Evaluation of greenhouse gas emissions avoided in the year 2020 attributable to the portfolio of wind energy and photovoltaic installations financed by Landwirtschaftliche Rentenbank

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Abbreviations and explanations

CO_2	Carbon dioxide
CO_{2eq}	see CO_2-equivalent
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 25 kg of CO_2.
GHG	Greenhouse gas
GWh	Gigawatt hour(s); 1 GWh = 1 million kWh
kW	Kilowatt(s)
kW_p	Kilowatts peak: peak power of PV facilities
kWh	Kilowatt hour(s)
kt	Kilo tonne (1,000 tonnes)
MW	Megawatt(s); 1 MW = 1,000 kW
PV	Photovoltaics
RE	Renewable energy
RES	Renewable energy sources
t	Tonne

1 Introduction

The main focus of the promotional activities of Landwirtschaftliche Rentenbank (hereinafter referred to as “Rentenbank”) lies on loans for agriculture-related projects of all kinds, as well as for providing finance in rural areas. Within its loan programmes Rentenbank supports investment in installations for using renewable energy, notably in bioenergy, wind energy and photovoltaic energy. On behalf of Rentenbank ZSW developed an approach to estimate the amount of greenhouse gas (GHG) emissions avoided by photovoltaic and wind energy installations supported by the low-interest loans (see Bickel 2020).

The present report describes the GHG emission savings attributable to the plant operation in the year 2020, based on the portfolio as of 31st December 2020. Figure 1 shows the installed power that can be attributed to the residual debt of loans by year of investment. An overview of the calculation approach is given in the annex.

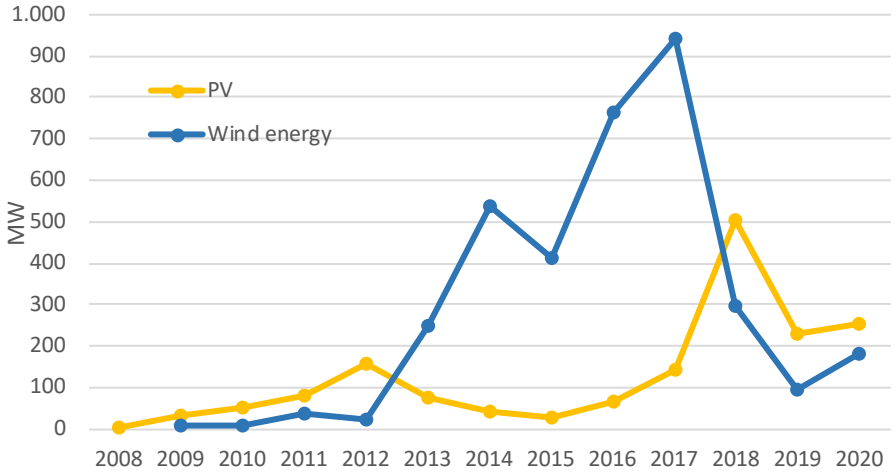

Figure 1: Installed power attributable to residual debt of loans by year of investment.

2 Emission savings

In 2020 wind energy and PV systems benefited from above-average sunny weather and very good wind conditions, particularly in the first half of the year. In conjunction with an increase in installed capacity, GHG emission savings attributable to the Rentenbank portfolio rose compared to the year 2019. For 2020 the savings amounted to 928,900 tonnes of CO_2-equivalent (CO_{2eq}) for PV installations (see Figure 2) and 5,551,400 tonnes of CO_{2eq} for wind energy installations (see Figure 3).

