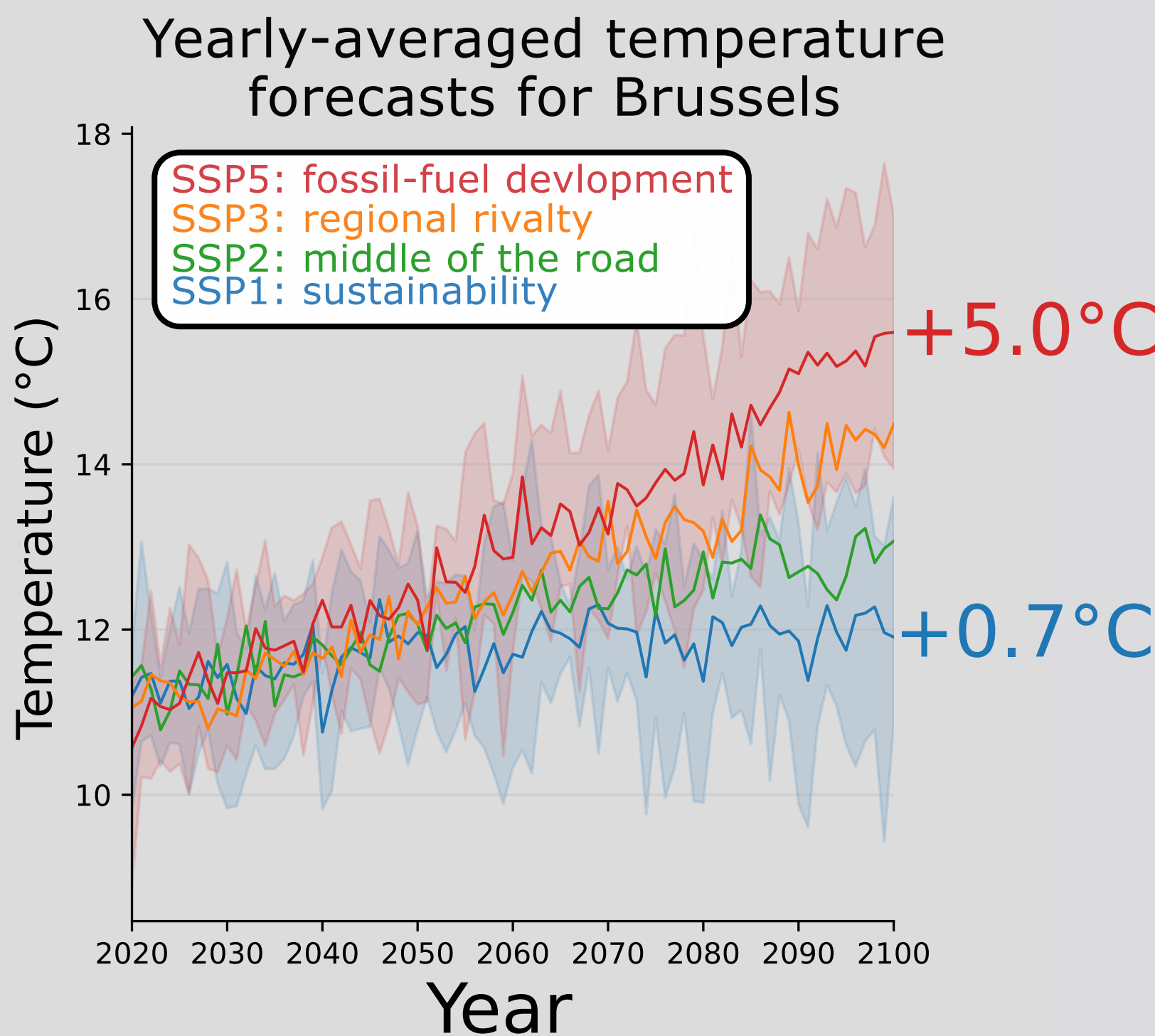
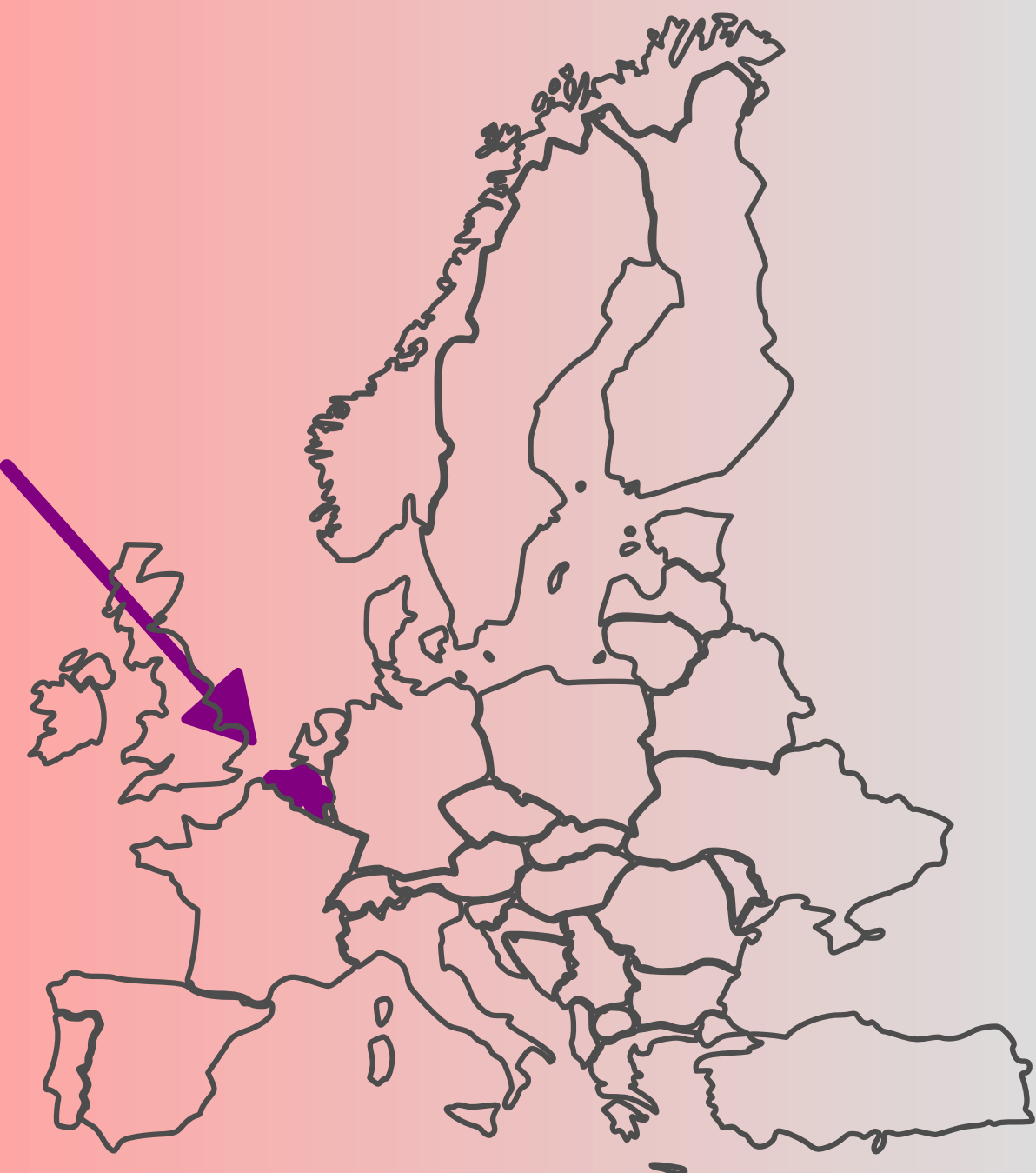


