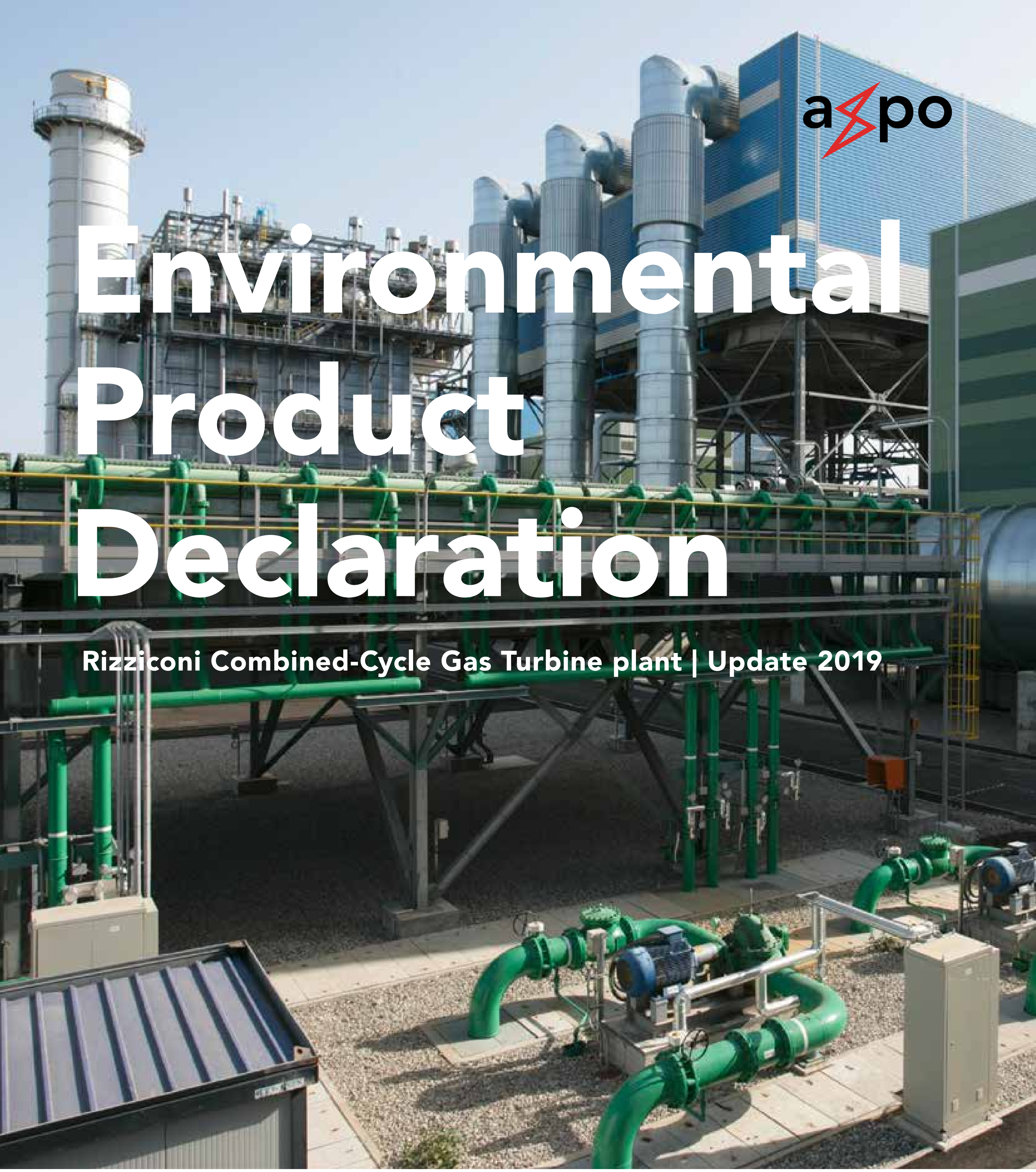

Environmental Product Declaration

Rizziconi Combined-Cycle Gas Turbine plant | Update 2019

EPD®

Valid until 28 May 2022
EPD registration number S-P-00456
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Summary

Company

Axpo is a leading Swiss electricity producer and guarantees a reliable supply of electricity. Axpo has its headquarters in Baden, Switzerland, but it works directly through its associate companies in 28 European countries and is present on the major European energy trading exchanges. The Group is present today in Italy with a production park with thermoelectric cycle combined power plants and wind farms. The local company, Axpo Italia SpA, is based in Genoa and operates offices in Milan and Rome. Rizziconi Energia SpA, a wholly owned subsidiary of the Axpo Group, is the builder, owner and operator of the Rizziconi CCGT plant.

Declared product

Commissioned in 2008, in the heart of the Gioia Tauro plain in the region Calabria, the Rizziconi plant is currently among the most modern plants for electricity generation. The plant has a modular structure, made up of two identical and independent sections of roughly 380 MW of electricity power each. Each module contains a gas turbine with an output of about 260 MW of electric power, fuelled by natural gas and by a steam turbine of approximately 120 MW of power output. The power plant has been originally built to contribute towards the power generation deficit existing in Italy at that time. Following the strong deployment of renewable power plants in Southern Italy over the last few years, the power plant is playing an increasingly important role in providing to the grid regulation services, needed to offset the power generation intermittency from wind and solar power plants.

The declared product is 1 kWh net electricity generated in Rizziconi CCGT power plant and thereafter distributed to consumers connected to the low-voltage grid level in Italy during the reference year 2018.

The International EPD® System

The International EPD® System, managed by EPD International AB, is a Type III environmental declaration programme according to ISO 14025. The relevant governing documents in hierarchical order are Product Category Rules for the product groups electricity, steam and hot/cold water generation (UN-CPC groups 171 and 173), General Programme Instructions for environmental product declaration (EPD), ISO 14025 and ISO 14044.

Verification of the results presented

The complete material presented in this EPD® has been reviewed and certified by the accredited certification body Bureau Veritas Certification Sweden.

Environmental impact of electricity generation in Rizziconi CCGT plant

The life cycle assessment methodology has been applied to quantify the environmental impact. It comprises the full fuel cycle and associated processes, as the construction and decommissioning phase. The main results of the life cycle impact assessment are summarized in the table below. Further results, including raw material consumption and emissions to the environment, are shown in the EPD®.

