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Flexibility from Thermal/Electric Energy System Integration: UK studies

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Content

- Heat decarbonisation challenges
- How important is the integration of heat, gas and electricity sectors?
- Benefits of integrating design and operation of heat and electricity sectors
- Performances of different heat decarbonisation pathways
- Impact of flexibility on electricity generation portfolio
- Role of different firm LCG technologies for deep decarbonisation
- Cross-energy system flexibility to maximise the use of RES
- Conclusions

Heat decarbonisation challenges

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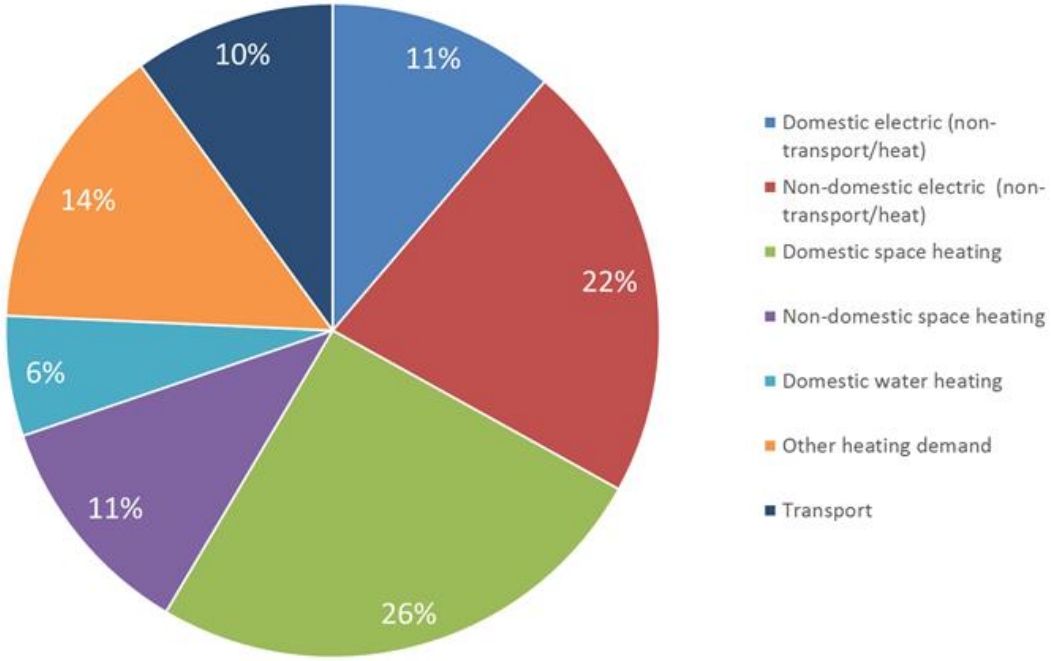

Which strategy?

- Hydrogen
  - Hydrogen boilers
- Electrification
  - Heat pumps
  - Resistive heating
- Hybrid
  - Hybrid heat pumps

- Electric:
  - Non-heat/transport: 367 TWh
  - Transport: 111 TWh
- Heat: 633 TWh

..include 13% household in district heating, and 18% off-gas grid homes

Objective: *provide fundamental evidence to support the development of policies for decarbonising heating and the electricity system in the UK*

https://www.theccc.org.uk/publication/analysis-of-alternative-uk-heat-decarbonisation-pathways/

