

Power to heat flexibility in Austria's electricity system in 2030

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IEWT 2021

Flexibility as enabler for the integration of renewables

Opinion Automotive Energy & environment Electric vehicles

Comment: How EVs will drive the flexibility market

27th August 2021 7:20 am

How flexibility can enable a 100% renewable energy future

16 Apr / 2021
13:55

Jukka Lehtonen
Vice president at
Wärtsilä Energy



THE ENGINEER JOBS

Policy paper

Transitioning to a net zero energy system: smart systems and flexibility plan 2021

This plan sets how we will transition to a smart, flexible, decarbonised energy system.

EXPERT BLOG · RACHEL FAKHRY

We Must Start Investing in Demand Flexibility Today

January 14, 2021 Rachel Fakhry



The screenshot shows a news article from Scoop Business. The article title is "Contact Energy to supply 'flexible' renewable electricity". It is dated Tuesday, 31 August 2021, 11:25 am and is a press release from Contact Energy. The page includes a navigation menu with categories like Scoop, Werewolf, Wellington, The Dig, Business Scoop, and Pacific. There are also social media sharing icons for search, email, print, Twitter, and LinkedIn.

- **Increasing capacities of heat pumps** or electric heating (fueled by RENEWABLE electricity) in the heating sector
- Sector coupling offers potential flexibility to the system by using the **heat storage potential of the building stock** (thermal mass) to shift electricity demand to hours of higher renewable energy production in the electricity grid

Motivation & objectives

Different **approaches** in literature and **energy system modeling practice** of how to model power-to-heat flexibility:

- Scheduled heat load profile can be shifted according to certain limitations
- Flexibility potential is limited by **shifting time** → size of storage is time-dependent
- Storage size is defined by the thermal mass that is present in the building stock
- Thermal **losses**

- **Studies** e.g. by Kirkerud et al. (2021), Olkkonen et al. (2018), Moser et al., (2015), Weiß, (2019), and Spreitzhofer (2018): Literature about a) quite detailed building models and b) energy system models

1. Identify **soft links between a detailed building model** and an **energy system model**

- **Appropriate** representation of **heat pump flexibility**
- What information of the detailed building model is **needed**?

2. **Case study:** What is the **flexibility potential residential heat pumps** (space heating) can provide to the electricity system in **Austria** for **2030**?

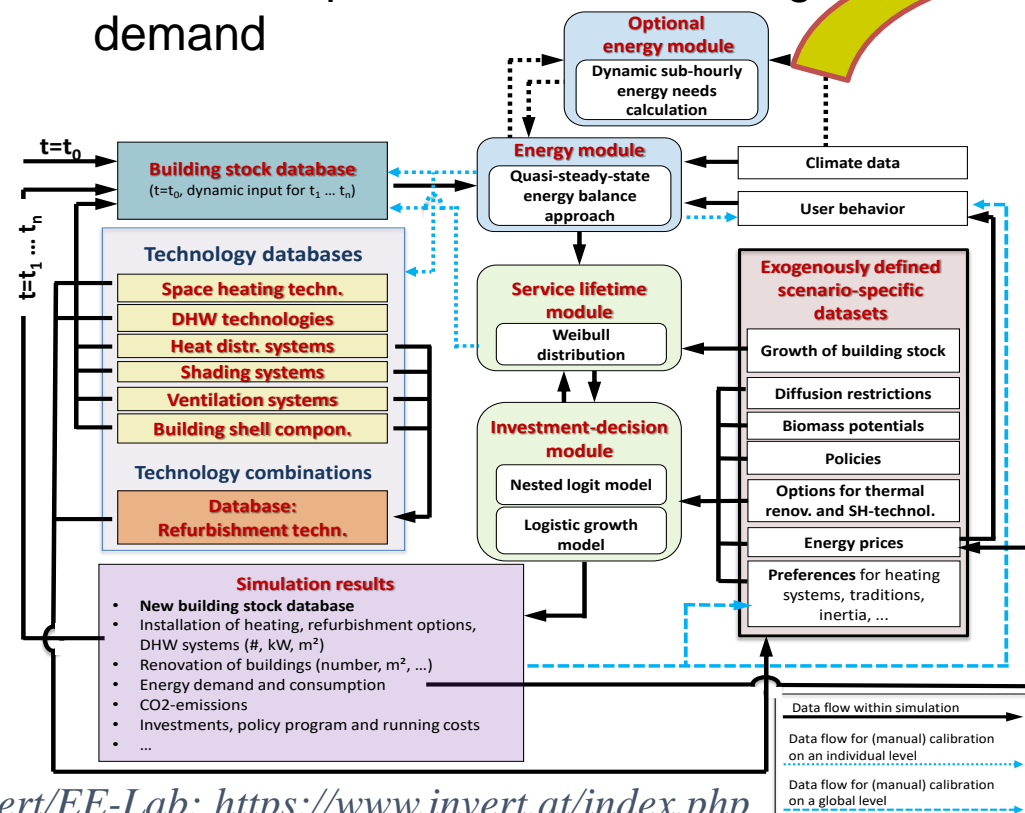
Different models need different information

Data from the detailed building model...

