5th International Conference on Smart Energy Systems

The effect of Heat Pumps operational profiles in exploiting renewables with different electricity mixes

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Copenhagen
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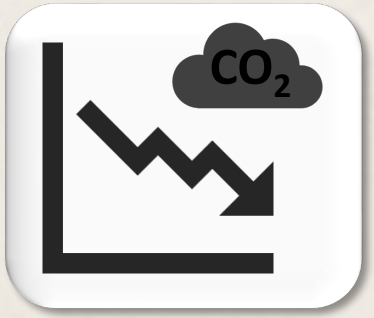
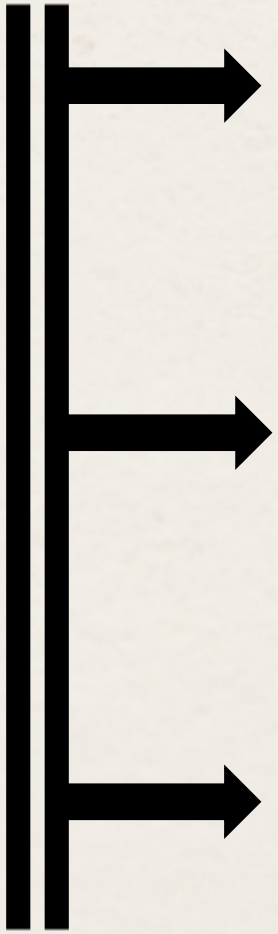
EU Goals (European Union, Clean Energy package 2030)

AVG Energy **Efficiency** improvement **of 32.5%** by **2030**

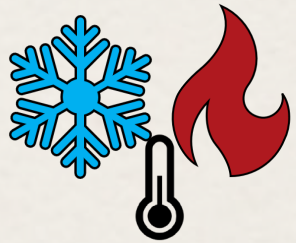
Renewable Energy Production **share to 32%** by **2030**



