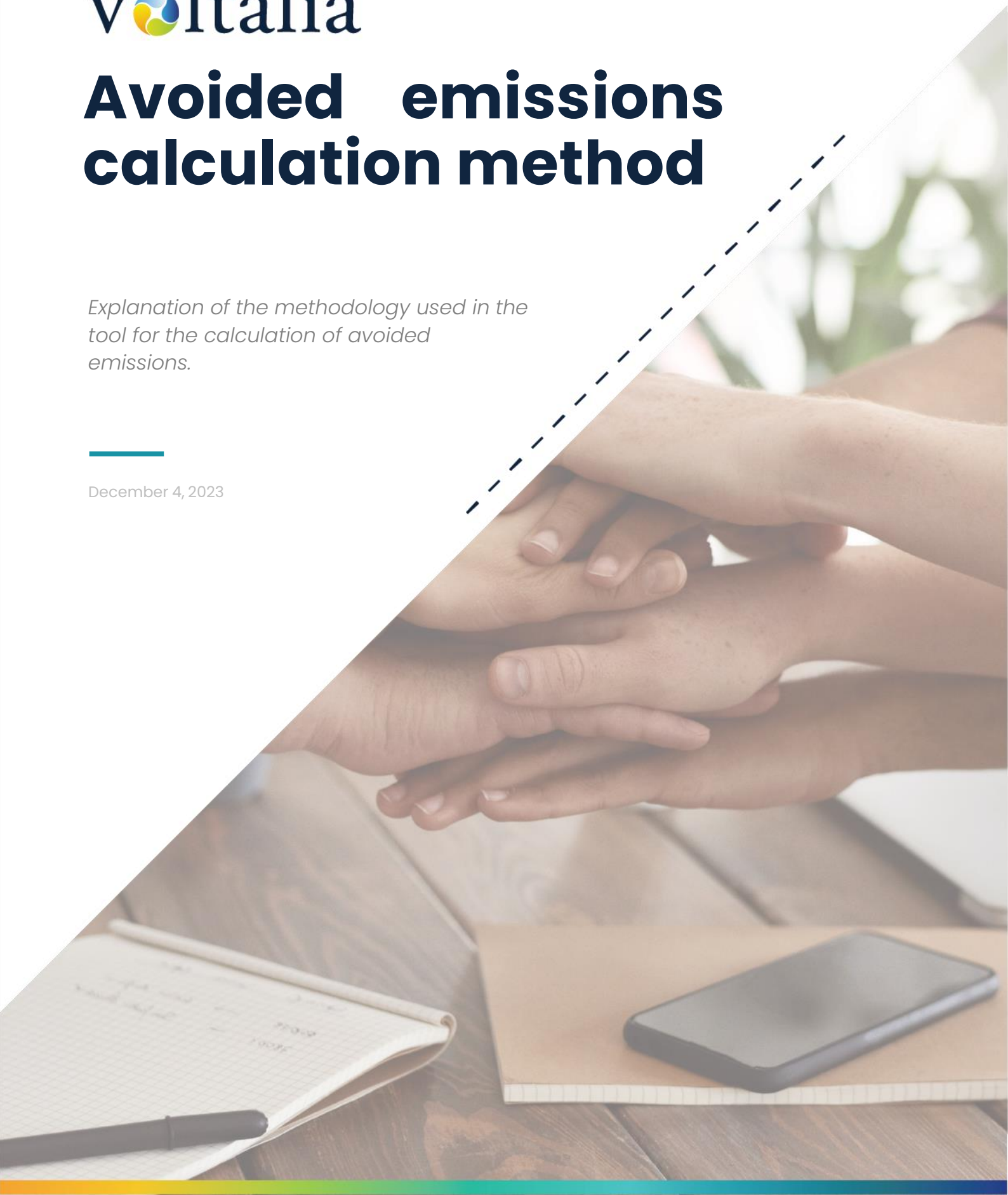
SOLAR • WIND • HYDRO • BIOMASS • STORAGE

voltalia

Avoided emissions calculation method

Explanation of the methodology used in the tool for the calculation of avoided emissions.