Modelling approach

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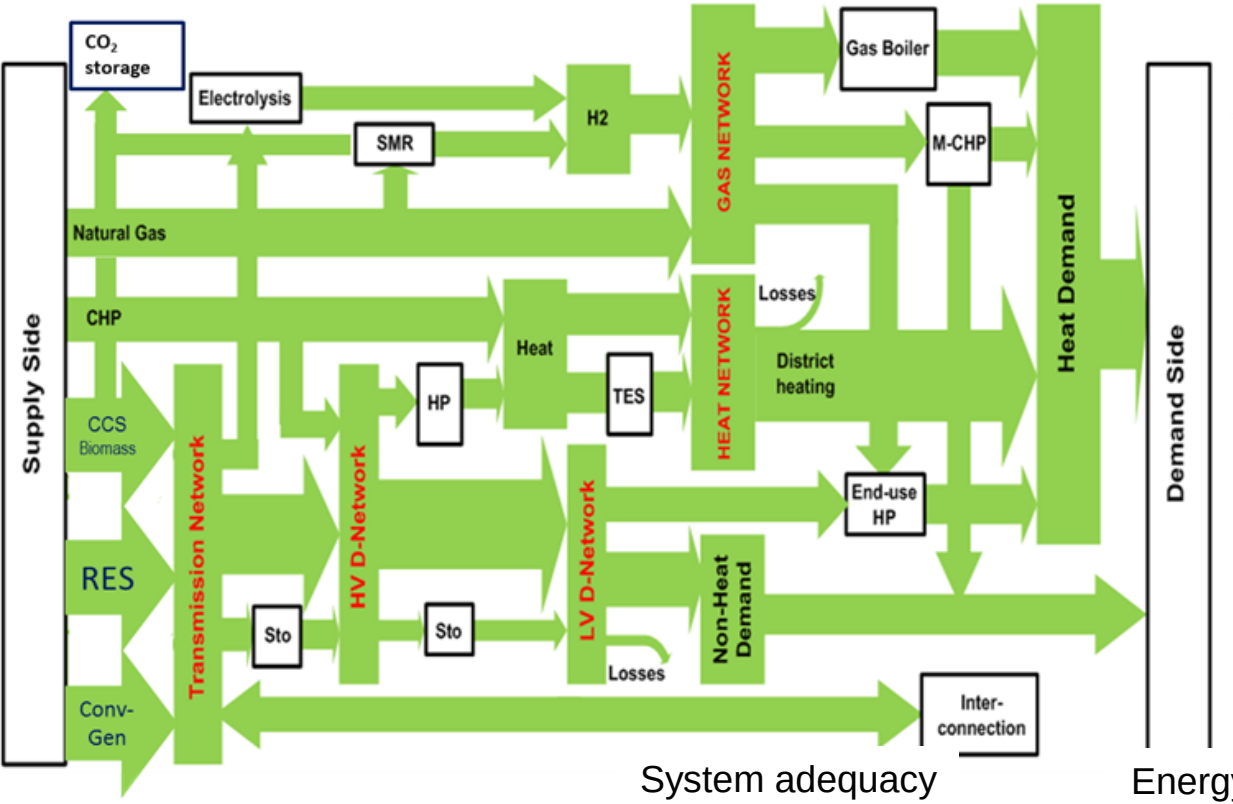
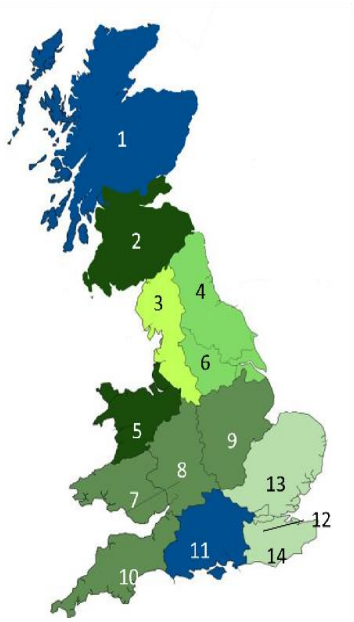
Modelling of technologies



Spatial resolution:
Local & National level



Region	Region name
1	North Scotland
2	South Scotland
3	North West England
4	North East England
5	North Wales, Merseyside and Cheshire
6	Yorkshire
7	South Wales
8	West Midlands
9	East Midlands
10	South West England
11	Southern England
12	London
13	East England
14	South East England

IWES – *Integrated, Whole-Energy System model*

System adequacy | Energy arbitrage | Reserve and Response

Years before delivery	Months to days before delivery	One day to one hour before delivery	Actual delivery: physical supply and consumption (second timescale)

