
IDEA2021
Powering the Future: District Energy/CHP/Microgrids
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The Potential for Development of District Cooling Networks: A Case Study in Paris (France)

Rémi Patureau, PhD student

Efficacity / Engie / Mines Paristech

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Problem

- How to develop the use of District Cooling Networks (DCN) to meet the increasing need for cooling in dense areas?

Solution

1. Use a georeferenced approach to estimate the potential space cooling demand, both for the commercial and the residential sector
2. Assess the potential of extending the already existing DCN

➔ Application of this method in the city of Paris (France)

Method

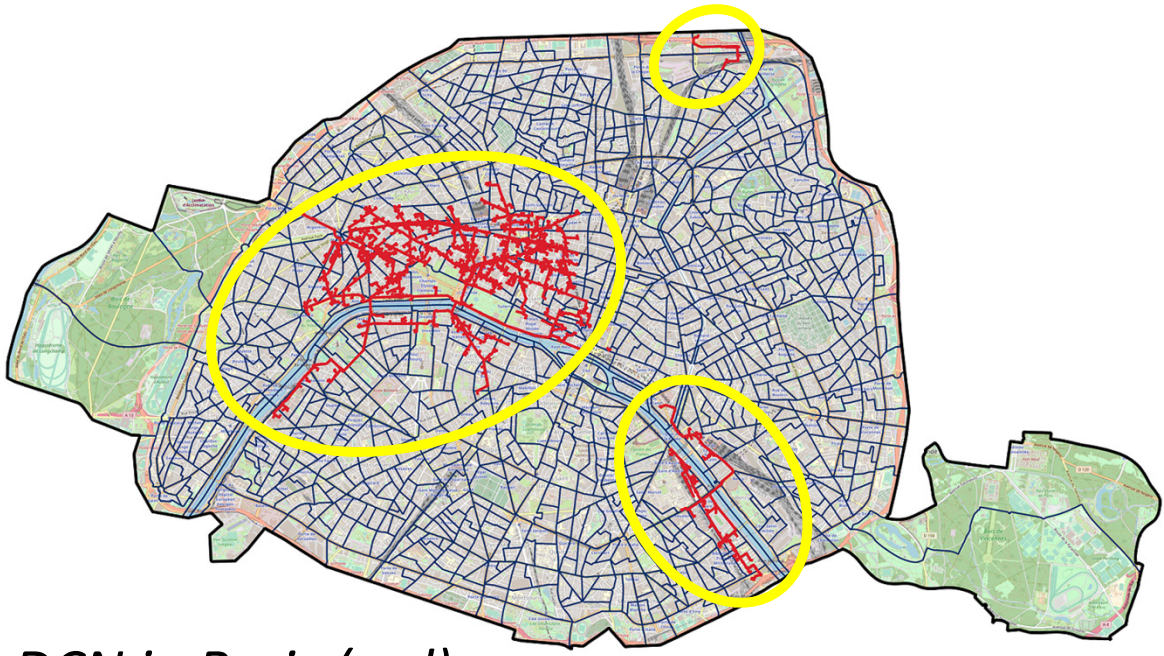
1. Estimate the potential space cooling demand
2. Assess a cooling linear density
3. Categorize the potential areas depending on:
   - The period of construction of the building stock
   - The share of the residential sector in the energy consumption

Current space cooling demand in Paris

- Estimated to be 2-3 TWh/y at the moment
  - Mostly from the commercial sector
- Increasing cooling needs, from both *Commercial* **AND** *Residential sector*