Environmental impact	Unit	1 kWh net electricity at Rizziconi power plant	1 kWh net electricity at consumer (low-voltage level)
Greenhouse gases	g CO_2-equiv.	414 (402 to 500)	469 (456 to 566)
Ozone-depleting gases	g CFC-11-equiv.	$7.4 \cdot 10^{-7}$ ($4.4 \cdot 10^{-7}$ to $1.2 \cdot 10^{-6}$)	$1.4 \cdot 10^{-6}$ ($9.5 \cdot 10^{-7}$ to $2.0 \cdot 10^{-6}$)
Formation of ground-level ozone	g ethylene-equiv.	$6.2 \cdot 10^{-2}$ ($4.9 \cdot 10^{-2}$ to $8.7 \cdot 10^{-2}$)	$7.7 \cdot 10^{-2}$ ($6.1 \cdot 10^{-2}$ to $1.0 \cdot 10^{-1}$)
Acidifying substances	g SO_2-equiv.	$1.7 \cdot 10^{-1}$ ($1.4 \cdot 10^{-1}$ to $2.4 \cdot 10^{-1}$)	$2.9 \cdot 10^{-1}$ ($2.4 \cdot 10^{-1}$ to $3.7 \cdot 10^{-1}$)
Eutrophying substances	g PO_4^{3-}-equiv.	$2.5 \cdot 10^{-2}$ ($2.2 \cdot 10^{-2}$ to $5.2 \cdot 10^{-2}$)	$5.7 \cdot 10^{-2}$ ($5.2 \cdot 10^{-2}$ to $2.4 \cdot 10^{-1}$)
Depletion of fossil resources	MJ-equiv.	7.8 (4.6 to 11.5)	8.8 (5.0 to 12.5)

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1 Introduction

1.1 The declared product

This document constitutes the certified Environmental Product Declaration EPD® of the Rizziconi Combined-Cycle Gas Turbine plant. The plant is operated by Rizziconi Energia SpA, a wholly owned subsidiary of the Axpo Group.

The declared product is 1 kWh net electricity generated in Rizziconi CCGT power plant and thereafter distributed to consumers connected to the low-voltage grid level in Italy during the reference year 2018.

1.2 The environmental product declaration and the International EPD® System

The primary purpose of the International EPD® System is to support companies in the assessment and publication of the environmental performance of their products and services so that they will be credible and understandable. To this end it:

- offers a complete Type III environmental declaration programme for any interested organisation in any country to develop and communicate EPDs® according to ISO 14025,
- supports other EPD® programmes (i.e. national, sectorial, etc.) in seeking cooperation and harmonization as well as helping organisations to advantageously broaden the use of their EPDs® on the international market.

This Environmental Product Declaration conforms to the standards of the International EPD® Programme www.environdec.com. EPD® is a system for the international application of Type III environmental declarations conforming to ISO 14025 standards. The International EPD® System and its applications are described in the general programme instructions. The principal documents for the EPD® System in order of hierarchical importance, are:

- Product Category Rules, UN-CPC 171 and 173, (Product Category Rules for Preparing an Environmental Product Declaration for Electrical Energy), Version 3.1
- General Programme Instructions for Environmental Product Declarations, EPD®, Version 2.5
- ISO 14025 on Type III environmental declarations
- ISO 14040 and ISO 14044 on Life Cycle Assessment (LCA)

This EPD® contains an environmental performance declaration based on life cycle assessment. Additional environmental information is presented in accordance with the PCR:

- Information on land use, based on a categorisation according to CORINE[1] Land Cover Classes
- Information on biodiversity
- Information on environmental risks
- Information on electromagnetic fields
- Information on noise and vibrations

1.3 Axpo, LCA and EPD®

There are many reasons to declare the environmental impact of electricity production. For Axpo, the decisive reasons are:

- Electricity generation is a fundamental component of modern society, as electricity is required for the production of most goods and the delivery of almost all services. Therefore, as one of the largest electricity producers in Switzerland, Axpo wants to take the initiative in communicating clearly and reliably.
- The scientific assessment and rigorous minimisation of environmental impact are core pillars of Axpo's sustainability strategy. Our main goal is to minimise greenhouse gas production throughout the total life cycle. An EPD® environmental declaration is a reliable foundation for the quantitative presentation of environmental impact, using a number of environmental indicators and taking into account the total production cycle.

For questions concerning this EPD®, please contact Axpo: sustainability.ch@axpo.com

For additional information, please visit our websites: www.axpo.com, www.rizziconienergia.it

[1] CORINE: Coordination of information on the environment: www.eea.europa.eu/publications/COR0-landcover

2 Manufacturer and product

2.1 Rizziconi Energia and Axpo

Axpo is a leading Swiss electricity producer and guarantees a reliable supply of electricity. Axpo has its headquarters in Baden, Switzerland, but it works directly through its associate companies in 28 European countries and is present on the major European energy trading exchanges. The Group is present today in Italy with a production park with thermoelectric cycle combined power plants and wind farms, realized in the past through its subsidiary EGL. The local company, Axpo Italia SpA, is based in Genoa and operates offices in Milan and Rome. It was founded in 2000 under the name EGL Italia SpA and then changed to Axpo Italia SpA in 2012. Rizziconi Energia SpA, a wholly owned subsidiary of the Axpo Group, is the builder, owner and operator of the Rizziconi CCGT plant, situated in the Rizziconi council area (RC) in the plain of Gioia Tauro in Calabria. Rizziconi Energia SpA has its legal and administrative headquarters in Genoa. Key figures of the energy procurement of Axpo Group are summarized in the table below.

Energy procurement 2017/18	Axpo Group (GWh)
Nuclear power plants	18 632
Hydroelectric plants	9307
New renewable energies	1292
Conventional thermal power plants (CCGTs)	6499

2.2 Management systems

Rizziconi Energia SpA has implemented an environmental management system, certified and registered according to ISO 14001. The implementation of the environmental management system is an evident sign of Rizziconi Energia's environmental policy, which sets out the continual improvement of "environmental performance" regarding its working operations, its dialogue with the authorities and the active participation of the staff members. Additionally, Rizziconi Energia has implemented and certified the OHSAS 18001 management system for occupational health and safety.

2.3 Product system description: Rizziconi Combined-Cycle Gas Turbine plant

Commissioned in 2008, in the heart of the Gioia Tauro plain in the region Calabria, the Rizziconi plant is currently among one of the most modern plants for electricity generation. The plant has a modular structure, made up of two identical and independent sections of roughly 380 MW of electricity power each. Each module contains a gas turbine of about 260 MW power and a steam turbine of about 120 MW power. A large amount of energy is recovered, which allows for high energy efficiency of more than 50%. The condenser, cooled with air, recovers the process water and feeds it back into the circulation in the production process. Compared to other systems, it does not create problems of water disposal from the drains and reduces the quantity of water intake. The generation modules were designed on a multi-shafted configuration, a more advantageous and flexible technological solution, where each turbine is linked to its own generator to transform mechanical energy into electricity. The stack to release the discharge fumes into the atmosphere is equipped with an emission analysis station to ensure continuous monitoring on environmental impact. Special attention was paid to the use of the fundamental resource water: the plant is equipped with a "Zero Liquid Discharge" system, allowing the reuse of the entire water intake used during the process and thereby eliminating the need for external drainage. The Rizziconi CCGT power plant has been originally built to contribute to cover the power generation deficit existing in Italy at that time. Following the strong deployment of renewable power plants in Southern Italy over the last few years, the Rizziconi power plant is playing an increasingly important role in providing to the grid regulation services, needed to offset the power generation intermittency from wind and solar power plants.