Planning heating and cooling supply for a warming century

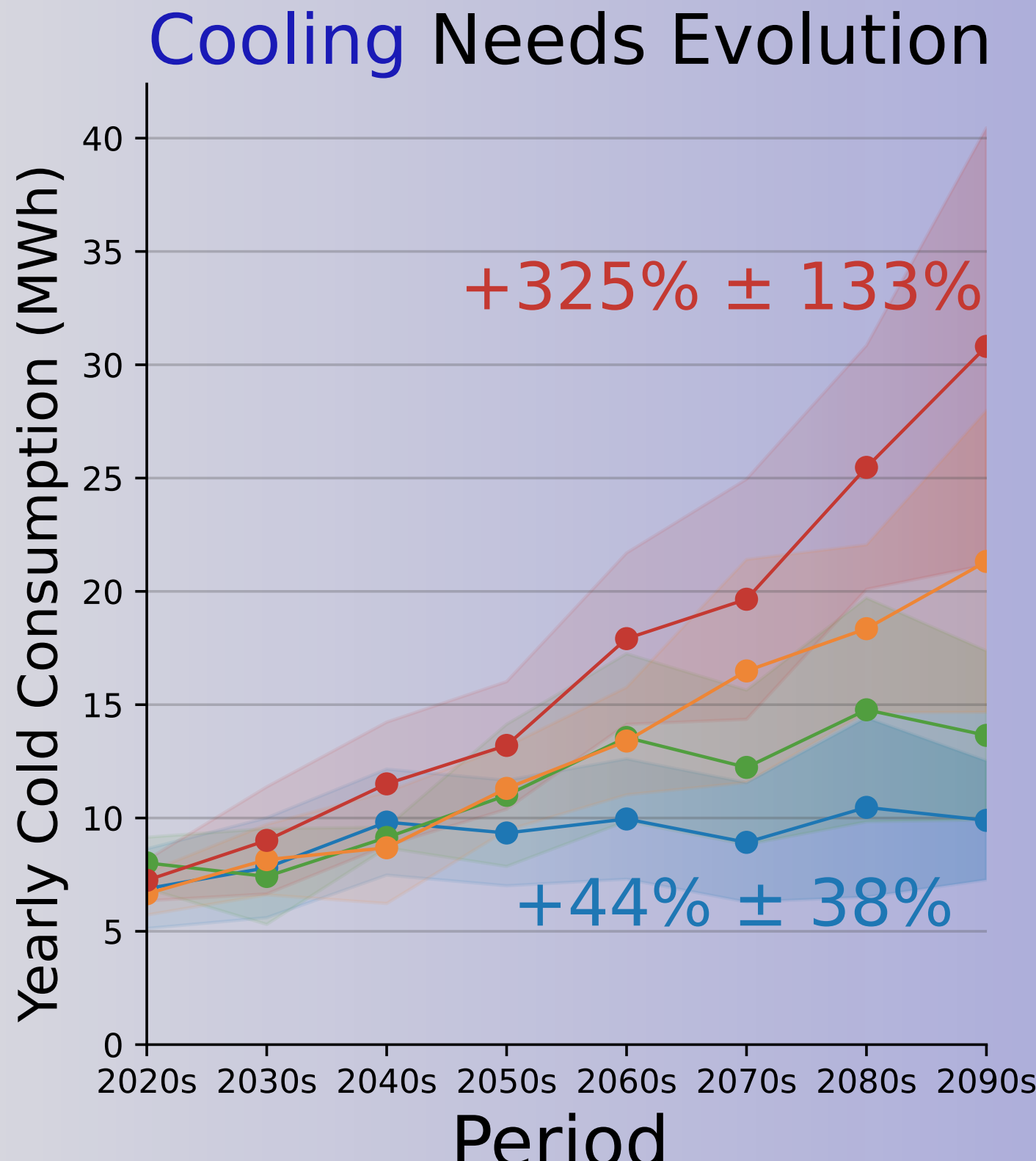
