Heat Roadmap Europe 2050

A low-carbon heating and cooling strategy

The Fantastic Four of heating and cooling modelling in HRE4

FORECAST
Cost Curves
JRC-EU-TIMES
EnergyPLAN

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A low-carbon heating and cooling strategy

The FORECAST model – H&C profiles and baseline scenario

Tobias Fleiter

Fraunhofer Institute for Systems and Innovation Research

Heat Roadmap Europe Workshop, Amsterdam, March 16, 2018

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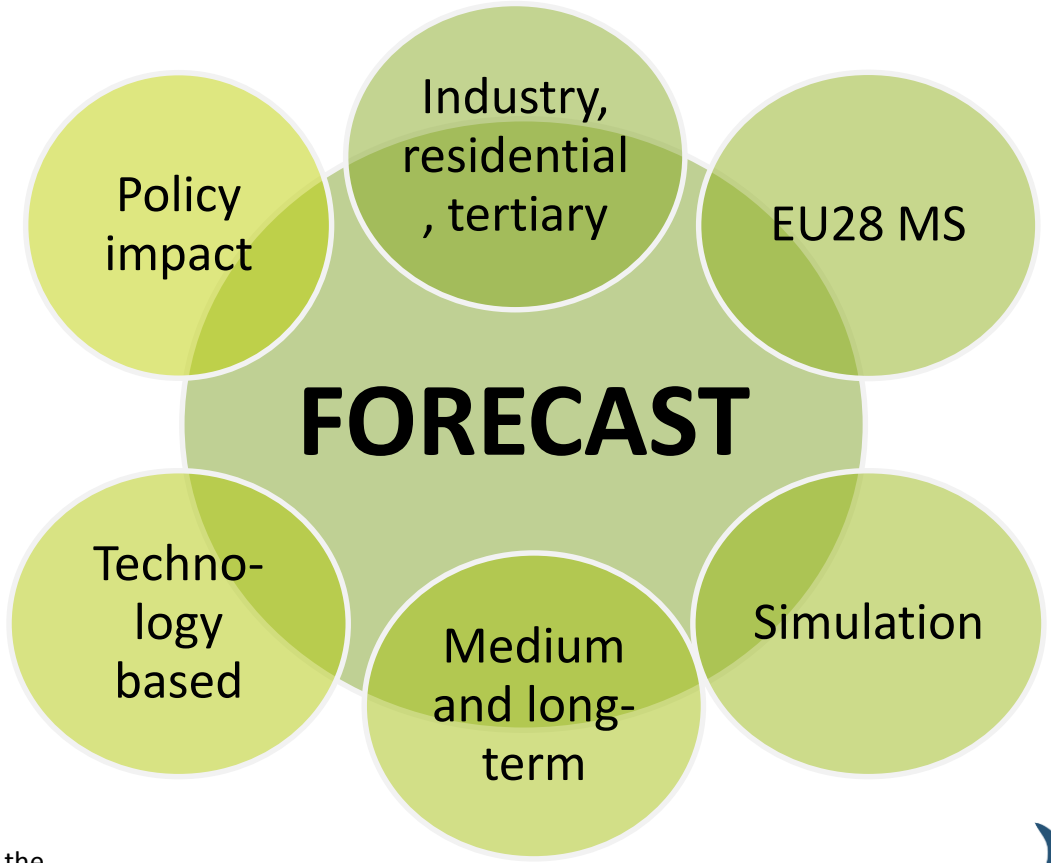
What is FORECAST?

Main purpose: *developing scenarios on the future long-term evolution of energy demand in industry, residential and tertiary sectors*



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Example: Calculation of heating and cooling profiles for 2015

Goal:

Dissaggregation of heating/cooling demand by including end-uses and technologies for 2015

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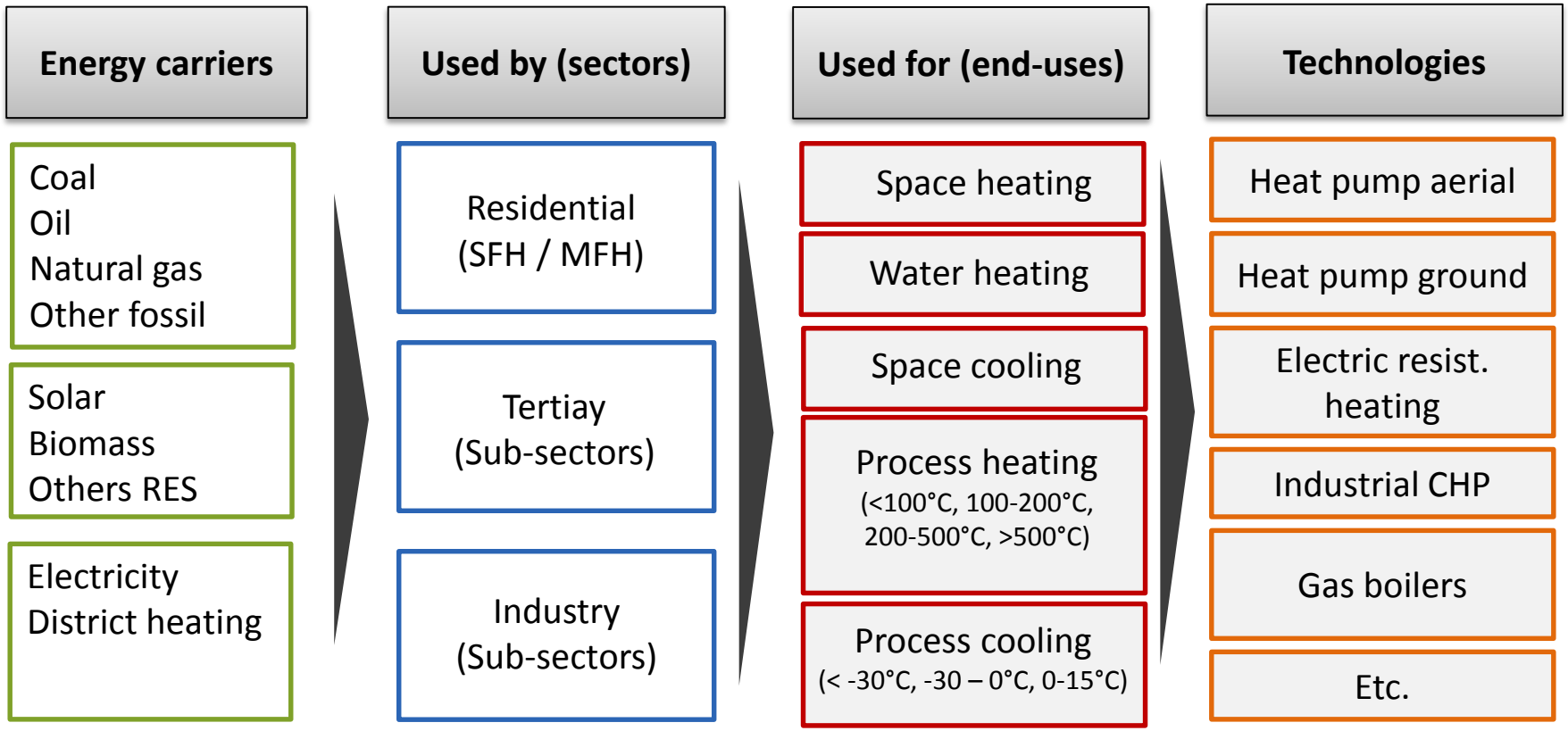
Dissaggregating final energy demand



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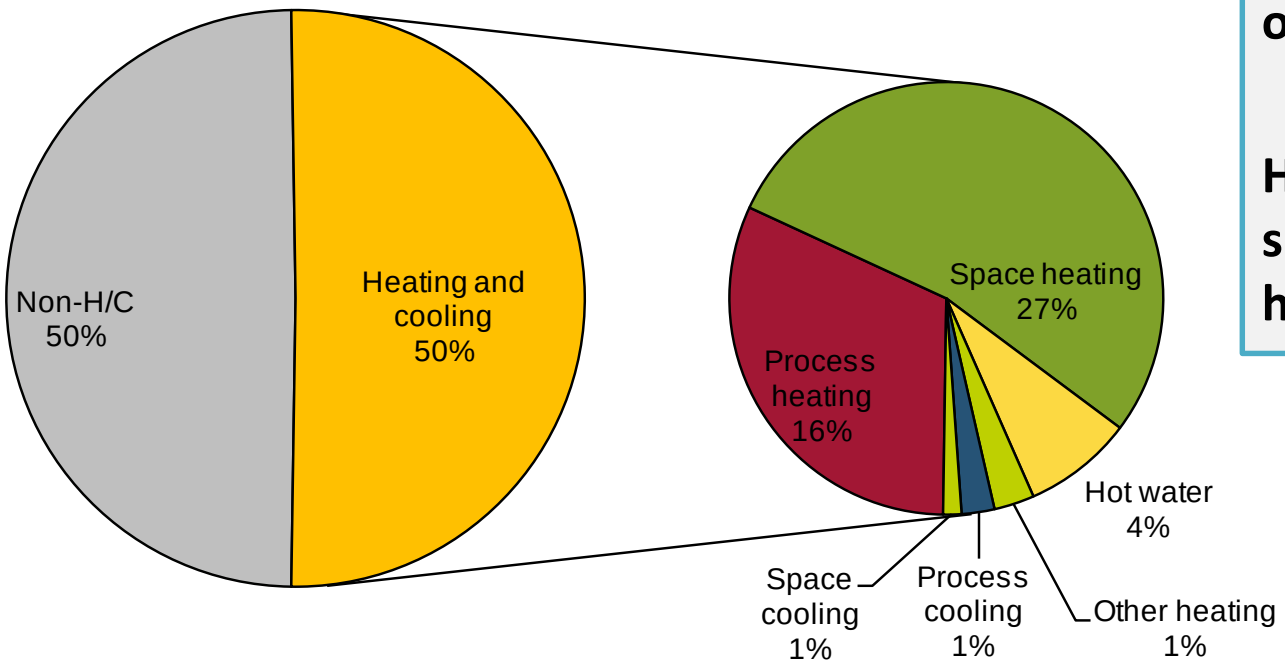
Results: Total final energy in 2015 (EU28)

Total final energy 2015: ~12,600 TWh



H&C about 50% of FED

High importance space and process heating

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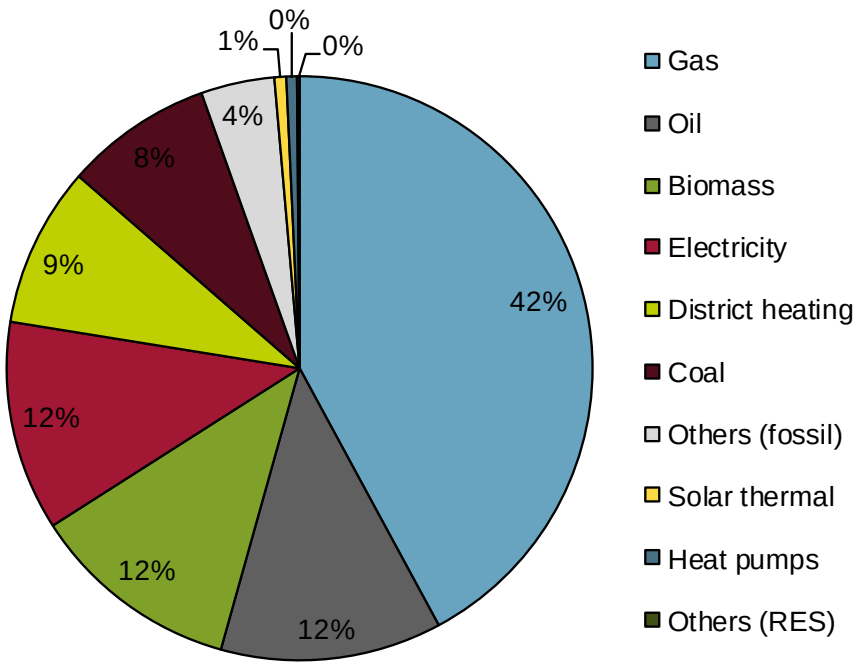
Results: H&C FED by energy carrier in 2015 (EU28)



2015 shares FED:

- **Fossil: 66%**
- **RES: 13%**
- **El+DH: 21%**

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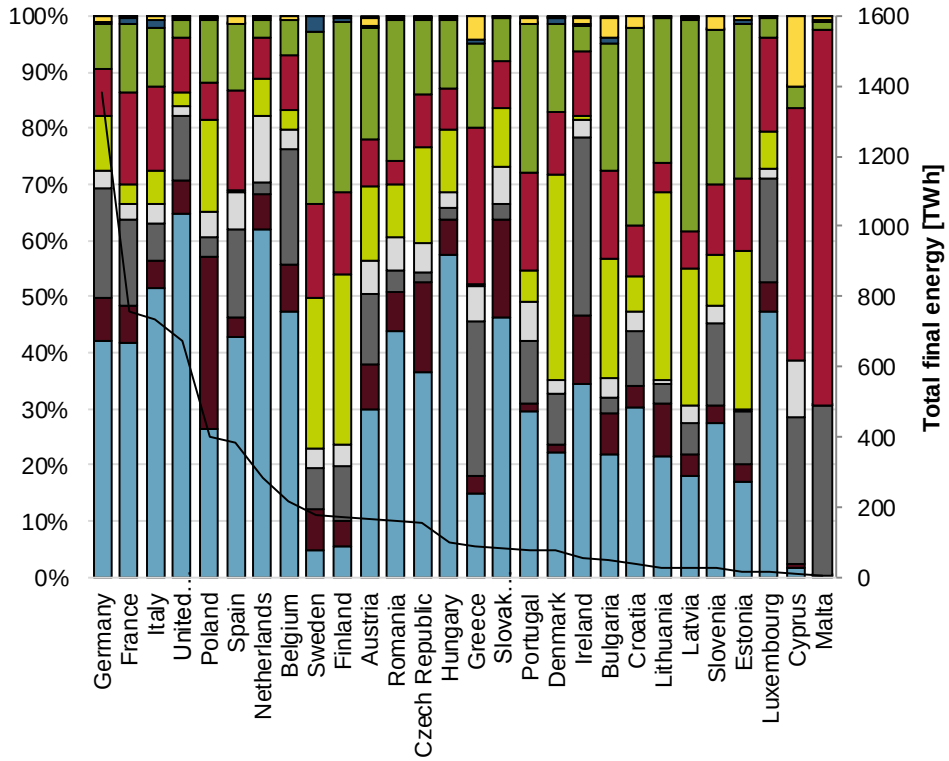
Results: H&C FED by energy carrier and country (EU28, 2015)



- **Energy carrier mix very country specific**
- **Gas important in most countries (less in SE and FI)**
- **Solar and heat pumps still marginal almost everywhere**