40% Cut in CO_2 emissions by **2030**
85% Cut in CO_2 emissions by **2050**



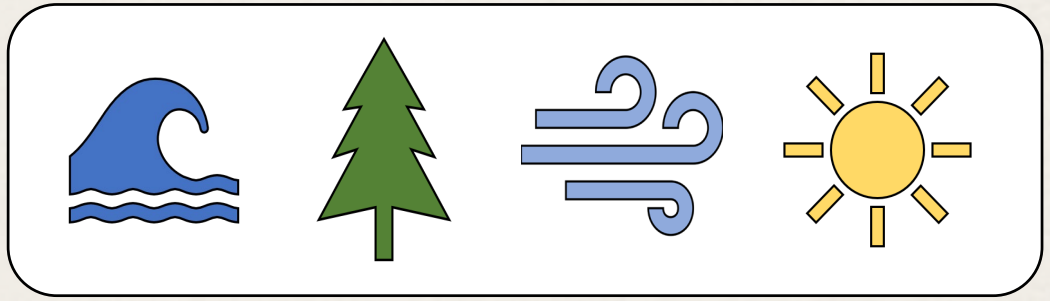
Electricity

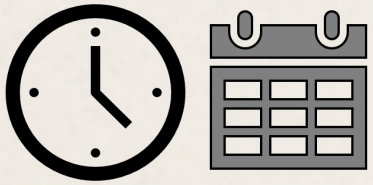


Heating and Cooling

Transport

Renewables: Dispatch Problem



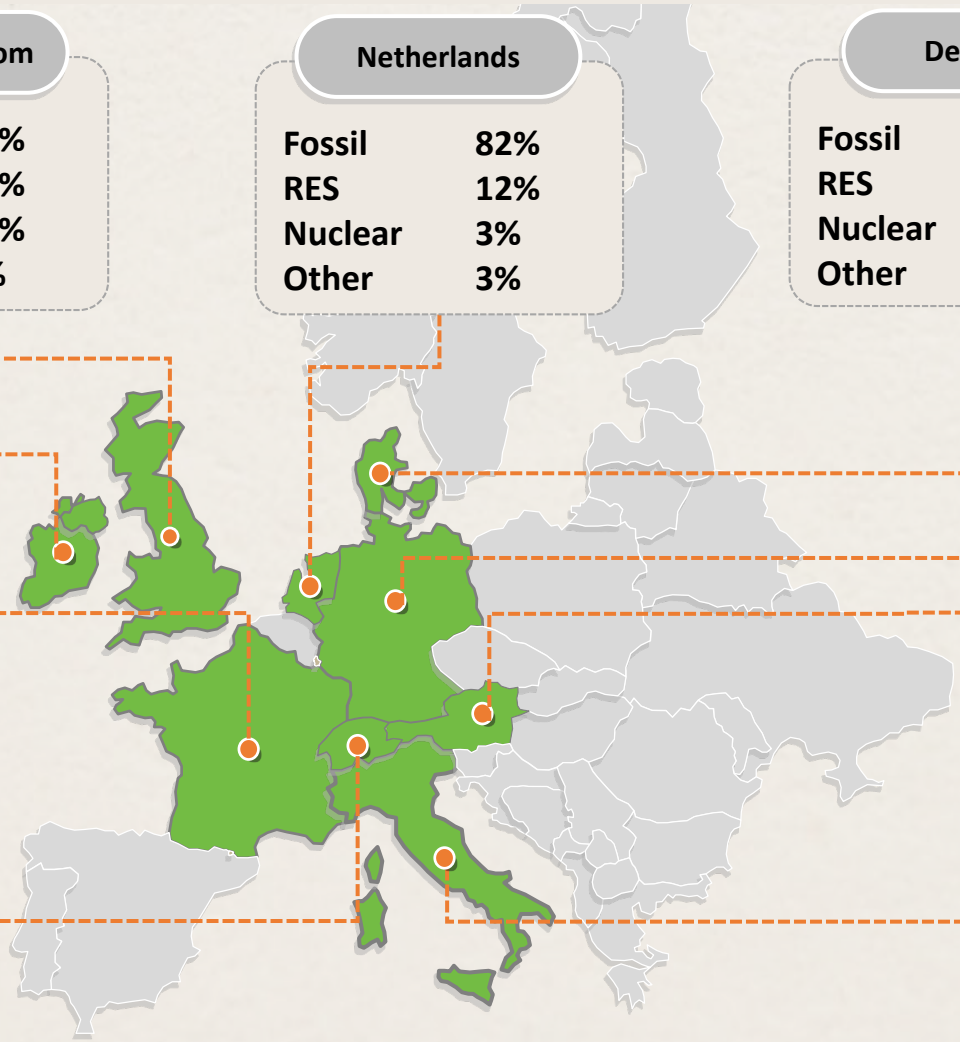


Daily and Monthly variations

Seasonal variations

Unpredictable variations

Countries Electricity Production Mix (IEA, 2016)