Current space cooling demand in Paris

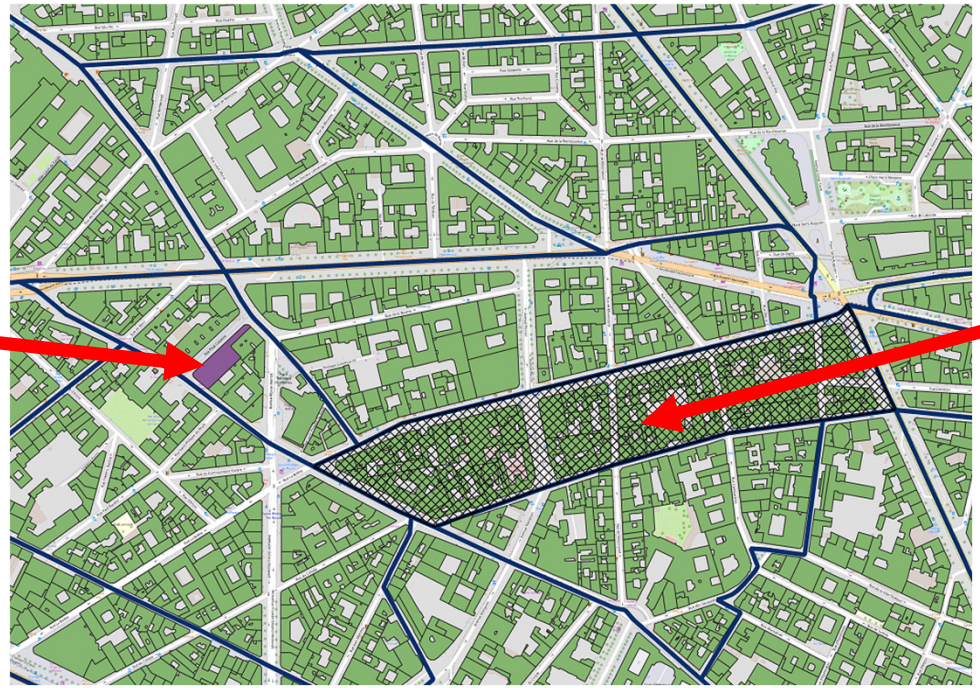
- District cooling network (DCN) in Paris
  - Climespace
  - 83km
  - 0.5GWh/y
  - Biggest DCN in Europe
  - Possible extension(s) ?



DCN in Paris (red)

Estimate the potential space cooling demand: Databases

Buildings (approx. 100,000)
- Surface footprint
- Height
- Sector of activity
- Period of construction



Areas / Districts (approx. 1,000)
- Period of construction
- Energy consumption

Buildings (green and purple) and districts (blue)

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INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Estimate the potential space cooling demand: method

- Based on the following papers:
  - “Estimation of European Union service sector space cooling potential”, M. Jakubcionis and J. Carlsson
  - “Estimation of European Union residential sector space cooling potential”, M. Jakubcionis and J. Carlsson

Estimate the potential space cooling demand: method

$$Space\ cooling\ demand\ (MWh) = Cooling\ demand\ intensity\ \left(\frac{kWh}{m^2}\right) \times Surface\ of\ the\ buildings\ with\ cooling\ equipment\ (m^2) \quad (1)$$

$$Surface\ of\ the\ buildings\ with\ cooling\ equipment(m^2) = Total\ surface\ of\ buildings(m^2) \times Market\ saturation(\%) \quad (2)$$

