



SENTINEL

SUSTAINABLE ENERGY TRANSITIONS



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NET-ZERO BUILDING SECTOR- A EUROPEAN DREAM?

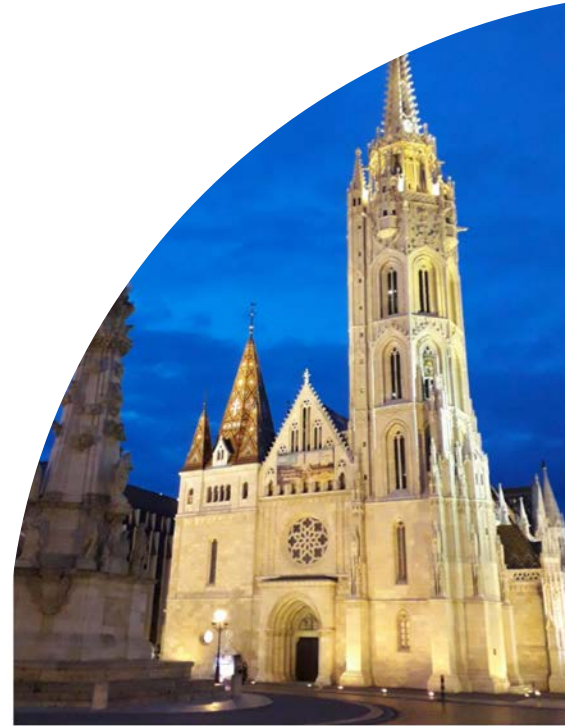
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Why building sector is important

- Buildings are responsible 40% of EU energy consumption and 36% of the greenhouse gas emissions => single largest energy consumer in Europe.
- 35% of the EU's buildings are over 50 years old and almost 75% of the building stock is energy inefficient.
- Renovation of existing buildings and construction of energy efficient buildings can lead to significant energy savings.
- Renovation rate in the EU is around 1%/yearly.

Data source: European Commission (2021), Energy performance of buildings directive (https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en)

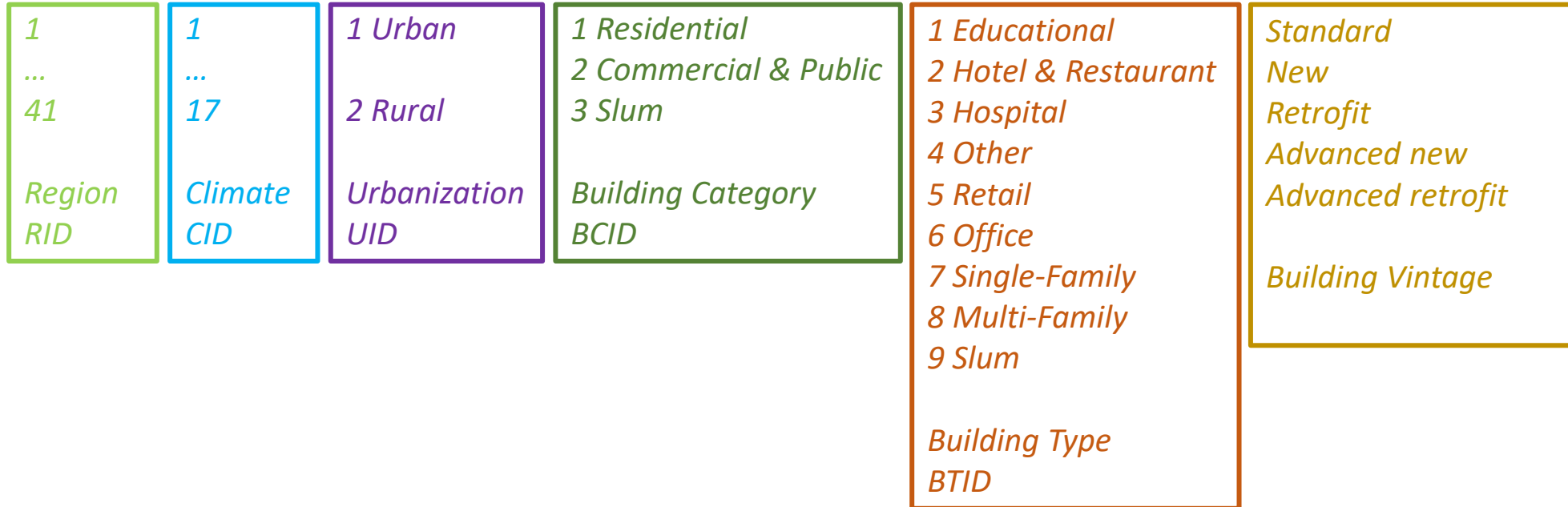


HEB model- Main Philosophy and Assumptions

- **Considers** buildings as complete systems rather than sums of components → *performance-based approach*
- **Recognizes** that
 - State-of-the-art building energy performance can be achieved through a broad variety of designs and component combinations
 - Systemic gains are important when buildings are optimized to very high energy performance, not typically captured by modeling buildings by components