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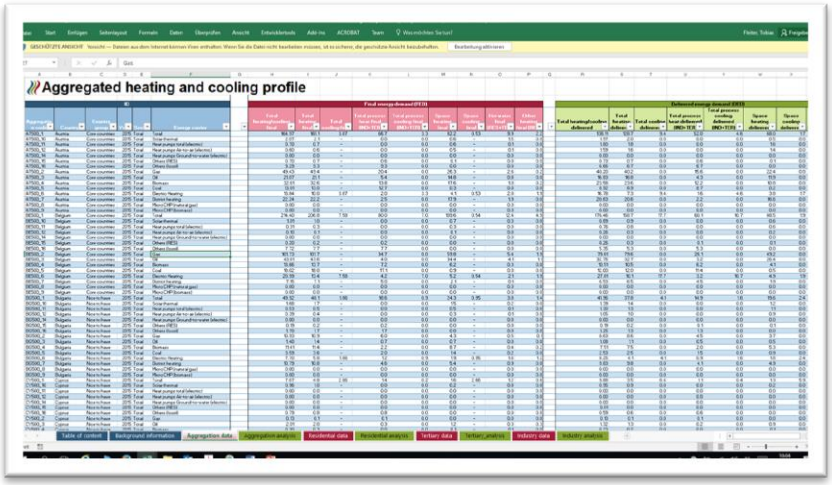
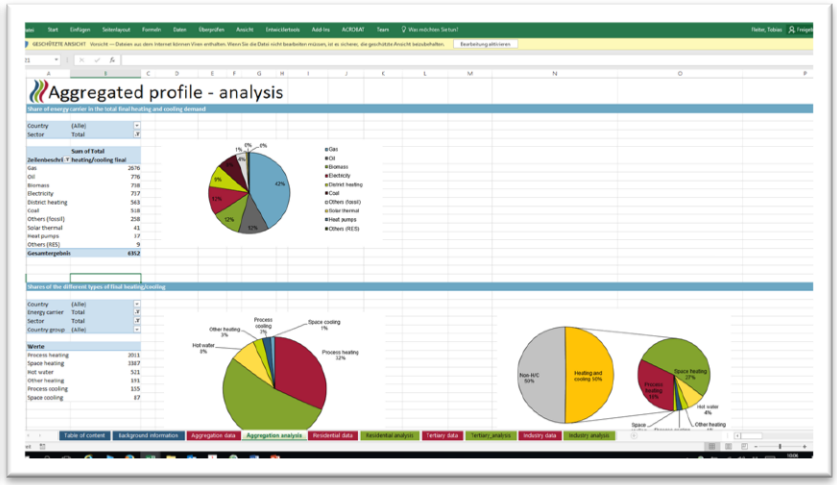
Interested?
Online dataset available

http://www.heatroadmap.eu/output.php

Download as spreadsheet raw-data with pre-defined graphs and tables allows deep-dive into country details





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Some conclusions

- Most detailed complete breakdown H&C energy demand for the EU28
- Basis for strategies for the transformation towards a low-carbon H&C sector
- Still uncertainties remaining; improvements possible with better empirical data (RES in industry & services, space cooling, etc.)

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Contact

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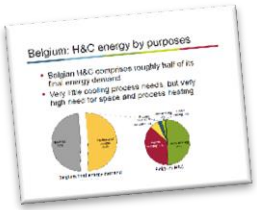
Thank you very much for your attention!



Online available

- Brochure
- Data set with 2015 profiles
- 14 Country fact sheets
- User guidelines and technical reports

http://heatroadmap.eu/output.php

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Heat Roadmap Europe 2050

A low-carbon heating and cooling strategy

Cost curves – Quantifying the Potential for Reducing the Heating and Cooling Demands in the EU

Robert Harmsen, Utrecht University

Heat Roadmap Europe workshop, Amsterdam,

16 March 2018

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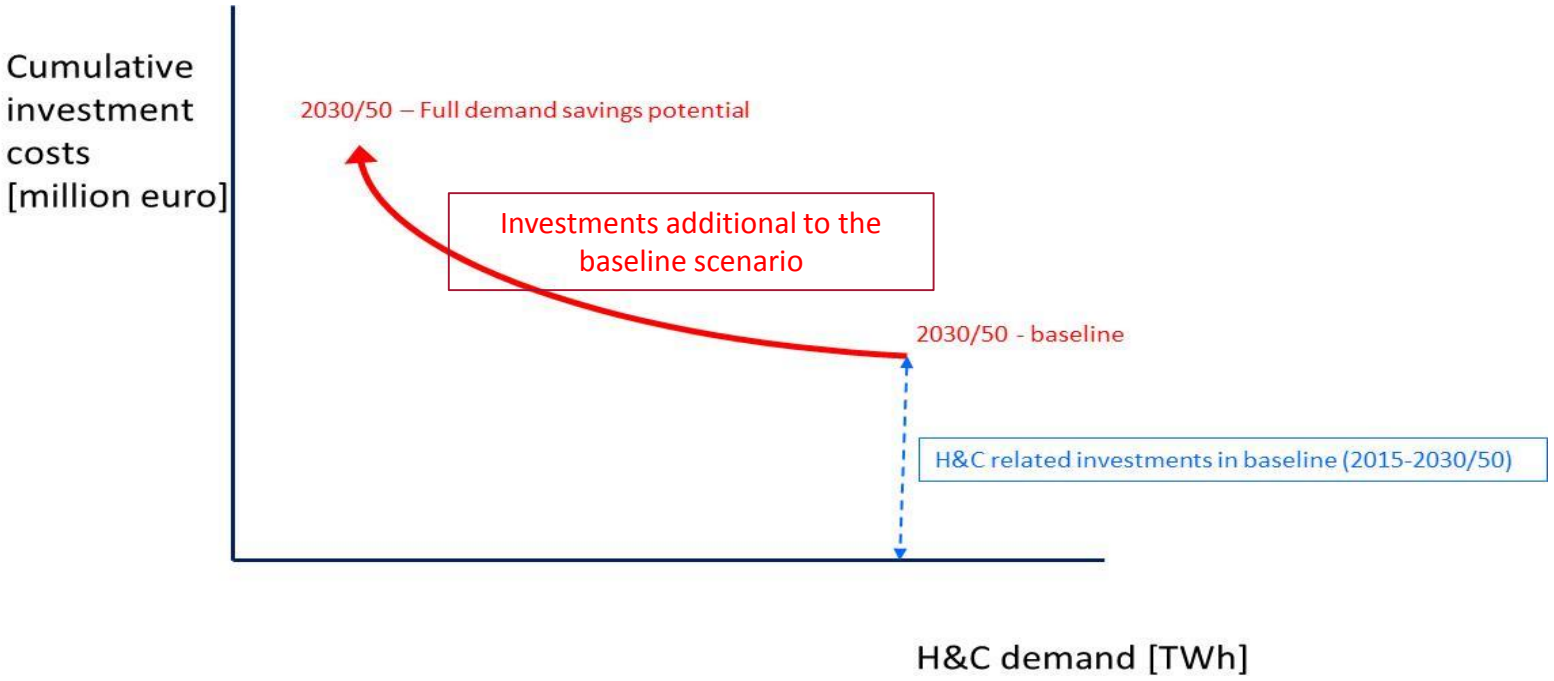
Cost curves focus on investment costs for reducing H&C demand, not on the lower energy bill



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Key features of the cost curves

- Based on detailed technology-specific, bottom-up modelling (FORECAST)
- Account for technical limitations of energy-saving measures
- Account for stock turnover cycles for industrial processes and realistic refurbishment rates for buildings
- Consider the individually-different starting points of EU countries and their individual framework conditions (e.g. climate, energy prices, etc.)
- Show additional savings beyond what is achievable with current policy measures (i.e. the savings in the cost curves are additional to the baseline)

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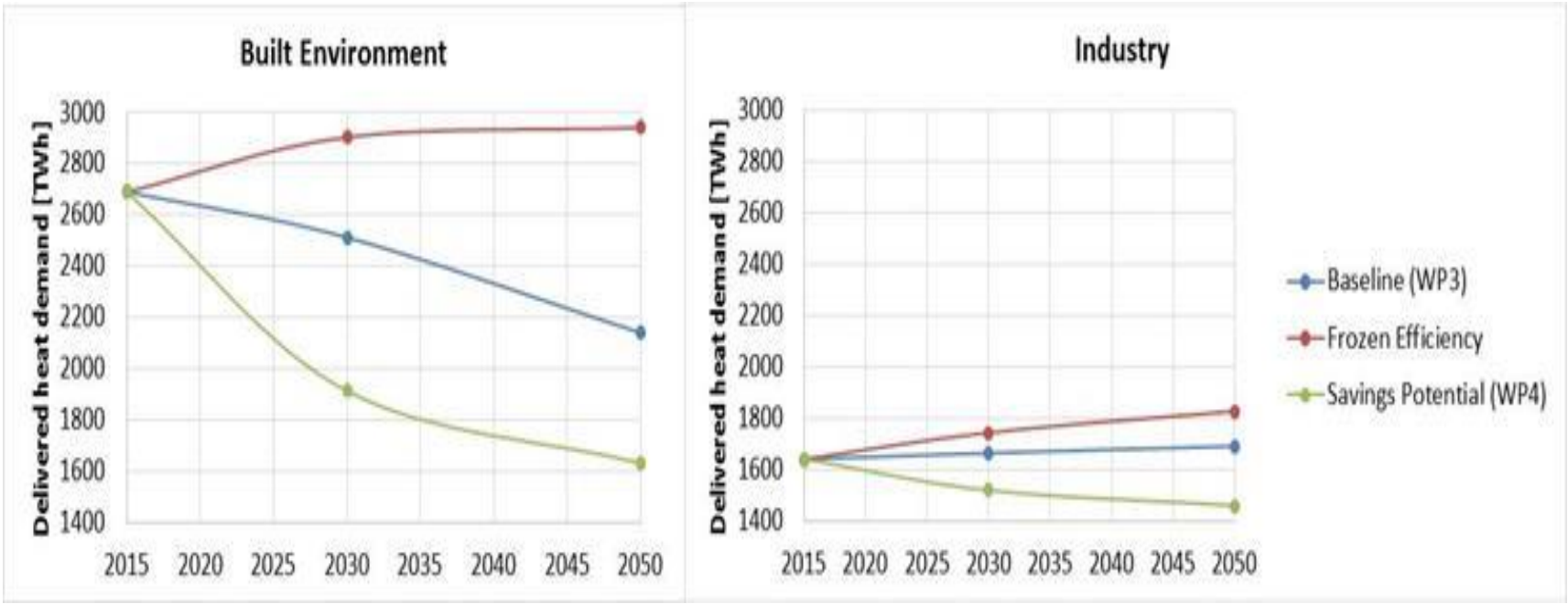
Heat demand savings potential 14 HRE4 countries



Both for built environment and industry there is significant untapped heat demand savings potential beyond the Forecast baseline scenario

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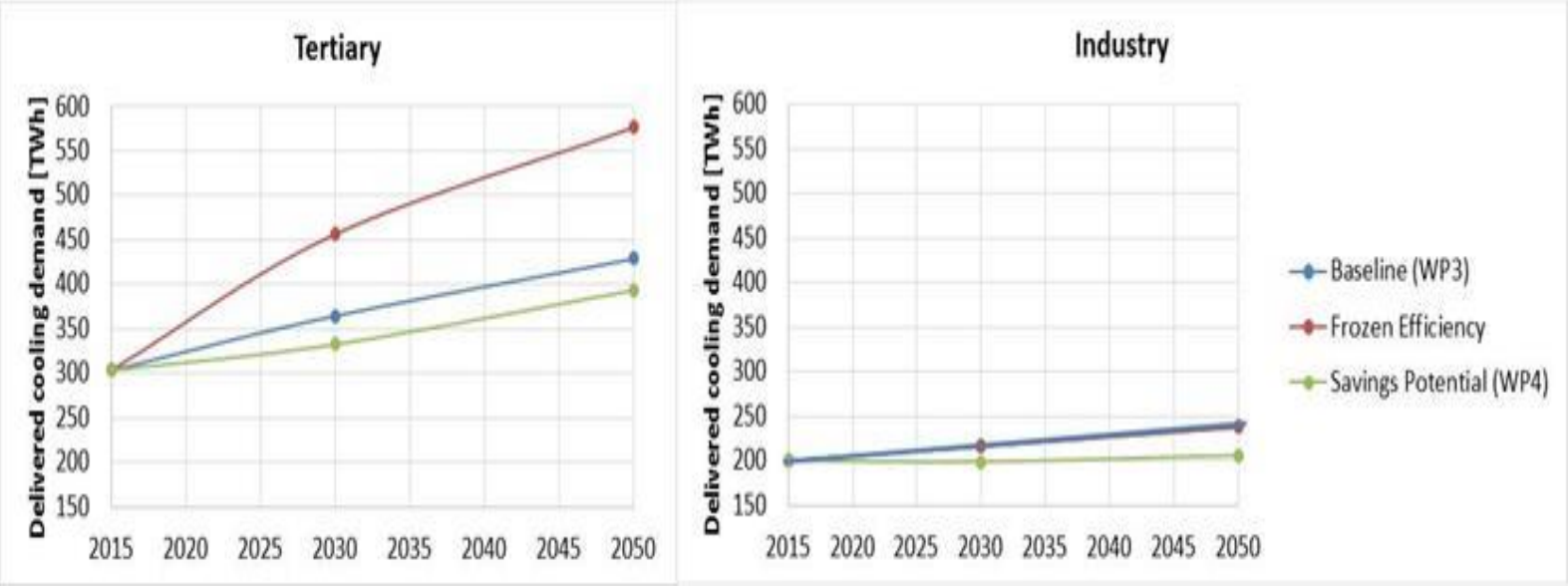
Cooling demand savings potential 14 HRE4 countries



Limiting the growth of cooling demand is especially important for the tertiary sector, especially in an absolute sense, but cooling demand in industry should certainly not be overlooked.