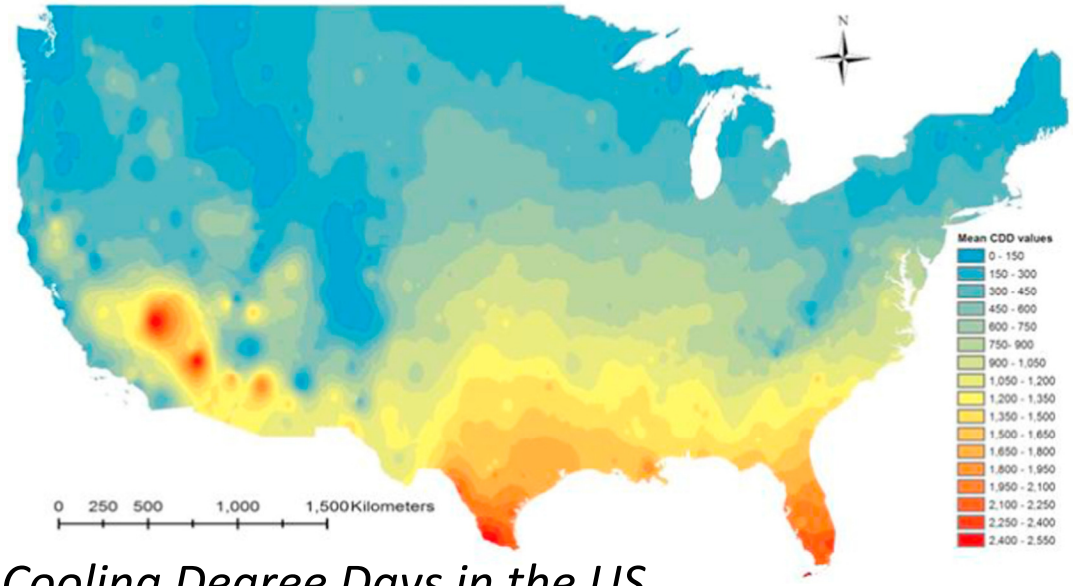
Estimate the potential space cooling demand: method

- *Cooling demand intensity (kWh/m²)*: The required cooling energy per unit of surface
- *Market saturation (%)*: Proportion of the buildings equipped with cooling equipment in the future

Estimate the potential space cooling demand: method

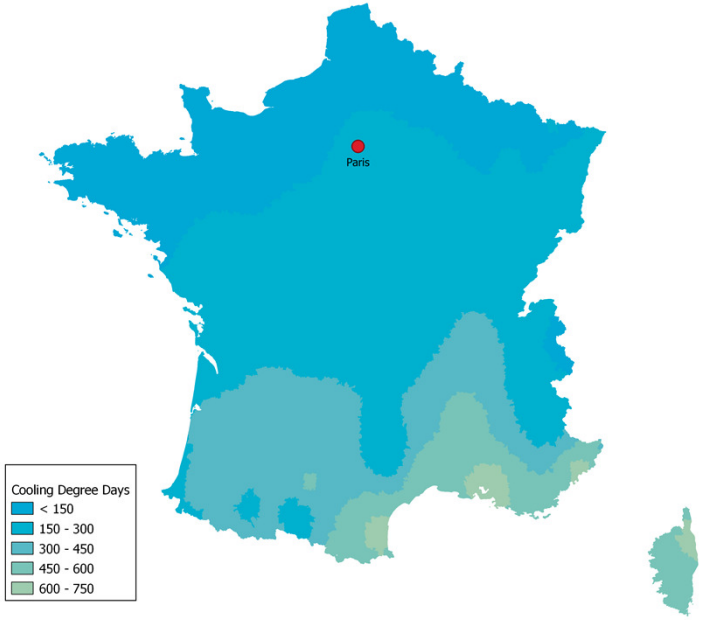
- $Cooling\ demand\ intensity$ and $Market\ saturation$ depend on ***Cooling Degree Days***
- Sum over a year of the daily difference between the mean outdoor temperatures and a reference temperature, 65°F here

Cooling Degree Days (US / France)



Cooling Degree Days in the US

"Estimation of European Union service sector space cooling potential", M. Jakubcionis and J. Carlsson



