GLOBAL BIODIVERSITY SCORE

ENERGY BIODIVERSITY FOOTPRINT

Sectoral appendix

June 2022

Version 1 – DRAFT

CDC BIODIVERSITÉ | Caisse des Dépôts GROUPE

Table of contents

A. PURPOSE OF THE DOCUMENT

The current **sectoral appendix** supports the **Energy benchmark factsheet** and provides additional content that could not be included in the factsheet due to space constraints. Such additional content relates to the perimeter of the factsheet, more detailed results and charts and specific methodology and references.

In addition to the sectoral appendix, this factsheet is supplemented by two documents, common to all the factsheets:

- A **general appendix**, which provides methodological elements to understand how the sectoral benchmark factsheets are built and how computations and charts are obtained. It includes all the methodology and references which are common to all the factsheets, as well as guidance on how to read and use the factsheets.

- A **reading guide**, which explains the structure of the factsheets. It provides the main contents, definitions and necessary elements to know how to read the factsheets for readers with limited knowledge about the Global Biodiversity Score.

Figure 1 below encapsulates the four benchmark documents available for each sector.

Figure 1: The four benchmark documents.

B. WHAT DOES THE SECTOR INCLUDE?

1. Scope of the factsheet in terms of impact calculation

In terms of **impact calculation**, the factsheet covers the energy sector consisting of one EXIOBASE industry group: **"Electricity, gas, steam and air conditioning supply"**. This group is divided in 16 industries, listed here with their code:

- i40.11.a. Production of electricity by coal
- i40.11.b. Production of electricity by gas
- i40.11.c. Production of electricity by nuclear
- i40.11.d. Production of electricity by hydro
- i40.11.e. Production of electricity by wind
- i40.11.f. Production of electricity by petroleum and other oil derivatives
- i40.11.g. Production of electricity by biomass and waste
- i40.11.h. Production of electricity by solar photovoltaic
- i40.11.i. Production of electricity by solar thermal
- i40.11.j. Production of electricity by tide, wave, ocean
- i40.11.k. Production of electricity by Geothermal
- i40.11.l. Production of electricity nec (not elsewhere classified)
- i40.12. Transmission of electricity
- i40.13. Distribution and trade of electricity
- i40.2. Manufacture of gas; distribution of gaseous fuels through mains
- i40.3. Steam and hot water supply

Most of the results in the factsheet are expressed per kEUR of turnover. When the results are detailed per industry, they can be expressed in MSA.m²/kEUR **of the entire industry group (**the weight of each industry in the industry group is then determined using their turnover), or in MSA.m²/kEUR **of the industry considered**. **It will always be clarified in the legend**.

Table 1 shows the repartition of the turnovers of the industries included in this factsheet.

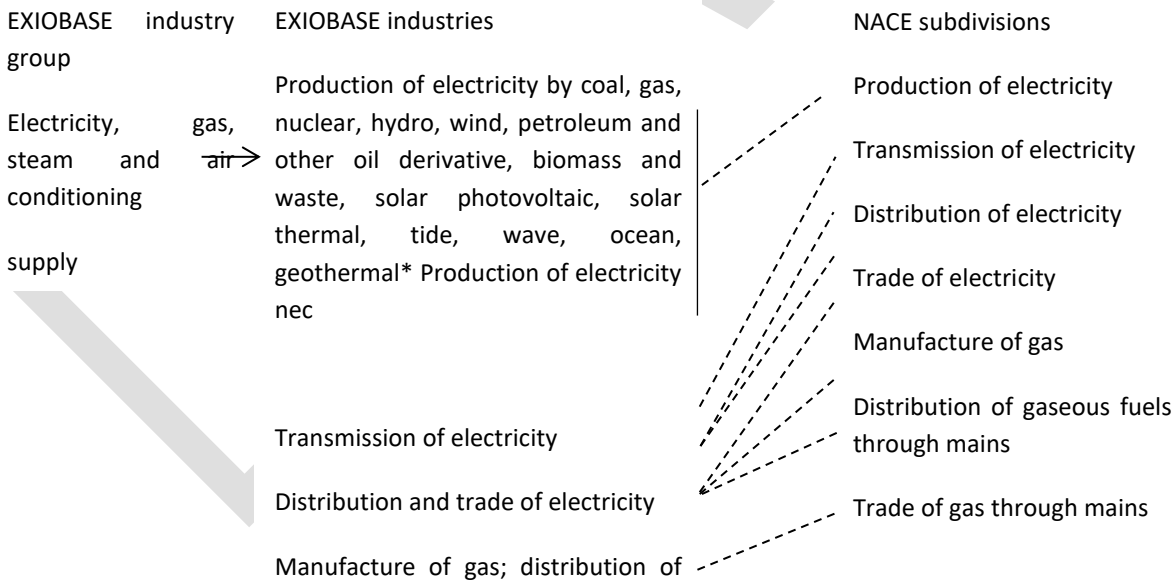
Table 1: Global turnover (based on 2011 data) of the EXIOBASE industries included in the Energy benchmark factsheet

EXIOBASE industry	**Turnover (mEUR)**	**Share of the EXIOBASE industry group**
Distribution and trade of electricity	724 591	26 %
Production of electricity by coal	566 780	21 %
Manufacture of gas; distribution of gaseous fuels through mains	398 312	15 %
Production of electricity by gas	321 879	12 %
Transmission of electricity	203 985	7.4 %
Production of electricity by hydro	182 045	6.6 %
Production of electricity by nuclear	169 140	6.2 %
Production of electricity by petroleum and other oil derivatives	85 602	3.1 %
Steam and hot water supply	44 511	1.6 %

EXIOBASE industry	Turnover (mEUR)	Share of the EXIOBASE industry group
Production of electricity by biomass and waste	20 250	0.74 %
Production of electricity by wind	15 115	0.55 %
Production of electricity nec	8 486	0.31%
Production of electricity by Geothermal	3 909	0.14%
Production of electricity by solar photovoltaic	1 140	0.04 %
Production of electricity by tide, wave, ocean	122	0.0044 %
Production of electricity by solar thermal	33	0.0012 %
Total	**2 745 900**	**100%**

In the NACE rev 2 classification, this EXIOBASE industry group corresponds to section D division 35: "Electricity, gas, steam and air conditioning supply" (see part 3 Section D of NACE rev 2)

Figure 2 below shows the correspondence between EXIOBASE and NACE rev 2:



* 10 industries of the EXIOBASE industry group are gathered in this category (industries i40.11.a to i40.11.k)

Figure 2: Correspondence between EXIOBASE and NACE rev 2 for the Energy benchmark factsheet

The perimeter of this Energy benchmark factsheet is limited to electricity, steam, heat and cold production. The extraction of raw materials such as coal, petroleum, or natural gas do not belong to the Scope 1 of this factsheet and are instead attributed to NACE's section B "Mining and quarrying" and belongs to Scope 1 of the benchmark factsheet "Raw materials extraction". The impacts of the extraction are however considered in the Upstream Scope 3 of this factsheet. In the same way, the cultivation of biomass constitutes the Scope 1 of the benchmark factsheet "Agriculture and agrifood" and is here considered in the Upstream Scope 3 impacts.

Similarly, the NACE subdivision "Manufacture of gas" does not include the extraction of natural gas, but includes:

- The production of gas for the purpose of gas supply by carbonation of coal, from by-products of agriculture or from waste.
- The manufacture of gaseous fuels with a specified calorific value, by purification, blending and other processes from gases of various types including natural gas.

Conversely, it is important to note that while the extraction of natural gas is not included in the Scope 1 of this factsheet, the distribution, supply, and trade of natural gas are included (see NACE divisions below).

Regarding oil, only the production of electricity by petroleum and other oil derivatives are included in the EXIOBASE industries considered here. As mentioned before, the extraction of crude petroleum is within the Scope 1 of the "Raw materials extraction" factsheet and is here included in the Upstream Scope 3. Considering consumption, currently about 56% of global oil demand comes from various forms of transportation (OPEC 2020) and therefore most of the impacts resulting from the combustion of petroleum are included in the Scope 1 of the "Transport" benchmark factsheet. The second sector in oil demand is petrochemicals and its oil consumption is therefore included in the Scope 1 of the "Chemical" benchmark factsheet. In the end, electricity generation only represents about 5 to 10% of the global oil demand.

Another activity is not included in this benchmark factsheet: long-distance transportation of gases by pipelines. Long distance transportation of gases by pipelines is included in the EXIOBASE industry "Transport via pipelines" and will be tackled in the "Transport" benchmark factsheet.

Figure 3 below describes more concretely the perimeter of the Energy factsheet, what are the main resources used by the sector, and in which Scopes the impacts related to those resources are classified. Note that the Downstream Scope 3 is presented on this figure but not yet evaluated by the GBS.

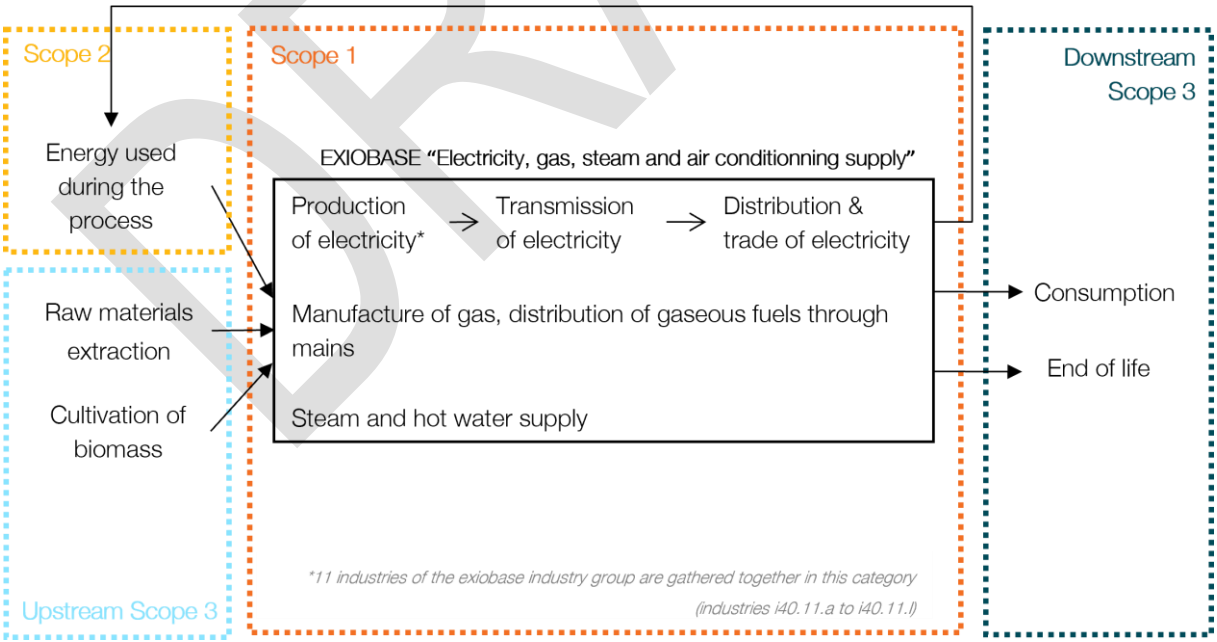


Figure 3: Perimeter of the Energy benchmark factsheet and associated Scopes

A detailed description of section D of NACE rev 2 listing its divisions and sub-divisions extracted from (EUROSTAT 2008) is presented below.

2. Scope of the factsheet in terms of dependencies

To understand the **dependencies** of the energy sector expressed in score by ENCORE, a correspondence of the sectors of EXIOBASE and ENCORE is necessary. The energy sector corresponds in ENCORE to the sectors "Utilities" with all its subsections (“Electric utilities”, “Gas Utilities”, “Independent Power Producers & energy traders”, “Renewable electricity” and “Water utilities”) and "Materials" with the subsection “Industrial gases”. Figure 4 below shows the correspondence between EXIOBASE and ENCORE.

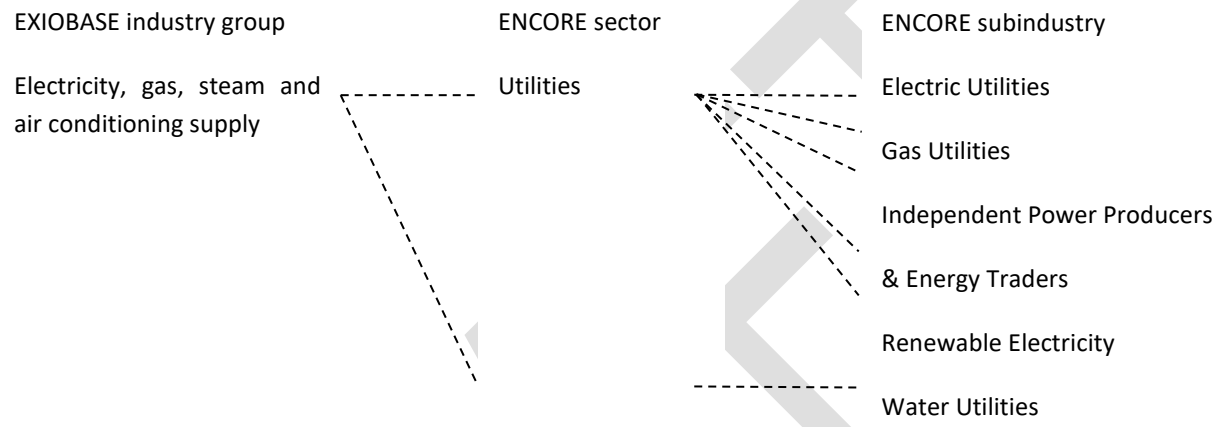


Figure 4: Correspondence between EXIOBASE and ENCORE for the Energy benchmark factsheet

3. Section D of NACE rev 2 (EUROSTAT 2008)

Section D – Electricity, gas, steam and air conditioning supply (NACE rev2)

This section includes the activity of providing electric power, natural gas, steam, hot water and the like through a permanent infrastructure (network) of lines, mains and pipes. The dimension of the network is not decisive; also included are the distribution of electricity, gas, steam, hot water and the like in industrial parks or residential buildings.

This section therefore includes the operation of electric and gas utilities, which generate, control and distribute electric power or gas.

Also included is the provision of steam and air-conditioning supply.

This section excludes the operation of water and sewerage utilities, see 36, 37. This section also excludes the (typically long-distance) transport of gas through pipelines.

Electricity, gas, steam and air conditioning supply **(35)**

- Electric power generation, transmission and distribution **(35.1)**

This group includes the generation of bulk electric power, transmission from generating facilities to distribution centres and distribution to end users.

- Production of electricity **(35.11)**

This class includes:

- operation of generation facilities that produce electric energy; including thermal, nuclear, hydroelectric, gas turbine, diesel and renewable

This class excludes:

- production of electricity through incineration of waste, see 38.21

- Transmission of electricity **(35.12)**

This class includes:

- operation of transmission systems that convey the electricity from the generation facility to the distribution system

- Distribution of electricity **(35.13)**

This class includes:

- operation of distribution systems (i.e., consisting of lines, poles, meters, and wiring) that convey electric power received from the generation facility or the transmission system to the final consumer

- Trade of electricity **(35.14)**

This class includes:

- sale of electricity to the user
- activities of electric power brokers or agents that arrange the sale of electricity via power distribution systems operated by others
- operation of electricity and transmission capacity exchanges for electric power

➢

- Manufacture of gas; distribution of gaseous fuels through mains **(35.2)**

This group includes the manufacture of gas and the distribution of natural or synthetic gas to the consumer through a system of mains. Gas marketers or brokers, which arrange the sale of natural gas over distribution systems operated by others, are included.

The separate operation of gas pipelines, typically done over long distances, connecting producers with distributors of gas, or between urban centres, is excluded from this group and classified with other pipeline transport activities.

- Manufacture of gas **(35.21)**

This class includes:

- production of gas for the purpose of gas supply by carbonation of coal, from by-products of agriculture or from waste
- manufacture of gaseous fuels with a specified calorific value, by purification, blending and other processes from gases of various types including natural gas

This class excludes:

- production of crude natural gas, see 06.20
- operation of coke ovens, see 19.10
- manufacture of refined petroleum products, see 19.20
- manufacture of industrial gases, see 20.11

- Distribution of gaseous fuels through mains **(35.22)**

This class includes:

- distribution and supply of gaseous fuels of all kinds through a system of mains

This class excludes:

- (long-distance) transportation of gases by pipelines, see 49.50

- Trade of gas through mains **(35.23)**

This class includes:

- sale of gas to the user through mains
- activities of gas brokers or agents that arrange the sale of gas over gas distribution systems operated by others
- commodity and transport capacity exchanges for gaseous fuels

This class excludes:

- wholesale of gaseous fuels, see 46.71
- retail sale of bottled gas, see 47.78
- direct selling of fuel, see 47.99

- Steam and air conditioning supply **(35.3)**
  - Steam and air conditioning supply **(35.30)**

This class includes:

- production, collection and distribution of steam and hot water for heating, power and other purposes
- production and distribution of cooled air
- production and distribution of chilled water for cooling purposes
- production of ice, for food and non-food (e.g. cooling) purposes

C. ADDITIONNAL RESULTS

1. Additional results on the sector's impacts

The following calculations presented in the tables were performed using GBS version 1.4.0 by Julie Bonnet in April 2022. In this version of the GBS, several impact factors are not yet included, thus underestimating some impacts:

The EXIOBASE Land use inventory data related to the production in TJ of energy are not connected to the Electricity ServiceTool[1] of the GBS, because of their low level of precision[2]. This creates an underestimation of the Scope 1 Land use (LU) impacts of the production of electricity. A focus is presented in this technical annex (part 5) to calculate these missing impacts. There are however already some Land use impacts related to the production or consumption of commodities in Scope 1 of the industries assessed (related to activities beyond their main activity, overall these are not significant).

The impacts due to the pressure "Hydrological disturbance due to direct water use" (HD_{water}) are underestimated. Indeed, the EXIOBASE inventory data regarding water consumption and withdrawal in m^3 are not used in the GBS 1.4.0[3]. For example, the impacts of the cooling water required for power plants is not taken into account by the GBS for the moment. There are however some HD_{water} impacts related to the production or consumption of commodities (as for Land use, this is related to other activities in Scope 1 and not significant). A focus is presented in this technical annex (part 9) to calculate these missing impacts.

The impacts related to uranium mining are not yet considered, thus underestimating the Upstream impacts of the EXIOBASE industry "Production of electricity by nuclear".

The absolute impact of the energy sector is presented in Table 2 below.

Table 2: Global biodiversity impact of the energy sector

Accounting category	Realms	Scope 1 impact in MSA.km²	Vertically integrated impact in MSA.km²
Dynamic	Aquatic	520	880
	Terrestrial	52 000	69 000
Static	Aquatic	360	41 000
	Terrestrial	6 600	550 000

•

[1] The Electricity ServiceTool of the GBS consists of impact factors in MSA.km²/TJ. The land use impacts are extracted from literature or from life cycle analysis (LCA) databases.
[2] This is not specific to electricity: the Land use inventory data from EXIOBASE are never used in the GBS for the same reason.
[3] Similarly, this is not specific to electricity, water use data from EXIOBASE are never used in the GBS for the same reason.

Table 3 below displays the Scope 1 biodiversity impact figures of the Energy sector, and Table 4 displays the Vertically Integrated figures (sum on Scope 1, Scope 2 and Upstream Scope 3). Results are expressed in MSA.m² per kEUR of turnover of the EXIOBASE industry group and in MSAppb per bEUR and the aggregated score is presented in MSAppb per bEUR (See the general technical appendix for methodology).*

Table 3: Scope 1 impact intensities for the Energy benchmark, computation with GBS 1.4.0 in April 2022, by Julie Bonnet

Accounting category	Realm	Footprint in MSA.m²/kEUR	Footprint in MSAppb/bEUR	Footprint in MSAppb/bEUR	Aggregated score in MSAppb*/bEUR
Dynamic	Aquatic	0.19	19	160	160
	Terrestrial	19	150		
Static	Aquatic	0.13	12	30	
	Terrestrial	2.4	18		

Table 4: Vertically integrated impact intensities for the Energy benchmark computation with GBS 1.4.0 in April 2022, by Julie Bonnet

Accounting category	Realm	Footprint in MSA.m²/kEUR	Footprint in MSAppb/bEUR	Footprint in MSAppb/bEUR	Aggregated score in MSAppb*/bEUR
Dynamic	Aquatic	0.32	31	220	280
	Terrestrial	25	190		
Static	Aquatic	15	1400	3000	
	Terrestrial	200	1500		

The aquatic dynamic results are included here to compute the results in MSAppb/bEUR and the aggregated score in MSAppb*/bEUR but are less reliable. These aquatic dynamic results were not included in the factsheet, hence the slight difference in the numbers.

The following figures display the vertically integrated results per Scope, EXIOBASE industry, pressure, or commodity that **are not shown in the factsheet.** The aquatic dynamic results are not presented here.

Breakdown by Scope

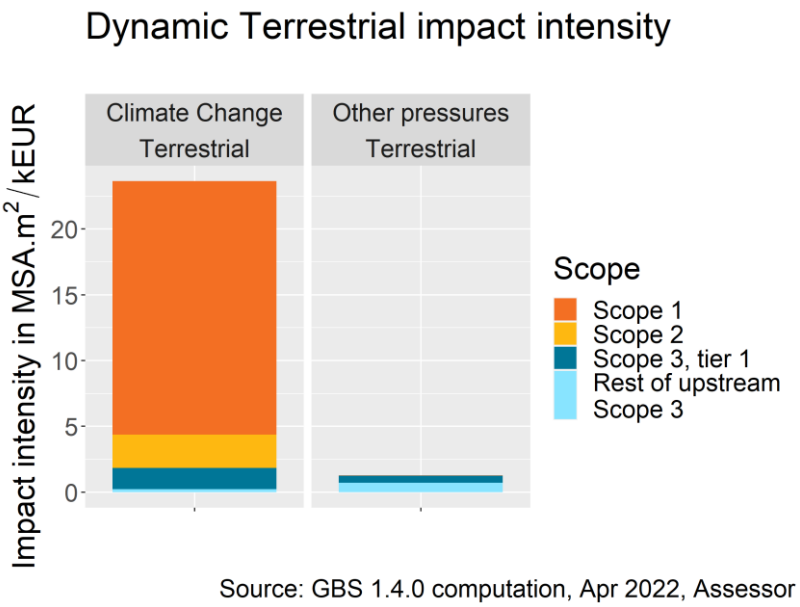


Figure 5: Breakdown by Scope, Terrestrial dynamic, Vertically integrated

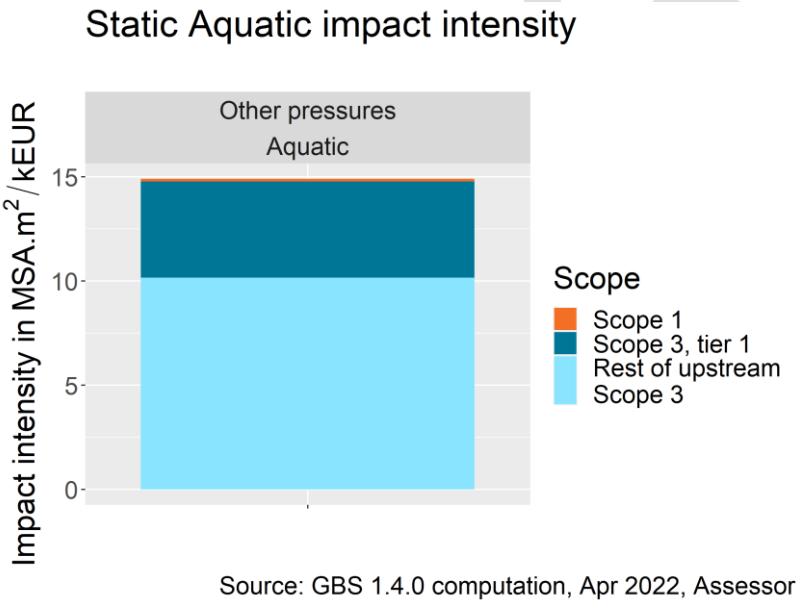


Figure 6: Breakdown by Scope, Aquatic static, Vertically integrated

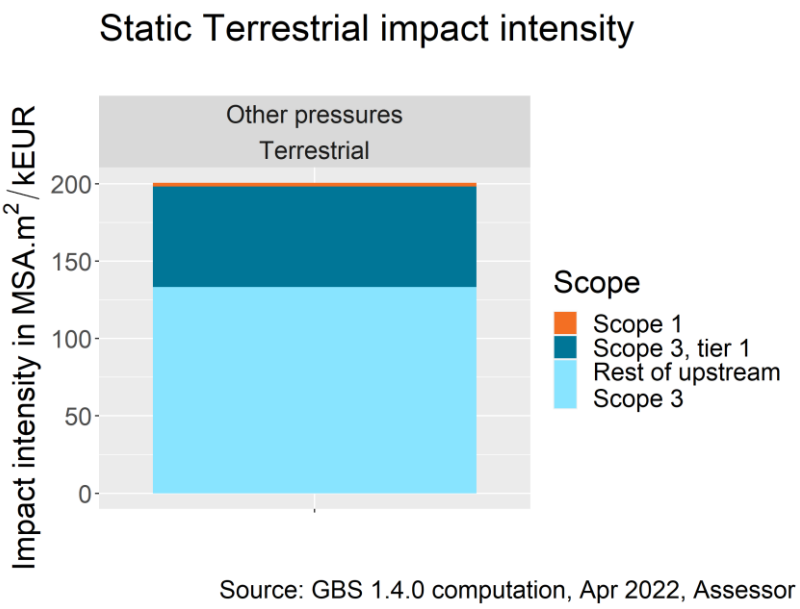


Figure 7: Breakdown by Scope, Terrestrial static, Vertically integrated

Breakdown by EXIOBASE industry and Scope

In Figure 8 Figure 9 and Figure 10 the impact intensity is presented in MSA.m²**/kEUR of the industry considered (and not of the industry group)**.

The impacts of the EXIOBASE industries "Production of electricity by tide, wave ocean" and "Production of electricity by solar thermals" are not presented here because of their lack of reliability and abnormal results.

