Assessment of environmental and social impacts of the KfW loan programme “Renewable Energies – Standard” for the years 2015 and 2016

Evaluation commissioned by KfW Group

Summary Results

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Abbreviations and explanations

a	Year
CO_2	Carbon dioxide
CO_2-equivalent	Unit used for measuring the global warming potential (i.e. the potential contribution to the warming of near-surface layers of the atmosphere) of a greenhouse gas in relation to the effect of CO_2. It states the quantity of CO_2 that would have the same greenhouse effect as the gas in question over a period of 100 years. For instance, one kg of methane (CH_4) has the same effect as 21 kg of CO_2.
GW	Gigawatt(s); 1 GW = 1 million kW
GWh	Gigawatt hour(s); 1 GWh = 1 million kWh
KfW	KfW Group
kW	Kilowatt(s)
kW_{el} / MW_{el}	Kilowatts/megawatt(s) electrical power
kW_{th} / MW_{th}	Kilowatts/megawatt(s) thermal power
kWh	Kilowatt hour(s)
mill.	Million
MW	Megawatt(s); 1 MW = 1,000 kW
NMVOC	Non-methane volatile organic compounds
NO_x	Nitrous oxide
n.q.	Not quantified
RE	Renewable energy
RES	Renewable energy sources
RE Standard	KfW loan programme “Renewable Energies – Standard“
SO_2	Sulphur dioxide
SO_2-equivalent	Unit used for measuring the acidification potential of an air pollutant in relation to the acidification potential of SO_2.
UBA	German Federal Environment Agency (Umweltbundesamt)
TWh	Terawatt hour(s); 1 TWh = 1,000 million kWh
VAT	Value added tax

Abstract for Political Decision Makers

The national renewable energy promotional activities of KfW Group (KfW) represent an important measure for reaching the targets for renewable energy (RE) use set in the German Federal Government's long-term strategy for future energy supply. These activities comprise low-interest loans for investments in RE, partly in combination with repayment bonuses financed by the Federal Government. In order to review their effectiveness and significance within the years 2015 and 2016, the resulting reductions in emissions of greenhouse gases and air pollutants, external costs, fossil fuel consumption and associated fossil fuel imports, as well as employment effects, were assessed for plants built in Germany with support of the KfW RE programmes. In addition, supported plants abroad were considered, covering investment volume, capacity installed and CO_2 emissions avoided.

This report summarises the impacts of the KfW loan programme "Renewable Energies – Standard" (RE Standard). This programme promotes the construction, extension or purchase of plants using renewable energy to produce electricity or heat by granting low-interest loans. The most important results of the evaluation at a glance:

- In the years 2015 and 2016 the KfW programme RE Standard supported a total investment in the construction of plants for using renewable energy of € 5.4 billion and € 5.7 billion respectively (of which € 1.3 billion and € 1.1 billion in plants outside Germany).
- The RE Standard programme is particularly important for renewable electricity production: In terms of electrical power, 49 % and 43 % of the renewable plants installed in Germany in the years 2015 and 2016 were co-financed through this programme (excluding offshore wind energy). With 62 % and 51 % respectively, the share is remarkably high for onshore wind turbines.
- Plants supported in 2015 and 2016 reduce German energy imports by approximately € 390 million per annum (total for both years). This cumulates to € 7.9 billion over the plants' lifetime of 20 years.
- The plants built in Germany and financed by KfW RE Standard in 2015 and 2016 lead to a reduction of approximately 7.1 million tonnes of CO_2-equivalent (of which 6.5 million tonnes CO_2) per annum (total for both years). The supported plants built abroad reduce another 0.3 million tonnes of CO_2 annually.
- Avoiding greenhouse gas and air pollutant emissions in Germany reduces external costs by approx. € 720 million a year (total for both years), 84 % of which refer to climate change effects.

- Manufacturing and construction of the plants built in 2015 and 2016 correspond to approx. 86,000 jobs created or preserved in Germany for one year (total for both years). A further 2,600 jobs per annum result from the operation and maintenance of the plants for the assumed 20 years of operation.
- Small and medium-sized enterprises with less than 500 employees account for approx. 52 % of the jobs generated by the construction and operation of plants built in the years 2015 and 2016.

1 Background

In the years 2015 and 2016, renewable energy sources (RES) continued to increase their share in Germany's electricity consumption: From 27.3 % in 2014, the share of RES in electricity consumption saw a sharp rise to 31.5 % 2015 and a further increase to 31.7 % in 2016. In other words: almost every third kilowatt hour consumed in Germany originates from renewable energy sources.