Ireland

Fossil	74%
RES	25%
Nuclear	0%
Other	1%

United Kingdom

Fossil	52%
RES	25%
Nuclear	21%
Other	2%

Netherlands

Fossil	82%
RES	12%
Nuclear	3%
Other	3%

Denmark

Fossil	37%
RES	58%
Nuclear	0%
Other	5%

Germany

Fossil	56%
RES	29%
Nuclear	13%
Other	2%

France

Fossil	9%
RES	17%
Nuclear	73%
Other	1%

Austria

Fossil	20%
RES	78%
Nuclear	0%
Other	2%

Switzerland

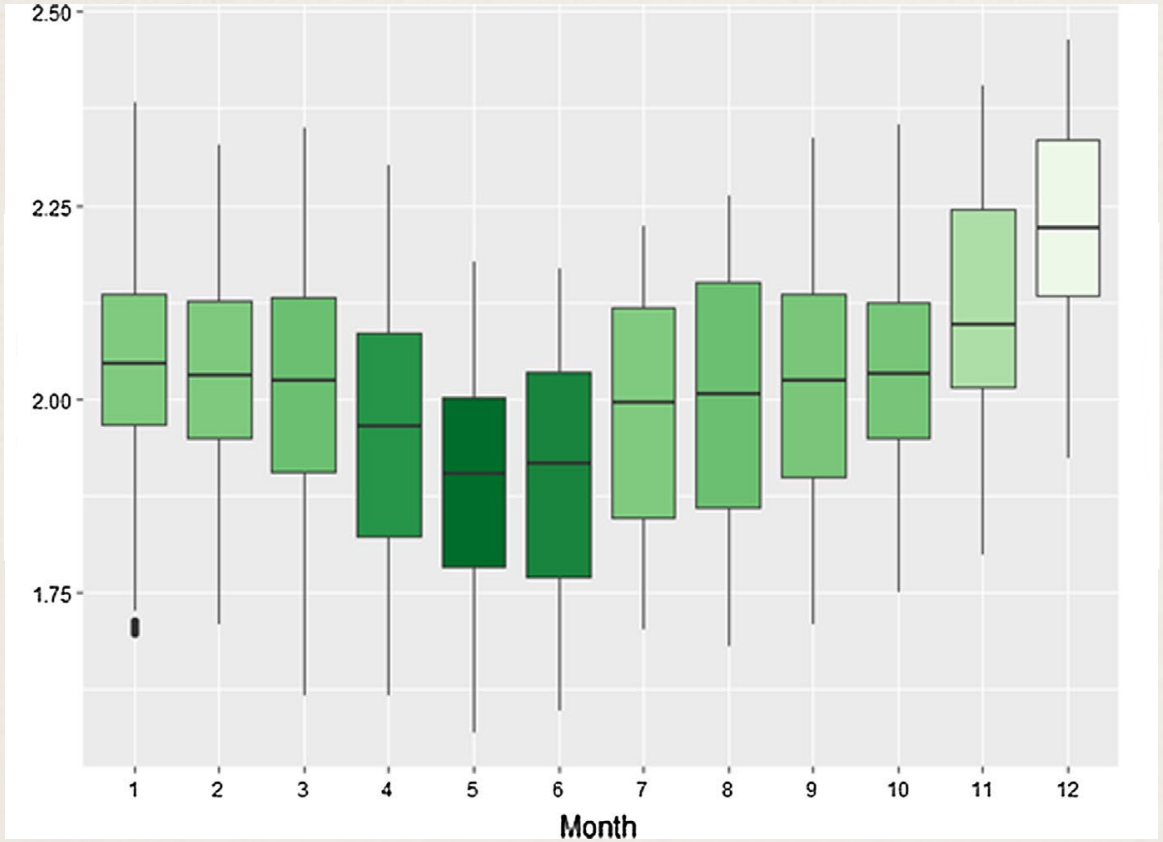
Fossil	2%
RES	61%
Nuclear	34%
Other	3%

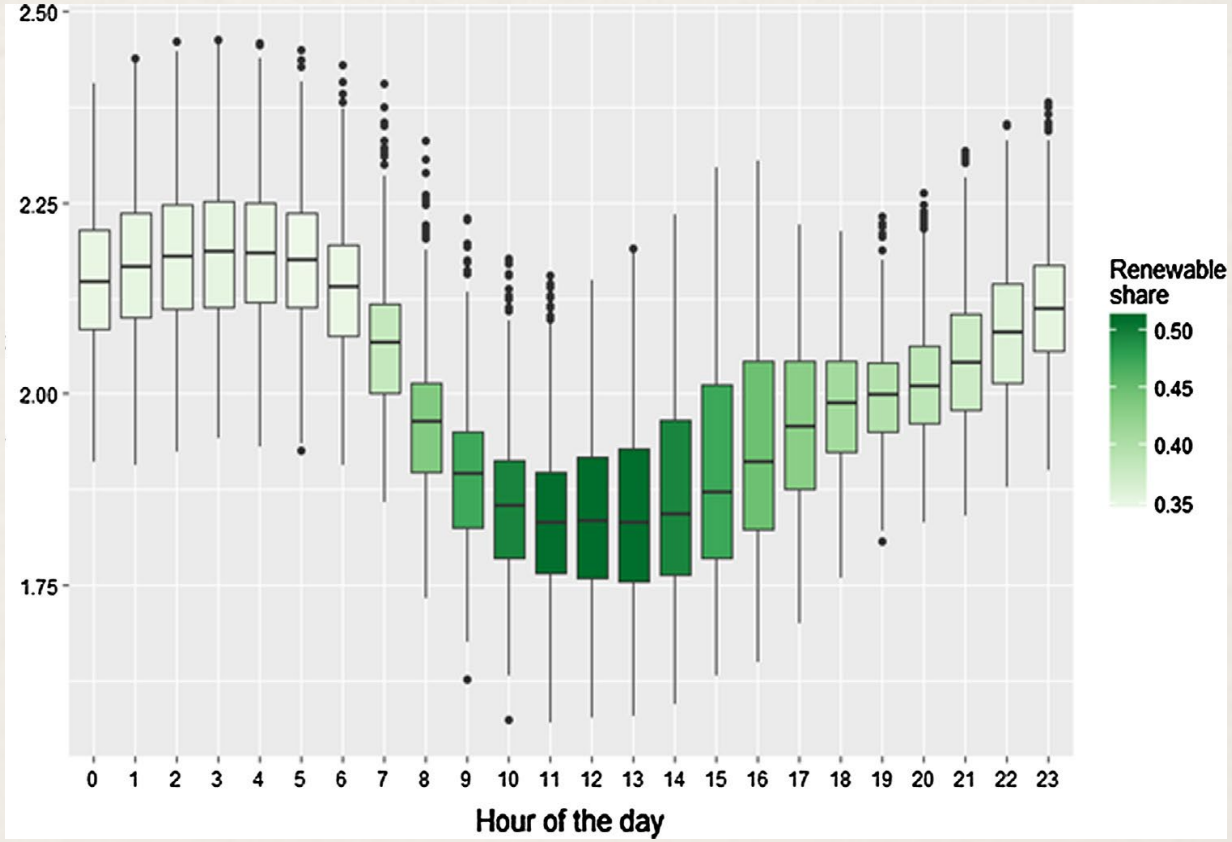
Italy

Fossil	61%
RES	37%
Nuclear	0%
Other	2%

Daily and Yearly Variation of Electricity PEF

(Jarre, Noussan, Simonetti. Primary energy consumption of heat pumps in high renewable share electricity mixes)