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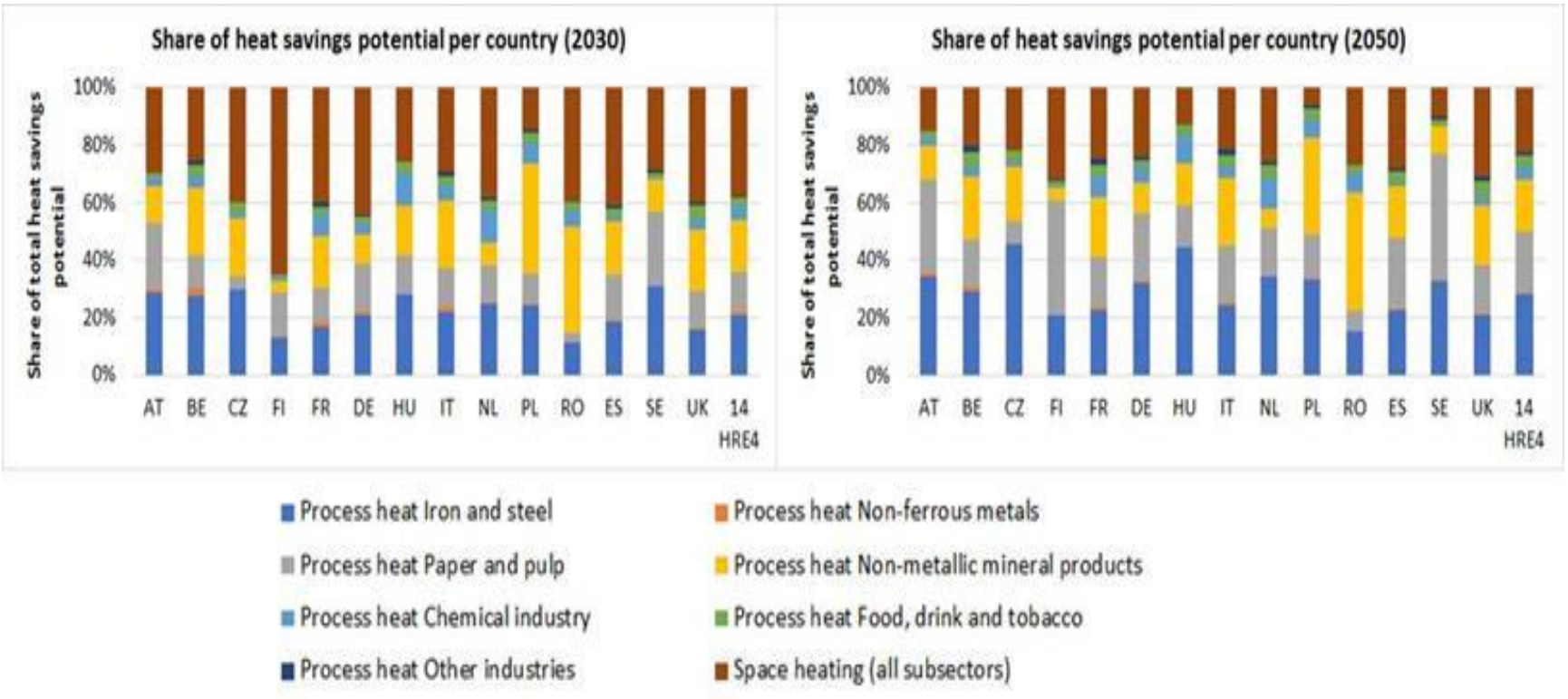
Industry: significant savings potential for space heating and a few dominating sectors regarding process heat



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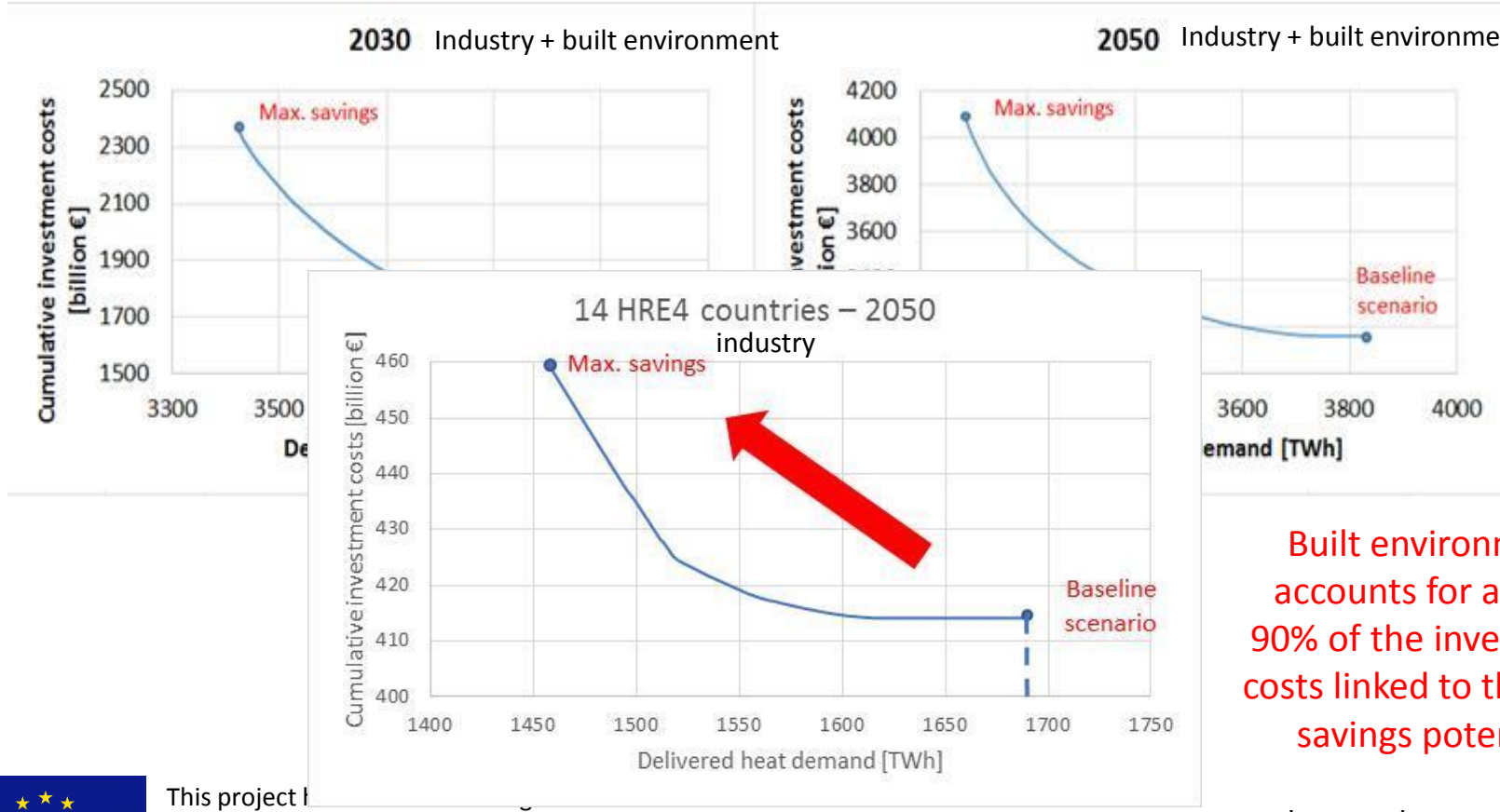
Cumulative investment costs for achieving max. heat demand savings



Built environment accounts for almost 90% of the investment costs linked to the max. savings potential

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Summary of main outcomes

- WP4 adds another 750 TWh (~heat demand France) to the 900 TWh savings in the WP3 baseline scenario
- The required investment costs amount to €4100 billion
- The majority of the extra savings revealed by WP4 for the residential sector are achieved by implementing more ambitious renovation measures than implemented in the WP3 baseline for buildings that undergo a renovation anyway. Further savings are achieved by increasing the refurbishment rate considered for the baseline scenario
- Lowering the demand of HT industrial processes tends to be more difficult than reducing LT heat demand within the residential or tertiary sectors

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Policy implications (demand perspective)

- In order to exploit all the additional H&C savings stronger policy instruments are required, which address missed opportunities in current policy and financial frameworks
- This includes a stringent implementation of existing policies, like the Energy Performance of Buildings Directive (EPBD) and the EcoDesign Directive
- More particular for industry a higher CO_2 price is needed but also working towards a circular economy approach, with a larger share of heat savings resulting from recycling of resources

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Heat Roadmap Europe 2050

A low-carbon heating and cooling strategy

JRC-EU-TIMES model Energy system transitions

Wouter Nijs 16/03/2018

HRE4 Public Workshop
NEMO Science Museum, Amsterdam

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Only a forecast within this bubble

A (baseline) scenario

Depicts the energy system with the **lowest private cost**, subject to **technical** constraints, that includes

- limitations from system dynamics
- policy measures
- specified targets (27%, 30% and 40%)

Not an official scenario of the EC

Policies like standards or economic instruments which imply a transfer of money

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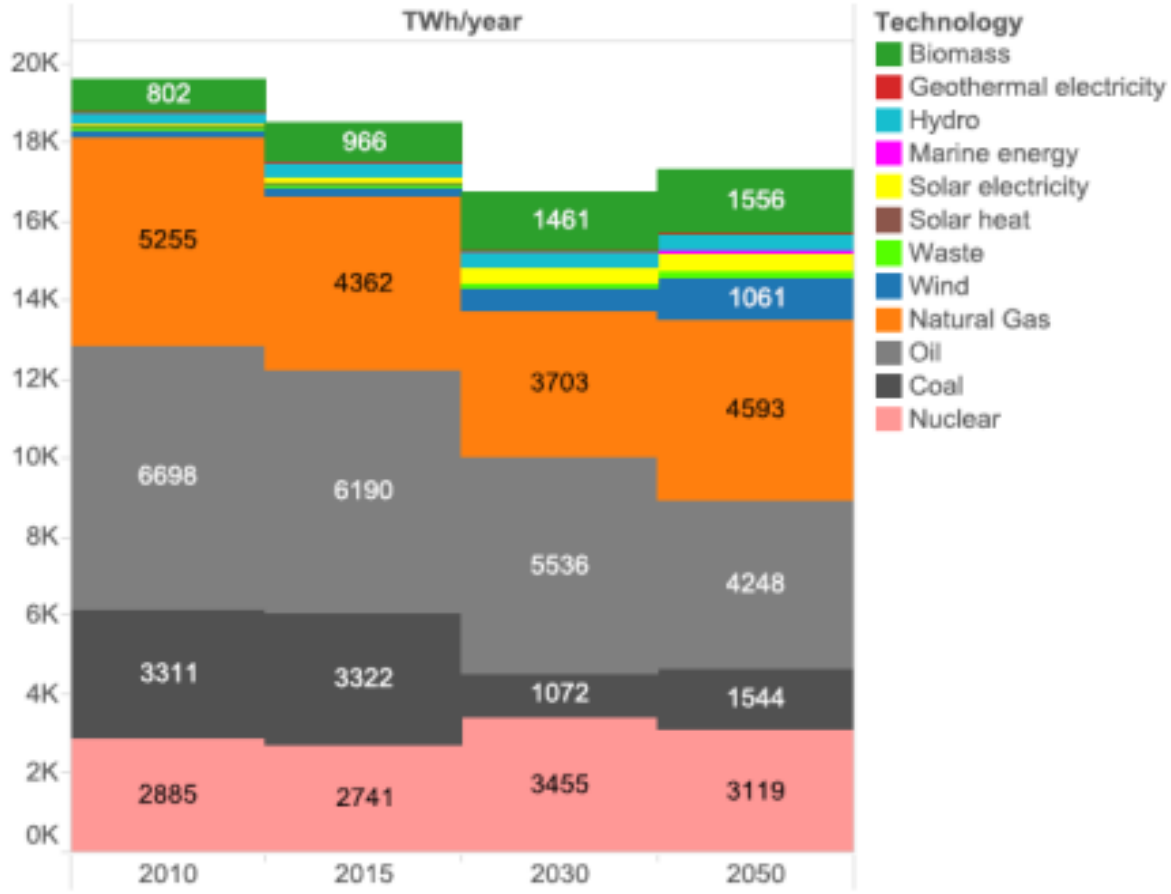
Coal halved, oil reduced by a third. Natural gas similar to 2015 levels.



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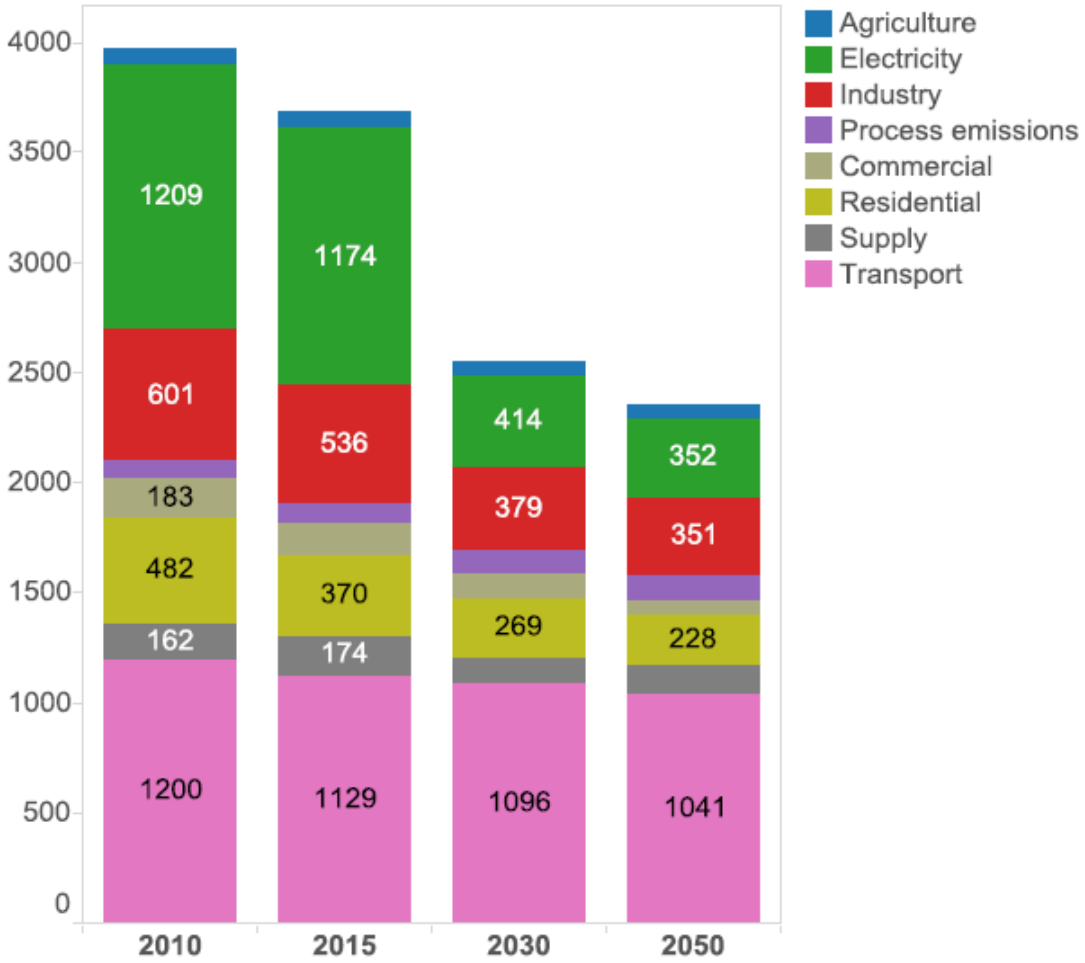
CO_2 from residential buildings halved