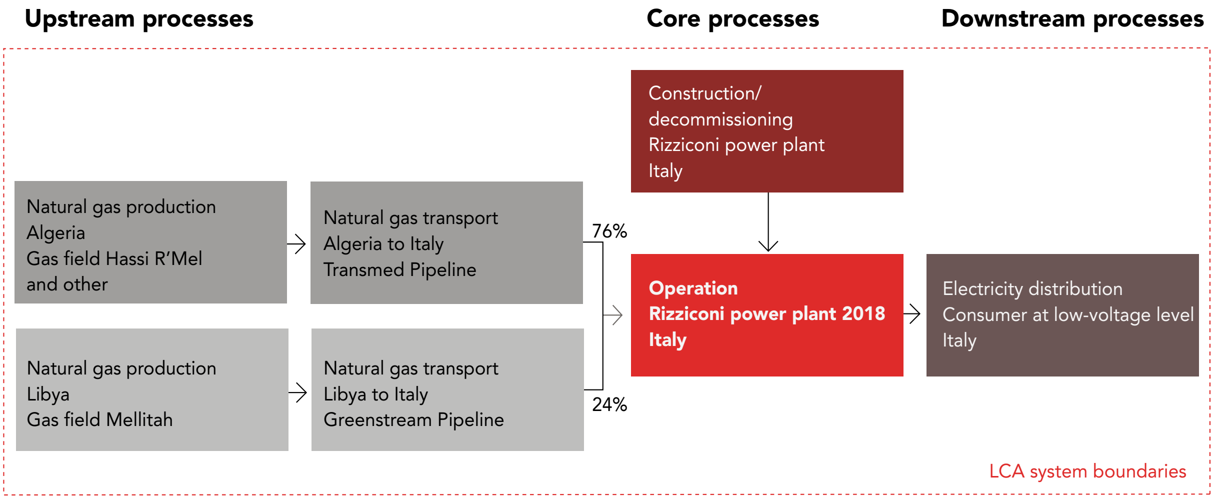
3 Environmental impact declaration

3.1 The life cycle assessment methodology

According to the ISO 14025 standard, the life cycle assessment (LCA) methodology was applied to quantify the environmental impact of the electricity generation in Rizziconi power plant and the subsequent distribution. LCA is a clearly structured framework, based on international standards[2], that facilitates the quantification and assessment of emissions to the environment and resource use along the entire electricity production chain. The LCA allows for comprehensive findings on overall energy, mass and emission flows, key processes that are involved and the quantification of important environmental impacts, such as greenhouse gas emissions. However, despite these advantages, there are also some issues beyond the scope of an LCA. For example, the LCA study only focuses on the normal operation of processes. Unusual process conditions or even accidents are not included. Additionally, due to the investigation of the full process chain, local effects on the environment may not be considered, such as the impact on flora and fauna in the immediate vicinity of the power plant. Finally, a LCA study only quantifies environmental impacts; no economic, social or ethical aspects are included.

3.2 System boundaries, allocations and data sources

The life cycle assessment comprises the full plant life cycle and associated processes from "cradle to grave". The reference period is from 1 January 2018 to 31 December 2018 – one business year of the Rizziconi power plant. The figure below is a simplified process chain with system boundaries for the LCA of electricity from Rizziconi power plant. Data for all processes in the process chain presented above was gathered from construction plans, experts, technical and environmental reports, gas procurement managers, managements systems or provided directly by the operating personnel of the Rizziconi power plant. These data provide a reliable basis for an LCA study. For the calculation of the LCA results, all available data was used without using a cut-off for supposedly unimportant data. Data on energy supply (power mix), building material supply (e.g. steel and concrete production) and transport services as well as on waste treatment processes (e.g. dismantling of the power plant) connected to the investigated process chain was taken from the ecoinvent database[3]. The ecoinvent database is a joint initiative of institutes and departments of the Swiss Federal Institute of Technology and provides consistent, transparent and quality-assured life cycle inventory (LCI) data.



Simplified process scheme of the electricity production and distribution of Rizziconi power plant.
Gas supply was modelled, based on physical gas flow. The percentages indicate the share of the gas origin.

[2] ISO 14040 and ISO 14044 as well as Product Category Rules, UN-CPC 171 and 173

[3] ecoinvent database, Swiss Centre for Life Cycle Inventories, www.ecoinvent.org

3.2.1 Core processes operation

Operational inputs in the reference year include the natural gas consumption, the electricity consumption from the grid, the fuel used by emergency generators as well as water consumption. Operational outputs mainly consist of direct emissions to air. Data were measured (e.g. NOx and CO emissions), taken from management systems (e.g. water consumption), calculated based on gas chromatogram measurements (CO_2) or calculated based on reference values taken from the ecoinvent database.

3.2.2 Core processes construction and dismantling

Construction processes include the production of materials for the power plant as well as materials used for construction and maintenance of the gas turbines (e.g. turbine blades). Additionally, the electrical and diesel energy required for these works is also included in the core processes as well as waste treatment processes for dismantling. Detailed data on material consumption were provided from the manufacturer of the plant, Ansaldo Energia. Data on energy consumption for construction and dismantling of the plant is calculated based on reference values taken from the ecoinvent database. For the plant, a technical service lifetime of 25 years was assumed in this study.

3.2.3 Upstream processes: natural gas procurement

The optimal logistics is a feature regarding the site which was chosen for the plant. Indeed, natural gas is flowed directly from the Snam Rete Gas distribution network (Italian gas grid) through a connecting pipeline roughly about 300 metres long, which runs inside the property itself.
In this study, gas supply for Rizziconi power plant was modelled based on the physical gas flow. 76% of the gas originates from Algeria and was transported via Transmed pipeline to Italy. The main gas field in Algeria is Hassi R'Mel. However, also the production of other Algerian gas fields flows to Hassi R'Mel and therefore a precise determination of the gas origin is not possible. Another 24% of the supplied gas originates from the gas field Mellitah in Libya and is transported via Greenstream pipeline to Italy. Information on losses and energy requirements in compressor stations was taken from environmental reports published by Snam Rete Gas. Data describing gas production in Algeria was taken from the ecoinvent database and also adapted to gas production in Libya.

3.2.4 Downstream processes

The connection of Rizziconi power plant to the National electricity grid is favourable, with the plant being directly connected to the adjacent electricity substation with 380 kV from Terna (Italian TSO), by means of 300 m-long overhead connections, which run inside through the area of the plant itself. According to the requirements stated in the PCR, downstream processes comprise the electricity distribution to consumer-connected low-level voltage grid. Italian-specific data on the operation, construction and decommissioning of the high-voltage, medium-voltage and low-voltage grid was taken from the ecoinvent database. Generic transport distances for the consumption of auxiliary materials were used.