Building Classification



= 18815 Building Classes



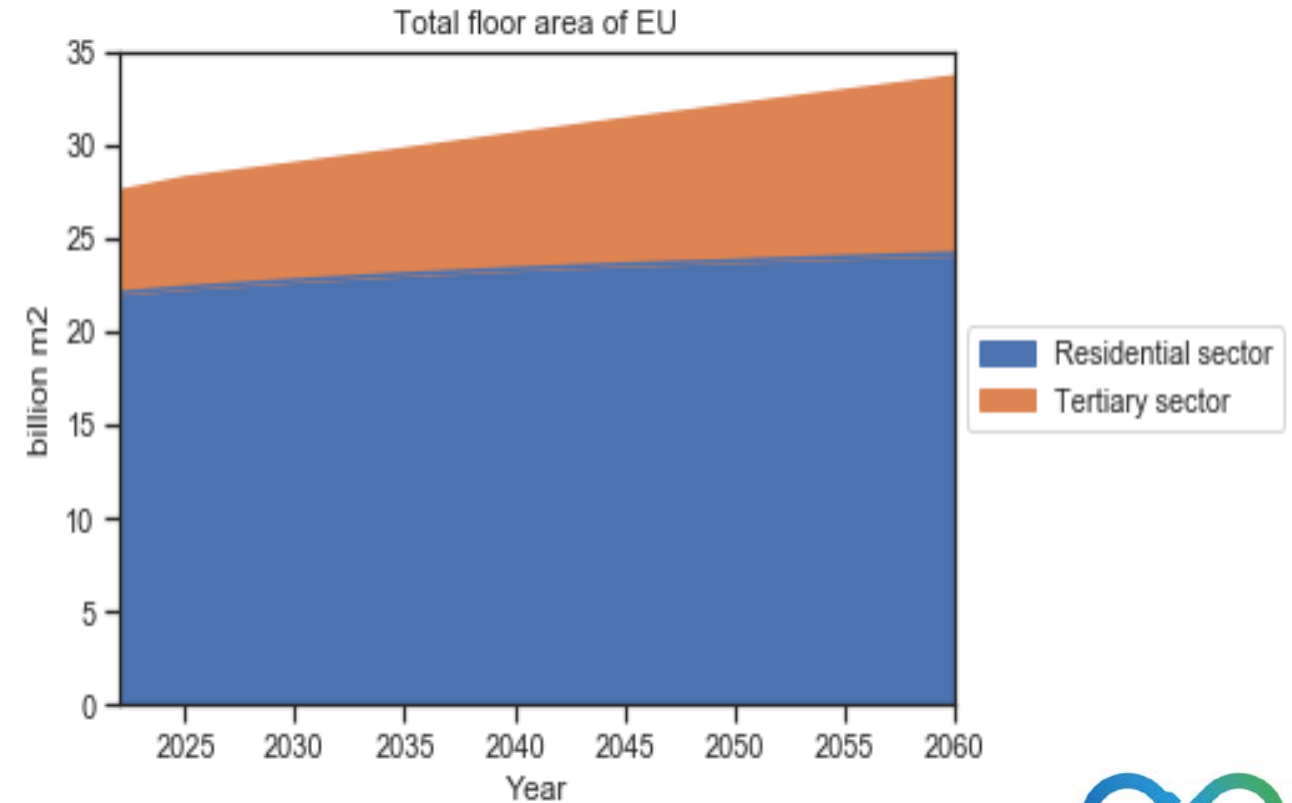
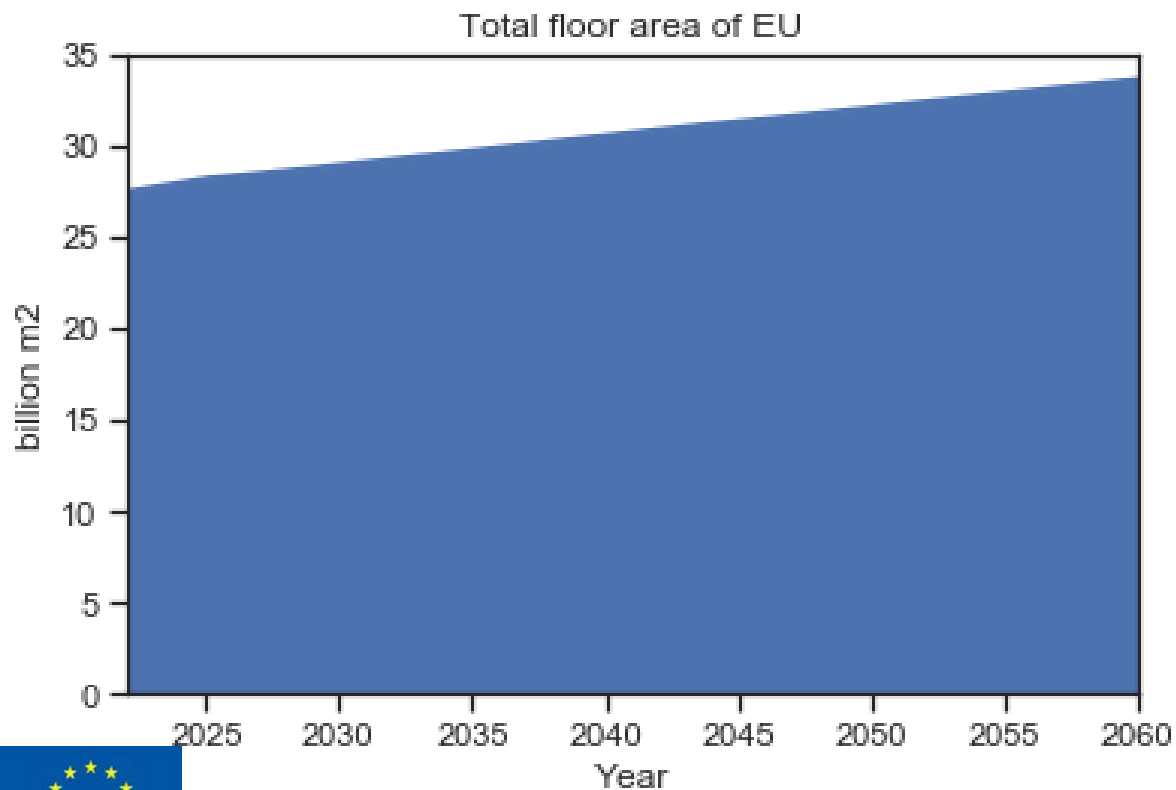
Scenario Analysis