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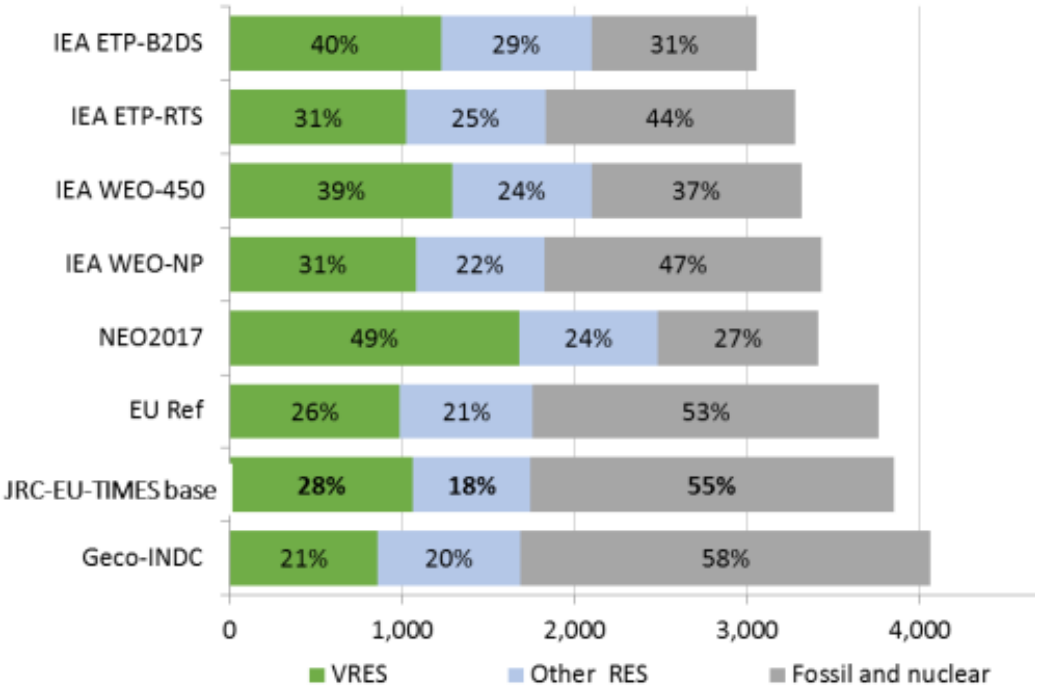
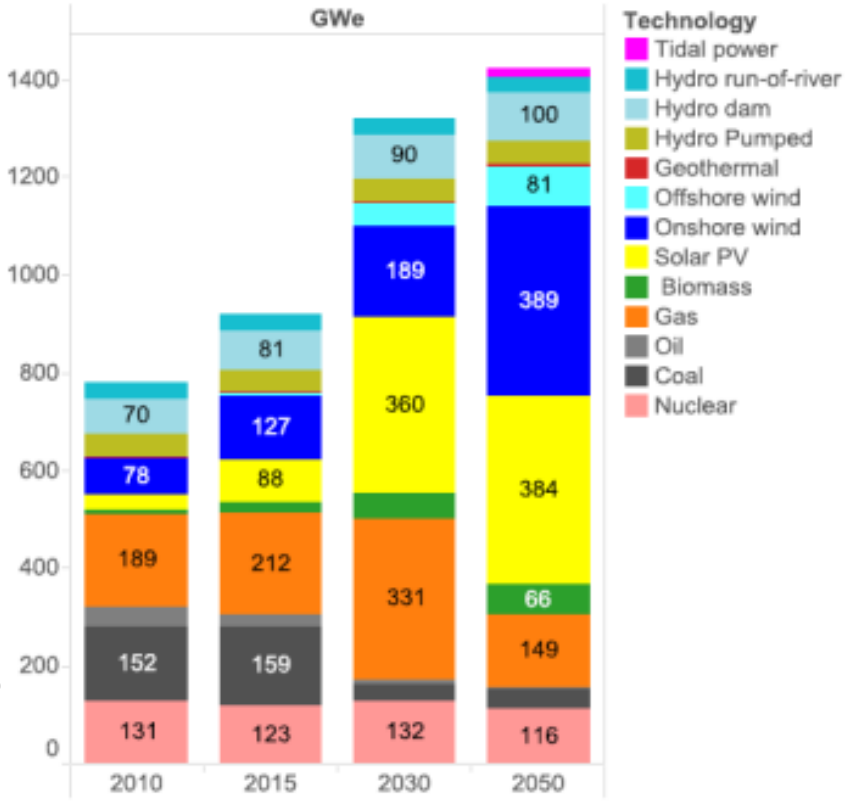
Ever-increasing integration of renewable energy sources





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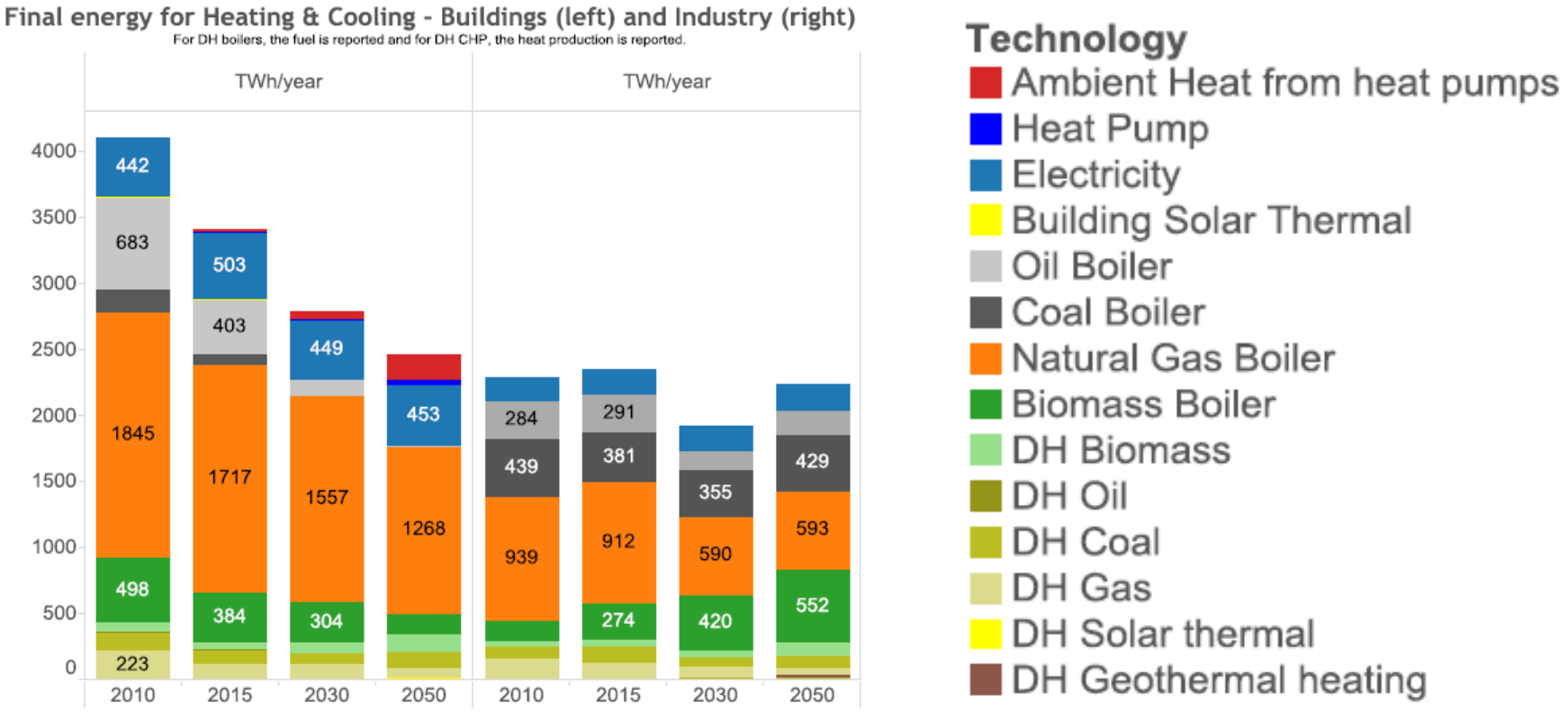
For buildings, coal and oil are pushed out of the market



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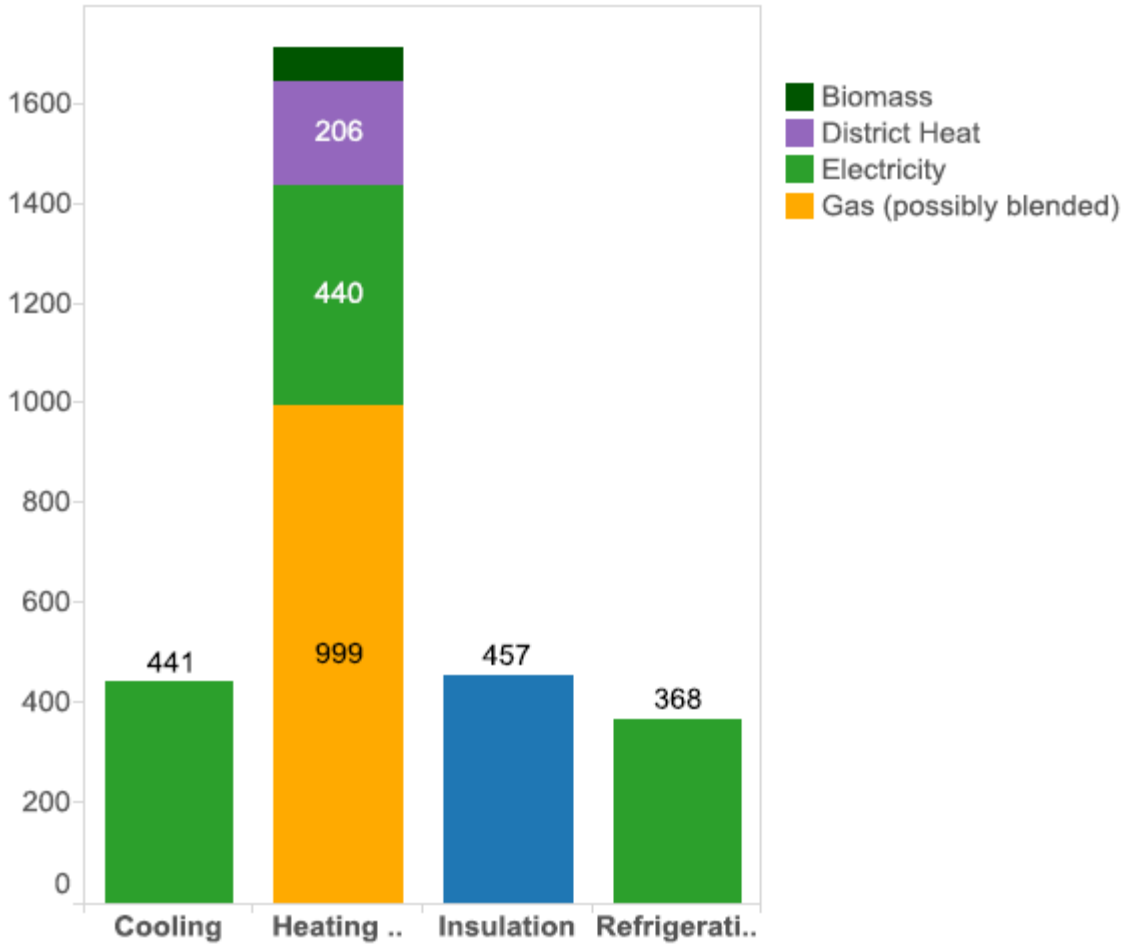
Still main investments in gas heaters Insulation 50% of this (BEUR up to 2050)



More results

- By 2030, around a sixth of all 300 million vehicles in the EU is fuelled by electricity
- Wind and solar make up 50% of investments made into new power generation capacities, with nuclear power plants accounting for 40%.
- http://www.heatroadmap.eu/resources/HRE4_D5.2.pdf

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Heat Roadmap Europe 2050

A low-carbon heating and cooling strategy

The EnergyPLAN tool

Andrei David

PhD Fellow

Sustainable Energy Planning Group

Aalborg University

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The modelling at AAU – Sustainable Energy Planning Research Group

- ✓ **Energy system analysis and modelling**
- ✓ **Energy and geographical information systems (GIS)**
- ✓ **Feasibility studies and socio-economics**
- ✓ **Public regulation and technological change**
- ✓ **Ownership models, participation and organisation**

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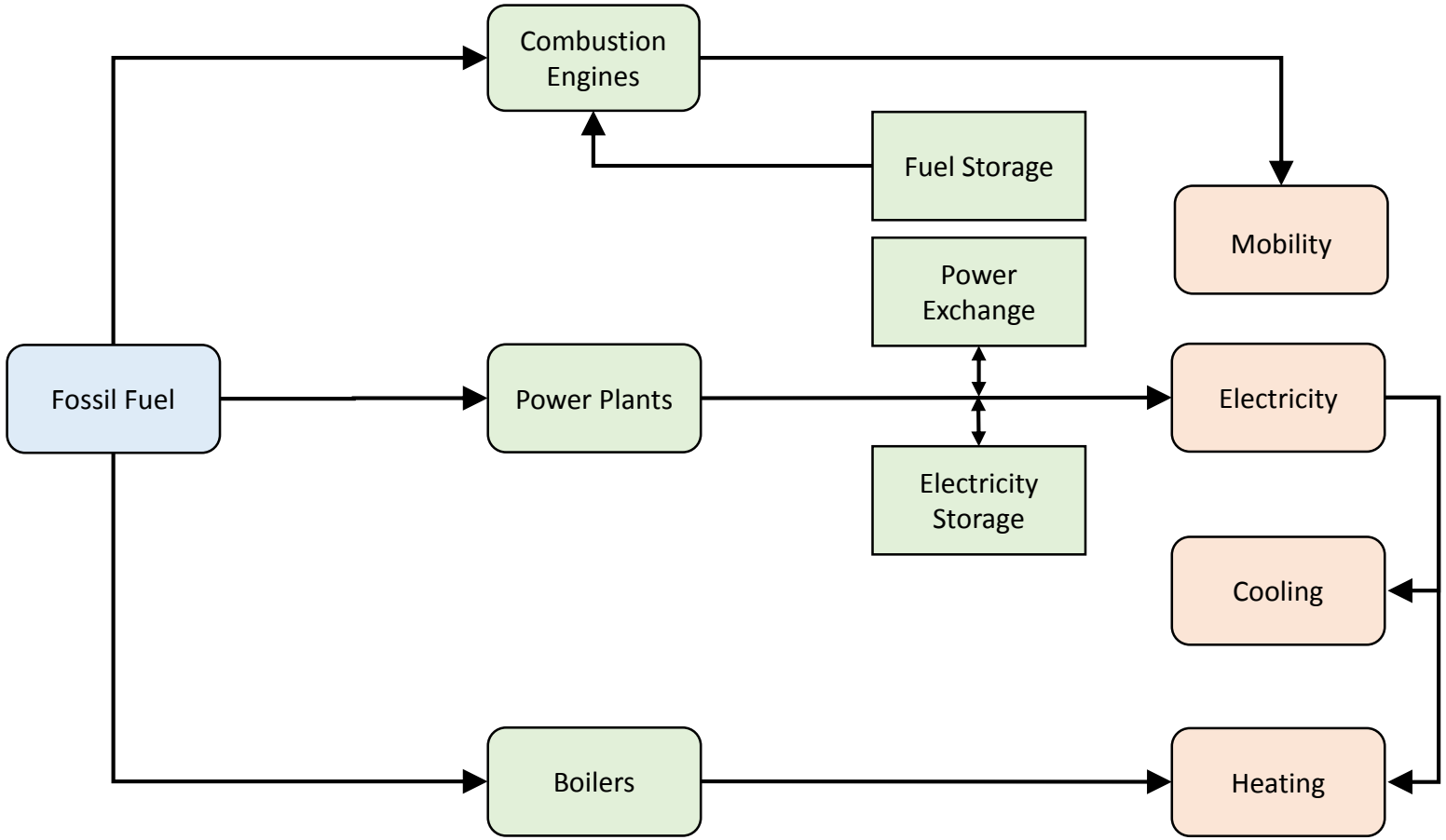
Today's Energy System



