



LCA4Regions

Interreg Europe



European Union
European Regional
Development Fund

Monitoring Life-Cycle Performance of European Geothermal Power Plants

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The Overall Project



THE NEED

clear assessment of geothermal plants' emissions

THE CHALLENGE

- uniqueness of geothermal reservoir
- numerous of technological options to produce and utilize geothermal energy

THE PATHWAY

- **clusterise** geothermal plants: geographical & technological
- include a **validation**: sectoral stakeholders
- tailor a set of **common rules**: LCA in geothermal sector

THE RESULTS

- **quantitative data** - impact categories
- **recommendations**
- **guidance** document: LCA Sector (geothermal) Category Rules

Methodological guidance to be followed to perform a LCA study on geothermal sector

Background documents to drive the future developments (research and policy level) within renewable energy and decarbonisation targets

18 months

Key Features of Our Approach

1) Methodology for the collection on geothermal emissions

- **Mapping**, classification of reservoirs/ plants
- Inventory of **technologies**
- Definition of geothermal energy **clusters**
- Definition of **key parameters**

Validation Workshop

2) Data collection and materials/ emissions inventory

- **Review** of literature and public reports
- **Surveys** and/or Proxy Consultation of experts
- **Inventory** (Life Cycle and GHG Emissions)

3) Definition of set of impact categories and related indicators

- **Calculation** and comparison of LCIA results
- **Interpretation** of LCIA results: environmental impacts
- **Interpretation** of LCIA results: impacts on human health

4) Final Output

- Main **outcomes**
- **Recommendations**
- LCA guidance document (**Sector Category Rules**)

Final Workshop

1. Methodology for Geothermal Emissions Data Collection (1/2)

- Mapping main **geothermal areas** of Europe and classification of **reservoirs**

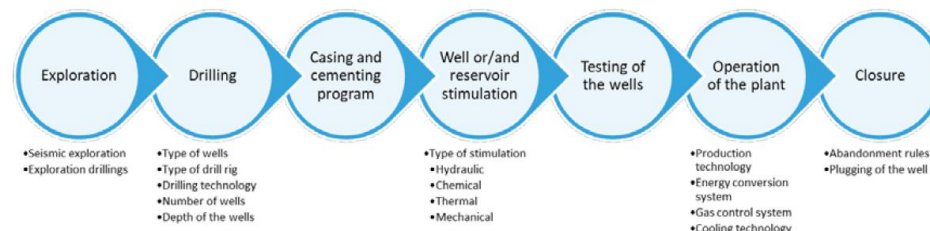
- Pannonian Basin
- Molasse basin
- South Permian Basin
- Paris and Aquitaine basins
- Upper Rhine graben
- Iberian Peninsula
- Italian peninsula
- Iceland
- Balkan region
- Greek Islands



- system temperature
- system depth
- dominant phase (liquid, vapor, gas)
- host rock type (igneous, carbonates, sandstones)
- reservoir type (matrix, void, fracture)
- stimulation requirements (hydrothermal or EGS)

- Classification of geothermal **plants**:
 - *Power* production → electrical energy production
 - *H&C* applications → thermal energy production
 - Combined Heat and Power production (CHP) → electrical and thermal energy

- Inventory of **technologies** used in each phase of plants' lifespan



→ **Clusterisation** of European geothermal plants

“group of geothermal plants having common characteristics in terms of geological and technological parameters.”

1. Methodology for Geothermal Emissions Data Collection (1/2)

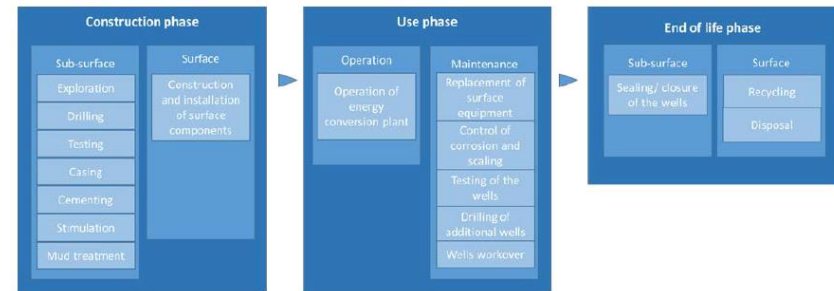
- Definition of **key parameters** to estimate emissions in each phase of the plants' lifespan:



