

# **Future domestic heating systems and their potential role in integrating variable renewable energy**

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**Workshop on ICT Enabling Thermal Energy Flexibility  
in Integrated Energy Systems**

KIER, Daejeon, 21<sup>st</sup> October 2015

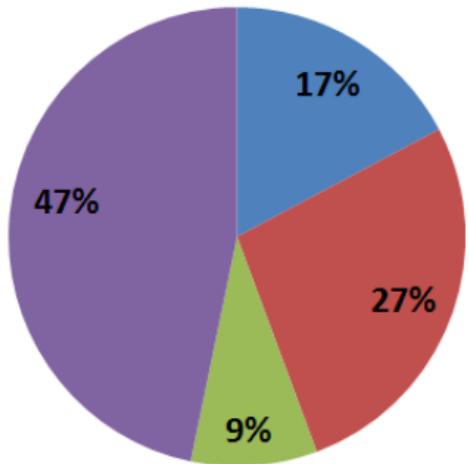
# SETTING THE SCENE

## Domestic Heat Technology

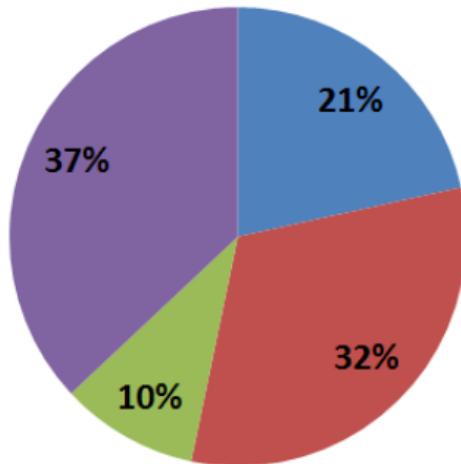
# We need to talk about heat...

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World



OECD



- Electricity
- Transport
- Non-energy use
- Heat

Note: Heat demand (estimated 2%) covered by electricity is not included in these figures  
Source: IEA (2012), Policies for renewable heat An integrated approach

# European heat decarbonisation strategy in the residential sector, simplified...

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## 1. Decarbonise supply



## 2. Insulate



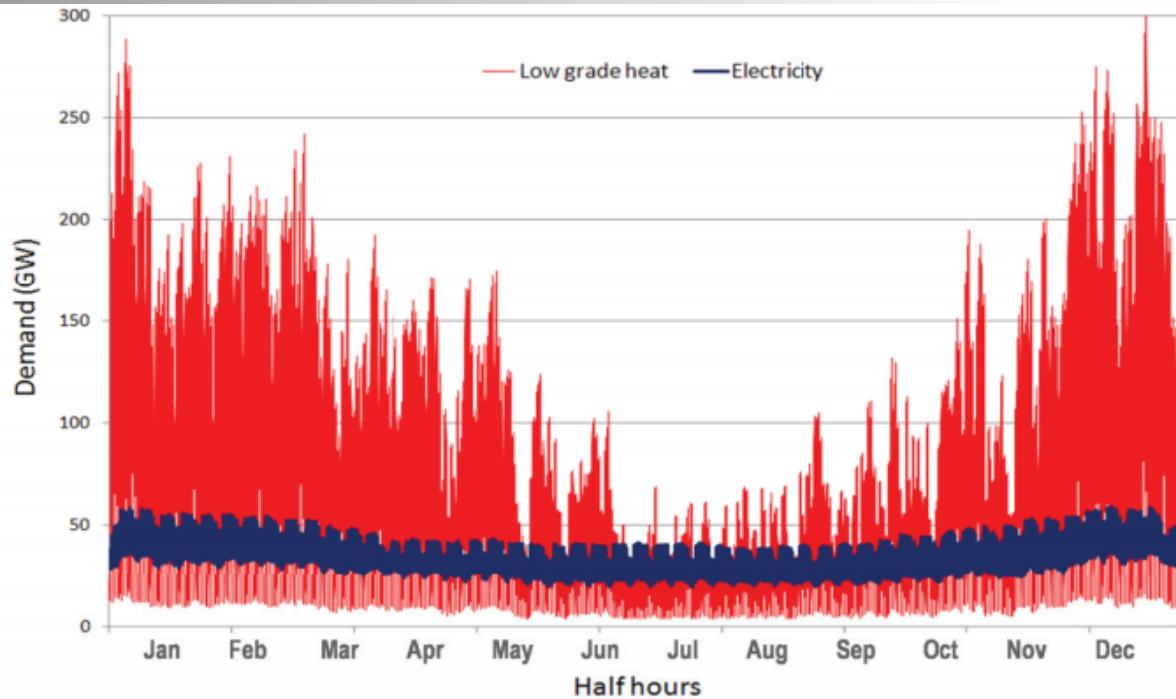
## 3. Electrify using efficient HPs



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# Heat demand in the UK, 2010

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New market for electricity utilities?