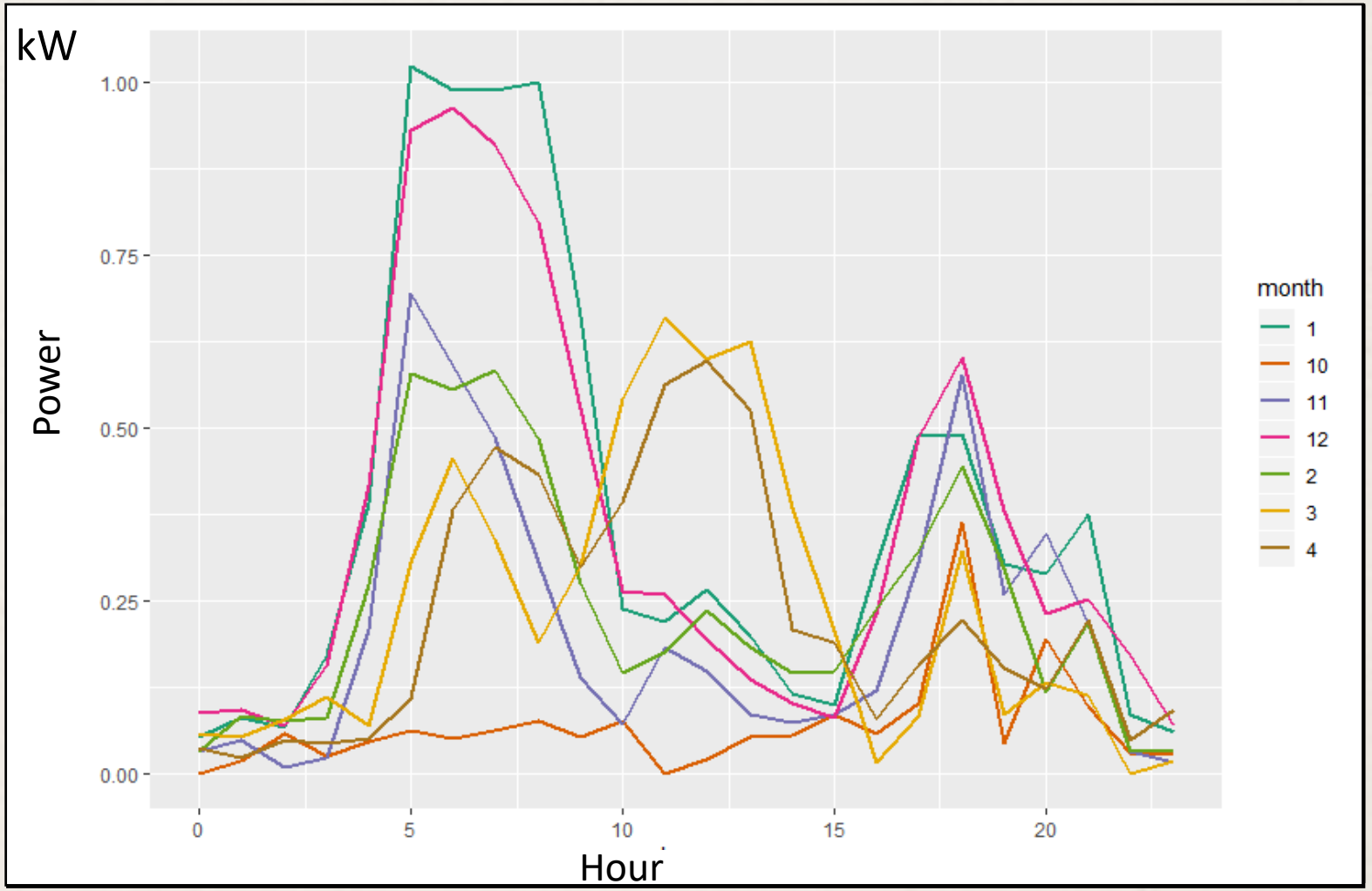


The average annual value is not representative anymore, there is the need of finest evaluation