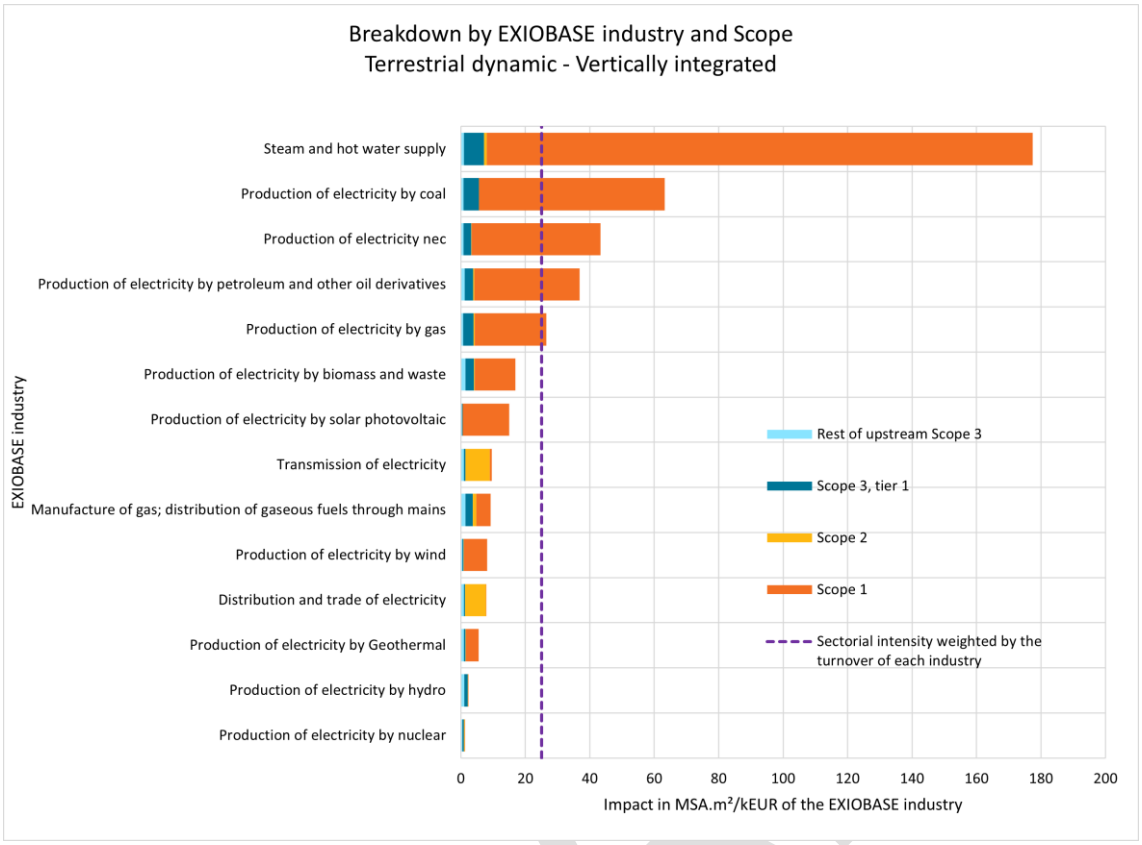


Figure 8: Breakdown by EXIOBASE industry and Scope, Terrestrial dynamic, Vertically integrated, results by kEUR of each industry

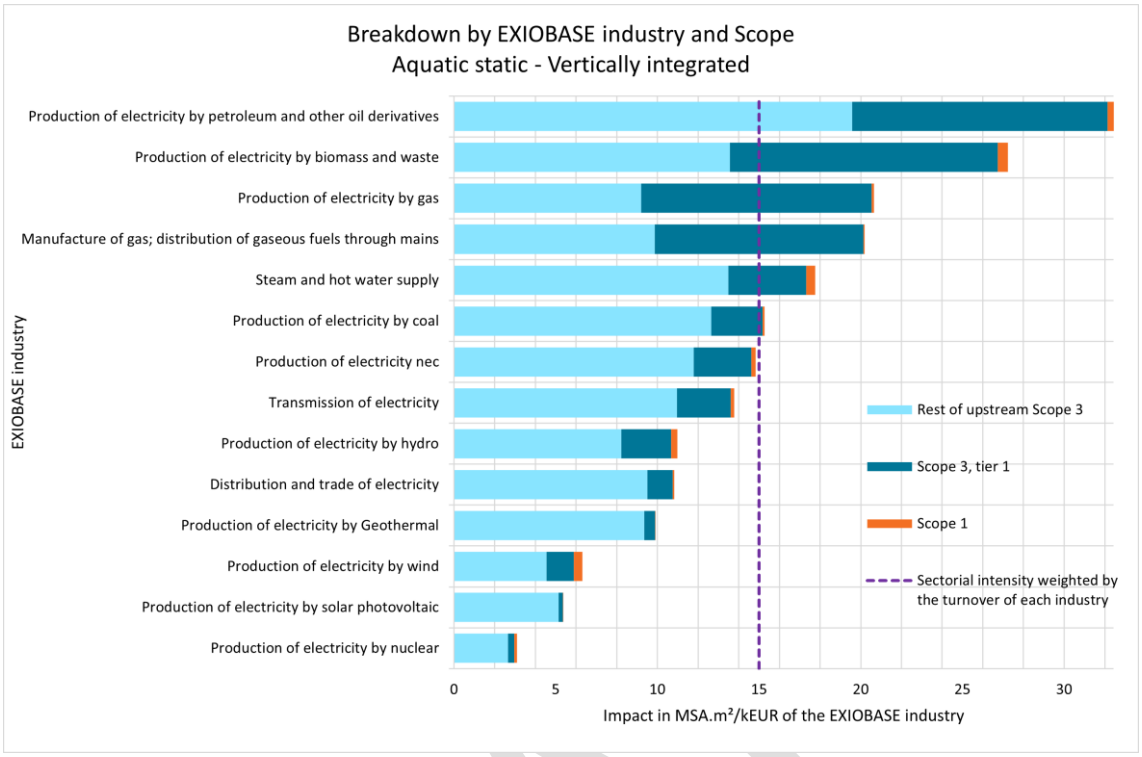


Figure 9: Breakdown by EXIOBASE industry and Scope, Aquatic static, Vertically integrated, results by kEUR of each industry

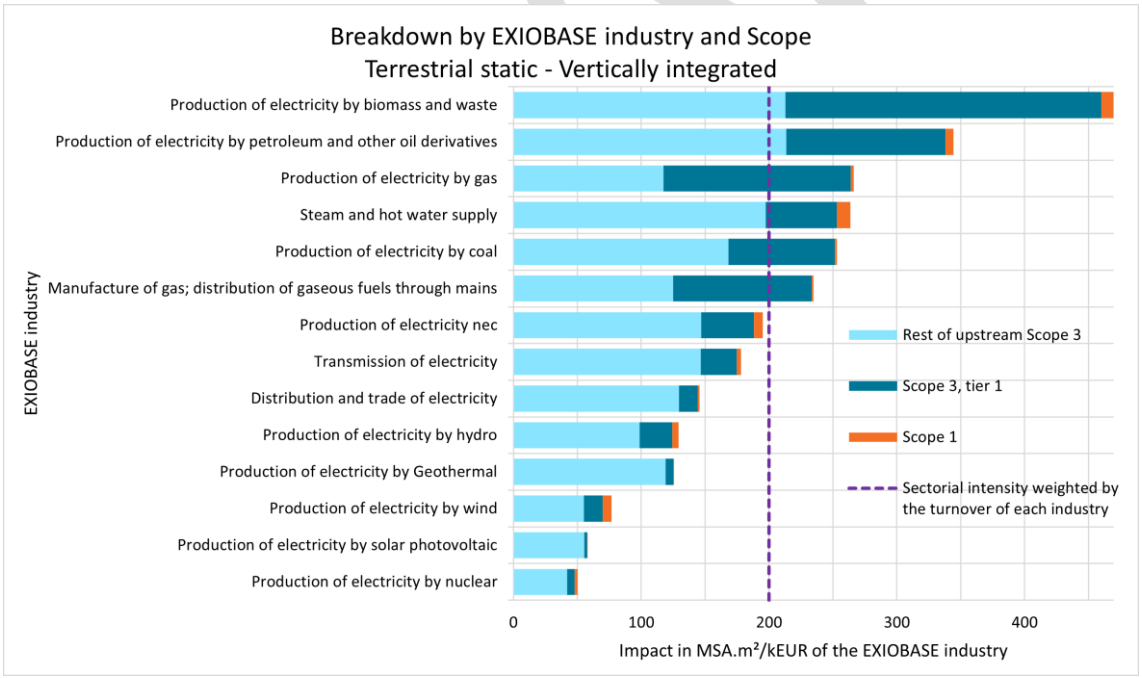
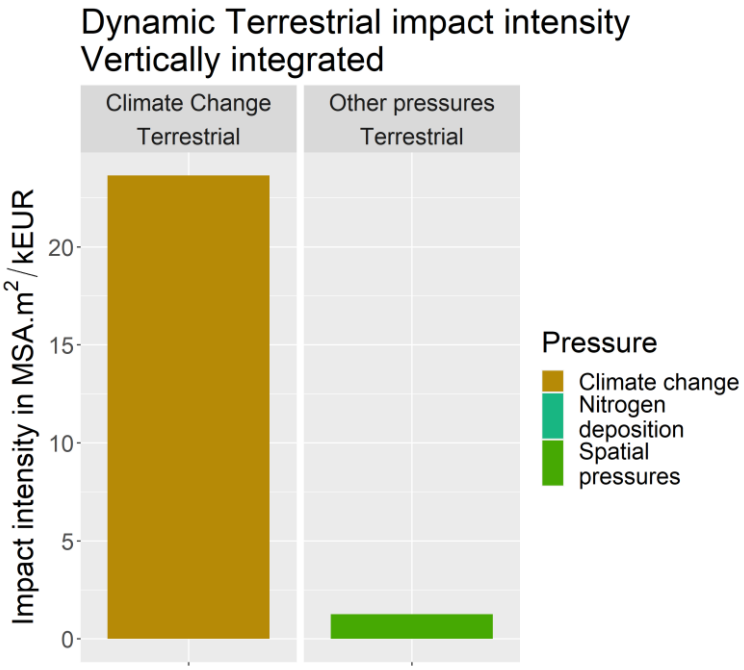


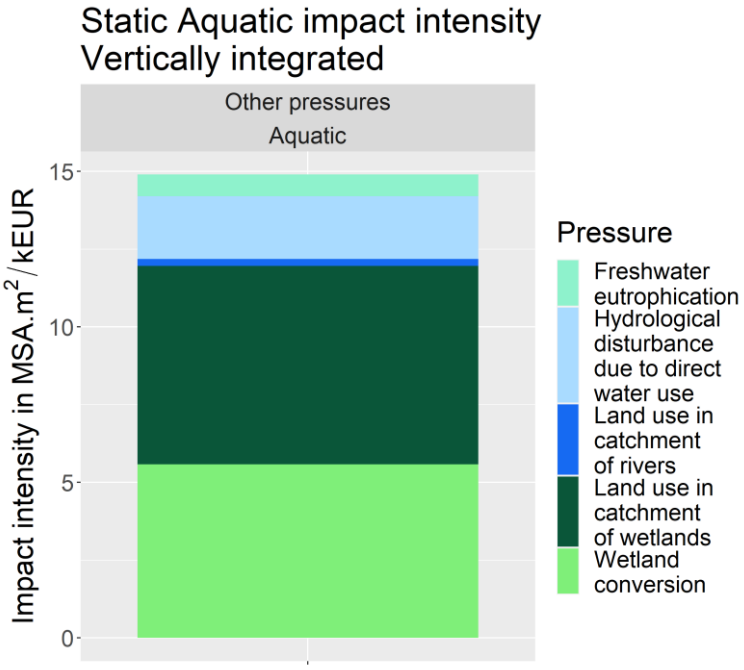
Figure 10: Breakdown by EXIOBASE industry and Scope, Terrestrial static, Vertically integrated, results by kEUR of each industry

Breakdown by pressure



Source: GBS 1.4.0 computation, Apr 2022,

Figure 11: Breakdown by pressure, Terrestrial dynamic, Vertically integrated



Source: GBS 1.4.0 computation, Apr 2022,

Figure 12: Breakdown by pressure, Aquatic static, Vertically integrated

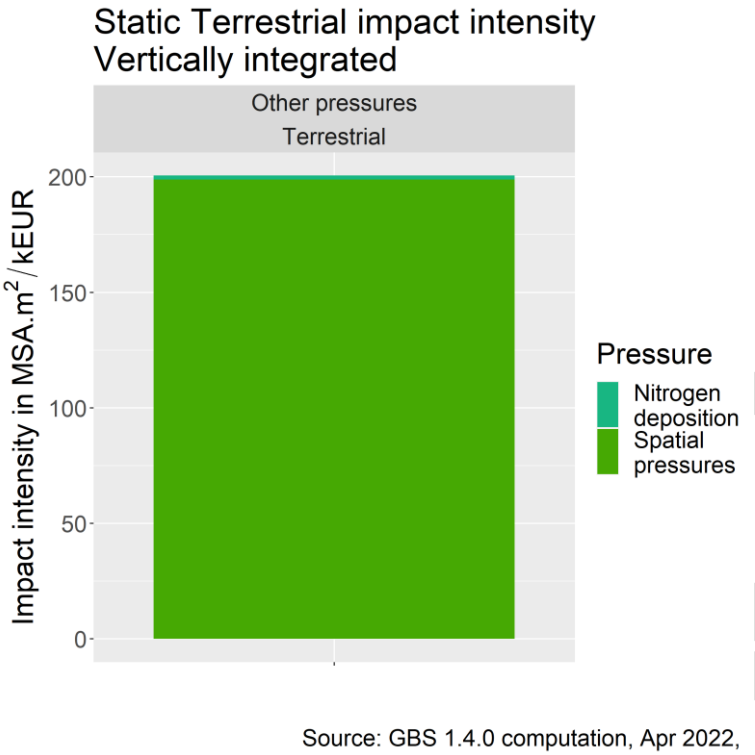


Figure 13: Breakdown by pressure, Terrestrial static, Vertically integrated

Breakdown by commodity

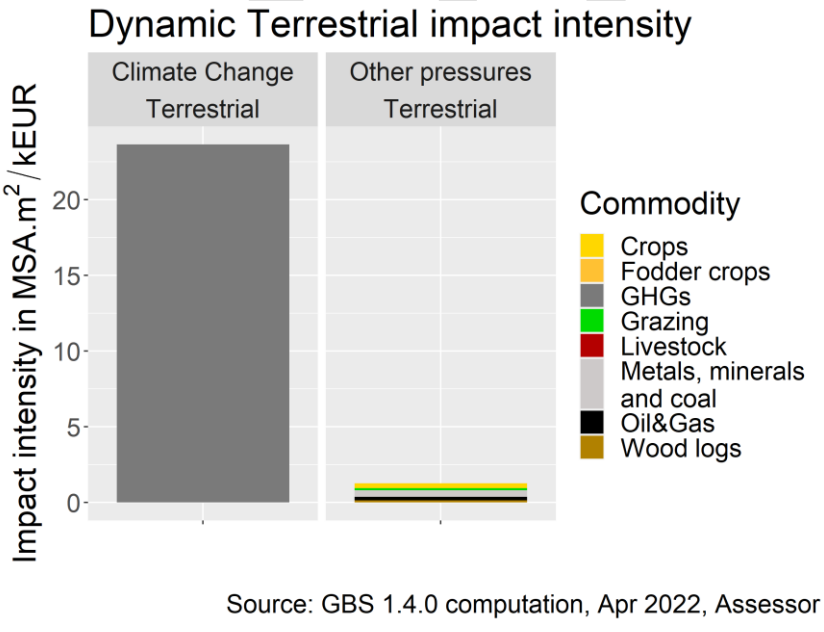


Figure 14: Breakdown by commodity, Terrestrial dynamic, Vertically integrated

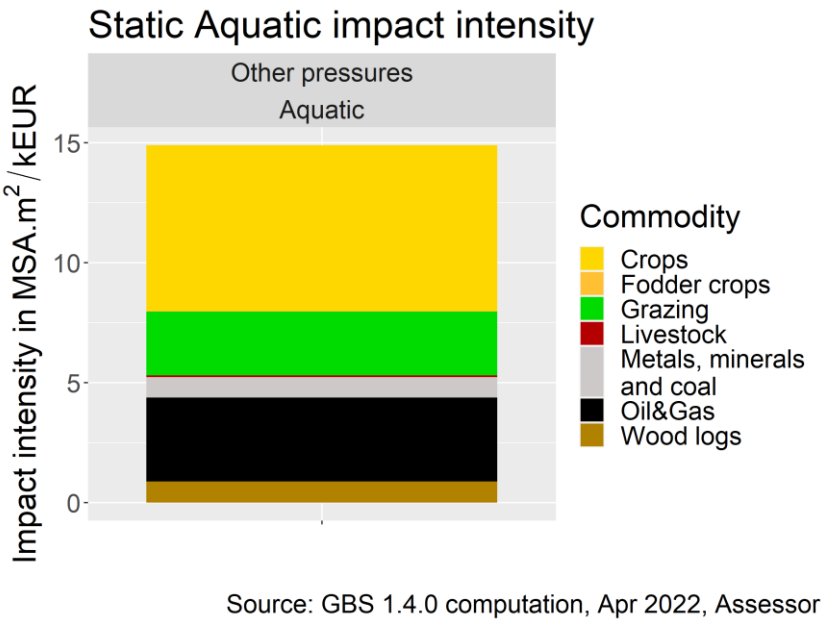


Figure 15: Breakdown by commodity, Aquatic static, Vertically integrated

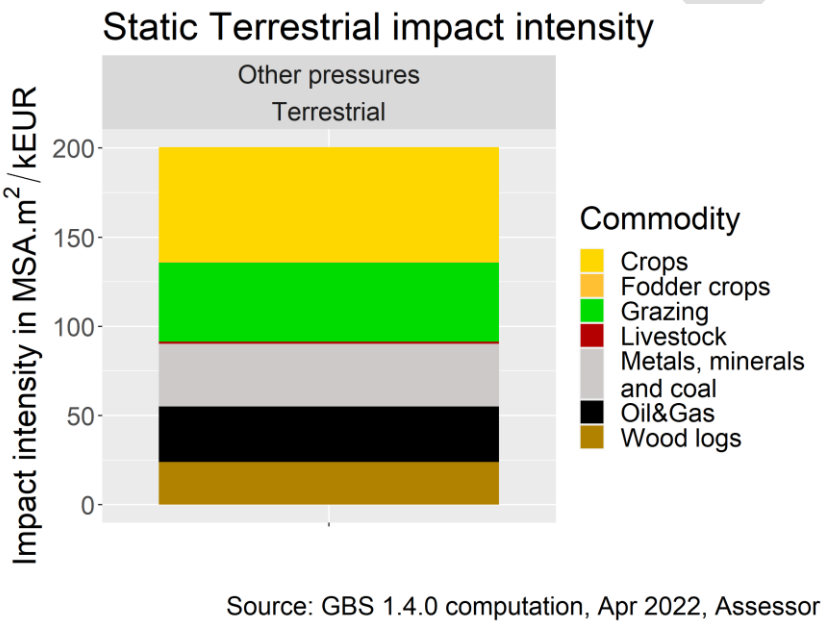


Figure 16: Breakdown by commodity, Terrestrial static, Vertically integrated

2. Additional results on the sector's dependencies

In this part are presented additional results on the sector's dependencies, including a breakdown by EXIOBASE industries. A methodological explanation is available in the general technical appendix. A translation table was created to link the EXIOBASE and ENCORE databases. For example, the EXIOBASE industry "Manufacture of gas, distribution of gaseous fuels through mains" includes the following ENCORE production processes:

- Catalytic cracking, fractional distillation and crystallization
- Cryogenic air separation
- Gas adsorption
- Membrane technology
- Natural gas combustion
- Recovery and separation of carbon dioxide
- Gas distribution
- Gas retail

Figure 17 below presents the Scope 1 dependencies of the Energy sector, with a breakdown by EXIOBASE industry. A majority of the industries are highly dependent on the ecosystem service "Surface water", which is provided through freshwater resources from collected precipitation and water flow from natural sources. The other important Scope 1 dependencies of the sector are "Flood and storm protection", which is provided by the sheltering, buffering and attenuating effects of natural and planted vegetation, and "Mass stabilization and erosion control" which is delivered through vegetation cover protected and stabilizing terrestrial, coastal and marine ecosystems, coastal wetlands and dunes. Vegetation on slopes also prevents avalanches and landslides, and mangroves, sea grass and macroalgae provide erosion protection of coasts and sediments.

The industries with the highest overall dependency scores are "Steam and hot water supply" and "Production of electricity by tide, wave and ocean", meaning they depend on more ecosystem services, or with a higher dependency score.

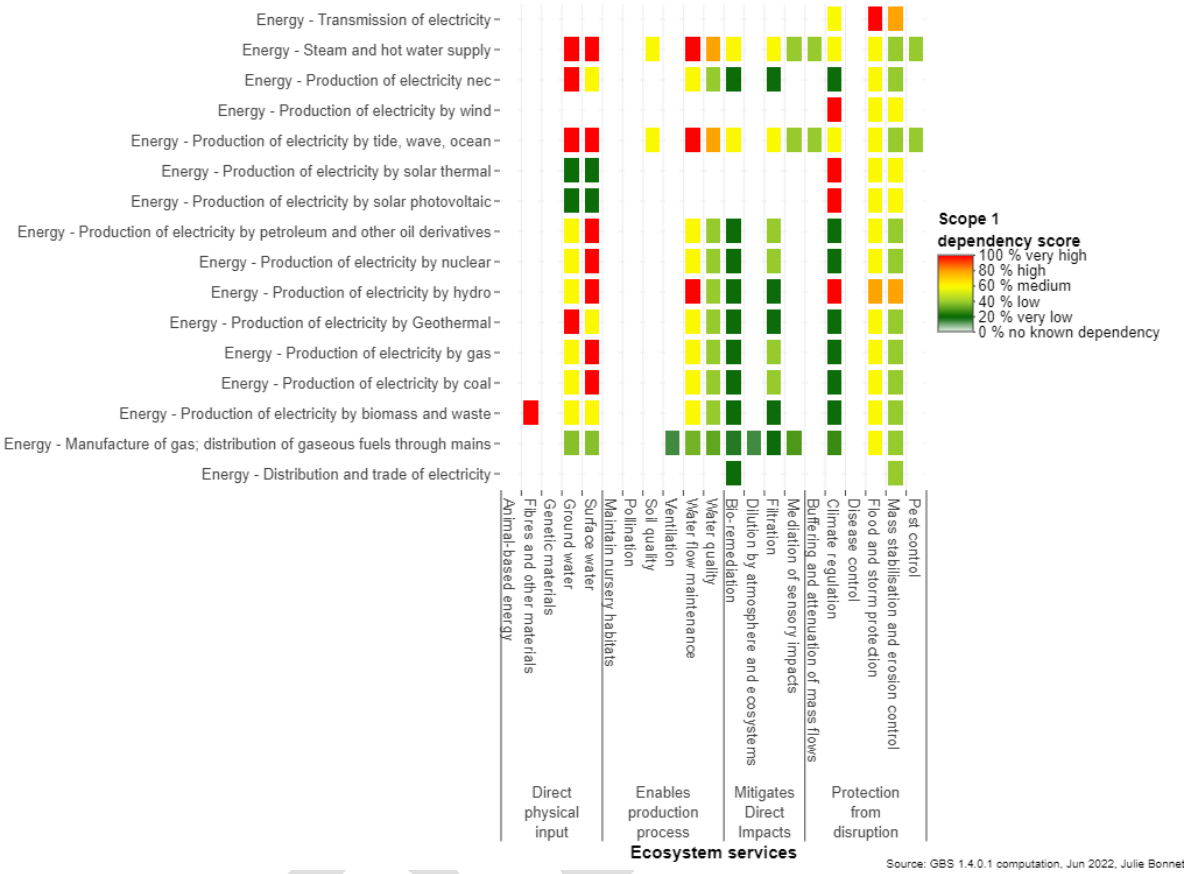


Figure 17: Dependency heatmaps for Scope 1 dependencies, based on ENCORE data

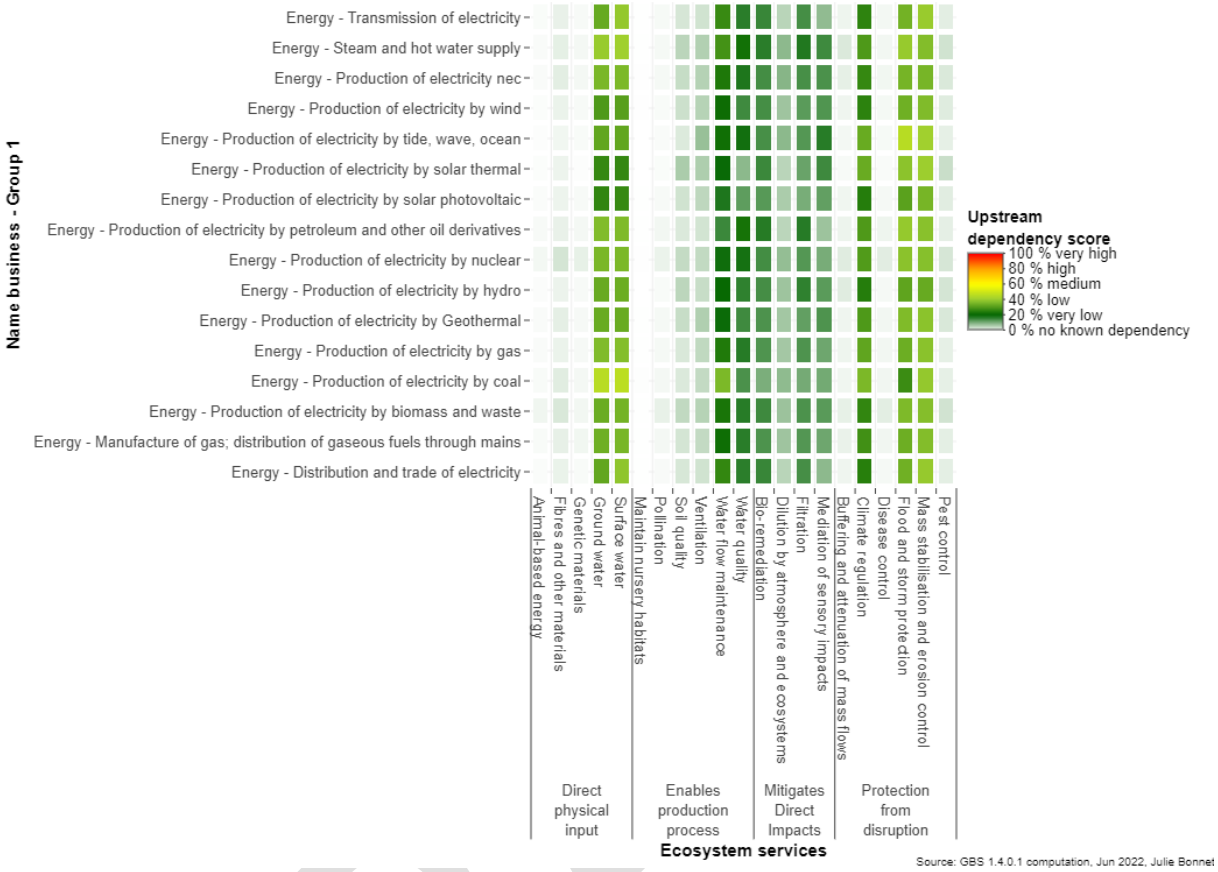


Figure 18: Dependency heatmaps for upstream dependencies, based on ENCORE data

Figure 19: Dependency heatmaps for vertically integrated dependencies, based on ENCORE data

3. Terrestrial static Climate Change calculation

Climate Change static impacts are not currently assessed by the GBS because historical emissions are needed to compute them. The methodology to estimate the terrestrial static impacts related to the Climate change pressure is available in the benchmark general appendix.