Increased peak load?

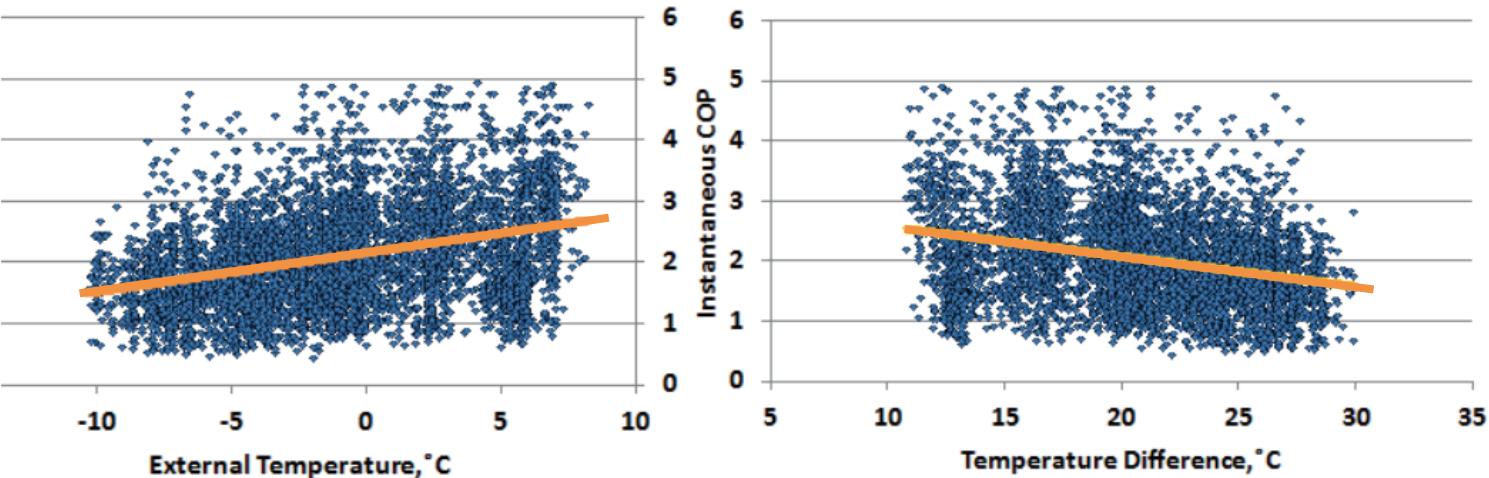
Decreased asset utilisation?

Source: Robert Sansom (Imperial College), Winter Peak Heat Demand

# Heat pump efficiency

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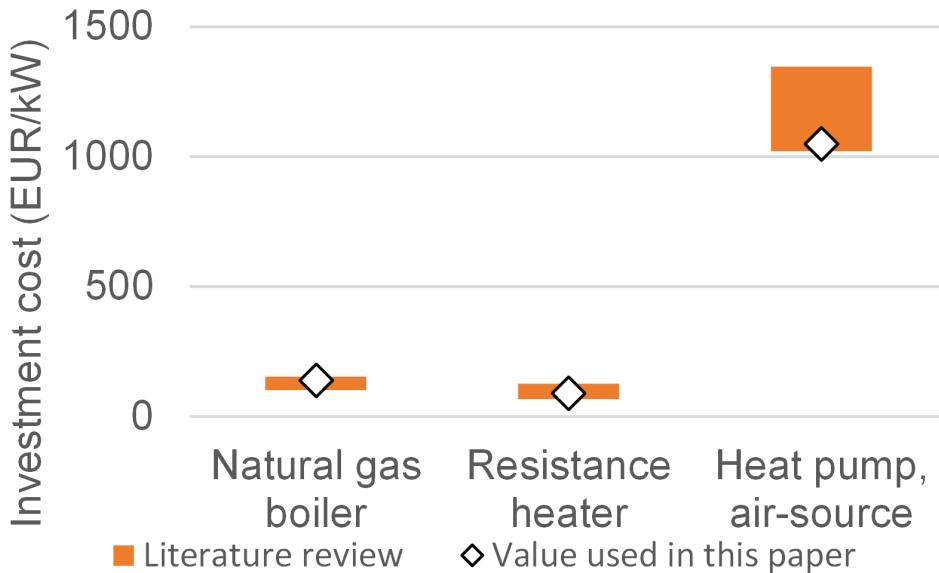
$$COP_{Carot} = \frac{Q_{Sink}}{W} = \frac{T_{Sink}}{T_{Sink} - T_{Source}}$$



Underperformance during cold temperature spells?  
Low-temp heat distribution system? Deep renovations...