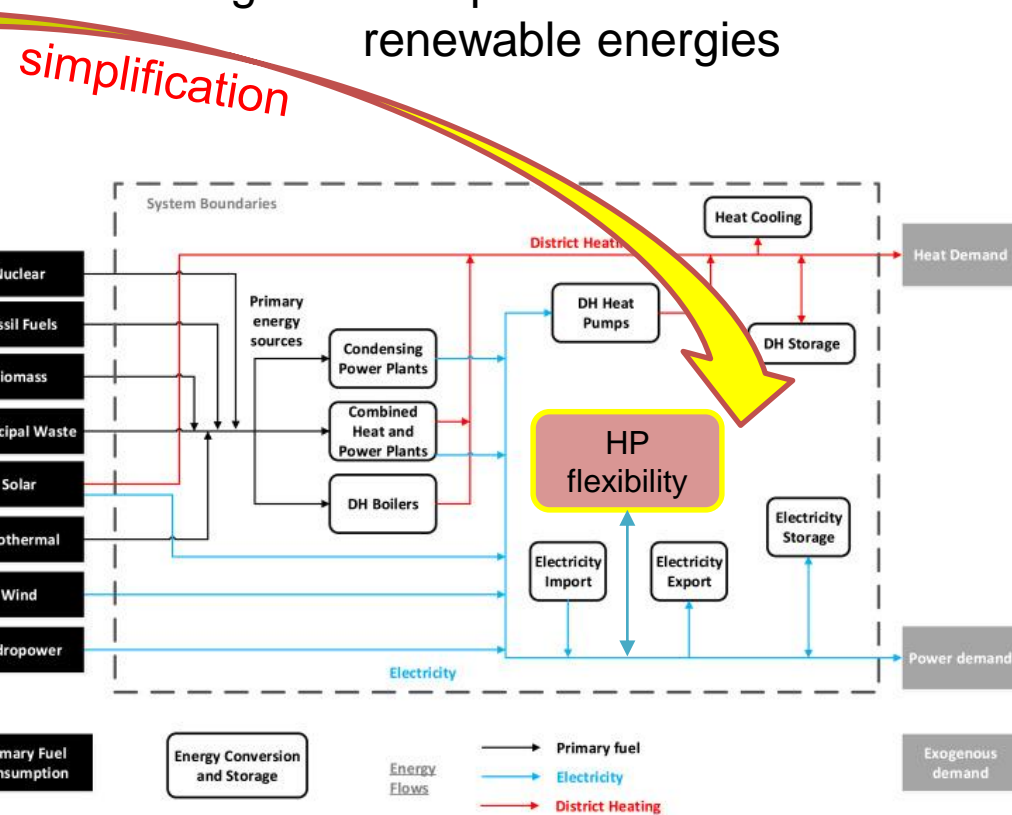
- Contains more than 1000 building types and their characteristics
- Detailed representation of heating demand

... feeding the energy system model

- Covers the electricity and district heat sector
- Includes generation patterns of variable renewable energies



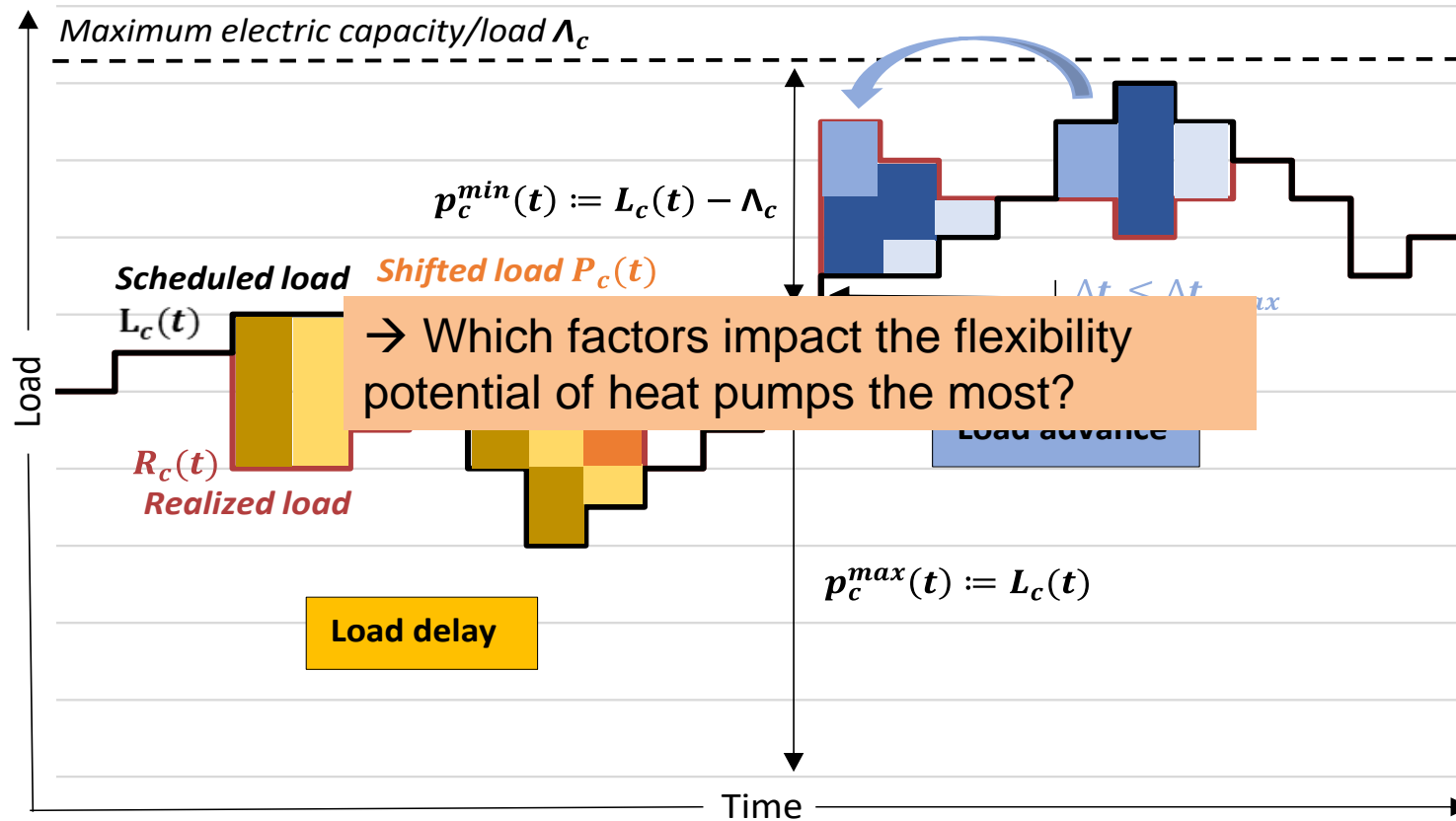
Invert/EE-Lab: <https://www.invert.at/index.php>



