RED ELÉCTRICA DE ESPAÑA

Grupo Red Eléctrica

CO_2 emissions of electricity generation in Spain

March 2021

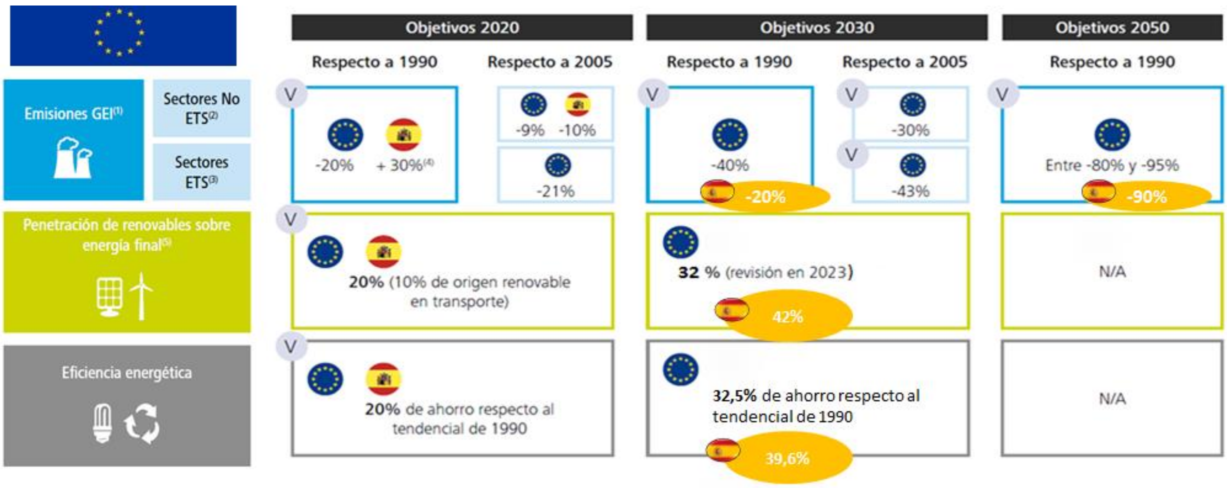
1. *Why are greenhouse gas emissions relevant?*

Paris agreement, signed in December 2015 in the XXI Conference of Parties (COP21) of the United Nations Framework on Climate Change (UNFCCC), set the target of all signatories to keep global warming below 2°C, referenced to preindustrial levels.

With this framework, European Energy System is suffering a deep change, boosted by common goal of decarbonization, and creating new opportunities and challenges for all participants. European targets include a 40% of greenhouse gases reduction by 2030, with the aim to reach an almost 100% decarbonized system by 2050.

These decarbonization goals are very close related to final energy integration coming from renewables and to energy efficiency, with targets of 32% of final energy coming from renewables in 2030, and an efficiency of 32,5% referenced to 1990 trend.

In the case of Spain, the 2030 targets are a 42% of final energy from renewables, and a reduction of greenhouse gases emissions of 20% referenced to 1990.



Targets in emissions, renewable energy and efficiency

2. *Which are greenhouse gases?*

Greenhouse gases (abbreviated GHG) are these considered by IPCC (*Intergovernmental Panel on Climate Change*) and by Spanish Emissions Inventory (SEI). These gases are CO_2, CH_4, N_2O and Fluor based compounds (F-gases like SF_6).