Heat Pumps Profiles

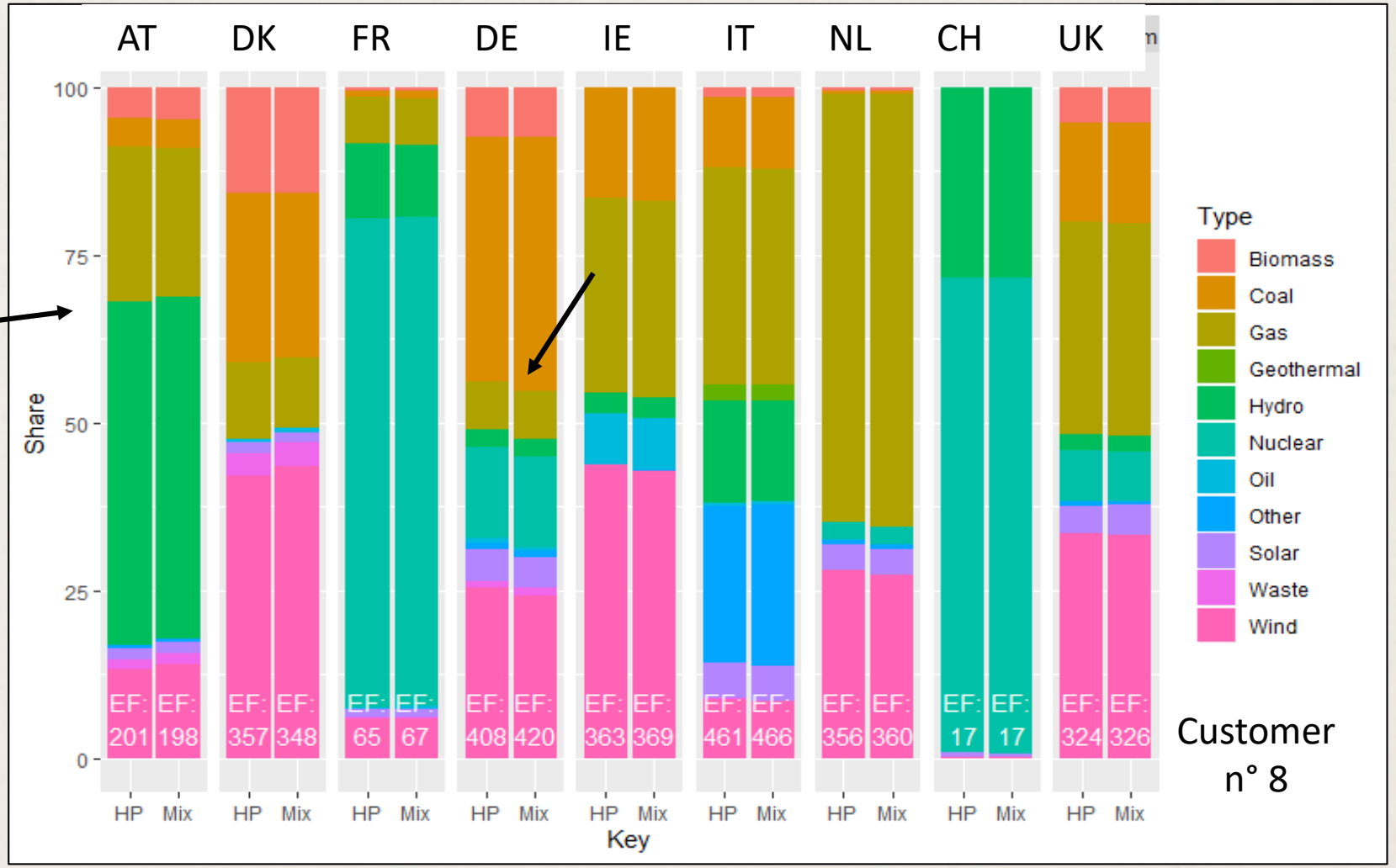
Electrical Profiles

- 10 Monitored HP of different types
- Residential and commercial use
- 1 year of data with 1min/15min timestamp. Winter period