3.3 Ecoprofile of electricity generation and distribution

Results of the life cycle assessment are presented in the ecoprofile tables below and then discussed in greater depth in chapter 3.5 "Dominance analysis and conclusions". More detailed LCA results were available for the certifier. Quantities are expressed per declared unit 1 kWh generated electricity (net) at Rizziconi power plant during the reference year 2018.

The ecoprofile consists of various types of life cycle assessment results, which can be summarised in three categories:

- **Life cycle inventory (LCI) results:**
  Inventory results are direct emissions to and resource consumption from the environment. Examples for inventory results are CO_2 emissions or the consumption of freshwater.

- **Life cycle impact assessment (LCIA) results:**
  In the impact assessment, inventory results, which contribute to the same environmental impact (e.g. climate change due to increasing greenhouse gas concentrations in the atmosphere), are grouped and their importance in relation to a specific basic substance is characterised with a factor (e.g. global warming potential of greenhouse gases such as CH_4 in relation to CO_2).

- **Material flows:**
  Selected materials, which are subject to waste treatment or recycling, are presented in this category.

Ecoprofile – Resource use	Unit	Upstream processes	Core processes operation	Core processes infrastructure	Per kWh at Rizziconi power plant	Per kWh at consumer (low-voltage level)
Non-renewable material resources						
Gravel and sand	g	$6.5 \cdot 10^{-1}$	$4.7 \cdot 10^{-2}$	$6.0 \cdot 10^{-1}$	1.3	2.7
Calcite	g	$4.1 \cdot 10^{-1}$	$1.3 \cdot 10^{-2}$	$1.6 \cdot 10^{-1}$	$5.9 \cdot 10^{-1}$	1.0
Iron	g	$6.4 \cdot 10^{-1}$	$1.6 \cdot 10^{-2}$	$2.3 \cdot 10^{-1}$	$8.8 \cdot 10^{-1}$	1.4
Clay	g	$1.0 \cdot 10^{-1}$	$2.4 \cdot 10^{-3}$	$4.1 \cdot 10^{-2}$	$1.5 \cdot 10^{-1}$	$3.5 \cdot 10^{-1}$
Nickel	g	$1.7 \cdot 10^{-2}$	$1.4 \cdot 10^{-4}$	$8.1 \cdot 10^{-3}$	$2.5 \cdot 10^{-2}$	$3.6 \cdot 10^{-2}$
Chromium	g	$4.7 \cdot 10^{-3}$	$4.9 \cdot 10^{-5}$	$2.6 \cdot 10^{-3}$	$7.3 \cdot 10^{-3}$	$1.0 \cdot 10^{-2}$
Barite	g	$2.0 \cdot 10^{-1}$	$9.1 \cdot 10^{-4}$	$2.8 \cdot 10^{-4}$	$2.0 \cdot 10^{-1}$	$2.2 \cdot 10^{-1}$
Aluminium	g	$1.3 \cdot 10^{-3}$	$1.3 \cdot 10^{-4}$	$2.8 \cdot 10^{-3}$	$4.2 \cdot 10^{-3}$	$5.4 \cdot 10^{-2}$
Fluorite	g	$2.6 \cdot 10^{-3}$	$2.5 \cdot 10^{-5}$	$4.6 \cdot 10^{-5}$	$2.6 \cdot 10^{-3}$	$4.6 \cdot 10^{-3}$
Copper	g	$1.6 \cdot 10^{-3}$	$8.9 \cdot 10^{-5}$	$5.7 \cdot 10^{-3}$	$7.4 \cdot 10^{-3}$	$2.4 \cdot 10^{-1}$
Magnesite	g	$2.7 \cdot 10^{-3}$	$6.0 \cdot 10^{-5}$	$2.2 \cdot 10^{-4}$	$3.0 \cdot 10^{-3}$	$3.7 \cdot 10^{-3}$
Zinc	g	$9.5 \cdot 10^{-5}$	$5.1 \cdot 10^{-6}$	$7.4 \cdot 10^{-5}$	$1.7 \cdot 10^{-4}$	$6.0 \cdot 10^{-4}$
Kaolinite	g	$3.9 \cdot 10^{-5}$	$3.0 \cdot 10^{-5}$	$1.1 \cdot 10^{-5}$	$8.0 \cdot 10^{-5}$	$2.9 \cdot 10^{-4}$
Uranium	g	$1.6 \cdot 10^{-5}$	$4.2 \cdot 10^{-6}$	$5.9 \cdot 10^{-7}$	$2.1 \cdot 10^{-5}$	$2.9 \cdot 10^{-5}$
Zirconium	g	$1.3 \cdot 10^{-4}$	$3.4 \cdot 10^{-6}$	$3.3 \cdot 10^{-6}$	$1.4 \cdot 10^{-4}$	$2.2 \cdot 10^{-4}$
Renewable material resources						
Wood	m^3	$3.6 \cdot 10^{-8}$	$6.9 \cdot 10^{-9}$	$6.2 \cdot 10^{-9}$	$4.9 \cdot 10^{-8}$	$3.1 \cdot 10^{-7}$
Non-renewable fossil energy resources						
Natural gas	MJ-equiv.	7.7	$1.2 \cdot 10^{-2}$	$2.8 \cdot 10^{-3}$	7.7	8.6
Crude oil	MJ-equiv.	$2.8 \cdot 10^{-2}$	$2.4 \cdot 10^{-3}$	$5.0 \cdot 10^{-3}$	$3.5 \cdot 10^{-2}$	$5.0 \cdot 10^{-2}$
Hard coal	MJ-equiv.	$5.2 \cdot 10^{-2}$	$5.3 \cdot 10^{-3}$	$5.9 \cdot 10^{-3}$	$6.4 \cdot 10^{-2}$	$9.0 \cdot 10^{-2}$
Lignite	MJ-equiv.	$2.8 \cdot 10^{-3}$	$2.5 \cdot 10^{-4}$	$1.1 \cdot 10^{-4}$	$3.1 \cdot 10^{-3}$	$4.7 \cdot 10^{-3}$
Electricity consumption in power station						
Electricity consumption in power station (own use)	kWh	–	$1.6 \cdot 10^{-2}$	–	$1.6 \cdot 10^{-2}$	$1.7 \cdot 10^{-2}$
Use of recycled material						
Iron scrap	g	$4.2 \cdot 10^{-1}$	$3.2 \cdot 10^{-3}$	$9.7 \cdot 10^{-2}$	$5.2 \cdot 10^{-1}$	$7.5 \cdot 10^{-1}$
Water consumption						
Freshwater	g	$4.6 \cdot 10^{1}$	$1.1 \cdot 10^{1}$	4.6	$6.1 \cdot 10^{1}$	$1.0 \cdot 10^{2}$
Saltwater	g	1.9	$9.9 \cdot 10^{-1}$	$2.0 \cdot 10^{-1}$	3.1	4.2

