SCIENTIFIC SUPPORT PLAN FOR A SUSTAINABLE DEVELOPMENT POLICY

SPSD II

RENEWABLE ENERGY TRACKING INDICATORS BELGIUM

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SUPPORTING ACTIONS

SCIENTIFIC SUPPORT PLAN FOR A SUSTAINABLE DEVELOPMENT POLICY (SPSD II)

Part 3:
Supporting actions – "Clusters"

FINAL REPORT

RENEWABLE ENERGY TRACKING INDICATORS BELGIUM

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1 INTRODUCTION

1.1 Context

The contribution of renewable energy is expected to grow for the next decades in the European Union. The official objective is to reach 12% of its gross primary energy consumption by 2010. For electricity explicitly, the objective is to reach 22,1% by 2010 as indicative target in the European directive on green electricity [RES-E 01], and significantly higher targets for the European Union for 2015 – 2020 are likely.

Belgium envisages to base 6% of its domestic gross electricity consumption on renewable sources of energy by 2010. There are no official objectives for the contribution of green heat although the regional governments have or will have sectorial targets including heat from renewable sources. Targets for 2015 and beyond are being set at regional levels.

The available statistics on renewable energy are often produced at a certain moment in time for one region, and/or for a restricted set of technologies. In addition, the methodologies used to report on renewable energy on regional, federal and European level differ.

1.2 Objective

The aim of this project is the development of indicators, i.e. aggregated sets of data, allowing a continuous monitoring of the progress of the renewable energy implementation in Belgium.

The indicators are selected in a way to allow for a professional monitoring of the renewable energy contribution in Belgium. Public authorities can be adapt policy schemes accordingly to optimise the growth path of renewable energy in Belgium. Private market actors can improve the operation of their installations during their lifetime.

The indicators have to be the reference statistical basis on renewable energy in Belgium built on the best-available data sources for further usage by regional and federal authorities, both as for the reporting to the European Commission and other international public authorities.

1.3 Scope

The project focusses on all renewable energy sources and conversion technologies eligible in the regional or federal definition of renewable energy.

1.4 Methodology

The project is executed in 4 steps:

1. Selection of useful indicators
2. Characterization of the indicators: definition, required input data, data source, and recommended update frequency.
3. Calculation of an exemplary set of the selected indicators, with an interpretation directed to the potential users
4. Formulations of recommendations to implement a continuous process of updating and disseminating the indicator values

Some indicators are mentioned as useful in step 2, but not calculated in step 3 because of confidentiality of data or the high cost of data. The first mainly concerns data, which are recorded by the regional and federal regulatory bodies for accountancy of tradable green certificates. The latter is the case for data sourced from surveys with statistical relevant results (socio-economic impact), or from large data volumes which have to be purchased from third parties (detailed data on solar radiation).

The given recommendations in the last chapter aim at finding the balance between the users’ needs for reliable and detailed indicators, and the cost of keeping them updated.

1.5 Guide to the Reader

This study does not intent to provide values for the full set of indicators for the whole of Belgium during a year or longer but rather to develop the indicators and give examples for their calculation.

In Section 2 of this report, the approach for the selection of indicators is explained. Indicators are generally divided into four different types: resource indicators, system indicators, energy indicators and impact indicators. The different indicators are listed in this section.

The full definition of each indicator together with an example and further suggestions for the use and interpretation of each indicator is provided in the following sections. Sections 3 contains resource indicators, Section 4 system indicators and Section 5 energy indicators. Impact indicators are detailed in Section 6.

Finally, Section 7 formulates recommendations on the appropriate medium for distribution, the frequency of updating and the organisation of the necessary data sorcing.

2 INDICATORS

The selection of indicators was mainly based on the needs of public and private entities that will use them.

Four types of indicators have been chosen: resource indicators, system indicators, energy indicators and impact indicators.

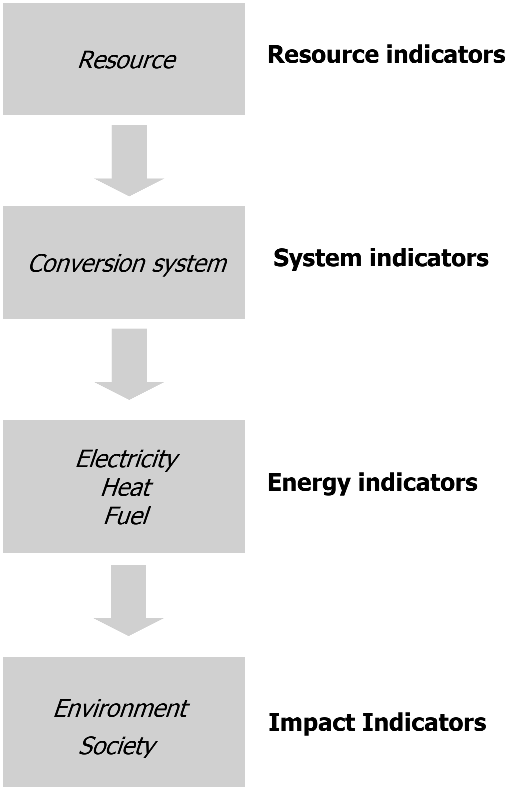


Figure 1: Four types of indicators on resource, system and energy level, completed with indicators reflecting the impact on environment and society.

The resource indicators aim at a characterization of the wind, solar and biomass resources. They serve as a basis for quick feasibility calculations or as reference values in comparison to real production data. They enable operators of renewable energy projects to check the performance and correct operation of their existing installations.

System indicators show a broad spectrum of characteristics of different renewable energy installations, including their performance.

The related energy indicators, including technological and regional split-up, allow policy makers to closely follow the impact of policy mechanisms and the interaction of system performance with introduced policy measures.

Impact indicators describe the environmental impact or assess the socio-economic impact of the renewable energy production in Belgium. The socio-economic indicators are structured as three types following the structure-conduct-results-scheme. They were drawn up in order to monitor the impact of renewable energy in Belgium yearly. This supposes an annual update in order to monitor the evolution of the socio-economic impact. In the survey only companies with importing (reselling) or manufacturing activities were restrained to calculate the socio-economic impact of renewable energy in Belgium.

Table 1 to Table 4 give an overview of the selected indicators. Note that Resource related, system related and energy related indicators are listed with a basic definition and a physical unit. The socio-economic indicators are rather comprehensive sets of figures than one single number and therefore definition, here, no definition or unit are listed. These are, however, provided for the socio-economic indicators as described in detail in the following section.

Table 1: Selected resource-related indicators and definitions

TYPE	INDICATOR	DEFINITION	UNIT
Solar energy	Global irradiation on the horizontal plane: monthly spatial distribution	Global irradiation on the horizontal plane; spatial distribution	kWh/m² per month
	Global irradiation on the 40° south-tilted plane: monthly spatial distribution	Global irradiation on the tilted plane; spatial distribution; tilt defined at 40° and south oriented as being optimal orientation for solar energy production	kWh/m² per month
	Yearly irradiation fraction	Representation of the yearly irradiation fraction as a function of the orientation and the tilt angle, with respect to the optimum	-
	Monthly average final yield (spatial distribution) of a standardised reference PV system	A reference PV system is defined and modelled. The monthly output of the reference system is simulated for different locations and a spatial distribution of the output is extrapolated	kWh/kWp
Wind energy	Windex	Energy amount in a certain period (1 month or 1 year) compared to a long term average energy for a certain geographical area.	-
	Long-term annual average specific energy output of a standardised wind turbine for different regions	Expected annual production of a reference wind turbine divided by its swept area	kWh/m² per year
Biomass	Indigenous biofuel used for energy conversion[1]	Total primary energy content of used indigenous biofuel for heating, electricity or transport applications	GJ
	Imported biofuel used for energy conversion[2]	Total primary energy content of used imported biofuel for heating, electricity or transport applications	GJ

[1] This indicator cannot be calculated with currently available data. The required information may be provided by the regulators.
[2] idem

Table 2: Selected system-related indicators and definitions

TYPE	INDICATOR	DEFINITION	UNIT
Solar thermal	Installed surface of solar thermal collectors [3]	Newly and totally (cumulative) installed area	m²
Solar PV	Installed grid-connected PV peak power[4]	Sums of rated power of newly installed and cumulatively installed systems	kWp
	Cumulated final yield	Total electricity production divided by installed PV peak power	kWh/kWp
	Estimated cumulated performance ratio	Cumulated final yield divided by reference yield at a reference site	-
Wind energy	Installed wind farm capacity [5]	Sums of rated power of newly installed and cumulatively installed systems	MW
	Specific energy output from Belgian wind farms	Total annual production of all wind turbines divided by the total swept area	kWh/m²/year
	Overall capacity factor of Belgian wind farms	Total production divided by total installed power divided by amount of hours considered in the period	-
Biomass	Installed capacity of biomass conversion systems[6]	Sums of rated power (electrical) of newly installed and cumulatively installed systems	MW
	Overall system efficiency	Total final energy production (separately for heat and electricity) divided by the total primary input of bio-fuel[7]	-
Hydropower	Installed hydropower capacity	Sums of rated power of newly installed and cumulatively installed systems	MW
All	Spatial distribution of installations	Map showing the regional distribution of installations including an indication of installed power per type of renewable energy	-
	Statistics of rated electrical power	Frequency distribution rated electrical power per type of renewable energy [8]	-
	Statistics of voltage levels	Frequency distribution voltage level grid connection per type of renewable energy [9]	-
	Frequency distribution of the age of installations	Frequency distribution of the ages of systems in operation[10]	-

[3] In the future, it may be possible to differentiate between flat plate, vacuum and naked collectors
[4] In the future, it may be possible to differentiate between amorphous silicon, crystalline silicon and other module types
[5] In the future, it may be possible to differentiate between onshore solitary, onshore and offshore wind farm
[6] Electrical capacity only; quantitative information on thermal capacity of the systems for heat production or cogeneration is currently not available.
[7] This indicator cannot be calculated with currently available data. The required information may be provided by the regulators.
[8] idem
[9] This indicator cannot be calculated with currently available data. The required information may be provided by the distribution system operators.
[10] Due to the long lifetime of installations this indicator may become of interest in the future in order to assess the product life cycles of renewable energy conversion equipment (e.g. repowering of wind turbines). This indicator cannot be calculated with currently available data. The required information may be provided by the regulators.

Table 3: Selected energy production-related indicators and definition[11]

TYPE	INDICATOR	DEFINITION	UNIT
Solar thermal	Solar thermal energy production	Calculated production	kWh/year
Solar PV	PV energy production	Total electricity production	MWh/year
Wind Energy	Wind energy production	Total electricity production	GWh/year
Biomass	Biomass electricity production[12]	Total electricity production	GWh/year
		Total heat production	GWh-th/year
		Total indigenous biofuel production for transport	GJ/year
Hydro power	Hydropower production	Total electricity production	GWh/year
All	Renewable electricity production	Total electricity production	GWh/year

[11] Possibly, this indicators can be shown per month.
[12] Electricity production only; quantitative information on heat production, cogeneration fraction and biofuel consumption is currently not available.