# Heat pump investment cost barrier

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Are consumers rational enough to invest in a system that delivers long-term savings?

# Where are the system interactions?

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## 1. Decarbonise supply



## 2. Insulate

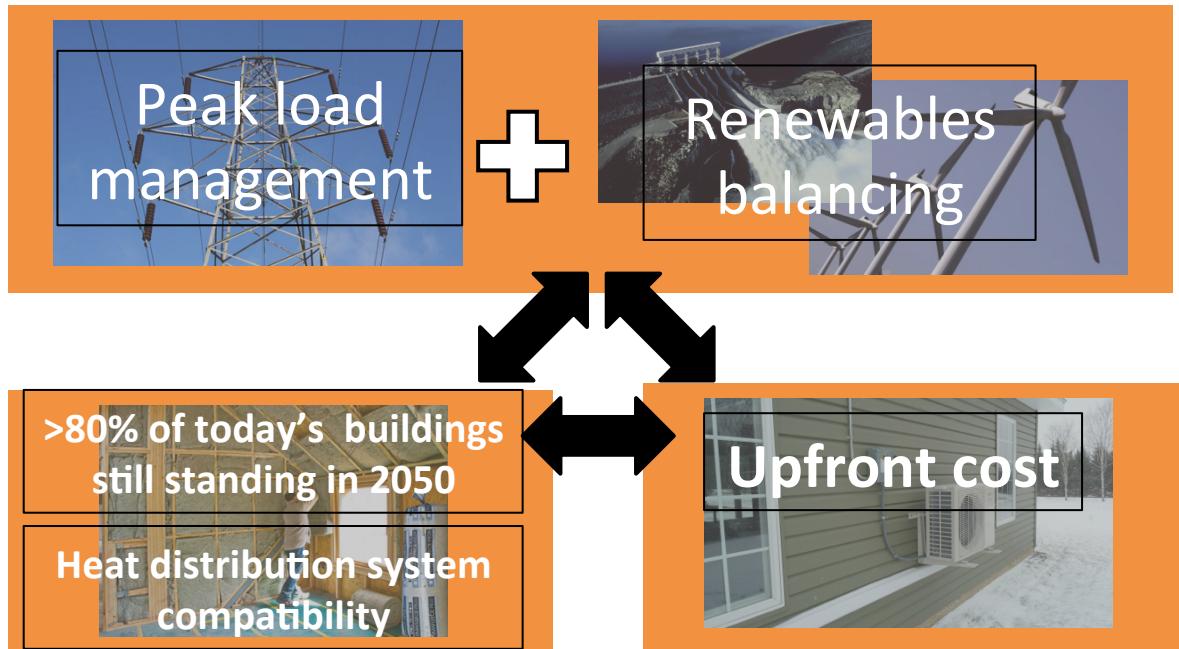


## 3. Electrify using efficient HPs



# Planning and operations is a dynamic process in an integrated energy system

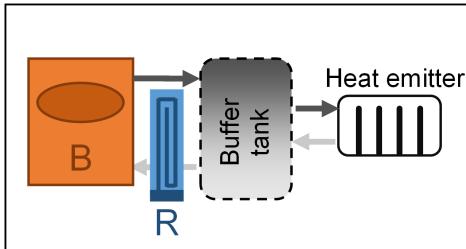
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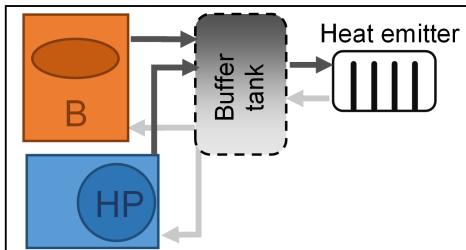
# Hybrid heaters an overlooked alternative?

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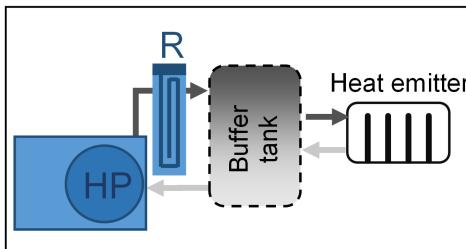
a. Hybrid B-R



b. Hybrid HP-B



c. Hybrid HP-R



- Hybrid heaters are composed of 2 appliances
- Enabled by ICT, hybrids can switch between those appliances during operation depending on market conditions.
- Different combinations feasible
  - Gas boiler – resistance heater (HP-R)
  - Heat pump - Gas boiler (B-HP)
  - Heat pump – resistance heater (HP-R)

→ **Can hybrid heating deploying provide system-wide planning benefits?**



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# Hybrid heaters are available commercially since about 2010