For the energy sector, the calculation to obtain the Climate change static impact is the following:

$$Climate\ change\ static_{2022} = 49 * Climate\ change\ dynamic_{2022}$$

The results are presented in Table 5.

Table 5: Terrestrial static Climate change impact of the benchmark Energy factsheet, Scope 1 and vertically integrated

	Climate Change terrestrial dynamic impact	Climate Change terrestrial static impact	Terrestrial static impact linked to other pressures
Scope 1 (in MSA.m²/kEUR)	19	930	2.4
Vertically integrated (in MSA.m²/kEUR)	24	1200	200

The Vertically integrated static impact associated with the pressure Climate Change is 6 times more important than the impact of other terrestrial pressures. Cumulated past GHG emissions by the energy utility sector have indeed been significant.

This static Climate Change impact is also highly significant when considering the Scope 1: it is 400 times higher than the impact of all other pressures combined. This can be explained as GHG emissions occur mostly within the Scope 1.

4. Conversion between the turnover (in kEUR) and the electricity production (in kWh)

For the energy sector, it might be more relevant in some cases to present the results in MSA.m²/kWh and not kEUR. To make this possible, a conversion table by EXIOBASE industry was computed using EXIOBASE data: the turnover of the industries considered and their energy production. This allowed to determine the ratio between kEUR and kWh for the industries. The preliminary results are shown in Table 6 below:

Table 6: Conversion table between kWh and kEUR

EXIOBASE industries	Turnover (MEUR)	Energy production (TJ)	Number of kWh in 1 kEUR
Production of electricity by coal	566 780	27 845 957	13 647

EXIOBASE industries	Turnover (MEUR)	Energy production (TJ)	Number of kWh in 1 kEUR
Production of electricity by gas	321 879	12 296 248	10 612
Production of electricity by nuclear	169 140	9 845 513	16 169
Production of electricity by hydro	182 045	12 395 464	18 914
Production of electricity by wind	15 115	1 229 037	22 587
Production of electricity by petroleum and other oil derivatives	85 602	2 819 276	9 149
Production of electricity by biomass and waste	20 250	240 959	3 305
Production of electricity by solar photovoltaic	1 140	116 630	28 425
Production of electricity by solar thermal	33	5 929	50 215
Production of electricity by tide, wave, ocean	122	1 847	4 221
Production of electricity by Geothermal	3 909	241 589	17 166
Production of electricity nec	8 486	2 976	97

The turnovers in this table correspond to the total production per industry from EXIOBASE data. The energy production is extracted from EXIOBASE data "Energy Carrier Supply: Total" for each industry, summed on all the EXIOBASE regions. This allows to consider the supply of energy of the EXIOBASE industries, meaning, for the industries considered here, the amount of electricity produced by the sector (Usubiaga and Acosta-Fernández 2018).

This conversion table will be used in other parts of this technical annex (see sections 5 and 8).

5. Focus on the Land use terrestrial static impact

The goal of this part is to complete the Land use static impacts of the Energy sector. Indeed, as mentioned earlier, the EXIOBASE land use inventory data of the production of electricity are not connected to the GBS, thus underestimating the Scope 1 Land use impacts.

Here, we estimate these Scope 1 impacts using the results of the Global Land Outlook Energy and Land Use 2017 (UNCCD and IRENA 2017), and especially one of its sources, the paper "Land use and electricity generation: A

life-cycle analysis" (Fthenakis and Kim 2009). It should be noted that data were only available for 6 industries, thus leading to non-exhaustive results. Furthermore, the results of this paper were obtained using US data only.

We then complete these results with the results of the Global Land Outlook Energy and Land Use 2017 presented in table 42, and especially one of its sources, the paper "Land use and electricity generation: A life-cycle analysis" (Fthenakis and Kim 2009). This table shows the land use intensity in m²/MWh of different primary energy sources. Note that data include land use from upstream life cycles (e.g., mining).

Table 7: Overview of land use intensity relating to a range of energy systems or electricity generation, extract from the Global Land Outlook - Energy and Land Use

Product	Primary energy source		Land use intensity [m²/MWh]				
			U.S. data[a])	U.S. data[b])	EU data[c])	UNEP[d])	Typical[e])
Electricity	Nuclear		0.1	0.1	1.0		0.1
	Natural gas		1.0	0.3	0.1	0.2	0.2
	Coal	Underground	0.6	0.2	0.2		0.2
		Surface ("open-cast")	8.2	0.2	0.4	15.0	5.0
	Renewables	Wind	1.3	1.0	0.7	0.3	1.0
		Geothermal	5.1		2.5	0.3	2.5
		Hydropower (large dams)	16.9	4.1	3.5	3.3	10
		Solar photovoltaic	15.0	0.3	8.7	13.0	10
		Solar – concentrated solar power	19.3		7.8	14.0	15
		Biomass (from crops)	810	13	450		500

The results presented in the Global Land Outlook are vertically integrated but using the results of the paper from Fthenakis and Kim (Fthenakis and Kim 2009), listed in Table 7 as "U.S. data[b]"), we can distinguish the Scope 1 impacts from the rest of the impacts for all the industries considered in this paper, see Table 9, Table 10 and Table 11.

First, this paper provides two types of land data: land transformation, and land occupation. The two concepts are defined in the article as follows: "*The life cycle assessment (LCA) for a process- and product-level appraisal commonly measures ''life-cycle land use'' via metrics that are parsed into* ***land transformation (unit: m2)****, and land occupation (unit: m2 year). The former indicates the* ***area of land altered from a reference state****, while the latter denotes the area of land occupied and the duration of the occupation. Incorporating static- or dynamic-land quality information into these metrics resolves the impact of the full life cycle from land use."* The land transformation data therefore represents the total area altered, in m², and can be used to calculate a static impact.

In this paper, for conventional fuel cycles (coal, nuclear and natural gas) and biomass, Fthenakis and Kim separate the land transformation of different steps. These steps are different depending on the energy source and can be mapped to different Scopes of our industries. Table 8 below presents the mapping determined for this focus, with justifications. Overall, we consider that Scope 1 Land use impacts correspond to the article's land transformation of the "Power plant" and "Generation" steps, depending on the fuel type. These impacts include land used as an exclusion area or a barrier space. Every other step fall within the Upstream or Downstream Scope 3 impacts.

Table 8: Breakdown of the steps from the Fthenakis and Kim (2009) study by Scope, depending on the industry considered

Scope associated with the step	Industry		
	Coal	Nuclear	Gas
Scope 1	Power plant: Location of the electricity generation, falls into the Scope 1.	Power plant: Location of the electricity generation, falls into the Scope 1.	Generation: Location of the electricity generation, falls into the Scope 1.
Upstream Scope 3	Mining: The raw material extraction industries are located upstream of the electricity generation.	Mining: The raw material extraction industries are located upstream of the electricity generation. Milling, Conversion: These processes are the Scope 1 of the "Processing of nuclear fuel" industry, upstream of the electricity generation. Enrichment: Included in the "Manufacture of other inorganic basic chemicals" industry, and therefore upstream of the electricity generation.	Extraction: The raw material extraction industries are located upstream of the electricity generation. Transmission – pipeline: The transmission via pipelines of natural gas is included in other EXIOBASE industries ("Transport via pipelines"), located upstream of the generation of electricity. Storage - underground: The storage of the gas is mainly not done by electricity generators, but during and in between the other steps (extraction and transport).
Downstream Scope 3		Fuel disposal: The collection and treatment of hazardous wastes are different EXIOBASE industries, downstream of the electricity generation.	

For renewable fuel cycles except biomass (wind, photovoltaic), the land transformation figures are not distinguished between different steps, since there isn't any fuel extraction or transport. The article therefore provides only one figure, corresponding to the land transformation of the power plant. This represents our Scope 1 Land use impacts.

Additionally, in this paper, for each step, Fthenakis and Kim distinguish between what they call "direct impacts" and "indirect impacts" (Fthenakis and Kim 2009). Indirect impacts are defined as "indirect land transformation from the materials and energy requirements for mining and operating the power plant", and therefore fall within the Scope 2 or Upstream Scope 3 perimeters. These indirect land transformations are not calculated for wind

and photovoltaic, as the article considers them small or insignificant compared to the direct usage. Direct impacts, on the other hand, include the land transformed on site for the different steps (mining, transmission, generation...).

Overall, the land transformation figure used from the article to calculate the Scope 1 Land use impacts of the different industries is the direct land transformation, from the electricity generation step (called "Power plant" or "Generation" depending on the fuel type).

The power plants were all associated with an "Urban" land use type, described by GLOBIO as "areas more than 80% built up". Indeed, power plants mostly consist of industrial sites, with generators, powerhouses, switchyards… However, the facilities can also include barrier spaces which are often vegetized, but in the absence of data and literature about the proportion of built-up areas in power plants, this conservative land use type was chosen. This could lead to an overestimation of the impact, especially for power plants with large barrier spaces, such as nuclear power plants.

Below the assumptions used for each method of electricity production, both in terms of land occupation (area without spacing) and Land use type with corresponding remaining biodiversity (MSA), are presented.

Coal

Table 9: Direct land transformation of a coal power plant, extract from Fthenakis and Kim (2009)

Direct land transformation for the power plant operation in the U.S. [7,22,48].

Plant type	Size (MW)	Land cover (acre)	Lifetime (years)	Land transformation (m^2/GWh)	Reference
Eastern U.S.	500	849	30	32.6	[22]
Western U.S.	500	156	30	6.0	[22]
FBD[a]—bituminous	831	246	20	10.8	[22]
FBD[b]—western subbituminous	536	442	20	20.1	[22]
U.S. average[b]	1000	500	30	9.1[c]	[48]
Eastern U.S.	500	na	30	32.4	[7]

[a] Fluidized bed combustion.
[b] Normalized for 1000 MW capacity.
[c] Facilities only, excluding waste storage yard.

A capacity factor of 0.85 was used in the study, meaning that on average over the power plant lifetime, the electricity generated represents 85 % of the theoretical maximum. To calculate the land transformation, the calculations done were therefore the following:

$$Land\ transformation\ (m^2/GWh) = \frac{Land\ cover\ (acre) * 4047}{\frac{Size\ (MW)}{1000} * 365 * 24 * Lifetime * Capacity\ factor}$$

The average land transformation for a coal power plant in the US is 9.1 m²/GWh. The power plant is associated with an urban Land use type by CDC Biodiversité, with a remaining biodiversity of 5 % MSA.

Nuclear

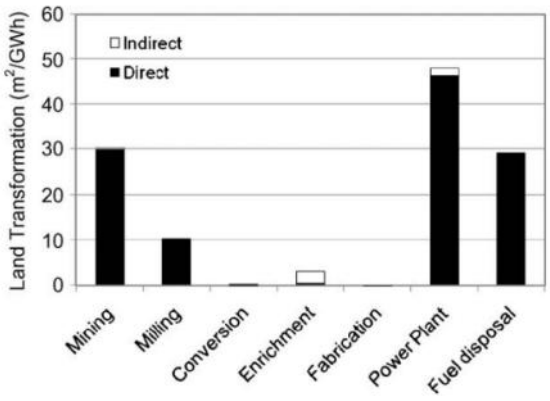


Fig. 1. Land transformation during the nuclear-fuel cycle. Mining method: open pit, 50%; underground, 50%. Enrichment method: centrifuge, 70%; diffusion, 30%. Sources: [6,13,22,23,48].

Figure 20: Land transformation during the nuclear fuel cycle, extract from Fthenakis and Kim (2009)

Using the graph, we estimate the land transformation due to the power plant at 46 m²/GWh. This land transformation is higher than for a coal power plant because it requires an exclusion area and barrier space for safety reasons. The share of such spaces is not detailed in the article, but some sources estimate that the entire area is still artificialized (RTE 2022b). Therefore, the power plant and its barrier space are associated with an urban Land use type by CDC Biodiversité, with a remaining biodiversity of 5 % MSA.

Natural gas

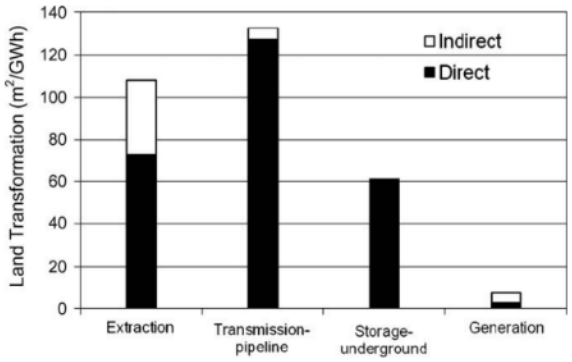


Fig. 2. Land transformation during the natural-gas fuel cycle [6,22,26].

Figure 21: Land transformation during the natural gas fuel cycle, extract from Fthenakis and Kim (2009)

Using the graph, we estimate the land transformation due to the electricity generation at 2.9 m²/GWh. This land use is smaller than for a coal power plant as large structures are not required for fuel storage and emission control equipment. The power plant is associated with an urban Land use type by CDC Biodiversité, with a remaining biodiversity of 5 % MSA.

Wind

Table 10: Direct land transformation of wind farm, extract from Fthenakis and Kim (2009)

Table 6
Direct land transformation of wind farm based on 30-year plant lifetime [5,32,36,53,54,57].

Location	Capacity factor	Area (10^4 m²/MW)	Land transformation (m²/GWh)	Reference
U.S.—case 1	0.26[a]	19[c]	2780	[32]
U.S.—case 2	0.36[b]	19[c]	2040	[32]
U.S., California	0.24	6.5	1030	[5,36,54]
Denmark, Tændpibe	0.2	17	3230	[32,57]
Denmark, Velling Mærsk-Tændpibe	0.2	12	2280	[32,57]
Germany, Fehmarn	0.2	11	2090	[32,53]

[a] Based on a wind speed of class 4, i.e., 5.8 m/s at 10 m.
[b] Based on a wind speed of class 6, i.e., 6.7 m/s at 10 m.
[c] Based on an array of 25 turbines by two rows. Each turbine is separated by 2.5 rotor diameters side-by-side and the rows are positioned 20 rotor diameters apart.

The direct land transformation of a wind farm in this study corresponds to the Scope 1 impact of the industry "Production of electricity by wind" with a value of 2200 m²/GWh (the average direct land transformation for all six windfarms included in the study). This result is based on a capacity factor of 0.24 and a lifetime of 30 years:

$$Land\ transformation\ (m^2/GWh) = \frac{Area\ (10^4\ m^2/MW) * 10^4}{\frac{1}{1000} * 365 * 24 * Lifetime * Capacity\ factor}$$

However, only 1-10% of the wind farm areas are used by wind turbines, the rest being called "spacing" and used for grazing, agriculture and recreation (Fthenakis and Kim 2009), as illustrated in Figure 22. These areas should not be considered in the calculation. The land use of a wind farm excluding this spacing (considered conservatively to represent 90% and not 99% of the surface area) is therefore 220 m²/GWh.

The land use associated with the wind turbines is a "urban" Land use type, with a remaining biodiversity of 5 % MSA, as the area is totally artificialized.

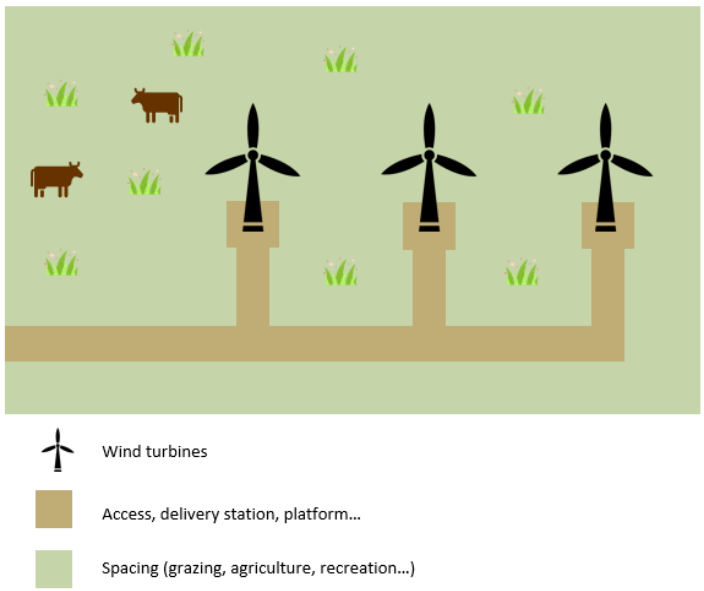


Figure 22: Illustration of a wind farm. Source: CDC Biodiversité, inspired by RTE (RTE 2022b)

Hydropower

The land required for hydropower generation varies depending on the technology: dams require an important area for their water reservoir, whereas run-of-river hydropower plants occupy a much smaller area, as illustrated

in Figure 23. As water reservoir converts terrestrial land use to aquatic land use, it is not evident to take it into account as a terrestrial Land use impact. These conversions are considered in the pressure "Wetland conversion", thus leading to an aquatic impact. For now, no additional Land use impact was added to the GBS results, thus underestimating significantly the impact of hydropower on terrestrial ecosystems.

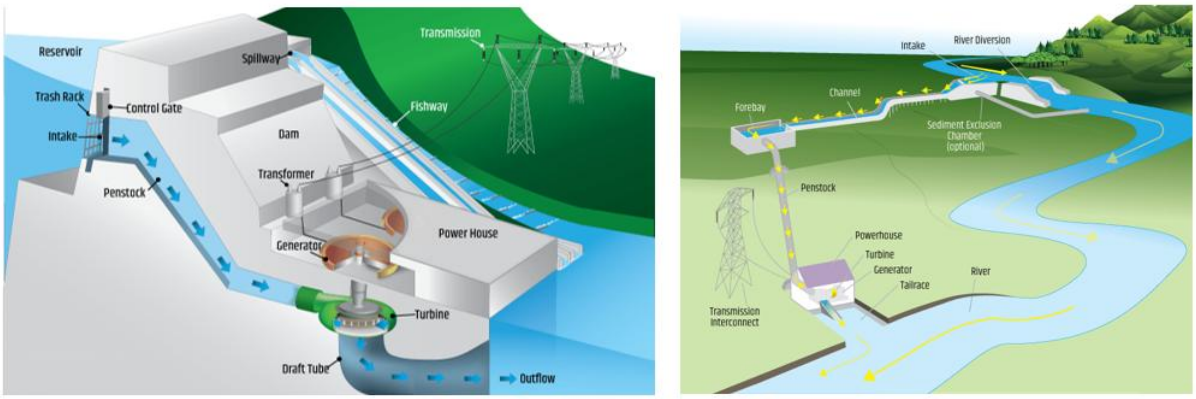


Figure 23: Hydropower infrastructures: dams (on the left) versus run-of-river (on the right), from Energy.gov (Office of Energy Efficiency & Renewable Energy, n.d.)

Solar photovoltaic

Table 11: Direct land transformation of solar electric power plant, extract from Fthenakis and Kim (2009)

Table 5
Direct land transformation of solar electric power plant [28,29,31–33,52].

Type	System efficiency[a] (%)	Packing factor	Insolation (kWh/m²/year)	Plant lifetime (years)	Land transformation (m²/GWh)	Reference
Multi-Si PV[b]—case 1	10.6	2.5	1800	30	438	Section 2.4
Multi-Si PV[b]—case 2	10.6	2.5	2400	30	329	Section 2.4
Multi-Si PV[b]—case 3	10.6	2.5	2400	60	164	Section 2.4
PV with 25° tilt	9.5	2.1	1770	30	402	[52]
PV with 1-axis tracker	9.5	2.8	2050	30	463	[52]
Concentrator PV—case 1	20.2	3.5	2500[c]	30	229	[31]
Concentrator PV—case 2	13.8	5	2200[c]	30	549	[32]
Solar thermal, tower	8.5	5	2700[c]	30	552	[32,33]
Solar thermal, parabolic trough	10.7	3.4	2900[c]	30	366	[32,33]

[a] Module efficiency times performance ratio.
[b] Optimum tilt.
[c] Direct Normal Insolation (DNI) with tracker.

The direct land use of a solar power plant is estimated at 370 m²/GWh (the average of the 7 PV power plants). Between 5,4 % and 9.2 % of this area is artificialized or impermeable (RTE 2022b), including the pillars, roads used for access and generators.

The rest of the area required is separated between:

- The area under the solar panels
- The area between the panels required for access, maintenance, and to avoid shading.

For these usages, the soil is often kept free of vegetation with herbicide or allowed to grow but kept under a few feet tall by frequent mowing (Turney and Fthenakis 2011). The power plant is also often enclosed by a fence. These considerations led to the choice of the "urban" Land use type, with a remaining biodiversity of 5 % MSA.

It should be noted that less impactful solar power plants exist, with the example of agrivoltaic solar plants, with less intensive land uses.

Solar thermal

A shown in Table 11, the direct land use of a solar thermal power plant is estimated at 460 m²/GWh (an average of the two solar thermal power plants available in the table). Solar thermal power plants collect and concentrate sunlight to produce heat and to generate electricity. Solar thermal power plants are mainly composed of *reflectors* (mirrors) that capture and focus sunlight onto a *receiver*. The land use associated with the solar thermal power plants is a "urban" Land use type, with a remaining biodiversity of 5 % MSA, as mirrors cover the majority of the area.

Biomass

In the article, the land used by the power plant is considered insignificant compared to the land used by croplands (which is part of the Upstream Scope 3), and therefore no analysis is conducted on the land use of the power plant. Therefore, we considered that the land use of a biomass powerplant is similar to the land use of a natural gas power plants, and therefore a land use factor of 3.2 m²/GWh was selected, with a remaining biodiversity of 5 % MSA.

Petroleum and other oil derivatives

Petroleum power plants are not covered in the Fthenakis and Kim article. By default, the same parameters than for a gas power plant were considered, with a land use intensity of 3.2 m²/GWh and a remaining biodiversity of 5 % MSA.

Geothermal

Geothermal power plants are not covered in the Fthenakis and Kim article. By default, the same parameters than for a gas power plant were considered, with a land use intensity of 3.2 m²/GWh and a remaining biodiversity of 5 % MSA.

Results

Using the conversion table between kWh and kEUR from part 4, the results of the Fthenakis and Kim (2009) study were converted in m²/kEUR, and then in MSA.m²/kEUR using the assumptions presented earlier. Table 12 below shows the results obtained.

Table 12: Additional Scope 1 Land use impact, calculated from the results of the study Fthenakis and Kim (2009)

EXIOBASE industry	Sectors' name in the Fthenakis and Kim (2009) paper	Scope 1 Land use intensity in m²/MWh	% MSA of the Scope 1 Land use type	Scope 1 Land use intensity in MSA.m²/kEUR
Production of electricity by coal	Coal	0.009	5 %	0.12
Production of electricity by gas	Natural gas	0.004	5 %	0.040
Production of electricity by nuclear	Nuclear	0.045	5 %	0.69
Production of electricity by wind	Wind	0.1	5 %	2.1

EXIOBASE industry	Sectors' name in the Fthenakis and Kim (2009) paper	Scope 1 Land use intensity in m²/MWh	% MSA of the Scope 1 Land use type	Scope 1 Land use intensity in MSA.m²/kEUR
Production of electricity by solar photovoltaic	Solar photovoltaic	0.3	9.6 %	7.7
Production of electricity by solar thermal	Solar thermal	0.4	10 %	18

Figure 24 below shows the total Scope 1 Land use impact, from EXIOBASE and the Fthenakis and Kim (2009) study. The Land use impacts from EXIOBASE are related to the production or consumption of commodities. The Scope 1 Land use impacts are more important for renewable sources (solar, wind, biomass) than for fossil sources (petroleum, gas, coal) and nuclear. The most impactful industries are the production of electricity by solar technologies. This shows the importance of estimating these Scope 1 additional impacts.

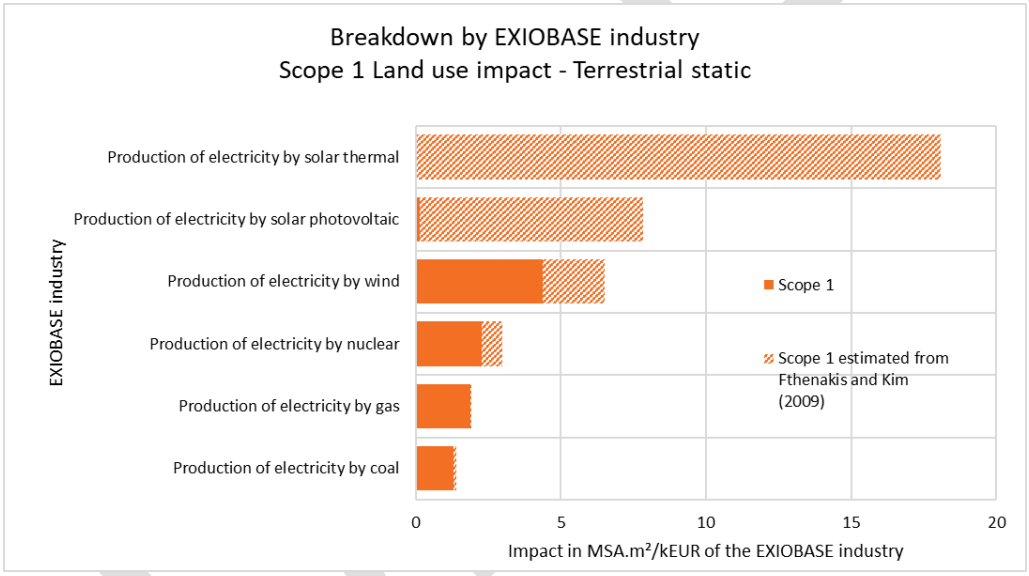


Figure 24: Breakdown by EXIOBASE industry of the terrestrial static Scope 1 Land use impact. The results include the additional Scope 1 calculated from the study Fthenakis and Kim (2009)

However, Figure 25 shows that when the impact of the entire value chain is considered, this additional impact is insignificant and that in terms of land use, the production of electricity by renewable sources with the exception of biomass and by nuclear are still the least impactful industries. Indeed, Figure 25 below presents the Land use impact of the different industries, with the Scope 1 impact calculated from this study added to the GBS results. This additional Scope 1 impact is insignificant for the non-renewable electricity sources when compared to the GBS results. For renewable electricity sources, this Scope 1 impact is visible on the figure but does not change the order between the different industries.