Table 4: Selected impact related indicators and definition

TYPE	INDICATOR
Environmental	Avoided CO_2 emissions per type of renewable energy[13]
	Visual impact of wind turbines
Socio-Economic (Structure)	Number of employees
	Numbers of companies
	Number of foreign companies
	International activity Belgian companies (export)
	Expenses R&D (total, per employee, %total) [14]
Socio-economic (Conduct)	Diversification over technologies
	Type of activities
	Investment intensity
	Vertical integration (value added/turnover)[15]
	Capital labour intensity (fixed assets per employee)[16]
	Entry and exit[17]
Socio-economic (Results)	Evolution of employment
	Evolution of turnover
	Trade balance effect
	Profitability[18]

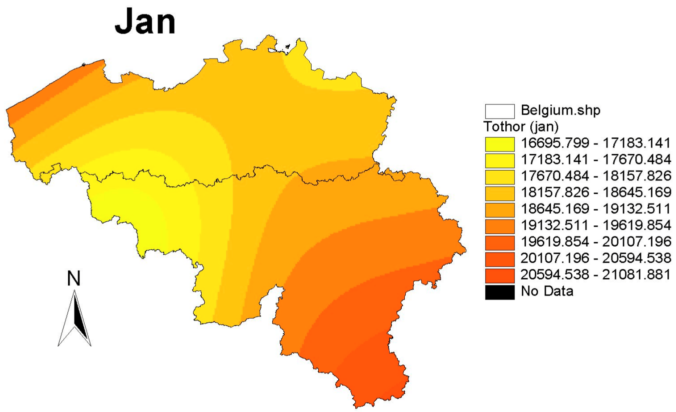
[13] In the future, differentiation may be considered between CO_2 and other greenhouse gas emissions.
[14] Due to the limited number of companies publishing their R&D expenses, currently the indicator cannot be determined. This may become possible in the future coming along with significant growth of the RE industry.
[15] This indicator cannot be calculated with currently available data. The required information may be acquired in the future by more in-depth surveys.
[16] idem
[17] idem
[18] idem

3 RESOURCE INDICATORS

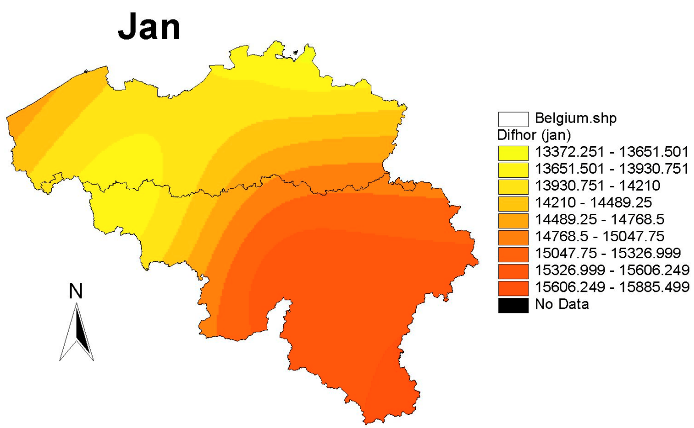
3.1 Global irradiation on the horizontal plane: monthly spatial distribution

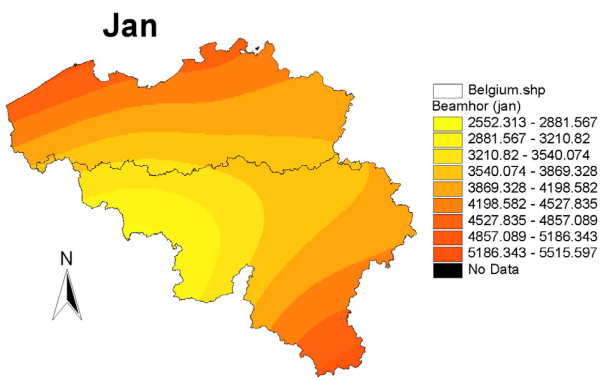
Definition	The distribution was interpolated from monthly average values over many years at 7 places representative of the whole of the Belgian territory. The data for each month were introduced into a spatial model by holding account of the geographical co-ordinates of the points of measurements to obtain a grid of interpolation. The intermediate values were calculated by balanced spatial interpolation and extrapolation for the points located on the territory but apart from the grid. The quality of this interpolation can still be improved by applying data from additional places (e.g. Maastricht, Luxembourg, Lille) and by the use of solar radiation tools based on satellite data.
Interpretation	The geographical distribution of the irradiation in Belgium together with coefficients of reduction due to a non-optimal slope should allow the user to easily estimate the long-term energy yield of a solar energy project. If in addition to the long-term averages, recent up-to-date data are made available, these can be applied by operators of solar energy installations in order to calculated the corresponding energy output to be expected and, thus, to verify the good functioning of their installation. A significant deviation may announce the presence of a technical problem and will encourage the system operator to solve the problem immediately without large losses of income.

Values



Long-term mean value of the global monthly irradiation (for January) for the horizontal plane (Wh/m²)



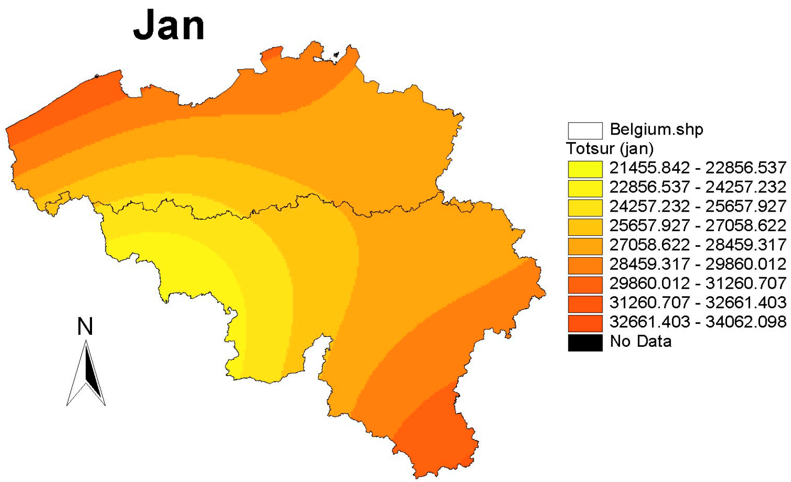


Long-term mean values of the diffuse and direct monthly irradiation (for January) for the horizontal plane (Wh/m²)

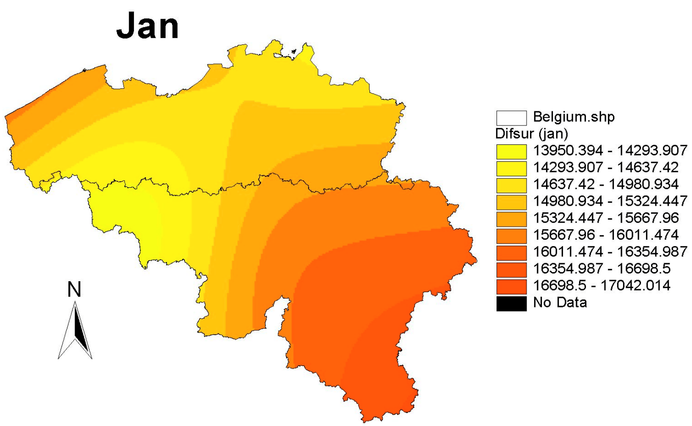
3.2 Global irradiation on the 40° south-tilted plane: monthly spatial distribution

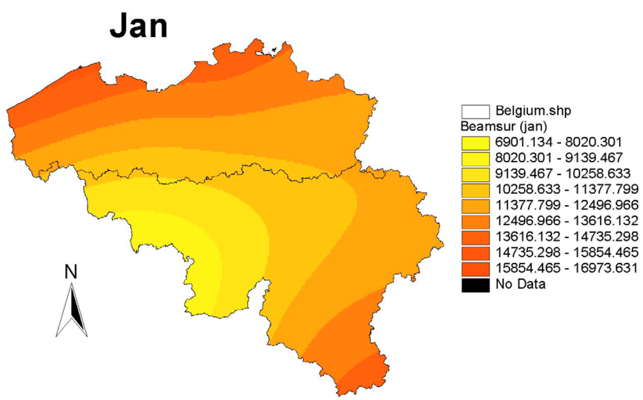
Definition	This distribution was interpolated from monthly average values over many years at 7 places representative of the whole of the Belgian territory. Diffuse and direct irradiation data were derived from synthetic time series on the basis of long-term mean values of horizontal irradiation. The conversion to the 40° south-tilted plane was made by applying the model of Perez [Per 87]. The data for each month were introduced into a spatial model by holding account of the geographical co-ordinates of the points of measurements to obtain a grid of interpolation. The intermediate values were calculated by balanced spatial interpolation and extrapolation for the points located on the territory but apart from the grid. The quality of this interpolation can still be improved by applying data from additional places (e.g. Maastricht, Luxembourg, Lille) and by the use of solar radiation tools based on satellite data.
Interpretation	The geographical distribution of the irradiation in Belgium together with coefficients of reduction due to a non-optimal slope should allow the user to easily estimate the long-term energy yield of a solar energy project. If in addition to the long-term averages, recent up-to-date data are made available, these can be applied by operators of solar energy installations in order to calculated the corresponding energy output to be expected and, thus, to verify the good functioning of their installation. A significant deviation may announce the presence of a technical problem and will encourage the system operator to solve the problem immediately without large losses of income.

Values



Long-term mean value of the global monthly irradiation (for January) for a 40° south-tilted plane (Wh/m²)





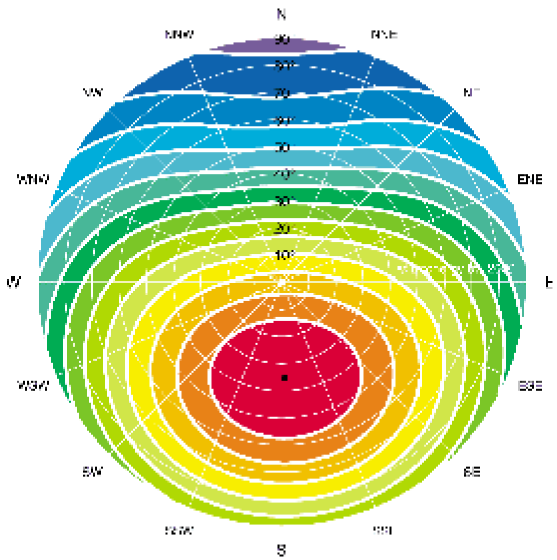
Long-term mean values of the d*iffuse and direct monthly irradiation (for January)* for a 40° south-tilted plane *(Wh/m²)*

3.3 Yearly irradiation fraction

Definition

The yearly irradiation fraction can be visualized as a radiation disk in polar coordinates. It indicates the solar irradiation on a plane with given orientation (tilt angle and azimuth) as a percentage of the irradiation on a plane with optimal orientation. At optimal orientation the long-term average of annual solar irradiation is maximal. For Uccle the maximum irradiation amounts to 1083 kWh/m^2 on a plane with 35° tilt angle and an azimuth of 2° out of the south direction to the east (the black spot).

Values



Interpretation

The irradiation disk can serve for the conversion of solar irradiation data for different array orientation. The disk for Uccle can serve as an estimate for the whole of Belgium. Moreover, specific irradiation disks could be calculated for each month. Together with monthly irradiation values from indicators 3.1 or 3.2, the conversion of monthly values to any desired orientation is possible.

3.4 Monthly average final yield of a standardised reference PV system

Definition	The quality of a PV installation is described by its performance ratio (PR). The performance ratio is the fraction of long-term energy efficiency in the field divided by the rated PV array efficiency. Well-operating grid-connected PV installations have a PR in the order of 0.75 to 0.8. The average final yield is calculated by multiplying the long-term average solar irradiation by the PR of a standard PV system (PR=0.75 in the present example). Based on irradiation data from 3.1, analogue distributions can be calculated for the final ield.
Values	For the irradiation data of January as presented above, the average reference yield in Belgium ranges between 16 and 26 kWh/kWp depending on the place. Over the whole year the average final yield in Belgium ranges between 790 and 910 kWh/kWp [Woy 03].
Interpretation	The monthly (and annual) average final yield serves as a reference value for PV system operators taking into account the variation over the place. In analogy to the spatial distributions of irradiation, this indicator can be converted for different array orientations by means of the radiation disk. Again, if recent up-to-date data are available, actual monthly final yield values can be calculated as a benchmark for PV system operators.