Balmorel: <https://github.com/balmorelcommunity/Balmorel>

Theoretical concept of load shifting in Balmorel

based on Kirkerud et al. (2021) and Gils (2016)

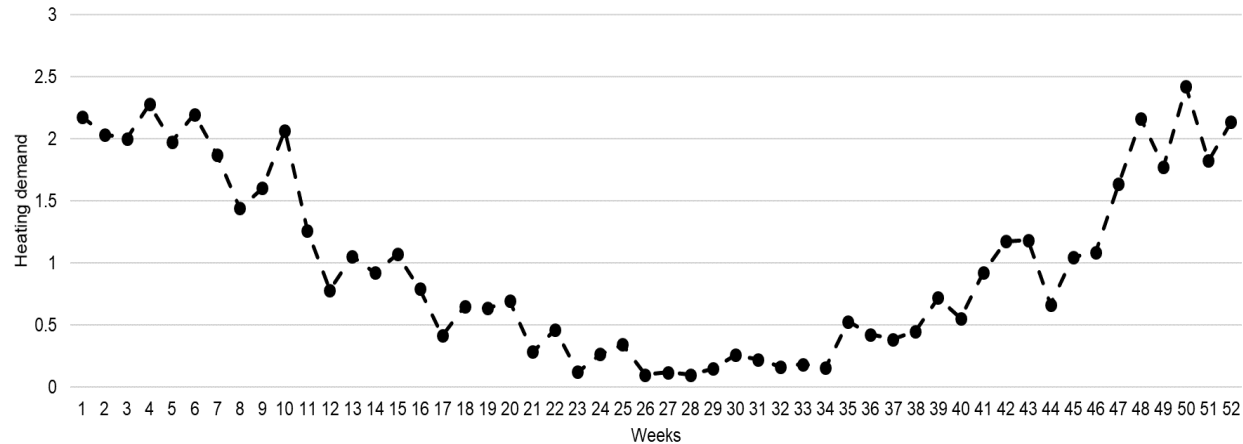


— Realized load after load shifting — Scheduled load

$$p_c^{min}(t) \leq P_c(t) \leq p_c^{max}(t) \quad \forall t, c$$

- c Load shifting technology
- $\Delta t_{c,ma}$ Maximal shifting time for technology c [hours]
- $L_c(t)$ Scheduled load of technology c [MW]
- $R_c(t)$ Realized load after load shifting of technology c [MW]
- $P_c(t)$ Shifted load of technology c [MW]**
- $E_c(t)$ Energy content of “virtual storage” of technology c [MWh]
- tt One timestep within the timeframe of load shifting
- Λ_c Maximum electric capacity/load of technology c