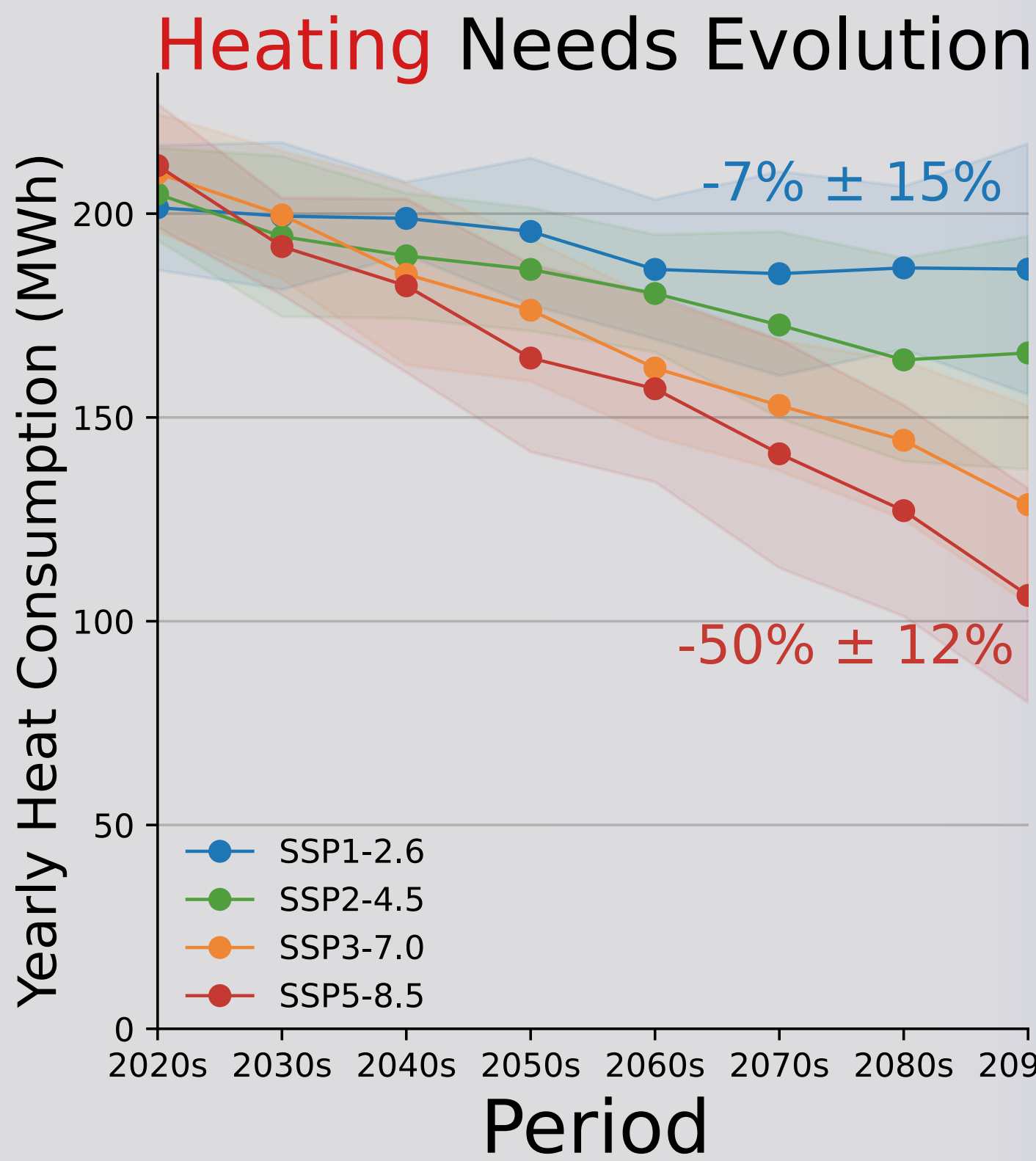
Jonathan Hachez, Nicolas Ghilain, Ali Kök, Diederik Coppitters