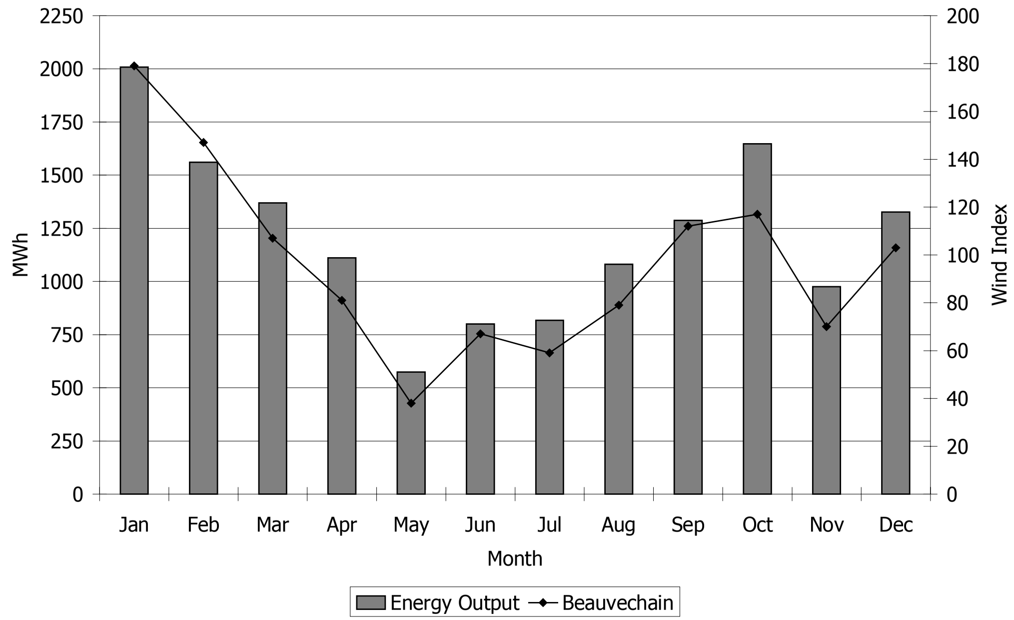
3.5 Windex

Definition

One defines Windex as follows

Windex = $P_{month} / P_{month\ LT}$ With P_{month} = real Production and $P_{month\ LT}$ = Awaited Production in the long run.

Values



Interpretation

Windex is a tool, which makes it possible to control the performances of the wind turbines under operation. It measures the relative offer of the wind over one given period (typically a month). With the windex, one can thus easily judge if the variation of production of a wind turbine compared to the average results from a technical hitch or offer from wind.

3.6 Long-term annual average specific energy output of a standardised wind turbine

Definition	Expected annual production of a reference wind turbine divided by its swept area
Values	Values will range between 600 and 900 kWh/m²/year depending on the wind during the specific year.
Interpretation	This indicator gives a normalized view on the specific energy output from wind turbines in Belgium.

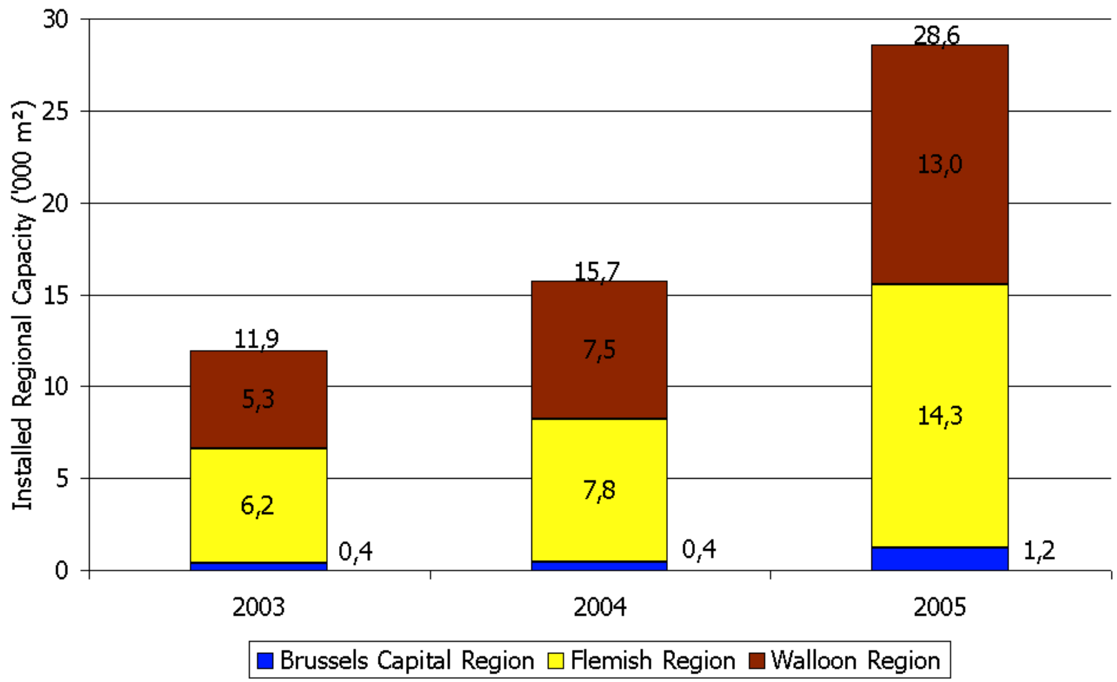
4 SYSTEM INDICATORS

4.1 Installed surface of solar thermal collectors

Definition

Sum of cumulative installed area (m²) of collectors.

Values



Interpretation

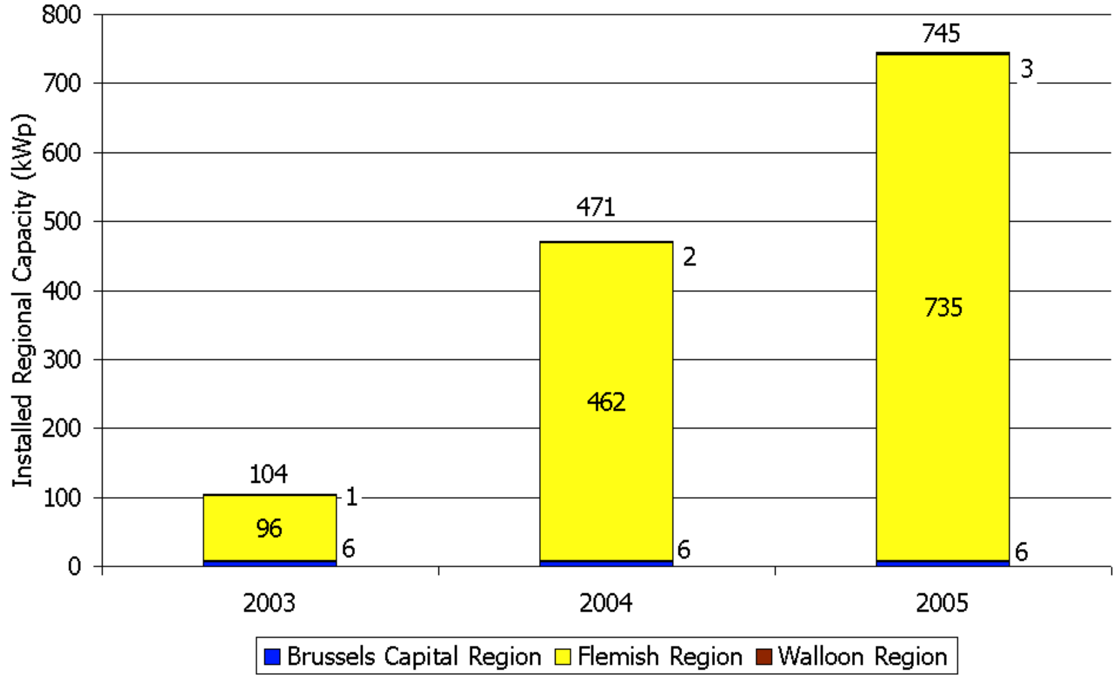
In 2005 28 600 m² of solar thermal panels were installed compared to 11 900 m² in the year 2003. Flemish region and Wallon region have about almost the same installed surface. The growth rate amounted 32% in 2004 and over 81% in 2005.

4.2 Installed grid-connected PV peak power

Definition

Sum of rated power of cumulatively installed systems, expressed in kWp.

Values



Interpretation

In 2005, 745 kWp of solar panels were installed. Nearly all the installations took place in the Flemish region, as consequence of the dedicated PV regulation. The growth rate amounted respectively 353% in 2004 and 59% in 2006. The high growth in 2004 is due to the Flemish subsidy scheme for PV that came into force.

4.3 Cumulated final yield

Definition	The cumulated final yield is the electricity production from PV during a year divided by the installed PV peak power
Values	Values will range between 700 and 1000 kWh/kWp depending on the quality of Belgian PV installations and on the solar irradiation during the specific year.
Interpretation	This indicator gives a normalized view on the specific power generation from PV in Belgium and, hence, an indicator for the capacity factor of cumulated PV in the power system.

4.4 Estimated cumulated performance ratio

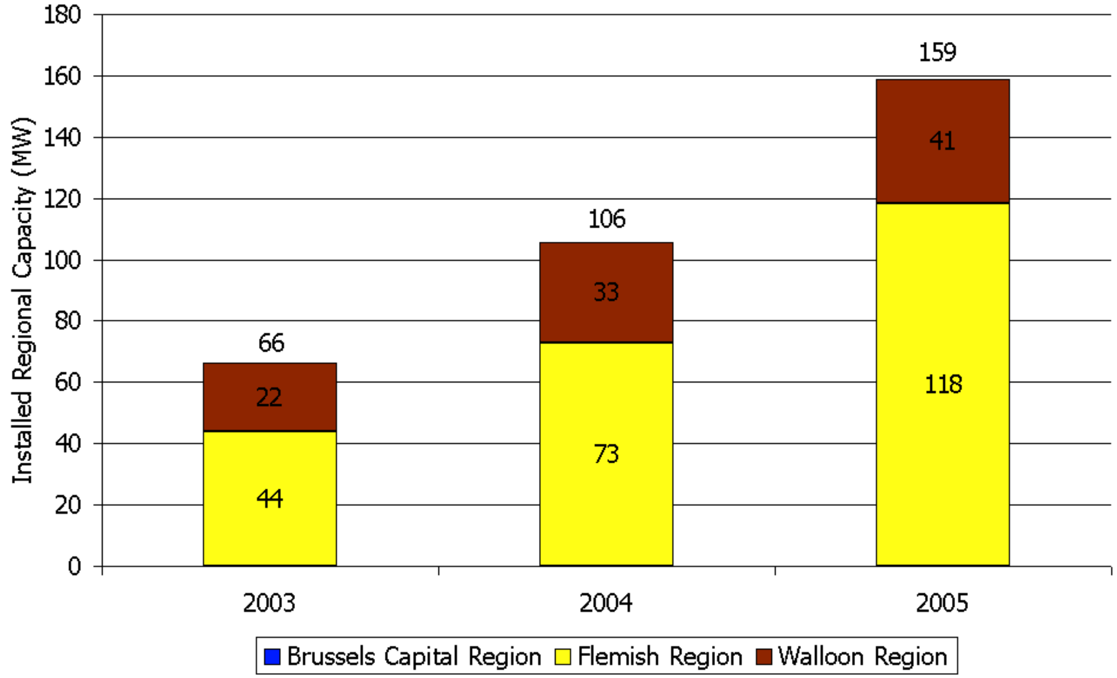
Definition	The estimated cumulated performance ratio is the fraction of the cumulated final yield during a year to the solar irradiation during that year at a reference site.
Values	Values are expected to range between 0.65 and 0.85.
Interpretation	This indicator estimates the long-term energy efficiency in the field of the total of all Belgian PV installation as a fraction of the rated efficiency of the PV array. The value is a total for all installations. Its development over the years can reveal significant tendencies over time. Expected tendencies are especially the degradation of older PV installations over the years and increasing system efficiencies for more recent installations.