- **Deep Efficiency Scenario:** It demonstrates the potential of state-of-the-art construction and retrofit technologies that can substantially reduce energy consumption of the building sector while also providing full thermal comfort in buildings.
 - **Towards Net Zero Scenario:** This scenario models the potential of deploying Net Zero Energy Buildings (buildings that can produce as much energy locally through the utilization of renewables as they consume on an annual balance) around the World.
 - **Moderate Efficiency Scenario:** Moderate scenario incorporates present policy initiatives particularly implementation of Energy Building Performance Directive (EPBD) in the EU and building codes for new buildings in other regions.
 - **Frozen Efficiency Scenario:** This scenario assumes that the energy performance of new and retrofit buildings do not improve as compared the baseline due to lower compliance with Building Codes.
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- The purpose of scenarios is **NOT** to predict the future
 - But to give “what.... If....” insights into consequences of certain decisions

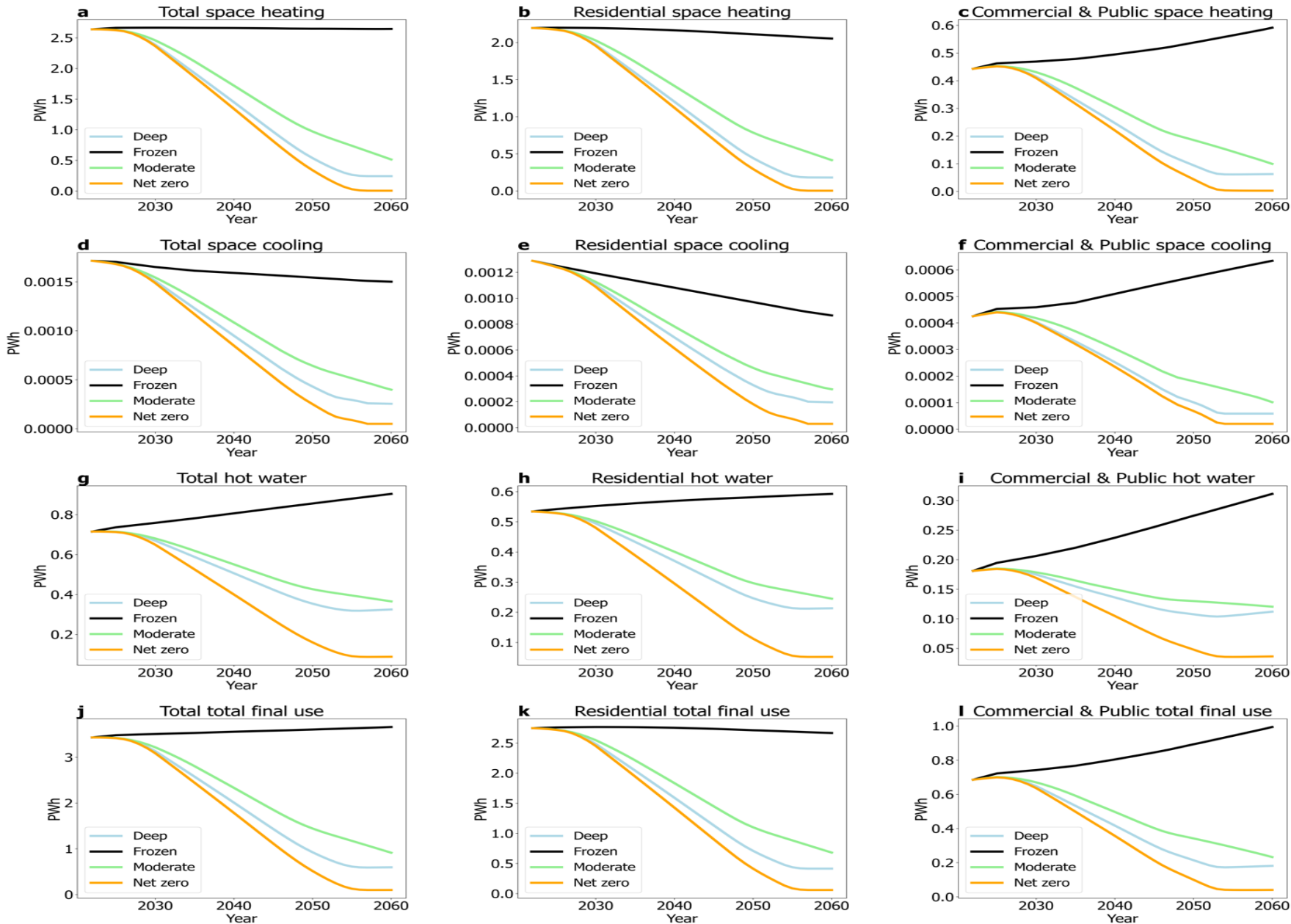


Floor area growth- Key messages

- 16% increase in total floor area by 2050
- 22% increase in total floor area by 2060
- 7% and 9% increase in the residential floor area by 2050 and 2060
- 53% and 74% increase in the tertiary floor area by 2050, and 2060