Our case study is based in **Brussels, Belgium**. To obtain the climatic forecast we considered **6 Global Circulation Model (GCM)**



However, **uncertainties** in the temperature projections are **significant** and driven by choices we make nowadays: which **shared socio-economic pathway (SSP)** are we gonna take ?

Due to climate change, by the century's end, my campus could use **50% less heat** but **4x more cooling**.



We need a **strategy** to determine how to size our assets.

We considered four different assets to keep the campus at an acceptable temperature level.



Natural gas boiler (NG boiler)



Air-source heat pump (ASHP)

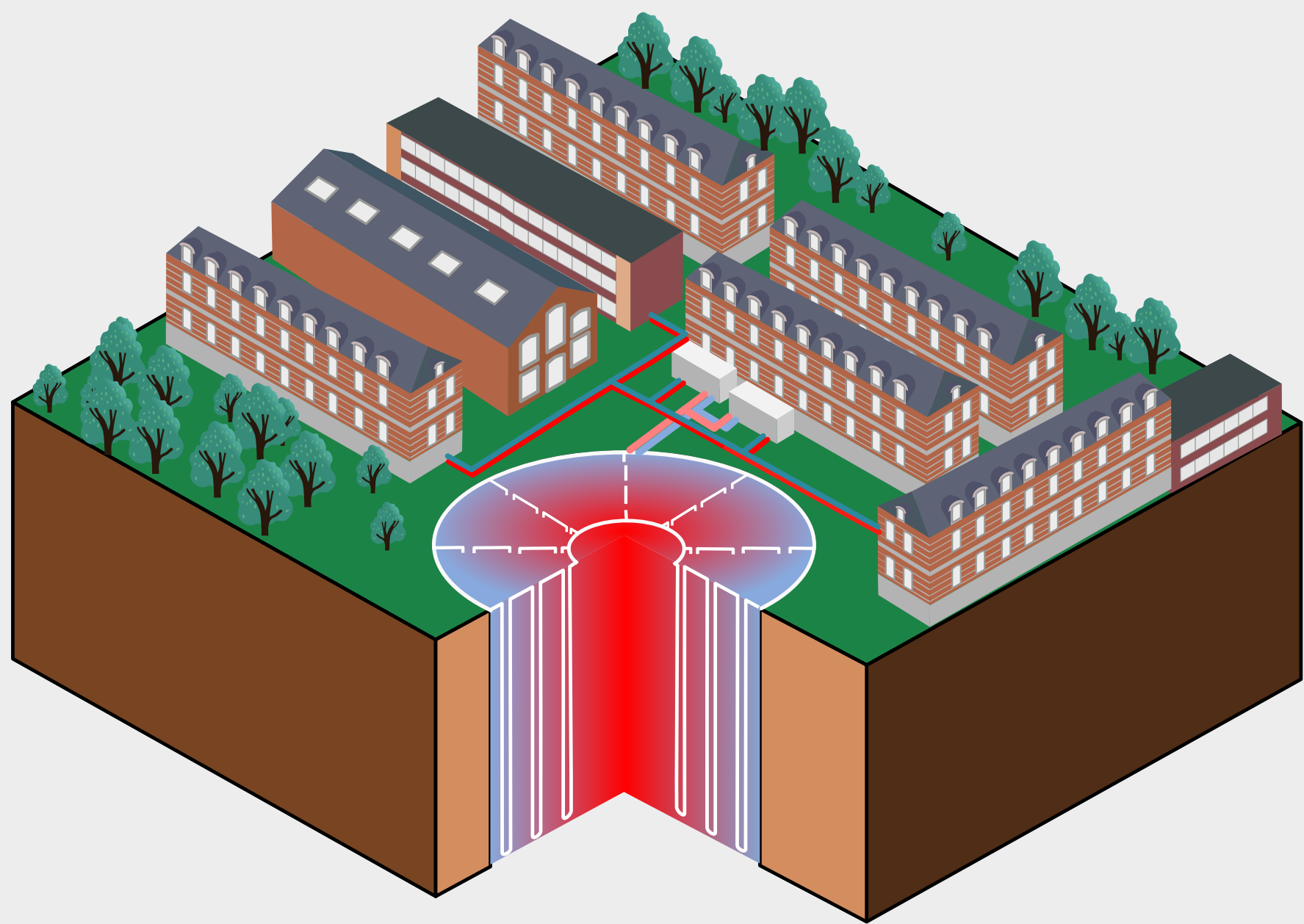


Ground-source heat pump (GSHP)



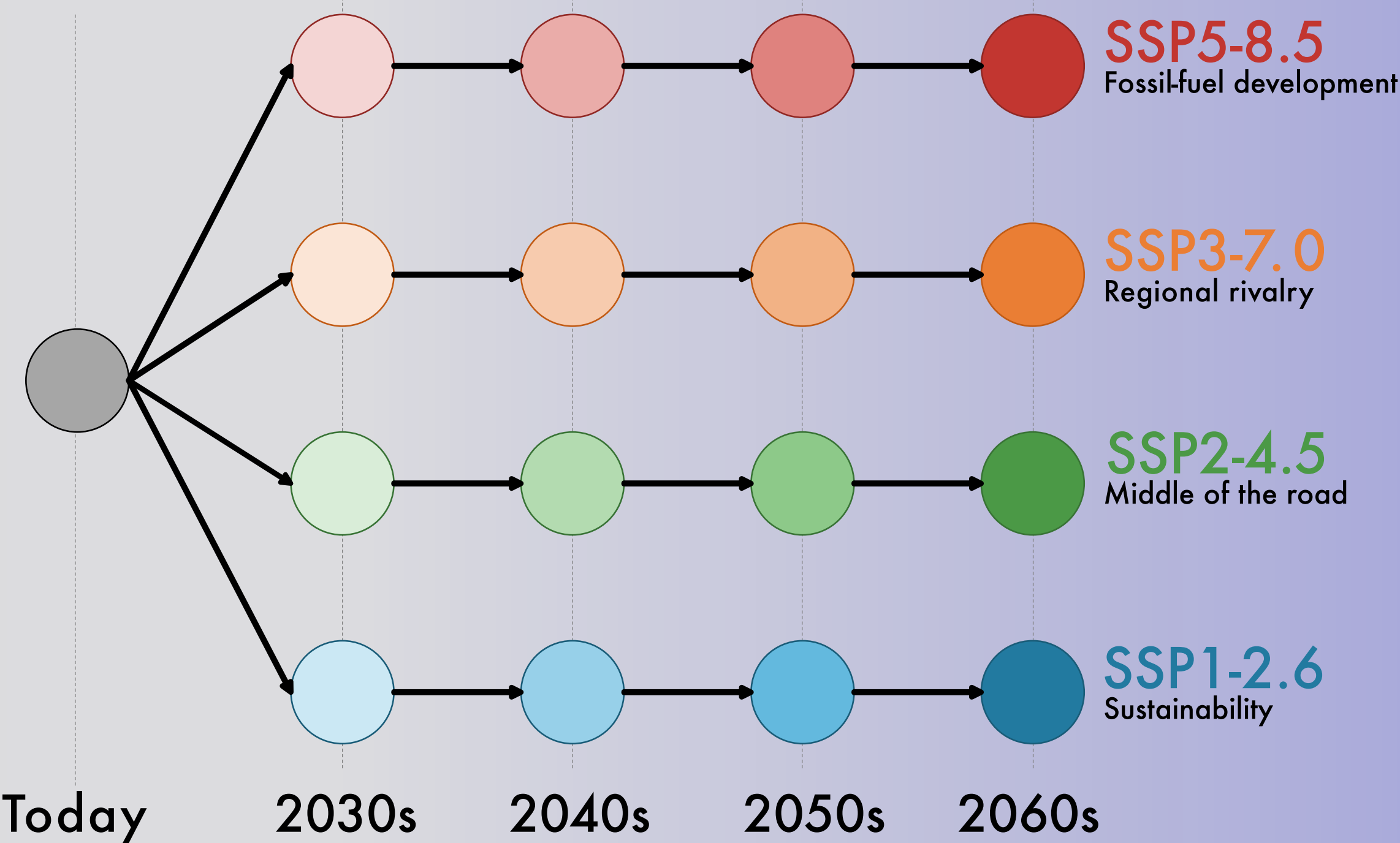
Boreholes capacity

Boreholes are challenging to size because we are **not sure** how our heating and cooling **demands** will **vary**.