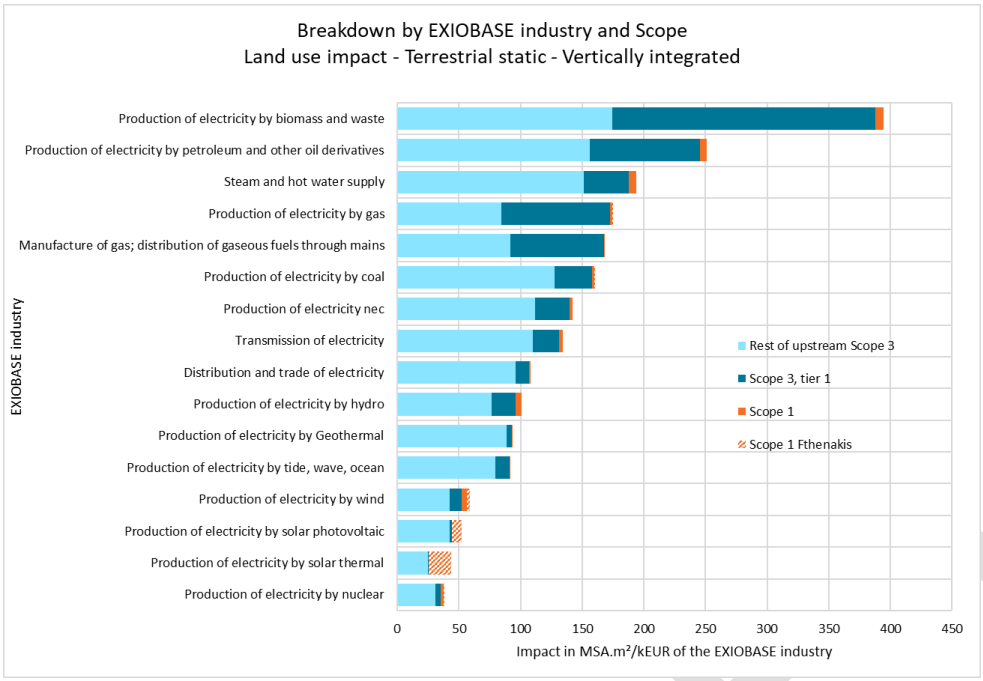


Figure 25: Breakdown by EXIOBASE industry and Scope of the terrestrial static Land use impact, Vertically integrated. The results include the additional Scope 1 calculated from the study Fthenakis and Kim (2009)

The total terrestrial static impact (including the pressures Encroachment, Fragmentation, and Atmospheric Nitrogen Depositions) is presented in Figure 26 below.

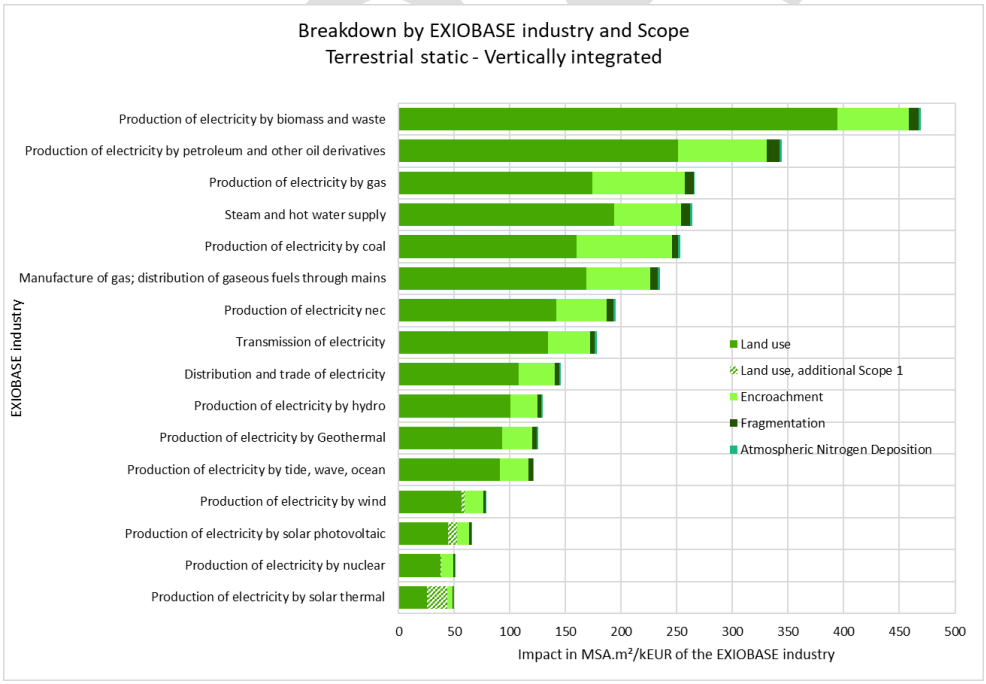


Figure 26: Breakdown by EXIOBASE industry and pressure of the terrestrial static impact, Vertically integrated. The results include the additional Scope 1 impact calculated from the study Fthenakis and Kim (2009)

It should be noted that the results of the Fthenakis and Kim (2009) study are the lowest of all the data included in the Global Land Outlook – Energy and Land Use, thus suggesting an underestimation of the impacts. Furthermore, these results were obtained using only US data. However, these results were the only results available detailed enough to allow a distinction between the Scopes of the impacts.

6. The impact of wind energy on birds and bats populations

Not all impacts can be included in the GBS results, and therefore, a qualitative analysis is necessary on certain subjects (see Environmental Safeguards of the Energy benchmark factsheet). It is the case for the impact of windmills on birds and bats which is not included in the results presented in the factsheet. This part aims to present results from reports and studies on the subject to bring a qualitative perspective on this issue.

Negative effects of windmills include direct impacts in the form of individual fatalities resulting from collisions with turbine blades or towers. The species most at risk are birds (especially small passerine, large soaring birds, migratory species, species with high wing loading and high perching birds) and bats (Bennun et al. 2021 - IUCN). At many wind energy facilities, regular searches are conducted for birds and bats that collided with turbines.

At a population level, migratory bird species may experience significant cumulative mortality as a greater proportion of the population may encounter multiple turbines during their movements. The fatality levels recorded at individual wind farms in the United States are considered unlikely to lead to population-level impacts for passerines or wetland bird species, but potential population-level effects may occur for some diurnal raptors (Bennun et al. 2021 – IUCN). For birds, mean adjusted fatality rates from most studies range from 3 to 6 birds per MW per year for all species combined. Adjusted bat fatality rates tend to be higher and more variable than bird fatality rates, generally ranging from a mean of 4 to 7 bats per MW per year(American Wind Wildlife Institute (AWWI) 2020).

For birds and bats, larger turbine capacity (megawatts) has been found to increase collision rates. However, for the same total energy output, it is preferable to deploy a smaller number of large turbines (with greater energy output per turbine) rather than a bigger number of small turbines (Thaxter et al. 2017).

Various mitigation strategies can be deployed at project levels. The most effective measure is to shut down turbines temporarily when species are at risk. This can include times with peak species activity, or migration seasons. Increasing visibility of rotor blades is another possibility to minimize bird collision, by painting one of the three turbine blades in black to make it easier for birds of pray to detect the blades. To minimize collision with bats, the installation of acoustic deterrent services has shown promise in North America and is now tested worldwide. Finally, projects should not be located close to birds migrating routes (See IUCN report entitled “Mitigating biodiversity impacts associated with solar and wind energy development" for more details, Bennun et al. 2021).

7. Transmission and distribution of electricity – the impact of power lines

Some impacts are not yet considered in the GBS version 1.4.0. This part aims to present a few studies and reports on the Scope 1 impact of power lines on biodiversity to offer a more comprehensive view of the subject. These documents focus primarily on transmission lines.

In the RTE report *Futurs Energétiques 2050* (Energy Pathways 2050), part 12 is dedicated to environmental analysis and includes a section on land use with a focus on transmission lines (RTE 2022b).

In this report, the land uses of power lines are divided in three categories:

- Artificialized areas,
- Impermeable areas,
- Joint-use areas, non-artificialized, where other uses are possible but limited.

For power lines, except the base of each pylon and electric posts which are artificialized, the area under the lines can host other uses. Agricultural spaces and natural spaces are possible under the lines. Other land uses like forests, residential, industrial, and terrestrial might be compatible provided that a distance of security is respected.

The results showed that in France power lines use on average 0.0001 ha/km of artificialized and impermeable areas, and 4.66 ha/km of joint-use areas. In France in 2020 the electricity grid used a total of 342 000 ha, with 4 000 ha artificialized and 200 ha waterproofed.

A second study allows to further characterize the impact of power lines, not only on land use but on biodiversity in general by conducting a systematic review (Biasotto and Kindel 2018). 206 scientific papers were selected, and their results examined.

The authors divided the effect of transmission lines into 10 different abiotic impacts, that can have a positive, negative, neutral, or inconclusive biotic impact. 25 biotic impacts were identified. Abiotic impacts are also divided depending on if they occur during the construction phase or the operation phase.

Figure 27 below is extracted from the study and summarises the impacts documented in the review.

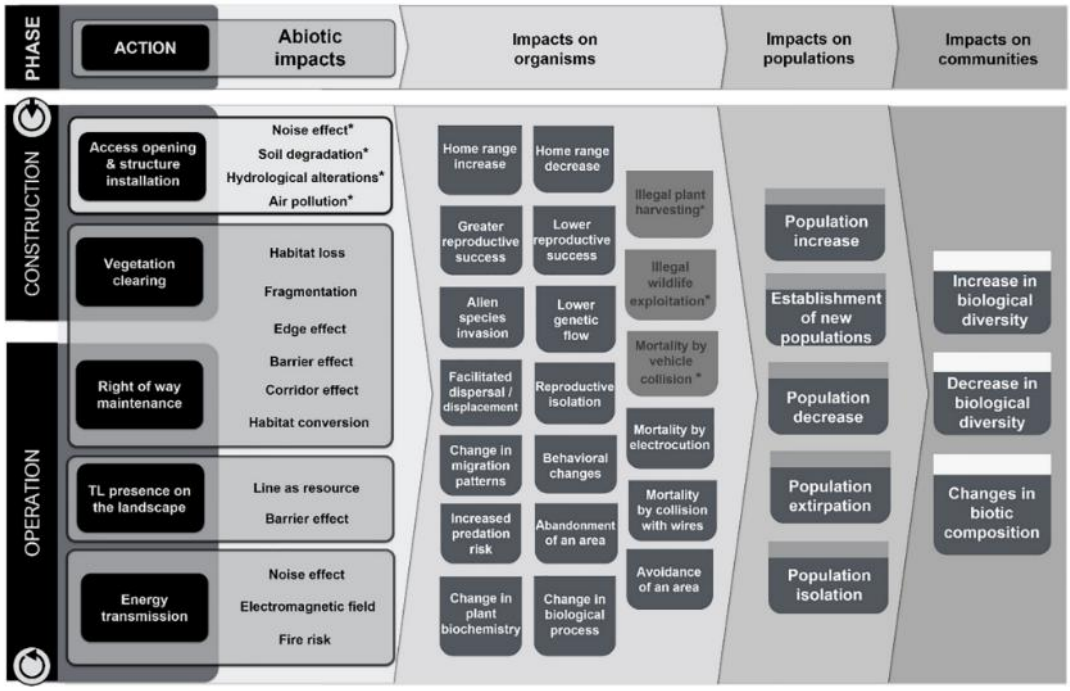


Fig. 3. Framework summarizing abiotic and biotic impacts documented in the systematic review, with their respective phases and main causal actions. Note that "Vegetation clearing" and "Right of way maintenance" are common to both phases and share the same set of abiotic impacts. *Indicates the impacts mentioned only on Environmental Impact Studies.

Figure 27: Abiotic and biotic impacts (Biasotto and Kindel 2018)

According to the study the abiotic impacts most referred to in articles are "barrier effect", "line as a resource" and "habitat conversion", they are described below. There is also a high concentration of studies focusing on birds.

- Barrier effect: Infrastructures can be a physical obstacle for some species, such as birds which are subjects to collisions with the power lines. Some studies showed a change in flight behaviour, with birds avoiding the barrier. Studies also suggest that the right of way (area under the lines) affected the distribution and density of ungulates because of a higher risk of predation, poor foraging conditions and decreased habitat quality.
- Line as a resource: The structures of transmission lines (cable and pylons) can be used are resources for some bird species. The infrastructures are used as perch to seek food, to reproduce or to nest. Several species are positively affected by the transmission lines in terms of home range and population size. However, power lines cause bird electrocutions and collisions which can have an impact on population scales.
- Habitat conversion: The impact associated with habitat conversion can be negative or positive. Indeed, the removal of vegetation is not typically desirable. But for some species like gastropods, habitat clearing can help establish rare species. However, a common result from the creation of these new habitats is the colonization by invasive species of plants.

Some mitigation strategies can be put in place to limit the impacts of power lines. To reduce collision risks, attaching bird flight diverters (like flappers, balls or spirals) to transmission grounding wires to increase their visibility can reduce average collision mortalities by 50% (Bennun et al. 2021).

8. Defining avoided impacts by describing counterfactual scenarios

For a renewable electricity project, avoided impacts *i.e*. the negative impacts prevented compared to a counterfactual scenario can be assessed. However, these impacts should always be reported separately.

CDC Biodiversité thus defined counterfactual scenarios for the energy sector, based on the recommendations of the report Taking Biodiversity into Account (PBAF 2022). Here is an extract from the focus on investment in green energy: "*Investments in renewable energy can take into account the avoided electricity production from grey electricity sources, as renewable energy replaces grey electricity from the grid. This can be done using the average grid mix from the country where the renewable energy is produced. Since the share of renewables in the electricity mixes worldwide is growing, the avoided emissions will decrease over time.*"

Using available data, the choice was made to present two counterfactual scenarios: one with the European electricity mix and one with the United States' electricity mix.

The perimeter of the counterfactual scenarios presented here is the following:

- Two pressures are considered: Climate change (dynamic impact) and Land use (static impact)
- Only the Scope 1 impacts are reported

The electricity mix of Europe and the USA

The electricity mixes were obtained from the website Our world in data (Ritchie, Roser, and Rosado 2020) and were available by percentage of electricity production, per country. Using the kWh/kEUR ratio table from section 4, the share of the region's electricity production turnover of each electricity type was assessed (Table 13).

Table 13: Electricity mixes of Europe and the United States, by share of kWh producedand turnover

	The European electricity mix		The US electricity mix	
	By share of electricity production	By share or turnover	By share of electricity production	By share or turnover
Coal	13 %	11 %	19 %	18 %
Gas	26 %	30 %	40 %	48 %
Hydro	17 %	11 %	6.9 %	4.7 %
Solar	3.7 %	1.6 %	3.2 %	1.4 %
Wind	11 %	5.9 %	8.3 %	4.7 %
Oil	2.7 %	3.7 %	0.85 %	1.2 %
Nuclear	23 %	18 %	20 %	15 %

	The European electricity mix		The US electricity mix	
	By share of electricity production	By share or turnover	By share of electricity production	By share or turnover
Other renewables including bioenergy	4.7 %	18 %	1.7 %	6.7 %

This allows to present the impacts of the counterfactual scenarios in two different units:

- in MSA.m²/kEUR of turnover of the electricity mix,
- in MSA.m²/kWh of electricity production of the mix

The Climate change impacts in the counterfactual scenarios

The Climate change impacts were estimated using the average GHG emissions of the production of electricity by different technologies and are reported in Table 14 below. For technologies not reported here the emissions were considered null.

Table 14: Emissions of electricity supply technologies

Electricity production by …	**Scope 1 emissions in gCO_2eq/kWh**	**Source**
Coal	760	Annex III: Technology-specific cost and performance parameters (Schlömer et al. 2014)
Gas	370	Annex III: Technology-specific cost and performance parameters (Schlömer et al. 2014)
Oil	777	RTE's éCO_2mix website (RTE 2022a)

The Scope 1 Climate change impacts were then calculated using the GBS version 1.4.1.

The Land use impacts in the counterfactual scenarios

The Scope 1 Land use impacts of the two electricity mixes were calculated using the land occupation data estimated in part 5.

Results

The Climate change dynamic impacts and Land use static impacts of the two electricity mixes used as counterfactual scenarios are presented in Table 15 below.

Table 15: Biodiversity impacts of the electricity mixes of the counterfactual scenarios

	Land use static impact intensity		Climate change dynamic impact intensity	
	MSA.m²/kEUR	MSA.m²/kWh	MSA.m²/kEUR	MSA.m²/kWh
Electricity mix of Europe	3.74	0.00030	12	0.00094
Electricity mix of the United States	2.80	0.00022	17	0.00130

The Land use impact of the European electricity mix is higher than the impact of the United States' mix because of more important share of biomass and other renewables. On the other hand, the Climate change impact of the USA mix is higher than the impact of the European mix due to a more important share of gas and coal.

For a renewable project, avoided impact can be computed using one of these two scenarios as a baseline scenario. However, these avoided impacts should always be presented separately from the negative impacts of the company.

9. Focus on the hydrological disturbance due to water use

The goal of this part is to complete the static impacts of the pressure "Hydrological disturbance due to direct water use" (HD_{water}). Indeed, as mentioned earlier, EXIOBASE data on water consumption and withdrawal are deemed incomplete and unreliable and are thus not connected to the GBS. In order to estimate Scope 1 HD_{water} impacts, it is thus necessary to seek other data sources.

Methodology

Here, we estimate these Scope 1 impacts using the results of the paper "Water use of electricity technologies: A global meta-analysis" (Jin et al. 2019). It should be noted that data were available for all 10 electricity production industries, therefore only the "Production of electricity nec" industry is excluded. In terms of geographical coverage, the meta-analysis includes studies from all continents, with a high preponderance of studies from the United States and China, visible in Figure 28.

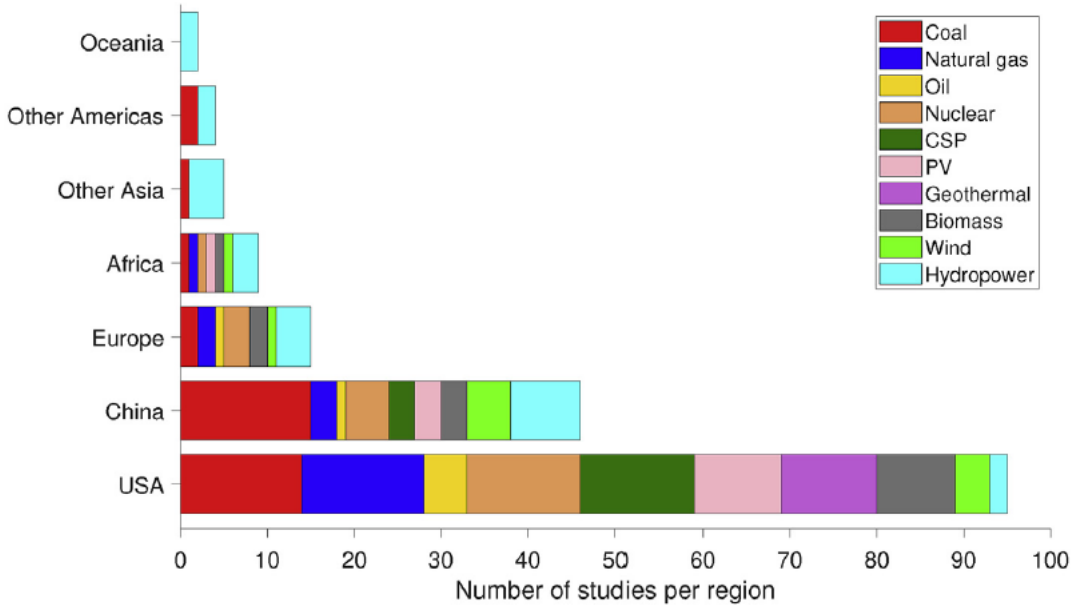


Figure 28: Number of studies per energy source per region. Many studies investigated more than one energy source and region, and can therefore occur multiple times. Extract from (Jin et al. 2019)

This paper was used as it presents both consumption and withdrawal data by electricity production type. For all the industries except the production of electricity by hydro, this water consumption and withdrawals corresponds to cooling water for the power plants. Water withdrawal is defined as the volume of water diverted from a water source for use, while consumption is the volume of withdrawn water not returned to the source due to evaporation, transpiration, or incorporation into products. These definitions are aligned with the definitions used to calculate HD_{water} impacts in the GBS. Furthermore, it distinguishes between the different stages of the life cycles, thus allowing to consider only Scope 1 impacts.

The consumption and withdrawal volumes are multiplied by the relevant impact factors in $MSA.km^2/m^3$ (using the impact factor of the world average). The consumption-based and withdrawal-based impacts thus calculated are compared and the highest impact is kept, as part of a conservative approach.

Deviations of the natural flow of water not caused by water consumption or withdrawal, such as deviations due to storage in dam reservoirs, are not assessed, thus still underestimating the impacts of EXIOBASE industries such as the Production of electricity by hydro. The impacts due to hydrological disturbance associated with the flow deviation caused by dams when they store or release water are likely to be very significant (and several times larger) compared to the impacts due to water evaporation (see below). Such impacts are generated only by reservoir dams and not run-of-river dams. They may not be under the control of dam operators, which may be forced by national or local regulations to achieve certain water flows or store certain volumes of water at different moments of the year.

Two figures were used from the supplementary materials, presented below. Figure 29 presents the water consumption by technology, and Figure 30 the water withdrawal.

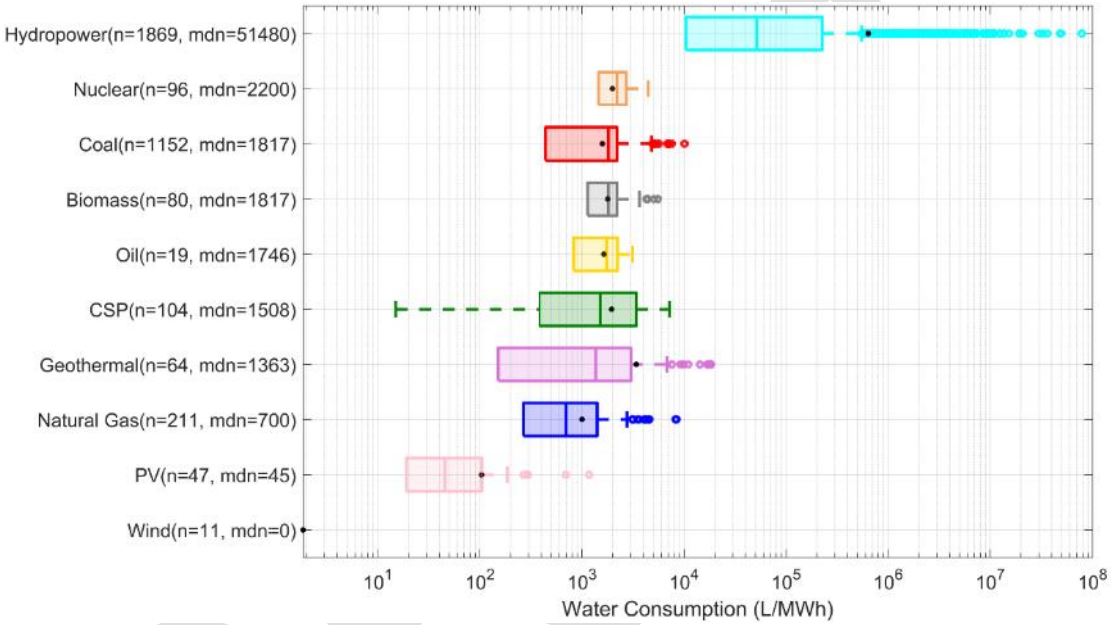


Figure 29: Water consumption of electricity generation, extract from (Jin et al. 2019). The signification of the annotation n is not explained in the paper, but supposedly represents the sample size. The annotation mdn represents the median value. CSP stands for "Concentrated Solar thermal Power". PV stands for "Photovoltaic".

Considering hydropower, the water consumption presented in Figure 29 is estimated from the water evaporation from reservoirs. This approach is coherent with the approach used by the UNESCO-IHE Institute for Water Education, in their report "The water footprint of electricity from hydropower", where the water footprint of electricity generated from hydropower is calculated by dividing the amount of water evaporated from the reservoir annually by the amount of energy generated. This approach comes with inherent limits, addressed in this report. First, the water consumption of dams through evaporation is fully attributed to hydroelectric generation, even though some of the reservoirs serve other purposes as well. This choice is justified by the fact that "all selected hydropower dams and associated reservoirs were primarily created for hydroelectric generation". Secondly, the report states that "one could argue that before the reservoir was created there was evaporation from the area as well". They justify it by stating the "the water footprint is not meant to refer to additional evaporation (compared to some reference situation), but for quantifying the volume of water consumption that can be associated with a specific human purpose (Hoekstra et al., 2011). From this perspective,

the full reservoir evaporation can be attributed to the purpose of the reservoir." (UNESCO-IHE, Mekonnen, M.M, and Hoekstra, A.Y 2011). The same logic can be applied here in terms of biodiversity impact.

The water consumption was regarded as zero for hydropower stations running without reservoirs (i.e. run-of-river plants). Currently, small hydropower (under 10 MW installed capacity, includes small reservoirs and run-of-river plants) represents less than 8% of the installed hydropower capacity (IEA-ETSAP and IRENA 2015). Therefore, here it was considered that the entire hydropower production comes from dams and reservoirs, meaning that the HD_{water} impact of the production of electricity by hydro calculated in this part might be slightly overestimated.

