How will geothermal energy transform the environmental performance of the heating mix of the State of Geneva from a life-cycle perspective?

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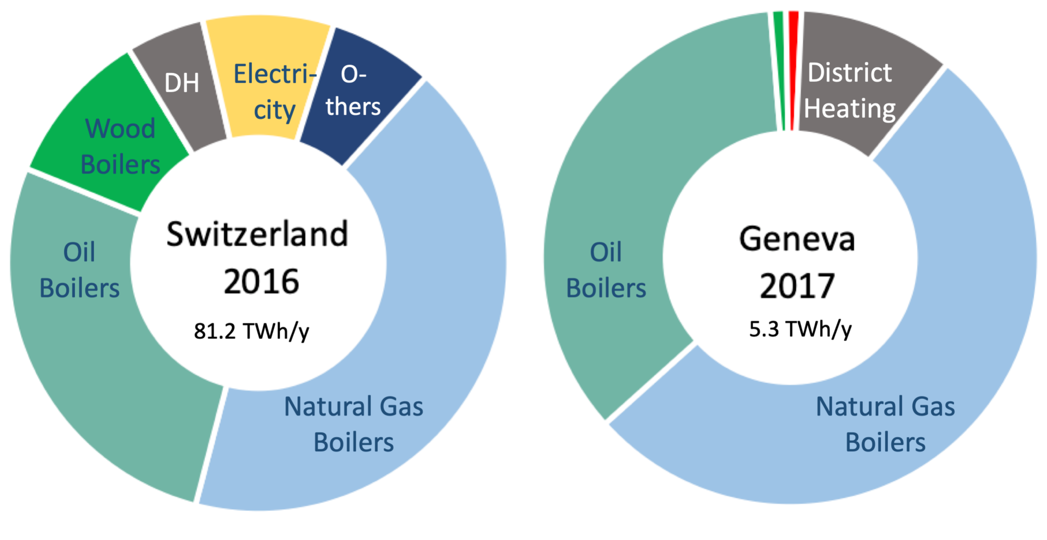


Figure 1. Heat delivery to buildings by source.
Adapted from Narula et al., 2019 and Quiquerez et al., 2020

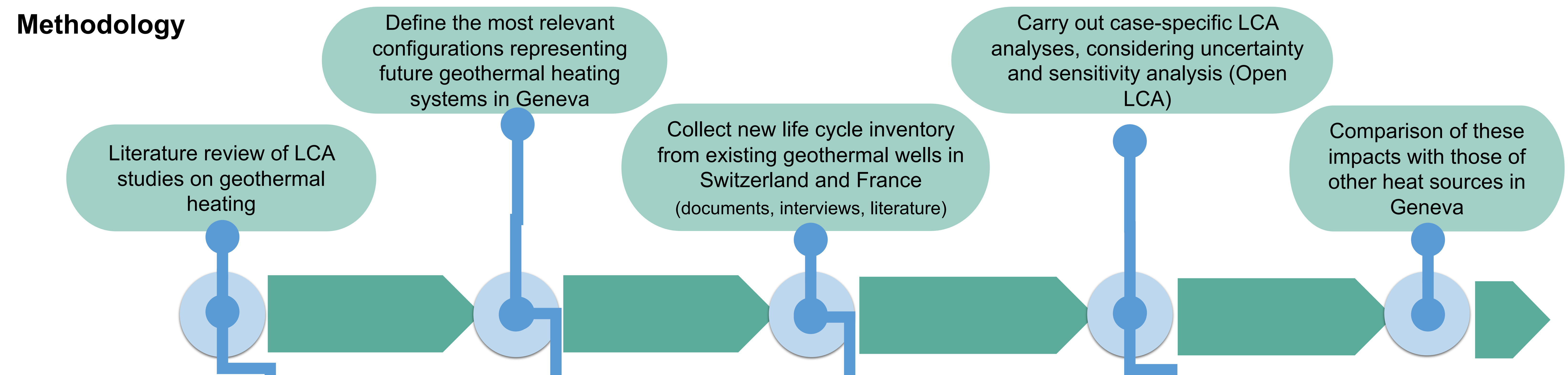
Background

- In Geneva, like Switzerland, fossil fuels dominate the heating sector [1] (Figure 1).
- A combination of geothermal heating applications in Geneva could potentially cover 75% of the heating demand by 2030 [2].
- GEothermie 2020 program [3] aims to better comprehend Geneva's subsurface characteristics and to develop new geothermal projects.
- The environmental impacts of geothermal energy inclusion in the heating and cooling mix need to be evaluated to ensure their sustainable deployment.
- Life Cycle Assessment (LCA), as a widely used component of sustainability assessments, is a suitable methodology to analyze the environmental performance of geothermal energy in the heating and cooling sector.