Temporal resolution

Benefits of integrating design and operation of heat and electricity sectors

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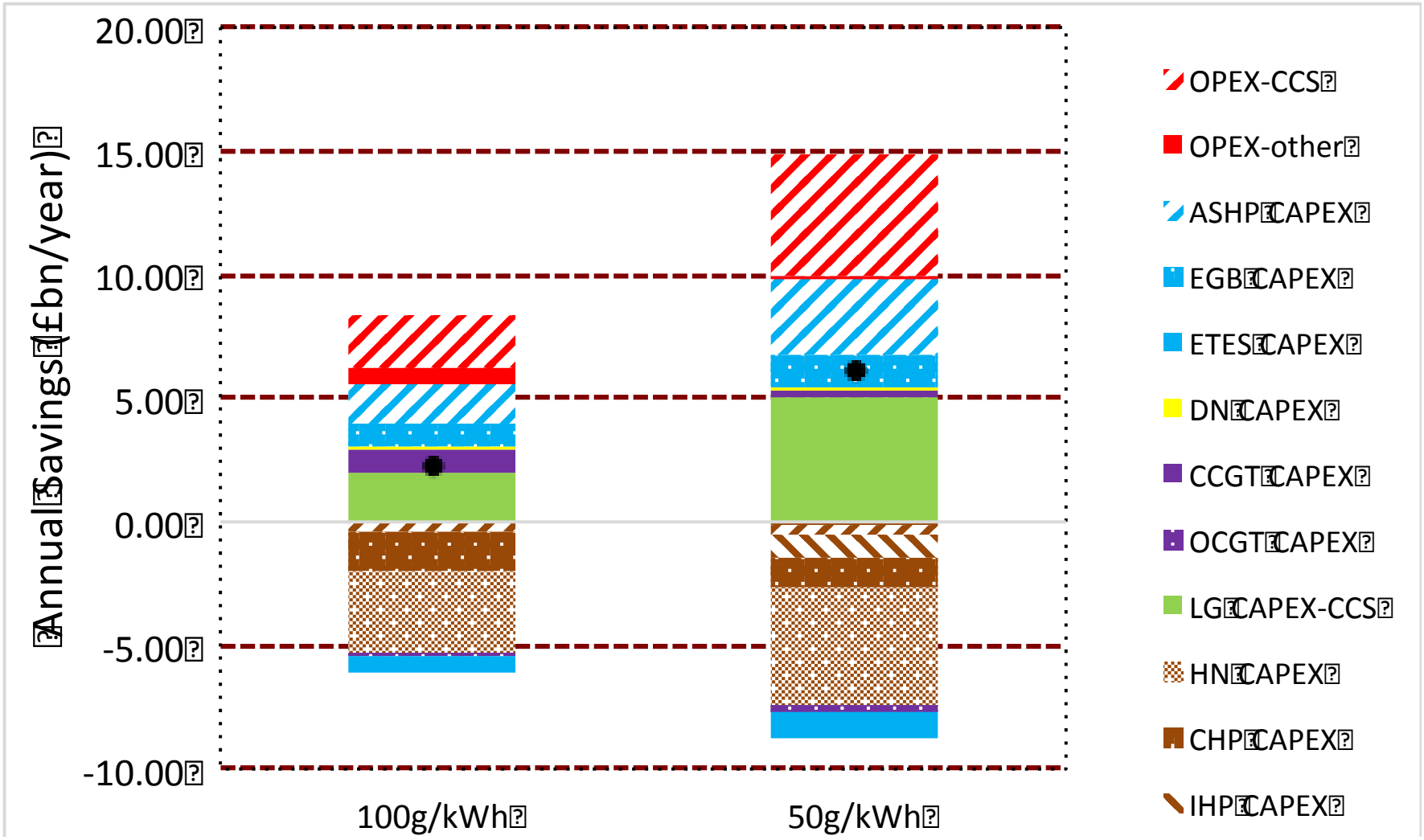

Increased investment in heating infrastructure delivers larger cost savings in the electricity system

Annual system cost of heat decarbonisation pathways

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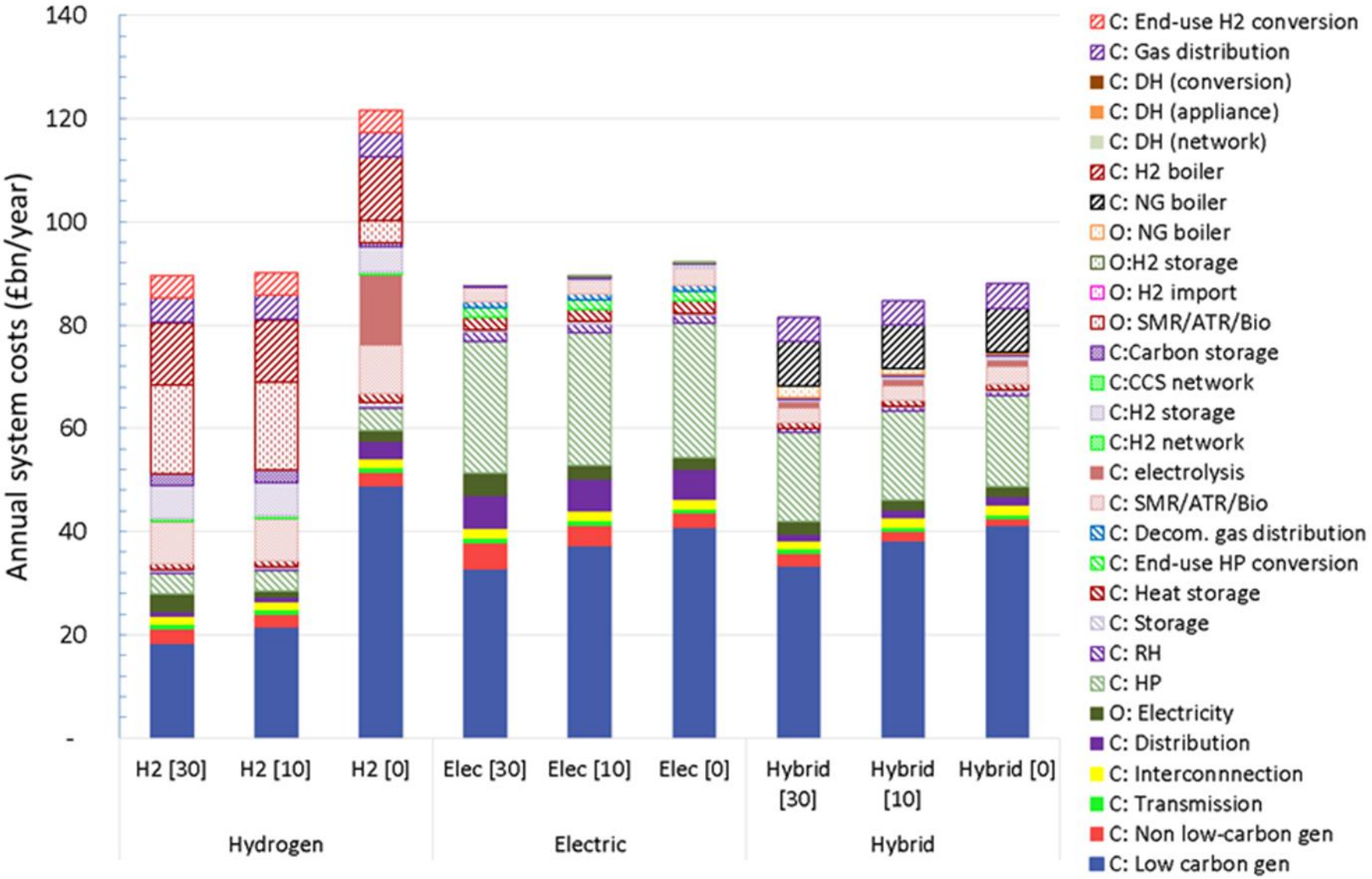