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Japan



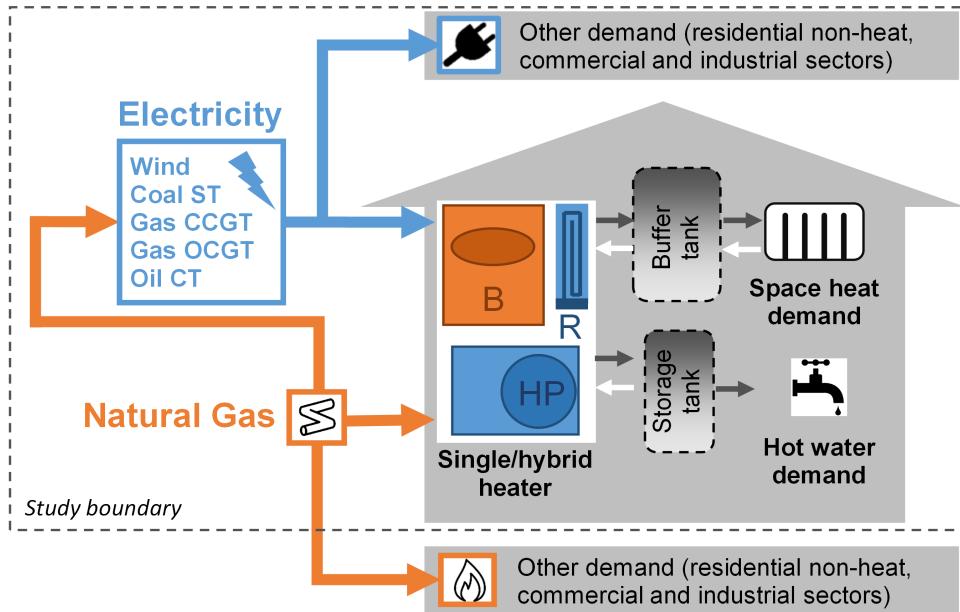
USA



# QUANTIFYING THE SYSTEM BENEFITS OF DEPLOYING DIFFERENT DOMESTIC HEATING TECHNOLOGIES

# Power-gas-heat system

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## Model

One stage planning  
Hourly resolution  
Linear

## Test System

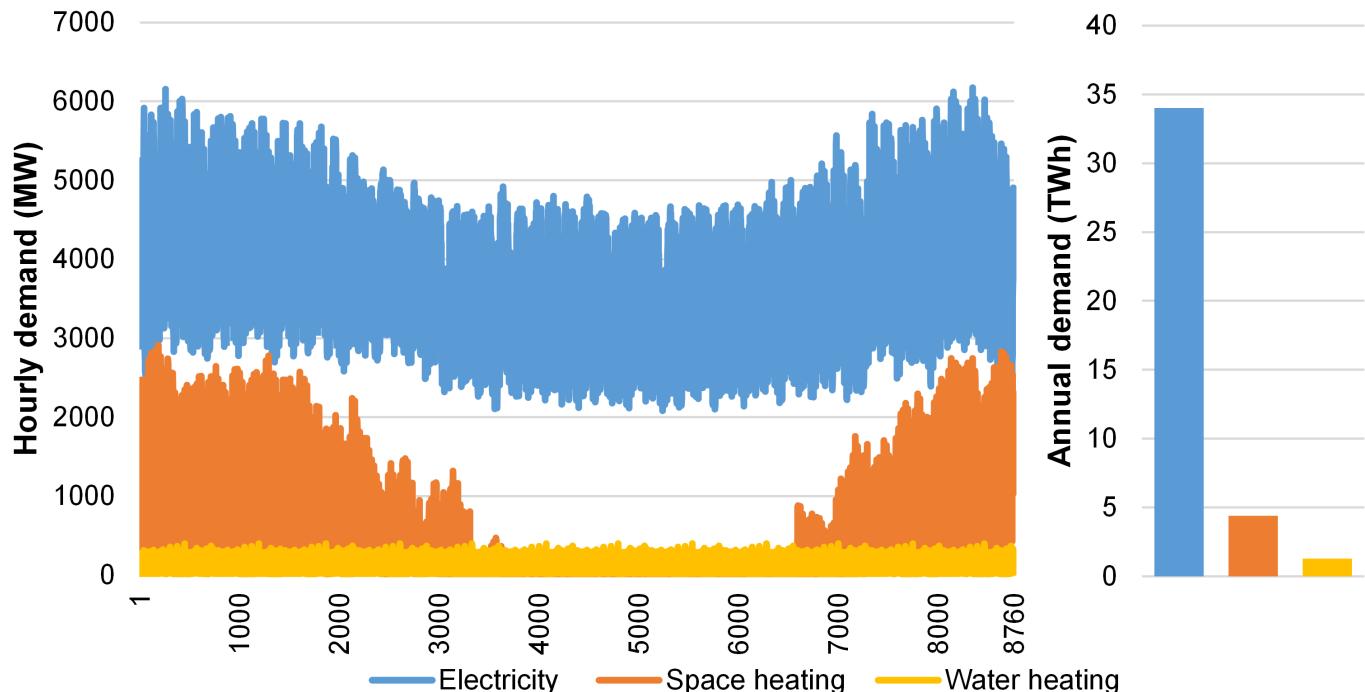
Ireland  
Planning horizon: 2030  
Wind capacity: 6000 MW  
(40% energy)  
Heaters installed in 25% of  
Irish households