1) Heating demand profile determines seasonal and hourly availability

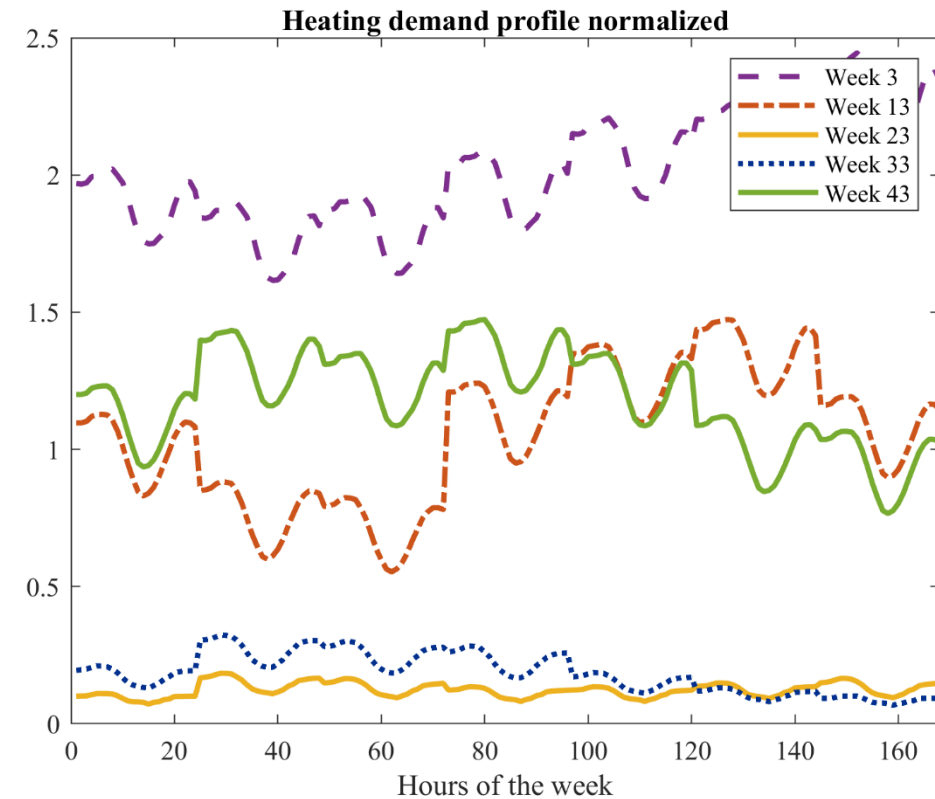


Seasonal...

- Original data on NUTS2 level, aggregated for Austria
- Year 2010, residential space heating
- Source: Hotmaps project: Pezzutto et al. (2018)

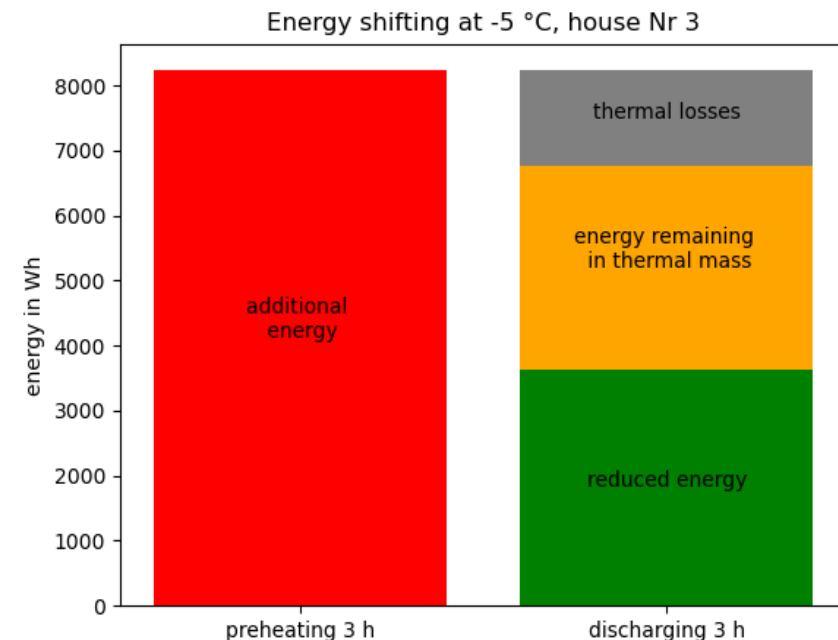
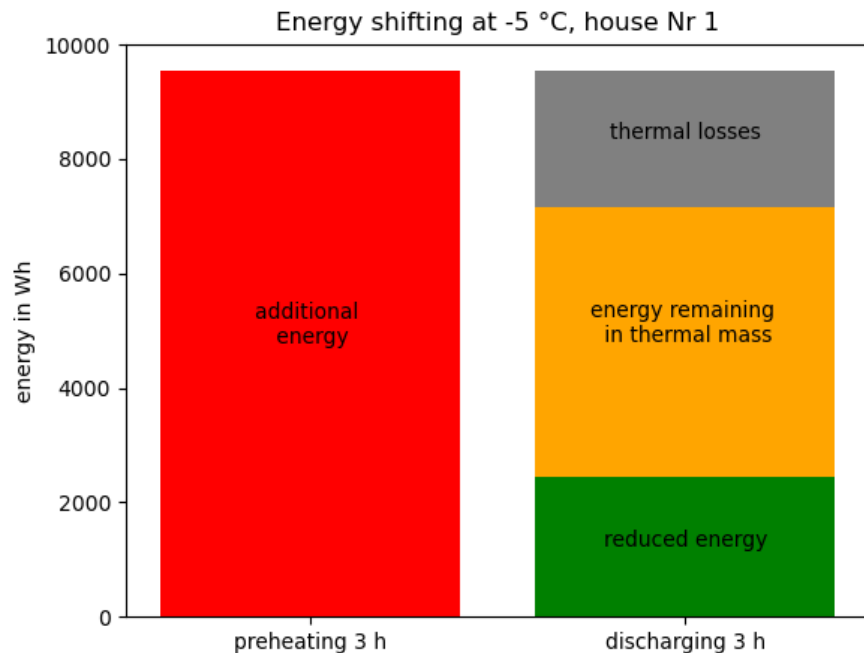
→ Variation of weekly profile

... x weekly patterns.



