Executive Summary

Generation of EDF nuclear kWh for operating fleet in France

Life Cycle **Analysis**

The ambition to build a net zero future is at the heart of EDF Group *raison d'être* and statutes: **"Build a net zero energy future with electricity and innovative solutions and services, to help save the planet and drive wellbeing and economic development"**. EDF is set to achieve carbon neutrality by 2050. This carbon trajectory is compliant with limiting global warming "well below 2 °C".

Will you find below the 16 CSR (or ESG) commitments of the EDF Group:

CARBON NEUTRALITY & CLIMATE

- An ambitious carbon trajectory
- Carbon offsetting solutions
- Adapting to climate change
- Development of electricity and energy services

WELL-BEING & SOLIDARITY

- Health and safety for all
- Equality, diversity and inclusion
- Ethics and human rights
- Energy precariousness and social innovation

PRESERVING THE PLANET'S RESSOURCES

- Biodiversity
- Responsible land management
- Integrated and sustainable water management
- Waste & circular economy

RESPONSIBLE DEVELOPMENT

- Dialogue and consultation
- Responsible regional development
- Development of industrial sectors
- Sustainable and inclusive digitalisation

That is the reason why EDF chose **to analyse the value chain of its main electricity generation sector in France: nuclear.**

The greenhouse gas footprint of the nuclear kWh generated by EDF's operating fleet in France is of 4 grams CO2 equivalent.

This is the result of a Life Cycle Analysis study carried out in **compliance with the related standards, covering the whole life cycle** and which was subjected to a **critical review by a panel of independent experts.**

An exhaustive survey that consolidates the **low carbon specificity of the French nuclear kWh**[1].

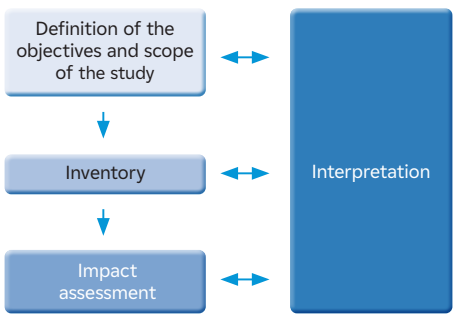
[1] According to the IEA, the energy mix of the industrial countries is of 340 g

Scientific framework and method

Life Cycle Analysis (LCA) was carried out by EDF's R&D experts. The analysis strictly complies with **ISO 14040 and 14044 standards**.

LCA **assesses the potential impacts of the operating nuclear fleet on the environment.** The method is based on the **inventory of the material and energy flows** at different stages of the life cycle of the product, **from the extraction of the raw materials to the management of the waste**. Thus, it allows to capture possible **pollution transfers in between steps** with an integrated multi-criteria approach. LCA approach request compliance with 4 consecutive stages (ISO 14 040 standard).

The four stages of a Life Cycle Analysis



Objectives of the study

The objectives of the study are:

- **Update the methodology and the results of a 2002 EDF study,** used to assess the "Greenhouse gas" index;
- **Allow the appropriation of the LCA by all the business lines** of the EDF nuclear generation;
- Offer for the EDF's nuclear kWh in France
  - a LCA inventory,
  - a multi-criteria environmental analysis with 10 LCA indices, with a focus on the "Climate change" index.

The study is part of EDF's environmental management strategy. It aims at **better understanding contributions of each stage and process**. It shall allow to identify **the best environmental improvement actions** to initiate and to achieve on the value chain.