December 4, 2023



INDEX

1 CONTEXT

As a Mission-driven company, one of Voltalia's objectives is to act for the production of a renewable energy, accessible to the many. Therefore, Voltalia actively contributes to the fight against climate change by decarbonizing energy and continuously improving its power plants.

By producing green electricity and providing low-carbon services, Voltalia contributes to the low-carbon society.

To measure this contribution, avoided emissions must be calculated.

2 OBJECTIVES

The objective of this document is to explain the methodology used to calculate the avoided emissions of Voltalia.

3 DEFINTION

The avoided (or added) emissions of a project are based on the comparison of:

- the emissions of a reference situation, i.e. the scenario that would have taken place without the project
- the emissions induced by the project

Avoided emissions = Reference situation emissions - Induced emissions

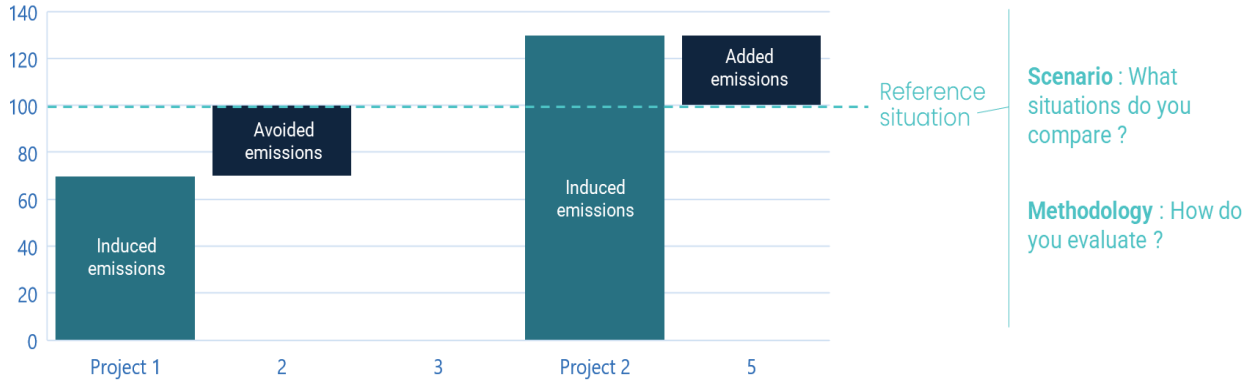


IMAGE 1: EXPLANATION OF AVOIDED EMISSIONS

Be careful, avoided emissions **are not reduction of CO_2 emissions**.

An organization's 'avoided emissions' refers to the emissions reductions achieved by its activities, products and/or services, where **these reductions occur outside the organization's scope of activity**.

Without questioning the environmental benefit of avoided emissions, every organization must reduce its own direct and indirect emissions throughout the value chain of its activities.

Voltalia's avoided emissions consist of the production of a low-carbon service: the production of renewable electricity.

In absolute terms, an organization can act in three ways to commit to the low-carbon transition at its scale:

- It can act directly by reducing the greenhouse gas emissions linked to its activity. For example, it can reduce its energy consumption, change its agricultural practices to increase soil carbon sequestration, use responsible purchasing and eco-design, change land use, etc...;
- It can produce/offer low-carbon solutions/services that allow their users to reduce their own impact compared to existing solutions. For example, the production of renewable energies can reduce emissions linked to energy consumption.
- It can finance low-carbon or carbon sequestration projects at a third party, outside its scope of activity.

Even if these three modes of action are complementary, acting on the emissions linked to its activity throughout its value chain is essential.

Consequently, avoided emissions and reduced emissions are different concepts, as they do not apply to the same perimeter.

4 RESULTS VALIDITY

Using the methodology explained after in the document requires 3 conditions:

1 – The powerplant is connected to the grid

2 – The data for the country where is implemented the plant are available

3 – When available, the OM method is preferred to the Average Grid

And is based on 3 hypotheses:

1 – Biomass / biofuel emissions are neglected

2 – The results are based on latest year available data for the country

3 – Electricity imports are taken into consideration

4.1 Condition 1: The powerplant is connected to the electricity network of the country

Indeed, if a power plant is built to supply energy to just an entity and not to the country energy network, the methodology cannot be used. The emission of the reference situation will be calculated according to the type of powerplant which would have been built instead of the power plant.