Energy Consumption and Production

- The EF are LCA values taken from IPCC
- The hourly production data from Entsoe platform



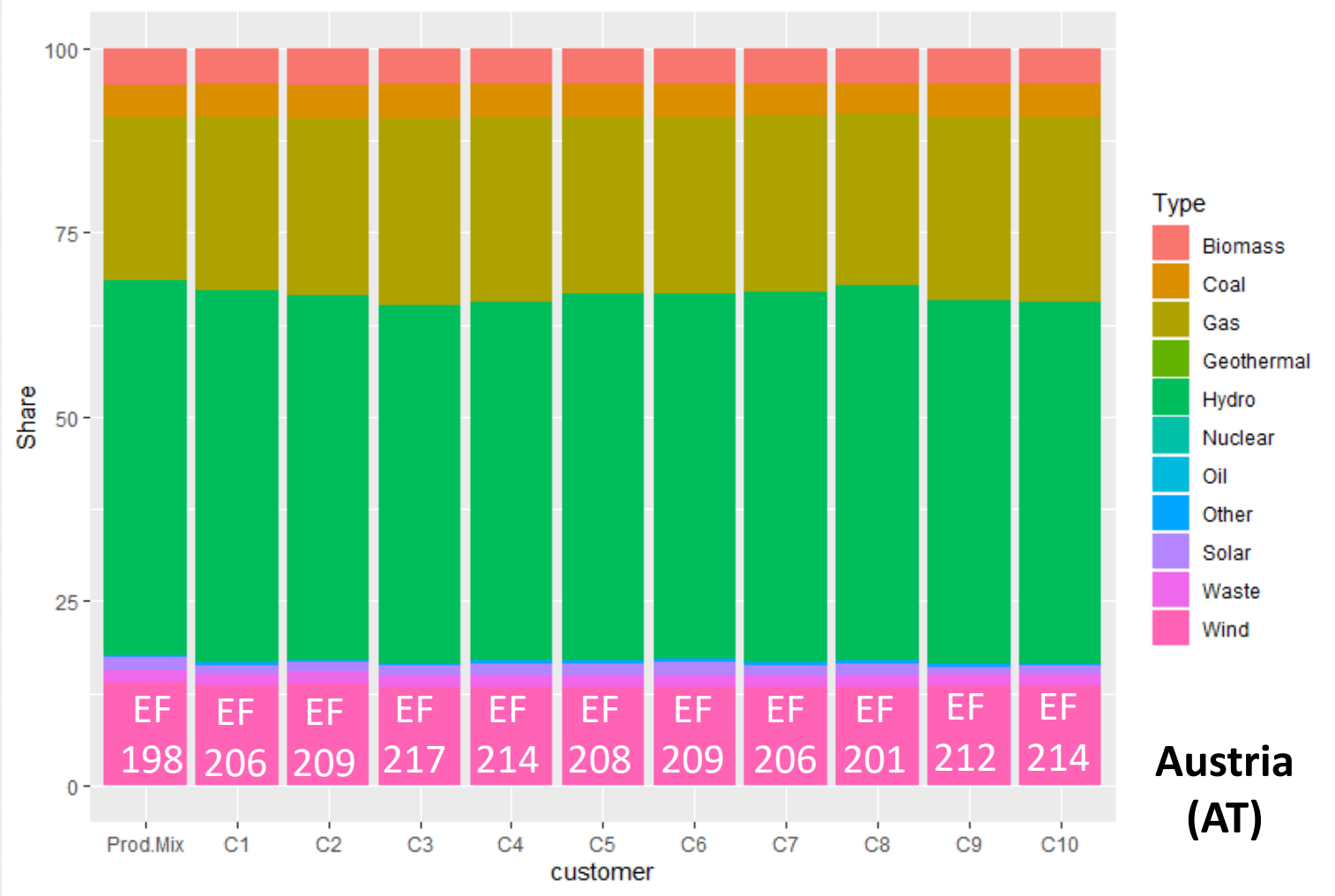
- Austria presents an higher EF for the HP consumption