The targets set for reaching the German energy transition (Energiewende) are based on the German Federal Government's long-term strategy for future energy supply, according to which at least 60 % of final energy consumption and 80 % of electricity consumption ought to be covered with renewable energies by the year 2050. In combination with challenging energy efficiency targets, greenhouse gas emissions are to be cut by 80 to 95 % in relation to the base year 1990. By the year 2020, 18 % of final energy consumption and at least 35 % of electricity consumption are to be covered with RES. Greenhouse gas emissions ought to be cut by 40 % compared to the year 1990.

The renewable energy promotional activities of KfW Group (KfW) represent an important measure for reaching the targets of the German Federal Government with respect to cutting greenhouse gas emissions by expanding the use of RES. These activities comprise low-interest loans for investments in plants using renewable energy, partly in combination with repayment bonuses financed by the federal government.

In the years 2015 and 2016, the KfW promotional programmes supported a total investment in the construction of plants for using renewable energies of € 7.4 billion and € 7.6 billion respectively (of which € 1.3 billion and € 1.1 billion in plants outside Germany). This implies that shares of 42.6 % and 40.1 % respectively of the total investment in plants for power and heat production from RES in Germany in 2015 and 2016 were co-financed by KfW programmes (without considering offshore wind energy).

In order to review the effectiveness and significance of these programmes for the years 2015 and 2016, the resulting reductions in emissions of greenhouse gases and air pollutants, external costs, fossil fuel consumption and associated fossil fuel imports, as well as employment effects, were assessed for plants built in Germany. In addition, investment volume, capacity installed and CO_2 emissions avoided were considered for plants built abroad.

The impacts of the KfW loan programme "Renewable Energies – Standard" (RE Standard) are summarised on the following pages. A detailed description (in German) of the

underlying calculation approaches and results of all national renewable energy promotional activities of KfW can be found in the evaluation report[1].

[1] Bickel, P., Kelm, T., Edler, D.: Evaluierung der inländischen KfW-Programme zur Förderung Erneuerbarer Energien in den Jahren 2015 und 2016. Gutachten im Auftrag der KfW Bankengruppe, Stuttgart, November 2017. www.kfw.de/KfW-Konzern/Service/Download-Center/Konzernthemen-(D)/Research/Evaluationen/ (available in German only)

2 Loan volume and resulting investment

The KfW promotional programme RE Standard was introduced on 1 January 2009 and supports the construction, extension or purchase of plants using renewable energy for producing electricity or heat by granting low-interest loans. The maximum loan per project amounts to € 50 million.

In the years 2015 and 2016, the volume of loan commitments totalled almost € 4.3 billion and € 4.5 billion respectively, of which € 1.1 billion and € 0.8 billion are attributable to supported renewable energy plants outside Germany (see Table 1).The loans triggered investments of € 5.4 billion and € 5.7 billion respectively, € 1.3 billion and € 1.1 billion of which in plants abroad. The average loan volume per commitment amounted to € 1.5 million in 2015 and € 1.4 million in 2016; the average investment per commitment amounted to € 1.9 million in 2015 and € 1.8 million in 2016. This corresponds to an average share of financing of 79 % and 80 % respectively.

Table 1: Number and volume of loans, as well as supported investment volume in the programme RE Standard for the years 2015 and 2016.

	2015	2016
Number of loan commitments	2,887	3,138
Volume of loan commitments (€ million)	4,266.4	4,515.5
of which plants outside Germany (€ million)	1,088.1	825.6
Investments financed (€ million)[1)]	5,420.8	5,669.9
of which plants outside Germany (€ million)[1)]	1,336.0	1,112.2
Average loan volume per commitment (€)	1,477,781	1,438,987
Average investment financed per commitment (€)[1)]	1,877,657	1,806,860
Average share of financing	79 %	80 %

Totals may differ due to rounding.
[1)] excl. VAT.

With shares of 86 % and 89 % in the total loan volume 2015 and 2016 of all KfW promotional programmes for renewable energy, the RE Standard programme was the largest of these programmes. In terms of investment volume supported, the shares of RE Standard amounted to 73 % and 75 %.