2) Impact of building type (thermal mass + heat demand)

- Calculations based on DIN ISO 13790: Energy performance of buildings - Calculation of energy use for space heating and cooling
 - Representative building types: Nr 3 better insulated than Nr 1
 - Room temperature increased from 20°C to 22°C for three hours



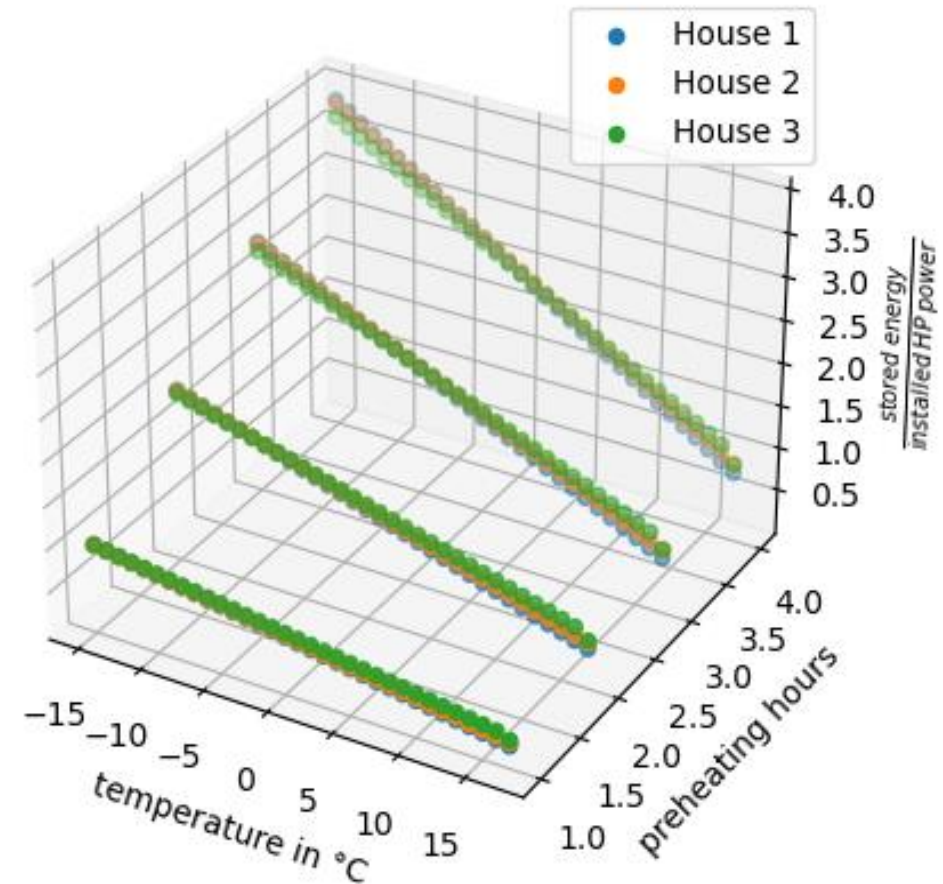
→ Variation of thermal losses in the storage process

What factors do influence the ability to shift?

Energy shifting potential is depending on

- Acceptable **time of interference** (here preheating phase) → comfort
- **building type**
- outside **temperature**/heating demand

→ Variation of time restrictions/storage volume (default 2)



Modelling assumptions

Austria 2030, hourly resolution, perfect foresight

- Installed, controllable residential heat pumps: 1818 MW_{el} and 2 TWh_{el} demand
- Electricity and district heating system of the neighbouring countries is modelled as well (without flexibility options)
- Default: storage 2.0 (3636 MWh_{el}), 5% thermal loss per hour, winter profile, no ramping
- Investment options for the electricity sector: large-scale batteries and natural gas CC

	Inflexible scenario (reference)	Summer profile (week 33)	Winter profile (week 43)						
			4 hours shifting time	Storage volume 2.0	Storage volume 4.0	10% loss	More HP (+50% inst. cap.)	Ramping (50%)	0% loss
Thermal loss per hour	-	5	5	5	5	10	5	5	0
Installed HP capacity flexible [MW]	0	1818	1818	1818	1818	1818	2727	1818	1818
Ramping constraints (% of installed HP capacity per hour)	-	-	-	-	-	-	-	50	-
Storage capacity [MWh/MW installed]		2.0	time-dependent	2.0	4.0	2.0	2.0	2.0	2.0