- Vice versa for Germany, where HP consumes more renewable energy

Energy Mix VS Customers

- Different heat pump profiles result in different energy uses
- In the case of **Austria** the EF of the mix is 198 [gCO_2 / kWh]

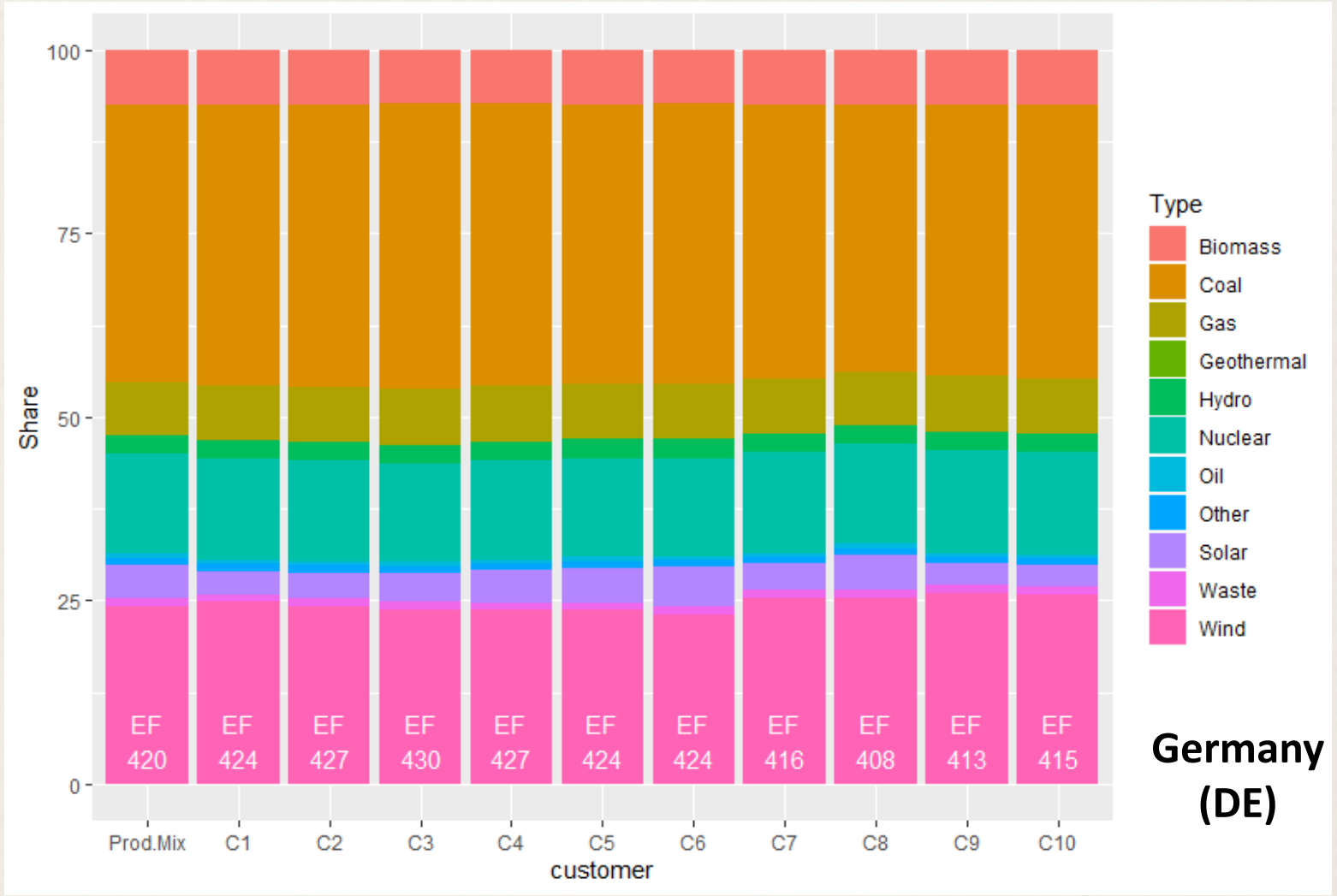
+1.5% for C8 [gCO_2 / kWh]
+8% for C10 [gCO_2 / kWh]