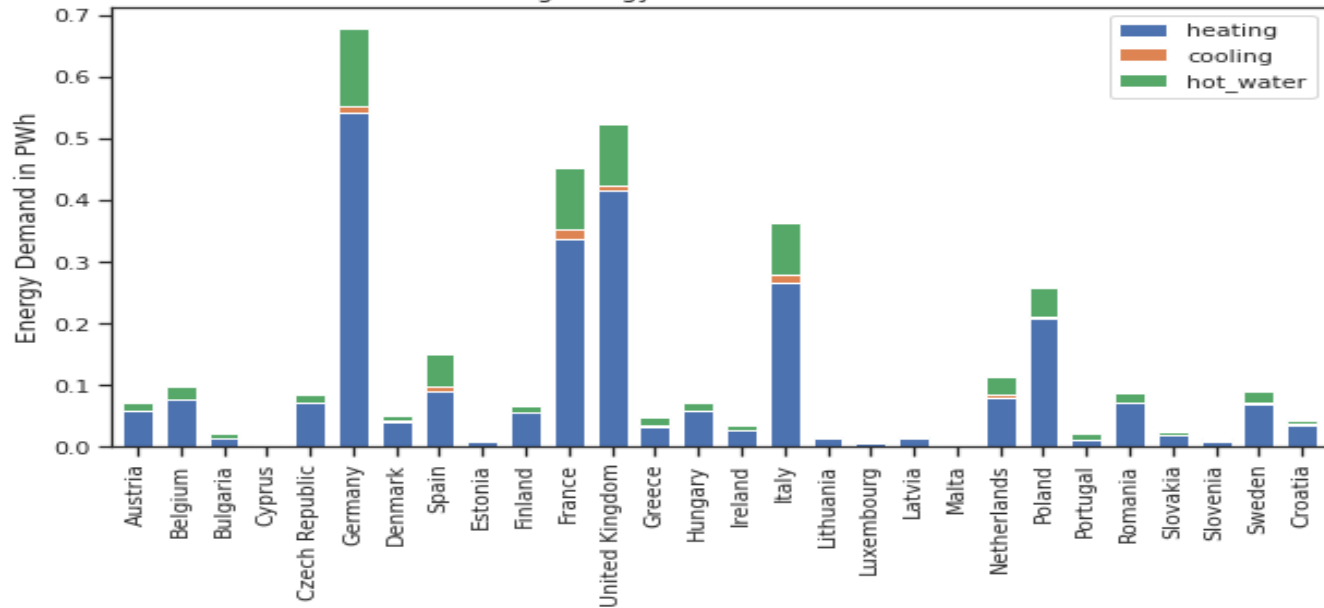
Annual demand profile



- The findings of our study show that the residential building sector, is highest energy consumer
- 98% reduction is possible in the residential sector, whereas the tertiary building sector can reduce up to 94% by 2060 under “Towards Net-zero” scenario.
- In Deep- Efficiency scenario residential building sectors can reduce 74% and 85% in 2050 and 2060 respectively.
- The tertiary building sector follows the same trend with a reduction potential of 69% and 74% in 2050 and 2060 respectively.

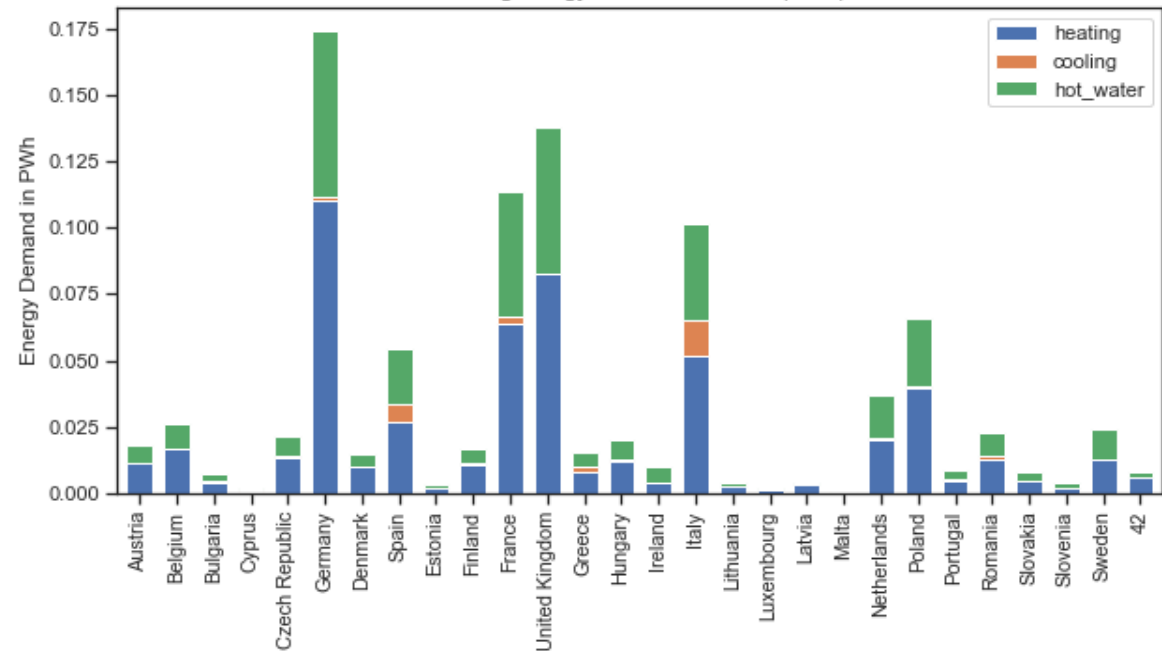
Reference scenarios

Building energy demand in the EU (2022)