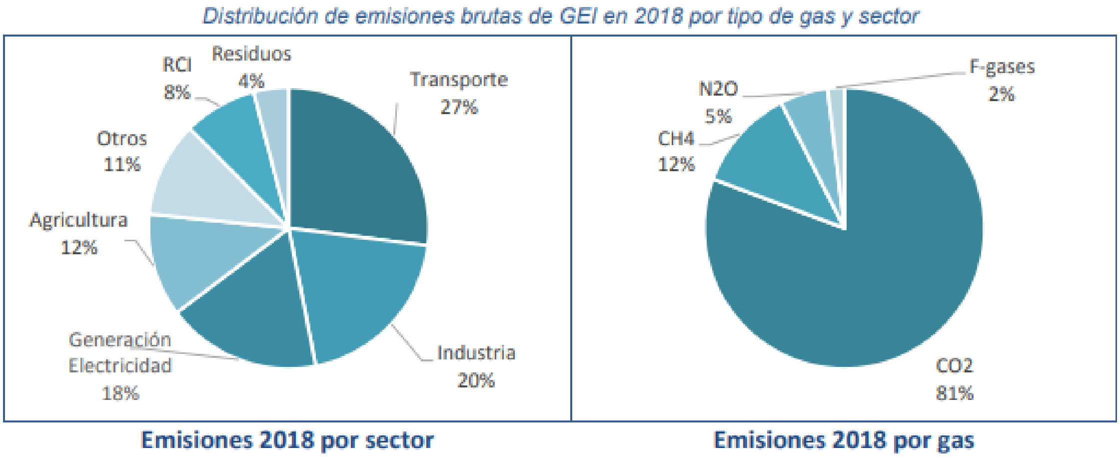
3. *What GHGs do we consider in electricity generation?*

GHG emissions in electricity generation are mainly caused by combustion gases, so CO_2 and N_2O emissions are taken into account.

In order to assess GHG potential of N_2O, GWP (*Global Warming Potential*) of IPCC Fifth Assessment Report *(AR5)* is used. This value is 265 for N2O, what means that 1 g N_2O has the same global warming potential than 265 g CO_2.

4. What were 2018 GHG emissions in Spain?

GHG emissions at national level are estimated in 334,3 $MtCO_2$-eq in 2018. Electricity generation was about 18% of this amount, a figure that can be compared with 27% of transport, and 20% of industry. These values are referred to CO_2-eq, so CO_2, N_2O, CH_4 and F-gases, are all included.

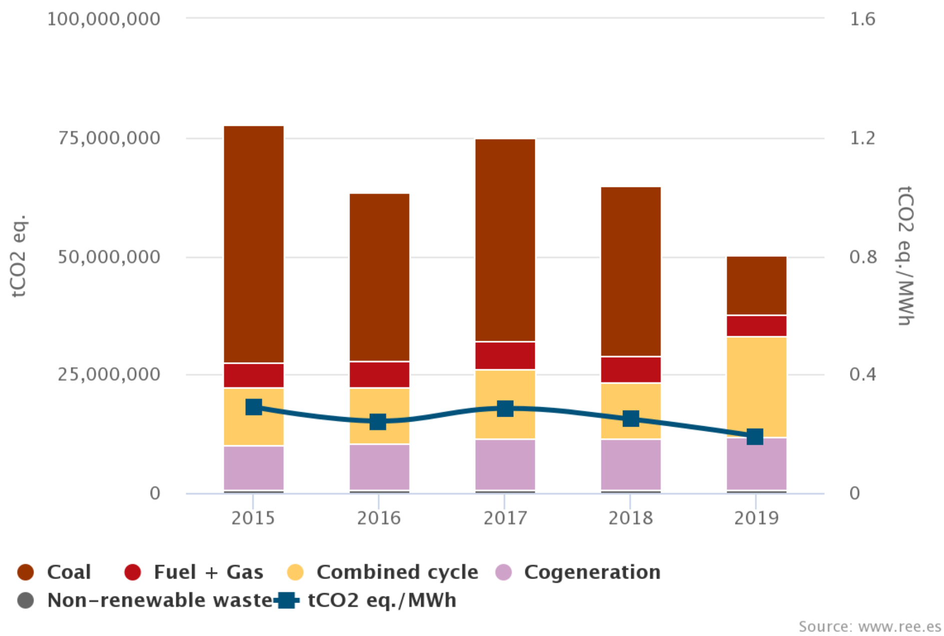


2018 GHG emissions by activity and gas.
Source: 2020 edition of "Inventario Nacional de GEI 2018" (Ministerio para la Transición Ecológica y el Reto Demográfico).

5. What are current electric GHG emissions associated to electricity generation?

In Electric Spanish System GHG emissions have been going down as a consequence of higher share of renewable energy, and the reduction of coal production share. The figures show a decrease from 80 $MtCO_2$-eq in 2015, to about 50 $MtCO_2$-eq in 2019.