For different heating technologies, model will determine least-cost solution by determining

- Capacities (MW) for power generation, heater and thermal storage
- Energy dispatch (MWh) for power generation, heaters and thermal storage

# Heat load for 25% of Irish households compared to TOTAL elec. load

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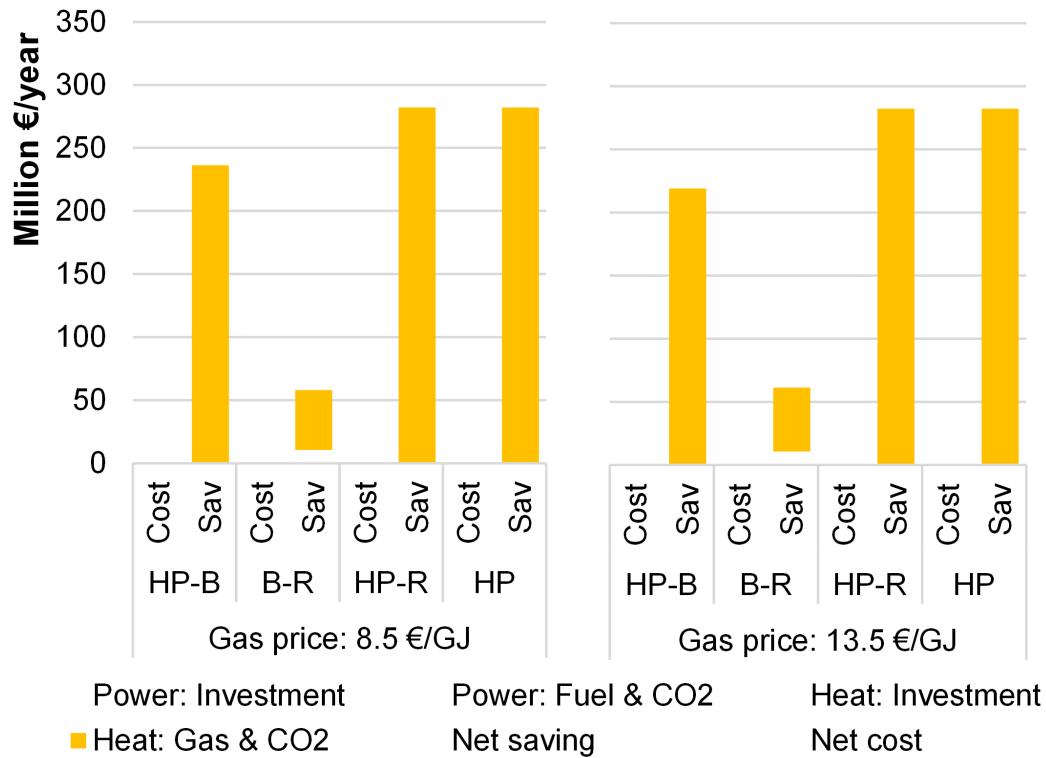


New market for electricity utilities?  
Increased peak load?  
Decreased asset utilisation?

Source: Eirgrid (2014), CER (2011)