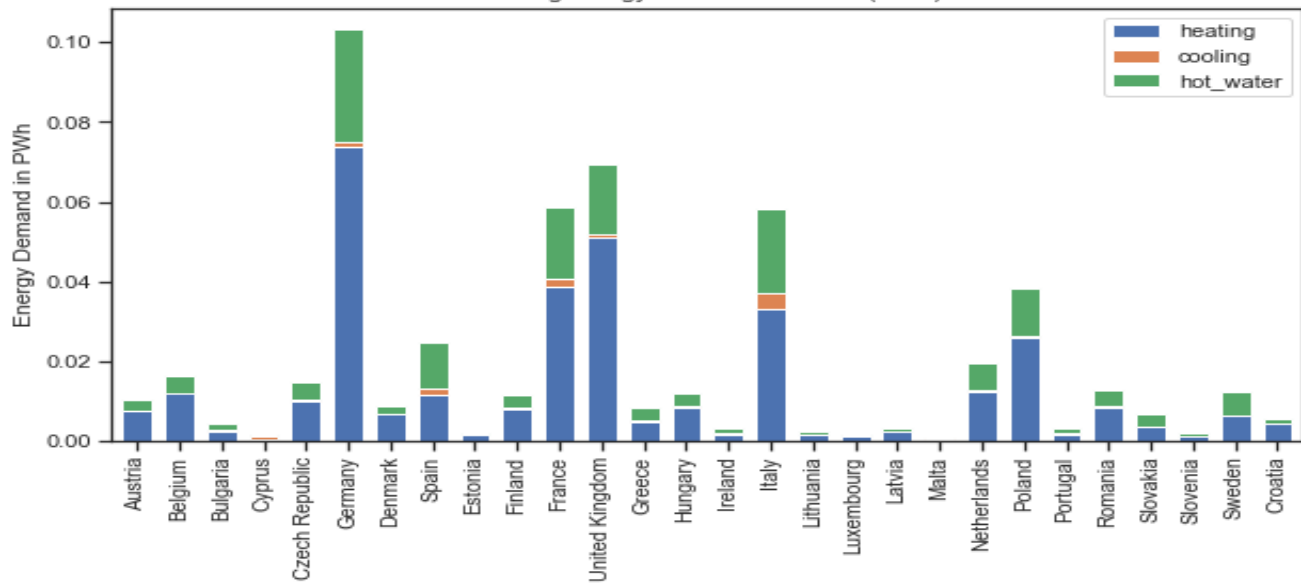
Deep efficiency scenarios

Building energy demand in the EU (2050)



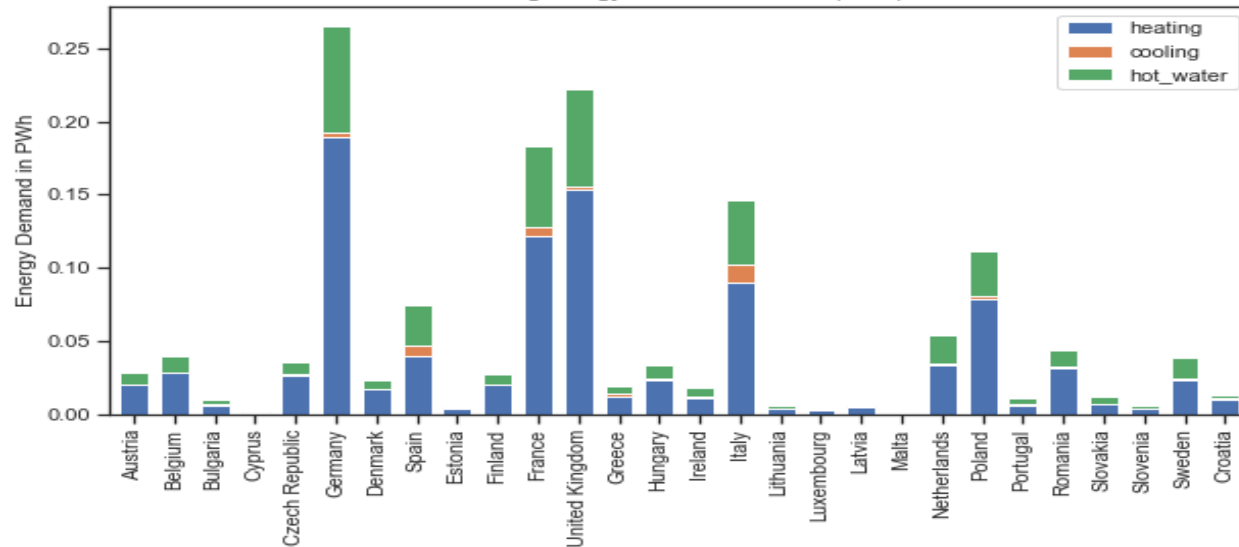
Towards net zero scenarios

Building energy demand in the EU (2050)