Table 2 presents the supported investment volume in RE Standard split by plant type. In the year 2015 (2016), wind energy onshore dominates the supported investment in Germany with 91 % (90 %) followed by photovoltaic energy 8 % (9 %). Other plant types play

only a marginal role. Outside Germany with 22 % (15 %) photovoltaics has a higher share with wind energy onshore still dominating (2015: 78 %, 2016: 85 %) and hydropower being practically negligible. Table 3 gives a detailed picture of the investment volume supported outside Germany by country and plant type.

Table 2: Volume of investment supported in the years 2015 and 2016 by plant type.

		2015 € million (excl. VAT)	%	2016 € million (excl. VAT)	%
Germany	**Biogas**	18.7	0.5	1.9[1)]	0.04
	Solid biomass	2.5	0.1	1.9	0.04
	Photovoltaic energy	314.2	7.7	417.5	9.2
	Solar thermal energy	0.05	0.001	0.01	0.0003
	Heat grid	1.3	0.03	1.0	0.02
	Heat store	0.04	0.001	-	-
	Hydropower	19.8	0.5	8.2	0.2
	Wind energy onshore	3,728.2	91.3	4,081.5	89.6
	Electricity storage	-	-	45.8	1.0
	Total Germany	**4,084.8**	**100.0**	**4,557.7**	**100.0**
Outside Germany	**Photovoltaic energy**	296.2	22.2	162.7	14.6
	Hydropower	1.8	0.1	0.5	0.04
	Wind energy onshore	1,038.0	77.7	949.0	85.3
	Total Outside Germany	**1,336.0**	**100.0**	**1,112.2**	**100.0**

Totals may differ due to rounding.

[1)] Electricity generation and biogas transportation.

Table 3: Investment volume supported outside Germany in the years 2015 and 2016 by plant type and country.

€ million (excl. VAT)	2015 PV	Hydro	Wind	Total	2016 PV	Hydro	Wind	Total
Austria	0.2	1.8	23.7	**25.7**	-	0.5	27.3	**27.8**
Canada	-	-	12.3	**12.3**	-	-	29.1	**29.1**
Croatia	-	-	-	**-**	-	-	39.7	**39.7**
Denmark	136.9	-	-	**136.9**	49.4	-	-	**49.4**
Finland	-	-	216.2	**216.2**	-	-	62.7	**62.7**
France	61.9	-	637.3	**699.2**	14.5	-	457.6	**472.2**
Ireland	-	-	14.9	**14.9**	-	-	16.2	**16.2**
Italy	-	-	112.8	**112.8**	-	-	33.0	**33.0**
Japan	-	-	-	**-**	28.8	-	-	**28.8**
Netherlands	-	-	-	**-**	33.3	-	-	**33.3**
Sweden	-	-	-	**-**	-	-	283.5	**283.5**
United Kingdom	97.2	-	20.9	**118.0**	36.7	-	-	**36.7**
Total	**296.2**	**1.8**	**1,038.0**	**1,336.0**	**162.7**	**0.5**	**949.0**	**1,112.2**

Totals may differ due to rounding.

3 Power installed

In the year 2015, the RE Standard programme co-financed renewable energy plants with a total electrical power of around 3.6 GW_{el}, of which 72 % belong to plants built in Germany and 28 % to plants built outside Germany (see Table 4). In 2016 the total electrical power installed remains at 3.6 GW_{el} with 78 % installed in plants in Germany and 22 % installed abroad. Table 5 gives a detailed picture of the installed electrical power supported outside Germany by country and plant type.

Table 4: Installed electrical power supported in the years 2015 and 2016 by plant type.

MW_{el}		2015	2016
Germany	**Biogas**	13.7	0.9
	Solid biomass	0.5	-
	Photovoltaic energy	294.9	397.8
	Hydropower	8.0	1.7
	Wind energy onshore	2,285.8	2,368.8
	Total Germany	**2,602.9**	**2,769.2**
Outside Germany	**Photovoltaic energy**	265.7	140.7
	Hydropower	0.3	0.08
	Wind energy onshore	730.1	646.4
	Total Outside Germany	**996.0**	**787.2**

Totals may differ due to rounding.

Table 5: Installed electrical power supported outside Germany in the years 2015 and 2016 by plant type and country.