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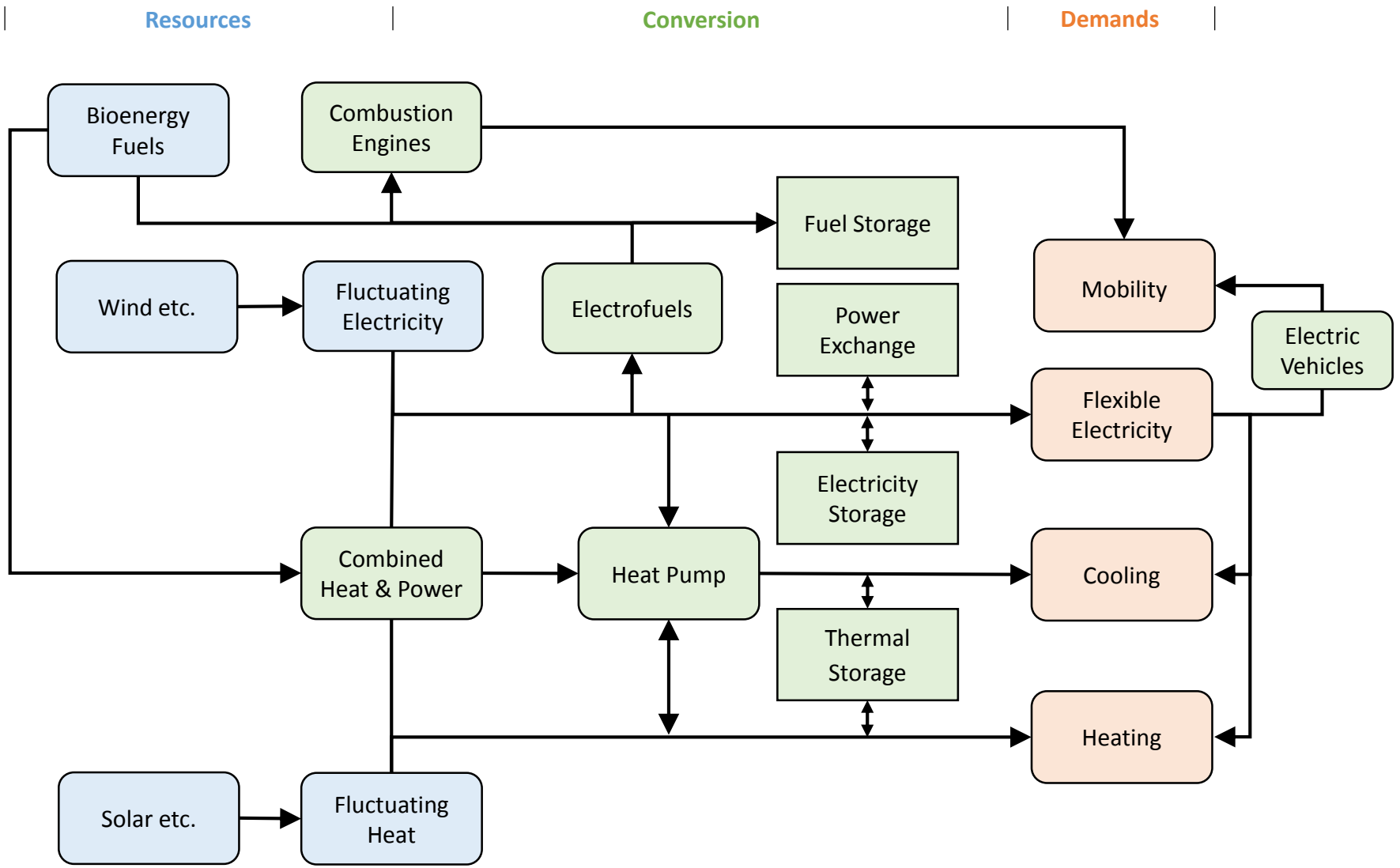
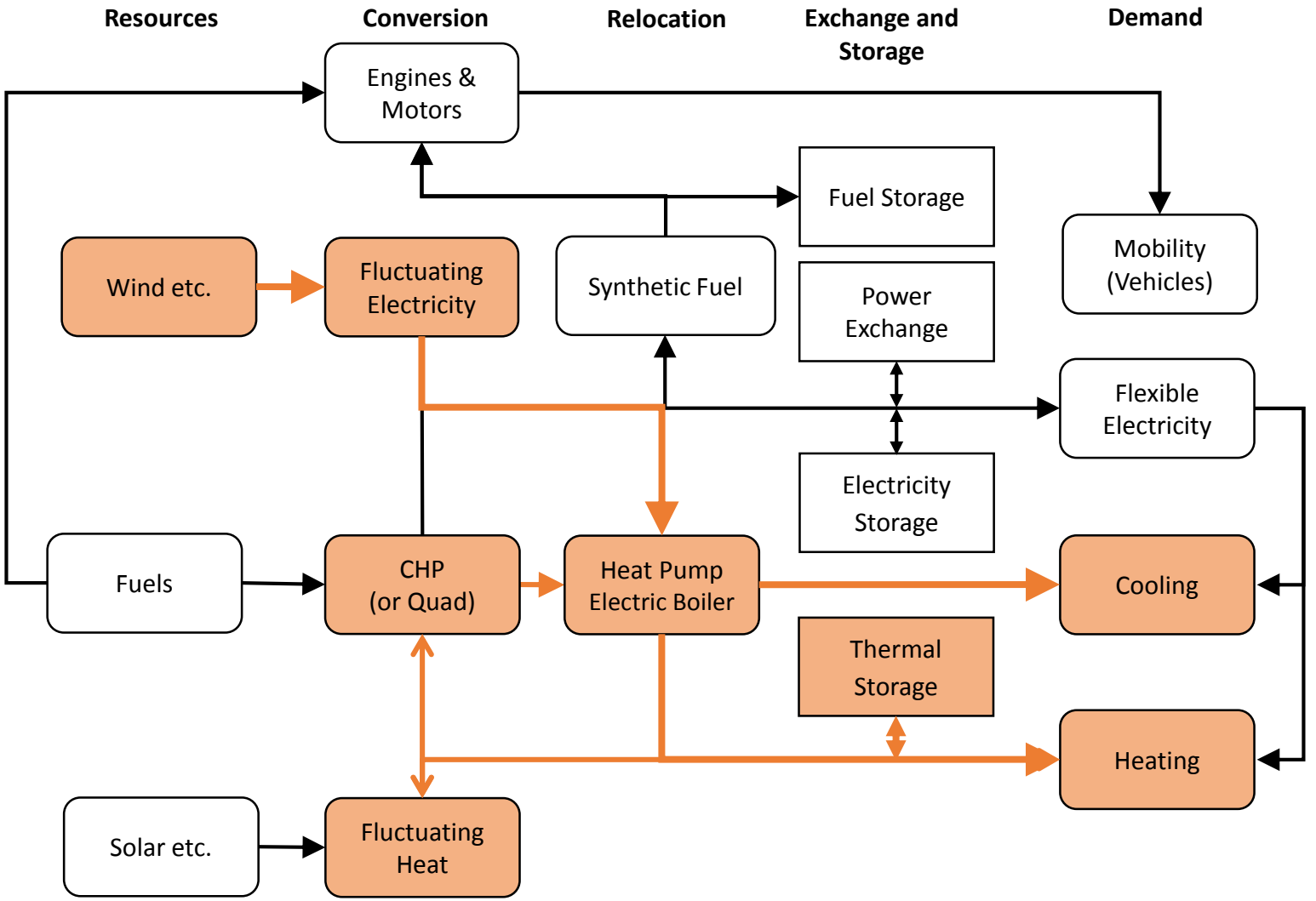
Smart Energy System

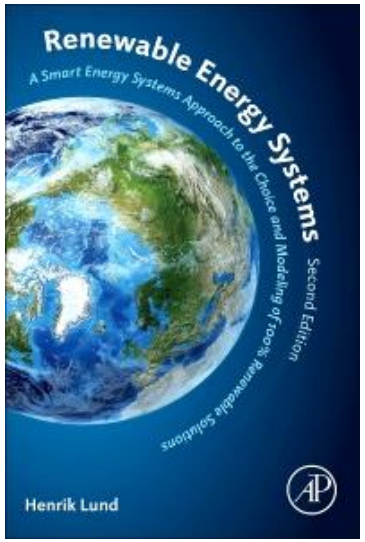
www.smartenergysystems.eu



Heating and cooling in EnergyPLAN



The EnergyPLAN tool



- Open-access modelling tool - www.energyplan.eu
- Simulates the entire energy system on a hourly basis
- Analyses the sector coupling
- Accounts for fluctuating RES as well as weakly and seasonal differences
- Explores a wide range of future scenarios (with high speed of calculation)
- Analyses radical technological change
- Provides aggregated information for feasibility studies and the design of public regulation measures
- Provides a consistent and comparative analysis of all alternatives in as well as a reference

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Energy PLAN
Advanced energy system analysis computer model

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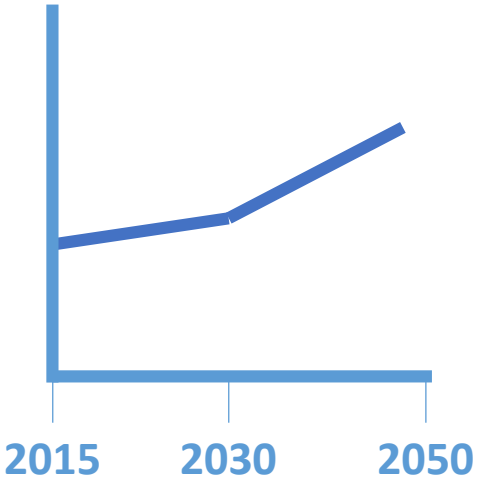
Combining the Strengths of Different Energy Models

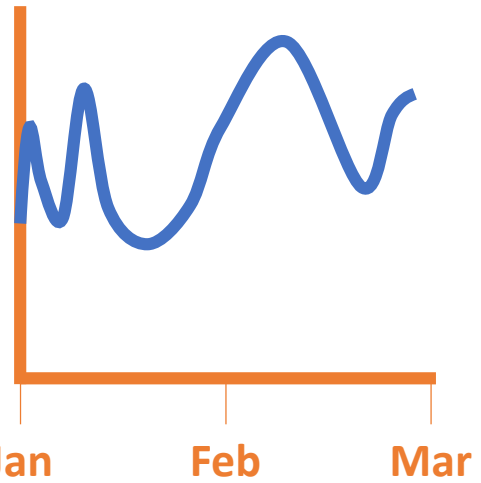
JRC-EU-TIMES

Tells us what happens between now and 2050



EnergyPLAN

Explains what is going on in each hour of the year



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Heat Roadmap Europe 2050

A low-carbon heating and cooling strategy

Thank you!

Andrei David

PhD Fellow

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Sustainable Energy Planning Research Group

Aalborg University

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Heat Roadmap Europe 2050
A low-carbon heating and cooling strategy

Reactions

Astrid Madsen, City of Rotterdam
Thomas Novak, Europen Heat Pump Association

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Heat Roadmap Europe 2050
A low-carbon heating and cooling strategy

Scenario-building leading to fantastic, but feasible, policies

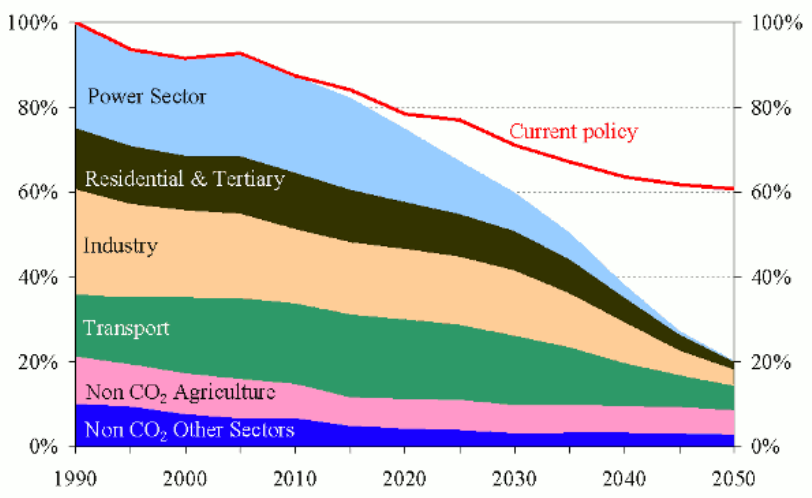
Professor Henrik Lund, Aalborg University

Flagship Research on Modelling for Unlocking the Decarbonising Potential in Heating and Cooling
Amsterdam, 16th March 2018

Targets and challenges in Europe

- Long-term target (2011)
  - 80-95% reduction of CO emissions in the energy sector
- Short term in the energy union (2015)

  Security of supply, solidarity and trust (gas, oil electricity)
  - An integrated marked (electricity)
  - Energy efficiency (first)
  - Lower CO2 emissions
  - Research and innovation



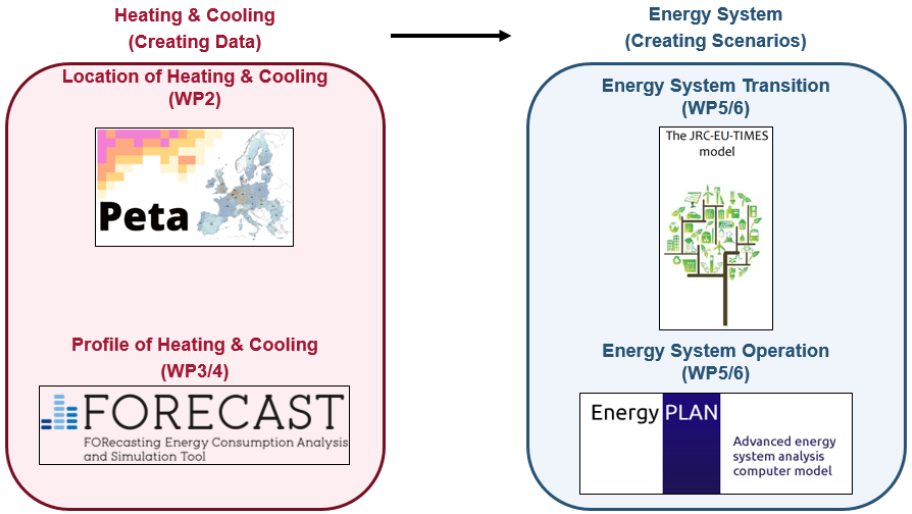
Our Purpose

- Creating scientific **evidence** to support long-term energy strategies at local, national, and EU level and empower the transition to a low-carbon energy system

- By **quantifying** the impact of various alternatives for addressing the heating and cooling sectors

Two important outputs

- Low-carbon scenarios for each of the 14 member states included
- Free access to tools including relevant data



Fuel Prices?

Wind Power?

Solar?

Insulation?

CHP?

District Heating?

Heat Savings?

Renewable Gas?

Hydrogen?

New Technologies?