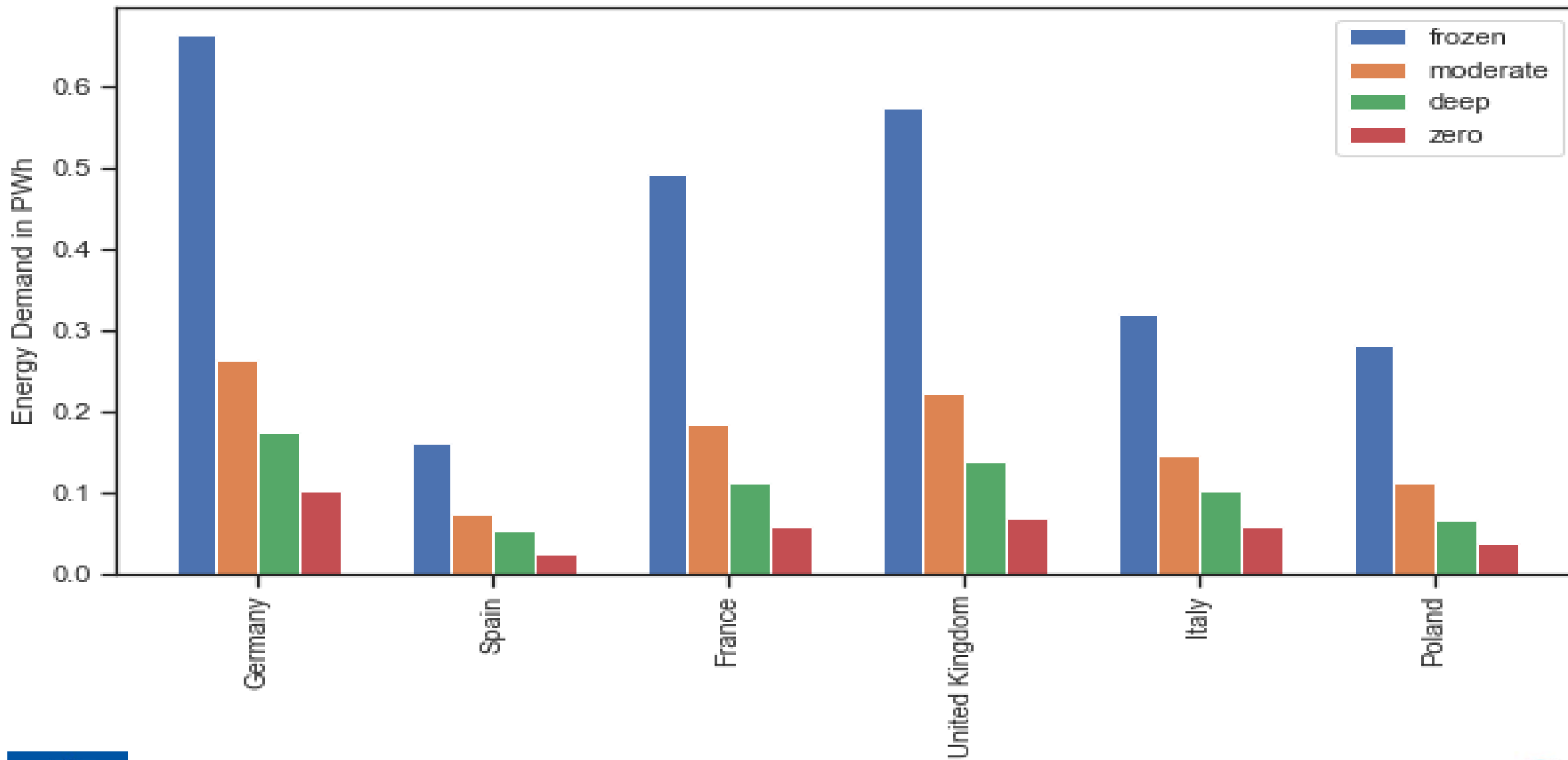


Moderate scenario

Building energy demand in the EU (2050)