An accurate field of study

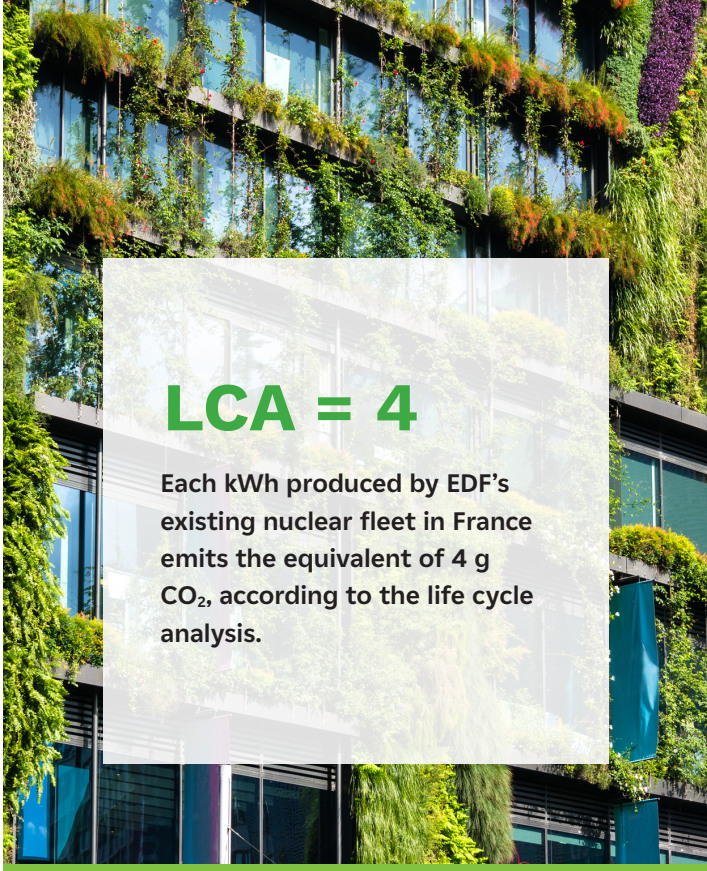
The LCA of the nuclear kWh concerns **the fleet currently operated by EDF in France**. It is based on **2019 data** (electricity generation and fuel cycle parameters). In 2019, EDF's nuclear generation in France reached 380 TWh.

EDF's nuclear fleet included **58 reactors** (including Fessenheim reactors, currently being decommissioned), **split in 19 sites** (one site can include from 2 to 6 reactors):

- 34 reactors of 900-MW. 22 of them being "MOX reactors", that is to say using at the same time UOX (Uranium Oxide) and MOX (Mixed Oxide) fuel, a blend of plutonium and depleted uranium;
- 20 reactors of 1300-MW which fuel is UOX only;
- 4 reactors of 1450-MW which fuel is UOX only.

Conservatively, reactors' lifetime has been set to **40 years**.

The transportation of the electricity by the transmission system and distribution grid, from the power plant to the user, is out of the scope of the study. However, all the transportation stages of the fuel cycle itself are fully accounted for.



LCA = 4

Each kWh produced by EDF's existing nuclear fleet in France emits the equivalent of 4 g CO_2, according to the life cycle analysis.

Data

Collection of specific data were carried out for each stage d**irectly managed by EDF**: generation (construction, operation and decommissioning) as well as fuel cycle parameters.

Moreover, **relevant partners within the nuclear industry have been involved** for the other stages falling **under their responsibility**. In the meantime, **incomplete or missing data were completed by those encompassed in the "Ecoinvent" international database**. If needed, data has been adapted to the specificities of the French fleet, in complete transparency, by the EDF experts.

An accurate inventory and representative data

The approach is based on an exhaustive inventory of the different stages of the kWh generation **from EDF's French nuclear fleet**.