4.5 Installed wind farm capacity

Definition

Sum of rated power of cumulative installed wind farms, expressed in MW

Values



Interpretation

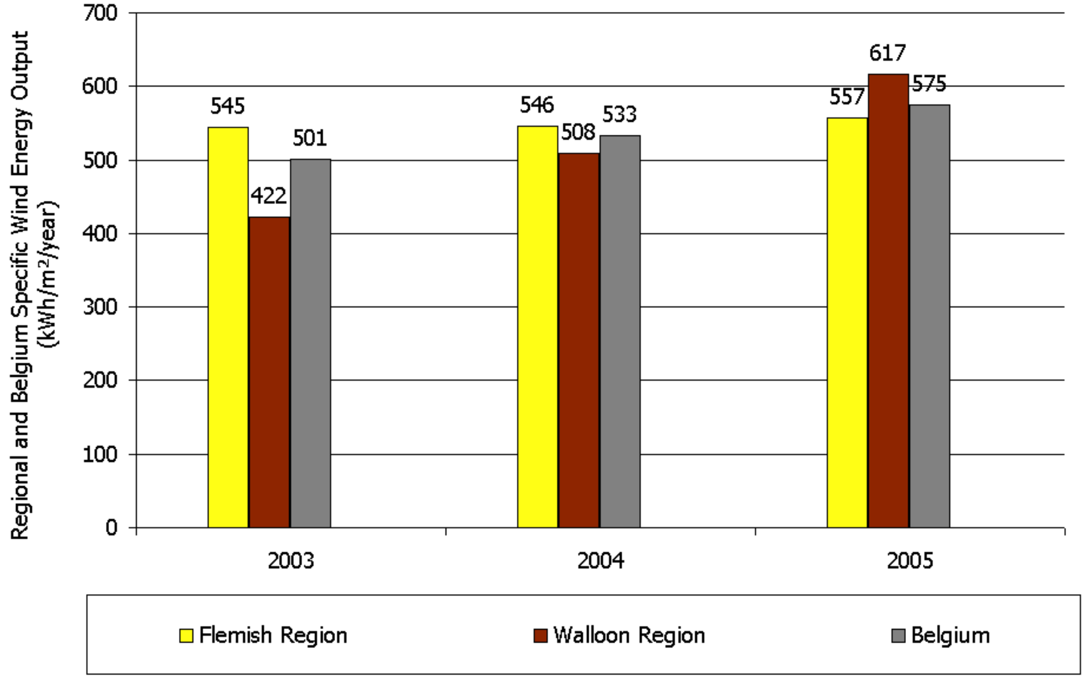
159 MW of wind energy was installed by the end of 2005, of which 3/4th in the Flemish region and 1/4th in the Walloon Region. In 2003 and 2004 the partition of the installations was 2/3rd in the Flemish Region and 1/3rd in the Wallon Region. So far no wind turbine is installed in the Brussels Capital Region. The growth rate in 2004 and 2005 was respectively 60% and 50%.

4.6 Specific energy output from Belgian wind farms

Definition

Total annual production of all wind turbines divided by the total swept area

Values



Interpretation

The specific energy output of the Belgian Wind farm is still lower than the long-term annual average specific energy output of a standardised wind turbine. The reason here for is that the market is still not mature and that during the years 2003-2005 a lot of wind power was installed (more of half of the existing power each year). The production of newly installed wind turbines are in the year of installation lower than their average annual production (since they do not generate electricity for the complete 12 months), but the swept area remains the same, so that the specific energy output in the year of installation is lower than the long-term annual average specific energy output. In a mature market, where new installations will be much lower than 10% of existing market, this effect will play less[19].

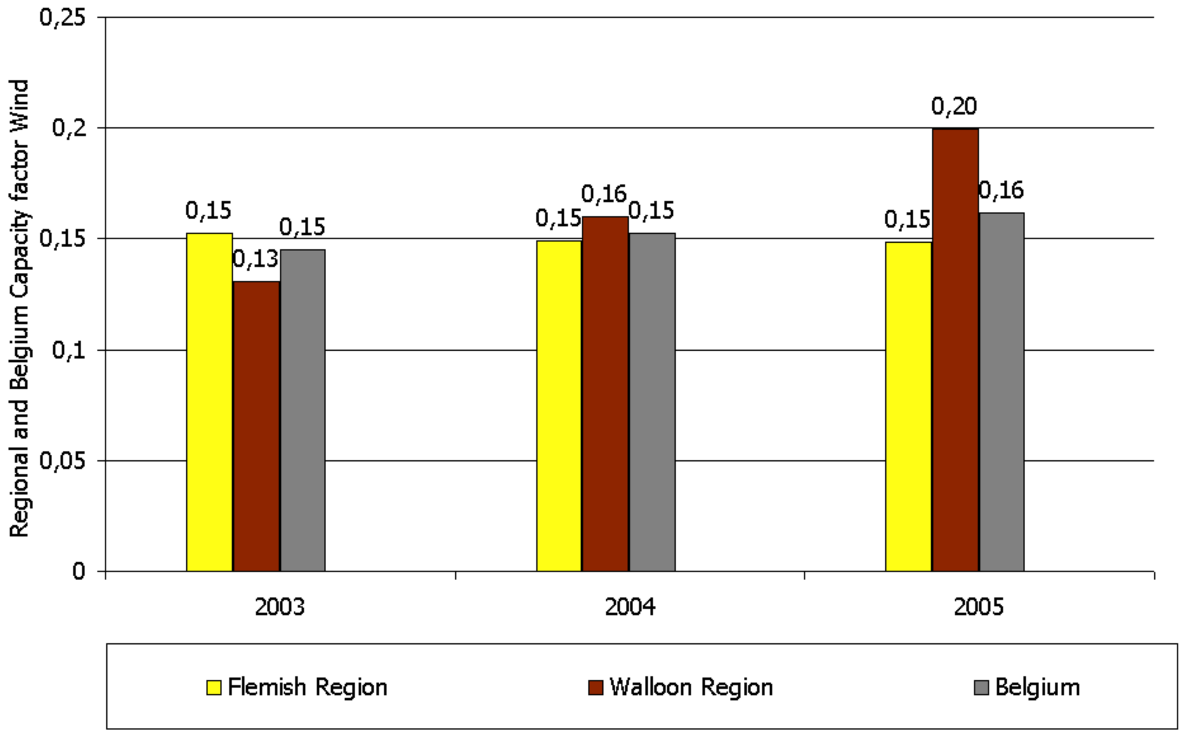
[19] This effect can be counteracted if the specific energy output per month is calculated for each turbine

4.7 Overall capacity factor of Belgian wind farms

Definition

The total production divided by the total installed power divided by the amount of hours considered in the period (for 1 year this will be 8760 hours).

Values



Interpretation

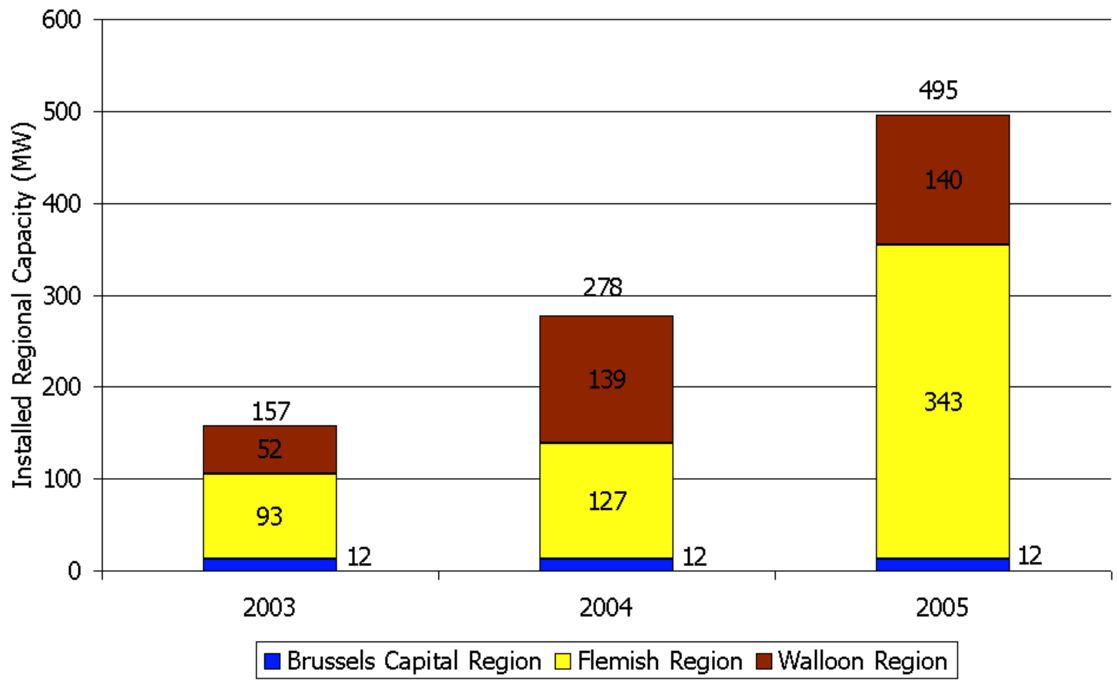
Due to the immature market and the high growth rate of installed wind power, this capacity factor is still lower than the long term average capacity factor will be (see also 4.6). In the long run capacity factors of wind farms in Belgium will range between 0.2 and 0.3.

4.8 Installed capacity of biomass conversion systems

Definition

Sum of rated (electrical) power of cumulative installed systems, expressed in MW

Values



Interpretation

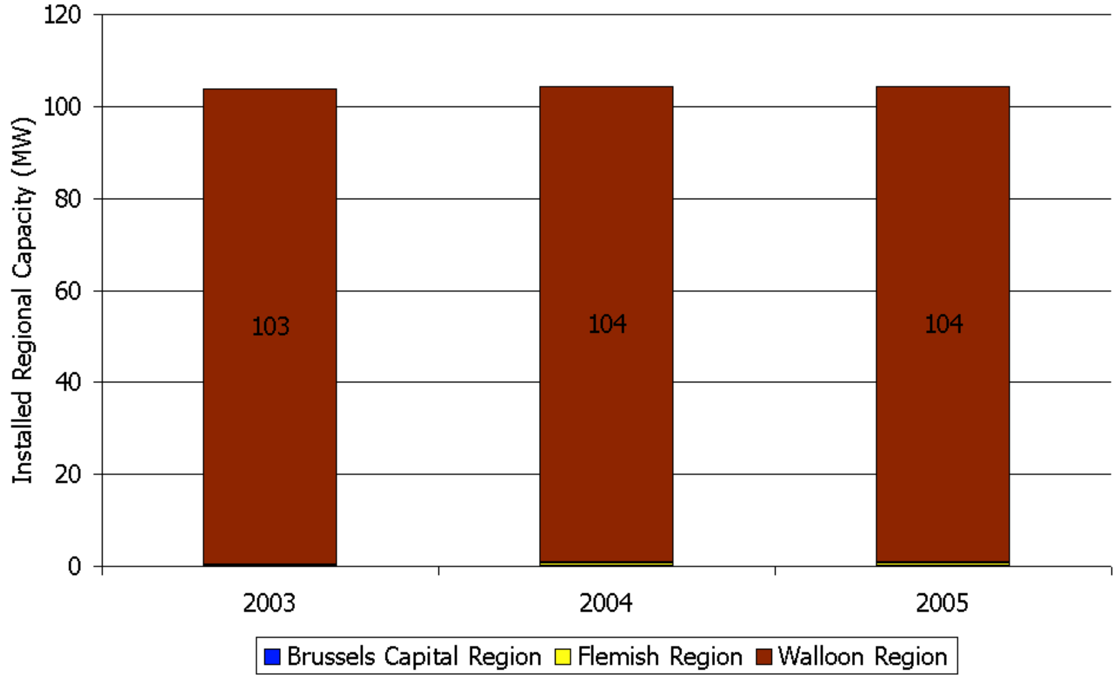
The installed capacity of installed biomass systems producing electricity in 2005 was 495 MW, of which 70% in the Flemish Region and 30% in the Walloon Region. The growth rate of the installations was respectively 170% and none in the last year for the Flemish Region and the Walloon Region and respectively 36% and 167% in 2004 for the Flemish and the Walloon Region. The Belgium growth rate in 2004 and 2005 was aboutnd 77% per year.

4.9 Installed hydropower capacity

Definition

Sum of rated power of cumulative installed systems, expressed in MW.