Research questions

1. What is the **environmental performance of geothermal heating and cooling systems** in the State of Geneva, also considering **uncertainties** ?
2. How will this performance change in the case of **multi-source district heating systems,** when geothermal heat is used in combination with other heating sources?
3. How do these environmental impacts compare with **other heating and cooling sources**?

Methodology



First results

- Out of 28 LCA-based studies on geothermal heating systems in the literature, 20 cover Ground Source Heat Pumps (GSHP).
- A comparison between LCA studies and existing installations shows a lack of LCA studies on medium-enthalpy geothermal systems involving extraction of groundwater, despite their popular deployment in Europe (Figure 2).
- The impacts of GSHP depend on the electricity mix and COP [4-6], thus have a large spread and are not always better than individual oil boilers (Figure 3).
- Groundwater systems are reported to perform relatively better than oil boilers (Figure 3).

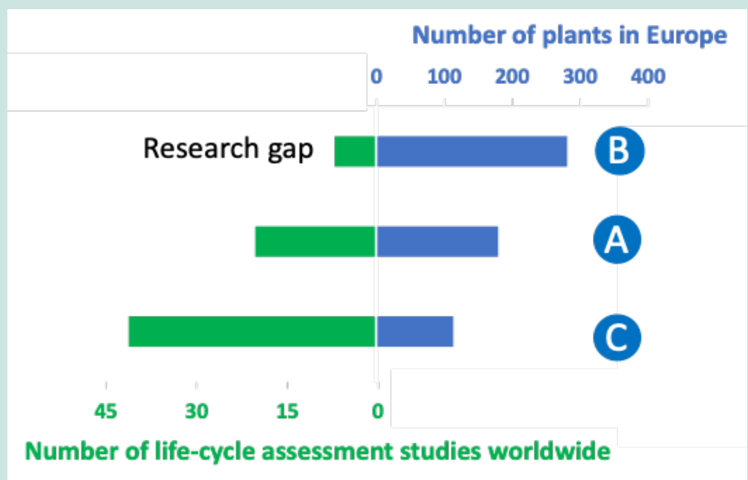


Figure 2. *Identified research gap in LCA for the geothermal open systems*

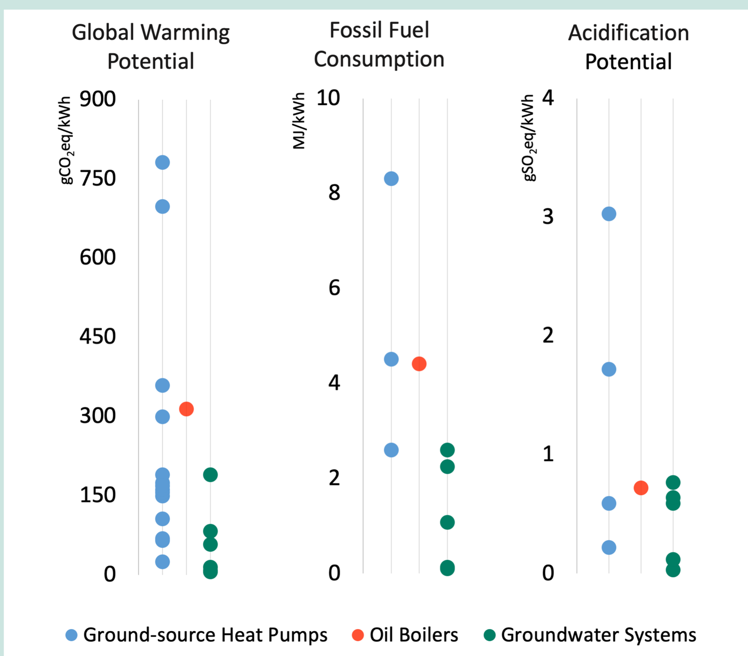


Figure 3. *Summary of the reported impacts in the literature, and comparison to the impacts of individual oil boilers (except for GWP, only CML-based calculations are plotted)*

- LCA on groundwater geothermal systems is needed to strengthen the literature, as well as to support GEothermie 2020 program.

HP INDIVIDUAL OR DECENTRALIZED (A) La Plaine, Jargonnant	HP + DISTRICT HEATING (B) Concorde	NO HP + DISTRICT HEATING (C) Versoix, Rive Gauche	
Scenario IA-1 (*EMS La Plaine) / Scenario IA-2 (*Jargonnant)	Scenario IB		SMALL DEPTH (I) < 100 m Versoix, Concorde
Scenario IIA	Scenario IIB	Scenario IIC	MEDIUM DEPTH (II) < 1500 m Satigny, Bassersdorf, Lavey-le-Bains
	Scenario IIIB	Scenario IIIC	LARGE DEPTH (III) >1500 Rittershoffen (FR), Riehen, Thônex

Table 1. *Scenarios of groundwater extraction geothermal systems that could be relevant in Geneva and their installation references. *The case studies analyzed so far are presented in the next section.*

- Several scenarios are defined to represent the probable configurations of subsurface and surface systems in Geneva (Table 1).
- Existing installations (written in green in Table 1) are the identified references to collect life cycle inventory, to develop LCA models, and to validate the models.