Direct emissions: deriving from the ground (e.g.: due to drilling phase) or emissions to atmosphere during operation phase



Indirect emissions: linked to other activities i.e. extraction of plants' construction materials



cradle to gate approach
decommissioning and downstream module omitted

Technology parameters

- Plant size (MW)
- Operation of the plant (h/y)
- Operating life (y)
- Well depth
- Production technology
- Number of wells (production and reinjection)
- Conversion technology (if applicable)
- Cooling system (if applicable)
- Gas treatment system (if applicable)
- Reinjection system (if applicable)
- Well stimulation (if applicable)

Geothermal source parameters

- Reservoir type
- Geothermal Fluid Composition
- Gas content
- Temperature

Validation Workshop:
data to be collected



2. Data Collection

- ✱ Literature and public reports
 - LCAs of geothermal projects available in the scientific literature
 - other general studies on air emissions and externalities of geothermal energy: analysis by the Geothermal Energy Association
 - study on GHG from geothermal power production by World Bank

📄 *Surveys* to European geothermal areas' responsible officers to obtain **measured** data

⚙️ Development of *proxies* in case of missing develop formulas to **estimate** data

Consultation of experts:
*collected data and proxy
validation*

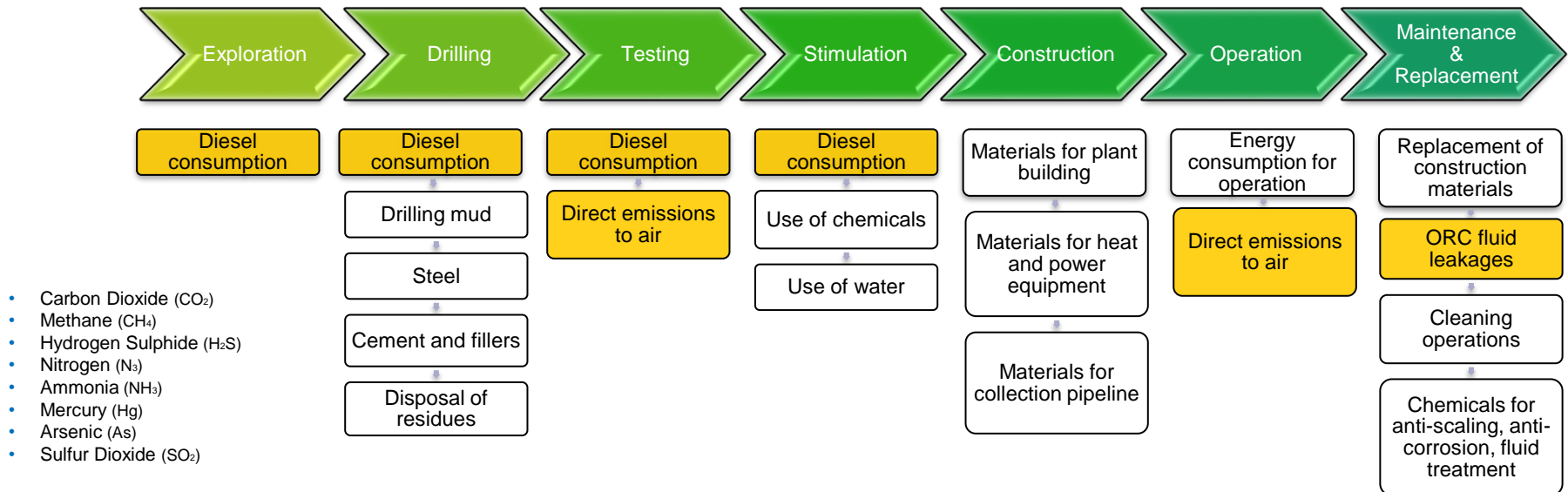


2. Life Cycle and GHG Emissions Inventory

...to feed the model to calculate emissions and consequently estimate the impacts...