Optimal generation portfolio in different heat decarbonisation pathways

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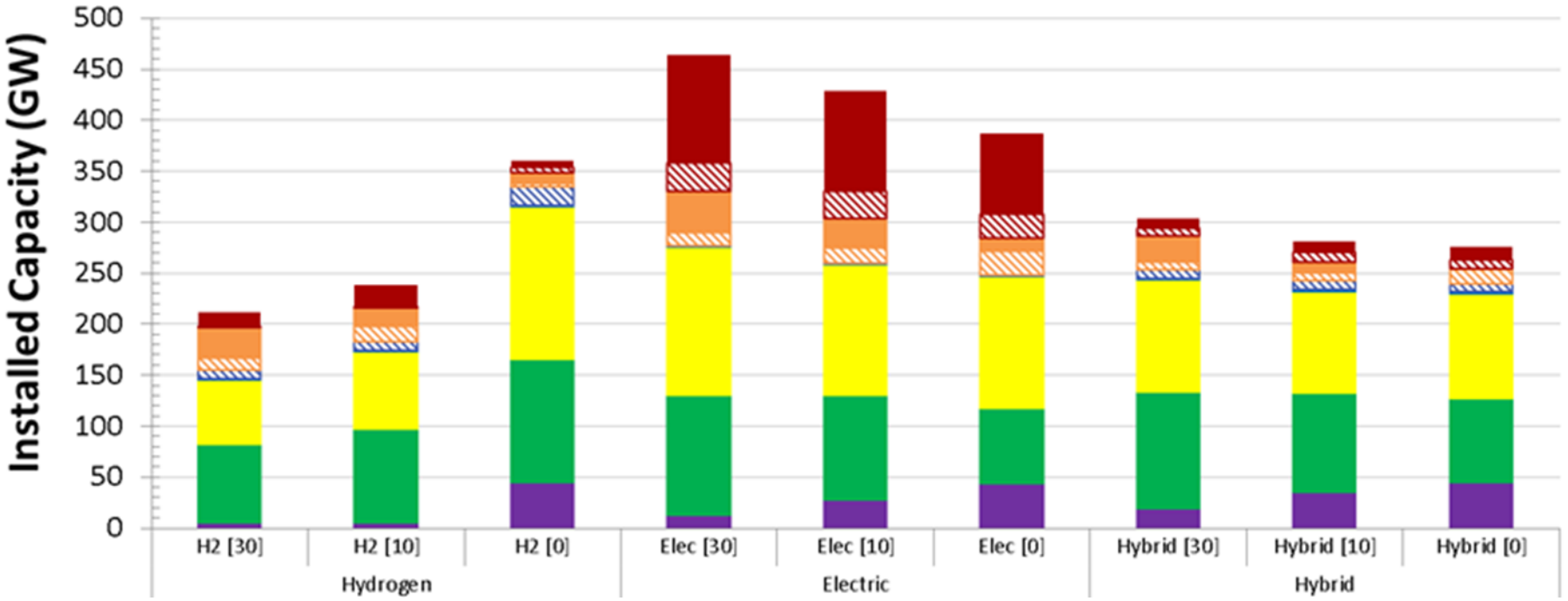
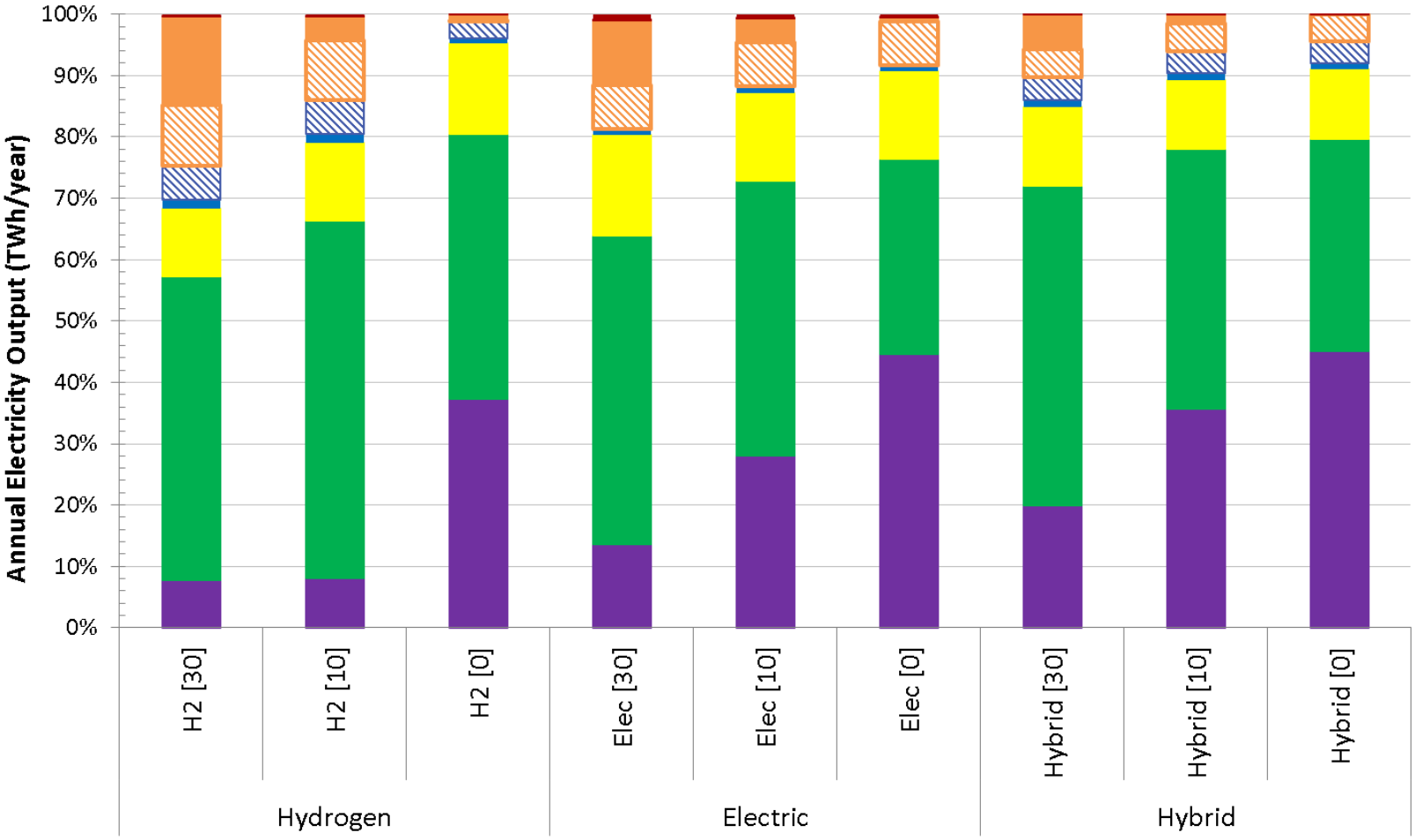