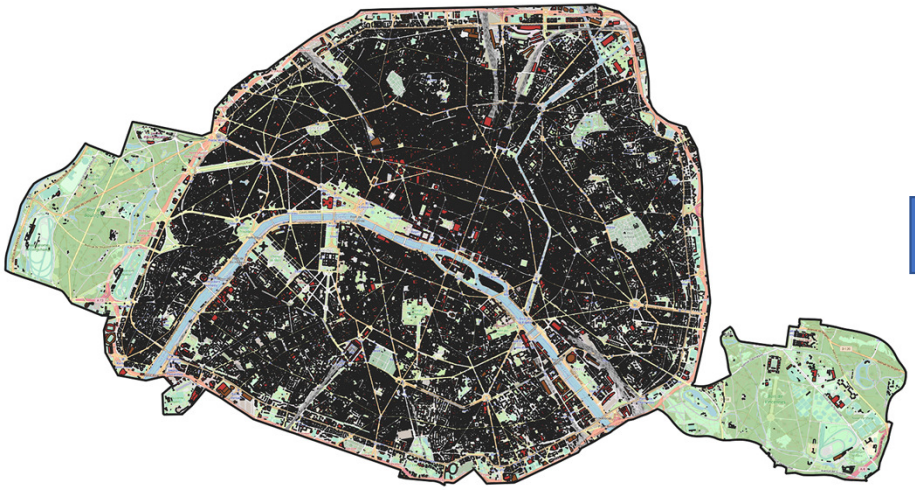
Cooling Degree Days in France

Estimate the potential space cooling demand: Results in Paris

- Commercial sector
  - Cooling Degree Days : 210
  - Market saturation: 66%
  - Cooling demand intensity: 36kWh/m²

- Commercial sector
  - Cooling Degree Days : 210
  - Market saturation: 59%
  - Cooling demand intensity: 12kWh/m²

Selection of the buildings that are the most likely to need cooling

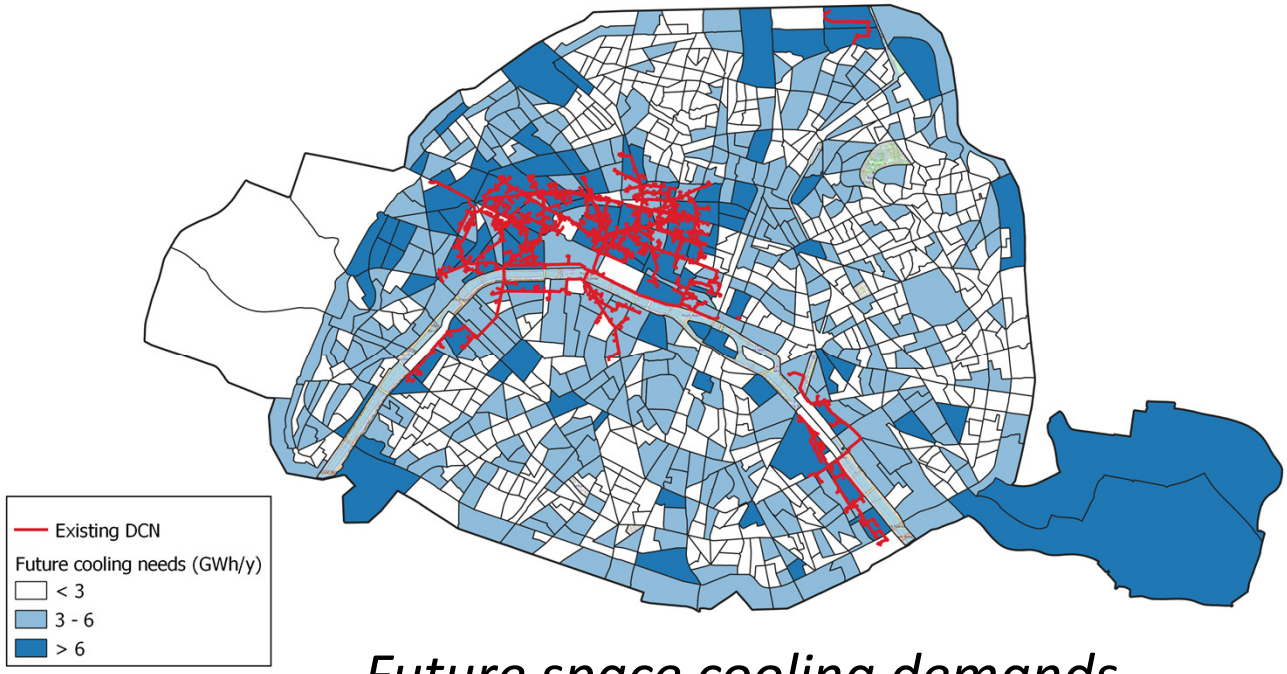


All the buildings in the city of Paris

The buildings with future cooling demands (according to market saturation)