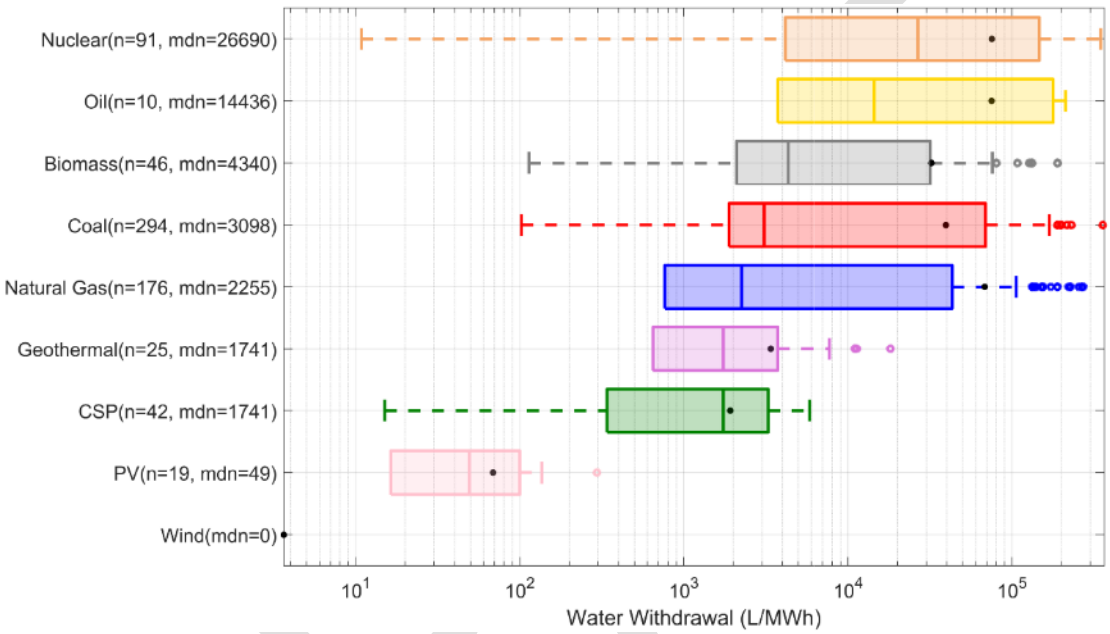


Figure 30: Water withdrawal of electricity generation, extract from (Jin et al. 2019). The signification of the annotation n is not explained in the paper, but supposedly represents the sample size. The annotation mdn represents the median value. CSP stands for "Concentrated Solar thermal Power" and PV stands for "Photovoltaic".

Finally, the Jin et al. study analyses water consumption and withdrawal by cooling type. This additional analysis allows to create differentiated impact factors by colling type. This is especially relevant since the authors conclude that "water uses of operation show greater agreement when grouped according to cooling types as opposed to power types". The two following figures were used to determine the water consumption and withdrawal by cooling and power type.

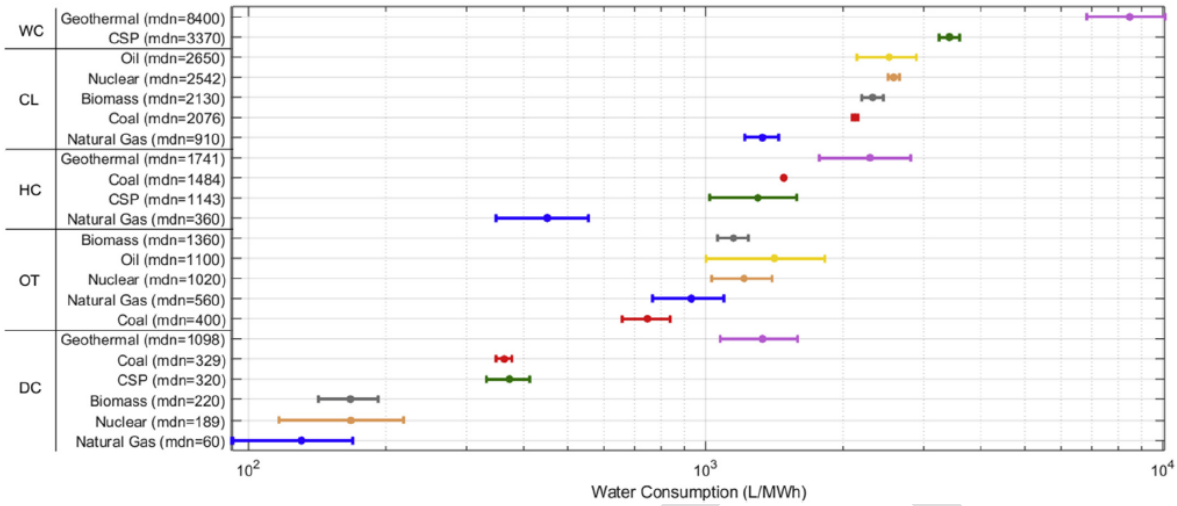


Figure 31: Blue water consumption of operation distinguished by power type and cooling type, extract from (Jin et al. 2019). The dots represent the average water consumption, while the linesegments represent the standard error of the average. The annotation mdn gives the median value. Hydropower, wind, and PV do not have cooling needs and are not included. The two-letter codes are as follows: WC wet cooling, CL closed-loop cooling, HC hybrid cooling (combining wet and dry cooling), OT once-through cooling, and DC dry cooling.

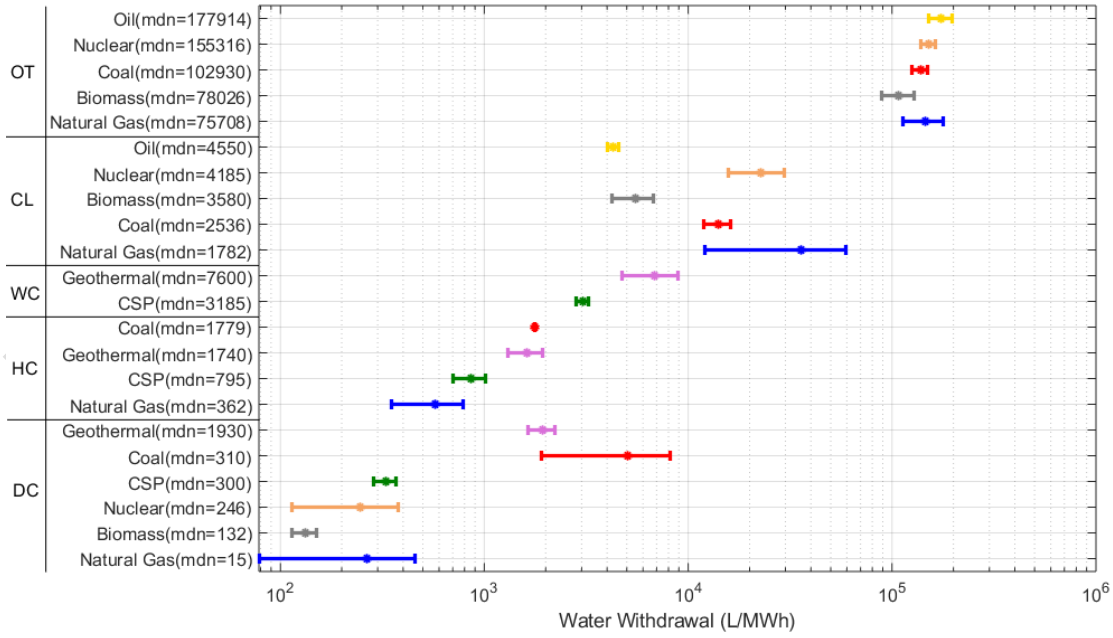


Figure 32: Blue water withdrawal of operation distinguished by power type and cooling type, extract from (Jin et al. 2019). The dots represent mean water consumption while the line segments represent the standard error of mean. The annotation mdn gives the median value. Hydropower, wind and PV do not have cooling needs and are not included. WC denotes wet cooling, CL denotes closed-loop cooling, HC denotes hybrid cooling (combining wet and dry cooling); OT denotes once-through cooling, and DC denotes dry cooling.

Results

The Scope 1 HD_{water} impacts related to these water consumption and withdrawal were then calculated using the GBS version 1.4.0. The results are presented in Table 16 below.

Table 16: Additional Scope 1 HDwater impact, calculated from the results of the study Jin et al (2019)

EXIOBASE industry	**Scope 1 HD_{water} aquatic static impact in MSA.m²/kEUR**
Production of electricity by coal	0.74
Production of electricity by gas	0.31
Production of electricity by nuclear	5.6
Production of electricity by hydro	29
Production of electricity by petroleum and other oil derivatives	1.7
Production of electricity by biomass and waste	0.19
Production of electricity by solar photovoltaic	0.038
Production of electricity by Geothermal	0.7

The HD_{water} impacts computed from financial data in the benchmark factsheet are related to the production or consumption of commodities. Therefore, the impacts included in the factsheet and these additional impacts can be added without leading to double counting. Figure 33 below shows the total Scope 1 HD_{water} impacts, from EXIOBASE and this additional calculation.

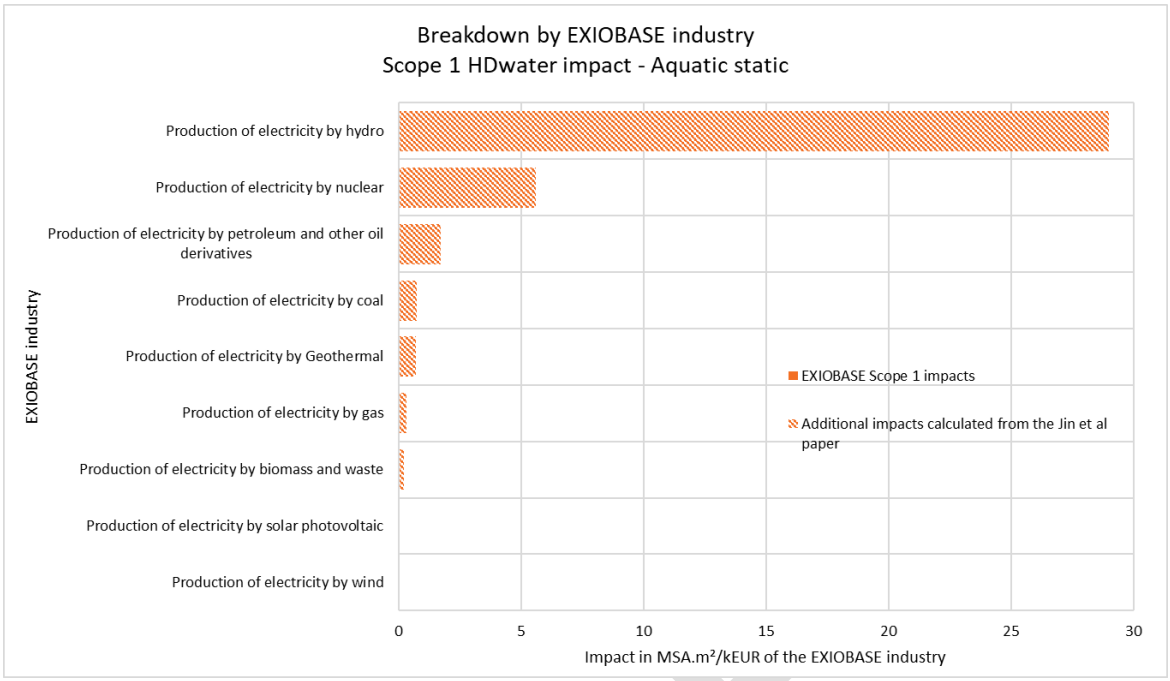


Figure 33: Breakdown by EXIOBASE industry of the aquatic static Scope 1 HDwater impact. The results include the additional Scope 1 calculated from the study Jin et al (2019)

The industry "Production of electricity by hydro" has the most important HD_{water} impact, which was expected with a water consumption between one and three orders of magnitude larger than other industries. The industry "Production of electricity by nuclear" comes in second, which can be explained because compared to thermal power plants, nuclear plants generate steam at lower temperatures and pressure for operational safety, and consequently, are less thermally efficient and withdraw more cooling water per unit of electricity.

On the other hand, the impacts of some industries are too small to be seen on this graph. Renewables such as wind or PV electricity have a small impact compared to other technologies.

Furthermore, Figure 34 below shows the effect of this additional Scope 1 HD_{water} impact when considering the entire value chain. This leads to the industry "Production of electricity by hydro" being the most impactful industry in terms of aquatic static footprint. This figure shows the importance of adding these additional HD_{water} impacts, especially for the industries "Production of electricity by hydro", "Production of electricity by nuclear", and "Production of electricity by petroleum and other oil derivatives".

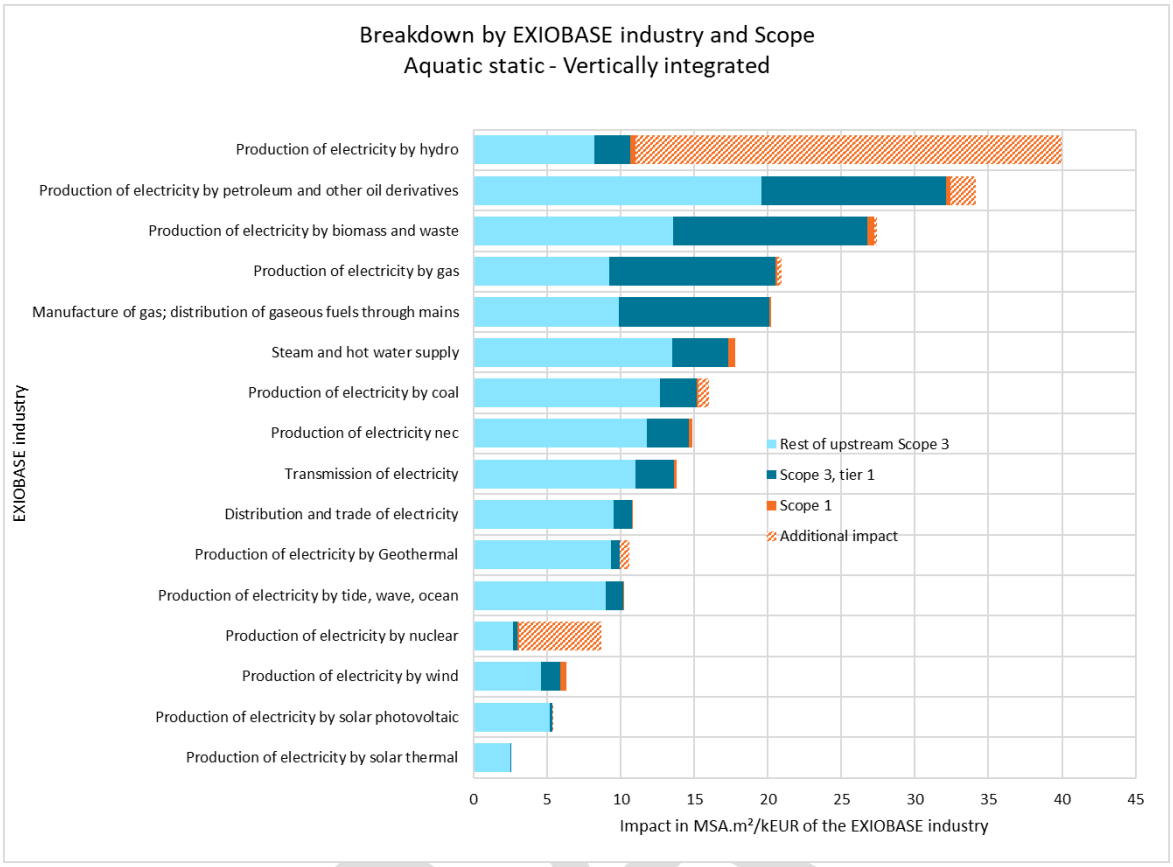


Figure 34: Breakdown by EXIOBASE industry and Scope of the aquatic static impact, vertically integrated. The results include the additional Scope 1 calculated from the study Jin et al (2019)

D. EU TAXONOMY GUIDELINES

1. Economic activities considered in the EU taxonomy and corresponding NACE codes

Table 17 presents the economic activities considered in the latest EU taxonomy reports:

- The Delegated act on the climate objectives (Official Journal of the European Union 2021)
- The Annex to the Platform on Sustainable Finance's report with recommendations on technical screening criteria for the four remaining environmental objectives of the EU taxonomy (Platform on Sustainable Finance 2022b)

Table 17: Economic activities of the Energy sector considered in the latest EU taxonomy reports

ST6 Energy	
Economic activity	Corresponding NACE codes
Environmental refurbishment of electricity generation facilities that produce electricity from hydropower	D35.11 | F42.9.1
Electricity generation using solar photovoltaic technology	D35.11 | F42.22
Electricity generation using concentrated solar power (CSP) technology	D35.11 | F42.22
Electricity generation from wind	D35.11 | F42.22
Electricity generation from ocean energy technologies	D35.11 | F42.22
Electricity generation from hydropower	D35.11 | F42.22
Electricity generation from geothermal energy	D35.11 | F42.22
Electricity generation from renewable non-fossil gaseous and liquid fuels	D35.11 | F42.22
Electricity generation from bioenergy	D35.11
Transmission and distribution of electricity	D.35.12 | D.35.13
Storage of electricity	No corresponding NACE code
Storage of thermal energy	No corresponding NACE code
Storage of hydrogen	No corresponding NACE code
Manufacture of biogas and biofuels for use in transport and of bioliquids	D.35.21
Transmission and distribution networks for renewable and low-carbon gases	D.35.22 | F.42.21 | H.49.50

ST6 Energy	
Economic activity	Corresponding NACE codes
District heating/cooling distribution	D.35.30
Installation and operation of electric heat pumps	D.35.30 | F43.22
Cogeneration of heat/cool and power from solar energy	D35.11 | D.35.30
Cogeneration of heat/cool and power from geothermal energy	D35.11 | D.35.30
Cogeneration of heat/cool and power from renewable non-fossil gaseous and liquid fuels	D35.11 | D.35.30
Cogeneration of heat/cool and power from bioenergy	D35.11 | D.35.30
Production of heat/cool from solar thermal heating	D.35.30
Production of heat/cool from geothermal energy	D.35.30
Production of heat/cool from renewable non-fossil gaseous and liquid fuels	D.35.30
Production of heat/cool from bioenergy	D.35.30
Production of heat/cool using waste heat	D.35.30

The perimeter of the EU taxonomy and the perimeter of the factsheet are not identical. Indeed, some industries are not included in the taxonomy, as they cannot be considered sustainable, regardless of technical screening criteria. The industries not included are the following:

- Production of electricity by coal
- Production of electricity by petroleum and other oil derivatives

Furthermore, the inclusion of some activities was just voted and should be effective in 2023 (see paragraph 4):

- Production of electricity by gas
- Production of electricity by nuclear

Finally, some activities are included in the EU taxonomy but not in the Energy benchmark factsheet:

- Environmental refurbishment of electricity generation facilities that produce electricity from hydropower
- Storage of electricity
- Storage of thermal energy
- Storage of hydrogen

2. Conditions for making a substantial contribution to the EU Taxonomy environmental objectives

The Technical Screening Criteria (TSC) for the objectives "Climate change mitigation" and "Climate change adaptation" are presented in the Delegated act on the climate objectives published in the official journal on December 9th, 2021. For the Energy sector, the TSC are available for every economic activity listed in part 1 except the economic activity "Environmental refurbishment of electricity generation facilities that produce electricity from hydropower". This delegated act is applicable since January 2022 (Official Journal of the European Union 2021).

In March 2022, the Platform on Sustainable Finance (PSF) provided recommendations on technical screening criteria to prepare this second delegated act. The Energy sector should refer to these criteria for a qualitative analysis of its impact. The report, that the Platform was mandated to prepare by the Commission, does not bind the European Commission on any decision on the matter.

Originally, the activities prioritised for the second delegated in the Energy sector were the economic activities presented in Table 18 below (Platform on Sustainable Finance 2022a). The environmental objectives considered were the objectives "Pollution prevention and control" and "Protection and restoration of biodiversity and ecosystems".

Table 18: Extract from the Platform on Sustainable Finance's report, original prioritized activities

ST6 Energy							
Economic Activities	**NACE codes**	**Mitigation**	**Adaptation**	**Water**	**Circular economy**	**Pollution**	**Biodiversity**
Electric power generation, transmission and	D35.1					X	
Hydropower (dams, weirs, run-off-the-river)	D35.1						X
Wind, wave and tidal power	D35.1						X

After a second selection process, some activities were deprioritized and the economic activities in the Energy sector that were finally included in this report are the following:

Table 19: Extract from the Platform on Sustainable Finance's report, list of activities included in the report

ST6 Energy								
Economic Activities	**NACE codes**	**Mitigation**	**Adaptation**	**Water**	**Circular economy**	**Pollution**	**Biodiversity**	**Publication**
Environmental refurbishment of facilities that produce electricity from hydropower	D35.1						X	March 2022
	F42.9.1						X	March 2022
Bioenergy (ongoing work)							X	May 2022

Therefore, in the Annex to the Platform on Sustainable Finance's report with recommendations on technical screening criteria for the four remaining environmental objectives of the EU taxonomy, are presented some technical screening criteria for the economic activity "Environmental refurbishment of electricity generation facilities that produce electricity from hydropower" for making a substantial contribution to the protection and restoration of biodiversity (Platform on Sustainable Finance 2022b).

Finally, before the publication of the report with recommendations from the PSF, the PSF published a draft which included some TSC for the objective pollution prevention and control, which can give an idea for the future TSC (Platform on Sustainable Finance 2021).

Technical screening criteria for a substantial contribution to the objective climate change mitigation, extracts from the delegated act on climate objectives

Below are some extracts of the technical screening criteria for climate change mitigation published in the official journal.

Electricity generation using solar photovoltaic technology

The activity generates electricity using solar PV technology.

Electricity generation using concentrated solar power (CSP) technology

The activity generates electricity using CSP technology.

Electricity generation from wind power

The activity generates electricity from wind power.

Electricity generation from ocean energy technologies

The activity generates electricity from ocean energy technologies

Electricity generation from hydropower

The activity complies with either of the following criteria: (a) the electricity generation facility is a run-of-river plant and does not have an artificial reservoir; (b) the power density of the electricity generation facility is above 5 W/m² ; (c) the life-cycle GHG emissions from the generation of electricity from hydropower, are lower than 100 g CO2 e/kWh. The life-cycle GHG emissions are calculated using Recommendation 2013/179/EU or, alternatively, using ISO 14067:2018, ISO 14064-1:2018 or the G-res tool. Quantified life- cycle GHG emissions are verified by an independent third party.

Electricity generation from geothermal energy

Life-cycle GHG emissions from the generation of electricity from geothermal energy are lower than 100 g CO2 e/kWh. Life-cycle GHG emission savings are calculated using Commission Recommendation 2013/179/EU or, alternatively, using ISO 14067:2018 or ISO 14064-1:2018. Quantified life-cycle GHG emissions are verified by an independent third party.

Electricity generation from renewable non-fossil gaseous and liquid fuels

1. Life-cycle GHG emissions from the generation of electricity using renewable gaseous and liquid fuels are lower than 100 g CO_2 e/kWh. Life-cycle GHG emissions are calculated based on project-specific data, where available, using Recommendation 2013/179/EU or, alternatively, using ISO 14067:2018 or ISO 14064-1:2018. Quantified life-cycle GHG emissions are verified by an independent third party.

2. Where facilities incorporate any form of abatement (including carbon capture or use of decarbonised fuels), that abatement activity complies with the criteria set out in the relevant Section of this Annex, where applicable. Where the CO_2 that would otherwise be emitted from the electricity generation process is captured for the purpose of underground storage, the CO_2 is transported and stored underground, in accordance with the technical screening criteria set out in Sections 5.11 and 5.12 of this Annex.

3. The activity meets either of the following criteria: (a) at construction, measurement equipment for monitoring of physical emissions, such as methane leakage is installed or a leak detection and repair program is introduced; (b) at operation, physical measurement of methane emissions are reported and leak is eliminated.

4. Where the activity blends renewable gaseous or liquid fuels with biogas or bioliquids, the agricultural biomass used for the production of the biogas or bioliquids complies with the criteria laid down in Article 29, paragraphs 2 to 5, of Directive (EU) 2018/2001 while forest biomass complies with the criteria laid down in Article 29, paragraphs 6 and 7, of that Directive.

Electricity generation from bioenergy

1. Agricultural biomass used in the activity complies with the criteria laid down in Article 29, paragraphs 2 to 5, of Directive (EU) 2018/2001. Forest biomass used in the activity complies with the criteria laid down in Article 29, paragraphs 6 and 7, of that Directive.

2. The greenhouse gas emission savings from the use of biomass are at least 80 % in relation to the GHG saving methodology and the relative fossil fuel comparator set out in Annex VI to Directive (EU) 2018/2001.

3. Where the installations rely on anaerobic digestion of organic material, the production of the digestate meets the criteria in Sections 5.6 and criteria 1 and 2 of Section 5.7 of this Annex, as applicable.

4. Points 1 and 2 do not apply to electricity generation installations with a total rated thermal input below 2 MW and using gaseous biomass fuels.

5. For electricity generation installations with a total rated thermal input from 50 to 100 MW, the activity applies high-efficiency cogeneration technology, or, for electricity-only installations, the activity meets an energy efficiency level associated with the best available techniques (BAT-AEL) ranges set out in the latest relevant best available techniques (BAT) conclusions, including the best available techniques (BAT) conclusions for large combustion plants.

6. For electricity generation installations with a total rated thermal input above 100 MW, the activity complies with one or more of the following criteria:

(a) attains electrical efficiency of at least 36 %;

(b) applies highly efficient CHP (combined heat and power) technology as referred to in Directive 2012/27/EU of the European Parliament and of the Council;

(c) uses carbon capture and storage technology. Where the CO_2 that would otherwise be emitted from the electricity generation process is captured for the purpose of underground storage, the CO_2 is transported and

stored underground in accordance with the technical screening criteria set out in Sections 5.11 and 5.12, respectively, of this Annex.

Transmission and distribution of electricity

The activity complies with one of the following criteria:

1. The transmission and distribution infrastructure or equipment is in an electricity system that complies with at least one of the following criteria:

(a) the system is the interconnected European system, i.e. the interconnected control areas of Member States, Norway, Switzerland and the United Kingdom, and its subordinated systems;

(b) more than 67 % of newly enabled generation capacity in the system is below the generation threshold value of 100 g CO_2 e/kWh measured on a life cycle basis in accordance with electricity generation criteria, over a rolling five-year period;

(c) the average system grid emissions factor, calculated as the total annual emissions from power generation connected to the system, divided by the total annual net electricity production in that system, is below the threshold value of 100 g CO_2 e/kWh measured on a life cycle basis in accordance with electricity generation criteria, over a rolling five-year period;

Infrastructure dedicated to creating a direct connection or expanding an existing direct connection between a substation or network and a power production plant that is more greenhouse gas intensive than 100 g CO_2 e/kWh measured on a life cycle basis is not compliant.