Ecoprofile – Pollutant emissions	Unit	Upstream processes	Core processes operation	Core processes infrastructure	Per kWh at Rizziconi power plant	Per kWh at consumer (low-voltage level)
Airborne emissions – impact assessment results						
Greenhouse gases	g CO_2-equiv.	$2.3 \cdot 10^{1}$	$3.9 \cdot 10^{2}$	1.1	$4.1 \cdot 10^{2}$	$4.7 \cdot 10^{2}$
Ozone-depleting gases	g CFC-11-equiv.	$5.3 \cdot 10^{-7}$	$1.6 \cdot 10^{-7}$	$5.7 \cdot 10^{-8}$	$7.4 \cdot 10^{-7}$	$1.4 \cdot 10^{-6}$
Formation of ground-level ozone	g ethylene-equiv.	$3.6 \cdot 10^{-2}$	$2.4 \cdot 10^{-2}$	$2.0 \cdot 10^{-3}$	$6.2 \cdot 10^{-2}$	$7.7 \cdot 10^{-2}$
Acidifying substances	g SO_2-equiv.	$8.4 \cdot 10^{-2}$	$7.7 \cdot 10^{-2}$	$9.1 \cdot 10^{-3}$	$1.7 \cdot 10^{-1}$	$2.9 \cdot 10^{-1}$
Airborne emissions contributing to given impact assessment results						
Ammonia	g	$1.9 \cdot 10^{-4}$	$2.3 \cdot 10^{-5}$	$5.8 \cdot 10^{-5}$	$2.7 \cdot 10^{-4}$	$1.4 \cdot 10^{-3}$
Carbon dioxide, fossil	g	$1.6 \cdot 10^{1}$	$3.9 \cdot 10^{2}$	$9.8 \cdot 10^{-1}$	$4.0 \cdot 10^{2}$	$4.5 \cdot 10^{2}$
Carbon monoxide, biogenic	g	$3.1 \cdot 10^{-4}$	$1.7 \cdot 10^{-5}$	$1.5 \cdot 10^{-5}$	$3.4 \cdot 10^{-4}$	$7.2 \cdot 10^{-4}$
Carbon monoxide, fossil	g	$4.7 \cdot 10^{-2}$	$5.3 \cdot 10^{-1}$	$8.8 \cdot 10^{-3}$	$5.9 \cdot 10^{-1}$	$6.7 \cdot 10^{-1}$
Dinitrogen monoxide	g	$3.5 \cdot 10^{-4}$	$6.3 \cdot 10^{-3}$	$2.7 \cdot 10^{-5}$	$6.7 \cdot 10^{-3}$	$1.3 \cdot 10^{-2}$
Methane, bromochlorodifluoro-, Halon 1211	g	$3.9 \cdot 10^{-8}$	$1.8 \cdot 10^{-8}$	$5.0 \cdot 10^{-10}$	$5.8 \cdot 10^{-8}$	$6.7 \cdot 10^{-8}$
Methane, bromotrifluoro-, Halon 1301	g	$1.2 \cdot 10^{-8}$	$1.2 \cdot 10^{-9}$	$2.5 \cdot 10^{-9}$	$1.5 \cdot 10^{-8}$	$2.0 \cdot 10^{-8}$
Methane, biogenic, total	g	$4.2 \cdot 10^{-4}$	$2.8 \cdot 10^{-5}$	$1.3 \cdot 10^{-5}$	$4.6 \cdot 10^{-4}$	$6.5 \cdot 10^{-4}$
Methane, fossil	g	$2.8 \cdot 10^{-1}$	$9.9 \cdot 10^{-3}$	$2.3 \cdot 10^{-3}$	$3.0 \cdot 10^{-1}$	$3.4 \cdot 10^{-1}$
Nitrogen oxides	g	$5.7 \cdot 10^{-2}$	$1.0 \cdot 10^{-1}$	$5.9 \cdot 10^{-3}$	$1.6 \cdot 10^{-1}$	$1.9 \cdot 10^{-1}$
NMVOC, non-methane volatile organic compounds	g	$2.6 \cdot 10^{-2}$	$4.5 \cdot 10^{-4}$	$1.5 \cdot 10^{-3}$	$2.8 \cdot 10^{-2}$	$3.5 \cdot 10^{-2}$
Sulphur dioxide	g	$4.3 \cdot 10^{-2}$	$6.6 \cdot 10^{-3}$	$4.2 \cdot 10^{-3}$	$5.3 \cdot 10^{-2}$	$1.3 \cdot 10^{-1}$
Other relevant non-radioactive airborne emissions						
Carbon dioxide, biogen	g	$1.0 \cdot 10^{-1}$	$1.7 \cdot 10^{-2}$	$7.2 \cdot 10^{-3}$	$1.2 \cdot 10^{-1}$	$3.9 \cdot 10^{-1}$
Particles <10 μm	g	$3.1 \cdot 10^{-3}$	$1.0 \cdot 10^{-4}$	$9.1 \cdot 10^{-4}$	$4.1 \cdot 10^{-3}$	$8.9 \cdot 10^{-3}$
Particles < 2.5 μm	g	$6.8 \cdot 10^{-3}$	$3.4 \cdot 10^{-3}$	$1.0 \cdot 10^{-3}$	$1.1 \cdot 10^{-2}$	$1.8 \cdot 10^{-2}$
Particles > 10 μm	g	$8.0 \cdot 10^{-3}$	$4.8 \cdot 10^{-4}$	$1.6 \cdot 10^{-3}$	$1.0 \cdot 10^{-2}$	$1.6 \cdot 10^{-2}$
Arsenic	g	$9.3 \cdot 10^{-7}$	$6.7 \cdot 10^{-8}$	$2.8 \cdot 10^{-6}$	$3.8 \cdot 10^{-6}$	$1.2 \cdot 10^{-4}$
Cadmium	g	$2.5 \cdot 10^{-7}$	$2.4 \cdot 10^{-8}$	$9.6 \cdot 10^{-7}$	$1.2 \cdot 10^{-6}$	$4.1 \cdot 10^{-5}$
Dioxins	g	$1.2 \cdot 10^{-11}$	$3.7 \cdot 10^{-13}$	$1.6 \cdot 10^{-12}$	$1.4 \cdot 10^{-11}$	$2.2 \cdot 10^{-11}$
PAH, polycyclic aromatic hydrocarbons	g	$1.5 \cdot 10^{-6}$	$5.0 \cdot 10^{-5}$	$6.9 \cdot 10^{-7}$	$5.2 \cdot 10^{-5}$	$6.1 \cdot 10^{-5}$
Radioactive airborne emissions						
Carbon 14	kBq	$3.7 \cdot 10^{-5}$	$5.2 \cdot 10^{-6}$	$3.0 \cdot 10^{-6}$	$4.5 \cdot 10^{-5}$	$5.8 \cdot 10^{-5}$
Krypton (all isotopes)	kBq	$1.6 \cdot 10^{-5}$	$1.9 \cdot 10^{-6}$	$4.3 \cdot 10^{-7}$	$1.8 \cdot 10^{-5}$	$2.3 \cdot 10^{-5}$
Radon (all isotopes)	kBq	$1.8 \cdot 10^{-2}$	$3.7 \cdot 10^{-3}$	$4.9 \cdot 10^{-4}$	$2.2 \cdot 10^{-2}$	$2.7 \cdot 10^{-2}$
Waterborne emissions – impact assessment results						
Eutrophying substances	g PO_4^{3-}-equiv.	$9.0 \cdot 10^{-3}$	$1.5 \cdot 10^{-2}$	$1.5 \cdot 10^{-3}$	$2.5 \cdot 10^{-2}$	$5.7 \cdot 10^{-2}$
Waterborne emissions contributing to given impact assessment results						
Phosphate	g	$8.6 \cdot 10^{-4}$	$8.3 \cdot 10^{-5}$	$6.5 \cdot 10^{-4}$	$1.6 \cdot 10^{-3}$	$2.6 \cdot 10^{-2}$
COD, Chemical Oxygen Demand	g	$4.6 \cdot 10^{-3}$	$2.5 \cdot 10^{-4}$	$4.8 \cdot 10^{-4}$	$5.4 \cdot 10^{-3}$	$7.1 \cdot 10^{-3}$
Other relevant non-radioactive waterborne emissions						
Ammonium, ion	g	$5.1 \cdot 10^{-5}$	$2.9 \cdot 10^{-6}$	$3.6 \cdot 10^{-6}$	$5.7 \cdot 10^{-5}$	$1.2 \cdot 10^{-4}$
Nitrate	g	$1.5 \cdot 10^{-4}$	$1.1 \cdot 10^{-4}$	$8.3 \cdot 10^{-5}$	$3.4 \cdot 10^{-4}$	$3.4 \cdot 10^{-3}$
Sulphate	g	$9.0 \cdot 10^{-3}$	$1.1 \cdot 10^{-3}$	$7.2 \cdot 10^{-3}$	$1.7 \cdot 10^{-2}$	$2.9 \cdot 10^{-1}$
Oil	g	$6.2 \cdot 10^{-4}$	$5.6 \cdot 10^{-5}$	$1.3 \cdot 10^{-4}$	$8.1 \cdot 10^{-4}$	$1.1 \cdot 10^{-3}$
Radioactive waterborne emissions						
Tritium H_3	kBq	$3.4 \cdot 10^{-3}$	$9.2 \cdot 10^{-4}$	$1.2 \cdot 10^{-4}$	$4.5 \cdot 10^{-3}$	$5.7 \cdot 10^{-3}$
Other relevant non-radioactive emissions soil						
Oil	g	$2.9 \cdot 10^{-4}$	$3.2 \cdot 10^{-5}$	$7.3 \cdot 10^{-5}$	$3.9 \cdot 10^{-4}$	$5.3 \cdot 10^{-4}$