Estimate the potential space cooling demand: Results in Paris

Future cooling needs for Paris: **3.3TWh**

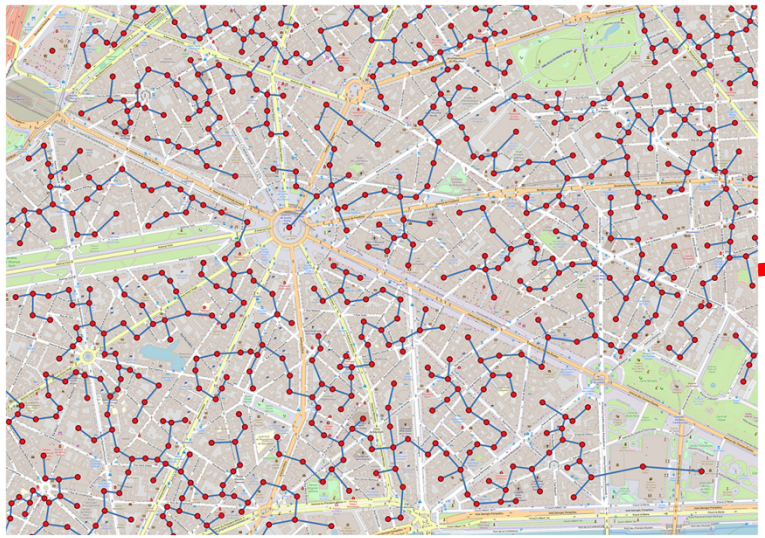


Future space cooling demands per district in GWh

Assess the cooling linear density

1. Application of a Delaunay triangulation
2. Use of Kruskal's algorithm to calculate a Minimum Spanning Tree to connect all the possible buildings