For example, the power plant of Oiapoque is not connected to the Brazilian national grid: therefore, using the methodology is not relevant to identify the substituted energy source. The plant replaces an old diesel plant: this diesel technology is the reference for Oiapoque.

4.2 Condition 2: The data for the country where is implemented the plant are available

Enough data are available to calculate emissions of the reference situation (volume of all produced energies and their emission factor).

Please refer to the section **Sources of database**.

4.3 Condition 3: when available, the simple adjusted OM method is preferred than the Average Grid emission factor method

As the merit order (see section **5.2**) rules many of electric markets, it is important to take it into account when the reference situation is calculated.

- The "Average grid" emissions factor, bases on the average electricity mix of the considered country gives the average carbon content of one kWh of electricity produced in the country.
- The "Operating Margin" emission factor, based on the merit order, reflects the optimal functioning of the market, and therefore anticipate accurately the source of electricity production that the power plant developed by Voltalia will replace. It will give the carbon content of one kWh of electricity displaced by a low-carbon electric capacity.

Therefore, by choosing the "Operating Margin" factor, Voltalia is more precise and closer to the reality of the local electricity market.

4.4 Hypothesis 1: Emissions factor of bioenergy (biomass, biofuels, waste…) are neglected

Biofuels: CO_2 emissions from biofuel are not accounted for in the total CO_2 emissions of the energy sector according to the tool 07 of the UNFCCC's Clean Development Mechanism (CDM). ("For biofuels the value applied to the CO_2 emission factor is zero").

4.5 Hypothesis 2: The results are based on latest year available data of the country

To be as close as possible to the reality, we use the latest available data of the country.

4.6 Hypothesis 3: Imports are taken into consideration

The UNFCC model clearly states that it is desirable to include "off-grid" generation plants in the calculation in the case of imports, with some guidance:

- "Electricity imports will be treated as a single LCMR power plant"

- If possible, it is better to model imported electricity as generated electricity

Therefore, to improve the emission factor of the reference situation, and to not complicate too many calculations (avoid iterative calculations), the imports which represent more than 10% of the total volume of generated electricity will be integrated.

Conversely, the UNFCC considers it desirable to keep exported emissions in the model - this is currently the case: "Electricity exports should not be subtracted from electricity generation data used for calculating and monitoring the electricity emission factors."

5 PRINCIPLES

5.1 What is the average country electricity mix?

To meet its electricity needs, each country uses different proportions of the energy available to it (fossil, nuclear, renewable etc.): this is called the electricity mix.

In other words, the average country electricity mix of a is the specific combination of different energy sources it uses to meet its energy consumption needs.

5.2 What is the “merit order” mechanism?

The economic logic is to call power plants onto the grid according to their marginal cost, i.e. the variable cost at which electricity is produced (essentially the cost of fuel). The "merit order" is the mechanism for establishing this order of priority in the implementation of power generation units.

In other words, it describes the sequence in which power plants are designated to deliver power, with the aim of economically optimizing the electricity supply.

According to the merit order, power plants that continuously produce electricity at very low prices are the first to be called upon to supply power (renewable then nuclear). Power plants with higher marginal costs are subsequently added until demand is met (fossils).