Values



Interpretation

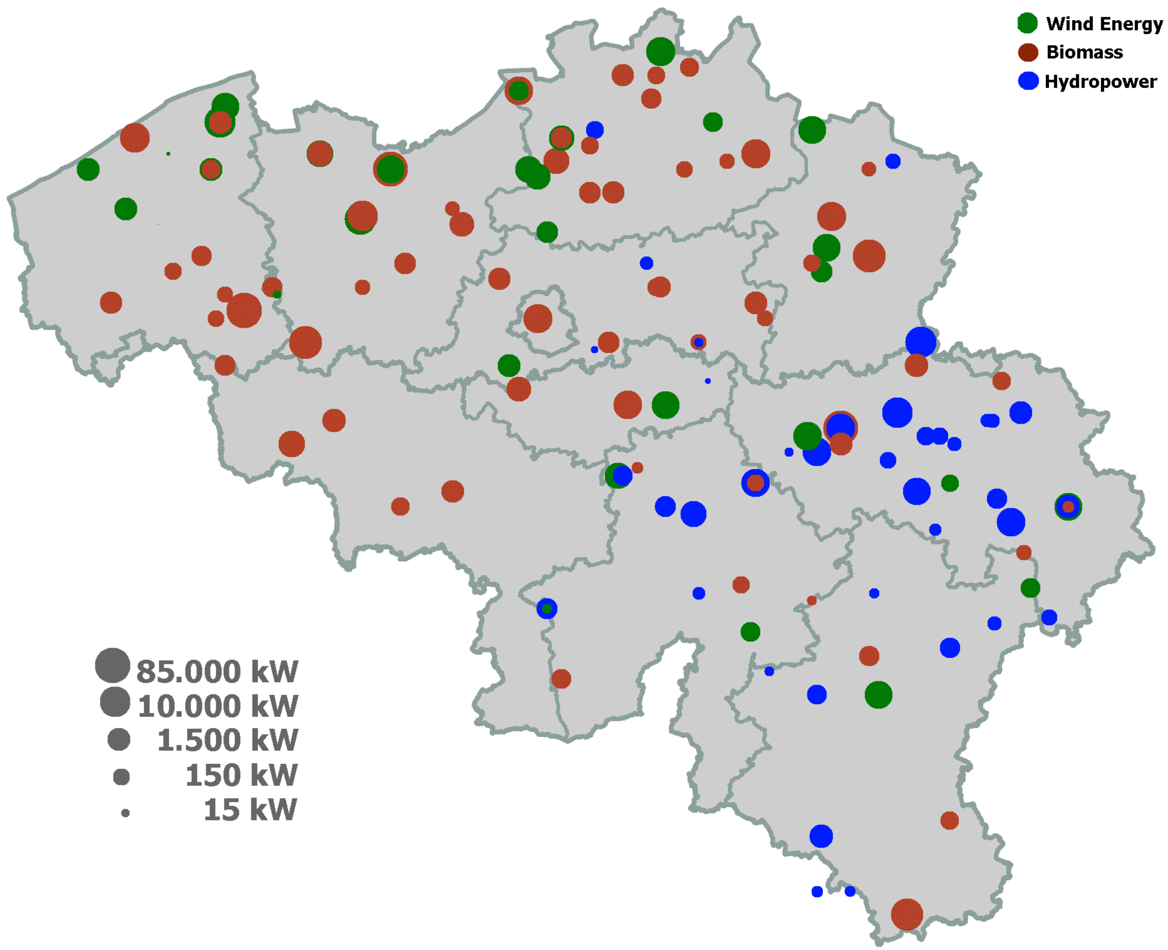
The installed capacity of hydropower in Belgium is stable over the last years.

4.10 Spatial distribution of installations (inclusive the rated power)

Definition

This map shows the regional distribution of the Renewable Energy installations and their rated power (exclusive PV) in Belgium.

Values



Interpretation

Most of the hydropower is installed in the Walloon Region. Wind and biomass dominate in the Flemish Region.

5 ENERGY INDICATORS

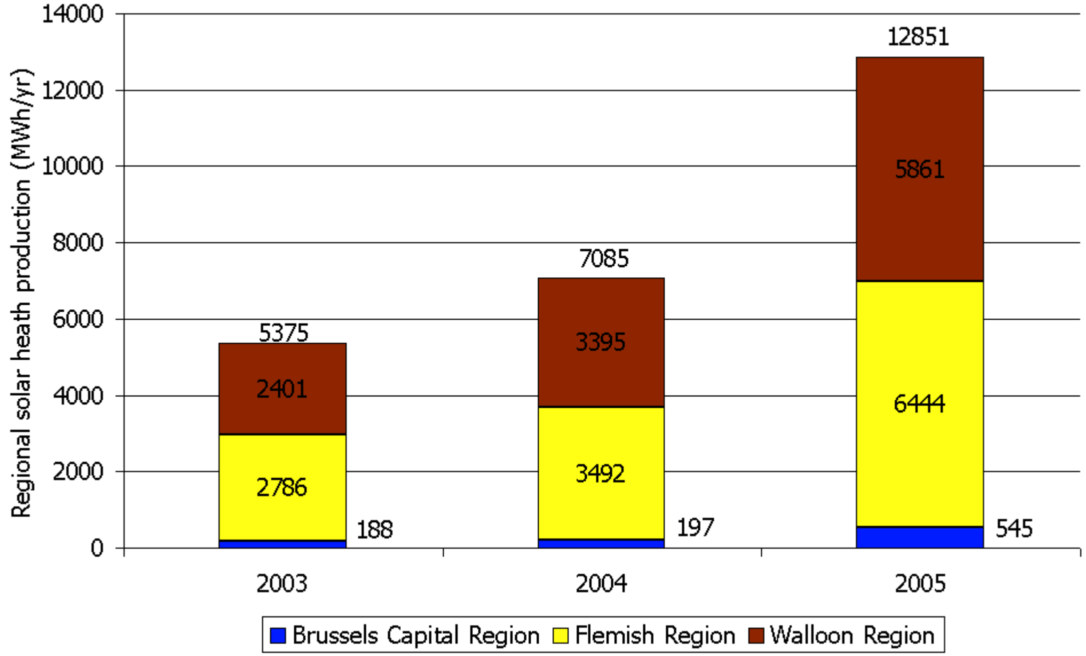
5.1 Solar thermal energy production

Definition

Total production of solar thermal energy, expressed in MWh/year. The total production from a solar system depends on several factors: the solar hot water demand, the inclination and orientation of the panels, and the efficiency of the system. In Belgium systems will have a total efficiency of 35% up to 55%. This means that about 35-55% of the solar irradiation can be transferred into heat.

For this indicator we assumend an efficiency of 45% and total yearly irradiation of 1000kWh/m², so that every m² of solar panels delivers 450kWh of heat. Together with the total installed surface, the total yearly heat production can be calculated.

Values



Interpretation

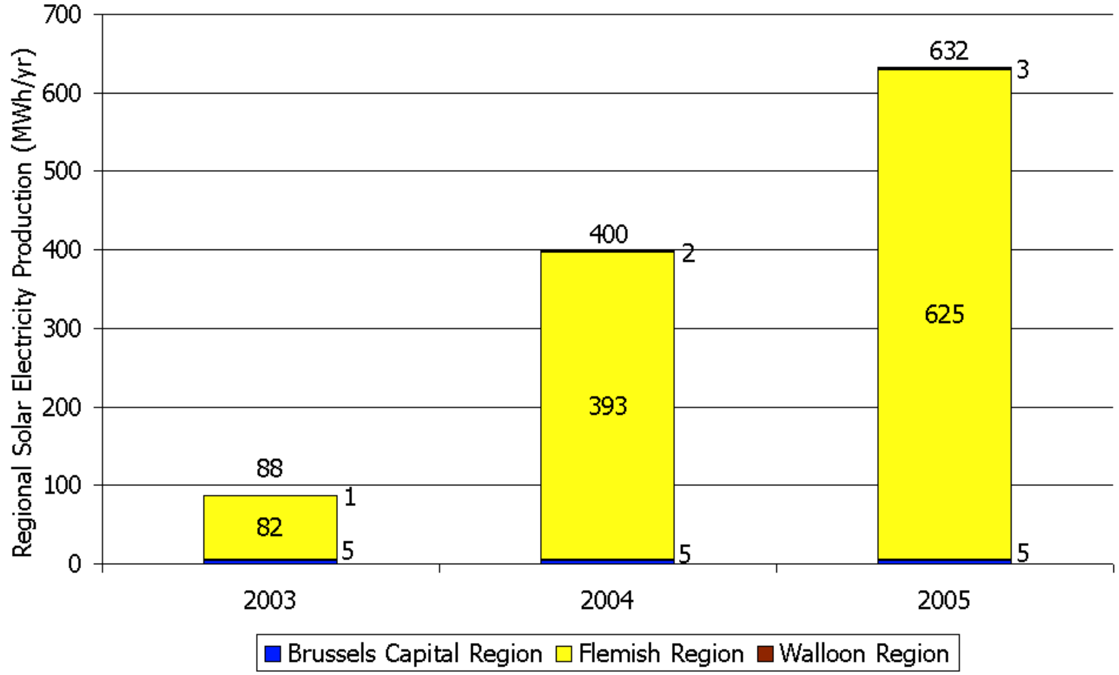
In 2005, 12 851 MWh thermal energy was produced by solar thermal panels compared to 5 375 MWh thermal energy in the year 2003. Flemish region and Wallon region have about almost the same production. The grow rate of the last two years was 32% in 2004 and over 81% in 2005.

5.2 PV energy production

Definition

Total production of solar PV energy, expressed in MWh/year

Values



Interpretation

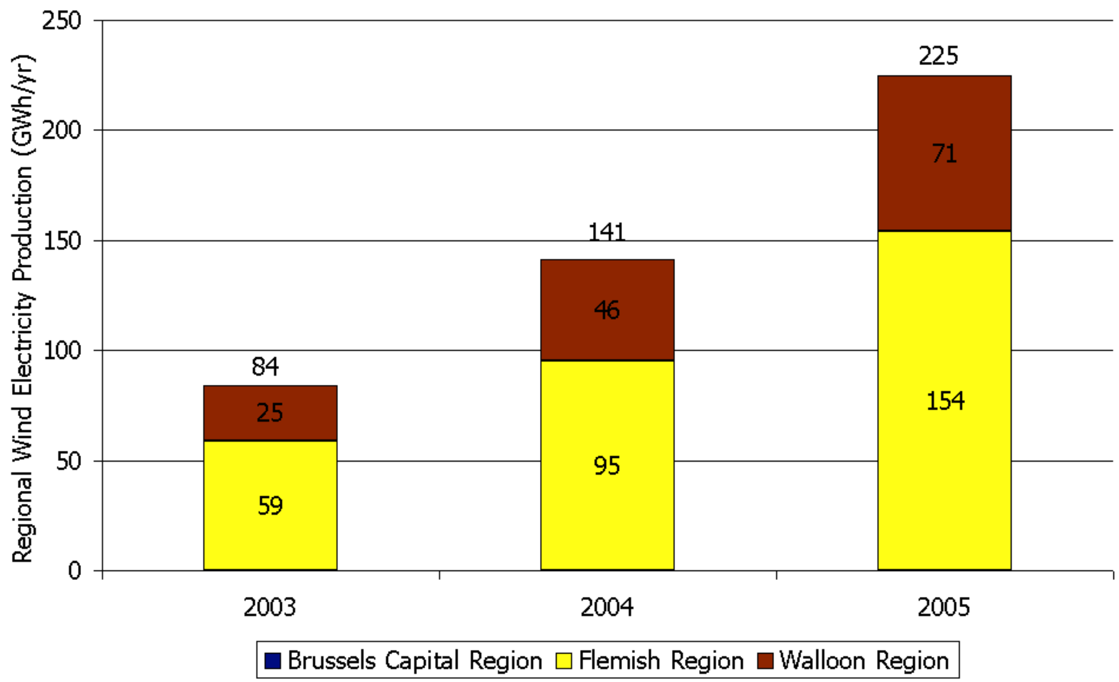
In 2005, 632 MWh electricity was generated with the solar PV panels. Nearly all the electricity was generated in the Flemish region. The growth rate in 2004 and 2005 was respectively 353% and 59%.

5.3 Wind energy production

Definition

Total production of wind energy, expressed in GWh/year.

Values



Interpretation

The total electricity production from wind energy amounted 225 GWh in 2005.

The growth rate of the last 2 years is about 68% and 59% (which is higher than the grow rate of the capacity, i.e. 60% and 50%, see §4.5). Although Walloon Region has in the years 2003 to 2005 respectively 33%, 31% and 26% of the total Belgian installed capacity for Wind energy, the share in the Belgian wind energy production increased from 30% to 32%.