Ecoprofile – Waste and material subject to recycling	Unit	Upstream processes	Core processes operation	Core processes infrastructure	Per kWh at Rizziconi power plant	Per kWh at consumer (low-voltage level)
Hazardous waste – radioactive						
SF/HLW/ILW[4] in final repository	m^3	$5.2 \cdot 10^{-12}$	$1.4 \cdot 10^{-12}$	$1.8 \cdot 10^{-13}$	$6.8 \cdot 10^{-12}$	$8.6 \cdot 10^{-12}$
LLW[5] in final repository	m^3	$1.2 \cdot 10^{-10}$	$1.9 \cdot 10^{-11}$	$1.7 \cdot 10^{-11}$	$1.6 \cdot 10^{-10}$	$2.1 \cdot 10^{-10}$
Hazardous waste – non-radioactive						
Hazardous waste to incineration	g	$8.2 \cdot 10^{-3}$	$2.6 \cdot 10^{-4}$	$2.1 \cdot 10^{-3}$	$1.1 \cdot 10^{-2}$	$4.0 \cdot 10^{-2}$
Other waste						
Non-hazardous waste to landfill	g	$3.9 \cdot 10^{-2}$	$8.7 \cdot 10^{-4}$	$1.2 \cdot 10^{-2}$	$5.3 \cdot 10^{-2}$	$6.1 \cdot 10^{-1}$
Non-hazardous waste for recycling	g	$2.2 \cdot 10^{-2}$	$6.0 \cdot 10^{-3}$	$2.2 \cdot 10^{-1}$	$2.5 \cdot 10^{-1}$	$3.8 \cdot 10^{-1}$
Non-hazardous waste for incineration	g	$3.7 \cdot 10^{-3}$	$1.4 \cdot 10^{-4}$	$2.7 \cdot 10^{-3}$	$6.5 \cdot 10^{-3}$	$2.1 \cdot 10^{-1}$

3.4 Uncertainty analysis

The purpose of the uncertainty analysis is to quantify the variability of the calculated life cycle assessment results. The variability results from the fact that the input and output parameters for the entire process chain (e.g. annual electricity production) are not precise values, but can fluctuate instead. To this end, probability distributions are assigned to the values of input and output parameters. Probability distributions were taken from the ecoinvent database for all background processes. Additional probability distributions were defined for the most important processes, modelled in the present study. For example, the annual plant efficiency is dominant with regards to most of the life cycle impact assessment categories. The plant efficiency is defined by the energy input of gas in relation to the generated electricity and is dependant on the operational characteristics of the plant, in particular regarding the annual number of starts and stops. To define the variability of that parameter, annual and monthly plant efficiency data over the past seven years was used as a basis. The annual plant efficiency varies from 51.6% to 53.2%, the monthly plant efficiency from 43.2% to 54.7%.

In order to calculate the variability of the life cycle impact assessment results, repeated random sampling, using a Monte Carlo algorithm, was performed. The uncertainty range is defined in this study as the 95% interval of the sampled distribution. Hence, the minimum value is determined as the 2.5th percentile and the maximum value as the 97.5th percentile. Results of the Monte Carlo analysis are given in the tables below.