Installation of metering infrastructure that does not meet the requirements of smart metering systems of Article 20 of Directive (EU) 2019/944 is not compliant.

2. The activity is one of the following:

(a) construction and operation of direct connection, or expansion of existing direct connection, of low carbon electricity generation below the threshold of 100 g CO_2 e/kWh measured on a life cycle basis to a substation or network;

(b) construction and operation of electric vehicle (EV) charging stations and supporting electric infrastructure for the electrification of transport, subject to compliance with the technical screening criteria under the transport Section of this Annex;

(c) installation of transmission and distribution transformers that comply with the Tier 2 (1 July 2021) requirements set out in Annex I to the Commission Regulation (EU) No 548/2014 and, for medium power transformers with highest voltage for equipment not exceeding 36 kV, with AAA0 level requirements on no-load losses set out in standard EN 50588-1.

(d) construction/installation and operation of equipment and infrastructure where the main objective is an increase of the generation or use of renewable electricity generation;

(e) installation of equipment to increase the controllability and observability of the electricity system and to enable the development and integration of renewable energy sources, including:

(i) sensors and measurement tools (including meteorological sensors for forecasting renewable production);

(ii) communication and control (including advanced software and control rooms, automation of substations or feeders, and voltage control capabilities to adapt to more decentralised renewable infeed).

(f) installation of equipment such as, but not limited to future smart metering systems or those replacing smart metering systems in line with Article 19(6) of Directive (EU) 2019/944 of the European Parliament and of the Council, which meet the requirements of Article 20 of Directive (EU) 2019/944, able to carry information to users for remotely acting on consumption, including customer data hubs;

(g) construction/installation of equipment to allow for exchange of specifically renewable electricity between users;

(h) construction and operation of interconnectors between transmission systems, provided that one of the systems is compliant.

For the purposes of this Section, the following specifications apply:

(a) the rolling five-year period used in determining compliance with the thresholds is based on five consecutive historical years, including the year for which the most recent data are available;

(b) a 'system' means the power control area of the transmission or distribution network where the infrastructure or equipment is installed;

(c) transmission systems may include generation capacity connected to subordinated distribution systems;

(d) distribution systems subordinated to a transmission system that is deemed to be on a trajectory to full decarbonisation may also be deemed to be on a trajectory to full decarbonisation;

(e) to determine compliance, it is possible to consider a system covering multiple control areas which are interconnected and with significant energy exchanges between them, in which case the weighted average emissions factor across all included control areas is used, and individual subordinated transmission or distribution systems within that system is not required to demonstrate compliance separately;

(f) it is possible for a system to become non-compliant after having previously been compliant. In systems that become non-compliant, no new transmission and distribution activities are compliant from that moment onward, until the system complies again with the threshold (except for those activities that are always compliant, see above). Activities in subordinated systems may still be compliant, where those subordinated systems meet the criteria of this Section;

(g) a direct connection or expansion of an existing direct connection to production plants includes infrastructure that is indispensable to carry the associated electricity from the power generating facility to a substation or to the network.

Storage of electricity

The activity is the construction and operation of electricity storage including pumped hydropower storage.

Where the activity includes chemical energy storage, the medium of storage (such as hydrogen or ammonia) complies with the criteria for manufacturing of the corresponding product specified in Sections 3.7 to 3.17 of this Annex. In case of using hydrogen as electricity storage, where hydrogen meets the technical screening criteria specified in Section 3.10 of this Annex, re-electrification of hydrogen is also considered part of the activity.

Storage of thermal energy

The activity stores thermal energy, including Underground Thermal Energy Storage (UTES) or Aquifer Thermal Energy Storage (ATES).

Storage of hydrogen

The activity is one of the following:

(a) construction of hydrogen storage facilities;

(b) conversion of existing underground gas storage facilities into storage facilities dedicated to hydrogen-storage;

(c) operation of hydrogen storage facilities where the hydrogen stored in the facility meets the criteria for manufacture of hydrogen set out in Section 3.10. of this Annex.

Manufacture of biogas and biofuels for use in transport and of bioliquids

1. Agricultural biomass used for the manufacture of biogas or biofuels for use in transport and for the manufacture of bioliquids complies with the criteria laid down in Article 29, paragraphs 2 to 5, of Directive (EU) 2018/2001. Forest biomass used for the manufacture of biogas or biofuels for use in transport and for the manufacture of bioliquids complies with the criteria laid down in Article 29, paragraphs 6 and 7, of that Directive.

Food-and feed crops are not used for the manufacture of biofuels for use in transport and for the manufacture of bioliquids.

2. The greenhouse gas emission savings from the manufacture of biofuels and biogas for use in transport and from the manufacture of bioliquids are at least 65 % in relation to the GHG saving methodology and the relative fossil fuel comparator set out in Annex V to Directive (EU) 2018/2001.

3. Where the manufacture of biogas relies on anaerobic digestion of organic material, the production of the digestate meets the criteria in Sections 5.6 and criteria 1 and 2 of Section 5.7 of this Annex, as applicable.

4. Where the CO_2 that otherwise would be emitted from the manufacturing process is captured for the purpose of underground storage, the CO_2 is transported and stored underground in accordance with the technical screening criteria set out in Sections 5.11 and 5.12 of this Annex.

Transmission and distribution networks for renewable and low-carbon gases

1. The activity consists in one of the following:

(a) construction or operation of new transmission and distribution networks dedicated to hydrogen or other low-carbon gases;

(b) conversion/repurposing of existing natural gas networks to 100 % hydrogen;

(c) retrofit of gas transmission and distribution networks that enables the integration of hydrogen and other low- carbon gases in the network, including any gas transmission or distribution network activity that enables the increase of the blend of hydrogen or other low carbon gasses in the gas system;

2. The activity includes leak detection and repair of existing gas pipelines and other network elements to reduce methane leakage.

District heating/cooling distribution

The activity complies with one of the following criteria:

(a) for construction and operation of pipelines and associated infrastructure for distributing heating and cooling, the system meets the definition of efficient district heating and cooling systems laid down in Article 2, point 41, of Directive 2012/27/EU;

(b) for refurbishment of pipelines and associated infrastructure for distributing heating and cooling, the investment that makes the system meet the definition of efficient district heating or cooling laid down in Article 2, point 41, of Directive 2012/27/EU starts within a three year period as underpinned by a contractual obligation or an equivalent in case of operators in charge of both generation and the network;

(c) the activity is the following:

(i) modification to lower temperature regimes;

(ii) advanced pilot systems (control and energy management systems, Internet of Things).

Installation and operation of electric heat pumps

The installation and operation of electric heat pumps complies with both of the following criteria:

(a) refrigerant threshold: Global Warming Potential does not exceed 675;

(b) energy efficiency requirements laid down in the implementing regulations under Directive 2009/125/EC are met.

Cogeneration of heat/cool and power from solar energy

The activity consists in the cogeneration of electricity and heat/cool from solar energy.

Cogeneration of heat/cool and power from geothermal energy

The life-cycle GHG emissions from the combined generation of heat/cool and power from geothermal energy are lower than 100 g CO_2 e per 1 kWh of energy output from the combined generation.

Life-cycle GHG emissions are calculated based on project-specific data, where available, using Commission Recommendation 2013/179/EU or, alternatively, using ISO 14067:2018 or ISO 14064-1:2018.

Quantified life-cycle GHG emissions are verified by an independent third party.

Cogeneration of heat/cool and power from renewable non-fossil gaseous and liquid fuels

1. The life-cycle GHG emissions from the co-generation of heat/cool and power from renewable gaseous and liquid fuels are lower than 100 g CO_2 e per 1 kWh of energy output from the co-generation. Life-cycle GHG emissions are calculated based on project-specific data, where available, using Recommendation 2013/179/EU or, alternatively, using ISO 14067:2018 or ISO 14064-1:2018. Quantified life-cycle GHG emissions are verified by an independent third party.

2. Where facilities incorporate any form of abatement (including carbon capture or use of decarbonised fuels) that abatement activity complies with the relevant Sections of this Annex, where applicable. Where the CO_2 that would otherwise be emitted from the cogeneration process is captured for the purpose of underground storage, the CO_2 is transported and stored underground, in accordance with the technical screening criteria set out in Sections 5.11 and 5.12 of this Annex.

3. The activity meets either of the following criteria:

(a) at construction, measurement equipment for monitoring of physical emissions, such as methane leakage is installed or a leak detection and repair program is introduced;

(b) at operation, physical measurement of methane emissions are reported and leak is eliminated.

4. Where the activity blends renewable gaseous or liquid fuels with biogas or bioliquids, the agricultural biomass used for the production of the biogas or bioliquids complies with the criteria laid down in Article 29, paragraphs 2 to 5, of Directive (EU) 2018/2001 while forest biomass complies with the criteria laid down in Article 29, paragraphs 6 and 7, of that Directive.

Cogeneration of heat/cool and power from bioenergy

1. Agricultural biomass used in the activity complies with the criteria laid down in Article 29, paragraphs 2 to 5, of Directive (EU) 2018/2001. Forest biomass used in the activity complies with the criteria laid down in Article 29, paragraphs 6 and 7 of that Directive.

2. The greenhouse gas emission savings from the use of biomass in cogeneration installations are at least 80 % in relation to the GHG emission saving methodology and fossil fuel comparator set out in Annex VI to Directive (EU) 2018/2001.

3. Where the cogeneration installations rely on anaerobic digestion of organic material, the production of the digestate meets the criteria in Sections 5.6 and criteria 1 and 2 of Section 5.7 of this Annex, as applicable.

4. Points 1 and 2 do not apply to cogeneration installations with a total rated thermal input below 2 MW and using gaseous biomass fuels.

Production of heat/cool from solar thermal heating

The activity produces heat/cool using solar thermal heating.

Production of heat/cool from geothermal energy

The life-cycle GHG emissions from the generation of heat/cool from geothermal energy are lower than 100 g CO2 e/kWh.

Life-cycle GHG emissions are calculated based on project-specific data, where available, using Commission Recommendation 2013/179/EU or, alternatively, using ISO 14067:2018 or ISO 14064-1:2018.

Quantified life-cycle GHG emissions are verified by an independent third party.

Production of heat/cool from renewable non-fossil gaseous and liquid fuels

1. The life-cycle GHG emissions from the generation of heat/cool using renewable gaseous and liquid fuels are lower than 100 g CO2 e/kWh. Life-cycle GHG emissions are calculated based on project-specific data, where available, using Recommendation 2013/179/EU or, alternatively, using ISO 14067:2018 or ISO 14064-1:2018. Quantified life-cycle GHG emissions are verified by an independent third party.

2. Where facilities incorporate any form of abatement (including carbon capture or use of decarbonised fuels), that abatement activity complies with the relevant Sections of this Annex, where applicable. Where the CO 2 that would otherwise be emitted from the electricity generation process is captured for the purpose of underground storage, the CO2 is transported and stored underground, in accordance with the technical screening criteria set out in Sections 5.11 and 5.12 of this Annex.

3. The activity meets either of the following criteria:

(a) at construction, measurement equipment for monitoring physical emissions, such as methane leakage is installed or a leak detection and repair program is introduced;

(b) at operation, physical measurement of methane emissions are reported and leak is eliminated.

4. Where the activity blends renewable gaseous or liquid fuels with biogas or bioliquids, the agricultural biomass used for the production of the biogas or bioliquids complies with the criteria laid down in Article 29, paragraphs 2 to 5, of Directive (EU) 2018/2001 while forest biomass complies with the criteria laid down in Article 29, paragraphs 6 and 7, of that Directive.

Production of heat/cool from bioenergy

1. Agricultural biomass used in the activity for the production of heat and cool complies with the criteria laid down in Article 29, paragraphs 2 to 5, of Directive (EU) 2018/2001. Forest biomass used in the activity complies with the criteria laid down in Article 29, paragraphs 6 and 7, of that Directive.

2. The greenhouse gas emission savings from the use of biomass are at least 80 % in relation to the GHG emission saving methodology and relative fossil fuel comparator set out in Annex VI to Directive (EU) 2018/2001.

3. Where the installations rely on anaerobic digestion of organic material, the production of the digestate meets the criteria in Sections 5.6 and criteria 1 and 2 of Section 5.7 of this Annex, as applicable.

4. Points 1 and 2 do not apply to heat generation installations with a total rated thermal input below 2 MW and using gaseous biomass fuels.

Production of heat/cool using waste heat

The activity produces heat/cool from waste heat.

Technical screening criteria for a substantial contribution to the objective climate change adaptation, extracts from the delegated act on climate objectives

Below are some extracts of the technical screening criteria for climate change adaptation published in the official journal. The technical screening criteria are the same for all the economic activities of the energy sector.

- Electricity generation using solar photovoltaic technology
- Electricity generation using concentrated solar power (CSP) technology
- Electricity generation from wind power
- Electricity generation from ocean energy technologies
- Electricity generation from hydropower
- Electricity generation from geothermal energy
- Electricity generation from renewable non-fossil gaseous and liquid fuels
- Electricity generation from bioenergy
- Transmission and distribution of electricity
- Storage of electricity
- Storage of thermal energy
- Storage of hydrogen
- Manufacture of biogas and biofuels for use in transport and of bioliquids
- Transmission and distribution networks for renewable and low-carbon gases
- District heating/cooling distribution
- Installation and operation of electric heat pumps
- Cogeneration of heat/cool and power from solar energy
- Cogeneration of heat/cool and power from geothermal energy
- Cogeneration of heat/cool and power from renewable non-fossil gaseous and liquid fuels
- Cogeneration of heat/cool and power from bioenergy
- Production of heat/cool from solar thermal heating
- Production of heat/cool from geothermal energy
- Production of heat/cool from renewable non-fossil gaseous and liquid fuels
- Production of heat/cool from bioenergy
- Production of heat/cool using waste heat

1. The economic activity has implemented physical and non-physical solutions ('adaptation solutions') that substantially reduce the most important physical climate risks that are material to that activity.

2. The physical climate risks that are material to the activity have been identified from those listed in Appendix A to this Annex by performing a robust climate risk and vulnerability assessment with the following steps:

(a) screening of the activity to identify which physical climate risks from the list in Appendix A to this Annex may affect the performance of the economic activity during its expected lifetime;

(b) where the activity is assessed to be at risk from one or more of the physical climate risks listed in Appendix A to this Annex, a climate risk and vulnerability assessment to assess the materiality of the physical climate risks on the economic activity;

(c) an assessment of adaptation solutions that can reduce the identified physical climate risk.

The climate risk and vulnerability assessment is proportionate to the scale of the activity and its expected lifespan, such that:

(a) for activities with an expected lifespan of less than 10 years, the assessment is performed, at least by using climate projections at the smallest appropriate scale;

(b) for all other activities, the assessment is performed using the highest available resolution, state-of-the-art climate projections across the existing range of future scenarios consistent with the expected lifetime of the activity, including, at least, 10 to 30 year climate projections scenarios for major investments.

3. The climate projections and assessment of impacts are based on best practice and available guidance and take into account the state-of-the-art science for vulnerability and risk analysis and related methodologies in line with the most recent Intergovernmental Panel on Climate Change reports scientific peer-reviewed publications and open source or paying models.

4. The adaptation solutions implemented:

(a) do not adversely affect the adaptation efforts or the level of resilience to physical climate risks of other people, of nature, of cultural heritage, of assets and of other economic activities;

(b) favour nature-based solutions or rely on blue or green infrastructure to the extent possible;

(c) are consistent with local, sectoral, regional or national adaptation plans and strategies;

(d) are monitored and measured against pre-defined indicators and remedial action is considered where those indicators are not met;

(e) where the solution implemented is physical and consists in an activity for which technical screening criteria have been specified in this Annex, the solution complies with the do no significant harm technical screening criteria for that activity.

Proposition of technical screening criteria for a substantial contribution to the objective protection and restoration of biodiversity and ecosystems, published by the PSF as a recommendation for the EU commission

Below are some extracts of the technical screening criteria for climate change adaptation recommended by the Platform for Sustainable Finance. These do not bind the European Commission on any decision on the matter, and should be considered as an indication of possible future TSC.

Environmental refurbishment of facilities that produce electricity from hydropower

The environmental refurbishment needs to fulfil all of the following criteria:

1. All the Technical Screening Criteria listed in Chapter 9.2 (Restoration of biodiversity and ecosystem) of this Annex are fulfilled. In addition, the following conditions apply.

1.1 The Restoration Plan or equivalent instrument, as detailed in Criteria 1 of Chapter 9.2, of this Annex demonstrates that the environmental refurbishment contributes to the improvement of the Status of the Water Body where the plant is located (as defined by the Water Framework Directive, Annex V) and does not compromise the achievement of good status/potential by 2027* in any of the water bodies in the same river basin district.

1.2 In accordance with Article 4 of Directive 2000/60/EC and Criteria 4.2 of Chapter 9.2 (Restoration of biodiversity and ecosystem) of this Annex, the Restoration Plan assesses all potential impacts of the environmental refurbishment on the status of water bodies within the same river basin and on protected habitats and species directly dependent on water, considering migration corridors, free-flowing rivers or ecosystems close to undisturbed conditions. The assessment is based on recent, comprehensive, and accurate data, including monitoring data on biological quality elements that are specifically sensitive to hydromorphological alterations, and on the expected status of the water body as a result of the activity. It assesses in particular the cumulated impacts of the environmental refurbishment with other existing or planned infrastructure in the river basin.

1.3 The Restoration Plan or equivalent instrument, as detailed in Criteria 1 of Chapter 9.2 of this Annex, includes, but is not limited to, measures to ensure upstream and downstream fish migration (such as fish passes, adapted turbines, fish guidance structures with adjacent bypass, measures to stop or minimise operation and discharges during migration or spawning, etc.) that allow for a vast majority (>85%) of individuals from each migratory species to swim safely through and/or past the hydropower plant; creation of nature-like fishways, creation of reproduction channels or off-channel habitats, restoration of the riparian zone or riverbank vegetation, measures to prevent erosion and ensure slope stability, measures to ensure sediment flow and, depending of ownership and property rights, removal of obsolete barriers in the river basin district, starting no later than the environmental refurbishment. All the above-mentioned measures are implemented according to the state-of-the-art developments and current best practices, and preliminary tests have validated their effectiveness.

A sound monitoring system is in place to demonstrate the effectiveness of the measures in accordance with the Restoration Plan or the equivalent instrument and in particular the contribution to the reduction of losses in freshwater species populations (in particular, migratory fish) at the hydropower station and further upstream/downstream and the improvement in other biological quality elements listed in Directive 2000/60/EC and where relevant, Directive 92/43/EEC12. Key monitoring results are available to the public.

2. The environmental refurbishment is conducted on hydropower plants having a capacity above 10 MW. 3. Retrofitting aiming at the conversion into hydropower plants of barriers built or used for other purposes, or not in use anymore at the time of the environmental refurbishment, is not eligible. *This criterion shall be revised no later than 2027, the deadline set by the Water Framework Directive to achieve good status, to consider possible higher thresholds.

3. Additional DNSH guidelines

Here are presented some extracts of the Do No Significant Harm criteria for the economic activities considered in the Delegated act on climate objectives and in the latest PSF report. Some criteria are shared by several economic activities, these generic criteria are available in Appendix A to E, also presented here.

DNSH criteria for the different economic activities, extracts from the delegated act on the climate objectives

Electricity generation using solar photovoltaic technology

Cogeneration of heat/cool and power from solar energy

Production of heat/cool from solar thermal heating

(1) Climate change mitigation	N/A
(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.
(3) Sustainable use and protection of water and marine resources	N/A
(4) Transition to a circular economy	The activity assesses availability of and, where feasible, uses equipment and components of high durability and recyclability and that are easy to dismantle and refurbish.
(5) Pollution prevention and control	N/A
(6) Protection and restoration of biodiversity and ecosystems	The activity complies with the criteria set out in Appendix D to this Annex.

Electricity generation using concentrated solar power (CSP) technology

(1) Climate change mitigation	N/A
(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.
(3) Sustainable use and protection of water and marine resources	The activity complies with the criteria set out in Appendix B to this Annex.

(4) Transition to a circular economy	The activity assesses availability of and, where feasible, uses equipment and components of high durability and recyclability and that are easy to dismantle and refurbish.
(5) Pollution prevention and control	N/A
(6) Protection and restoration of biodiversity and ecosystems	The activity complies with the criteria set out in Appendix D to this Annex.

Electricity generation from wind power

(1) Climate change mitigation	N/A
(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.
(3) Sustainable use and protection of water and marine resources	In case of construction of offshore wind, the activity does not hamper the achievement of good environmental status as set out in Directive 2008/56/EC of the European Parliament and of the Council, requiring that the appropriate measures are taken to prevent or mitigate impacts in relation to that Directive's Descriptor 11 (Noise/Energy), laid down in Annex I to that Directive, and as set out in Commission Decision (EU) 2017/848 in relation to the relevant criteria and methodological standards for that descriptor.
(4) Transition to a circular economy	The activity assesses availability of and, where feasible, uses equipment and components of high durability and recyclability and that are easy to dismantle and refurbish.
(5) Pollution prevention and control	N/A
(6) Protection and restoration of biodiversity and ecosystems	The activity complies with the criteria set out in Appendix D to this Annex. In case of offshore wind, the activity does not hamper the achievement of good environmental status as set out in Directive 2008/56/EC, requiring that the appropriate measures are taken to prevent or mitigate impacts in relation to that Directive's Descriptors 1 (biodiversity) and 6 (seabed integrity), laid down in Annex I to that Directive, and as set out in Decision (EU) 2017/848 in relation to the relevant criteria and methodological standards for those descriptors.

Electricity generation from ocean energy technologies

(1) Climate change mitigation	N/A

(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.
(3) Sustainable use and protection of water and marine resources	The activity does not hamper the achievement of good environmental status, as set out in Directive 2008/56/EC, requiring that the appropriate measures are taken to prevent or mitigate impacts in relation to that Directive's Descriptor 11 (Noise/Energy), laid down in Annex I to that Directive, and as set out in Decision (EU) 2017/848 in relation to the relevant criteria and methodological standards for that descriptor.
(4) Transition to a circular economy	The activity assesses availability of and, where feasible, uses equipment and components of high durability and recyclability and that are easy to dismantle and refurbish.
(5) Pollution prevention and control	Measures are in place to minimise toxicity of anti-fouling paint and biocides as laid down in Regulation (EU) No 528/2012 of the European Parliament and of the Council, which implements in Union law the International Convention on the Control of Harmful Anti-fouling Systems on Ships adopted on 5 October 2001.
(6) Protection and restoration of biodiversity and ecosystems	The activity complies with the criteria set out in Appendix D to this Annex. The activity does not hamper the achievement of good environmental status, as set out in Directive 2008/56/EC, requiring that the appropriate measures are taken to prevent or mitigate impacts in relation to that Directive's Descriptor 1 (biodiversity), laid down in Annex I to that Directive, and as set out in Decision (EU) 2017/848 in relation to the relevant criteria and methodological standards for that descriptor.

Electricity generation from hydropower

(1) Climate change mitigation	The direct GHG emissions of the activity are lower than 270 g CO2 e/kWh.
(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.
(3) Sustainable use and protection of water and marine resources	1. The activity complies with the provisions of Directive 2000/60/EC, in particular with all the requirements laid down in Article 4 of the Directive. 2. For operation of existing hydropower plants, including refurbishment activities to enhance renewable energy or energy storage potential, the activity complies with the following criteria:

	2.1. In accordance with Directive 2000/60/EC and in particular Articles 4 and 11 of that Directive, all technically feasible and ecologically relevant mitigation measures have been implemented to reduce adverse impacts on water as well as on protected habitats and species directly dependent on water. 2.2. Measures include, where relevant and depending on the ecosystems naturally present in the affected water bodies: (a) measures to ensure downstream and upstream fish migration (such as fish friendly turbines, fish guidance structures, state-of-the-art fully functional fish passes, measures to stop or minimise operation and discharges during migration or spawning); (b) measures to ensure minimum ecological flow (including mitigation of rapid, short-term variations in flow or hydro-peaking operations) and sediment flow; (c) measures to protect or enhance habitats. 2.3. The effectiveness of those measures is monitored in the context of the authorisation or permit setting out the conditions aimed at achieving good status or potential of the affected water body. 3. For construction of new hydropower plants, the activity complies with the following criteria: 3.1. In accordance with Article 4 of Directive 2000/60/EC and in particular paragraph 7 of that Article, prior to construction, an impact assessment of the project is carried out to assess all its potential impacts on the status of water bodies within the same river basin and on protected habitats and species directly dependent on water, considering in particular migration corridors, free-flowing rivers or ecosystems close to undisturbed conditions. The assessment is based on recent, comprehensive and accurate data, including monitoring data on biological quality elements that are specifically sensitive to hydromorphological alterations, and on the expected status of the water body as a result of the new activities, as compared to its current one. It assesses in particular the cumulated impacts of this new project with other existing or planned infrastructure in the river basin. 3.2. On the basis of that impact assessment, it has been established that the plant is conceived, by design and location and by mitigation measures, so that it complies with one of the following requirements:

	(a) the plant does not entail any deterioration nor compromises the achievement of good status or potential of the specific water body it relates to; (b) where the plant risks to deteriorate or compromise the achievement of good status/potential of the specific water body it relates to, such deterioration is not significant, and is justified by a detailed cost- benefit assessment demonstrating both of the following: (i) the reasons of overriding public interest or the fact that benefits expected from the planned hydropower plant outweigh the costs from deteriorating the status of water that are accruing to the environment and to society; (ii) the fact that the overriding public interest or the benefits expected from the plant cannot, for reasons of technical feasibility or disproportionate cost, be achieved by alternative means that would lead to a better environmental outcome (such as refurbishing of existing hydropower plants or use of technologies not disrupting river continuity). 3.3. All technically feasible and ecologically relevant mitigation measures are implemented to reduce adverse impacts on water as well as on protected habitats and species directly dependent on water. Mitigation measures include, where relevant and depending on the ecosystems naturally present in the affected water bodies: (a) measures to ensure downstream and upstream fish migration (such as fish friendly turbines, fish guidance structures, state-of the-art fully functional fish passes, measures to stop or minimise operation and discharges during migration or spawning); (b) measures to ensure minimum ecological flow (including mitigation of rapid, short-term variations in flow or hydro-peaking operations) and sediment flow; (c) measures to protect or enhance habitats. The effectiveness of those measures is monitored in the context of the authorisation or permit setting out the conditions aimed at achieving good status or potential of the affected water body. 3.4. The plant does not permanently compromise the achievement of good status/potential in any of the water bodies in the same river basin district.