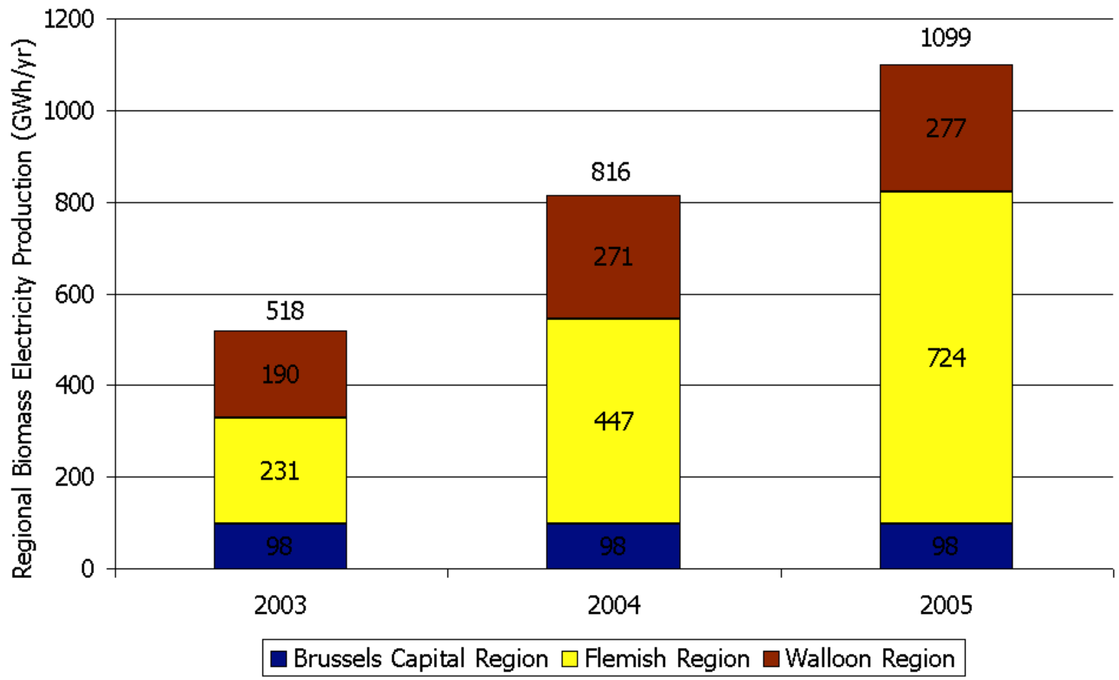
Many installations in Flemish Region were installed in the course of 2005, and did not yet produce a fulll year of energy.

5.4 Biomass electricity production

Definition

Total production of biomass electricity, expressed in GWh/year.

Values



Interpretation

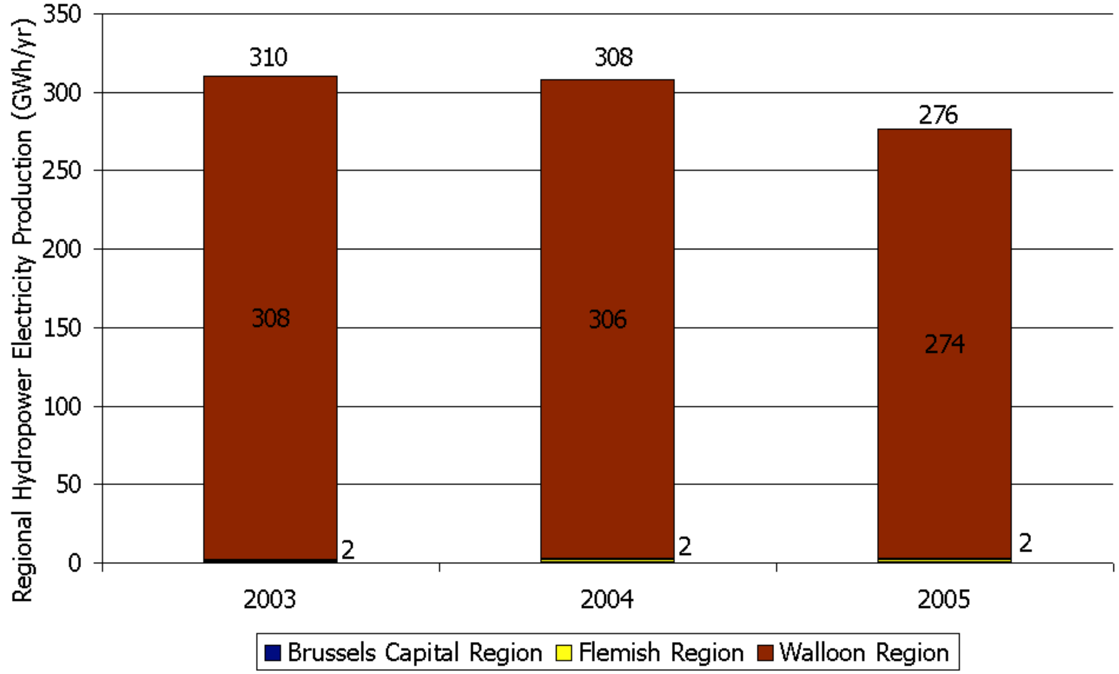
The electricity production of (electrical) installed biomass systems in 2005 was 1099 MWh, of which 66% in the Flemish Region and 25% in the Walloon Region. The growth rate of the last 2 years is about 57% and 35%. Note that this is a lower grow rate than the grow rate of the installed capacity. The new installations did not yet produce a full year of electricity.

5.5 Hydropower production

Definition

Total production of hydropower electricity, expressed in GWh/year. The figures are based on the published figures for the regulators VREG, CWAPE, BIM.

Values



Interpretation

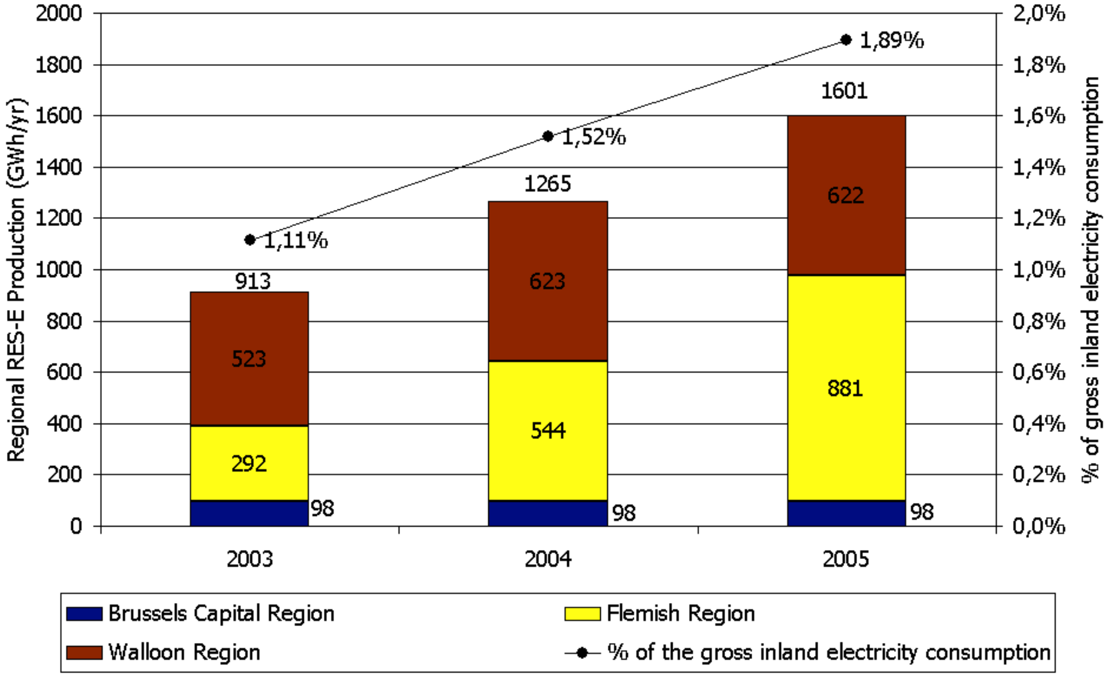
Although the installed capacity stayed stable over the years, the production went down in 2005. This is due to the renovation of the barrage in Butchenbach. When this renovation will have been finalized, the energy production is expected to come back to the previous level.

5.6 Renewable electricity production

Definition

Total production of renewable electricity, expressed in GWh/year and in percentage of the gross inland electricity consumption in Belgium

Values



Interpretation

In 2005 renewable electricity production counted for 1.89% of the gross inland electricity consumption in Belgium.

In total, over 1600 GWh electricity was produced by renewable energy sources. The growth in the last two years was respectively 39% and 27%. The growth of the wind energy production and the biomass electricity production in the Walloon Region is completely compensated by the fall of the hydropower electricity production, i.e. there seems to be no growth for the total renewable electricity in the Walloon Region in 2005. While the Walloon Region produced 57% of the Belgian renewable electricity in 2003, it produced 39% of the Belgian renewable electricity in 2005.

6 IMPACT INDICATORS

6.1 Environmental impact – avoided CO_2 emissions

Definition

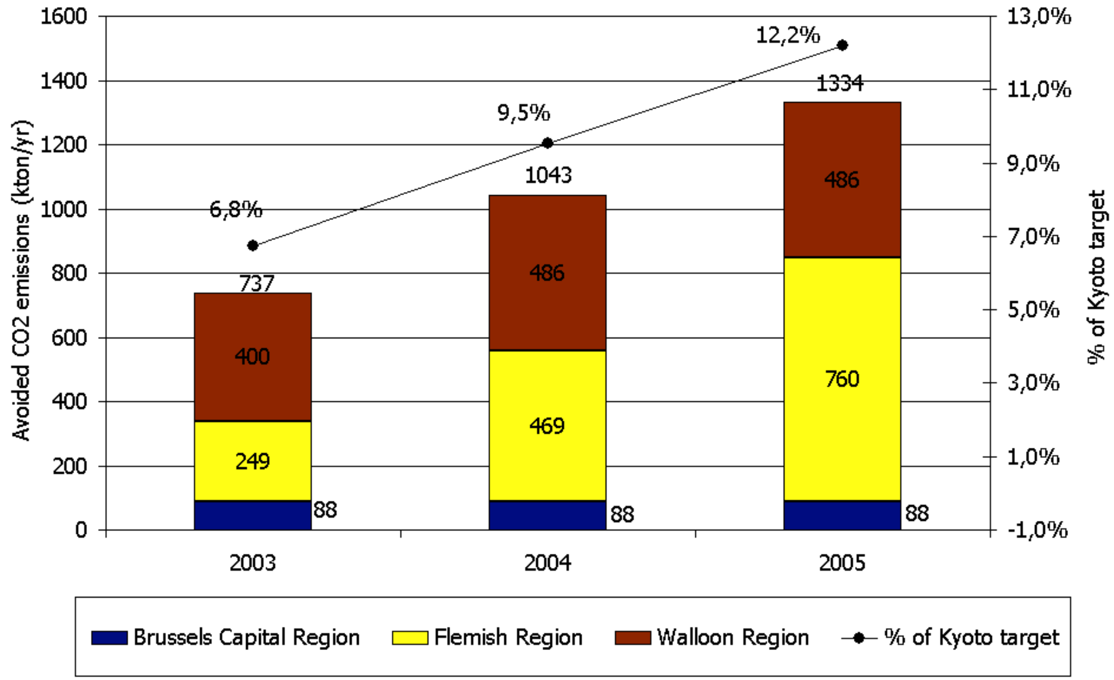
Now and in the coming years, electricity from wind, hydro and PV power plant will substitute the electricity from the central power plant with the highest marginal cost. This is due to the high investment costs for these technologies and the free availability of the primary energy flows. Therefore, a precise calculation of the CO_2 abatement due to the use of renewable energy should be accounted for at the CO_2 emissions the power plant with the highest marginal cost.

In the past these were sometimes coal and often gas fired plant. The Emis database, assumes for this abatement the average emissions for the electricity production from fossil fuels only, being 687g per kWh [Emis 02]. In practice, due to the relatively high gas prices, currently gas turbines and gas-fired combined cycle power plant are virtually always the plant with the highest marginal costs. The specific CO_2 emissions of these plants are lower than the average 687g per kWh of the fossil fuel mix. Nevertheless, for the calculation of this indicator, the average value of 687g per kWh has been assumed in order to guarantee a comparability of the indicator over the long run and independently from the gas markets.

Electricity from biomass replaces is mainly co-fired in coal fired power plant and, therefore, replaces electricity from coal, with a specific emission of 900g CO_2 per kWh [Voor 01].