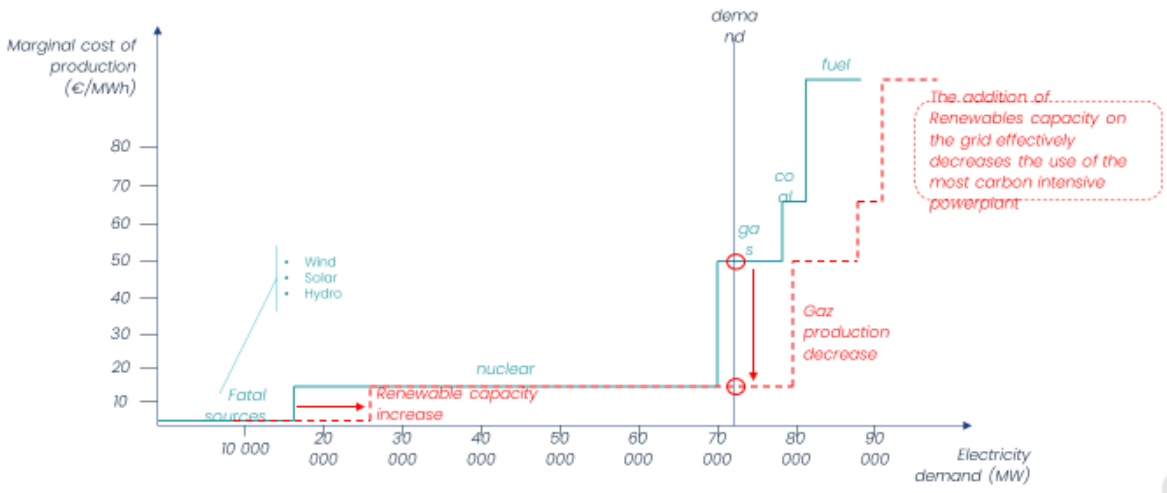


IMAGE 2: EXPLANATION OF “MERIT ORDER”:

6 METHODOLOGY

The avoided (or added) emissions of a project are based on the comparison of:

- the emissions of a reference situation, i.e. the counterfactual scenario that would have taken place without the project
- the emissions induced by the project

Avoided emissions = Reference situation emissions - Induced emissions

6.1 Reference situation emissions

To know the reference situation emissions, the emission factor of it must be multiplied by the produced energy of the powerplant (P_{50} for example).

$$E_{ref\_sit} = EF * P_{50}$$

Where P_{50} is the produced energy of the plant of the 1st year (considering the availability of the plant).

The emission factor can be calculated through two different methodologies:

6.1.1 Simple Adjusted Operating Margin factor

Reference situation emissions are mainly calculated thanks to the use of the **Simple Adjusted Operating Margin factor**, calculated after a methodology described in the UNFCCC's Clean Development Mechanism (CDM): The Tool 07 to calculate the emission factor for an electricity system.

The Simple Adjusted Operating Margin factor reflects the **Merit Order**, which is, at any time offer is higher than demand, priority is given to electricity sources with the lowest marginal cost of production (renewable energies, then nuclear and then fossils), which is correlated to CO_2 emissions.

This method can only be used if the hypothesis of availabilities of data is respected. It means that the country has a mature grid with electricity production data for each source.

6.1.1.1 Determination of $\boldsymbol{EF_{OM}}$

$$\boldsymbol{EF_{OM}} = \lambda * EF_{non-fossil} + (1 - \lambda) * EF_{fossil}$$

Where:

- $EF_{non-fossil}$ and EF_{fossil} are respectively the emission factor of the non-fossil energies (renewable and nuclear) and the fossil energies
- λ is calculated thanks to the share of LCMR in the national grid.

LCMR: Low-cost/must-run resources: they are defined as power plants with low marginal generation costs or dispatched independently of the daily or seasonal load of the grid).

$$\text{Share of LCMR} = \frac{\sum Volume_{non-fossil}}{\sum Volume}$$

SHARE OF LCMR		λ
Min	Max	
0.00%	50.00%	0
50.00%	54.54%	0.05
54.54%	59.20%	0.1
59.20%	63.60%	0.15
63.60%	67.76%	0.2
67.76%	71.66%	0.25
71.66%	75.32%	0.3
75.32%	78.72%	0.35
78.72%	81.86%	0.4
81.86%	84.76%	0.45
84.76%	87.41%	0.5

SHARE OF LCMR		λ
Min	Max	
87.41%	89.80%	0.55
89.80%	91.94%	0.6
91.94%	93.83%	0.65
93.83%	95.47%	0.7
95.47%	96.85%	0.75
96.85%	97.98%	0.8
97.98%	98.87%	0.85
98.87%	99.50%	0.9
99.50%	99.87%	0.95
99.87%	100.00%	1

TABLE 1: DETERMINATION OF λ

6.1.1.2 Average grid emission factor

Even if the Simple Adjusted Operating Margin factor is mainly used in the tool, when all the data are not available, or if the energy market is not ruled by the merit order mechanism, the Operating Margin cannot be used.