1 kWh net electricity at Rizziconi power plant		Value calculated without uncertainty	Median (50th percentile)	Minimum value (2.5th percentile)	Maximum value (97.5th percentile)
Environmental impact	**Unit**				
Greenhouse gases	g CO_2-equiv.	414	448	402	500
Ozone-depleting gases	g CFC-11-equiv.	$7.4 \cdot 10^{-7}$	$7.1 \cdot 10^{-7}$	$4.4 \cdot 10^{-7}$	$1.2 \cdot 10^{-6}$
Formation of ground-level ozone	g ethylene-equiv.	$6.2 \cdot 10^{-2}$	$6.1 \cdot 10^{-2}$	$4.9 \cdot 10^{-2}$	$8.7 \cdot 10^{-2}$
Acidifying substances	g SO_2-equiv.	$1.7 \cdot 10^{-1}$	$1.7 \cdot 10^{-1}$	$1.4 \cdot 10^{-1}$	$2.4 \cdot 10^{-1}$
Eutrophying substances	g PO_4^{3-}-equiv.	$2.5 \cdot 10^{-2}$	$3.4 \cdot 10^{-2}$	$2.2 \cdot 10^{-2}$	$5.2 \cdot 10^{-2}$
Depletion of fossil resources	MJ-equiv.	7.8	7.3	4.6	11.5

1 kWh net electricity at consumer (low-voltage level)		Value calculated without uncertainty	Median (50th percentile)	Minimum value (2.5th percentile)	Maximum value (97.5th percentile)
Environmental impact	**Unit**				
Greenhouse gases	g CO_2-equiv.	469	507	456	566
Ozone-depleting gases	g CFC-11-equiv.	$1.4 \cdot 10^{-6}$	$1.4 \cdot 10^{-6}$	$9.5 \cdot 10^{-7}$	$2.0 \cdot 10^{-6}$
Formation of ground-level ozone	g ethylene-equiv.	$7.7 \cdot 10^{-2}$	$7.6 \cdot 10^{-2}$	$6.1 \cdot 10^{-2}$	$1.0 \cdot 10^{-1}$
Acidifying substances	g SO_2-equiv.	$2.9 \cdot 10^{-1}$	$2.9 \cdot 10^{-1}$	$2.4 \cdot 10^{-1}$	$3.7 \cdot 10^{-1}$
Eutrophying substances	g PO_4^{3-}-equiv.	$5.7 \cdot 10^{-2}$	$9.6 \cdot 10^{-2}$	$5.2 \cdot 10^{-2}$	$2.4 \cdot 10^{-1}$
Depletion of fossil resources	MJ-equiv.	8.8	8.0	5.0	12.5

All results are rounded.

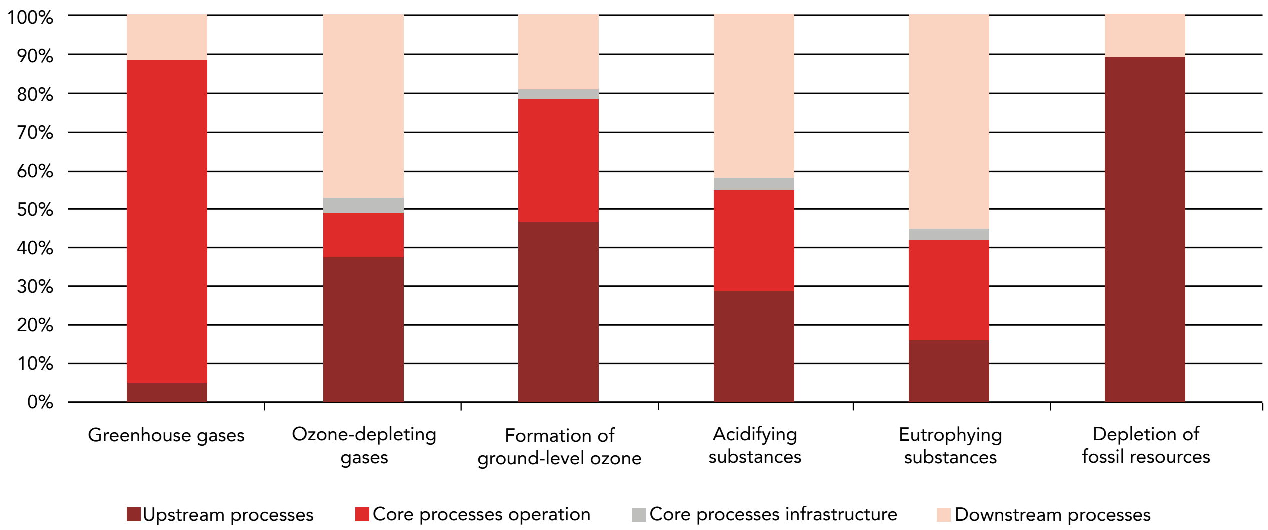
[4] SF/HLW/ILW: Spent fuel / high-level waste / long-lived intermediate-level waste

[5] LLW: Low- and intermediate-level waste

3.5 Dominance analysis and conclusions

The contribution of the different life cycle stages to the overall results are shown in the figure below for all life cycle impact categories. The life cycle stages comprise:

- Upstream processes: Natural gas production and transport.
- Core processes operation: electricity consumption from the grid, the fuel used by emergency generators and direct emissions to air.
- Core processes infrastructure: Materials and energy used for construction and dismantling of the power station, including maintenance of the gas turbines.
- Downstream processes: Distribution of electricity within the Italian grid to consumers on low-level voltage.



The overall comparison of the life cycle stages shows that, depending on the LCIA categories, the contributions of the life cycle stages vary significantly. Regarding the impact categories "greenhouse gas emissions" and "depletion of fossil resources", the operation of the power plant is dominating because natural gas is burnt in the plant, generating CO_2 emissions. With respect to the impact categories "acidification" and "eutrophication", electricity distribution is dominating due to NOx and phosphate (relevant for "eutrophication") emissions, as a consequence of copper production used in the distribution network (cables). In the impact category "formation of ground-level ozone", NMVOC emissions contribute most to the overall result. NMVOC emissions mainly arise from the natural gas production and equally from gas drying processes. The main substances contributing to the impact category "ozone depletion" are Halon 1211 and Halon 1301 emissions. Halon 1211 and Halon 1301 are important components in fire-extinguishing systems, installed in petrochemical production facilities. Therefore, energy-intensive processes such as the fabrication of copper and steel, used in the distribution network (downstream processes), as well as diesel consumption in natural gas production (upstream processes) contribute to that impact category.

3.6 Differences versus the earlier version of the EPD® for Rizziconi Power Plant

Updated material and energy flows

In the presented EPD® material, energy and emission flows related to the new reference year 2018 are considered. The main difference with previous versions of this environmental declaration is the update of the origin of the gas. The physical gas flow still comes from the two countries Algeria and Libya. However, the shares from the two countries have changed significantly.

Database update

A new version of the ETH ecoinvent database was used (version 3) for modelling background processes.