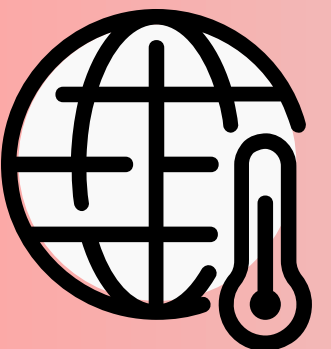


However, they are a **robust technology** as they can supply **efficiently cooling and heating** under various conditions.

To size the assets, we suggest a **stochastic multi-stage** formulation, where we can adapt our design every 10 years to **minimize our costs**.



We can use **stochastic dual dynamic programming** as an algorithm, enhancing convergence. We used **JUDGE.jl**.



In a system **dominated by heating** demand, global warming could lead to a **cost decrease** between -8 and -57% of **operational costs by 2090**.



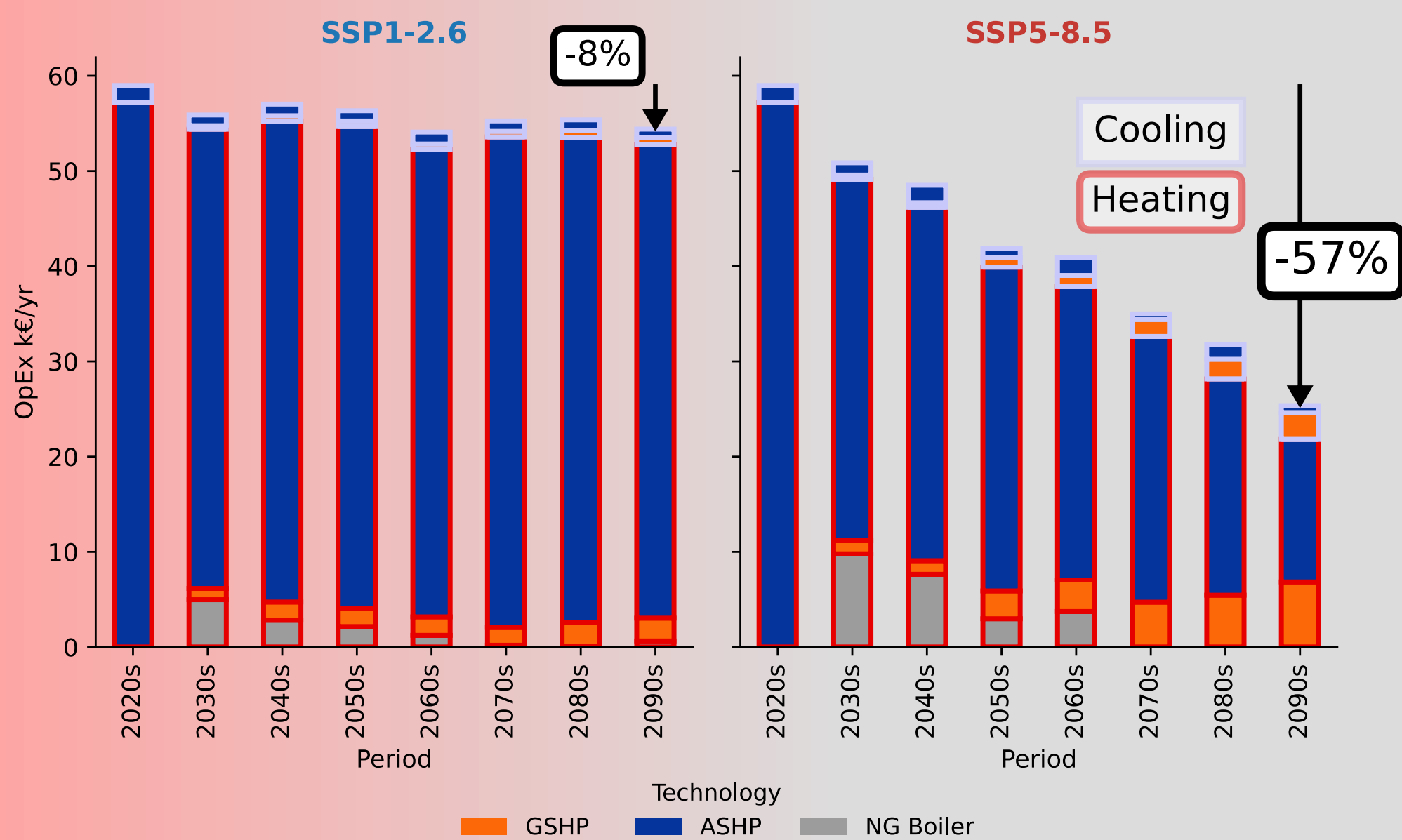
The share of **GSHP** in the system can reach up to **33%** of the heating demand and cover the entire cooling demand.