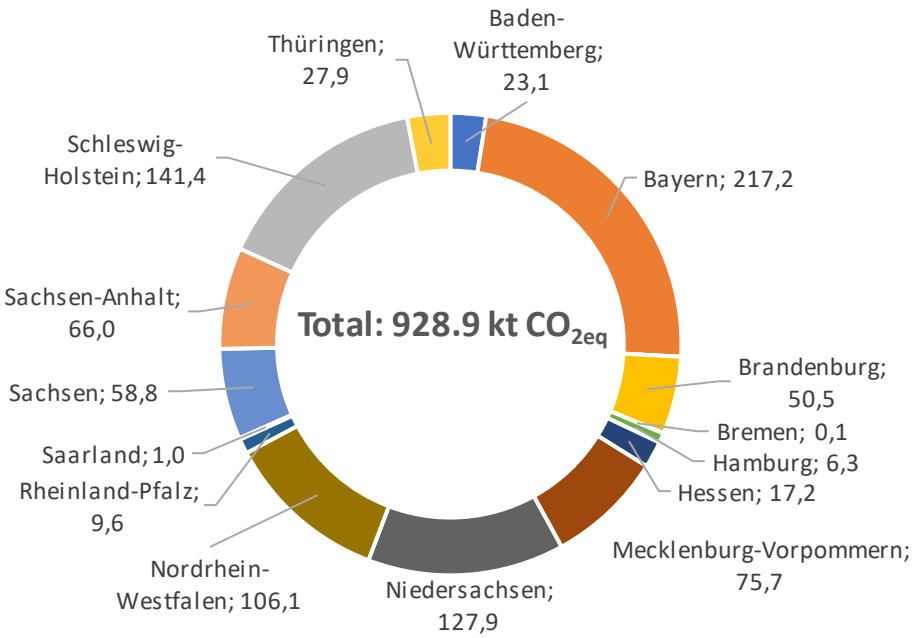

Figure 2: Greenhouse gas emission savings 2020 attributable to photovoltaic installations supported by Rentenbank loans (kt = 1,000 tonnes).

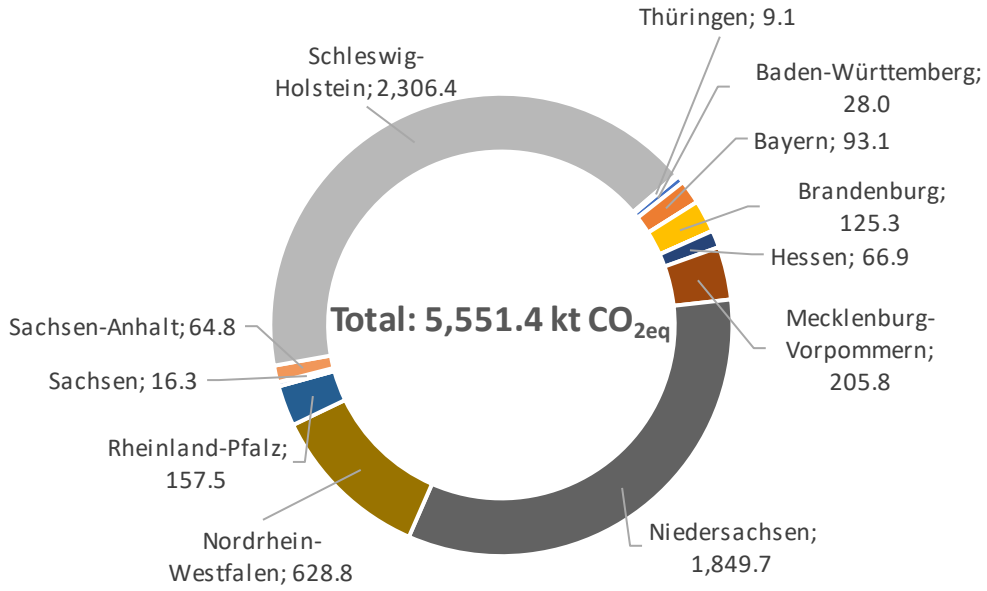

Figure 3: Greenhouse gas emission savings 2020 attributable to wind energy installations supported by Rentenbank loans (kt = 1,000 tonnes).

Table 1 and Table 2 present the results by federal state. It has to be noted that the values are aggregated over all years of investment. The average specific investment costs reflect the underlying time structure of investments in the portfolio. As PV installations saw a steep decline in specific investment cost, considerable variation can be observed between federal

states according to different financing volumes over time. High values result from early investments with higher specific costs. For wind energy installations the variation is comparably small as there was relatively little variation in specific costs.

Table 1: Loans for photovoltaic installations as of 31st Dec. 2020 and attributable effects in the year 2020 by German federal state.

	Loans		Average specific inv. cost	Attributable to loans			
	Count	Residual debt		Installed power	Electricity production	GHG emissions avoided	
		Million €	€/kW$_p$	MW$_p$	GWh	t CO$_2$	t CO$_{2Eq}$
Total	**19,367**	**-1,856.6**	**1,120**	**1,651.9**	**1,519.5**	**876,800**	**928,900**
Baden-Württemberg	693	-44.5	1,180	37.6	37.8	21,800	23,100
Bayern	4,856	-401.4	1,090	369.6	355.4	205,100	217,200
Brandenburg	147	-72.3	910	79.5	82.6	47,700	50,500
Bremen	7	-0.4	2,610	0.1	0.1	67	71
Hamburg	33	-12.2	900	13.6	10.4	6,000	6,300
Hessen	327	-32.8	1,070	30.8	28.2	16,300	17,200
Mecklenburg-Vorpommern	315	-134.6	910	147.5	123.9	71,500	75,700
Niedersachsen	5,776	-310.0	1,340	231.1	209.1	120,700	127,900
Nordrhein-Westfalen	3,696	-239.5	1,170	204.5	173.5	100,100	106,100
Rheinland-Pfalz	465	-23.4	1,450	16.1	15.8	9,100	9,600
Saarland	8	-1.6	990	1.6	1.6	920	980
Sachsen	234	-92.8	980	94.6	96.2	55,500	58,800
Sachsen-Anhalt	317	-97.7	960	102.3	107.9	62,300	66,000
Schleswig-Holstein	2,321	-342.9	1,250	273.6	231.2	133,400	141,400
Thüringen	172	-50.6	1,030	49.2	45.7	26,400	27,900

Totals may differ due to rounding.