Energy Mix VS Customers

- Different heat pump profiles result in different energy uses
- In the case of **Germany** the EF of the mix is 420 [gCO_2 / kWh]

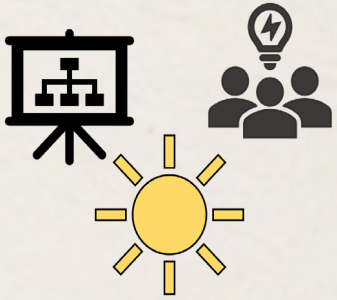
  - 2.9% for C8 [gCO_2 / kWh]
  + 2.5% for C3 [gCO_2 / kWh]

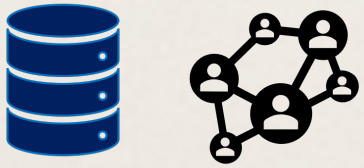


Conclusions

Importance of **Hourly evaluation VS Annual evaluation**, especially for users and sources with a strong seasonality (e.g. heating vs PV/hydro)

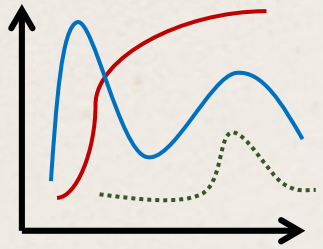
The current **push for the electrification** of the heating sector may be **supported by** a careful **planning of power generation from RES** considering their actual profiles



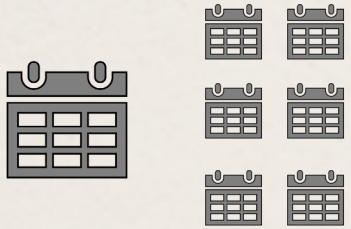


Future requirements: daily and seasonal **electricity storage**, **demand side response** and/or **sector coupling**, **control system** to handle the RES electricity consumption.

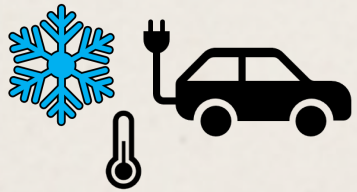
Future Developments



This study has been based on a small number of heat pumps electrical profiles. The comparison with a **larger number** of **HP systems** and **heating/electrical load profiles** will provide more robust results. Moreover, **sensitivity analysis** of **EF** and **Production mix** has to be carried out



Extending the analysis on **multiple years** will ensure a better reliability of the results.



Similar analyses may be extended to other systems (e.g. electric vehicles, cooling, etc.). The results can be combined together.

Thank You For Your Attention !

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POLITECNICO DI TORINO

References

[1] European Commission – Clean Energy Package for All European

[2] European Network of Transmission System Operators for Electricity – Entso-E

[3] IEA Energy Statistics - Website

[4] Jarre, M., Noussan, M., & Simonetti, M. (2018). Primary energy consumption of heat pumps in high renewable share electricity mixes. *Energy Conversion and Management*, *171*, 1339–1351. https://doi.org/10.1016/J.ENCONMAN.2018.06.067

Backup

Energy Mix VS Costumers

- Different heat pump profiles result in different energy uses
- In the case of Italy the EF of the mix is 450 [gCO_2 / kWh]

+5.1% for C3 [gCO_2 / kWh]
+2.5 for C8 [gCO_2 / kWh]