the international food industry, foodservice channel (restaurants, caterers, and wholesalers) and retail outlets. Cosun Food Technology Centre (CFTC) is the expertise centre for research and product and process technology development, fulfilling demands from businesses -among subsidiary Nedalco that produces high-quality alcohol for the industry and bioethanol for the transport sector- for both operational support and product & process innovation (Cosun, 2006).

Nedalco's high-quality alcohol is used for several industries, like beverage, medical, cosmetic and chemical industry. In 2006, a new alcohol factory with a capacity of 40 million litres of ethanol annually was built and taken into operation at Sas van Gent (the Netherlands). It mainly serves Nedalco's established markets. Also in 2006, Nedalco supplied its first alcohol for use as an additive to engine fuel in the Netherlands and abroad.

In March 2007, Nedalco and Mascoma Corporation, USA, signed a license and joint development agreement to commercialise ethanol production from lignocellulosic biomass. This technology partnership has the objective to license Nedalco's yeast-based technology for use in Mascoma's recently announced demonstration plant and for use in future Mascoma biofuels plants, and to explore collaborative research efforts to accelerate production of second-generation bioethanol (Internet Source 51). Using this technology based on a patented yeast converting xylose into bioethanol, CO_2 emissions from road transport may be reduced by 60-80% compared with gasoline (Internet Source 52). Also, Nedalco plans to build a bioethanol plant at Sas van Gent for production of second-generation bioethanol. At the end of 2008, the

[12] In 2005, Royal Cosun (Breda, the Netherlands) achieved a turnover of € 1.34 billion. At the end of 2005, the workforce was about 4,200 FTEs.

plant (investment € 150 mln) will be operational - capacity 200 mln litres of bioethanol annually. It will be one of the first plants producing second-generation biofuels on an industrial scale. Nedalco is reported to have approximately 5 R&D employees. No further data on turnover and total number of employees is available.

OGIN Biogasinstallaties Nederland
OGIN Biogasinstallaties Nederland, in Dronten (Flevoland), supplies biogas plants for the agricultural sector, as a representative of Linde-KCA Dresden (Germany) for the Benelux countries. This company supplies farm-scale biogas reactors for the digestion of manure and co-substrate (Leveranciersgids 1, 2006).

Orgaworld
Orgaworld, in Uden (Noord Brabant), is an innovative and fast growing company which focuses on organic waste treatment, and particularly on the processing of organic waste to produce final products such as energy, fuels, and agricultural products. The technologies used are anaerobic digestion (the Biocel concept) combined with CHP producing electricity and compost as residual product (Leveranciersgids 1, 2006).

Polow Energy Systems
Polow Energy Systems, in the Hague, is specialised in process technology, and particularly in energy recovery and heat processes in industry and agriculture. Polow is the sole supplier of the Torbed® technology (Leveranciersgids 4, 2006).

Thecogas PlanET Biogastechniek
Thecogas PlanET Biogastechniek, in Lochem (Gelderland), is a Dutch/German company with about 40 employees, specialised in the construction of biogas plants. The German headquarter is in Vreden (Leveranciersgids 1, 2006).

Unica Ecopower
Unica Ecopower, in Hoevelaken (Utrecht), is an installation group consisting of 16 companies through the Netherlands. The group has a staff of about 1,600 people. Unica Ecopower provides complete solutions, including design, engineering, erection, installation works, commissioning, and maintenance, of, e.g., bio-energy plants - plants based on rapeseed oil, palm oil, animal fats, etc (Leveranciersgids 3, 2006).

Key data and (estimates of) RTD expenditures
Table M.1 summarises key data presented above of bio-energy companies (research centres) in the Netherlands. The Table also includes (estimates of) turnover and number of researchers of Shell Netherlands in the area of bio-energy. Possibly, private RTD expenditure in the Netherlands - including that of Shell Netherlands - amounts to approximately € 10 mln (2005).