	2015				2016			
MW_{el}	PV	Hydro	Wind	Total	PV	Hydro	Wind	Total
Austria	0.2	0.3	16.3	**16.7**	-	0.08	18.3	**18.4**
Canada	-	-	4.1	**4.1**	-	-	10.3	**10.3**
Croatia	-	-	-	**-**	-	-	34.2	**34.2**
Denmark	141.8	-	-	**141.8**	62.9	-	-	**62.9**
Finland	-	-	135.0	**135.0**	-	-	20.4	**20.4**
France	64.0	-	462.9	**526.9**	12.3	-	321.7	**334.0**
Ireland	-	-	9.2	**9.2**	-	-	9.2	**9.2**
Italy	-	-	88.5	**88.5**	-	-	20.0	**20.0**
Japan	-	-	-	**-**	10.3	-	-	**10.3**
Netherlands	-	-	-	**-**	30.8	-	-	**30.8**
Sweden	-	-	-	**-**	-	-	212.4	**212.4**
United Kingdom	59.8	-	14.1	**73.9**	24.4	-	-	**24.4**
Total	**265.7**	**0.3**	**730.1**	**996.0**	**140.7**	**0.08**	**646.4**	**787.2**

Totals may differ due to rounding.

The estimated electricity production of the plants financed 2015 (2016) built in Germany amounts to 5.2 (5.4) TWh per year over the lifetime of the plants. The plants financed outside Germany produce an estimated 1.5 (1.3) TWh of electricity per year. Over 20 years of life and operation time of the plants, electricity generation accumulates to an estimated 104 (108) and 30 (26) TWh respectively.

Table 6: Installed thermal power supported in the years 2015 and 2016 by plant type.

MW_{th}		2015	2016
Germany	**Solar thermal energy**	0.06	0.05
	Solid biomass	0.9	2.4
	Total Germany	**1.0**	**2.5**
Outside Germany	**Solar thermal energy**	-	-
	Solid biomass	-	-
	Total Outside Germany	**-**	**-**

Totals may differ due to rounding.

In the years 2015 and 2016, the RE Standard programme supported also 1.0 MW and 2.5 MW respectively of thermal power (mainly solid biomass), all of which was in plants located in Germany (see Table 6). The heat production of the financed plants can be estimated at 0.03 and 0.01 TWh per year. Assuming a 20-year operational lifetime of the plants, this adds up to a total production of an estimated 0.6 and 0.2 TWh respectively.

4 Estimated impacts

4.1 Savings in fossil fuel consumption and avoided energy costs for imported fossil fuels in Germany

Electricity and heat produced in the plants financed by the RE Standard programme replaces energy produced from fossil fuel. The savings in fossil fuel are determined by the type of power plant substituted (e.g. coal, natural gas, etc.). They are calculated starting with the estimated electricity or heat produced by the newly built plants. Specific substitution factors allow quantifying the amount of fossil energy replaced by each type of renewable energy plant. The fossil fuel savings (which were calculated for RE plants built in Germany only) finally result by applying primary energy factors to the quantities of substituted electricity/heat.[2]

Table 7 presents the annual fossil fuel savings of plants financed in Germany in the years 2015 and 2016, which amount to 11.5 and 11.8 TWh per year. The share of hard coal amounts to 67 % in both years, that of natural gas to almost 33 %. The shares of lignite and mineral oil are negligible.

Table 7: Annual fossil fuel savings (primary energy) in Germany resulting from the use of renewables in plants supported by RE Standard in the years 2015 and 2016.

GWh/a	2015	2016
Hard coal	7,696	7,919
Natural gas	3,736	3,849
Lignite	2	1
Mineral oil	17	1
Total	**11,450**	**11,770**

Totals may differ due to rounding.

As Germany has to import most of the fossil energy carriers consumed, the savings in fossil fuel use reduce the country's dependency on energy imports. To measure this effect, the corresponding reductions in energy costs were calculated using import prices[3]. It was assumed that the savings given in Table 7 fully lead to a reduction in energy imports with one exception: None of the lignite, which is the only relevant fossil energy source extracted in Germany, is substituted by the RE plants. Decreased imports of hard coal, natural gas and mineral oil lead to annual savings in energy costs for imported fuel of € 191 million and € 202 million for 2015 and 2016 (see Table 8).

[2] A brief description is given in Annex A.1. Details of the calculation approach including substitution and primary energy factors can be found in the evaluation report (in German; see footnote 1).

[3] Details on the import price scenario are given in the evaluation report (see footnote 1).

Table 8: Annual savings in energy costs for imported fossil fuels in Germany resulting from the use of renewables in plants supported by RE Standard in the years 2015 and 2016.