As no other methods are practicable, the average grid methodology has to be used. Therefore, the average grid emission factor (EF_{Ave}) of the country is used, it is in other word the emission factor of the electricity mix of a country.

$$EF_{Ave} = \frac{\sum_{tech=1}^{n} EF_{tech} * Production_{tech}}{Production_{total}}$$

This method is the most standard, but it provides only a rough approximation of marginal displaced emissions. It is recognized by the ADEME (French ecological transition agency).

6.2 Project CO_2 emissions

The project CO_2 emissions depends on the technology of the powerplant.

$$E_{project} = EF_{Project} * P_{50}$$

Where $EF_{Project}$ is the Emission factor of the energy used (solar, wind...).

Where P_{50} is the produced energy of the plant of the 1st year (considering the availability of the plant).

Thanks to a tool develop by the Centre of Expertise of Voltalia, a more precise emission factor of the power plant can be calculated thanks to the total carbon footprint of the power plant.

The emissions of the project are precise, they consider **the entire life cycle** of the power plant. The lifetime of the project will be **30years**.

$$Carbon\ footprint = EF_{Project} * (P_{50} * 30 * \text{factor})$$

Where the factor is the rate of decline in plant output over the 30 years. It depends on the technology used and materials.

6.3 Avoided CO_2 emissions

Finally, the CO_2 emissions of the project has just to be retrieve from the reference situation.

$$Avoided\ emissions = E_{ref\_sit} - E_{project}$$

Be careful: the avoided emissions calculated are for the first year of production of the powerplant. Indeed, the emission factor of the reference situation is not fixed and evolve each year, Furthermore, the produced electricity of the plant is the one for the first year of use, the production capacity of a power plant decreases over the years.

6.4 Carbon payback time

The 'Carbon payback' is a term referring to the length of time it takes for the negative environmental impact from the construction of a power plant to be offset by the positive environmental impact of generating clean energy.

$$Payback\ time = \frac{\text{Carbon footprint}}{E_{ref\_sit}}$$

Where **Carbon footprint** is the total CO_2 emissions of the power plant through its entire life cycle (construction, use, end of life).

Note: If the total Carbon Footprint of the project is not known, an estimation is required.

Be careful: here it is also supposed that the merit order does not change during the 30 years.

7 SOURCES OF DATABASE

Data are updated annually at the beginning of the year.

7.1 Volumes of energy

For all countries: IEA website https://www.iea.org/countries (Energy supply graphs with the indicator Electricity generation by source).

For some countries, where more recent data is required, we use data from the national electricity transmission networks. (France: RTE, Brazil: EPE, French Guiana: EDF)

7.2 Emission factors

7.2.1 Fossil energies

Voltalia use the IEA emission factors 2023 database: https://www.iea.org/data-and-statistics/data-product/emissions-factors-2023

7.2.2 Non-fossil energies

International: Median emission factors (tCO_2/MWh): https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_full.pdf Annex III, Table A.III.2

WIND	SOLAR	HYDRO	NUCLEAR	GEOTHERMAL
0.011	0.048	0.024	0.012	0.038

TABLE 1: INTERNATIONAL MEDIAN FACTOR EMISSION FOR NON-FOSSIL ENERGIES

Table A.III.2 | Emissions of selected electricity supply technologies (gCO_2eq/kWh)[i]