4 Additional environmental information

4.1 Land use

The building, operation and decommissioning activities related to the Rizziconi power plant changed the land use from its natural condition. In accordance with the PCR instructions, this land use is systematically classified and quantified using the Land Cover Classes of the EU CORINE programme. Part of the CORINE programme, launched by the European Commission in 1985, is the recording of land cover across Europe, using a common nomenclature. The system has 44 classes and three hierarchical levels (i.e. use for industry, mining or forestry).

Most important land uses are the power plant site itself (core processes) and the land use for natural gas exploration and gas production (upstream processes). With the commissioning of the power plant, the land area was transformed from agriculture to industrial land area. Regarding the natural gas production in Algeria and Libya, the land area was transformed from sparsely vegetated area to mineral extraction area. The table below shows the dominating land uses calculated per kWh electricity.

Transformation, from	Unit	Upstream processes	Core processes	Total generation and distribution
Arable (CORINE Code 21)	m^2	$3.58 \cdot 10^{-6}$	$5.39 \cdot 10^{-5}$	$6.62 \cdot 10^{-5}$
Sparsely vegetated areas (CORINE Code 331)	m^2	$4.91 \cdot 10^{-5}$	$1.03 \cdot 10^{-7}$	$5.52 \cdot 10^{-5}$
Total land use per kWh	**m^2**	**$6.08 \cdot 10^{-5}$**	**$5.86 \cdot 10^{-5}$**	**$1.43 \cdot 10^{-4}$**
Transformation, to	**Unit**	**Upstream processes**	**Core processes**	**Total generation and distribution**
Industrial area (CORINE Code 121)	m^2	$4.90 \cdot 10^{-5}$	$8.79 \cdot 10^{-8}$	$5.50 \cdot 10^{-5}$
Mineral extraction site (CORINE Code 131)	m^2	$4.90 \cdot 10^{-5}$	$8.79 \cdot 10^{-8}$	$5.50 \cdot 10^{-5}$
Total land use per kWh	**m^2**	**$6.08 \cdot 10^{-5}$**	**$5.86 \cdot 10^{-5}$**	**$1.43 \cdot 10^{-4}$**

4.2 Biodiversity

According to Italian law, a comprehensive environmental impact assessment study was performed for Rizziconi power plant prior to construction. The Department of Environment and Environmental Conservation together with the Ministry of Cultural Heritage issued the VIA decree, in which is stated that no significant adverse effects on local biodiversity were identified. Based on that, Rizziconi Energia SpA received the permit for construction and operation of the power plant (Directorial Decree no. 55/04/2004, the Ministry of Economic Development).

4.3 Environmental risks

According to the Italian Safety and Health Protection Act, Rizziconi power plant has evaluated the main risks due to operation and, where necessary, has adopted adequate measures to remove or decrease them. The results of this evaluation are periodically verified and updated. The most significant hazards are fire risk and pressure parts explosion risk. Rizziconi has adopted technical and organizational measures to control these risks. Technical measures comprise the implementation of a fire-fighting system. The fire-fighting system includes both active and passive fire protection and life safety systems, which are interconnected. Operational measures include protocols for testing procedures, responsibilities for various parties, methods and documentation for verifying the operational readiness and sequence of the fire-fighting systems. In accordance with Italian law and internal procedures, the system is verified periodically to ensure permanent operational availability.

4.4 Electromagnetic fields

According to the Italian law, electromagnetic fields were measured within the power plant site to ensure the occupational safety. Areas with high electromagnetic fields are marked and every employee is informed and receives a specific training about correct behaviour in these working areas.

4.5 Noise

The power plant is surrounded by agricultural area. According to Italian Law (DPCM 01/03/91) the limits for agricultural areas are stipulated to be 70 dB(A) in the daytime and 60 dB(A) at night. To comply with the requirements of the local Environmental Protection Agency (Agenzia Regionale per la Protezione Ambientale), measurements were done in order to verify that the emission limits are respected.

4.6 Water scarcity

According to environmental decree, special attention was paid to the use of a fundamental resource, which is water, and to the necessity to avoid any waste water discharge in an agricultural area. The plant is equipped with a recovery system for rainwater, which is used as a primary source, and with a "Zero Liquid Discharge" system, which allows the reuse of the entire water intake used during the process and thereby reduces the consumption of fresh water and eliminates the need for external discharge.

5 Certification body and mandatory statements

5.1 Information from the certification body

The certification of the Environmental Product Declaration, EPD®, of electricity from the Rizziconi Combined-Cycle Gas Turbine plant has been carried out by Bureau Veritas Certification Sweden. Bureau Veritas Certification Sweden has made an independent verification of the declaration and data according to ISO 14025:2006 EPD verification. The EPD® has been made in accordance with General Programme Instructions for an Environmental Product Declaration, EPD®, published by the International EPD® System, and UN-CPC 171 and 173, Product Category Rules (PCR) for preparing an Environmental Product Declaration (EPD®) for Electricity, Steam, and Hot and Cold Water Generation and Distribution. Bureau Veritas Certification Sweden has been accredited by SWEDAC, the Swedish Board for Accreditation and Conformity Assessment, to certify Environmental Product Declarations, EPD®.
This certification is valid until 28 May 2022.
The registration number is S-P-00456.

5.2 Mandatory statements

5.2.1 General statements

Note that EPDs from different EPD programmes may not be comparable.

5.2.2 Omission of life cycle stages

In accordance with the PCR, the use stage of produced electricity has been omitted since the use of electricity fulfils various functions in different contexts.

5.2.3 Means of obtaining explanatory materials

ISO 14025 prescribes that explanatory material must be available if the EPD® is communicated to final consumers. This EPD® is aimed at industrial customers and not meant for B2C (business-to-consumer) communication.

5.2.4 Information on verification

EPD® programme
The International EPD® System, managed by the International EPD® System.
www.environdec.com

Product Category Rules
UN-CPC 171 and 173, Product Category Rules (PCR) for preparing an Environmental Product Declaration (EPD®) for Electricity, Steam, and Hot and Cold Water Generation and Distribution, version 3.1.

PCR review
The Technical Committee of the International EPD® System. Full list of TC members available on www.environdec.com/TC.

Independent verification
Independent verification of the declaration and data, according to ISO 14025: External, Bureau Veritas Certification Sweden.
info@se.bureauveritas.com

6 Links and references

Further information on the company
www.rizziconienergia.it
www.axpo.com

International EPD® programme information
www.environdec.com
Information on the International EPD® System, EPDs® and PCRs, and General Programme Instructions GPI, v 2.5.

Background LCA data
www.ecoinvent.org
The ecoinvent database version 3, Swiss Centre for Life Cycle Inventories.

7 Frequently used abbreviations

EPD®	Environmental Product Declaration
CCGT plant	Combined-Cycle Gas Turbine plant
ISO	International Organisation for Standardization
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle impact assessment
NMVOC	Non-methane volatile organic compounds
PCR	Product Category Rule

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