A stricter carbon target drives the need for firm low-carbon generation and reduces the case for variable low-carbon (wind, PV).

*Current (2018) installed capacity of UK wind: 19GW. By 2050, at least it needs 74GW.

Optimal generation mixes



Although expensive, nuclear may be needed to meet a very demanding carbon target.

Integrated versus silo decarbonization

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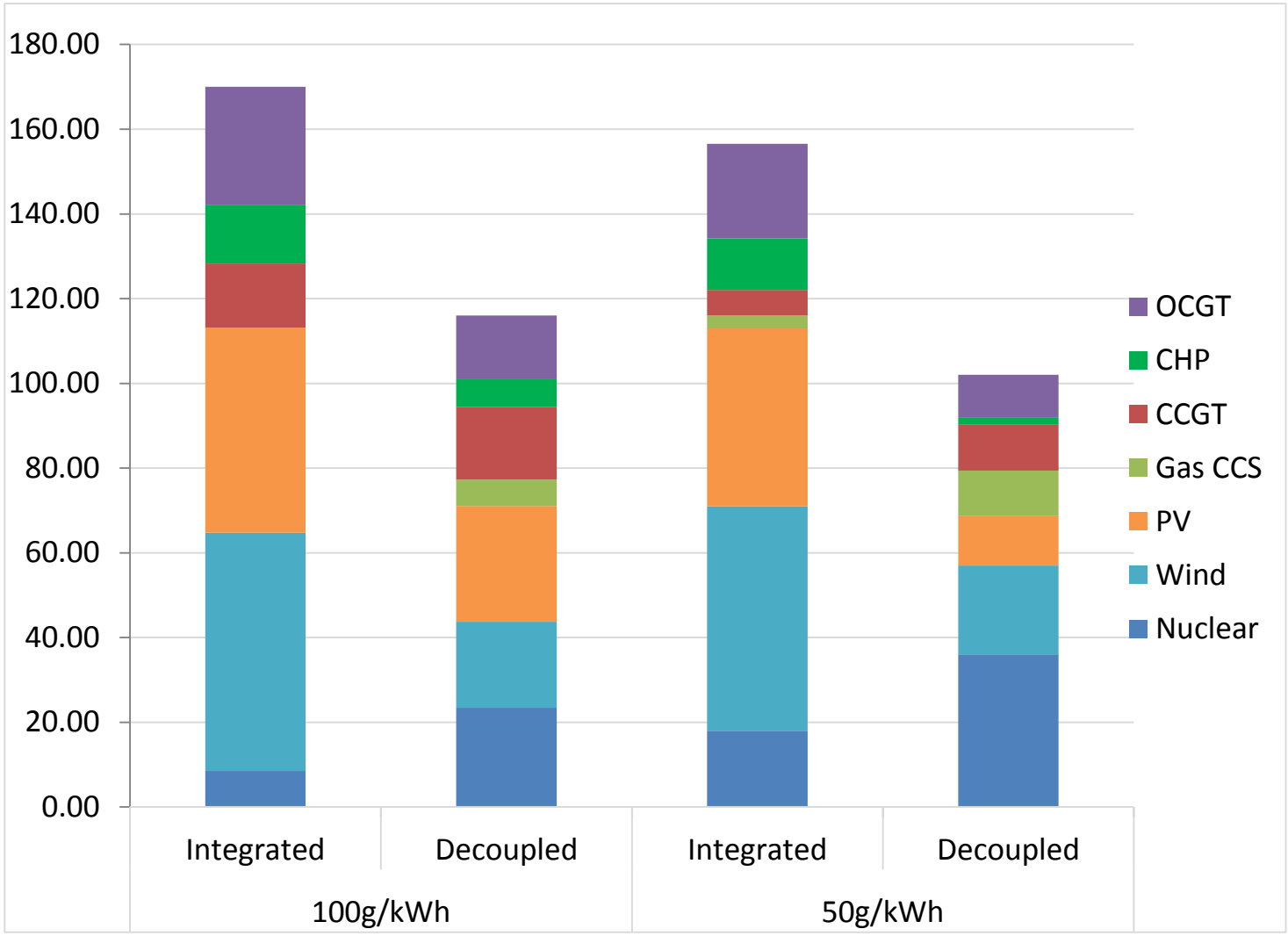
GW



Paper: X. Zhang, G. Strbac, N. Shah, F. Teng, D. Pudjianto," Whole-System Assessment of the Benefits of Integrated Electricity and Heat System," accepted for publication, Sep. 2019

Impact of flexibility on electricity generation portfolio

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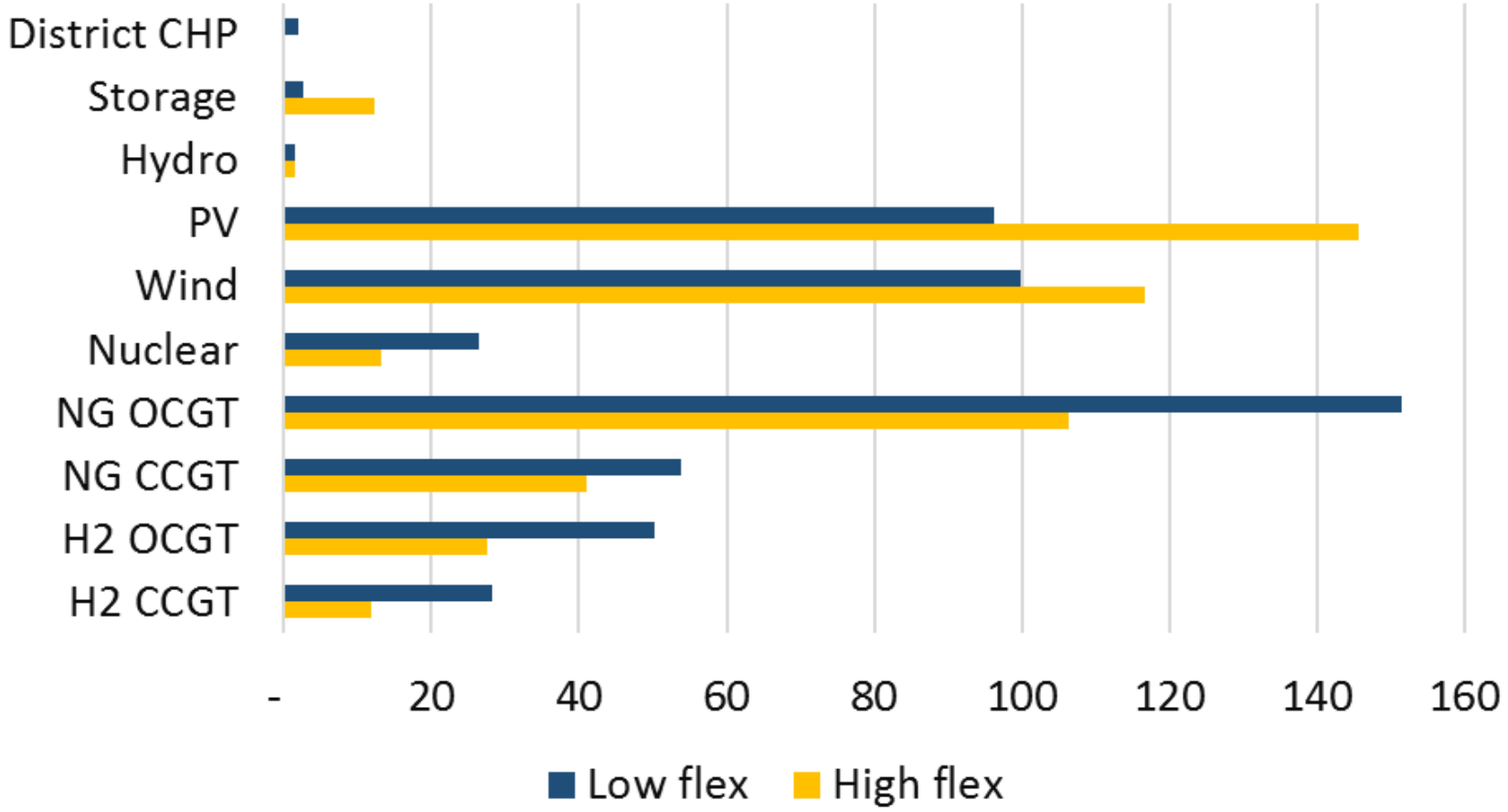