Table 2: Loans for wind energy installations as of 31st Dec. 2020 and attributable effects in the year 2020 by German federal state.

	Loans		Average specific inv. cost	Attributable to loans			
	Count	Residual debt		Installed power	Electricity production	GHG emissions avoided	
		Million €	€/kW	MW	GWh	t CO_2	t CO_{2Eq}
Total	**3,241**	**-5,091.0**	**1,430**	**3,550.4**	**7,900.6**	**5,250,200**	**5,551,400**
Baden-Württemberg	13	-28.5	1,410	20.3	39.9	26,500	28,000
Bayern	201	-106.9	1,480	72.4	132.5	88,000	93,100
Brandenburg	25	-138.5	1,390	99.9	178.3	118,500	125,300
Hessen	30	-63.6	1,450	44.0	95.1	63,200	66,900
Mecklenburg-Vorpommern	79	-197.7	1,450	136.7	292.8	194,600	205,800
Niedersachsen	1,014	-1,715.7	1,420	1,210.1	2,632.4	1,749,300	1,849,700
Nordrhein-Westfalen	635	-603.6	1,430	421.0	894.8	594,600	628,800
Rheinland-Pfalz	33	-147.9	1,380	107.3	224.2	149,000	157,500
Sachsen	10	-17.4	1,370	12.7	23.2	15,400	16,300
Sachsen-Anhalt	34	-70.2	1,450	48.5	92.2	61,300	64,800
Schleswig-Holstein	1,161	-1,991.5	1,450	1,371.2	3,282.3	2,181,200	2,306,400
Thüringen	6	-9.7	1,500	6.5	13.0	8,600	9,100

Totals may differ due to rounding.

Table 3 shows the comparison of the GHG emissions avoided per kWh of electricity produced with the corresponding values calculated for the total 2020 electricity production from PV and wind onshore installations in Germany reported in BMWi (2021). The specific GHG-avoidance is lower for the Rentenbank portfolio for both PV and wind energy. Possible reasons for the differences are deviations in the underlying portfolio of installations (e.g. more plants located in areas with less yield or lower efficiency of plants) or uncertainties in the estimation of the electricity production. The reported differences of 11.4 % for PV and 8.6 % for wind energy are within a reasonable range, however.

Table 3: GHG emissions avoided per kWh.

g CO_{2eq} / kWh	Rentenbank	BMWi (2021)	Relative Difference
Photovoltaic energy	611	690	11.4 %
Wind energy onshore	703	769	8.6 %

Table 4 illustrates the amount of CO_{2eq} avoided per Euro invested. The values of the Rentenbank portfolio are compared with the latest availabe figures (2018) for the RE loan programmes assessed in Bickel and Kelm (2019). For PV the Rentenbank portfolio 2020 avoided less GHG emissions per invested Euro than the loan programmes 2018; for wind energy the avoidance was higher. Most problably this is due to the composition of the portfolio: The PV portfolio contains installations from 2008 to 2020 with high specific investment costs for the earlier years. The comparison with the value for the year 2012 (based on Bickel and Kelm 2013) confirms this correlation. The Rentenbank wind energy portfolio comprises installations from 2009 to 2020 and the weight of the two most recent years exceeds that of

the older, more expensive and less efficient wind turbines. In effect a slightly higher avoidance compared to the installations of 2018 appears plausible.

Table 4: GHG emissions avoided per €.

g CO_{2eq} / €	Rentenbank	Bickel and Kelm (2019, 2013)		Relative Difference	
year	2020	2018	2012	2018	2012
Photovoltaic energy	500	563	426	11.1 %	-17.5 %
Wind energy onshore	1,090	1,060	1,038	-2.8 %	-5.1 %

The calculations presented are estimates based on limited information and to the best of our knowledge. They do not represent exact calculations. However, according to the current state of knowledge and under the assumptions made, the estimates provide a realistic indication of the actual savings in GHG gas emissions resulting from the operation of the PV and wind power installations supported by Rentenbank loans. This is confirmed by the plausibility checks performed.

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Annex: Calculation Approach

The following sections describe the calculation approach in general as well as the data used and the assumptions taken. A more detailed description of the approach can be found in Bickel (2020).

The only information available on the photovoltaic (PV) and wind energy plants built with the support of Rentenbank loan programmes is the residual debt of loans as of 31st December 2020, categorised by year of investment and German federal state. This can be interpreted as share of the installations and their operation that is attributable to the loan programmes and is the starting point of the calculation. Figure 4 illustrates the calculation approach with light green arrows indicating input values and dark green arrows displaying calculation results.