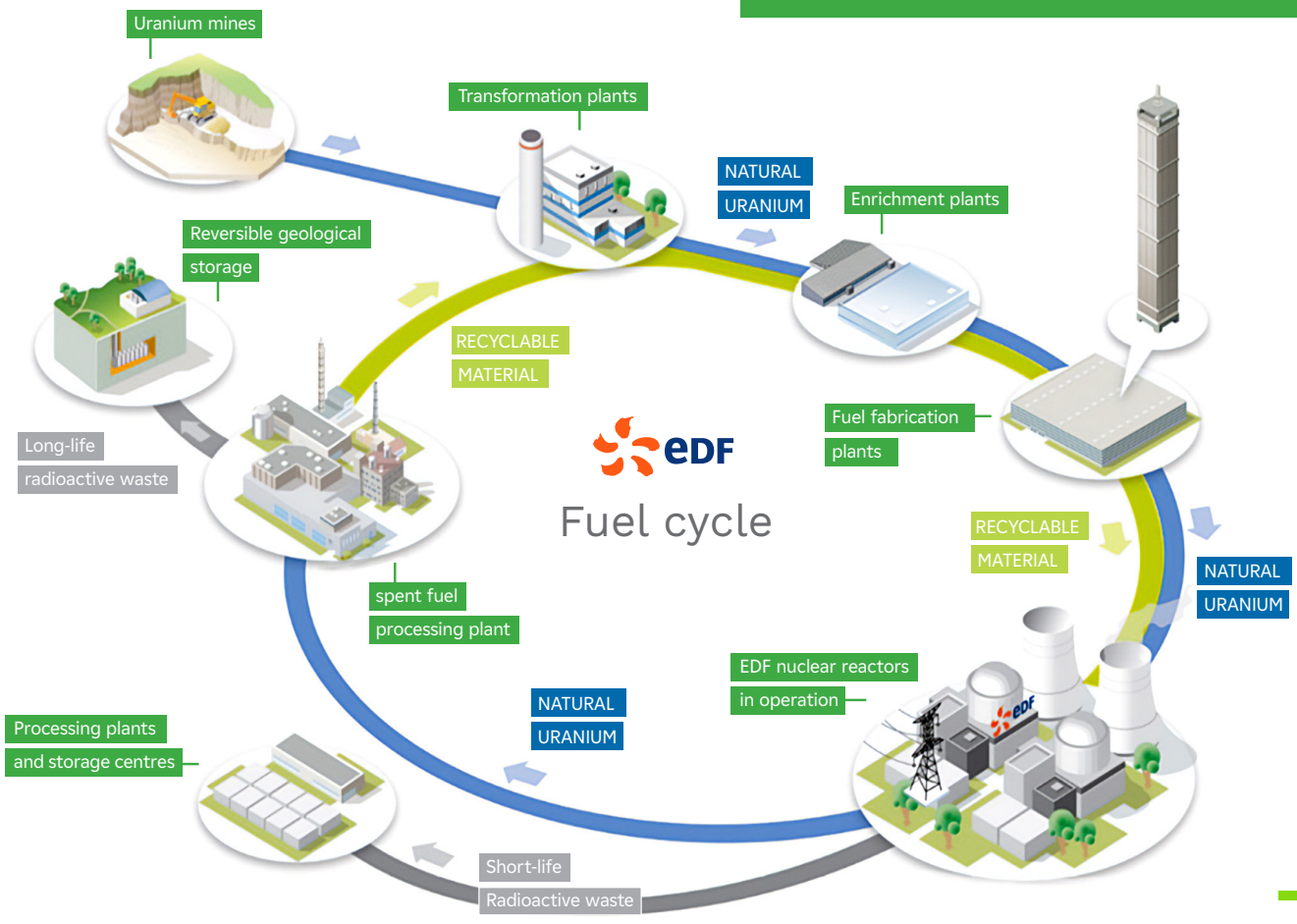
It covers **all the stages of the life cycle of the EDF nuclear kWh**:

- **extraction** of the uranium ore and its processing ("mines");
- **transportation** across the whole fuel cycle (from the mine till spent fuel processing);
- **conversion**, enrichment, fuel fabrication ("fuel");
- **electricity generation** (including the building, the operation - of which the maintenance-, and the decommissioning of the nuclear power plants), ("generation");
- **spent fuel processing** ("SF processing");
- **storage of all radioactive waste**.