Options	Direct emissions	Infrastructure & supply chain emissions	Biogenic CO_2 emissions and albedo effect	Methane emissions	Lifecycle emissions (incl. albedo effect)
	Min/Median/Max	Typical values			Min/Median/Max
Currently Commercially Available Technologies					
Coal—PC	670/760/870	*9.6*	*0*	*47*	**740/820/910**
Gas—Combined Cycle	350/370/490	*1.6*	*0*	*91*	**410/490/650**
Biomass—cofiring	n.a.[ii]	–	–	–	**620/740/890**[iii]
Biomass—dedicated	n.a.[ii]	*210*	*27*	*0*	**130/230/420**[iv]
Geothermal	0	*45*	*0*	*0*	**6.0/38/79**
Hydropower	0	*19*	*0*	*88*	**1.0/24/2200**
Nuclear	0	*18*	*0*	*0*	**3.7/12/110**
Concentrated Solar Power	0	*29*	*0*	*0*	**8.8/27/63**
Solar PV—rooftop	0	*42*	*0*	*0*	**26/41/60**
Solar PV—utility	0	*66*	*0*	*0*	**18/48/180**
Wind onshore	0	*15*	*0*	*0*	**7.0/11/56**
Wind offshore	0	*17*	*0*	*0*	**8.0/12/35**
Pre-commercial Technologies					
CCS—Coal—Oxyfuel	14/76/110	*17*	*0*	*67*	**100/160/200**
CCS—Coal—PC	95/120/140	*28*	*0*	*68*	**190/220/250**
CCS—Coal—IGCC	100/120/150	*9.9*	*0*	*62*	**170/200/230**
CCS—Gas—Combined Cycle	30/57/98	*8.9*	*0*	*110*	**94/170/340**
Ocean	0	*17*	*0*	*0*	**5.6/17/28**

IMAGE 3: TABLE A.III.2 OF WORKING GROUP III CONTRIBUTION TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

France: Emission factors (tCO_2/MWh): https://www.bilans-ges.ademe.fr/fr/basecarbone/donnees-consulter/choix-categorie/categorie/69

WIND	SOLAR (SOLAR PANELS FROM CHINA)	HYDRO	NUCLEAR	GEOTHERMAL
0.0141	0.0439	0.006	0.006	0.045

TABLE 2: EMISSIONS FACTOR OF NON-FOSSIL ENERGY

8 QUESTIONS & ANSWERS

8.1 Why do we prefer the merit order methodology (rather than the average grid emissions)?

This method is a good representation of the reality of the local electricity market.

Indeed, it reflects the optimal functioning of the market and therefore accurately identifies the source of electricity production that the new power plant will replace.

It gives the carbon content of one kWh of electricity displaced by the construction of the new powerplant.

8.2 Is this method used because it gives better results in decarbonized countries like France?

No. This method reflects the true mechanics of the electricity market.

In France it does give better results than the average grid method. This is because gas powerplants are the marginal powerplants in France (the last called).

8.3 What guarantees do we have about the reliability of your calculation methodology and the figures you give us?

Voltalia's methodology and tool were reviewed and certified by an external company, ekodev.

The **Reference situation emissions** are calculated thanks to the use of the **Simple Adjusted Operating Margin factor**, calculated after a methodology described in the UNFCCC's Clean Development Mechanism (CDM).

Under the Clean Development Mechanism, emission-reduction projects in developing countries can earn certified emission reduction credits. UNFCCC stands for United Nations Framework Convention on Climate Change. The Convention has near universal membership (197 Parties) and is the parent treaty of the 2015 Paris Agreement.

All of our data are from official sources: Assessment Report of the (IPCC) Intergovernmental Panel on Climate Change, ADEME (Environmental and Energy Management Agency, International Energy Agency. All international recognized.

8.4 What is the difference between avoided and reduced emissions? Can I subtract avoided emissions from my carbon assessment?

An organization's 'avoided emissions' refers to the emissions reductions achieved by its activities, products and/or services, where **these reductions occur outside the organization's scope of activity**.

Voltalia's avoided emissions consist of the production of a low-carbon service: the production of renewable electricity.

Avoided emissions and reduced emissions are different concepts, as they do not apply to the same perimeter. Consequently, we cannot subtract avoided emissions from the carbon footprint.

For more information, please refer to **Erreur ! Source du renvoi introuvable.**.

8.5 How long does it take to compensate the carbon footprint of my powerplant?

Thanks to this methodology, we can calculate the payback time of carbon debt, which is modelled as the number of years it takes to reach parity between the cumulated additional emissions from the construction of the power plant and avoided emissions from renewable energies production.