Kruskal's algorithm



Creation of a virtual network to connect all the buildings with cooling demands

The networks in the entire city

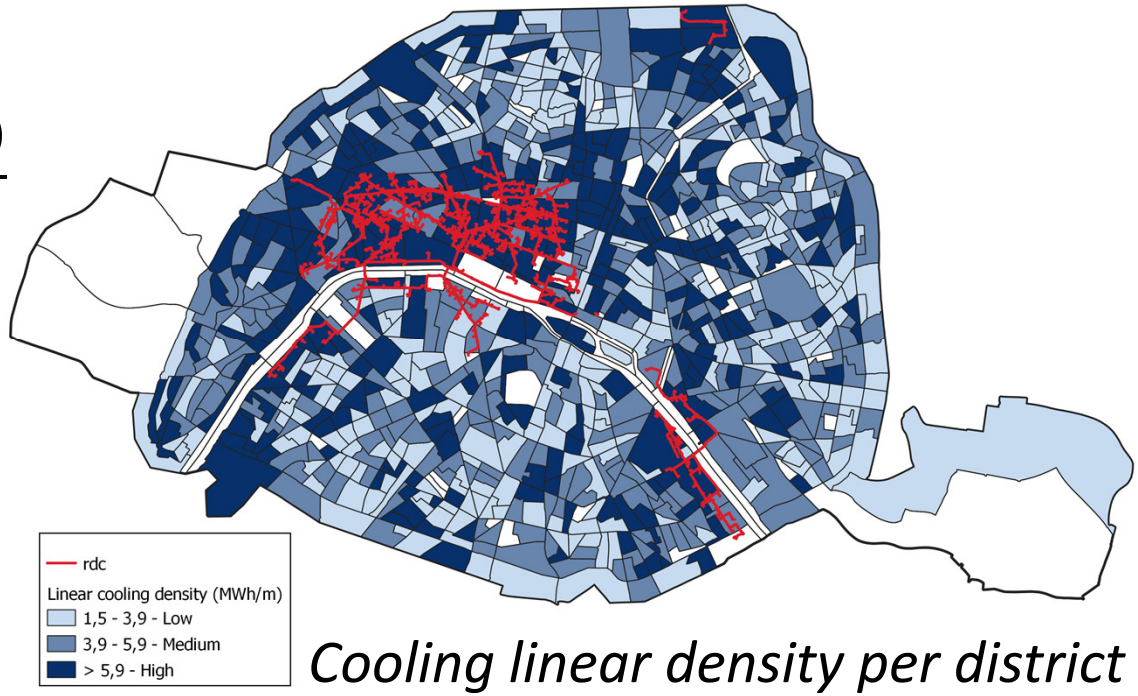
Cooling Linear density

Cooling linear density (MWh/m) =

$$\frac{\text{Energy consumption per district (MWh)}}{\text{length of virtual network (m)}}$$

Minimum for viability 1.5MWh/m

To extend the current DCN, prioritize the areas near the DCN with a high linear cooling density



Cooling linear density per district

Period of construction of the building stock

Most of the districts in Paris contain a majority of buildings built before 1990

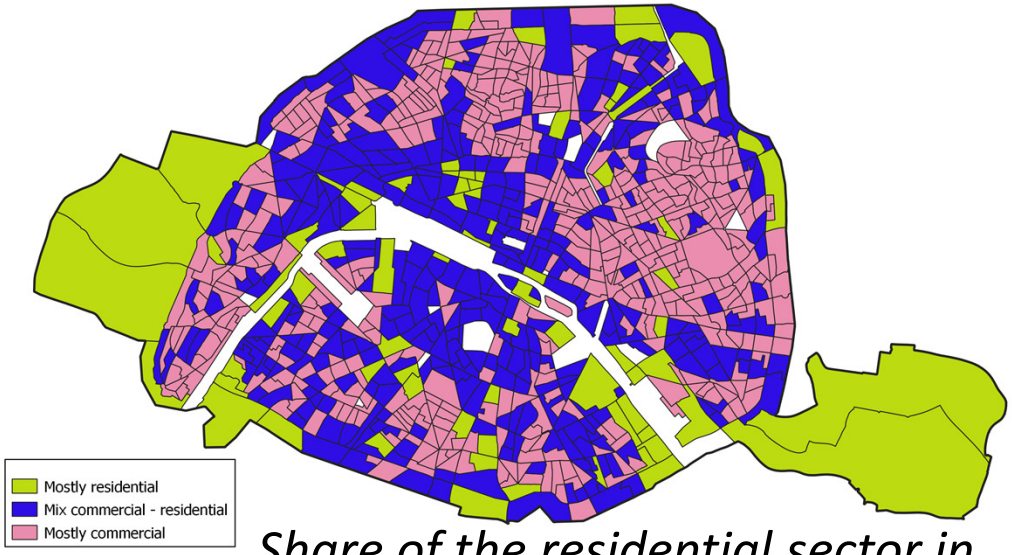
Period of construction per district

Share of the residential sector in the energy demand

$$\text{Share of the residential sector (\%)} = \frac{\text{Energy consumption from residential secor}}{\text{Energy consumption from residential+commercial sector}}$$

Most of the districts in Paris are either commercial areas or a mix between commercial and residential