The emission factor in 2015 was 0,29 tCO_2-eq/MWh, and the figure in 2019 was 0,19 tCO_2-eq/MWh, with a cut down higher than 30%,



GHG emissions and emission factor evolution in Electric Spanish System. Source REE.

6. How do we calculate this GHG emissions?

The whole CO_2-eq emissions are assessed from specific emission factors, expressed in tCO_2-eq per MWh of produced electricity. These factors are grouped by geographic area and by generation technology. Total amount of CO_2-eq tones are estimated by multiplying the emission factor by the total amount of produced energy (MWh). This is the way we calculate total emissions produced by electricity generation in Spanish Electric System.

7. What are used data sources?

Red Eléctrica gathers information from several sources, regarding the best data availability, in order to asses emission factors for every generation technology, fuel, and geographical area. In particular:

- Emissions registry for every single power plant. Available in: Registro Estatal de Emisiones y Fuentes Contaminantes.
- Actual energy production for every single power plant, coming from SIMEL (electricity metering information system)
- Emission factors from Reglamento (UE) 601/2012 de la Comisión Europea de 21 de junio de 2012.
- Emission factors by technology from Plan Nacional de Asignación de Derechos de Emisión.
- Emission factors by technology in the islands Resolución de la DGPEM de 30 de junio de 2017.
- Efficiency by technology from Plan de Energías Renovables en España 2005-2010.
- Equivalent electric efficiency of combined heat and power (CHP) from Real Decreto 413/2014.

8. What are GHG emission factors?

Emission factors of electricity generation are summed up in the following table. Details on calculations can be found in Annex I:

Mainland system	
Technology	Emissions CO_2-eq (tCO_2-eq/MWh)
Coal power plant	0,95
Combined cycle power plant (Natural Gas)	0,37
Fuel-Gas power plant	0,77
Combined heat and power (CHP)	0,38
Wastes	0,24

Islands and isolated systems	
Technology	Emissions CO_2-eq (tCO_2-eq/MWh)
Combined cycle power plant (Diesel Oil)	0,60
Combined cycle power plant (Natural Gas)	0,41
Coal power plant	1,05
Diesel engine (Diesel oil, fuel, natural gas)	0,68
Steam power plant	0,90
Gas turbine (Diesel oil)	1,12
Gas turbine (Natural gas)	0,84
Combined heat and power (CHP)	0,38
Wastes	0,24

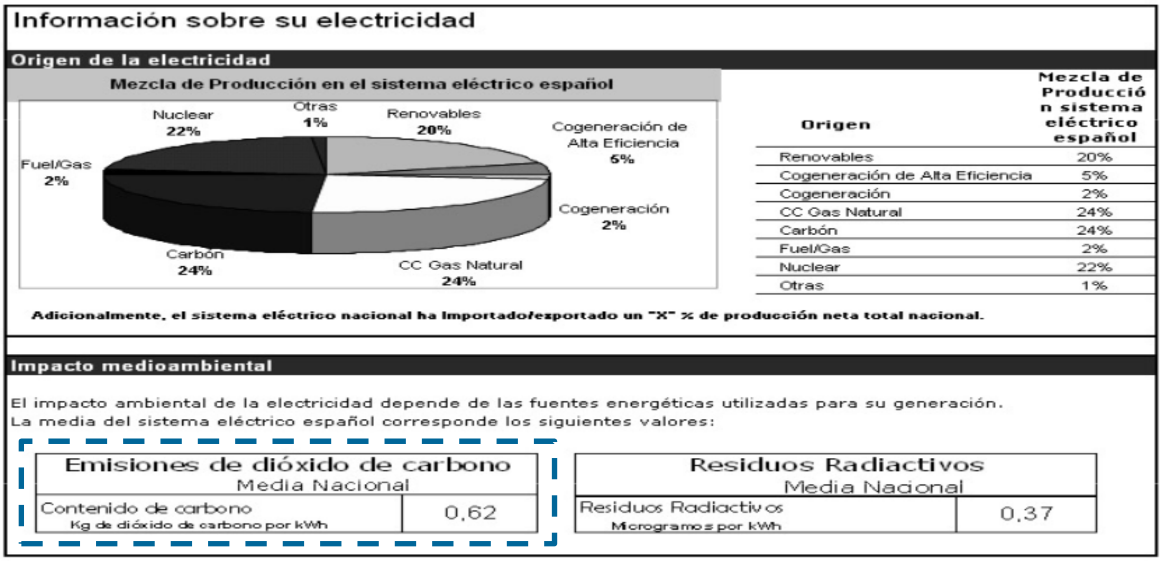
9. When do we update GHG emission factors?