Life Cycle Inventory (LCI): identify and quantify the input flows and output flows of a system

GHG Emissions Inventory: split the emissions (energy source and gas released) along the life cycle phase of each geothermal energy technology investigated



Direct emissions

3. Definition of Impact Categories – LCIA

For each identified **impact categories**, RINA identify the main responsible emission phase in the geothermal plant lifetime, for each cluster

Impact Category*	UdM	Main Responsible Emission Phase	Non-Negligible Responsibles
Acidification Potential	[kg SO _{2eq}]	Drilling, Operation Emissions	Equipment, Maintenance
Human toxicity: Cancer Effects	[kg DCB _{eq}]	Equipment	Drilling
Human toxicity: Non-Cancer Effects	[kg DCB _{eq}]	Drilling, Equipment, Operation Emissions (where present)	Replacement
Climate Change - Global Warming Potential	[kgCO _{2eq}]	Drilling, Operation Emissions	Equipment
Ecotoxicity Potential - Freshwater	[kg DCB _{eq}]	Drilling, Operation Emissions	Maintenance
Eutrophication Potential – Freshwater	[kg Phosphate _{eq}]	Drilling	Maintenance
Eutrophication Potential – Marine	[kg Phosphate _{eq}]	Drilling, Operation Emissions	Maintenance, Equipment
Eutrophication Potential – Terrestrial	[kg Phosphate _{eq}]	Drilling, Operation Emissions	-
Ozone Depletion Potential	[kg R11 _{eq}]	Drilling	Maintenance
Photochemical Ozone Formation	[kg Ethene _{eq}]	Drilling, Operation Emissions (where present)	Maintenance, Equipment
Particulate matters - Respiratory Inorganics	Disease incidences	Drilling, Operation Emissions (where present)	-

*Sources

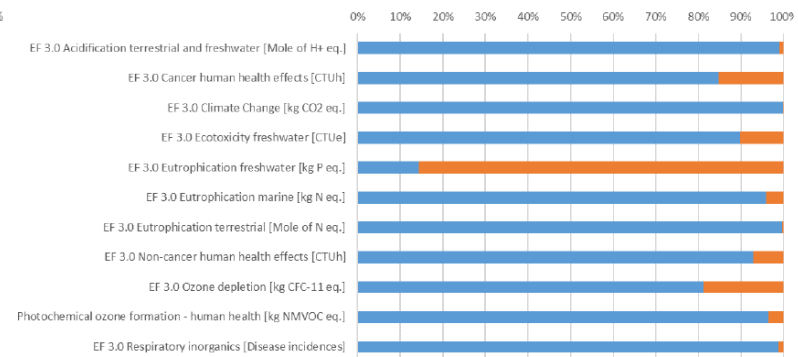
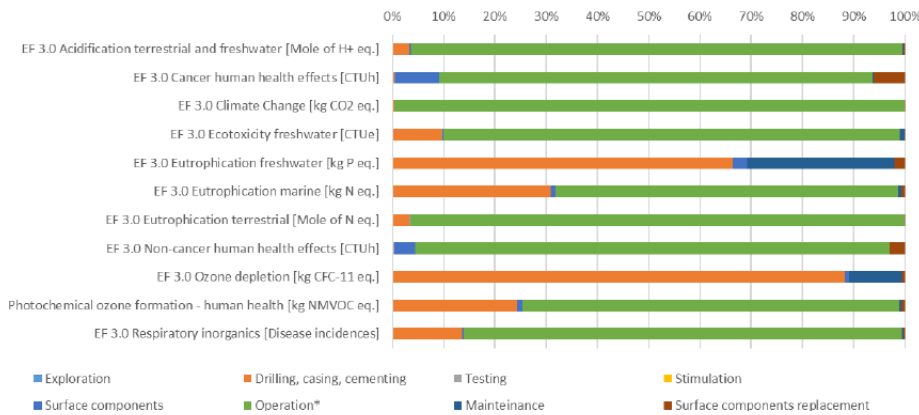
- JRC on the Environmental Footprint methodology
- EPD PCR "Product group classification: UN CPC 171 AND 173 - Electricity, steam and hot/cold water generation and distribution