# Economic assessment – cost breakdown

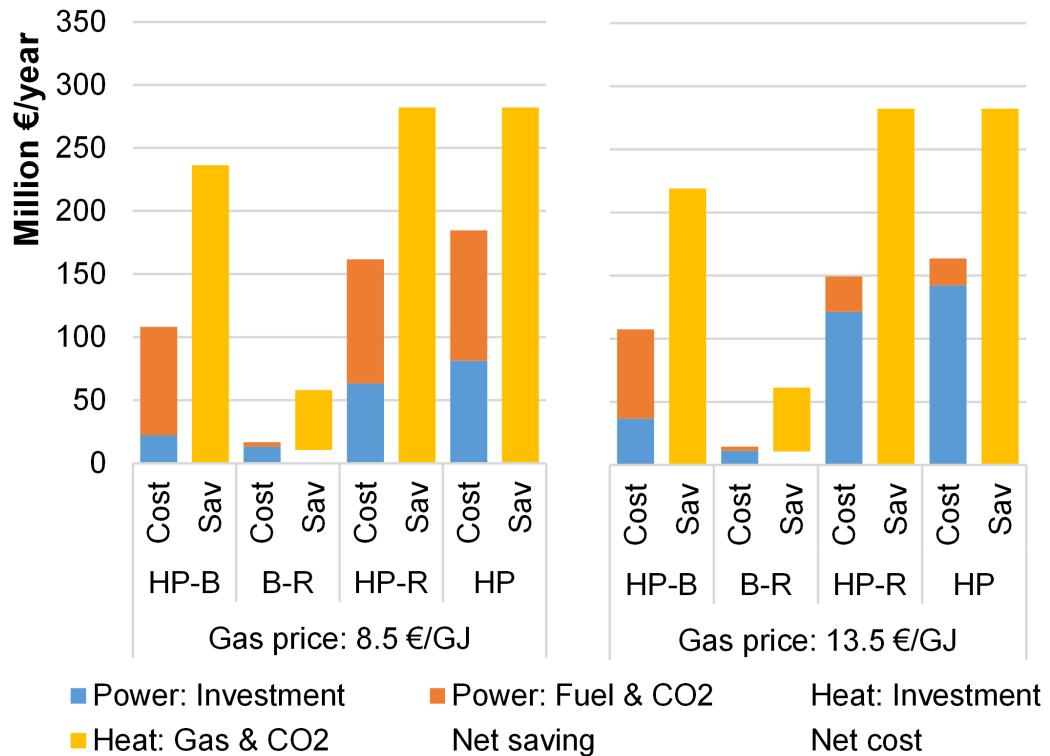
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**Compared to gas boiler deployment**

# Economic assessment – cost breakdown

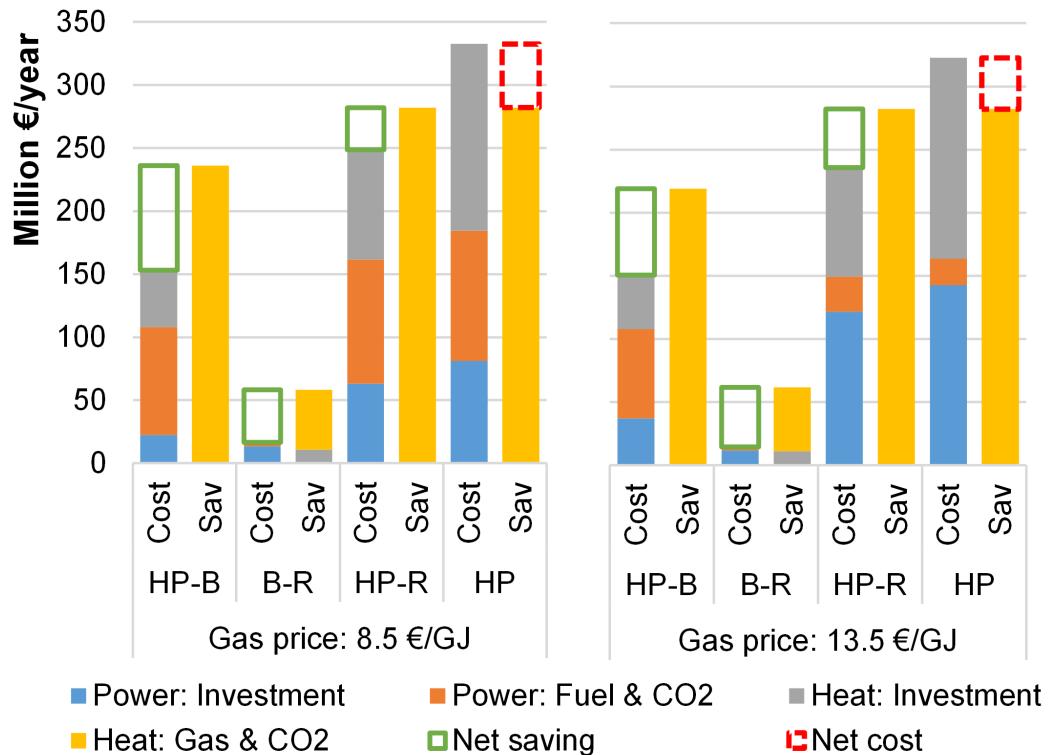
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Compared to gas boiler deployment