We update GHG emission factors annually. Furthermore, GHG emission factors are updated when necessary.

10. What are GHG emission factors used for?

We provide GHG emission factors in order to track the evolution of GHG emission associated to electricity generation in the Spanish Electric System, which is one of the key performance indicators of the energy transition.

In addition, after the *Circular 2/2021, de 10 de febrero, de la Comisión Nacional de los Mercados y la Competencia, por la que se establece la metodología y condiciones del etiquetado de la electricidad para informar sobre el origen de la electricidad consumida y su impacto sobre el medio ambiente* entered in force, the electric System Operator proposes the regulator GHG emission factors, based on this methodology, to build the information related to the origin of the electricity produced. This information is provided to all consumers with their electricity bill, following a standard format.



Información sobre su electricidad

Origen de la electricidad

Origen	Mezcla de Producción sistema eléctrico español
Renovables	20%
Cogeneración de Alta Eficiencia	5%
Cogeneración	2%
CC Gas Natural	24%
Carbón	24%
Fuel/Gas	2%
Nuclear	22%
Otras	1%

Adicionalmente, el sistema eléctrico nacional ha importado/exportado un "X" % de producción neta total nacional.

Impacto medioambiental

El impacto ambiental de la electricidad depende de las fuentes energéticas utilizadas para su generación.
La media del sistema eléctrico español corresponde los siguientes valores:

Emisiones de dióxido de carbono Media Nacional	
Contenido de carbono Kg de dióxido de carbono por kWh	0,62

Residuos Radiactivos Media Nacional	
Residuos Radiactivos Microgramos por kWh	0,37

Annex I. Methodology for CO_2-eq emission factors calculation

This methodology allows to obtain CO_2-eq emission factors with technology and fuel desegregation.

CO_2-eq emission factors assessed with this methodology are expressed in tCO_2-eq/MWh, and they allow to get total CO_2-eq tones emitted by a single power plant or a group of power plants, by multiplying the emission factor (tCO_2-eq/MWh) by the total energy production (MWh).

These emission factors take into account direct CO_2 emissions because of electricity generation, but indirect emissions, associated to power plants building, fuel transportation, maintenance, etc., are not included in this calculation.

GHG included in this methodology.

CO_2 and N_2O emissions are taken into account for CHG emission factors of this methodology.

In order to assess GHG potential of N_2O, GWP (*Global Warming Potential*) of IPCC Fifth Assessment Report *(AR5)* is used. This value is 265 for N_2O, what means that 1 g N_2O has the same global warming potential than 265 g CO_2.

Information sources.

Red Eléctrica gathers information from several sources, regarding the best data availability, in order to asses emission factors for every generation technology, fuel, and geographical area. In particular:

- Emissions registry for every single power plant, available in Registro Estatal de Emisiones y Fuentes Contaminantes.

    The *Registro Estatal de Emisiones y Fuentes Contaminantes (PRTR)* has information on emissions inventory of CO_2, N_2O and other pollutant agents, for electricity generation power plants with an installed nominal thermal power equal or higher than 50 MW_t. Latest year with available information is 2018. Year n information is published by November the 15th of year n+1.

    This information (expressed in tCO_2/year or tN_2O/year) is combined with real electricity production of every single power plant, in order to produce particular emission factors.

- Actual energy production for every single power plant, coming from SIMEL (electricity metering information system)

    Actual energy produced by every single power plant and registered in SIMEL (electricity metering information system) is used in order to assess individual emission factors from PRTR.

    Having total amount of CO_2 and N_2O emissions (tCO_2-eq), and total energy production (MWh), emission factor (tCO_2/MWh) is calculated.

- Emission factors from Reglamento (UE) 601/2012 de la Comisión Europea de 21 de junio de 2012.