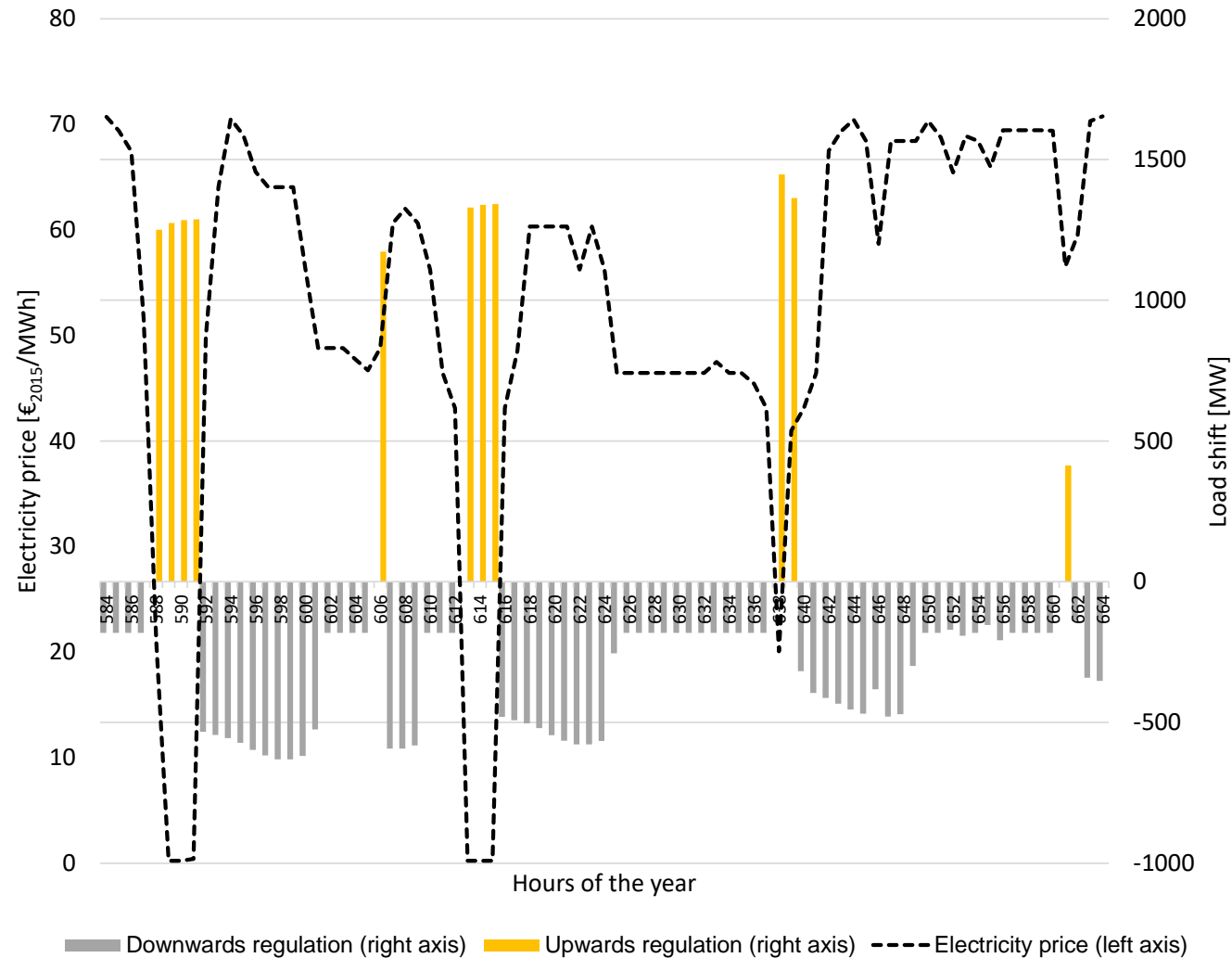
Installed el. capacities

MW	Austria
Coal	
Geothermal	1
Lignite	
Natural gas	4176
Oil	6
Waste	150
Nuclear	
PV central	776
PV decentral	11 529
Hydro reservoirs	
Hydro pump storage	
Hydro run-of-river	6 940
Biogas	109
Biomass	686
Wind offshore	
Wind onshore	5 316
Sum	29 687