4. Results and Interpretation

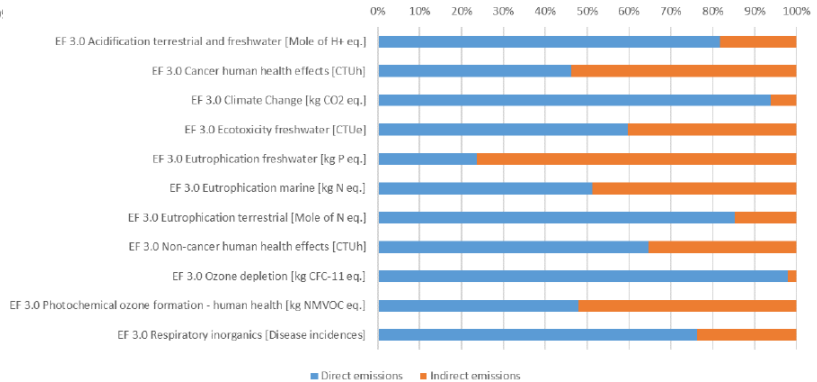
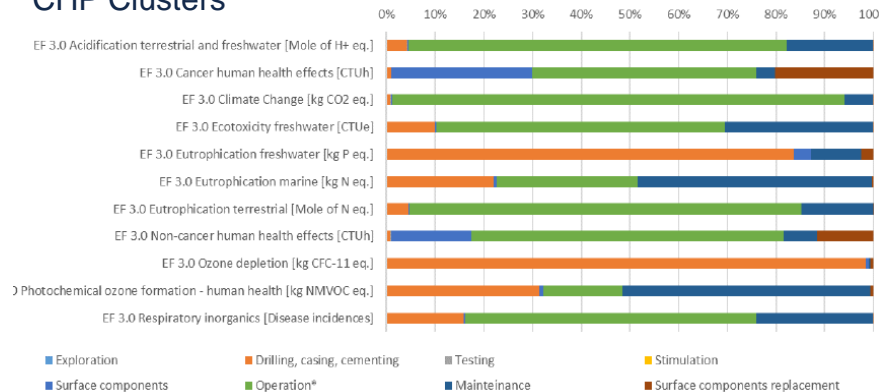
Emissions during each phase of geothermal plants' lifespan - Italian Clusters

Power Clusters

GaBi ts© by Thinkstep AG/Sphera
professional database (8.7, service pack 39)
EcoInvent 3.5 database



CHP Clusters



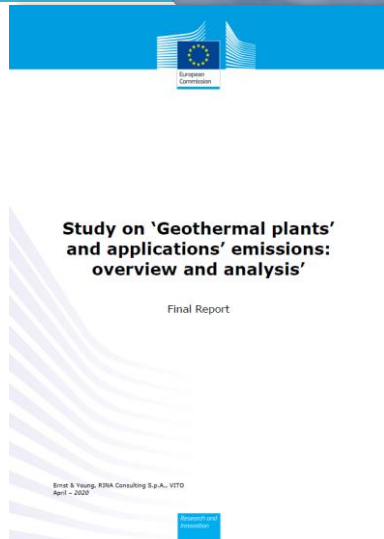
4. Main Outcomes

- ✓ **clusterization** of European P and DHC applications based on geological and technological parameters
- ✓ **sector category rules** for LCA related to geothermal sector
- ✓ **proxies** for deriving inventory flows from key parameters

4. Recommendations

- **Acknowledge and understand the extreme variability of geothermal sector**
→ policy making, financial/funding instruments, technological developments shall be fairly addressed to cover it
- **Improve data availability/sharing and harmonize and promote best practice**
→ promote a harmonization of available info and a standardization of data to be collected at international scale
- **Address the development for the most significant LC phases of geoth. energy generation**
(e.g.: electricity-based drilling rigs, development of low-impact chemicals or equivalent)
- **Limit the flow of direct emissions with mitigation measures** (e.g.: total reinjection of the geothermal fluid, regulation of pressure of operation, AMIS technology)
 - **Large potential for the use of the proposed approach to monitor and evaluate the performance of geothermal plants for internal/external benchmarking**

For More Details...



<https://op.europa.eu/it/publication-detail/-/publication/b100f4de-932e-11ea-aac4-01aa75ed71a1>