€ million per year[1)]	2015	2016
Hard coal	83	88
Natural gas	107	114
Mineral oil	1	0
Total	**191**	**202**

Totals may differ due to rounding.

1) Assumption: no lignite imported, therefore no resulting cost savings.

4.2 Savings in greenhouse gas emissions

The calculation of reductions in greenhouse gas emissions for plants built in Germany builds upon the approach for quantifying savings in fossil fuel consumption. It applies emission reduction factors that are based on the substitution factors mentioned in the previous section. These are provided by the German Umweltbundesamt (UBA – Federal Environment Agency) and consider net reduction effects: additional emissions from using renewable energy sources (e.g. methane emissions during biogas production) are subtracted from the reduction in emissions from fossil fuels. For plants built outside Germany a simpler approach had to be applied as no emission factors of equivalent quality were available.[4]

The plants built in Germany und financed by KfW in 2015 lead to a reduction of 3.51 million tonnes of CO_2-equivalent (of which 3.21 million tonnes CO_2) per year. The plants with KfW-support built abroad reduce another 0.19 million tonnes of CO_2 annually. Plants supported in 2016 avoid annual emissions in the amount of 3.62 million tonnes of CO_2-equivalent (of which 3.29 million tonnes CO_2) in Germany and 0.11 million tonnes of CO_2 outside Germany (see Table 9).

Table 9: Annual savings in greenhouse gas emissions resulting from the use of renewables in plants supported by RE Standard in the years 2015 and 2016 by location of plant.

	2015		2016	
Million tonnes per year	**Germany**	**Outside Germany**	**Germany**	**Outside Germany**
CO_2	3.21[1)]	0.19[1)]	3.29[1)]	0.11[1)]
CO_2-equivalent	3.51	n.q.	3.62	n.q.

1) Figures based on different sets of emission factors.

In many countries abroad in which plants are financed, electricity generation already has a low carbon intensity (e.g. in France due to a high share of nuclear energy or in Sweden

4 A brief description is given in Annex A.2. Details of the calculation approach including emission factors can be found in the evaluation report (in German; see footnote 1).

due to a high share of renewable and nuclear energy). Therefore, the total savings in greenhouse gas emissions from supported plants outside Germany are comparatively low.

4.3 Savings in external costs through supported plants in Germany

Savings in fossil fuel combustion not only result in reduced CO_2 emissions but in decreasing emissions of air pollutants such as NO_x, SO_2 etc. as well. Based on emission factors provided by the UBA annual reductions of airborne emissions were calculated for the RE plants financed in Germany as presented in Table 10.

Table 10: Annual savings in air pollutant emissions resulting from the use of renewables in plants in Germany supported by RE Standard in the years 2015 and 2016.

Tonnes per year	2015	2016
SO_2	1,264	1,349
NO_x	2,208	2,427
SO_2-equivalent	2,801	3,038
NMVOC	106	128
Fine particulate matter	72	75

Air pollutants and greenhouse gases cause damage to human health, as well as the natural and man-made environment which represents costs to the society that are not borne by the polluter. These so-called external costs can be quantified by applying (monetary) damage cost factors that link emissions to damages caused by a certain quantity (e.g. one tonne) of pollutant emitted. Accordingly, the reduction of pollutant emissions leads to a decrease in external costs, which was quantified for the plants supported in Germany. The cost categories considered for deriving the savings in external costs comprise climate change, human health impacts, crop losses, damage to materials and losses in biodiversity.[5]

Avoiding greenhouse gas and air pollutant emissions through financed plants in Germany reduces external costs by € 353 million per year for 2015 and € 368 million per year for 2016 (see Table 11). The largest part of saved external costs can be attributed to global climate change impacts which are caused by the emission of greenhouse gases.

[5] A brief description is given in Annexes A.2 and A.3. Details of the calculation approach including damage cost factors can be found in the evaluation report (in German; see footnote 1).

Table 11: Annual savings in external costs resulting from the use of renewables in plants in Germany supported by RE Standard in the years 2015 and 2016.

€ million per year	2015	2016
Climate change	296.2	306.2
Health impacts	48.5	52.7
Crop losses	1.1	1.2
Material damage	1.0	1.0
Biodiversity losses	6.2	6.7
Total	**353.0**	**367.9**

Totals may differ due to rounding.