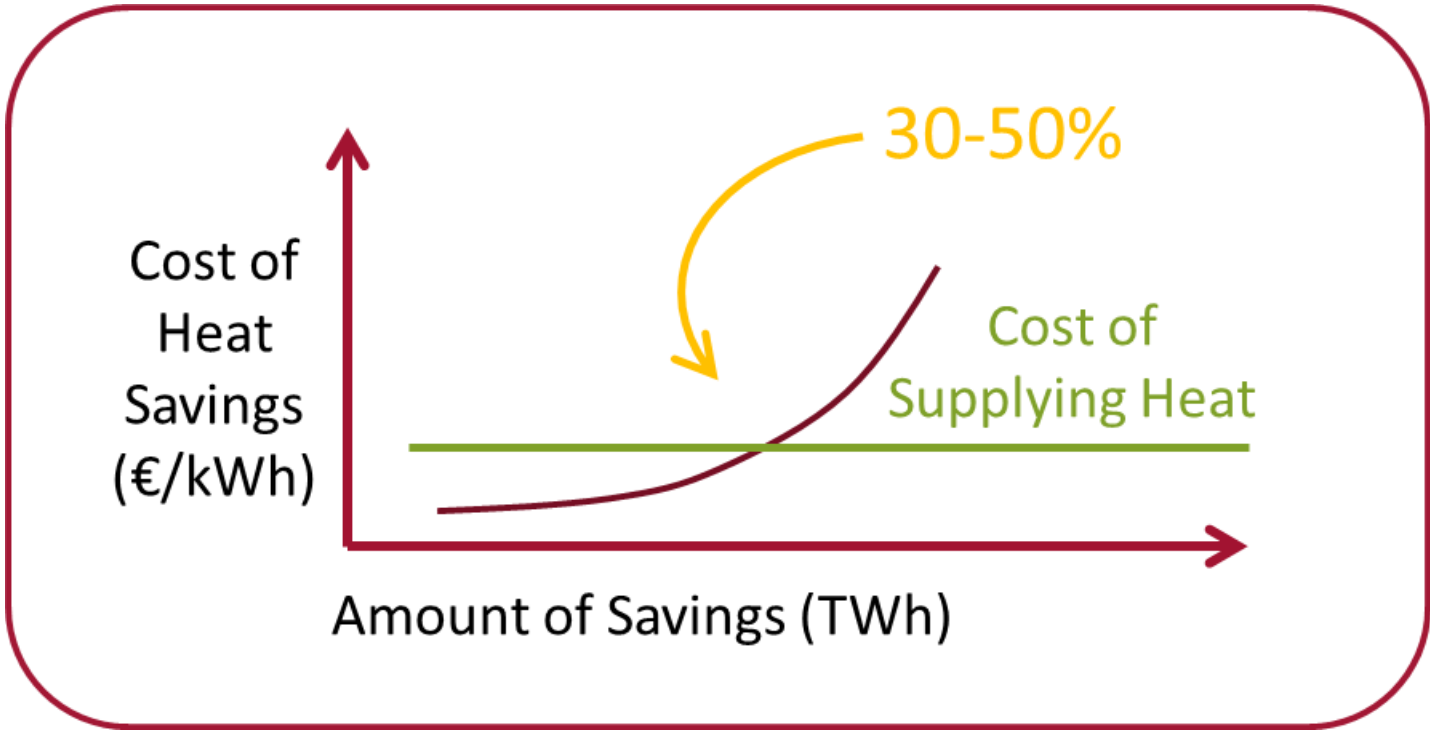
Heat Pumps?

Biomass Boilers?

Smart Grids?

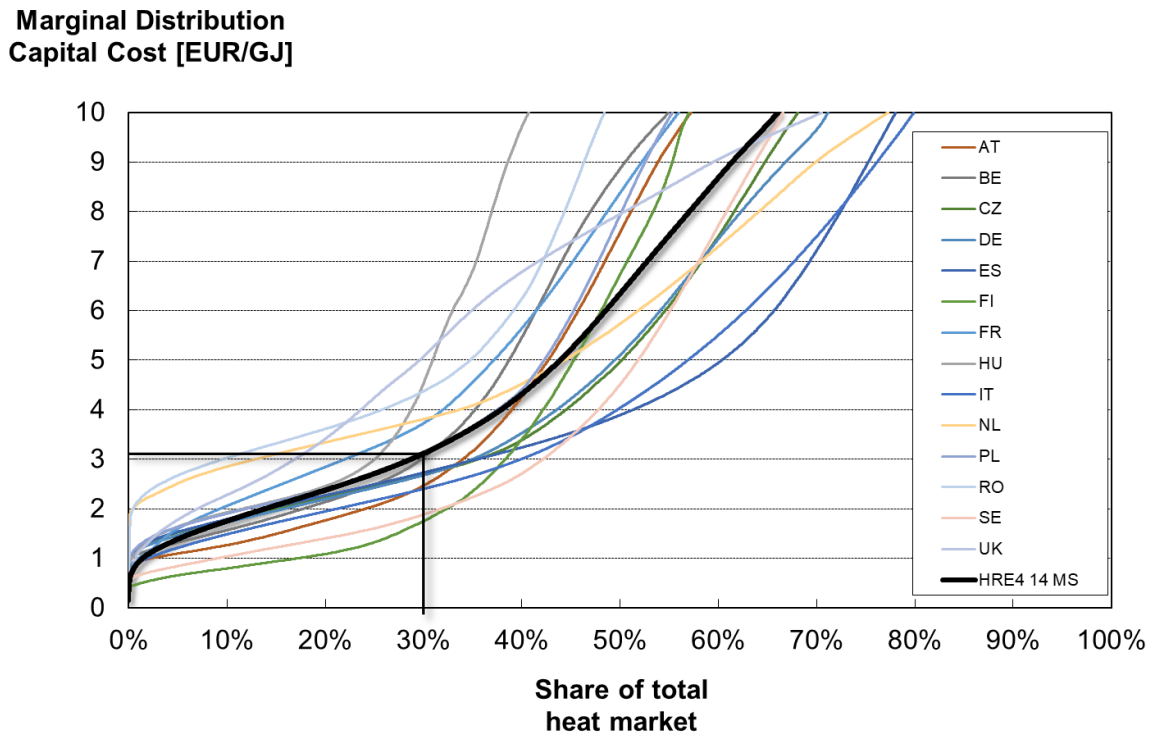
Identifying the Balance Between Supply and Savings

- Supply curve includes
  - DH investment (heat density)
  - Excess heat potential in specific areas
  - Fuel and other heat supply costs
- Where DH not feasible:
  - Heat pumps
- District cooling
- Introduction of RES
- Final checks
  - Saving-supply balance
  - Carbon emission level

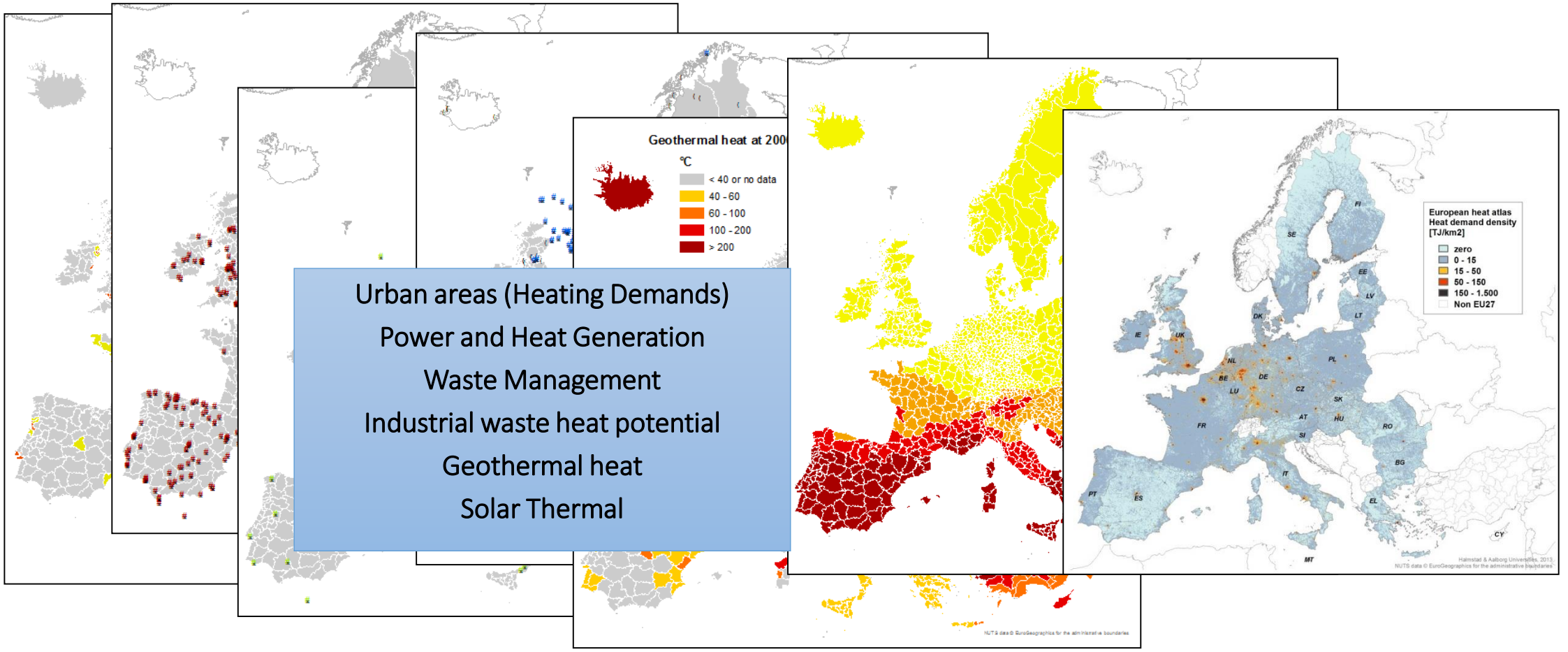


Identifying the Balance Between District Heating/Cooling and Individual supply

- Distribution capital costs for district heating



Identifying heating sources



Urban areas (Heating Demands)

Power and Heat Generation

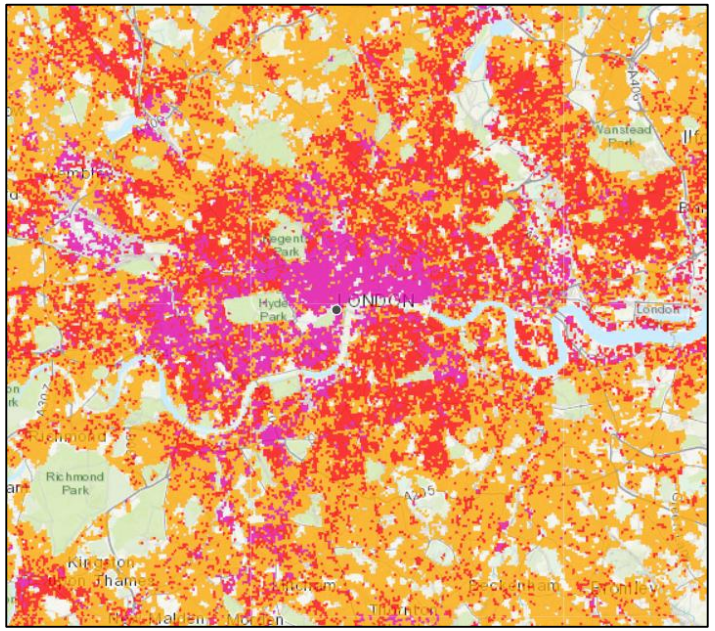
Waste Management

Industrial waste heat potential

Geothermal heat

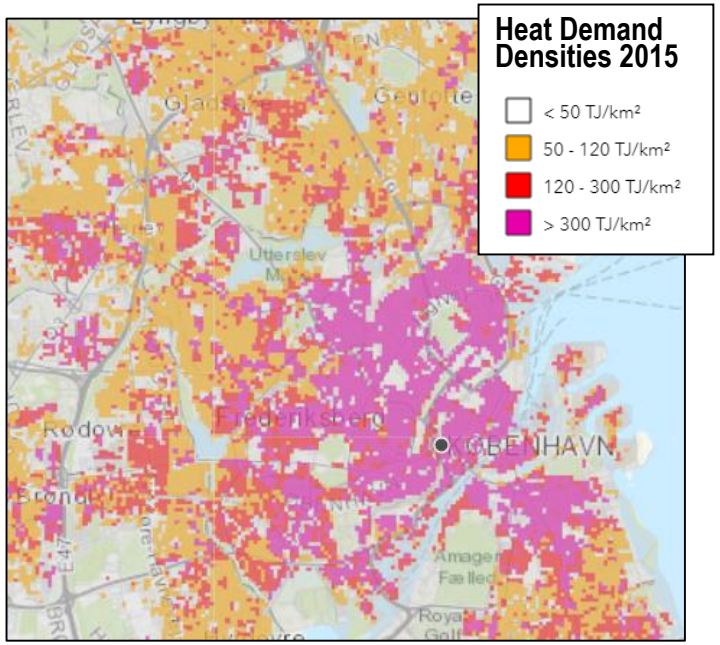
Solar Thermal

Today's Heat Demand from Peta 4.2 (www.heatroadmap.eu)