Preliminary results & conclusions

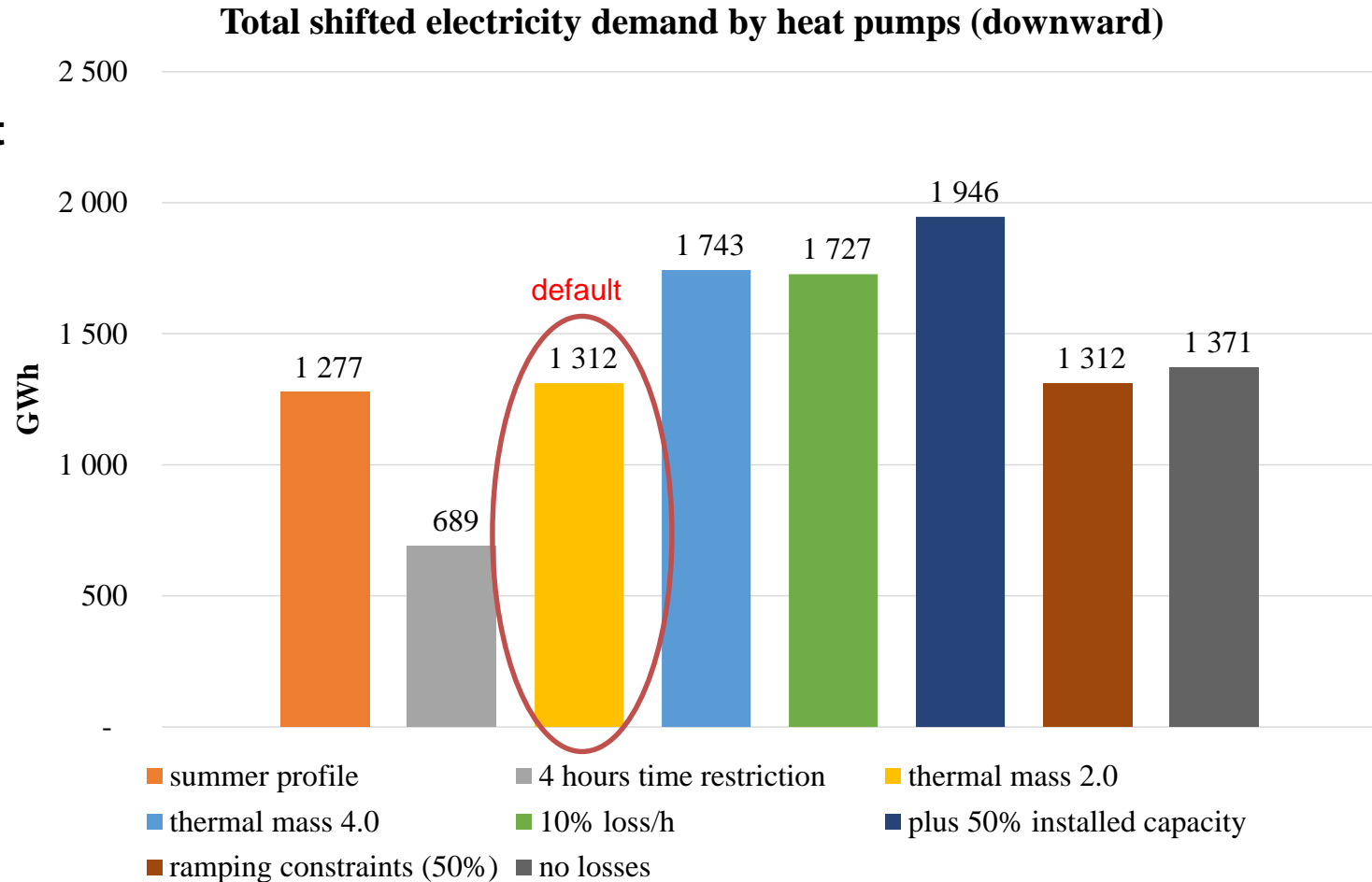
Flexible heat pumps react to market price signals

- 80 consecutive hours (randomly chosen)
- In hours of low prices, we see upwards regulation of the heat pumps and in hours of high prices downwards regulation



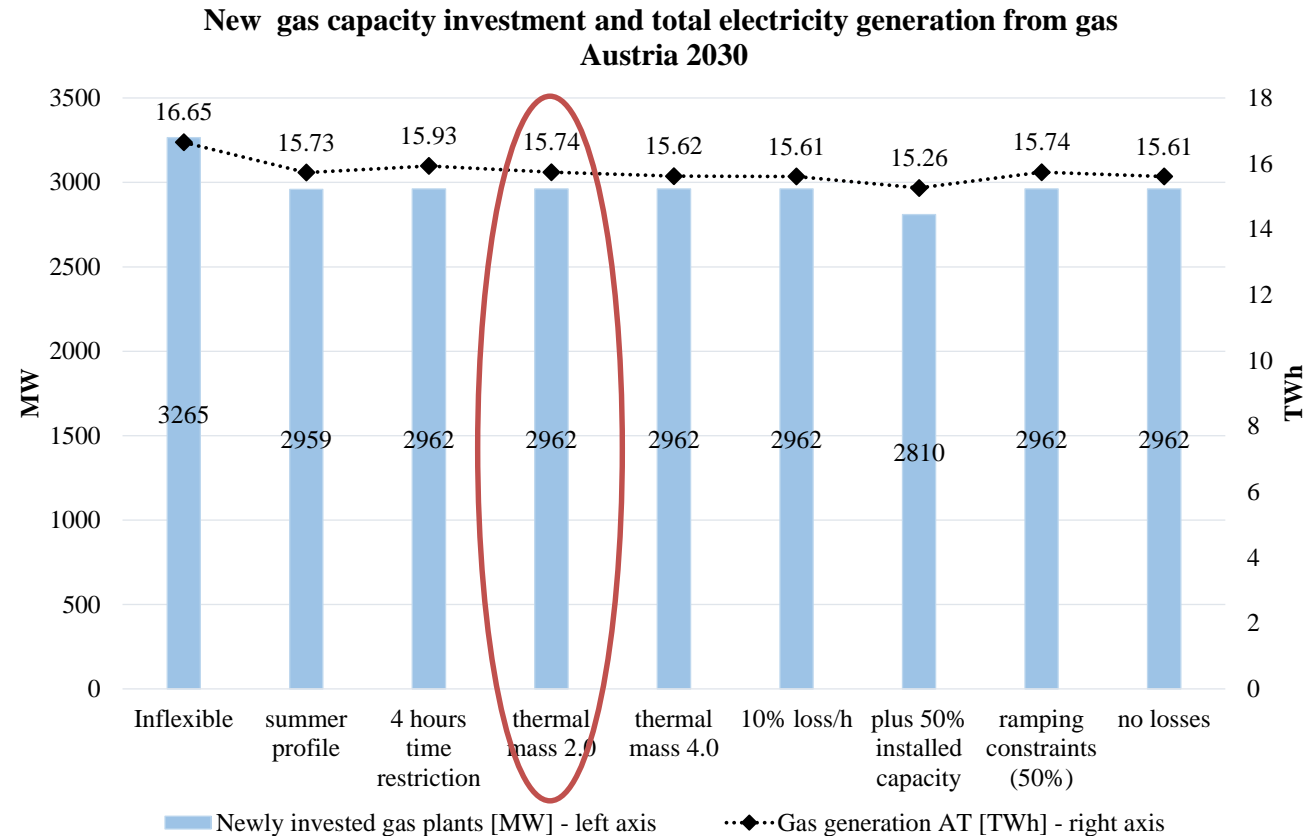
Total shifted electricity → flexibility provided