The Kyoto target for Belgium is set at –7.5% of the total emissions in 1990 (145,7 Mton CO_2-equivalents) and thus 10,9 Mton CO_2-equivalents)

Values



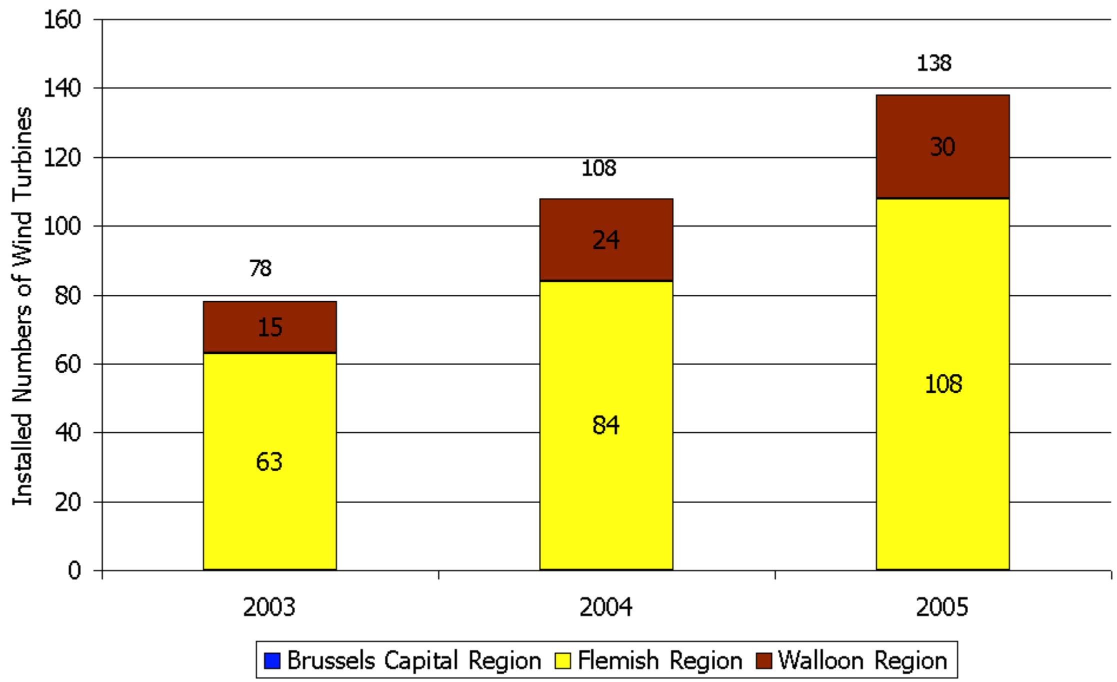
Interpretation

6.2 Environmental impact – visual impact of wind turbines

Definition

The amount of installed wind turbines in Belgium.

Values



Interpretation

This figure tracks the penetration of wind turbines in the landscape compared to other well-know obstacles with public functions.

The total amount of wind turbines in Belgium was 138 in 2005. This number can be compared with e.g. the amount of water towers in (792 anno 1991), the amount of stand-alone GSM towers (estimated at 2220 in 2004), or the total amount of high voltage towers (more than 21 800).

6.3 Socio-economic impact – sector structure

Definition

See below:

Values

Employment characteristics:

- Average number of employees in Belgian offices of companies with activities in renewable energy = 128
- Averyage number of employees related to renewable energy activities = 83
- % of employees related to renewable energy activities = 64%

Countries of origin of companies with activities in renewable energy (% with foreign nationality) 36%

RD&D expenses: due to the limited number of companies in the sample publishing their R&D expenses, no significant indictor could be determined.

Interpretation

The companies in our sample employed on average 128 people in their Belgian branches. One major player employed almost 60% of the employees in the sample, which means that the average number of employees for the other companies was about 60. Most of the companies in the sample are as a consequence medium sized companies.

Activities related to renewable energy are responsible for approximately two thirds of the total number of employees, which is similar to the percentages we perceive when examining the overall and renewable energy turnover

The main shareholder of two thirds of the companies in the sample has the Belgian nationality.

Note that the input data has been gathered from a limited survey of a set of the key players, identified by sector specialists. For the fiscal year 2004, 17 companies replied of which 11 companies were importing or manufacturing companies.

6.4 Socio-economic impact – sector conduct

Definition

See below

Values

Diversification among renewable energy technologies (100% minus percentage of companies with 1 renewable energy technology) : 0%

Sector diversification (% of companies active in a technology sector):

- Wind: 36%
- Solar: 46%
- Hydro: 0%
- Biomass: 18%

Type of activities:

- Importer of finished materials: 36%
- Producer of raw materials and semi-finished materials: 36%
- Producer of finished materials: 36%

Investments[20]:

- Investment intensity of all activities (overall investments as % of turnover): 1,98%
- Investment intensity of renewable energy related activities : 2,12%
- Investment intensity per employee: 5080 EUR
- Investment intensity of renewable energy related activities per employee: 5780 EUR

Interpretation

Based on the result of the survey among the key players, all companies with importing or manufacturing activities indicated that they are active in 1 renewable energy technology only. 46% of the surveyd companies showed activities in the field of solar energy, followed by the wind related activities (36%). In the selected sample, there were no companies active in hydro energy.

An similar distribution among the three sorts of activities could be recognized.

Companies who communicated about their yearly investments, are investing about 2% of their turnover, with a slightly higher investment intensity (as % of turnover) for renewable energy related activities. Expressing the investments per emplyee, it appears to be more than 13% higher for renewable energy related activities as compared to overall activities.

[20] Figures only based on surveys from companies who communicated about their investments in 2004

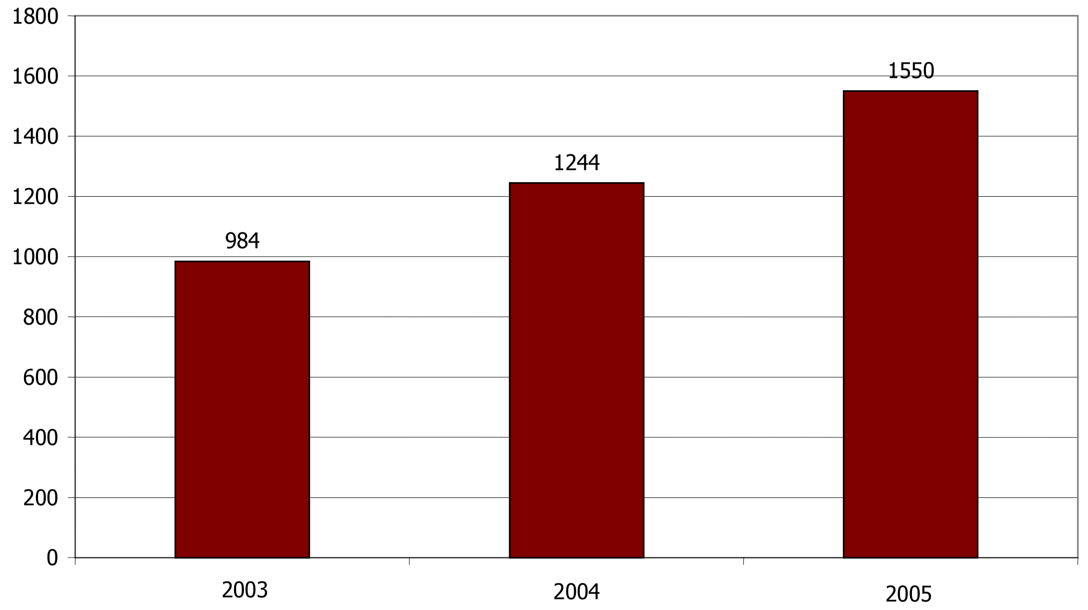
Note that the input data has been gathered from a limited survey of a set of the key players, identified by sector specialists. For the fiscal year 2004, 17 companies replied of which 11 companies were importing or manufacturing companies.

6.5 Socio-economic impact – sector results: evolution of employment

Definition

Direct employment related to the renewable energy sector

Values



Interpretation

There are no reliable data available at this moment. Only limited surveys have been done by EDORA (2004 - www.edora.be) and GENERATIES (2005 - www.generaties.net).

The direct employment related to the technology production and services, mostly for export, amounts at least 1550 full time equivalents with a growth rate of typically 25% per year, based on a limited survey of selected companies with major renewable energy related activities.

This figure shows a lower limit due to limited selection of surveyed companies, and the exclusion of the employment in installation and maintenance in Belgium. A more reliable figure could be generated as described in annex C.

6.6 Socio-economic impact – sector results: evolution of turnover

Definition

See below

Values

Turnover characteristics:

- Average turnover from all activities in Belgian branches: 36,95 MEUR
- Average turnover from all activities related to renewable energy in Belgian branches: 23,11 MEUR
- % of turnover related to renewable energy activities: 62,6 %
- % of total turnover from export activities: 71,2 %
- % of total turnover related to renewable energy activities from export activities: 69,8 %

Interpretation

The average turnover of the surveyed companies amounts about 37 MEUR, which is relatively high partly due to the set-up of the survey (only key-players) and partly due to one company generating almost half of the total turnover of the surveyed companies. Without the input from that company, the average turnover drops to about 20 MEUR. Nearly two third of the average turnover comes from renewable energy related activities.

Approximately 70% of the overall turnover and the renewable energy related turnover has been generated by exports, i.e. the companies active in the renewable energy sector in Belgium are higly export oriented.

6.7 Socio-economic impact – sector results: trade balance effect

Definition

The effect on the Belgian trade balance from avoiding import of fossil and nuclear fuels by using renewable resources

Values

- 16,10 MEUR (+ 0,16%) – assuming nuclear fuel mix (see an)
- 10,23 MEUR (+ 0,20%) – assuming non-nuclear fuel mix (see

Interpretation

In order to calculate the positive effect on the Belgian trade balance from avoiding importing fossil fuels by using renewable resources, we started gathering the 2003 primary production figures for renewable resources. Using these figures, calculations were made to determine the equivalent amount of fossil fuels in order to produce an equivalent primary production. We distinguished between 2 scenarios: one (progressive) scenario where renewable resources can substitute nuclear fuels and one scenario where nuclear fuels cannot be substituted by renewable resources. As Belgium is no longer producing fossil fuels, all fossil fuels have to be imported from abroad which affects negatively the trade balance.

The positive effect on the trade balance from avoiding importing fossil fuels, was calculated by multiplying the imported amounts of fossil fuels by the average 2003 commodity prices published by the Worldbank and Eurostat and by using the 2003 average exchange rate published by the ECB.

We would emphasize the fact that we only calculated the (positive) effect on the trade balance from avoiding importing fossil fuels by using renewable resources. It was not possible to take into account the import of foreign technology and raw, semi-finished and finished materials which will also have a (negative) effect on the trade balance.

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7 IMPLEMENTATION

The presented indicators need to be updated on regular basis and made available to target groups.

In this chapter, recommendations are formulated on the appropriate medium for distribution, the frequency of updating and the organisation of the data sourcing.

Medium for publication

The appropriate medium for distribution is an internet-based one. It is proposed that:

- in agreement with the main public authorities involved in renewable energy matters, the indicators are presented in graphs and tables in the format needed for their websites (e.g. www.fgov.mineco.be, possibly the regulatory bodies);
- data are generated and made available on internet in tables to allow third parties to use data in the format required.

Frequency of update

The frequency of update differs from indicator to indicator. Suited frequencies of update are suggested in Table 6. They range from monthly to yearly which is more than sufficient for most users.

Data sourcing

The main costs associated with the generation of the indicators are linked to the costs of data collection. These costs are mainly:

- the cost of purchase of raw data,
- the cost of manpower to collect data.

The data sources are indicated in Table 6. Most data for the calculation of monthly updated indicators are sourced from the Royal Meteorological Institute of Belgium or from wind energy databases of 3E. The table shows that most yearly updates of the indicators can be generated on the basis of data available in the databases of green certificates of the regulatory bodies VREG, CWAPE, BIM, and CREG.

It is highly recommended to organise an - if possible automated - aggregation of data to generate the indicators on the basis of these databases. This an approach would at the same time allow for regional differentiation suited to regional public authorities and regulators, while realising indicators on Belgian level – suitable for international (EC, IEA) reporting requirements.