Adaptation of the capacity is possible due to the slow evolution of climate change.

Natural gas boiler keep being a reserve for low-carbon emissions scenarios due to the persistence of **harsh winter conditions**.



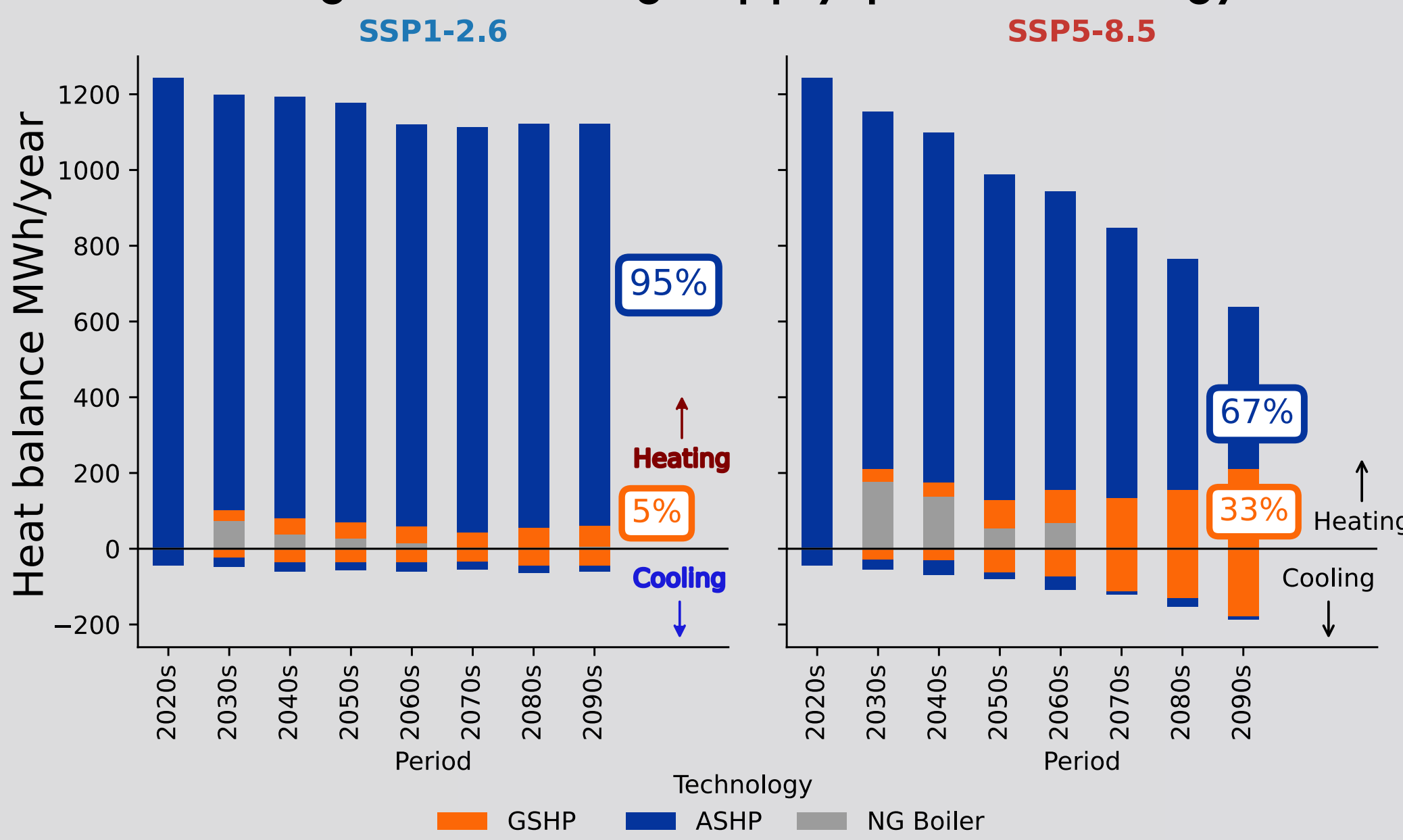
Breakdown of the operational cost for heating and cooling



In particular, the **free cooling** with the boreholes allows to reduce the energy used for cooling, making the increase in **cooling costs insignificant**.