- **Summer profile** (slightly less variation) results in slightly less shifted energy → **no big impact**
- Results are quite **sensitive** to **limitation of shifting time** (in line with literature)
- **Ramping constraints** (50% of installed capacity) have **no impact**



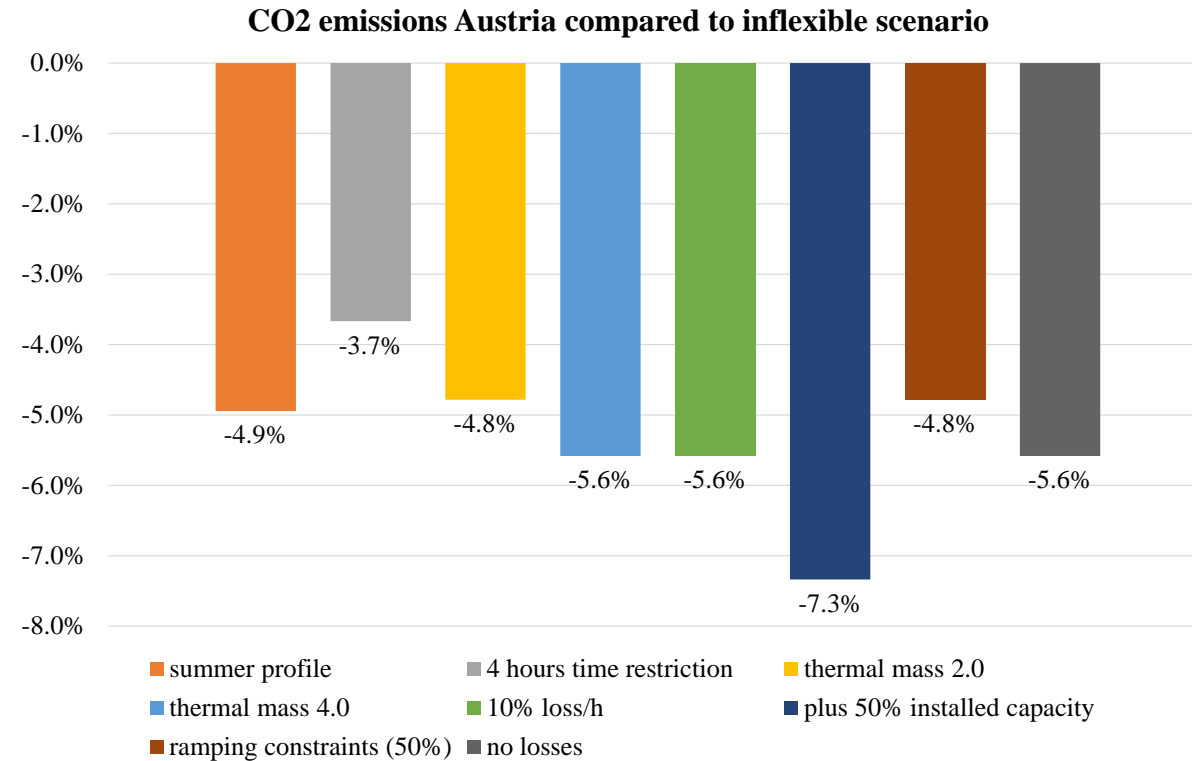
Reduced natural gas capacities and generation by flexible heat pumps

- **Installed natural gas capacity is decreased** in all flexible scenarios almost to the same extent (exception: more flexible HP capacity reduces need for flexible power plant capacity significantly)
- Bigger **differences in the generated electricity from natural gas**: in the case of time restriction, it is higher → **correlation with shifted energy**



Reduced CO₂ emissions by flexible heat pumps

- Increased power-to-heat sector coupling decreases need for electricity from natural gas in Austria
→ reduced CO₂ emissions in the electricity and district heat sector



Findings

- Flexibility provided by heat pumps can **reduce electricity system costs, required investments in other flexibility options** as well as **reduce CO₂ emissions** in the Austrian electricity system of 2030
- **Impact of weekly heating demand profile** (summer vs. winter) is rather **limited**
- Flexibility potential is very sensitive to **assumptions on installed heat pump capacity** and the **flexible share** of them as well as **shifting time** limitations (comfort)

Outlook

- **Refine** and discuss **shifting time limitations** (social vs. technical limitations) → high impact!
- Include **other sectors** than residential (**industrial, tertiary**)
- Split potentials in seasonal parts with varying parameters (e.g. losses higher in winter)

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