Table M.1 *Key data of turnover & employees of bio-energy companies in the Netherlands*

	Turnover 2005 [€ mln]	Turnover 2006 [€ mln]	Employees 2006
Agrotechnology and Food innovations (Wageningen)	N/A	N/A	N/A
BiogaS International Project	N/A	N/A	N/A
Biomass Technology Group	2	2	30
Brouwers BioEnergy	N/A	N/A	N/A
Certified-Energy	N/A	N/A	N/A
W.K. Crone	N/A	N/A	N/A
Dordtech Engineering	N/A	N/A	N/A
HoSt	N/A	N/A	N/A
Nedalco (Cosun) [a]	N/A	N/A	N/A
OGIN Biogasinstallaties Nederland	N/A	N/A	N/A
Orgaworld	N/A	N/A	N/A
Polow Energy Systems	N/A	N/A	N/A
Thecogas PlanET Biogastechniek	N/A	N/A	40
Unica Ecopower	N/A	N/A	N/A
Subtotal Dutch companies and research centres	5	6	~ 75
Shell Netherlands, division biomass (Global Solutions)	8	10	~ 50
Total bio-energy companies	13	16	~ 125

a Nedalco is reported to have about 5 R&D employees.

b Data of Shell Netherlands is based on a disaggregation of its RTD expenditures in Appendix D. It is reiterated that this disaggregation is fraught with considerable uncertainty: 'poor' data. Therefore, the quality of the inferred total RTD expenditure on bio-energy in the Netherlands - € 12 mln in 2006 - is 'poor' too.

Appendix N Country fact sheet Netherlands

Format Country Reports for public and private ERTD expenditures				
	Approach used	**Sources available**	**Data quality**	**Comments**
Public	Personal contact with Mr. F Denys, SenterNovem	Personal communication Mr. F. Denys, SenterNovem Utrecht	Excellent	Expenditures on hydrogen en fuel cell RTD 1997-2001
Private	Main source: SenterNovem (2007): Energieonderzoek in Nederland - Energie-technologie projecten in de WBSO 2003 tot en met 2005. SenterNovem, Utrecht/Sittard/Zwolle, the Netherlands, January 2007. Annual reports, websites, articles in, e.g., magazines, and interviews or tele-phone communication and email contact	Shell annual reports, etc.	Total excellent	Disaggregated 2000-2005, poor
		Annual reports chemical industries	Acceptable	2000-2005
		Data of and interview with Corus	Acceptable	Expenditures 2004-2005
		Data of and interview with KEMA	Acceptable	Expenditures 2001-2005
		Data of PV and wind (component) in-dustry	Acceptable	Expenditures 2005-2006

Report for public (and private) ERTD expenditures the Netherlands				
	Approach used	**Sources available**	**Data quality**	**Comments**
Public	***5. Search into international organizations*** Data for public ERTD was not available from the official IEA website.	(www.iea.org)	(IEA study)	IEA data virtually complete, except hydrogen en fuel cell RTD
Public	***6. In personal contacts*** At the quest for public ERTD data, personal contacts were made with Mr. V. Mollen, Société de l'information, science-technologie-innovation, tourisme, environnement, Luxembourg, February 26, 2007.	Data of SenterNovem on hydrogen en fuel cell RTD	Excellent	⇗ Addition to IEA database requires subtraction for another category (hydrogen en fuel cell RTD is already included in total public RTD)
Private	***Search for collaborative ERTD projects*** Main source: SenterNovem (2007): Energieonderzoek in Nederland - Energietechnologie projecten in de WBSO 2003 tot en met 2005. SenterNovem, Utrecht/Sittard/Zwolle, the Netherlands, January 2007.	Annual reports, websites, articles in, e.g., magazines, and interviews or telephone communication and email contact	Mostly acceptable, except for ERTD of Philips NL and disaggregate ERTD of Shell NL	Synthesis of data SenterNovem (2003-2005) and data of ECN: Lako, P., M.E. Ros (2007): Public and private energy RTD expenditures in Belgium, Luxembourg and the Netherlands. ECN-E-07-xyz, Petten, May 2007.