    Regulation UE 601/202 from European Commission provides emission factors, expressed in tCO_2/TJ, which are associated to fuel calorific power. These factors allow to obtain total CO_2 emissions from total amount of used fuel.

    Electricity conversion efficiency (for every power plant or technology) is needed in order to obtain a set of emission factors in tCO_2/MWh of produced electricity.

- Emission factors by technology in the islands Plan Nacional de Asignación de Derechos de Emisión.

    The *Plan Nacional de Asignación de Derechos de Emisión* (emission rights national assignment plan) provides a set of emission factors in tCO_2 per MWh of produced electricity, including desegregation by technology and fuel in islands and isolated systems. These factors were recently updated in Resolución de la DGPEM de 30 de junio de 2017.

- Efficiency by technology from Plan de Energías Renovables en España 2005-2010.

  Efficiency coefficients allow to move from emission factors associated to fuel (tCO_2/TJ) to emissions factors associated to electricity generation (tCO_2/MWh). Specifically, efficiency coefficients of coal power plants and combined cycles natural gas power plants, are used.

- Equivalent electric efficiency of combined heat and power (CHP) from Real Decreto 413/2014.

  For combined heat and power (CHP), this methodology allocates a part of combustion emissions to electricity productions, and other part to heat productions. In order to quantify these two parts, equivalent electric efficiency, from RD 413/2014, is used.

Assessment of emission factor for power plants in Spain

Para el cálculo de los factores de emisión de CO_2 equivalente por tecnología y combustible se combinan las diferentes fuentes de información conforme a los siguientes criterios:

- Coal power plants

  Coal power plants use basically coal in electricity productions. Coal es a fuel with a high carbon contain, so its combustion produces high quantities of CO_2, per MWh produced of electricity.

  For these power plants, four types of coal are distinguished: luminous coal, anthracite, brown lignite and black lignite, with a different emission factor for each of them.

  For the whole mix of coal in Spain, a technology efficiency of 36% (η), is used. Value coming from *Plan de Energías Renovables en España 2005-2010*, and the following formula is used:

$$f\left(\frac{tCO_2}{MWh}\right) = \frac{tCO_2}{TJ} \cdot \frac{3{,}6\ TJ}{1000\ MWh} \cdot \frac{100}{\eta}$$

Obtaining:

Fuel	ktCO₂/ktep	TJ/ktep	Fuel emission factor (tCO₂/TJ)	Electric efficiency (%)	tCO₂/MWhₑ
luminous coal + anthracite	4,032	41,868	96,303	36%	0,96
Imported coal	4,032	41,868	96,303	36%	0,96
Black lignite	3,861	41,868	92,218	36%	0,92
Browin lignite	3,983	41,868	95,132	36%	0,95

The values are weighted with electricity production in order to get a global emission factor for coal in Spain in a period.

The current average value in the mainland power system for coal power plants is 0,95 tCO_2/MWh.

This methodology considers that N_2O emissions of coal power plants are no relevant as GHG compared with CO_2 emissions.

- Combined cycle power plants firing natural gas

Combined cycle power plants that fire natural gas, use a fuel with a carbon contain lower than coal. This issue, with the higher efficiency of this power plants, produce a much lower emission factor than coal power plants.

For emission factor associated to natural gas and efficiency, values from *Plan de Energías Renovables en España 2005-2010*, are used in the following conversion formula:

$$f\left(\frac{tCO_2}{MWh}\right) = \frac{tCO_2}{TJ} \cdot \frac{3{,}6\ TJ}{1000\ MWh} \cdot \frac{100}{\eta}$$

Obtaining:

Fuel	ktCO₂/ktep	TJ/ktep	Fuel emission factor (tCO_2/TJ)	Electric efficiency (%)	tCO_2/MWh_e
Natural Gas	2,337	41,868	55,818	54%	0,37

This methodology considers that N_2O emissions of combined cycle power plants are no relevant as GHG compared with CO_2 emissions.

- Fuel-gas conventional power plants

These type of power plants include thermal power plants firing fuel, diesel, natural gas, or others, but using open cycle turbines.

Empiric values are used because of heterogeneity of this category.