Dissemination

The indicators should be made available to different public authorities with direct interest in the market development of renewable energy. A non-exhaustive list is given in Table 5.

Table 5: Overview of public authorities with direct interest in renewable energy indicators.

FOD Economie Bestuur Energie
Vlaams Energie Agentschap
Ministère de la Region Wallonne, DGTRE
Federal Planning Bureau
Regulatory bodies: CREG, VREG, CWAPE, BIM/IBGE

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[RES-E 01] Directive 2001/77/EC of the European Parliament and the Council of 27 September 2001 on the promotion of electricity from renewable energy sources in the internal electricity market, Official Journal of the European Communities, 27 October 2001.

[Voor 01] K.Voorspools, W.D'haeseleer. Broeikasgasemissies veroorzaakt door elektrische centrales, Departement Toegepaste Mechanica en Energieconversie, K.U.Leuven, Leuven, Belgium, September 1997.

[Woy 03] A.Woyte, *Design Issues of Photovoltaic Systems and Their Grid Integration*. PhD thesis, Faculty of Engineering, K.U.Leuven, Leuven, Belgium, 2003.

ANNEX A: OVERVIEW OF SELECTED INDICATORS, INPUT DATA AND DATA SOURCE

Table 6 : Overview of indicators with indication of data source and proposed update frequency

TYPE	INDICATOR	INPUT DATA	SOURCE	UPDATE FREQUENCY	REMARKS
RESOURCE					
Solar energy	Global irradiation on the horizontal plane: monthly spatial distribution	Measured monthly irradiation data	KMI, DWD, KNMI, Meteofrance	Monthly	It is proposed that KMI publishes the distribution maps itselfs, in the case they do not want to offer this service, an extrapolation algorithm should be developed in order to perform a frequent update of the data
	Global irradiation on the 40° south-tilted plane: monthly spatial distribution	Recalculation of measured global and diffuse irradiation on the horizontal plane	KMI, DWD, KNMI, meteofrance	Every month/year	It is proposed that KMI publishes the distribution maps itselfs, in the case they do not want to offer this service, an extrapolation algorithm (spatial extrapolation and recalculation of data on tilted plane) should be developed in order to perform a frequent update of the data
	Yearly irradiation fraction	10 years irradiation data of Uccle or test reference year	KMI, DWD, KNMI, meteofrance	No update	Calculation can be performed by 3E
	Monthly average final yield (spatial distribution) of a standardised reference PV system	Measured hourly irradiation data (horizontal + diffuse) for 5 locations	KMI, DWD, KNMI, meteofrance +IEA PV/PS Task 2	Monthly	This indicator requires the development and automation of the data collection and simulation. The financing of this process will be investigated.
Wind energy	Windex	Energy production of WT, better would be based on metereological data	3E, KNMI	Monthly	Select some WT as a reference, per region
	Long-term annual average specific energy output of a standardised wind turbine for different regions	Average wind speed and Weibull parameters	Wind atlas with standard turbine	Yearly	For # climatological regions ; the financing of this process will be investigated.
Biomass	Indigenous biofuel used for energy conversion	Type and quantities of bio-fuels used as primary input to conversions sytems	Regulators, (avoided CO_2 emissions)	Yearly	Difficult to get data / in the future, a certification system of bio-energy can solve the problem
	Imported biofuel used for energy conversion	Type and quantities of bio-fuels used as primary input to conversions systems	Regulators, (avoided CO_2 emissions)	Yearly	Difficult to get data / in the future, a certification system of bio-energy can solve the problem

TYPE	INDICATOR	INPUT DATA	SOURCE	UPDATE FREQUENCY	REMARKS
Hydropower	Equivalent hydro primary energy input				
SYSTEM					
Solar thermal	Installed surface of solar thermal collectors	Annual sales of collectors	BELSOLAR	Yearly	
Solar PV	Installed grid-connected PV peak power	Annual new installed peak power	Regulators	Yearly	
	Cumulated final yield	Electricity generation according to green certificates	Regulators	Yearly	
	Estimated cumulated performance ratio	Cumulated final yield, irradiation in Uccle	Irradiation data from KMI	Yearly	
Wind	Installed wind farm capacity	Regularly new installed capacity	Regulators	Monthly	
	Specific energy output from Belgian wind farm	Total production and total swept area	Regulators	Monthly	
	Overall capacity factor of Belgian wind farms	Total production and total installed power	Regulators	Monthly	
Biomass	Installed capacity of biomass conversion systems	Regularly new installed capacity	Regulators	Yearly	
Biomass	Overall system efficiency	Type and quantities of biofuels used as primary input, and total final energy production from installations	Regulators	Yearly	Practical feasibility to be discussed
All renewable energy systems	Spatial distribution of installations	Postal code and type of installation	Permitting authorities, regulators	Yearly	
All	Statistics of rated electrical power[21]	Rated electrical power of individual units of installed capacity	DNB's, ELIA	Yearly	

[21] Differentiation between solar PV, wind energy, biomass and hydro

TYPE	INDICATOR	INPUT DATA	SOURCE	UPDATE FREQUENCY	REMARKS
All	Statistics of voltage levels	Voltage levels at which installations are connected	DNB's, ELIA	Yearly	
All	Frequency distribution of the age of installations	commissioning / decommissioning		Yearly	Reliable source to be identified, Regulators for commissioning
ENERGY					
Solar thermal	Solar thermal energy production	Calculation, model, mean collector performance	BELSOLAR	Monthly	Mean calculated value in GJ/month for residential solar collector or per m² collector of large systems should be feasible if someone performs the simulations
Solar PV	PV energy production	Metering data of GC Database	VREG	Yearly	
Wind Energy	Wind energy production	Measured data	Regulators	Monthly	
Biomass	Biomass electricity production	Measured data	Regulators	Monthly	Figures for heat and power would be good.
Hydro	Hydropower production	Measured data	Regulators	Monthly	
IMPACT					
Environmental	Avoided CO_2 emissions[22]	CO_2 emissions of marginal electricity with Belgian energy mix.	Regulators	Yearly	
	Avoided other emissions[23]			Yearly	
	Visual impact of wind turbines		Regulators		
Socio-Economic	Productivity development	companies: survey			Survey related input can not be included in this project; the cost to do a survey will be to high
	Cooperation agreements and networks	companies: survey			
Socio-Economic: Structure	Expenses R&D (total, per employee,%total)	companies: survey			

[22] Differentiation between solar PV, solar thermal, wind energy, biomass, hydro
[23] Idem

TYPE	INDICATOR	INPUT DATA	SOURCE	UPDATE FREQUENCY	REMARKS
	Investments per MW	companies: survey			
	Numbers of companies	sector organisations or research projects (ODE, SERV, EDORA)			
	Number of employees	companies: survey	government or research projects		
	Number of foreign companies	sector organisations or companies: survey			
	International activity Belgian companies (export)	research projects or companies: survey			
Socio-Economic: Conduct	Entry and exit	government NBB			
	Vertical integration (value added/turnover)	government NBB or companies:survey			
	Specialisation in RE	companies: survey			
	Diversification among technologies	companies: survey			
	Investment intensity (as % turnover per employee)	research projects or companies: survey			
	Capital labour intensity (fixed assets per employee)	government NBB or companies:survey			
Socio-Economic: Results	Evolution of employement	companies: survey			
	Evolution of turnover	companies: survey			
	Profitability	companies: survey			
	Import/export (balace trade)	companies: survey			

ANNEX B: INPUT DATA USED FOR CALCULATION OF THE TRADE BALANCE EFFECT

Input data 2003

	primary production	source
wind	90 GWh	*Eurostat*[24]
hydro	247 GWh	*Eurostat*
sun photovoltaic	82,5 MWh	*www.vreg.be; www.cwape.be*
biomass	1339 GWh	*Eurostat*
	average annual commodity price	source
coal (Australia)	27,84 $/MT	*Worldbank.org*
natural gas, Europe	3,91 $/MMBTU	*Worldbank.org*
uranium	3,5 €/kg	*Eurostat*
2003 exchange rate	1€ = 1,1312$	*ECB bilateral exchange rates*

To calculate the amount of fossil fuels that can be avoided by using renewable resources, the following conversion matrix has been used.

[24] Note that the figures from Eurostat used here for calculation of the trade balance effect do not correspond precisely to the figures as available from the Belgian regulatory bodies. This is due to differences in methodology of accounting.

1 KWh of electricity from	fossil fuel mix	equivalent resources from fossil fuels	
wind, sun photovoltaic, hydro	nuclear mix	1,93 KWh nuclear	0,000000087 kg uranium
		0,36 KWh coal	0,0538 kg coal
		0,41 KWh natural gas	0,0462 m^3 natural gas
	non-nuclear mix	0,99 KWh coal	0,1483 kg coal
		1,12 KWh natural gas	0,1273 m^3 natural gas
biomass	non-nuclear mix	2,78 KWh coal	0,4175 kg coal

ANNEX C: SIMPLIFIED METHODOLOGY FOR THE CALCULATION OF THE DIRECT EMPLOYMENT

Introduction

In this annex, only the employment realised in Belgium is considered.

Criteria for a simplified methodology

- Reliable, i.e. giving e.g. a reliable underlimit
- Relatively cheap, i.e. not requiring large scale surveys

Proposal for a simplified methodology

A simplified methodology, satifying the above criteria, is the following.

One can consider the total employment in Belgium related to the renewable energy market as being composed of 4 components:

- Wbp = employment related to energy installations in Belgium during the pre-commissiong phase
- Wbo = employment related to energy installations in Belgium during the operational phase
- Bip = employment related to energy installations outside Belgium during the pre-commissioning phase
- Bbo = employment related to energy installations outside Belgium during the operational phase

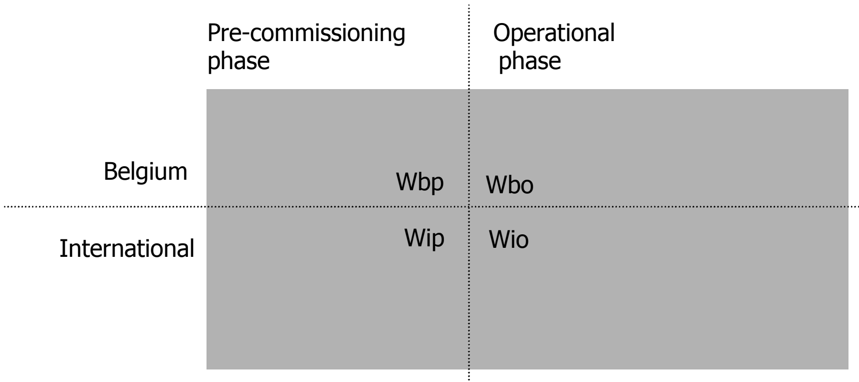

Figure A.1: components employment in Belgium related to the Belgian and international renewable energy market

The different components can be assessed in the next manner (Table A.1).

The employment related to other installations in Belgium (Wbp en Wbo) can be defined on the basis of:

- Statistical indicators of employment linked to the different phases of a life cycle of a renewable energy project, identified by technology. The installed capacity per technology and the installed capacity that has recently become operational.

The employment related to projects outside Belgium is more difficult to evaluate. That employment linked to the precommissioning phase (wip) is built up of the supply of products and services. The employment linked to the operational phase (Wio) is expected to be small with respect to the other 3 components, and is neglected for the sake of simplicity.

Wip can be assessed on the basis of an accurate survey directed to a selection of members of EDORA, GENERATIES and other organisations. The top 20 of companies for the component ‘Wip’ maintains a critical point in the methodology. It is assumed realistic to define the top 20 in a reliable way because of the relatively small group of companies that contribute to Wip in Belgium and the strong involvement of these companies in EDORA, GENERATIES and other organisations.

On the mid-long term, the realisation of more thourough surveys could be mandatory.

Table A.1: Data source for the calculation of every component in employment

Component	Data source
Wbp	• D-base regulators, installations that obtained recognition for the GSC allocation • Statistical indicators per type of technology
Wbo	▪ D-Base regulators, installations that receive green certificats yearly for at least over a year now ▪ Statistical indicators per type of technology
Wip	Limited survey top 20 EDORA , GENERATIES, and others
Wio	negligible