➔ Variability of the cooling demand



Share of the residential sector in the energy demand

Conclusion

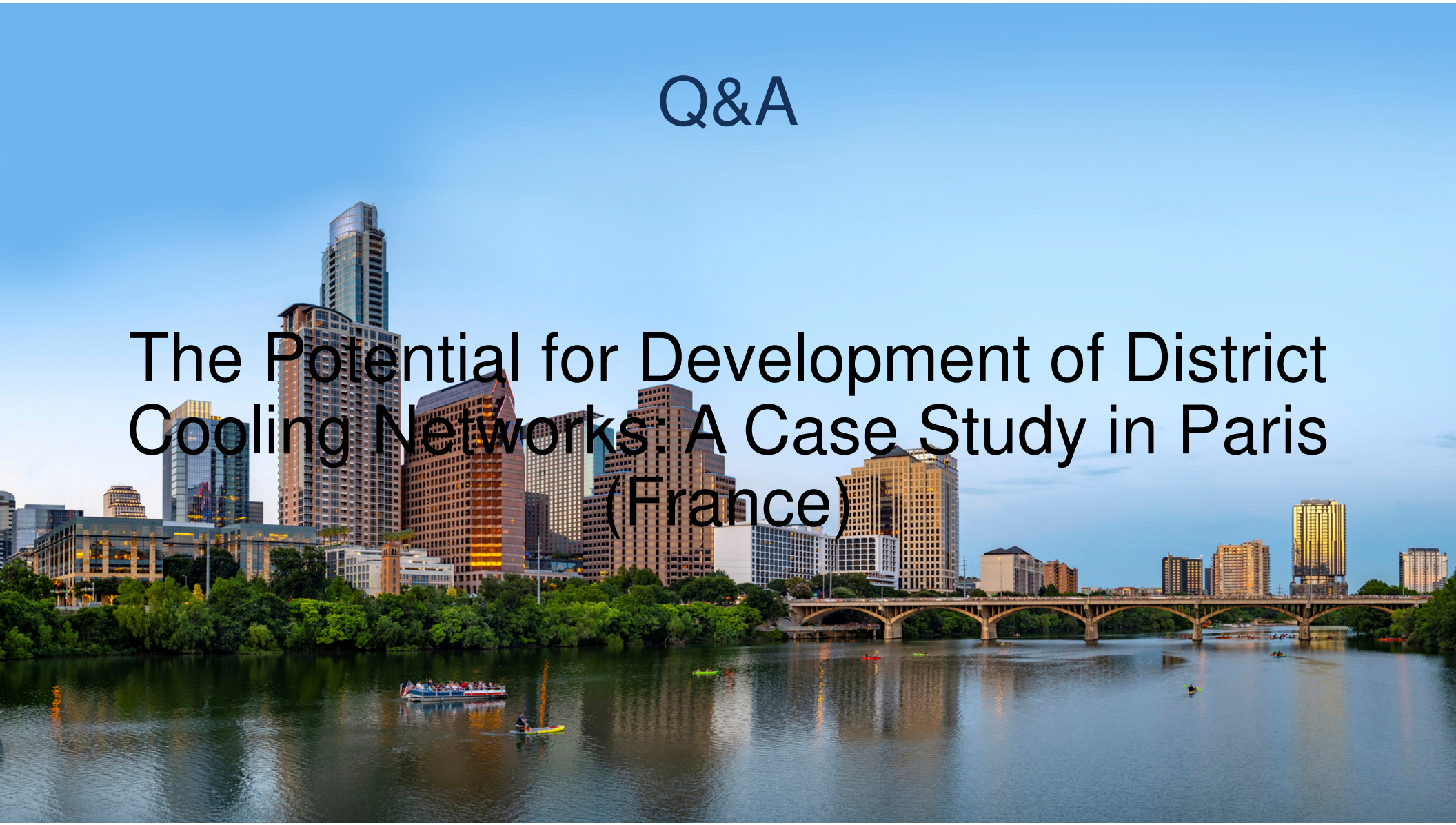
- Study as a first approach to explore the potential for extending existing DCN / creating new DCN
- For each area, we calculate:
  - A linear cooling density
  - Variability of the cooling demand
  - Period of construction of the buildings

Limits

- Statistical approach
- Potential new buildings not taken into account
- Climate (cooling degree days) supposed to remain constant to a certain extent

- More about the method in the article:
  "The new generation of District heating & cooling networks and their potential development in France"
  Energy, R. Patureau, C.T. Tran, V. Gavan, P. Stabat
  https://doi.org/10.1016/j.energy.2021.121477

Q&A



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Thank You!

Rémi Patureau

PhD Student

remi.patureau@mines-paristech.fr