Low flexibility requires firm LCG (at a higher cost)

System benefits of HHP in a system with different level of flexibility

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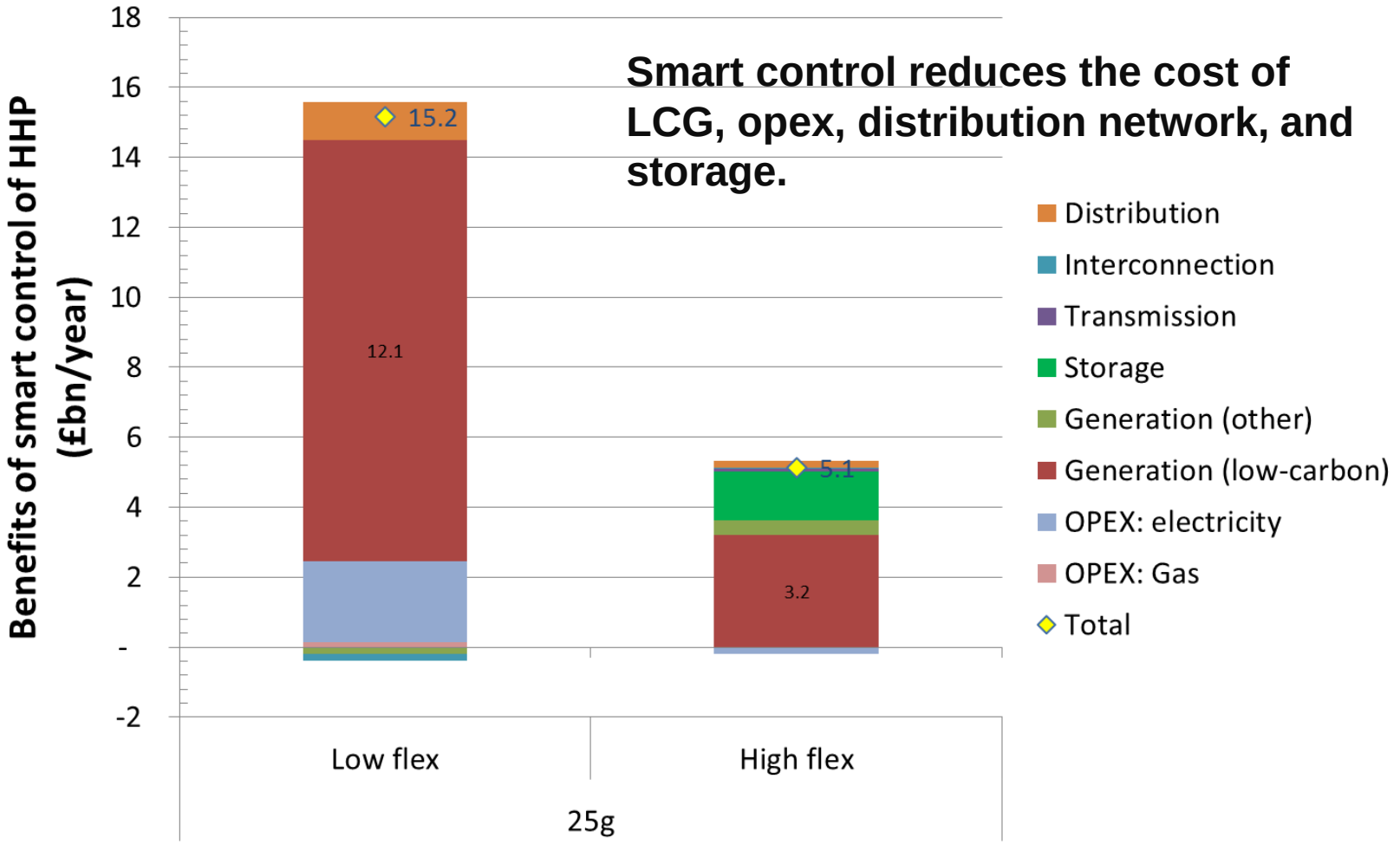