# Economic assessment – cost breakdown

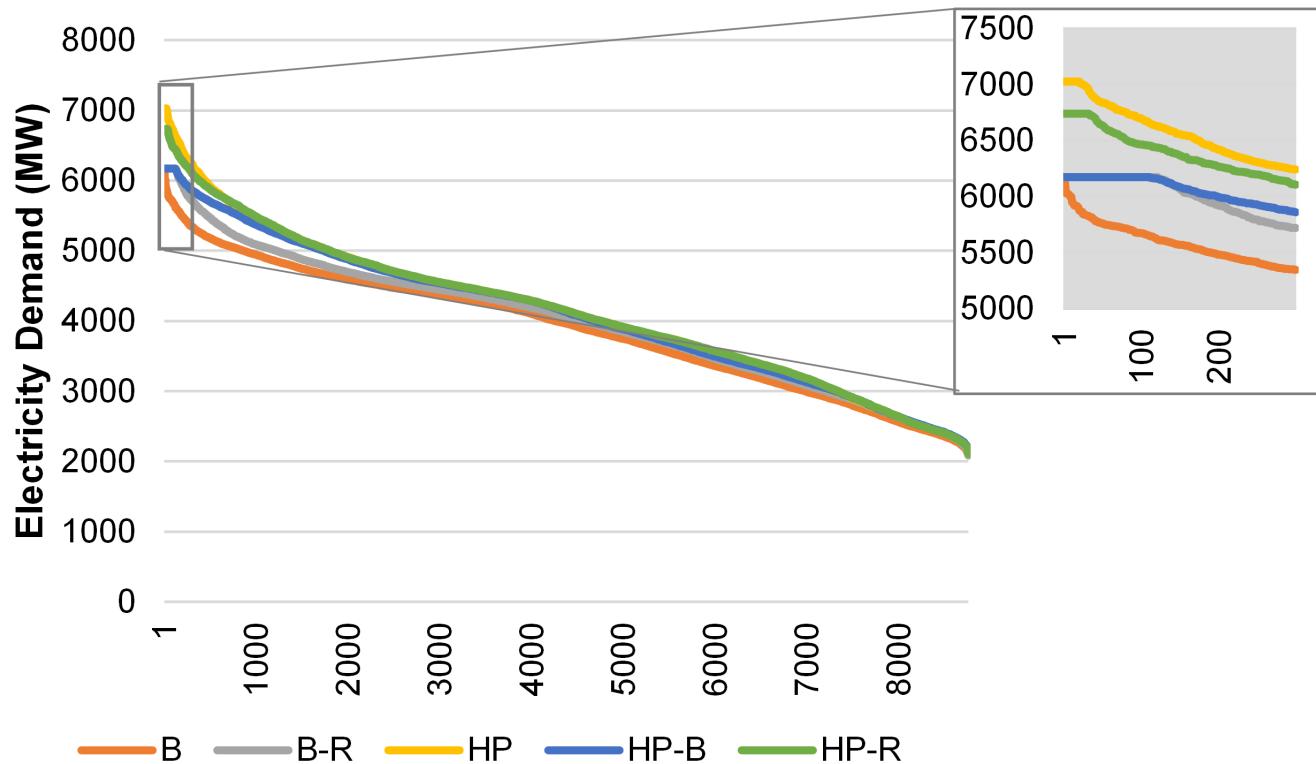
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**Compared to gas boiler deployment**

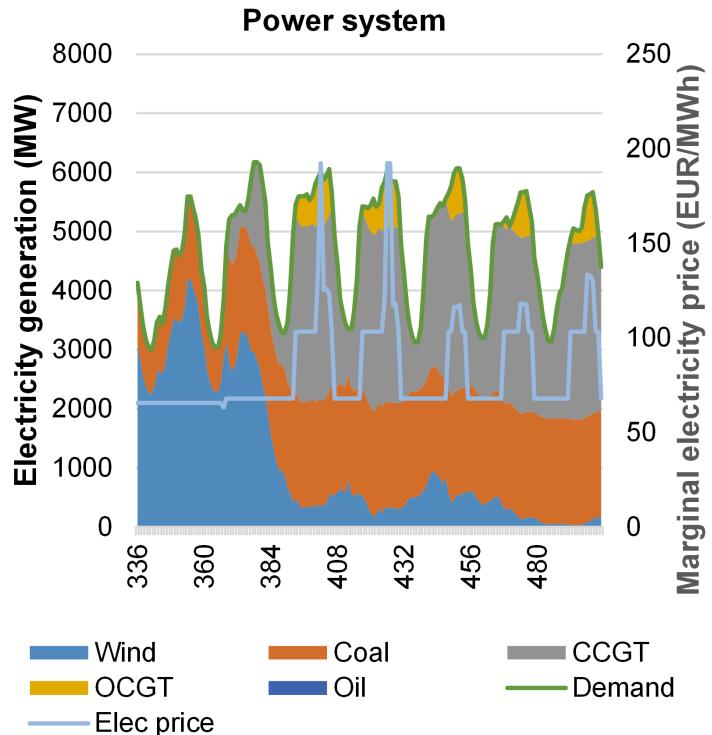
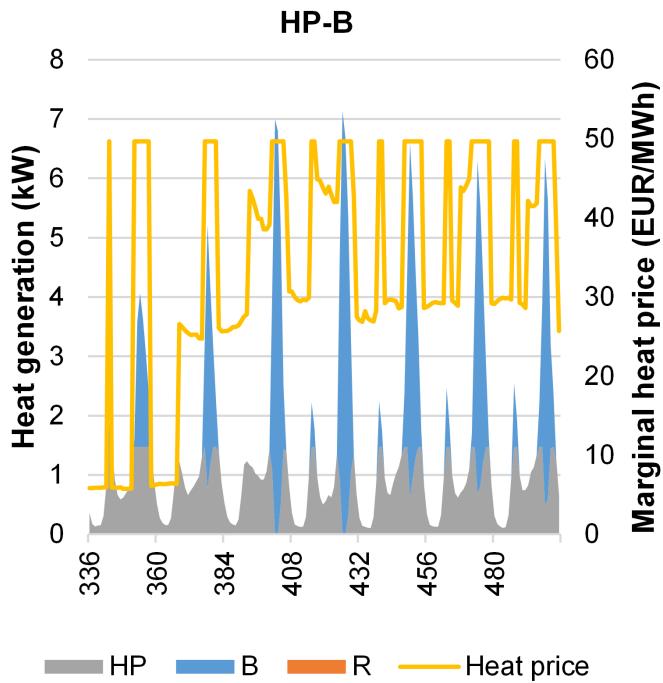
# Electricity load duration curve