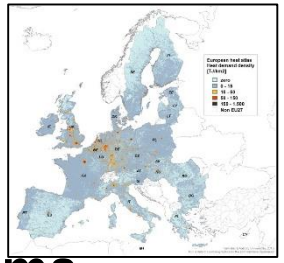
London

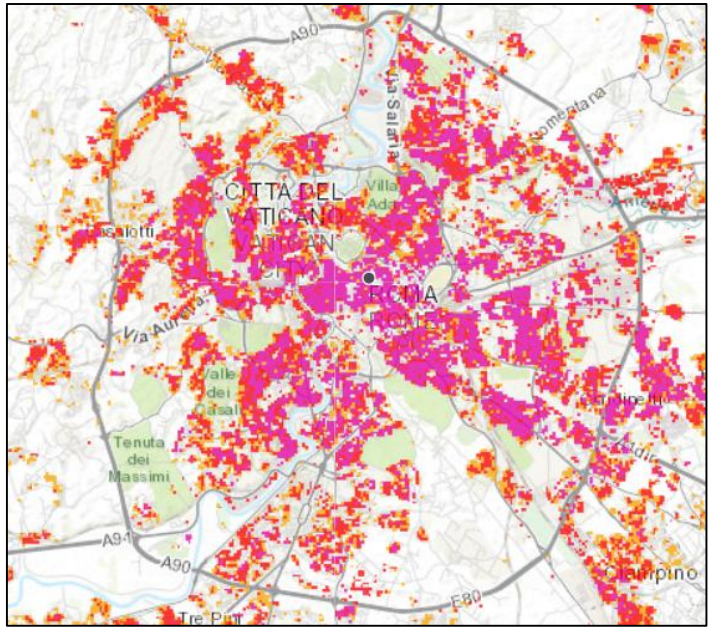
←<5% DH



Copenhagen

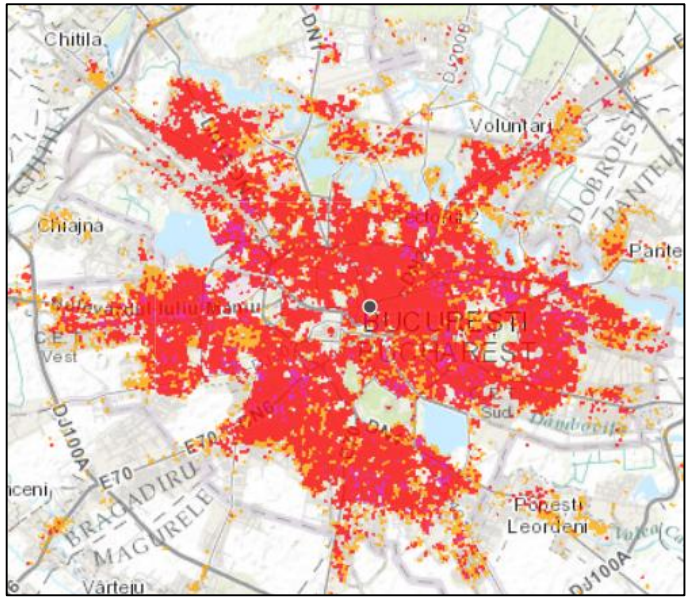
>90% DH →





Roma

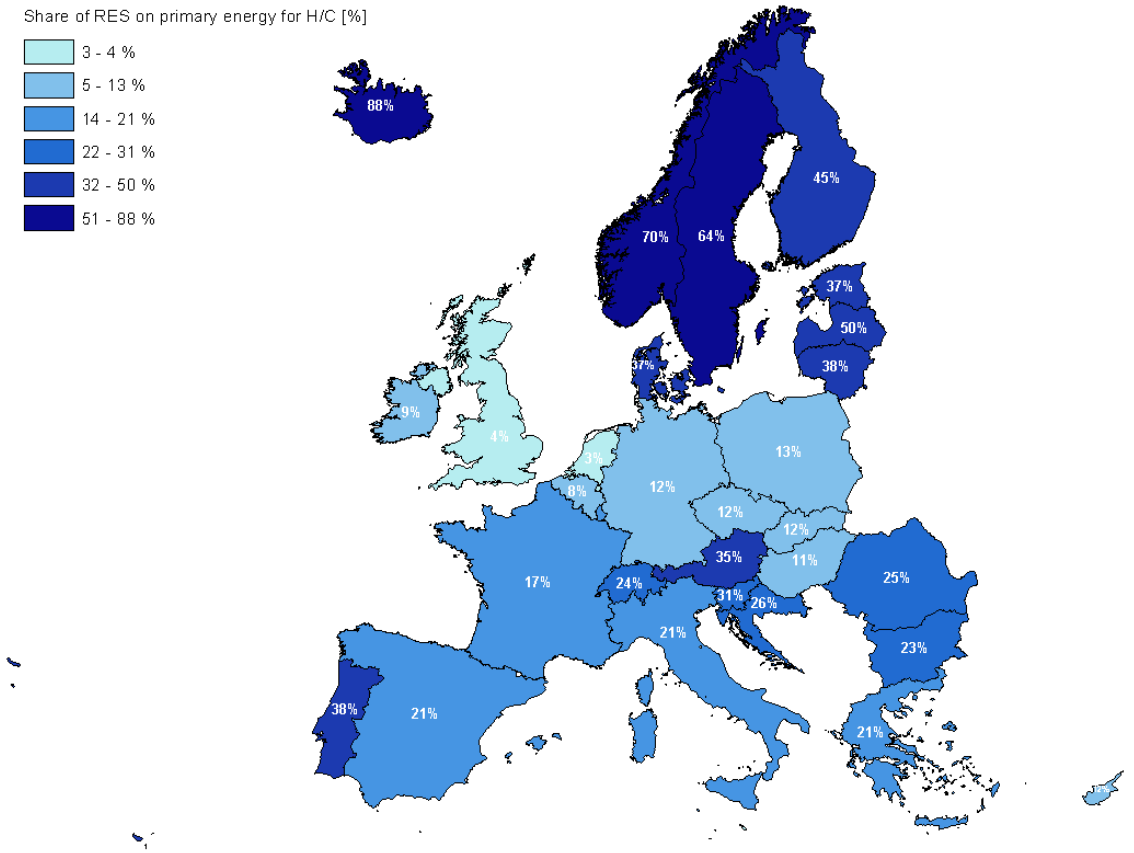
←<5% DH



Bucharest

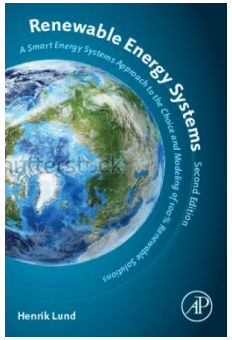
~75% DH →

Heating and Cooling Can Have Very High Renewable Energy Penetrations



Source: Mapping and analyses of the current and future heating-cooling fuel deployment, 2016

Energy Systems Integration



4DH
4th Generation District Heating Technologies and Systems

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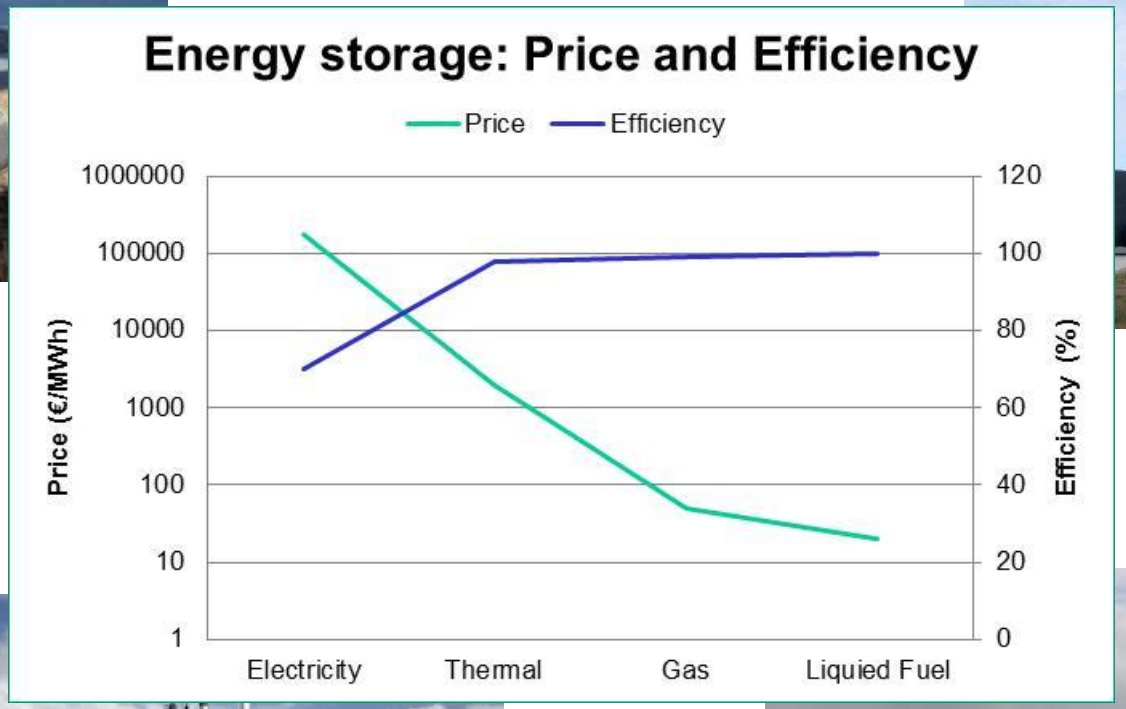
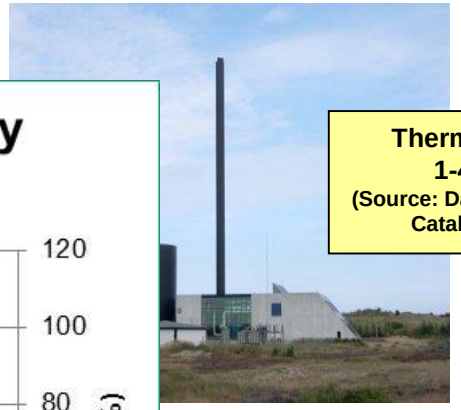
Energy Storage

Pump Hydro Storage
175 €/kWh
(Source: Electricity Energy Storage Technology Options: A White Paper Primer on Applications, Costs, and Benefits. Electric Power Research Institute, 2010)





Thermal Storage
1-4 €/kWh
(Source: Danish Technology Catalogue, 2012)

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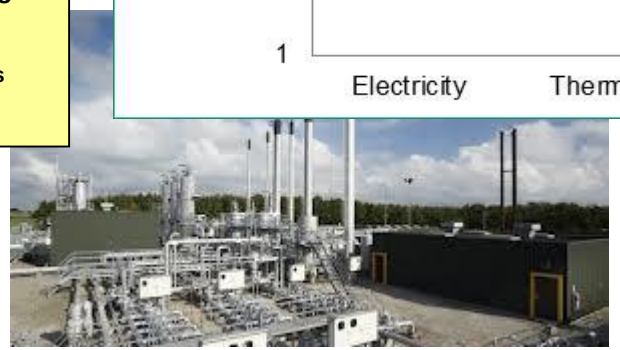
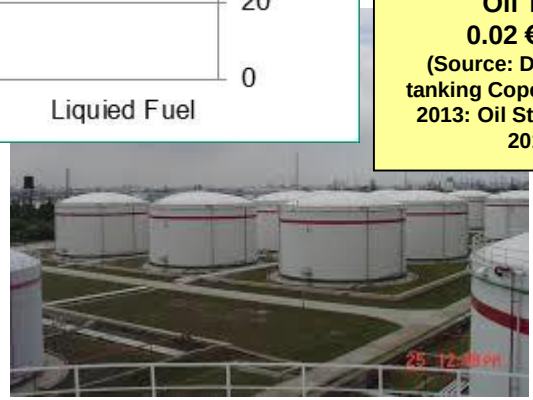
Natural Gas Underground Storage
0.05 €/kWh
(Source: Current State Of and Issues Concerning Underground Natural Gas Storage. Federal Energy Regulatory Commission, 2004)

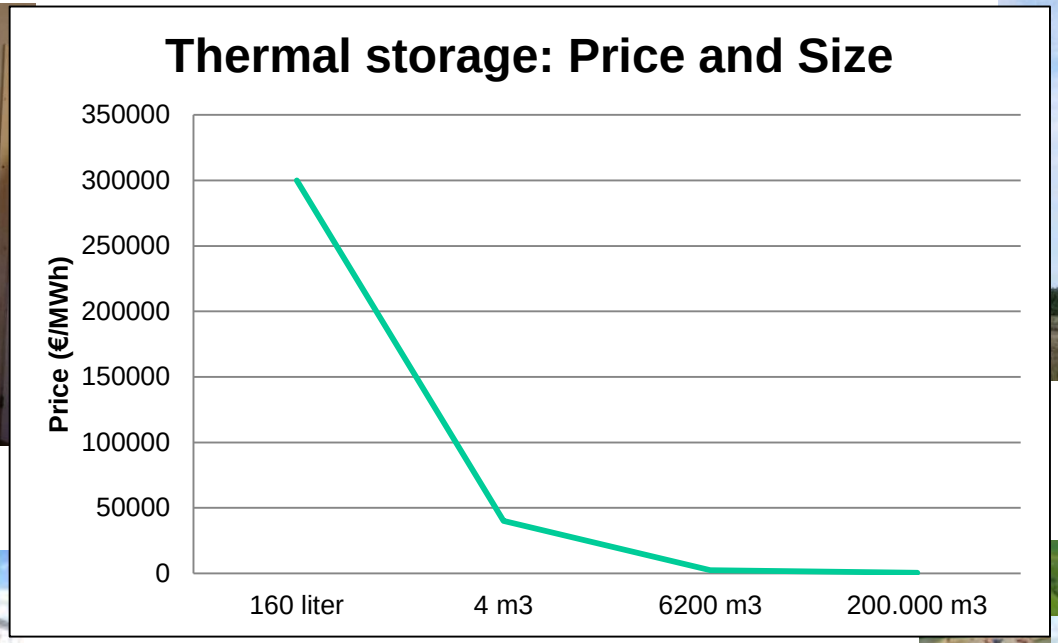


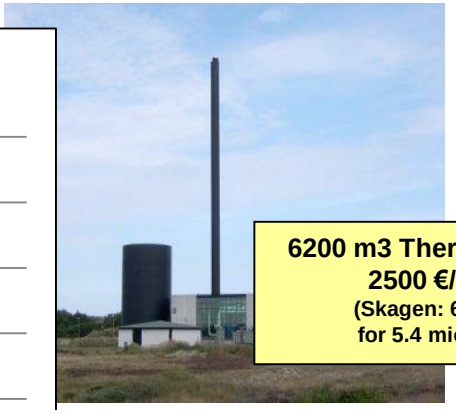
Oil Tank
0.02 €/kWh
(Source: Dahl KH, Oil tanking Copenhagen A/S, 2013: Oil Storage Tank. 2013)



Thermal Storage

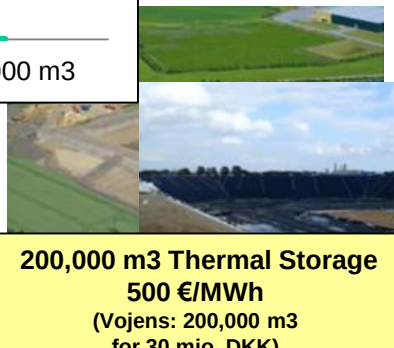
0.16 m3 Thermal Storage
300.000 €/MWh
(Private house: 160 liter for 15000 DKK)