Results

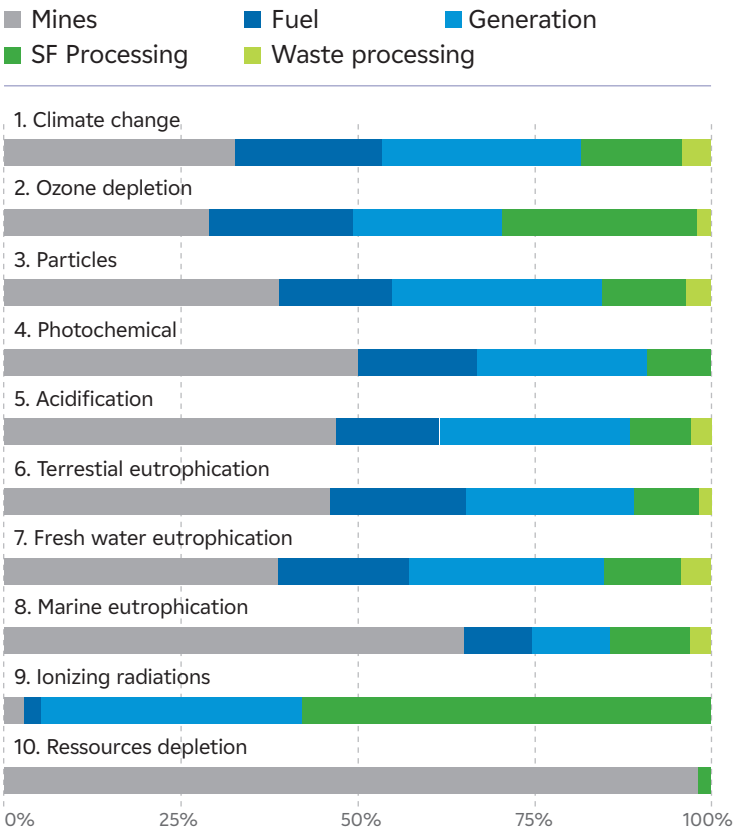
The multi-criteria analysis covers **the main 10 ILCD (International Life Cycle Data) indicators selected and considered as the most mature indicators by the Joint Research Centre**, internal scientific department of the European Union.

The study focuses on the climate change indicator (4 g CO2 eq. per kWh). It also offers analyses regarding ozone depletion, particles emissions, ionizing radiations, photochemical ozone, acidification, eutrophication (terrestrial, freshwater and marine) and resource depletion. The issues of water and waste are also covered by specific approaches explained in the study.



Synthesis of the electronuclear life cycle

It embeds contributions of the different stages of EDF's nuclear kWh to each of the selected LCA indicators (the analysis shall be read horizontally, the sum of each line being equal to 100 %).



This study accounted for a critical review by a panel of independent experts whose complementarity met the requirements of ISO 14044 and ISO/TS14071:

- Delphine Bauchot and Philippe Osset (Solinnen, environment consulting company) representing France to the ISO committees for LCA issues and leading the LCA experts group within the Environment and Climate Change Standardisation Commission;
- Alain Grandjean and Aurélien Schuller (Carbon 4 consulting company), experts in carbon accounting;
- Christophe Poinssot, Deputy Executive Officer and Scientific Director of the French geological survey (BRGM), expert of the electronuclear cycle.

These experts deem that "the provided results meet in an appropriate and credible way the mentioned objectives and comply with the mentioned standards".

Key findings

The "Climate Change" indicator is the sum of numerous contributions.

- The front-end of the cycle is the main contributor (57%).
- "**Generation**" stage accounts for 28% of the "climate change" indicator.
- "**Building**" stage accounts for 16% of the indicator. The main contributors are cement (6%), unalloyed steel (3%) and reinforcing bars (2%)
- **Decommisioning** has a marginal contribution: 3%,
- Operation itself accounts for 9%.

"**Resource depletion**" indicator is dominated by the uranium demand.

The "**Ionizing radiations**" indicator is dominated by the atmospheric release of carbon-14 during spent fuel processing and electricity generation.

Contribution of the "**waste**" stage in EDF's electronuclear life cycle is low.

Conclusion

This life cycle analysis, compliant with the standards and reviewed by a panel of independent experts shows that with 4 grams CO_2 equivalent, the nuclear kWh of the EDF French fleet is part of the less CO_2-emitting energies.

Find all the study

https://www.edf.fr/cycle-de-vie-kWH-nucleaire

Download the comparative analysis published in 2021 by the UNECE

https://unece.org/sites/default/files/2021-10/LCA-2.pdf

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