Here we consider that a plant is good for climate when the carbon payback is greater than 0 years and lower than 30 years (lifetime of a power plant). Thus, the more the payback time is close to 0 years the better it is for the climate.

8.6 What are your sources for emission factors?

Voltalia uses the IEA emission factors database, it contains all emission factors for fossil energies.

For non-fossil energies:

- For all countries except for France, data are from the Table A.III.2 of Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).
- For France, data are from the ADEME database.

Please refer to the Sources of database chapter for more information.

8.7 Is the Operating Margin method reliable?

The tool 07 (which explain the Operating Margin method) is referenced in an approved methodology by the UNFCCC's Clean Development Mechanism methodologies.

Over the past 17 years, the Clean Development Mechanism (CDM) has seen peaks and valleys: from the years when it was widely used as one of the chief tools to fight climate change to the recent situation of reduced demand for its Certified Emission Reductions (CERs). The CDM's strong methodologies and verification processes mean investors can trust that one CER represents a true ton of reduced or avoided emissions, creating a reliable, tradeable commodity.

Furthermore, the Clean Development Mechanism (CDM), established under the Kyoto Protocol, is the primary international offset program in existence today, and while not perfect, it has helped to establish a global market for greenhouse gas (GHG) emission reductions.

UNFCCC: United Nations Framework Convention on Climate Change

8.8 What is the Merit Order? Does it apply all the time and everywhere?

The logic of "merit order" consists in calling on the various electricity production units, as and when they are needed, according to their increasing marginal costs (renewable energies, then nuclear, and finally fossil energies).

The merit order mechanism cannot be applied all the time: sometimes it is difficult to have all the data required and some countries electricity markets are not ruled by the merit order.

For example, in Germany few years ago, the Energiewende was driving growth in renewable electricity production, in line with the rise in electricity consumption and the decline in nuclear energy. The simple adjusted OM method would therefore have produced a false result where renewable plants replace coal and gas, while they actually replace nuclear plants. (AG Energiebilanzen 2016)

8.9 Why should companies communicate about Avoided Emissions?

Avoided emissions are one facet of the of the company's climate change strategy. From when a company discloses the avoided emissions of some of its solutions, it is appropriate that it includes the presentation of its climate strategy.

Following the Paris Agreement signed in 2015 many initiatives have been developed to encourage companies to communicate on their consideration of climate change and its integration into their business business model. This encourages companies to establish a corporate strategy that is consistent with the objective of containing global warming below 2°C. Companies are therefore increasingly required to show how they are reducing their own emissions and those of their partners, but also to develop new products and services that are compatible with a decarbonization trajectory for economies. Avoided emissions can be used to integrate this dimension into business strategies.

But, be careful, an organization can calculate its avoided emissions only if it produces/offers low-carbon solutions/services that allow their users to reduce their own impact compared to existing solutions.