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# HP-B operation during low wind week

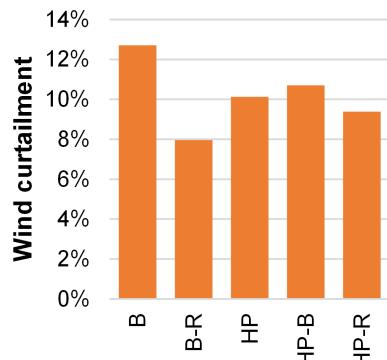
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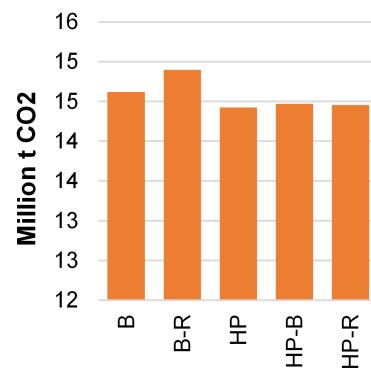
# Strategic assessment

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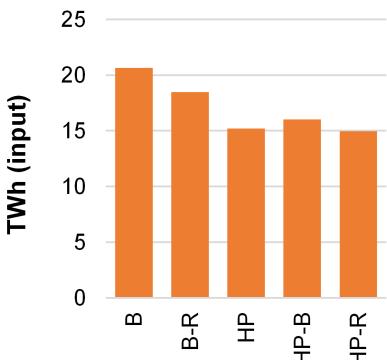
a. Wind curtailment



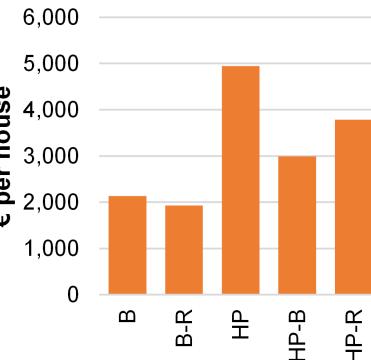
b. CO<sub>2</sub> emissions



c. Natural gas use



d. Heater capital cost



# Overall assessment

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- Hybrid heaters can provide planning benefits by integrating gas, electricity and heat without district heating network, only through intelligent integration of individual technologies.
- **HP-B system**
  - Least-cost system
  - Heater investment savings (smaller HP)
  - Power investment (lower electric peak) and fuel savings (efficient HP)
  - Large gas and CO<sub>2</sub> savings compared to gas boiler, small increase in gas and CO<sub>2</sub> emissions compared to HP
- **B-R system**
  - Reduced wind curtailment, but increased coal usage
- **HP-R system**
  - Heater investment reduction
  - Small power system benefits

# Thank you for your attention

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## Questions and discussion

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Fonds National de la  
Recherche Luxembourg

# Open questions

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- System benefits of having a portfolio of different heating technologies deployed
- Planning risk mitigation potential of hybrid heaters
- Power system adequacy and reliability with different heaters deployed
- Manage wind forecast uncertainty with different heaters

# Can hybrids reconcile different objectives and stakeholders?

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- Maintain access to storage capacity and flexibility of gas network?
- Decarbonise residential heat through electrification with renewables while minimising generation expansion?
- Provide the consumer with a low-carbon alternative to heat pumps?