- LCA studies were carried out for EMS La Plaine (Configuration 1) and Jargonnant (Scenario IA-2) for a lifetime of 30 years. Table 2 presents the differences between the two.
- Operation stage is the major contributor to almost all environmental impacts (Figure 4).
- Compared to oil boilers, the two systems have lower climate change impact, emit less particulate matter, and depend less on fossil fuel (Figure 5).

	Scenario IA-1 EMS La Plaine	Scenario IA-2 Jargonnant
Well diameter / depth	0.18 m / 10 m	1 m / 30 m
Flowrate	5.5 l/s	30 l/s
Cooling	Passive	Active
Solar Thermal	Yes	No

Table 2. *Main differences between Scenario IA-1and IA-2*

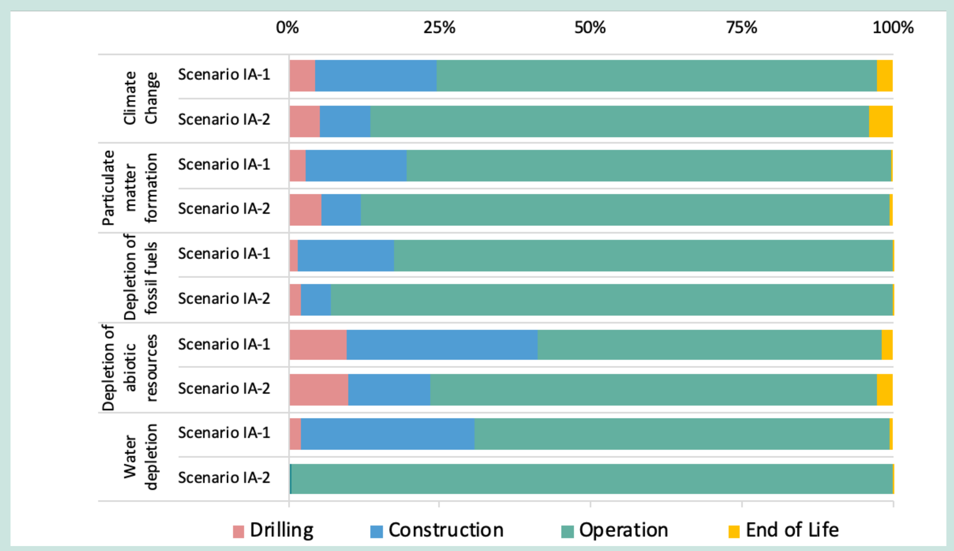


Figure 4. *Preliminary results on the contribution of different life-cycle stages of Scenario IA-1 and Scenario IA-2 towards five selected environmental impacts*

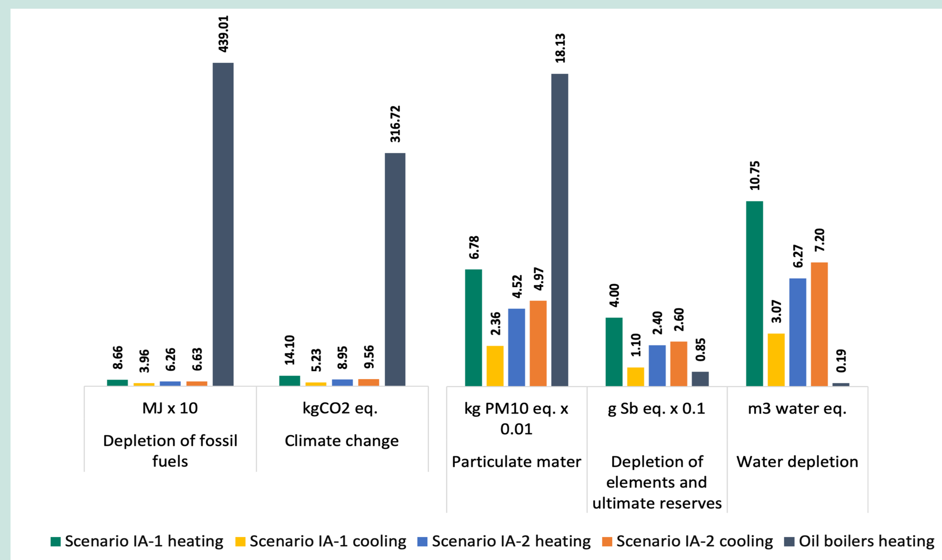


Figure 5. *Preliminary results on environmental impacts by Scenario IA-1 and Scenario IA-2 as compared to oil boilers*

- The high impacts on water and abiotic resources are mainly due to the use of reservoir hydro-electricity and metal-based materials (Figure 5).

Acknowledgement

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