In particular, using values of CO2 emissions coming PRTR and electricity production from SIMEL, an average value of 0,77 tCO2/MWh.

Currently, there aren´t production of electricity with these technologies in the mainland power system.

This methodology considers that N_2O emissions of fuel-gas conventional power plants are no relevant as GHG compared with CO_2 emissions.

- Hydro, wind and nuclear power plants

These technologies are no producing CO_2 during their operation, because of no firing fossil fuels, so an emission factor of 0,0 tCO_2/MWh, is used.

- Combined heat and power (CHP) power plants

CHP is the combined production of heat and electricity in the same asset, what has a combined efficiency higher than producing electricity and heat independently.

An emission factor is considered for every CHP technology, and they are weighted in order to get a global emission factor for CHP in Spain.

The following formula is used:

$$f\left(\frac{tCO_2}{MWh}\right) = \frac{tCO_2}{TJ} \cdot \frac{3{,}6\ TJ}{1000\ MWh} \cdot \frac{100}{\eta}$$

Obtienen:

Technology	Fuel emission factor (tCO_2/TJ)	Equivalent electric efficiency (%)	tCO_2/MWh_e	Weight %[1]
Turbine Natural Gas	56,100	59%	0,34	52,1%
Engine (ICE) Natural Gas	56,100	55%	0,37	37,7%
Engine (ICE) Diesel oil	73,300	56%	0,47	0,4%
Engine (ICE) Fuel oil	76,600	56%	0,49	9,1%
Coal	95,550	49%	0,70	0,5%
Refinery gas	66,100	59%	0,40	0,1%
CHP			**0,37**	

Average weighted emission factor of CO_2 for CHP is 0,37 tCO_2/MWh.

For CHP technologies, the average weighted equivalent CHG emission factor associated to N_2O is 0,01 tCO2/MWh, so the final value of equivalent emissions for CHP in the mainland power system is 0,38 tCO_2/MWh.

- Wastes power plants

Wastes power plants are extremely heterogenous, because the variety in used fuels. As an average, an emission factor of 0,24 tCO_2/MWh is used.

In case of power plants firing biogas or biomass, the emission factor is 0,0 tCO_2/MWh, because according to Regulation UE 6061/2012 these fuels are neutral from CHG emissions point of view.

This methodology considers that N_2O emissions of wastes power plants are no relevant as GHG compared with CO_2 emissions.

- Electrical international interconnections

This methodology only takes into account CO_2 emissions of power plants in Spain, so emissions associated to electricity generated in other countries are not considered. Consequently, emissions due to exports are not subtracted.

[1] *Weighted with information from IDAE and CNMC 2004-2014.*

Particularities for islands and isolated electric systems

Special circumstances in islands and small isolated systems make necessary an adaptation of some emission factor for these electric systems, because of fuels, size and technologies of power plants in these systems.

In particular, values from *Resolución de la DGPEM de 30 de junio de 2017*, that updates factors from *Plan Nacional de Asignación de Derechos de Emisión*, are used. These factors are basically the same that used to determine emissions rights costs retribution for power plants in this systems, as established in *Real Decreto 738/2015 de 31 de julio, por el que se regula la actividad de producción de energía eléctrica y el procedimiento de despacho en los sistemas eléctricos de los territorios no peninsulares*.

Technology	Emissions CO_2 (tCO_2/MWh)	Emissions N_2O (tCO_2 eq/MWh)	Emissions CHG (tCO_2 eq/MWh)
Combined cycle power plant (Diesel oil)	0,60	0,00	0,60
Combined cycle power plant (Natural gas)	0,41	0,00	0,41
Coal power plant	1,05	0,00	1,05
ICE [2] engine (Diesel oil, fuel, natural gas)	0,65	0,03	0,68
Steam power plant	0,90	0,00	0,90
Gas turbine (Diesel oil)	1,12	0,00	1,12
Gas turbine (Natural gas)	0,84	0,00	0,84

Emission factors for TNP, as established in Resolución de la DGPEM de 10 de julio de 2017.

This methodology only takes into account N_2O emissions produced by ICE (internal combustion engines), no matter the fuel used.

For **CHP** and **wastes**, same values than in the mainland power system, are used.

[2] Internal combustion engine (ICE)

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