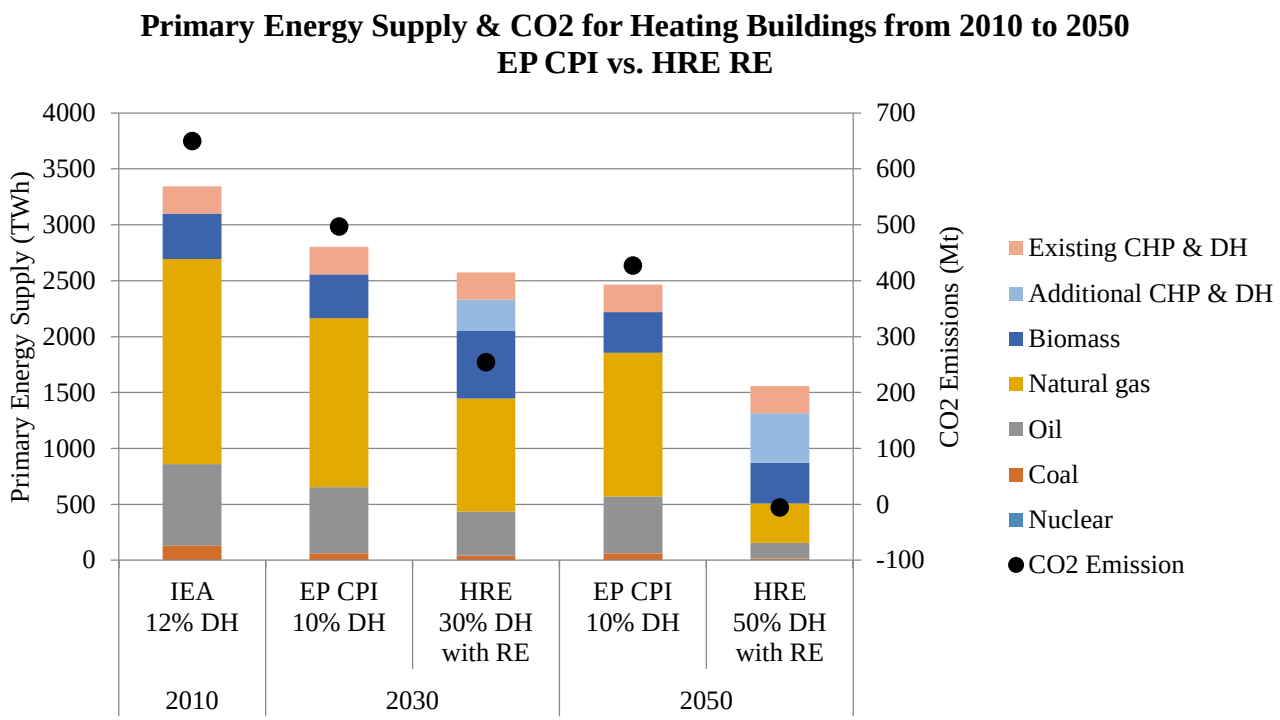
6200 m3 Thermal Storage
2500 €/MWh
(Skagen: 6200 m3 for 5.4 mio. DKK)

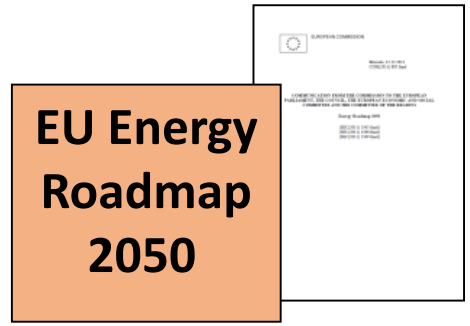
4 m3 Thermal Storage
40,000 €/MWh
(Private outdoor: 4000 m3 for 50,000 DKK)

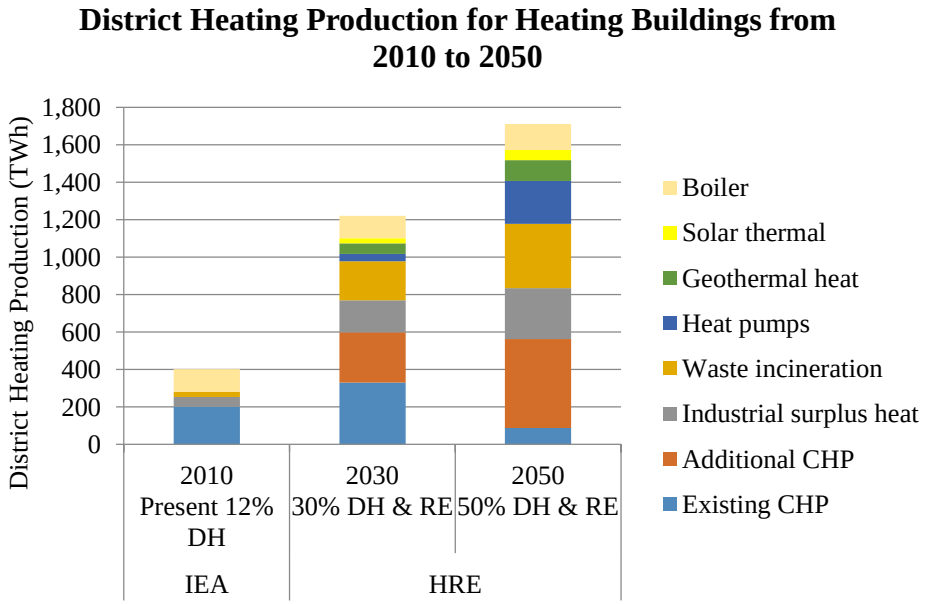


200,000 m3 Thermal Storage
500 €/MWh
(Vojens: 200,000 m3 for 30 mio. DKK)

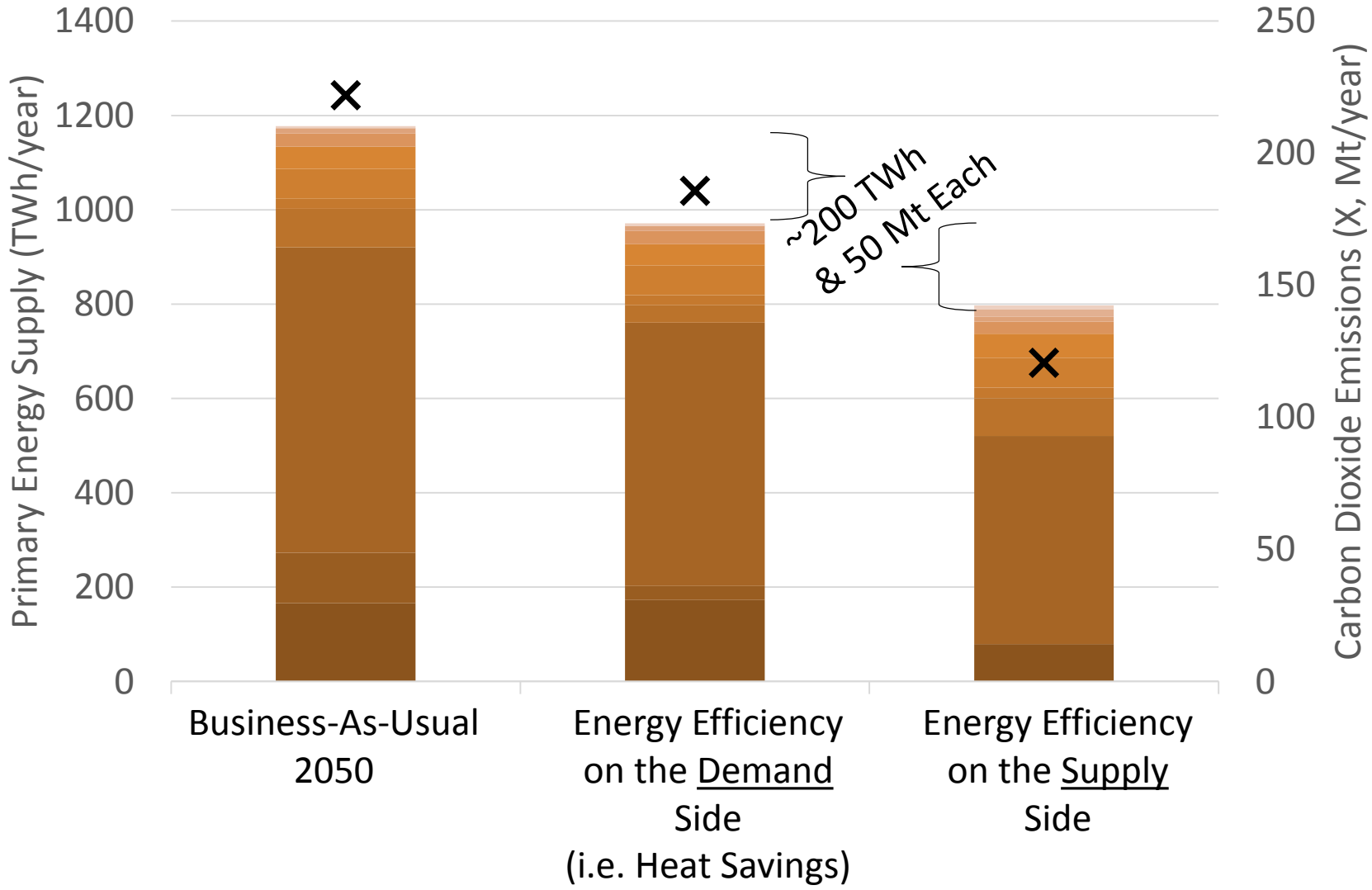
Type of results (previous HRE studies)



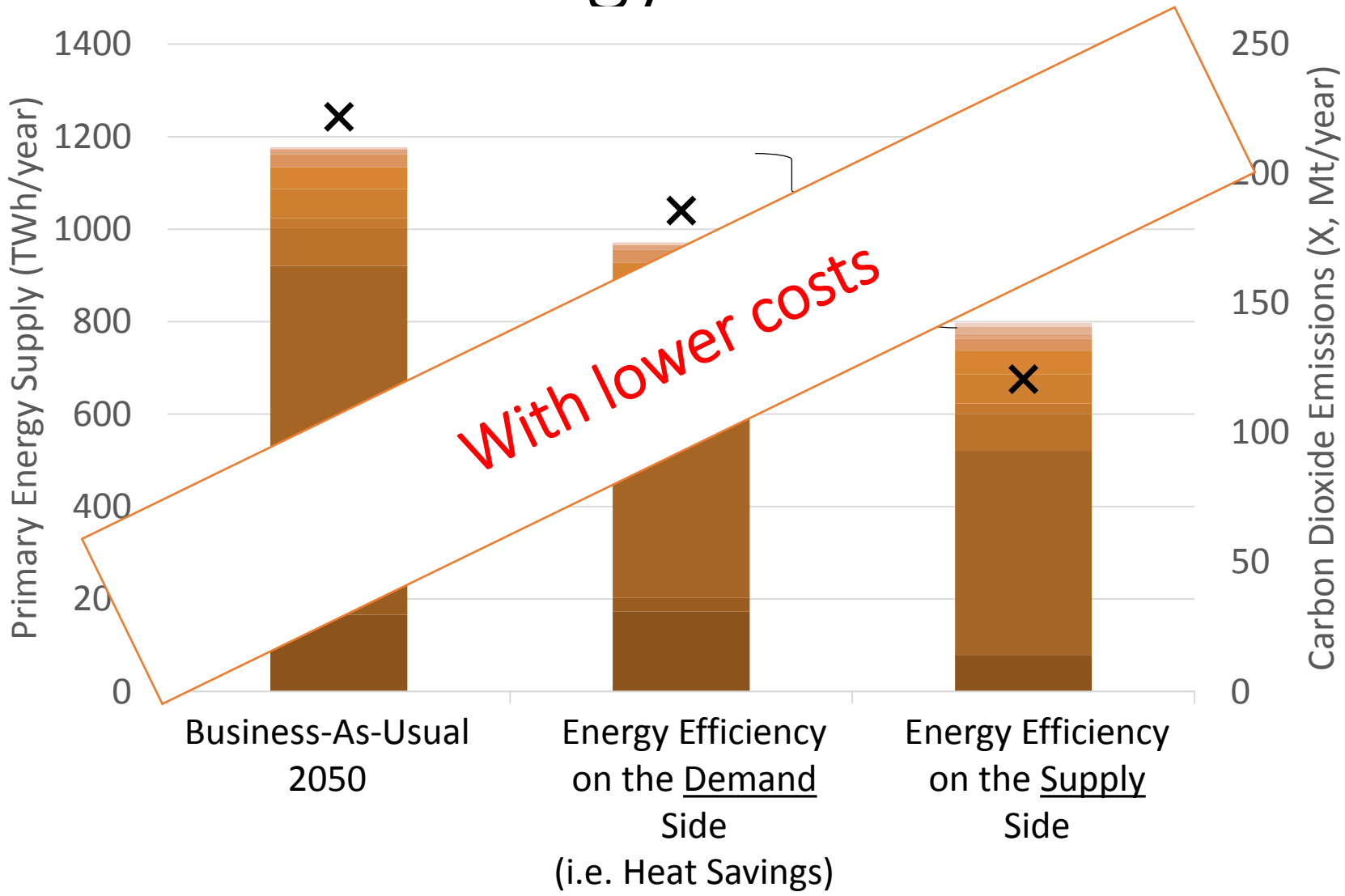




Energy Efficiency on Both Sides Can Save Similar Levels of Energy & CO2



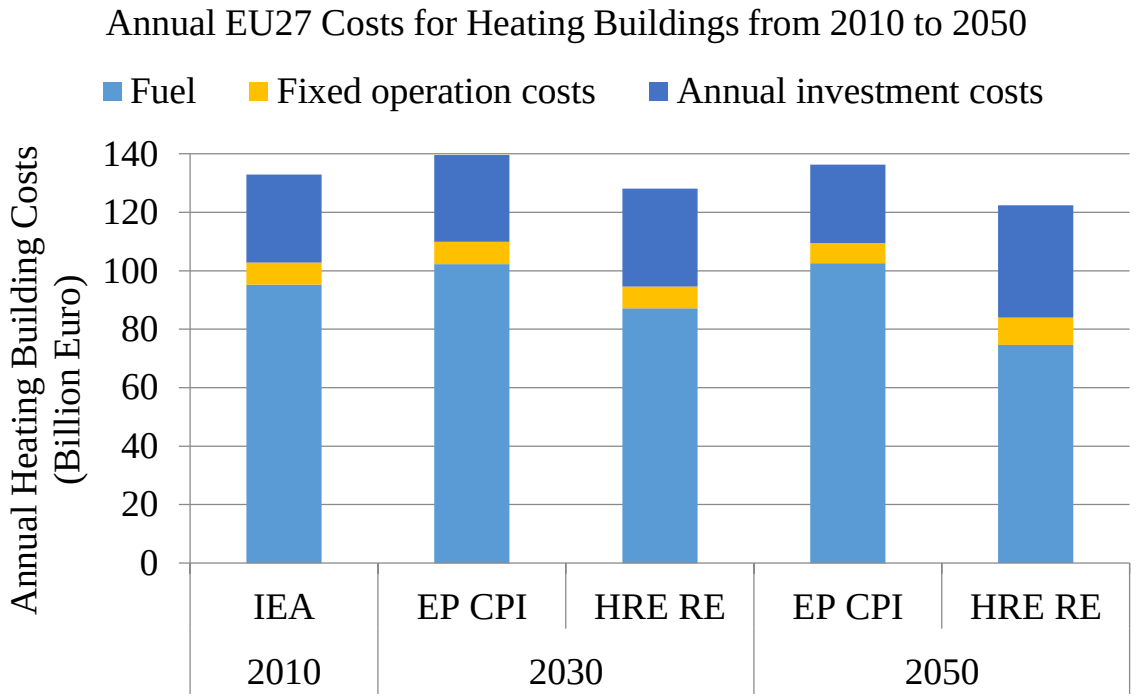
Energy Efficiency on Both Sides Can Save Similar Levels of Energy & CO2



Cost and Jobs

- Saved fuel costs of annual approx. 30 Billion EUR in 2050
- In total cost are reduced by 14 Billion EUR in 2050
- Additional investments of a total of 500 billion EUR
- Additional jobs from to 2013 to 2050: 8-9 million man-year in total

  Approx. 220,000 jobs.



Previous HRE Conclusion

- Decrease primary energy supply and especially fossil fuels and CO2 emissions

LESS FUEL

- Decrease annual costs of energy in Europe by approximately €14 Billion in 2050

LESS MONEY

- Create additional 220,000 jobs over the period 2013-2050

MORE EU JOBS

- Further integration of RES

MORE RE