4.4 Employment effects in Germany

Construction and operation of renewable energy plants leads to a demand in goods and services which creates or preserves employment. Employment effects in Germany caused by the plants supported in Germany were calculated using an approach based on input-output analysis. This approach allows consideration of both direct employment (e.g. building a wind turbine) and indirect employment (e.g. producing steel for a wind turbine). The sum of direct and indirect employment results in the so-called gross employment.[6]

Manufacturing and construction of the plants supported in Germany in 2015 and 2016 correspond to approx. 41,000 jobs and 45,000 jobs respectively created or preserved in Germany for one year. A further 1,300 (1,330) jobs per annum result from the operation and maintenance of the plants over the assumed 20 years of operation, adding up to 25,990 (26,540) jobs. Over a period of 20 years, building and operating the plants supported by the RE Standard programme in the years 2015 and 2016 creates or preserves employment of more than 67,000 and 71,000 person years (see Table 12).

Table 12: Gross employment effects in Germany resulting from the use of renewables in plants in Germany supported by RE Standard in the years 2015 and 2016.

Person years[1)]	2015	2016
Construction of plants	41,170	44,810
Operation of plants (over a 20-year period)	25,990	26,540
Total	**67,160**	**71,340**

Totals may differ due to rounding.

1) One person year equals one person employed for the duration of one year (or 2 persons employed for half a year etc.)

6 A brief description is given in Annex A.4. Details of the calculation approach can be found in the evaluation report (in German; see footnote 1).

5 Summary of effects

Table 13 and Table 14 summarise the evaluation results of the KfW´s RE Standard programme for the years 2015 and 2016.

Table 13: Overview of evaluation results 2015 for the KfW programme RE Standard.

	Unit	Germany	Outside Germany	Total
Volume of loan commitments	€ million	3,178.3	1,088.1	4,266.4
Investments financed[1)]	€ million	4,084.8	1,336.0	5,420.8
Supported installed electrical power	MW_{el}	2,602.9	996.0	3,598.9
Annual electricity production	TWh_{el} / a	5.2	1.5	6.7
Supported installed thermal power	MW_{th}	1.0	-	1.0
Annual heat production	TWh_{th} / a	0.03	-	0.03
Annual savings in greenhouse gas emissions due to plants supported	million tonnes CO_2-equiv. / a	3.51	0.19[2)]	-[3)]
Annual savings in energy imports	€ million / a	191	n.q.	
Gross employment effects	person years	67,160	n.q.	
due to plant construction	person years	41,170	n.q.	
due to plant operation (over a 20-year period)	person years	25,990	n.q.	
Annual savings in external costs	€ million / a	353.0	n.q.	

Totals may differ due to rounding.

[1)] excl. VAT.

[2)] in million tonnes CO_2 / a

[3)] Figures based on different sets of emission factors.

Table 14: Overview of evaluation results 2016 for the KfW programme RE Standard.

	Unit	Germany	Outside Germany	Total
Volume of loan commitments	€ million	3,689.9	825.6	4,515.5
Investments financed[1)]	€ million	4,557.7	1,112.2	5,669.9
Supported installed electrical power	MW_{el}	2,769.2	787.2	3,556.4
Annual electricity production	TWh_{el} / a	5.4	1.3	6.7
Supported installed thermal power	MW_{th}	2.5	-	2.5
Annual heat production	TWh_{th} / a	0.01	-	0.01
Annual savings in greenhouse gas emissions due to plants supported	million tonnes CO_2-equiv. / a	3.62	0.11[2)]	-[3)]
Annual savings in energy imports	€ million / a	202	n.q.	
Gross employment effects	person years	71,340	n.q.	
due to plant construction	person years	44,810	n.q.	
due to plant operation (over a 20-year period)	person years	26,540	n.q.	
Annual savings in external costs	€ million / a	367.9	n.q.	

Totals may differ due to rounding.

[1)] excl. VAT.

[2)] in million tonnes CO_2 / a

[3)] Figures based on different sets of emission factors.

Annex: Overview of the underlying methodology

The following sections give a brief description of the methodology used for evaluating the effects caused by the renewable energy plants supported by the KfW´s RE Standard programme. Detailed information is available in the evaluation report[7].