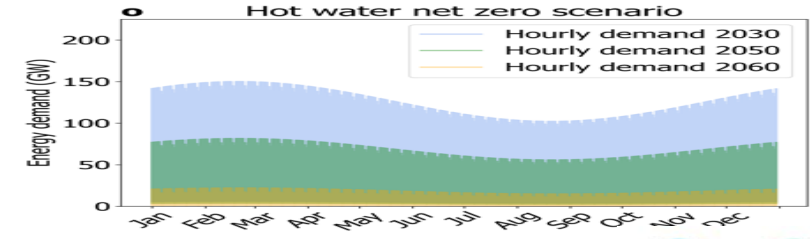
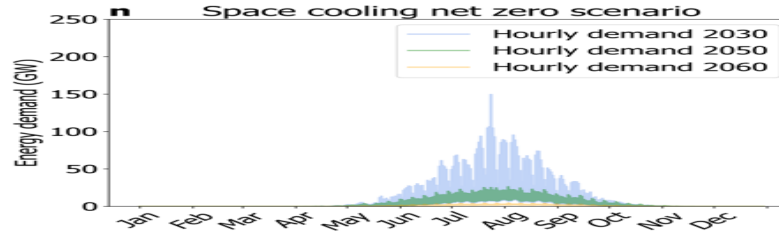
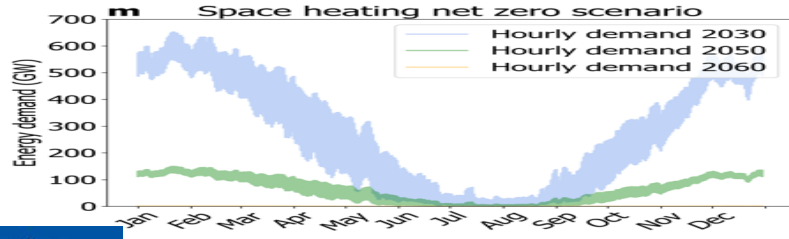
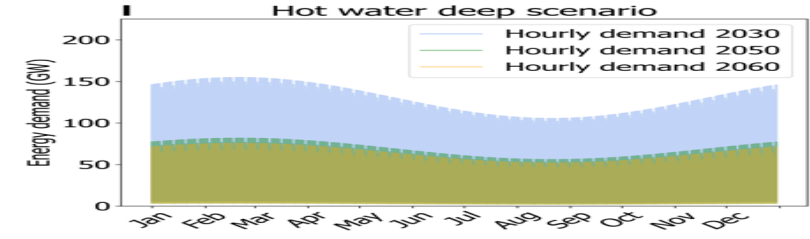
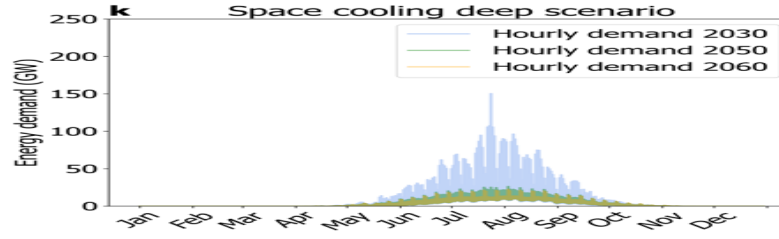
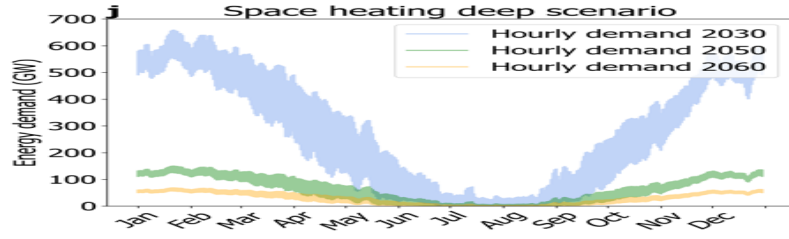
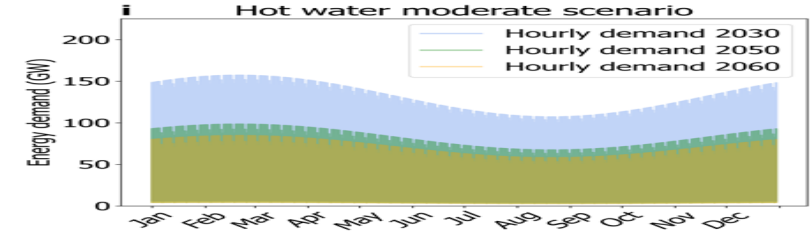
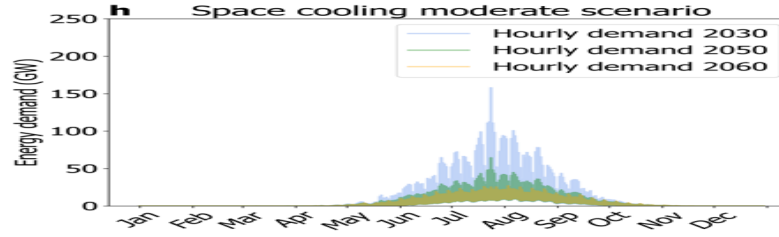
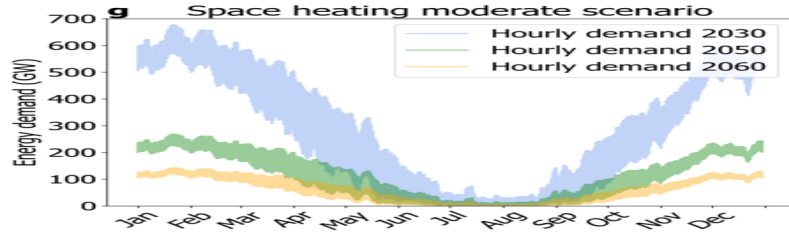
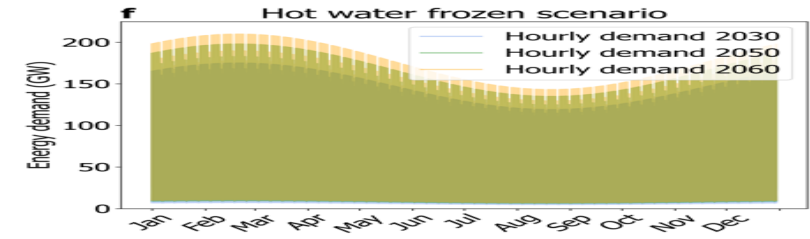
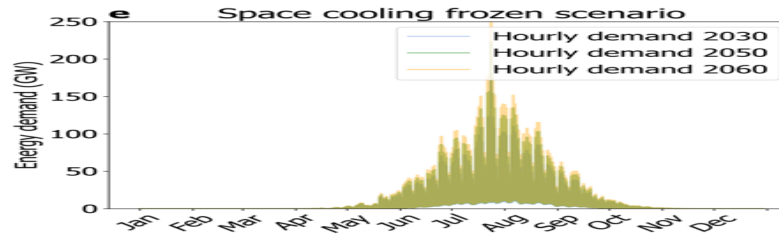
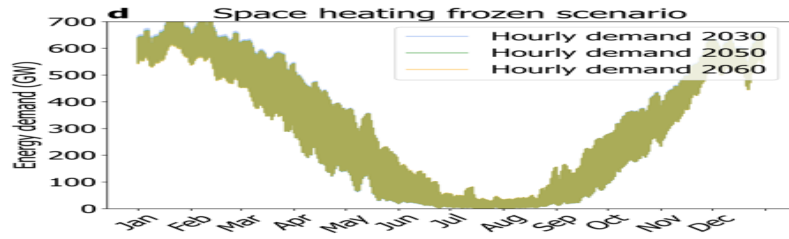
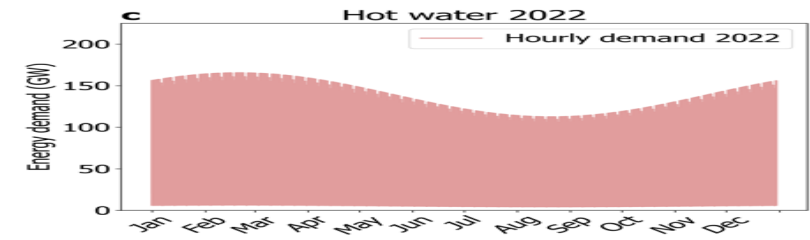
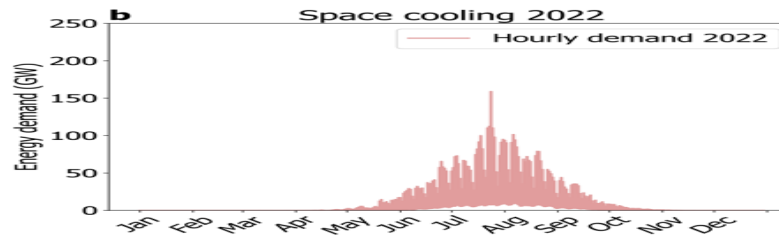
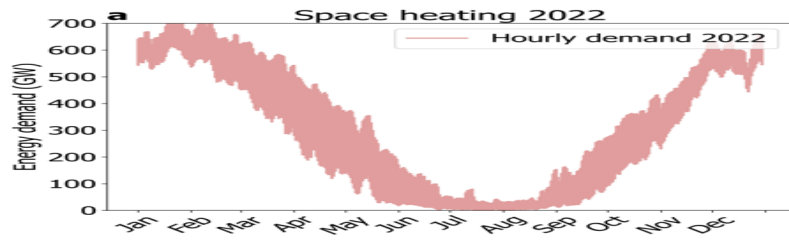
Building energy demand in the EU (2050)