	3.5. In addition to the mitigation measures referred to above, and where relevant, compensatory measures are implemented to ensure that the project does not increase the fragmentation of water bodies in the same river basin district. This is achieved by restoring continuity within the same river basin district to an extent that compensates the disruption of continuity, which the planned hydropower plant
(4) Transition to a circular economy	N/A
(5) Pollution prevention and control	N/A
(6) Protection and restoration of biodiversity and ecosystems	The activity complies with the criteria set out in Appendix D to this Annex.

Electricity generation from geothermal energy

Cogeneration of heat/cool and power from geothermal energy

Production of heat/cool from geothermal energy

(1) Climate change mitigation	The direct GHG emissions of the activity are lower than 270 g CO2 e/kWh.
(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.
(3) Sustainable use and protection of water and marine resources	The activity complies with the criteria set out in Appendix B to this Annex.
(4) Transition to a circular economy	N/A
(5) Pollution prevention and control	For the operation of high-enthalpy geothermal energy systems, adequate abatement systems are in place to reduce emission levels in order not to hamper the achievement of air quality limit values set out in Directive 2004/107/EC of the European Parliament and of the Council and Directive 2008/50/EC of the European Parliament and of the Council.
(6) Protection and restoration of biodiversity and ecosystems	The activity complies with the criteria set out in Appendix D to this Annex.

Electricity generation from renewable non-fossil gaseous and liquid fuels

Cogeneration of heat/cool and power from renewable non-fossil gaseous and liquid fuels

Production of heat/cool from renewable non-fossil gaseous and liquid fuels

(1) Climate change mitigation	The direct GHG emissions of the activity are lower than 270 g CO2 e/kWh.
(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.
(3) Sustainable use and protection of water and marine resources	The activity complies with the criteria set out in Appendix B to this Annex.
(4) Transition to a circular economy	N/A
(5) Pollution prevention and control	Emissions are within or lower than the emission levels associated with the best available techniques (BAT-AEL) ranges set out in the latest relevant best available techniques (BAT) conclusions, including the best available techniques (BAT) conclusions for large combustion plants. No significant cross-media effects occur. For combustion plants with thermal input greater than 1 MW but below the thresholds for the BAT conclusions for large combustion plants to apply, emissions are below the emission limit values set out in Annex II, part 2, to Directive (EU) 2015/2193 of the European Parliament and of the Council.
(6) Protection and restoration of biodiversity and ecosystems	The activity complies with the criteria set out in Appendix D to this Annex.

Electricity generation from bioenergy

Cogeneration of heat/cool and power from bioenergy

Production of heat/cool from bioenergy

(1) Climate change mitigation	The activity meets the requirements relating to sustainability, greenhouse gas emission savings and efficiency laid down in Article 29 of Directive 2018/2001.
(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.
(3) Sustainable use and protection of water and marine resources	The activity complies with the criteria set out in Appendix B to this Annex.
(4) Transition to a circular economy	N/A
(5) Pollution prevention and control	For installations falling within the scope of Directive 2010/75/EU of the European Parliament and of the Council, emissions are within or lower than the emission levels associated with the best available techniques (BAT-AEL) ranges set out in the latest relevant best available techniques (BAT) conclusions, including the best available

	techniques (BAT) conclusions for large combustion plants. No significant cross-media effects occur. For combustion plants with thermal input greater than 1 MW but below the thresholds for the BAT conclusions for large combustion plants to apply, emissions are below the emission limit values set out in Annex II, part 2, to Directive (EU) 2015/2193. For plants in zones or parts of zones not complying with the air quality limit values laid down in Directive 2008/50/EC, measures are implemented to reduce emission levels taking into account the results of the information exchange which are published by the Commission in accordance with Article 6, paragraphs 9 and 10, of Directive (EU) 2015/2193. For anaerobic digestion of organic material, where the produced digestate is used as fertiliser or soil improver, either directly or after composting or any other treatment, it meets the requirements for fertilising materials set out in Component Material Categories (CMC) 4 and 5 in Annex II to Regulation (EU) 2019/1009 or national rules on fertilisers or soil improvers for agricultural use. For anaerobic digestion plants treating over 100 tonnes per day, emissions to air and water are within or lower than the emission levels associated with the best available techniques (BAT-AEL) ranges set for anaerobic treatment of waste in the latest relevant best available techniques (BAT) conclusions, including the best available techniques (BAT) conclusions for waste treatment. No significant cross-media effects occur.
(6) Protection and restoration of biodiversity and ecosystems	The activity complies with the criteria set out in Appendix D to this Annex.

Transmission and distribution of electricity

(1) Climate change mitigation	The infrastructure is not dedicated to creating a direct connection, or expanding an existing direct connection to a power production plant where the direct greenhouse gas emissions exceed 270 g CO2 e/kWh.
(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.
(3) Sustainable use and protection of water and marine resources	N/A
(4) Transition to a circular economy	A waste management plan is in place and ensures maximal reuse or recycling at end of life in accordance with the waste hierarchy, including through contractual agreements with waste management

	partners, reflection in financial projections or official project documentation.
(5) Pollution prevention and control	Overground high voltage lines: (a) for construction site activities, activities follow the principles of the IFC General Environmental, Health, and Safety Guidelines. (b) activities respect applicable norms and regulations to limit impact of electromagnetic radiation on human health, including for activities carried out in the Union, the Council recommendation on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) and for activities carried out in third countries, the 1998 Guidelines of International Commission on Non-Ionizing Radiation Protection (ICNIRP). Activities do not use PCBs polyclorinated biphenyls.
(6) Protection and restoration of biodiversity and ecosystems	The activity complies with the criteria set out in Appendix D to this Annex.

Storage of electricity

(1) Climate change mitigation	N/A
(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.
(3) Sustainable use and protection of water and marine resources	In case of pumped hydropower storage not connected to a river body, the activity complies with the criteria set out in Appendix B to this Annex. In case of pumped hydropower storage connected to a river body, the activity complies with the criteria for DNSH to sustainable use and protection of water and marine resources specified in Section 4.5 (Electricity production from hydropower).
(4) Transition to a circular economy	A waste management plan is in place and ensures maximal reuse or recycling at end of life in accordance with the waste hierarchy, including through contractual agreements with waste management partners, reflection in financial projections or official project documentation.
(5) Pollution prevention and control	N/A
(6) Protection and restoration of biodiversity and ecosystems	The activity complies with the criteria set out in Appendix D to this Annex.

Storage of thermal energy

(1) Climate change mitigation	N/A
(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.
(3) Sustainable use and protection of water and marine resources	For Aquifer Thermal Energy Storage, the activity complies with the criteria set out in Appendix B to this Annex.
(4) Transition to a circular economy	A waste management plan is in place and ensures maximal reuse, remanufacturing or recycling at end of life, including through contractual agreements with waste management partners, reflection in financial projections or official project documentation.
(5) Pollution prevention and control	N/A
(6) Protection and restoration of biodiversity and ecosystems	The activity complies with the criteria set out in Appendix D to this Annex.

Storage of hydrogen

(1) Climate change mitigation	N/A
(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.
(3) Sustainable use and protection of water and marine resources	N/A
(4) Transition to a circular economy	A waste management plan is in place and ensures maximal reuse, remanufacturing or recycling at end of life, including through contractual agreements with waste management partners, reflection in financial projections or official project documentation.
(5) Pollution prevention and control	In the case of storage above five tonnes, the activity complies with Directive 2012/18/EU of the European Parliament and of the Council.
(6) Protection and restoration of biodiversity and ecosystems	The activity complies with the criteria set out in Appendix D to this Annex.

Manufacture of biogas and biofuels for use in transport and of bioliquids

(1) Climate change mitigation	The activity meets the requirements relating to sustainability, greenhouse gas emission savings and efficiency laid down in Article 29 of Directive 2018/2001.
(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.

(3) Sustainable use and protection of water and marine resources	The activity complies with the criteria set out in Appendix B to this Annex.
(4) Transition to a circular economy	N/A
(5) Pollution prevention and control	For biogas production, a gas-tight cover on the digestate storage is applied. For anaerobic digestion plants treating over 100 tonnes per day, emissions to air and water are within or lower than the emission levels associated with the best available techniques (BAT-AEL) ranges set for anaerobic treatment of waste in the latest relevant best available techniques (BAT) conclusions, including the best available techniques (BAT) conclusions for waste treatment. No significant cross-media effects occur. In case of anaerobic digestion of organic material, where the produced digestate is used as fertiliser or soil improver, either directly or after composting or any other treatment, it meets the requirements for fertilising materials set out in Component Material Categories (CMC) 4 and 5 for digestate or CMC 3 for compost, as applicable, in Annex II to Regulation EU 2019/1009 or national rules on fertilisers or soil improvers for agricultural use.
(6) Protection and restoration of biodiversity and ecosystems	The activity complies with the criteria set out in Appendix D to this Annex.

Transmission and distribution networks for renewable and low-carbon gases

(1) Climate change mitigation	The repurposing does not increase gas transmission and distribution capacity. The repurposing does not extend the lifespan of the networks beyond their pre-retrofit projected lifespan, unless the network is dedicated to hydrogen or other low-carbon gases.
(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.
(3) Sustainable use and protection of water and marine resources	The activity complies with the criteria set out in Appendix B to this Annex.
(4) Transition to a circular economy	N/A
(5) Pollution prevention and control	Fans, compressors, pumps and other equipment used which is covered by Directive 2009/125/EC of the European Parliament and of the Council comply, where relevant, with the top class requirements

	of the energy label, and with implementing regulations under that Directive and represent the best available technology.
(6) Protection and restoration of biodiversity and ecosystems	The activity complies with the criteria set out in Appendix D to this Annex.

District heating/cooling distribution

(1) Climate change mitigation	N/A
(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.
(3) Sustainable use and protection of water and marine resources	The activity complies with the criteria set out in Appendix B to this Annex.
(4) Transition to a circular economy	N/A
(5) Pollution prevention and control	Fans, compressors, pumps and other equipment used which is covered by Directive 2009/125/EC comply, where relevant, with the top class requirements of the energy label, and otherwise comply with implementing regulations under that Directive and represent the best available technology.
(6) Protection and restoration of biodiversity and ecosystems	The activity complies with the criteria set out in Appendix D to this Annex.

Installation and operation of electric heat pumps

(1) Climate change mitigation	N/A
(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.
(3) Sustainable use and protection of water and marine resources	The activity complies with the criteria set out in Appendix B to this Annex.
(4) Transition to a circular economy	The activity assesses availability of and, where feasible, uses equipment and components of high durability and recyclability and that are easy to dismantle and refurbish. A waste management plan is in place and ensures maximal reuse, remanufacturing or recycling at end of life, including through contractual agreements with waste management partners, reflection in financial projections or official project documentation.

(5) Pollution prevention and control	For air to air heat pumps with rated capacity of 12 kW or below, indoor and outdoor sound power levels are below the threshold set out in Commission Regulation (EU) No 206/2012
(6) Protection and restoration of biodiversity and ecosystems	N/A

Production of heat/cool using waste heat

(1) Climate change mitigation	N/A
(2) Climate change adaptation	The activity complies with the criteria set out in Appendix A to this Annex.
(3) Sustainable use and protection of water and marine resources	N/A
(4) Transition to a circular economy	The activity assesses availability of and, where feasible, uses equipment and components of high durability and recyclability and that are easy to dismantle and refurbish.
(5) Pollution prevention and control	Pumps and the kind of equipment used, which is covered by Ecodesign and Energy labelling comply, where relevant, with the top class requirements of the energy label laid down in Regulation (EU) 2017/1369, and with implementing regulations under Directive 2009/125/EC and represent the best available technology.
(6) Protection and restoration of biodiversity and ecosystems	The activity complies with the criteria set out in Appendix D to this Annex.

Generic DNSH criteria, Appendix A to D

Appendix A – Generic criteria for DNSH to climate change adaptation

The physical climate risks that are material to the activity have been identified from those listed in the table in Section II of this Appendix by performing a robust climate risk and vulnerability assessment with the following steps:

(a) screening of the activity to identify which physical climate risks from the list in Section II of this Appendix may affect the performance of the economic activity during its expected lifetime;

(b) where the activity is assessed to be at risk from one or more of the physical climate risks listed in Section II of this Appendix, a climate risk and vulnerability assessment to assess the materiality of the physical climate risks on the economic activity;

(c) an assessment of adaptation solutions that can reduce the identified physical climate risk.

The climate risk and vulnerability assessment is proportionate to the scale of the activity and its expected lifespan, such that:

(a) for activities with an expected lifespan of less than 10 years, the assessment is performed, at least by using climate projections at the smallest appropriate scale;

(b) for all other activities, the assessment is performed using the highest available resolution, state-of-the-art climate projections across the existing range of future scenarios consistent with the expected lifetime of the activity, including, at least, 10 to 30 year climate projections scenarios for major investments.

The climate projections and assessment of impacts are based on best practice and available guidance and take into account the state-of-the-art science for vulnerability and risk analysis and related methodologies in line with the most recent Intergovernmental Panel on Climate Change reports, scientific peer-reviewed publications, and open source or paying models.

For existing activities and new activities using existing physical assets, the economic operator implements physical and non-physical solutions ('adaptation solutions'), over a period of time of up to five years, that reduce the most important identified physical climate risks that are material to that activity. An adaptation plan for the implementation of those solutions is drawn up accordingly.

For new activities and existing activities using newly-built physical assets, the economic operator integrates the adaptation solutions that reduce the most important identified physical climate risks that are material to that activity at the time of design and construction and has implemented them before the start of operations.

The adaptation solutions implemented do not adversely affect the adaptation efforts or the level of resilience to physical climate risks of other people, of nature, of cultural heritage, of assets and of other economic activities; are consistent with local, sectoral, regional or national adaptation strategies and plans; and consider the use of nature- based solutions or rely on blue or green infrastructure to the extent possible.

Appendix B – Generic criteria for DNSH to sustainable use and protection of water and marine resources

Environmental degradation risks related to preserving water quality and avoiding water stress are identified and addressed with the aim of achieving good water status and good ecological potential as defined in Article 2, points (22) and (23), of Regulation (EU) 2020/852, in accordance with Directive 2000/60/EC of the European Parliament and of the Council (1) and a water use and protection management plan, developed thereunder for the potentially affected water body or bodies, in consultation with relevant stakeholders.

Where an Environmental Impact Assessment is carried out in accordance with Directive 2011/92/EU of the European Parliament and of the Council (2) and includes an assessment of the impact on water in accordance with Directive 2000/60/EC, no additional assessment of impact on water is required, provided the risks identified have been addressed.

Appendix C – Generic criteria for DNSH to pollution prevention and control regarding use and presence of chemicals

The activity does not lead to the manufacture, placing on the market or use of:

(a) substances, whether on their own, in mixtures or in articles, listed in Annexes I or II to Regulation (EU) 2019/1021 of the European Parliament and of the Council, except in the case of substances present as an unintentional trace contaminant;

(b) mercury and mercury compounds, their mixtures and mercury-added products as defined in Article 2 of Regulation (EU) 2017/852 of the European Parliament and of the Council;

(c) substances, whether on their own, in mixture or in articles, listed in Annexes I or II to Regulation (EC) No 1005/2009 of the European Parliament and of the Council;

(d) substances, whether on their own, in mixtures or in an articles, listed in Annex II to Directive 2011/65/EU of the European Parliament and of the Council, except where there is full compliance with Article 4(1) of that Directive;

(e) substances, whether on their own, in mixtures or in an article, listed in Annex XVII to Regulation (EC) 1907/2006 of the European Parliament and of the Council, except where there is full compliance with the conditions specified in that Annex;

(f) substances, whether on their own, in mixtures or in an article, meeting the criteria laid down in Article 57 of Regulation (EC) 1907/2006 and identified in accordance with Article 59(1) of that Regulation, except where their use has been proven to be essential for the society;

(g) other substances, whether on their own, in mixtures or in an article, that meet the criteria laid down in Article 57 of Regulation (EC) 1907/2006, except where their use has been proven to be essential for the society.

Appendix D – Generic criteria for DNSH to protection and restoration of biodiversity and ecosystems

An Environmental Impact Assessment (EIA) or screening has been completed in accordance with Directive 2011/92/EU.

Where an EIA has been carried out, the required mitigation and compensation measures for protecting the environment are implemented.

For sites/operations located in or near biodiversity-sensitive areas (including the Natura 2000 network of protected areas, UNESCO World Heritage sites and Key Biodiversity Areas, as well as other protected areas), an appropriate assessment, where applicable, has been conducted and based on its conclusions the necessary mitigation measures are implemented.

4. Gas and nuclear activities in the EU taxonomy

On February 2nd, 2022, the EU Commission adopted a Complementary Climate Delegated Act (the "CCDA") on climate change mitigation and adaptation covering certain gas and nuclear activities. Its formal adoption in all EU official languages took place on March 9th, 2022.

The text sets out conditions, under Article 10(2) of the Taxonomy Regulation, subject to which certain nuclear and gas activities can be added as transitional activities to those already covered by the first Delegated Act. These stringent conditions are: for both gas and nuclear, that they contribute to the transition to climate neutrality; for nuclear, that it fulfils nuclear and environmental safety requirements; and for gas, that it contributes to the transition from coal to renewables.

More specific additional conditions apply for all the above activities and are specified in the Annex I (European Commission 2022a) and Annex II (European Commission 2022b) of the CCDA.

The activities included in the CCDA are the following:

Table 20: Economic nuclear and gas activities and their corresponding NACE codes

Economic activity	Corresponding NACE codes
Pre-commercial stages of advanced technologies to produce energy from nuclear processes with minimal waste from the fuel cycle	M72 | M72.1
Construction and safe operation of new nuclear power plants, for the generation of electricity or heat, including for hydrogen production, using best-available technologies	D35.11 | F42.22
Electricity generation form nuclear energy in existing installations	D35.11 | F42.22
Electricity generation from fossil gaseous fuels	D35.11 | F42.22
High efficiency co-generation of heat/cool and power from fossil gaseous fuels	D35.11 | D35.30
Production of heat/cool from fossil gaseous fuels in an efficient district heating and cooling system	D35.30

As for the other Delegated Acts under the Taxonomy Regulation, the European Parliament and the Council (who have delegated the power to the Commission to adopt Delegated Acts under the Taxonomy Regulation) have

four months to scrutinise the document and to object to it. The Council will have the right to object to it by reinforced qualified majority, which means that at least 72% of Member States (i.e. at least 20 Member States) representing at least 65% of the EU population are needed to object to the Delegated Act. The European Parliament can object by a majority of its members voting against in plenary (i.e. at least 353 MEPs).

Once the scrutiny period is over and if neither of the co-legislators objects, the Complementary Delegated Act will enter into force and apply as of 1 January 2023.

On June 14, the European Parliament's environment and economy committees voted against the inclusion of gas and nuclear in the EU's list of environmentally sustainable investments, by a margin of 76-62, with four abstentions. This vote does not have a direct impact but gave an idea of the tendencies at the EU Parliament.

The motion was submitted again for a decisive vote at the Parliament's July plenary, where European Union lawmakers voted to allow natural gas and nuclear energy to be labelled as green investments. Regulation will most likely enter into force at start of 2023.

General criteria pertaining to substantial contribution to climate change mitigation and Do no significant harm ('DNSH')

Pre-commercial stages of advanced technologies to produce energy from nuclear processes with minimal waste from the fuel cycle

1. The project related to the economic activity ('the project') is located in a Member State which complies with all of the following:

(a) the Member State has fully transposed Council Directive 2009/71/Euratom*1 and Council Directive 2011/70/Euratom;

(b) the Member State complies with the Treaty establishing the European Atomic Energy Community ('Euratom Treaty') and with legislation adopted on its basis, in particular, Directive 2009/71/Euratom, Directive 2011/70/Euratom and Council Directive 2013/59/Euratom, as well as applicable Union environmental law adopted under Article 192 TFEU, in particular Directive 2011/92/EU of the European Parliament and of the Council and Directive 2000/60/EC of the European Parliament and of the Council;

(c) the Member State has in place, as of the approval date of the project, a radioactive waste management fund and a nuclear decommissioning fund which can be combined;

(d) the Member State has demonstrated that it will have resources available at the end of the estimated useful life of the nuclear power plant corresponding to the estimated cost of radioactive waste management and decommissioning in compliance with Commission Recommendation 2006/851/Euratom;

(e) the Member State has operational final disposal facilities for all very low-, low- and intermediate-level radioactive waste, notified to the Commission under Article 41 Euratom Treaty or Article 1(4) of Council Regulation (Euratom) No 2587/1999, and included in the national programme updated under Directive 2011/70/Euratom;

(f) the Member State has a documented plan with detailed steps to have in operation, by 2050, a disposal facility for high-level radioactive waste describing all of the following:

(i) concepts or plans and technical solutions for spent fuel and radioactive waste management from generation to disposal;

(ii) concepts or plans for the post-closure period of a disposal facility's lifetime, including the period during which appropriate controls are retained and the means to be employed to preserve knowledge of that facility in the longer term;

(iii) the responsibilities for the plan implementation and the key performance indicators to monitor its progress;

(iv) cost assessments and financing schemes.

For the purposes of point (f), Member States may use plans drawn up as part of the national programme required by Articles 11 and 12 of Directive 2011/70/Euratom.

2. The project is part of a Union financed research programme or the project has been notified to the Commission in accordance with Article 41 of the Euratom Treaty or with Article 1(4) of Council Regulation (Euratom) No 2587/1999, where either of these provisions is applicable, the Commission has given its opinion on it in accordance with Article 43 of the Euratom Treaty, and all the issues raised in the opinion, with relevance for the application of Article 10(2) and Article 17 of Regulation (EU) 2020/852, and of the technical screening criteria laid down in this Section have been satisfactorily addressed.

3. The Member State concerned has committed to report to the Commission every five years for each project on all of the following:

(a) the adequacy of the accumulated resources referred to in point 1(c);

(b) actual progress in the implementation of the plan referred to in point 1(f).

On the basis of the reports, the Commission shall review the adequacy of the accumulated resources of the radioactive waste management fund and the nuclear decommissioning fund referred to in point 1(c) and the progress in the implementation of the documented plan referred to in point 1(f) and it may address an opinion to the Member State concerned.

4. The activity complies with national legislation that transposes the legislation referred to in point 1(a) and (b), including as regards the evaluation, in particular through stress tests, of the resilience of the nuclear power plants located on the territory of the Union against extreme natural hazards, including earthquakes. Accordingly, the activity takes place on the territory of a Member State where the operator of a nuclear installation:

(a) has submitted a demonstration of nuclear safety, whose scope and level of detail is commensurate with the potential magnitude and nature of the hazard relevant for the nuclear installation and its site (Article 6, point (b), of Directive 2009/71/Euratom);

(b) has taken defence-in-depth measures to ensure, inter alia, that the impact of extreme external natural and unintended man-made hazards is minimised (Article 8b(1), point (a) of Directive 2009/71/Euratom);

(c) has performed an appropriate site and installation-specific assessment when the operator concerned applies for a licence to construct or operate a nuclear power plant (Article 8c(a) of Directive 2009/71/Euratom).

5. The activity fulfils the requirements of Directive 2009/71/Euratom, supported by the latest international guidance from the International Atomic Energy Agency ('IAEA') and the Western European Nuclear Regulator's Association ('WENRA'), contributing to increasing the resilience and the ability of new and existing nuclear power plants to cope with extreme natural hazards, including floods and extreme weather conditions.

6. Radioactive waste as referred to in point 1(e) and (f), is disposed of in the Member State in which it was generated, unless there is an agreement between the Member State concerned and the Member State of destination, as established in Directive 2011/70/Euratom. In that case, the Member State of destination has radioactive waste management and disposal programmes and a suitable disposal facility in operation in compliance with the requirements of Directive 2011/70/Euratom.

Construction and safe operation of new nuclear power plants, for the generation of electricity or heat, including for hydrogen production, using best-available technologies

1. The project related to the economic activity ('the project') is located in a Member State which complies with all of the following:

(a) the Member State has fully transposed Council Directive 2009/71/Euratom and Council Directive 2011/70/Euratom;

(b) the Member State complies with the Euratom Treaty and with legislation adopted on its basis, in particular, Directive 2009/71/Euratom, Directive 2011/70/Euratom and Directive 2013/59/Euratom, as well as applicable Union environmental law adopted under Article 192 TFEU, in particular Directive 2011/92/EU and Directive 2000/60/EC;

(c) the Member State has in place, as of the approval date of the project, a radioactive waste management fund and a nuclear decommissioning fund which can be combined;

(d) the Member State has demonstrated that it will have resources available at the end of the estimated useful life of the nuclear power plant corresponding to the estimated cost of radioactive waste management and decommissioning in compliance with Recommendation 2006/851/Euratom;

(e) the Member State has operational final disposal facilities for all very low-, low- and intermediate-level radioactive waste, notified to the Commission under Article 41 of the Euratom Treaty or under Article 1(4) of Council Regulation 2587/1999 and included in the national programme updated under Council Directive 2011/70/Euratom;

(f) the Member State has a documented plan with detailed steps to have in operation, by 2050, a disposal facility for high-level radioactive waste describing all of the following:

(i) concepts or plans and technical solutions for spent fuel and radioactive waste management from generation to disposal;

(ii) concepts or plans for the post-closure period of a disposal facility's lifetime, including the period during which appropriate controls are retained and the means to be employed to preserve knowledge of that facility in the longer term;

(iii) the responsibilities for the plan implementation and the key performance indicators to monitor its progress;

(iv) cost assessments and financing schemes.

For the purposes of point (f), Member States may use the plans drawn up as part of the national programme required by Articles 11 and 12 of Directive 2011/70/Euratom.

2. The project fully applies the best-available technology and from 2025 accident-tolerant fuel. The technology is certified and approved by the national safety regulator.

3. The project has been notified to the Commission in accordance with Article 41 of the Euratom Treaty or with Article 1(4) of Council Regulation 2587/1999, where either of these provisions is applicable, the Commission has given its opinion on it in accordance with Article 43 of the Euratom Treaty, and all the issues raised in the opinion, with relevance for the application of Article 10(2) and Article 17 of Regulation (EU) 2020/852, and of the technical screening criteria laid down in this Section, have been satisfactorily addressed.

4. The Member State concerned has committed to report to the Commission every five years for each project on all of the following:

(a) the adequacy of the accumulated resources referred to in point 1(c);

(b) actual progress in the implementation of the plan referred to in point 1(f).

On the basis of the reports, the Commission shall review the adequacy of the accumulated resources of the radioactive waste management fund and the nuclear decommissioning fund referred to in point 1(c) and the progress in the implementation of the documented plan referred to in point 1(f) and it may address an opinion to the Member State concerned.