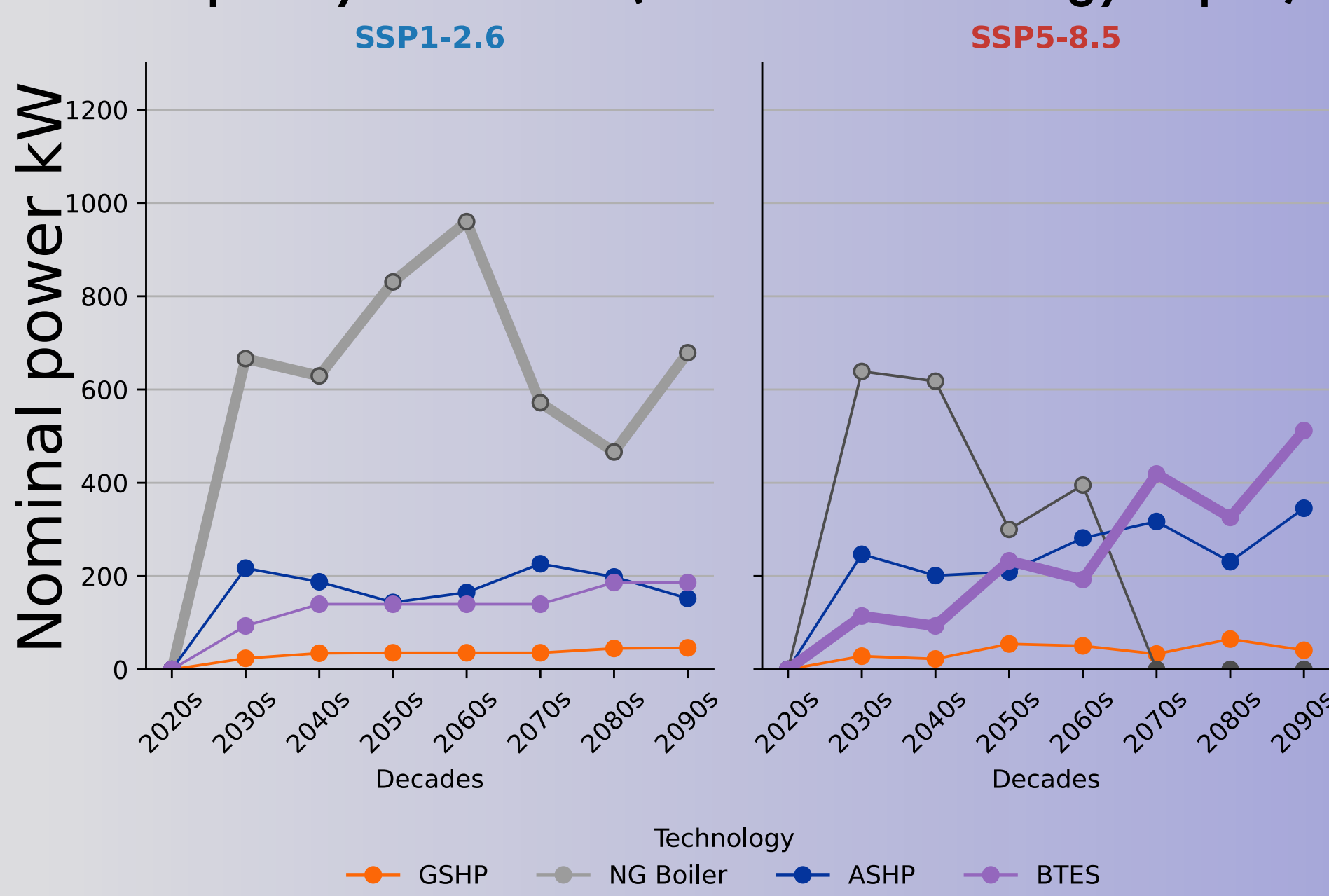
Heating and cooling supply per technology



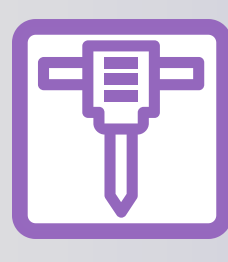
ASHP cover most of the demand, due to high carbon price (cost driven) or favorable conditions (efficiency driven).



Capacity installed (in terms of energy input)



The installed capacity of **geothermal** is linked to the **cooling demand** and evolve strongly in high emission scenarios.



Check our preprint !

Climate-driven load shifts and the optimal design of district heating and cooling systems: planning energy supply for a warming century

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Let's Connect !

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