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Hourly demand profile





Thank you

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Building Energy Demand

Simplifications

Specific energy demand is the most important aspect of the building energy efficiency in HEB. Total consumption of the building stock is calculated by multiplying the specific energy demand with the corresponding floor area value.

The detailed classification scheme of HEB requires a specific energy consumption value to be defined for each building class. Due to the large number of building classes, some simplifications are introduced.

Final Thermal Comfort Energy Use Calculation

$$\text{Final Energy} = \sum_{i=1}^{41} \sum_{j=1}^{12} \sum_{k=1}^{17} \sum_{l=1}^5 \text{Floor Area}_{i,j,k} \times \text{Energy Intensity}_{i,j,k} \left(\text{m}^2 \times \frac{\text{kWh}}{\text{m}^2 \cdot \text{year}} \right)$$

❖ Energy Use Calculation:

- ❖ $i = 1$ to 41 (14 Regions + 27 Countries in EU-27)
 - ❖ $j = 1$ to 12 Building Types
 - ❖ $k = 1$ to 17 Climate Zones
 - ❖ $l = 1$ to 5 Different Building Vintages
- ❖ Energy use is calculated for each region and each climate zone with the split to building types and building vintages

Water Heating Main Concepts

- ❖ Much more complex than Thermal Comfort
- ❖ Energy sources: fuels, electricity, renewables
- ❖ Comparison of performance: **energy factor (EF)**
 - ❖ *definition:*
$$EF = \frac{\text{useful hot water energy}}{\text{input non-renewable energy}}$$
 - ❖ → the same as efficiency for conventional sources
e.g. EF~0,9 for an efficient gas heater
 - ❖ → EF > 1 for renewable sources
e.g. solar system in Sweden: EF~2 (~50% backup)*
solar system in Cyprus: EF~5 (~20% backup)*
 - ❖ EF > 1 for heat pumps (cheap air source: 2,2-2,5)



Water Heating Scenarios

- ❖ **Technology mixes** used to achieve specific EF values
- ❖ **Scenario assumptions** (illustrative ways of achieving the assumed EF values)
 - ❖ *Frozen technology mix*
 - ❖ *Moderate*: heat pumps for electric water heaters, condensing (tankless) gas heaters, improved technologies for liquid fuels, LPG stoves (instead of biomass).
 - ❖ *Deep*: solar systems, heat pumps, gas backup, improved stoves + waste heat recovery (30% in 15-25% of buildings) and consumption reduction (20% less than REF)

EF values	US	China	India
FRO	0,66	0,72	0,21
MOD	1	1,08	0,5
DEEP	1,94	2,09	1,1

Water Heating Energy Use Calculation

$$\text{WH Energy} = \sum_{i=1}^{41} \sum_{j=1}^{12} \sum_{k=1}^5 \text{Floor Area}_{i,j,k} \times \text{WH Energy Intensity}_{i,j,k} \left(\text{m}^2 \times \frac{\text{kWh}}{\text{m}^2 \cdot \text{year}} \right)$$

❖ WH Energy Use Calculation:

- ❖ $i = 1$ to 41 (14 Regions + 27 Countries in EU-27)
- ❖ $j = 1$ to 12 Building Types
- ❖ $k = 1$ to 3 Building Vintages (standard / retrofitted / advanced)
- ❖ 2005 WH Energy values: literature data or calculated (residential: population based, C&P: floorspace based)
- ❖ WH Energy Intensity is calculated on the basis of regional average energy factor assumptions for 2005 and 2050 (climate considered in these averages)
- ❖ If no EF calculation can be performed (no data), existing energy intensity assumptions are used