5. The Commission shall review, as of 2025 and at least every 10 years, the technical parameters corresponding to the best-available technology on the basis of the assessment by the European Nuclear Safety Regulators' Group ('ENSREG').

6. The activity complies with national legislation that transposes the legislation referred to in point 1(a) and (b), including as regards the evaluation, in particular through stress-tests, of the resilience of the nuclear power plants located on the territory of the Union against extreme natural hazards, including earthquakes. Accordingly, the activity takes place on the territory of a Member State where the operator of a nuclear installation:

(a) has submitted a demonstration of nuclear safety, whose scope and level of detail is commensurate with the potential magnitude and nature of the hazard relevant for the nuclear installation and its site (Article 6, point (b), of Directive 2009/71/Euratom);

(b) has taken defence-in-depth measures to ensure, inter alia, that the impact of extreme external natural and unintended man-made hazards is minimised (Article 8b(1), point (a), of Directive 2009/71/Euratom);

(c) has performed an appropriate site and installation-specific assessment when the operator concerned applies for a licence to construct or operate a nuclear power plant (Article 8c(a) of Directive 2009/71/Euratom).

7. The activity fulfils the requirements of Directive 2009/71/Euratom, supported by the latest international guidance from the IAEA and WENRA, contributing to increasing the resilience and the ability of new and existing nuclear power plants to cope with extreme natural hazards, including floods and extreme weather conditions.

8. Radioactive waste as referred to in point 1 (e) and (f) is disposed of in the Member State in which it was generated, unless there is an agreement between the Member State concerned and the Member State of destination, as established in Directive 2011/70/Euratom. In that case, the Member State of destination has radioactive waste management and disposal programmes and a suitable disposal facility in operation in compliance with the requirements of Directive 2011/70/Euratom.

Electricity generation form nuclear energy in existing installations

1. The project related to the economic activity ('the project') is located in a Member State which complies with all of the following:

(a) the Member State has fully transposed Council Directive 2009/71/Euratom and Council Directive 2011/70/Euratom;

(b) the Member State complies with the Euratom Treaty and with legislation adopted on its basis, in particular, Directive 2009/71/Euratom, Directive 2011/70/Euratom and Directive 2013/59/Euratom, and with applicable Union environmental law adopted under Article 192 TFEU, in particular Directive 2011/92/EU and Directive 2000/60/EC;

(c) the Member State has in place, as of the approval date of the project, a radioactive waste management fund and a nuclear decommissioning fund which can be combined;

(d) the Member State has demonstrated that it will have resources available at the end of the estimated useful life of the nuclear power plant corresponding to the estimated cost of radioactive waste management and decommissioning in compliance with Recommendation 2006/851/Euratom;

(e) the Member State has operational final disposal facilities for all very low-, low- and intermediate-level radioactive waste, notified to the Commission under Article 41 of the Euratom Treaty or under Article 1(4) of Council Regulation 2587/1999 and included in the national programme updated under Council Directive 2011/70/Euratom;

(f) for projects authorised after 2025, the Member State has a documented plan with detailed steps to have in operation, by 2050, a disposal facility for high-level radioactive waste describing all of the following:

(i) concepts or plans and technical solutions for spent fuel and radioactive waste management from generation to disposal;

(ii) concepts or plans for the post-closure period of a disposal facility's lifetime, including the period during which appropriate controls are retained and the means to be employed to preserve knowledge of that facility in the longer term;

(iii) the responsibilities for the plan implementation and the key performance indicators to monitor its progress;

(iv) cost assessments and financing schemes.

For the purposes of point (f), Member States may use the plans drawn up as part of the national programme required by Articles 11 and 12 of Directive 2011/70/Euratom.

2. The upgraded project implements any reasonably practicable safety improvement and from 2025 makes use of accident-tolerant fuel. The technology is certified and approved by the national safety regulator.

3. The project has been notified to the Commission in accordance with Article 41 of the Euratom Treaty or with Article 1(4) of Council Regulation 2587/1999, where either of these provisions is applicable, the Commission has given its opinion on it in accordance with Article 43 of the Euratom Treaty, and all the issues raised in the opinion, with relevance for the application of Article 10(2) and Article 17 of Regulation (EU) 2020/852, and of the technical screening criteria laid down in this Section, have been satisfactorily addressed.

4. The Member State concerned has committed to report to the Commission every five years for each project on all of the following:

(a) the adequacy of the accumulated resources referred to in point 1(c);

(b) actual progress in the implementation of the plan referred to in point 1(f).

On the basis of the reports, the Commission shall review the adequacy of the accumulated resources of the radioactive waste management fund and the nuclear decommissioning fund referred to in point 1(c) and the progress in the implementation of the documented plan referred to in point 1(f) and it may address an opinion to the Member State concerned.

5. The activity complies with national legislation that transposes the legislation referred to in point 1 (a) and (b), including as regards the evaluation, in particular through stress-tests, of the resilience of the Union nuclear power plants against extreme natural hazards, including earthquakes. Accordingly, the activity takes place on the territory of a Member State where the operator of a nuclear installation:

(a) has submitted a demonstration of nuclear safety, whose scope and level of detail is commensurate with the potential magnitude and nature of the hazard relevant for the nuclear installation and its site (Article 6, point (b), of Directive 2009/71/Euratom);

(b) has taken defence-in-depth measures to ensure, inter alia, that the impact of extreme external natural and unintended man-made hazards is minimised (Article 8b(1), point (a), of Directive 2009/71/Euratom);

(c) has performed an appropriate site and installation-specific assessment when the operator concerned applies for a licence to construct or operate a nuclear power plant (Article 8c(a) of Directive 2009/71/Euratom).

6. The activity fulfils the requirements of Directive 2009/71/Euratom, supported by the latest international guidance from the IAEA and WENRA, contributing to increasing the resilience and the ability of new and existing nuclear power plants to cope with extreme natural hazards, including floods and extreme weather conditions.

7. Radioactive waste referred to in point 1 (e) and (f) is disposed of in the Member State in which it was generated, unless there is an agreement between the Member State concerned and the Member State of destination, as established in Directive 2011/70/Euratom. In that case, the Member State of destination has radioactive waste management and disposal programmes and a suitable disposal facility in operation in compliance with the requirements of Directive 2011/70/Euratom.

Electricity generation from fossil gaseous fuels

1. The activity meets either of the following criteria:

(a) the life-cycle GHG emissions from the generation of electricity using fossil gaseous fuels are lower than 100 g CO2e/kWh.

Life-cycle GHG emissions are calculated based on project-specific data, where available, using Recommendation 2013/179/EU or, alternatively, using ISO 14067:2018 or ISO 14064-1:2018.

Quantified life-cycle GHG emissions are verified by an independent third party.

Where facilities incorporate any form of abatement, including carbon capture or use of renewable or low-carbon gases, that abatement activity complies with the criteria set out in the relevant Section of this Annex, where applicable. Where the CO2 that would otherwise be emitted from the electricity generation process is captured for the purpose of underground storage, the CO2 is transported and stored underground, in accordance with the technical screening criteria set out in Sections 5.11 and 5.12 of this Annex.

(b) facilities for which the construction permit is granted by 31 December 2030 comply with all of the following:

(i) direct GHG emissions of the activity are lower than 270g CO2e/kWh of the output energy, or annual direct GHG emissions of the activity do not exceed an average of 550kgCO2e/kW of the facility's capacity over 20 years;

(ii) the power to be replaced cannot be generated from renewable energy sources, based on a comparative assessment with the most cost-effective and technically feasible renewable alternative for the same capacity identified; the result of this comparative assessment is published and is subject to a stakeholder consultation;

(iii) the activity replaces an existing high emitting electricity generation activity that uses solid or liquid fossil fuels;

(iv) the newly installed production capacity does not exceed the capacity of the replaced facility by more than 15%;

(v) the facility is designed and constructed to use renewable and/or low-carbon gaseous fuels and the switch to full use of renewable and/or low-carbon gaseous fuels takes place by 31 December 2035, with a commitment and verifiable plan approved by the management body of the undertaking;

(vi) the replacement leads to a reduction in emissions of at least 55% GHG over the lifetime of the newly installed production capacity;

(vii) where the activity takes place on the territory of a Member State in which coal is used for energy generation, that Member State has committed to phase-out the use of energy generation from coal and has reported this in its integrated national energy and climate plan referred to in Article 3 of Regulation (EU) 2018/1999 of the European Parliament and of the Council*8 or in another instrument.

Compliance with the criteria referred to in point 1(b) is verified by an independent third party. The independent third-party verifier has the necessary resources and expertise to perform such verification. The independent third party verifier does not have any conflict of interest with the owner or the funder, and is not involved in the development or operation of the activity. The independent third party verifier carries out diligently the verification of compliance with the technical screening criteria. In particular, every year the independent third party publishes and transmits to the Commission a report:

(a) certifying the level of direct GHG emissions referred to in point 1(b)(i);

(b) where applicable, assessing whether annual direct GHG emissions of the activity are on a credible trajectory to comply with the average threshold over 20 years referred to in point 1(b)(i);

(c) assessing whether the activity is on a credible trajectory to comply with point 1(b)(v).

When undertaking the assessment referred to in point 1(b), the independent third party verifier takes into account in particular the planned annual direct GHG emissions for each year of the trajectory, realised annual direct GHG emissions, planned and realised operating hours, and planned and realised use of renewable or low carbon gases.

On the basis of the reports transmitted to it, the Commission may address an opinion to the relevant operators. The Commission shall take those reports into account when performing the review referred to in Article 19(5) of Regulation (EU) 2020/852.

2. The activity meets either of the following criteria:

(a) at construction, measurement equipment for monitoring of physical emissions, such as those from methane leakage, is installed or a leak detection and repair programme is introduced;

(b) at operation, physical measurement of emissions are reported and leak is eliminated.

3. Where the activity blends fossil gaseous fuels with gaseous or liquid biofuels, the agricultural biomass used for the production of the biofuels complies with the criteria laid down in Article 29, paragraphs 2 to 5, of Directive (EU) 2018/2001 while forest biomass complies with the criteria laid down in Article 29, paragraphs 6 and 7, of that Directive.

High efficiency co-generation of heat/cool and power from fossil gaseous fuels

1. The activity meets either of the following criteria:

(a) the life-cycle GHG emissions from the co-generation of heat/cool and power from gaseous fuels are lower than 100 g CO2e per 1 kWh of energy output of the co-generation.

Life-cycle GHG emissions are calculated based on project-specific data, where available, using Recommendation 2013/179/EU or, alternatively, using ISO 14067:2018 or ISO 14064-1:2018.

Quantified life-cycle GHG emissions are verified by an independent third party.

Where facilities incorporate any form of abatement, including carbon capture or use of renewable or low-carbon gases, that abatement activity complies with the relevant Sections of this Annex, where applicable. Where the CO2 emitted from the electricity generation is captured, the CO2 shall meet the emissions limit set out in point 1 of this Section and, the CO2 be transported and stored underground in a way that meets the technical screening criteria for transport of CO2 and storage of CO2 set out in Sections 5.11 and 5.12, respectively of this Annex.

(b) facilities for which the construction permit is granted by 31 December 2030 comply with all of the following:

(i) the activity achieves primary energy savings of at least 10% compared with the references to separate production of heat and electricity; the primary energy savings are calculated on the basis of formula provided in Directive 2012/27/EU;

(ii) direct GHG emissions of the activity are lower than 270 g CO2e/kWh of the output energy;

(iii) the power and/or heat/cool to be replaced cannot be generated from renewable energy sources, based on a comparative assessment with the most cost-effective and technically feasible renewable alternative for the same capacity identified; the result of this comparative assessment is published and is subject to a stakeholder consultation;

(iv) the activity replaces an existing high emitting combined heat/cool and power generation activity, a separate heat/cool generation activity, or a separate power generation activity that uses solid or liquid fossil fuels;

(v) the newly installed production capacity does not exceed the capacity of the replaced facility;

(vi) the facility is designed and constructed to use renewable and/or low-carbon gaseous fuels and the switch to full use of renewable and/or low-carbon gaseous fuels takes place by 31 December 2035, with a commitment and verifiable plan approved by the management body of the undertaking;

(vii) the replacement leads to a reduction in emissions of at least 55% GHG per kWh of output energy;

(viii) the refurbishment of the facility does not increase production capacity of the facility;

(ix) where the activity takes place on the territory of a Member State in which coal is used for energy generation, that Member State has committed to phase-out the use of energy generation from coal and has

reported this in its integrated national energy and climate plan referred to in Article 3 of Regulation (EU) 2018/1999 or in another instrument.

Compliance with the criteria referred to in point 1(b) is verified by an independent third party. The independent third party verifier has the necessary resources and expertise to perform such verification. The independent third party verifier does not have any conflict of interest with the owner or the funder, and is not involved in the development or operation of the activity. The independent third party verifier carries out diligently the verification of compliance with the technical screening criteria. In particular, every year the independent third party publishes and transmits to the Commission a report:

(a) certifying the level of direct GHG emissions referred to in point 1(b)(ii);

(b) assessing whether the activity is on a credible trajectory to comply with point 1(b)(vi).

On the basis of the reports transmitted to it, the Commission may address an opinion to the operators concerned. The Commission shall take those reports into account when performing the review referred to in Article 19(5) of Regulation (EU) 2020/852.

2. The activity meets either of the following criteria:

(a) at construction, measurement equipment for monitoring of physical emissions, including those from methane leakage, is installed or a leak detection and repair program is introduced;

(b) at operation, physical measurement of emissions are reported and any leak is eliminated.

Production of heat/cool from fossil gaseous fuels in an efficient district heating and cooling system

1. The activity meets either of the following criteria:

(a) Life-cycle GHG emissions from the generation of heat/cool from gaseous fuels are lower than 100 g CO2e/kWh. Life-cycle GHG emission savings are calculated using Recommendation 2013/179/EU or, alternatively, using ISO 14067:2018 or ISO 14064-1:2018.

Quantified life-cycle GHG emissions are verified by an independent third party.

Where facilities incorporate any form of abatement, including carbon capture or use of renewable or low-carbon gases, that abatement activity complies with the relevant Sections of this Annex, where applicable. Where the CO2 emitted from the electricity generation is captured, the CO2 shall meet the emissions limit set out in point 1 of this Section and shall be transported and stored underground in a way that meets the technical screening criteria for transport of CO2 and storage of CO2 set out in Sections 5.11 and 5.12, respectively of this Annex.

(b) facilities for which the construction permit is granted by 31 December 2030 comply with all of the following:

(i) the thermal energy generated by the activity is used in an efficient district heating and cooling system as defined in Directive 2012/27/EU;

(ii) the direct GHG emissions of the activity are lower than 270 g CO2e/kWh of the output energy;

(iii) the heat/cool to be replaced cannot be generated from renewable energy sources, based on a comparative assessment with the most cost-effective and technically feasible renewable alternative for the same capacity identified; the result of this comparative assessment is published and is subject to a stakeholder consultation;

(iv) the activity replaces an existing high emitting heating/cooling activity using solid or liquid fossil fuel;

(v) the newly installed production capacity does not exceed the capacity of the replaced facility;

(vi) the facility is designed and constructed to use renewable and/or low-carbon gaseous fuels and the switch to full use of renewable and/or low-carbon gaseous fuels takes place by 31 December 2035, with a commitment and verifiable plan approved by the management body of the undertaking;

(vii) the replacement leads to a reduction in emissions of at least 55% GHG per kWh of output energy;

(viii) the refurbishment of the facility does not increase production capacity of the facility;

(ix) where the activity takes place on the territory of a Member State in which coal is used for energy generation, that Member State has committed to phase-out the use of energy generation from coal and has reported this in its integrated national energy and climate plan referred to in Article 3 of Regulation (EU) 2018/1999 or in another instrument.

Compliance with the criteria referred to in point 1(b) is verified by an independent third party. The independent third-party verifier has the necessary resources and expertise to perform such verification. The independent third party verifier does not have any conflict of interest with the owner or the funder, and is not be involved in the development or operation of the activity. The independent third party verifier carries out diligently the verification of compliance with the technical screening criteria. In particular, every year the independent third party publishes and transmits to the Commission a report:

(a) certifying the level of direct GHG emissions referred to in point 1(b)(ii);

(b) assessing whether the activity is on a credible trajectory to comply with point 1(b)(vi).

On the basis of the reports transmitted to it, the Commission may address an opinion to the operators concerned. The Commission shall take those reports into account when performing the review referred to in Article 19(5) of Regulation (EU) 2020/852.

2. The activity meets either of the following criteria:

(a) at construction, measurement equipment for monitoring of physical emissions, such as those from methane leakage, is installed or a leak detection and repair program is introduced;

(b) at operation, physical measurement of emissions are reported and any leak is eliminated.

General criteria pertaining to substantial contribution to climate change adaptation

Pre-commercial stages of advanced technologies to produce energy from nuclear processes with minimal waste from the fuel cycle

Construction and safe operation of new nuclear power plants, for the generation of electricity or heat, including for hydrogen production, using best-available technologies

Electricity generation form nuclear energy in existing installations

1. The economic activity has implemented physical and non-physical solutions ('adaptation solutions') that substantially reduce the most important physical climate risks that are material to that activity.

2. The physical climate risks that are material to the activity have been identified from those listed in Appendix A to this Annex by performing a robust climate risk and vulnerability assessment with the following steps:

(a) screening of the activity to identify which physical climate risks from the list in Appendix A to this Annex may affect the performance of the economic activity during its expected lifetime;

(b) where the activity is assessed to be at risk from one or more of the physical climate risks listed in Appendix A to this Annex, a climate risk and vulnerability assessment to assess the materiality of the physical climate risks on the economic activity;

(c) an assessment of adaptation solutions that can reduce the identified physical climate risk.

The climate risk and vulnerability assessment is proportionate to the scale of the activity and its expected lifespan, such that:

(a) for activities with an expected lifespan of less than 10 years, the assessment is performed, at least by using climate projections at the smallest appropriate scale;

(b) for all other activities, the assessment is performed using the highest available resolution, state-of-the-art climate projections across the existing range of future scenarios1 consistent with the expected lifetime of the activity, including, at least, 10 to 30 year climate projections scenarios for major investments.

3. The climate projections and assessment of impacts are based on best practice and available guidance and take into account the state-of-the-art science for vulnerability and risk analysis and related methodologies in line with the most recent Intergovernmental Panel on Climate Change reports2 , scientific peer-reviewed publications and open source3 or paying models.

4. The adaptation solutions implemented:

(a) do not adversely affect the adaptation efforts or the level of resilience to physical climate risks of other people, of nature, of cultural heritage, of assets and of other economic activities;

(b) favour nature-based solutions4 or rely on blue or green infrastructure5 to the extent possible;

(c) are consistent with local, sectoral, regional or national adaptation plans and strategies;

(d) are monitored and measured against pre-defined indicators and remedial action is considered where those indicators are not met;

(e) where the solution implemented is physical and consists in an activity for which technical screening criteria have been specified in this Annex, the solution complies with the do no significant harm technical screening criteria for that activity.

5. The activity complies with the provisions laid down in the Euratom Treaty and the legislation adopted on its basis, in particular, Directive 2013/59/Euratom, Directive 2009/71/Euratom, and Directive 2011/70/Euratom as well as applicable Union environmental law adopted under Article 192 TFEU, in particular Directive 2011/92/EU and Directive 2000/60/EC.

6. The activity complies with national legislation that transposes Directive 2009/71/Euratom, including as regards the evaluation, through stress-tests, of the resilience of the Union nuclear power plants against extreme natural hazards, including earthquakes. Accordingly, the activity takes place on the territory of a Member State where the operator of a nuclear installation:

(a) has submitted a demonstration of nuclear safety, whose scope and level of detail is commensurate with the potential magnitude and nature of the hazard relevant for the nuclear installation and its site (Article 6, point (b), of Directive 2009/71/Euratom);

(b) has taken defence-in-depth measures to ensure, inter alia, that the impact of extreme external natural and unintended man-made hazards is minimised (Article 8b(1), point (a), of Directive 2009/71/Euratom);

(c) has performed an appropriate site and installation-specific assessment when the operator concerned applies for a licence to construct or operate a nuclear power plant (Article 8c(a) of Directive 2009/71/Euratom).

The activity fulfils the requirements of Directive 2009/71/Euratom, supported by the latest international guidance through the IAEA and WENRA, contributing to increasing the resilience and the ability of new and existing nuclear power plants to cope with extreme natural hazards, including floods and extreme weather conditions.

Electricity generation from fossil gaseous fuels

High efficiency co-generation of heat/cool and power from fossil gaseous fuels

Production of heat/cool from fossil gaseous fuels in an efficient district heating and cooling system

1. The economic activity has implemented physical and non-physical solutions (‘adaptation solutions’) that substantially reduce the most important physical climate risks that are material to that activity.

2. The physical climate risks that are material to the activity have been identified from those listed in Appendix A to this Annex by performing a robust climate risk and vulnerability assessment with the following steps:

(a) screening of the activity to identify which physical climate risks from the list in Appendix A to this Annex may affect the performance of the economic activity during its expected lifetime;

(b) where the activity is assessed to be at risk from one or more of the physical climate risks listed in Appendix A to this Annex, a climate risk and vulnerability assessment to assess the materiality of the physical climate risks on the economic activity;

(c) an assessment of adaptation solutions that can reduce the identified physical climate risk.

The climate risk and vulnerability assessment is proportionate to the scale of the activity and its expected lifespan, such that:

(a) for activities with an expected lifespan of less than 10 years, the assessment is performed, at least by using climate projections at the smallest appropriate scale;

(b) for all other activities, the assessment is performed using the highest available resolution, state-of-the-art climate projections across the existing range of future scenarios16 consistent with the expected lifetime of the activity, including, at least, 10 to 30 year climate projections scenarios for major investments.

3. The climate projections and assessment of impacts are based on best practice and available guidance and take into account the state-of-the-art science for vulnerability and risk analysis and related methodologies in line with the most recent Intergovernmental Panel on Climate Change reports17, scientific peer-reviewed publications and open source18 or paying models.

4. The adaptation solutions implemented:

(a) do not adversely affect the adaptation efforts or the level of resilience to physical climate risks of other people, of nature, of cultural heritage, of assets and of other economic activities;

(b) favour nature-based solutions19 or rely on blue or green infrastructure20 to the extent possible;

(c) are consistent with local, sectoral, regional or national adaptation plans and strategies;

(d) are monitored and measured against pre-defined indicators and remedial action is considered where those indicators are not met;

(e) where the solution implemented is physical and consists in an activity for which technical screening criteria have been specified in this Annex, the solution complies with the do no significant harm technical screening criteria for that activity.

E. SOURCES

American Wind Wildlife Institute (AWWI). « Wind Turbine Interactions with Wildlife and Their Habitats: A Summary of Research Results and Priority Questions. », 2020. https://tethys.pnnl.gov/sites/default/files/publications/AWWI-Wind-Power-Wildlife-Interactions-Summary-2020.pdf.

Bennun, L., J. van Bochove, C. Ng, C. Fletcher, D. Wilson, N. Phair, et G. Carbone. « IUCN ». IUCN, International Union for Conservation of Nature, 23 février 2021. https://doi.org/10.2305/IUCN.CH.2021.04.en.

Biasotto, Larissa D., et Andreas Kindel. « Power Lines and Impacts on Biodiversity: A Systematic Review ». *Environmental Impact Assessment Review* 71 (juillet 2018): 110-19. https://doi.org/10.1016/j.eiar.2018.04.010.

European Commission. « ANNEX I to the COMMISSION DELEGATED REGULATION (EU) .../... amending Delegated Regulation (EU) 2021/2139 as regards economic activities in certain energy sectors and Delegated Regulation (EU) 2021/2178 as regards specific public disclosures for those economic activities », 2 février 2022.

———. « ANNEX II to the COMMISSION DELEGATED REGULATION (EU) .../... amending Delegated Regulation (EU) 2021/2139 as regards economic activities in certain energy sectors and Delegated Regulation (EU) 2021/2178 as regards specific public disclosures for those economic activities », 2 février 2022.

EUROSTAT. *NACE Rev. 2*. Luxembourg: Office for Official Publications of the European Communities, 2008.

Fthenakis, Vasilis, et Hyung Chul Kim. « Land Use and Electricity Generation: A Life-Cycle Analysis ». *Renewable and Sustainable Energy Reviews* 13, n° 6-7 (août 2009): 1465-74. https://doi.org/10.1016/j.rser.2008.09.017.

Official Journal of the European Union. Commission Delegated Regulation (EU) 2021/ of 4 June 2021 supplementing Regulation (EU) 2020/852 of the European Parliament and of the Council by establishing the technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change mitigation or climate change adaptation and for determining whether that economic activity causes no significant harm to any of the other environmental objectives (2021).

OPEC. « World Oil Outlook 2020 », 2020.

Platform on sustainable finance. « Platform on Sustainable finance: Technical working group Part A: Methodological report », mars 2022.

———. « Platform on sustainable finance: technical working group. Part B - Annex: Full list of technical screening criteria », août 2021.

Platform on Sustainable Finance. « Platform on sustainable finance: Technical working group Part B - Annex: Technical screening criteria », 30 mars 2022.

Ritchie, Hannah, Max Roser, et Pablo Rosado. « CO_2 and Greenhouse Gas Emissions ». *Our World in Data*, 11 mai 2020. https://ourworldindata.org/co2-emissions.

RTE. « Futurs Energétiques 2050 », 2022. https://assets.rte-france.com/prod/public/2022-02/BP50_Principaux%20re%CC%81sultats_fev2022_Chap12_analyse%20environnementale.pdf.

Thaxter, Chris B., Graeme M. Buchanan, Jamie Carr, Stuart H. M. Butchart, Tim Newbold, Rhys E. Green, Joseph A. Tobias, Wendy B. Foden, Sue O'Brien, et James W. Pearce-Higgins. « Bird and bat species' global vulnerability to collision mortality at wind farms revealed through a trait-based assessment ». *Proceedings of the Royal Society B: Biological Sciences* 284, n° 1862 (13 septembre 2017): 20170829. https://doi.org/10.1098/rspb.2017.0829.

UNCCD, et IRENA. « Global Land Outlook - Energy and Land Use », 2017. https://www.unccd.int/sites/default/files/2018-06/2.%20Fritsche%2Bet%2Bal%2B%282017%29%2BEnergy%2Band%2BLand%2BUse%2B-%2BGLO%2Bpaper-corr.pdf.

Usubiaga, Arkaitz, et José Acosta-Fernández. « SI_energy Supporting Information for Energy Accounts ». *Journal of Industrial Ecology*, 2018, 28.

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