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SECTION DE GÉNIE CIVIL

Energy performance of a high BHEs density at district scale

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Introduction

In **2018** building sector represented **28%** of total energy consumption and **36%** of total CO_2 emissions in **U.S.** Therefore, it exists a real need of decarbonize this sector. **BHEs** are of a great interest in an environment where place is limited as in cities. **Thermal interference** is the main issue which arises when there is a dense deployment of BHEs. Currently, **no framework** subsists to manage this phenomenon caused by a high deployment of BHEs.

Case study

This study focused on a district situated in **Chicago** (State of **Illinois**, U.S.), called the **Loop**. It is the **second** main business core of North America. In 2018, its population exceeded 37'000 inhabitants, corresponding to a demographic density of **9'500 people/km²**. The district extends over a surface of **4km²** (1.3km² covered by the Grant Park).

Goal and workplan

This Master project aims to investigate the **energy performance** of a high BHEs deployment of BHEs over a dense populated district of Chicago. This goal in purchased by establishing two different approaches: an **analytical modelling** applied at **district scale** and a **numerical modelling** performed for two **reference blocks of buildings**.

Evaluate **energy performance** of a high BHEs density over a **dense populated** district in Chicago

1. Preliminary investigation
2. Analytical modelling
3. Numerical modelling

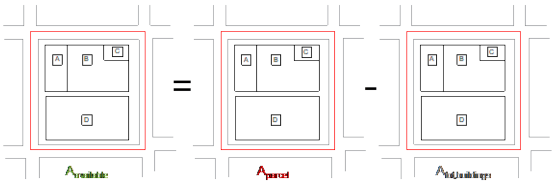
Analytical modelling

1. Design of BHEs
   - Length of single BHE: **200m**
   - Borehole diameter: **150mm**
   - Separation distance between BHEs: **8m**
   - Buffer distance from boundaries: **4m**
   - Linear thermal power: **50W/m**
2. Design of GSHPs
   - COP of **4** (assumed **constant**)
   - Operating hours

	Heating	Cooling
Residential building	2500h	700h
Commercial building	870h	600h

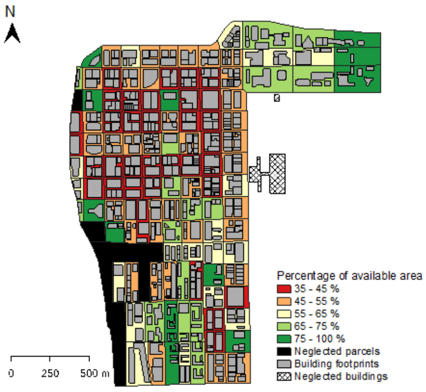
3. Processing to quantify the number of BHEs

$$A_{available}\ (green) = A_{parcel}\ (red) - A_{buildings}\ (grey)$$



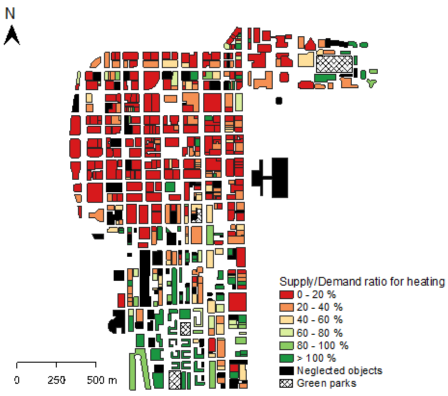
4. Results
   - Available area

Out of **2.63 km²**, an available area of **2.45 km²** is assessed for BHEs deployment. More than **20'000 BHE units** can be virtually installed.



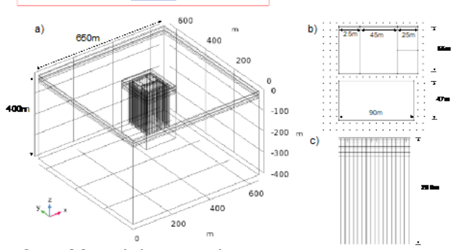
   - Covered demand for heating

The BHEs deployed yield to **4.2 x 10⁵ MWh** of heat energy extractable from the ground, corresponding to **171 kWh/m²**. This identified geothermal potential satisfies **24%** of the total district heating



Numerical modelling

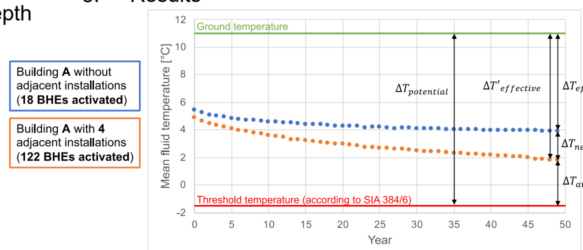
1. Model geometry
   - Building represented by its basement depth
   - BHE simplified as **finite line**



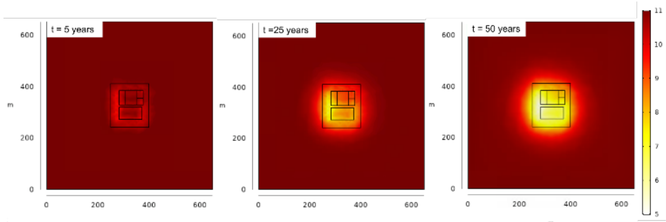
2. Material properties

Geological layer	Thermal conductivity λ $[W/(mK)]$	Heat capacity at constant pressure c_P $[J/(kgK)]$	Density ρ $[kg/m^{-3}]$	Layer thickness $[m]$
Sand	1	782	1918	4
Soft clay	1.22	1456	1846	12
Stiff clay	1.22	1456	2000	3
Hard clay	1.22	1456	2081	8
Sand and boulders	1.035	740	2320	7
Dolomitic limestone	3	853	2639	∞

3. Results



We propose to integrate the temperature gaps experienced by the fluid circulating in pipes and highlighted by numerical calculations to optimise or to adjust the BHEs **design accounting for the presence of neighbouring geothermal installations.** We suggested to apply **correction factors** to each single field based on the temperature reserve or drop experienced by the corresponding heat carrier fluid compared to threshold limit of 1.5 ° C fixed by the Swiss geothermal norm.



Ground temperature distribution around BHEs at a depth of **z = 100 m** – five BHEs fields activated (i.e. **122 BHEs**)

Conclusion

The workflow summaries the main steps applied during the project.