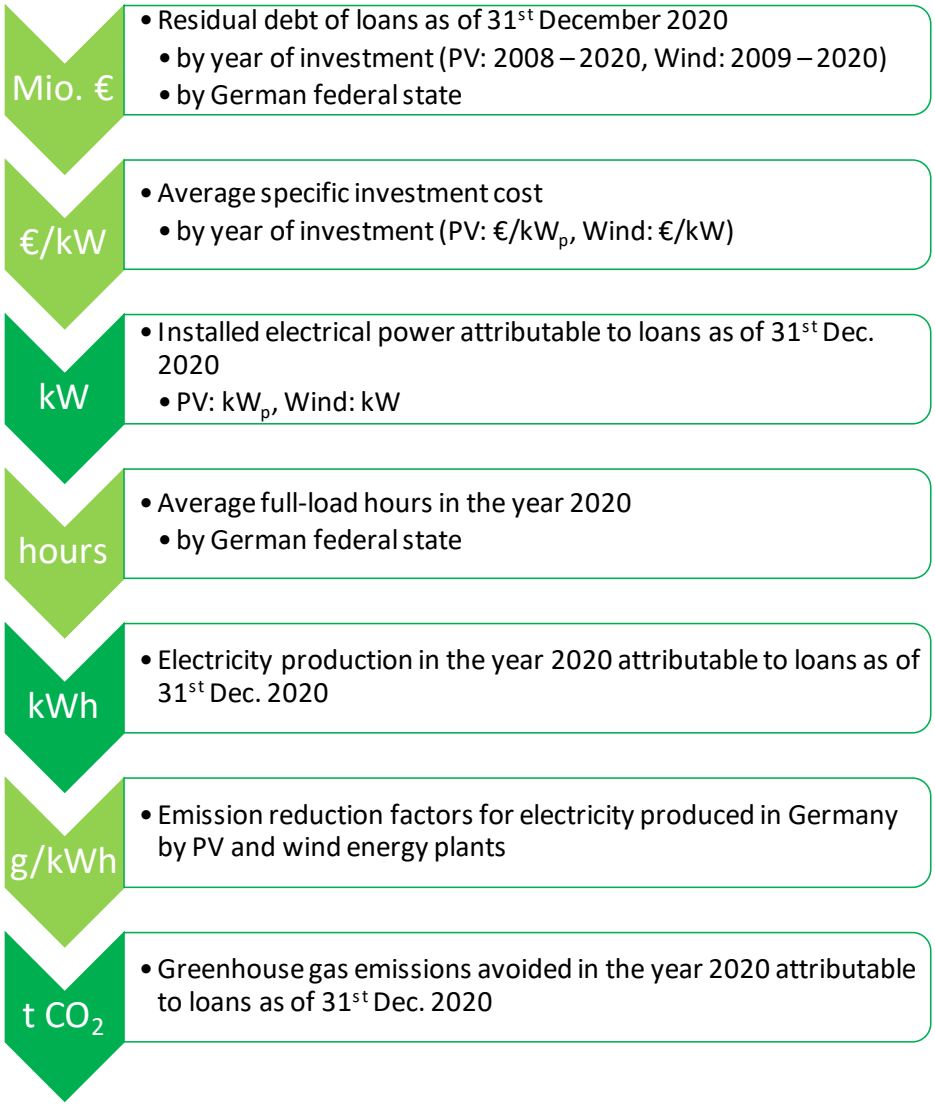

Figure 4: Overview of the calculation approach (light green arrows indicate input values, dark green arrows show calculation results).

In the first step the installed electrical power can be estimated from the residual debt of loans using specific investment cost values. As the cost per kW of electrical power installed has changed over the last years, average values differentiated by year of investment are used for both PV and wind installations. As for the previous years specific investment costs for the installation year 2020 were provided by ZSW.

In the next step the electricity production is calculated from the installed electrical power and average full-load hours in the year 2020. Full-load hours and thus the electricity produced by a PV or wind energy plant vary with geographical location within Germany. This is taken into account by using full-load hours differentiated by German federal state, which were derived based on data from DWD (2021) and Anemos (2021).

The final step is the multiplication of the electricity production by emission reduction factors for electricity produced in German PV and wind energy plants. These factors 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 due to fossil sources having been replaced with renewables. They are provided for emissions of CO_2 and CO_2-equivalents, both for PV and wind energy (as well as other renewable energy sources), by the German Umweltbundesamt. Table 5 shows the values for 2019, the most recent year available.

Table 5: Emission reduction factors for the year 2019.

g/kWh	CO_2	CO_{2eq}
Photovoltaic energy	577	611
Wind energy onshore	665	703

Source: UBA 2021, values rounded.