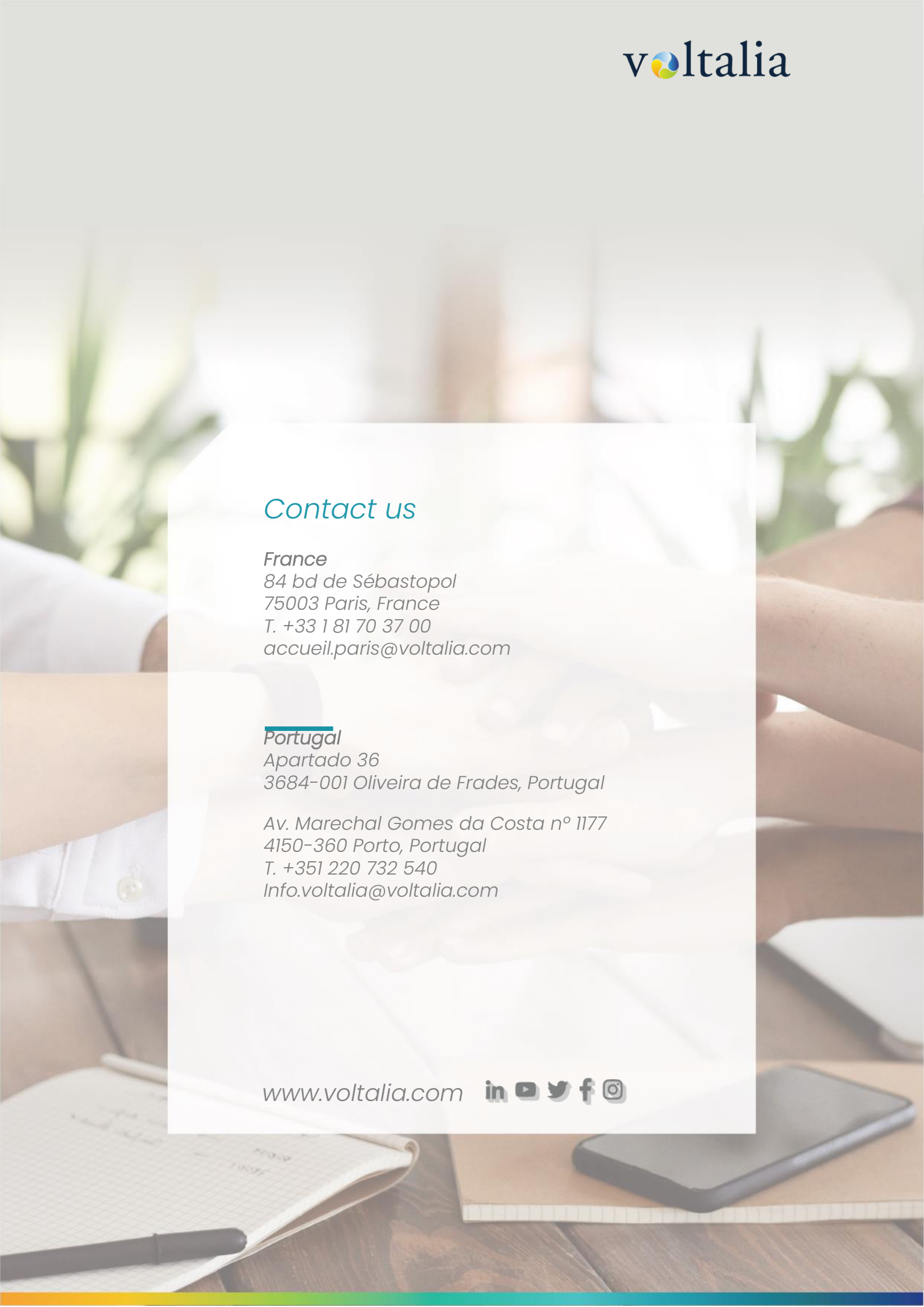
8.10 How can companies communicate about Avoided Emissions?

As a producer of low-carbon services, Voltalia can calculate its avoided emissions and can communicate about it. while making a clear distinction between avoided emissions, reduction of emissions and carbon assessment.

Clients who buy electricity, can communicate as they reduced their own emissions as they use renewable energies instead of fossil energies.

9 SOURCES

- UNFCCC's Clean Development Mechanism (CDM): The Tool 07 to calculate the emission factor for an electricity system: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v7.0.pdf
- Merit Order mechanism:
    - https://www.ifri.org/sites/default/files/atoms/files/percebois_transformation_defis_2019.pdf
    - https://www.wattvalue.fr/prix-electricite-merit-order/
    - https://www.connaissancedesenergies.org/electricite-qu-est-ce-que-la-logique-de-merit-order-120215
- Energy mix definition: https://www.planete-energies.com/en/medias/close/what-energy-mix
- Avoided emissions: https://librairie.ademe.fr/cadic/406/fiche-technique-emissions-evitees-2020-02.pdf?modal=false/
- https://unfccc.int/sites/default/files/resource/UNFCCC_CDM_report_2018.pdf CDM reliable methodologies.



Contact us

France
84 bd de Sébastopol
75003 Paris, France
T. +33 1 81 70 37 00
accueil.paris@voltalia.com

Portugal
Apartado 36
3684-001 Oliveira de Frades, Portugal

Av. Marechal Gomes da Costa nº 1177
4150-360 Porto, Portugal
T. +351 220 732 540
Info.voltalia@voltalia.com

www.voltalia.com