A.1 Estimation of savings in fossil fuel consumption and avoided energy costs for imported fossil fuels in Germany

Electricity and heat from renewable energy sources replace fossil fuels. The savings in fuel use are calculated in two steps. In the first step, substitution factors for electricity and heat production provided by the German Umweltbundesamt (UBA – Federal Environment Agency) are applied. These factors give the shares of electricity from lignite, hard coal, natural gas and mineral oil that are replaced in Germany by electricity from renewables. Every technology (wind energy, hydro power, solid biomass, photovoltaics, biogas and geothermal energy) has its specific substitution pattern, determined mainly by the time structure of energy provision. In the second step, the amounts of electricity replaced are combined with primary energy factors for each energy carrier that give the units of fossil primary energy (including up- and downstream processes) necessary to provide one unit of electricity. The fossil energy use associated to the use of renewable energy (in up- and downstream processes) is subtracted from the calculated fossil energy savings, resulting in net savings in fossil energy due to electricity produced in the renewable energy plants supported.

The amounts of net fossil energy saved due to heat provision from renewable energy are calculated accordingly, based on substitution and primary energy factors for fuel oil, natural gas, hard coal, lignite, district heating and electricity for heat provided by solar thermal plants, heat pumps, biogas, solid biomass and geothermal plants.

Since a large share of Germany's fossil fuels have to be imported, the savings calculated lead to a reduction in German energy imports. Lignite, as the only major German domestic fossil fuel source, is assumed not to be imported. The associated costs due to savings in fossil fuel imports are calculated using price forecasts for the import prices of crude oil, hard coal and natural gas.

[7] Available in German only – see footnote 1.

A.2 Estimation of savings in greenhouse gas emissions and air pollutant emissions

Savings in greenhouse gas (CO_2, CH_4, N_2O) and air pollutant (SO_2, NO_x, NMVOC, fine particles) emissions due to supported plants in Germany are calculated based on emission reduction factors provided by the German Umweltbundesamt (UBA – Federal Environment Agency). These factors are based on the substitution factors mentioned in the previous section and reflect the specific fossil fuels that the renewable energy sources replace. They describe net emission savings, setting off the volume of emissions caused by the use of renewables (final energy supply) against the volume of gross emissions that are no longer being released thanks to fossil sources having been replaced with renewables. All upstream process chains involved in the production and supply of the various energy sources and in plant construction and operation (but not dismantling) are also taken into account.

When calculating the savings in greenhouse gas emissions due to supported plants in countries other than Germany, emission reduction factors are required for each country. No consistent emission factor set of comparable quality is available therefore emission reductions are estimated based on CO_2 emission factors of the average electricity mix of the countries considered as a second-best approach.

A.3 Valuation of external costs avoided

Air pollutant emissions cause changes in environmental burdens and associated impacts on various receptors, such as human beings (e.g. emissions of air pollutants leading to respiratory diseases), crops (decrease in yields), building materials (mainly degradation and soiling) or ecosystems (mainly due to acidification and eutrophication). This change in impacts leads either directly or indirectly (e.g. through health effects) to a change in the utility of the affected persons. Welfare changes resulting from these impacts can be transferred into monetary values and represent external costs to society as they are not borne by the polluter. The German Umweltbundesamt (UBA – Federal Environment Agency) provides pollutant-specific damage cost factors that link emissions to damages caused by a certain quantity (e.g. one tonne) of pollutant emitted in Germany. In addition to the damage cost factors for air pollutants (SO_2, NO_x, NMVOC, fine particles), cost factors for greenhouse gas emissions (CO_2, CH_4, N_2O) are provided. The cost categories considered for deriving the external costs avoided comprise climate change, human health impacts, crop losses, damage to materials and losses in biodiversity.

The external costs avoided by supporting RE plants in Germany are then calculated by multiplying the savings in pollutant and greenhouse gas emissions (in tonnes) by the specific cost factor per tonne of pollutant or greenhouse gas emitted.

A.4 Estimation of employment effects

Employment effects arise from the construction and the operation of renewable energy plants. Investments in facilities, operation and maintenance create direct employment for manufacturers, operators and service companies. They in turn demand goods from other economic sectors, thus creating indirect employment for suppliers of intermediate inputs. The total of direct and indirect employment is the so-called gross employment.

Starting point for the calculation of gross employment effects is the demand for goods in Germany resulting from the investments in renewable energy plants supported by the KfW RE standard programme. Direct and indirect effects resulting from this demand are modelled by means of input-output tables, which map the flow of goods and interdependencies of industries within the German economy and with foreign countries. In the final step, employment effects are calculated using sector-specific labour intensities, which reflect the productivities in the different economic sectors.