SIC vs. VRES penetration and flexibility

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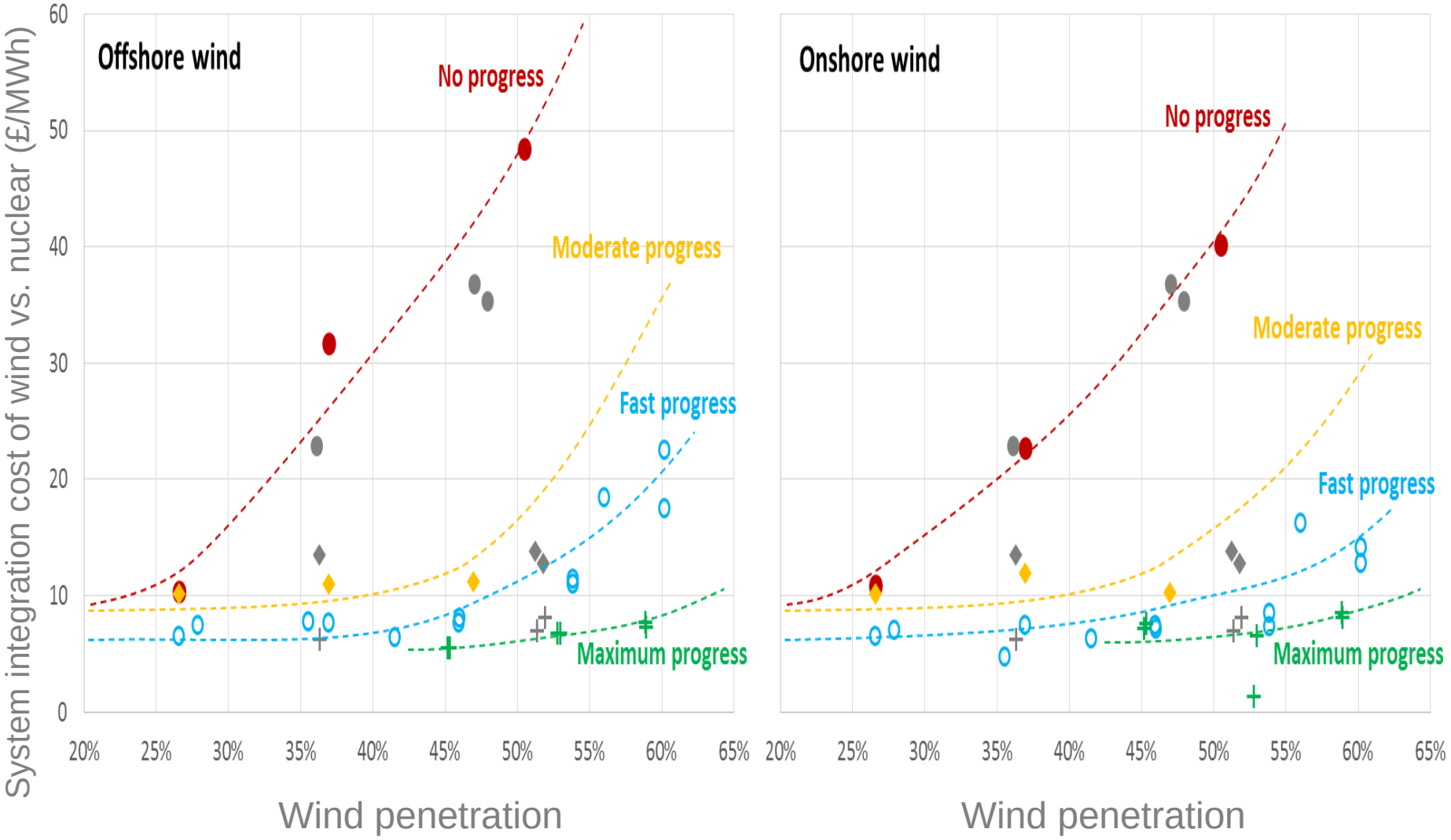

Role of firm low-carbon generation in deep decarbonisation

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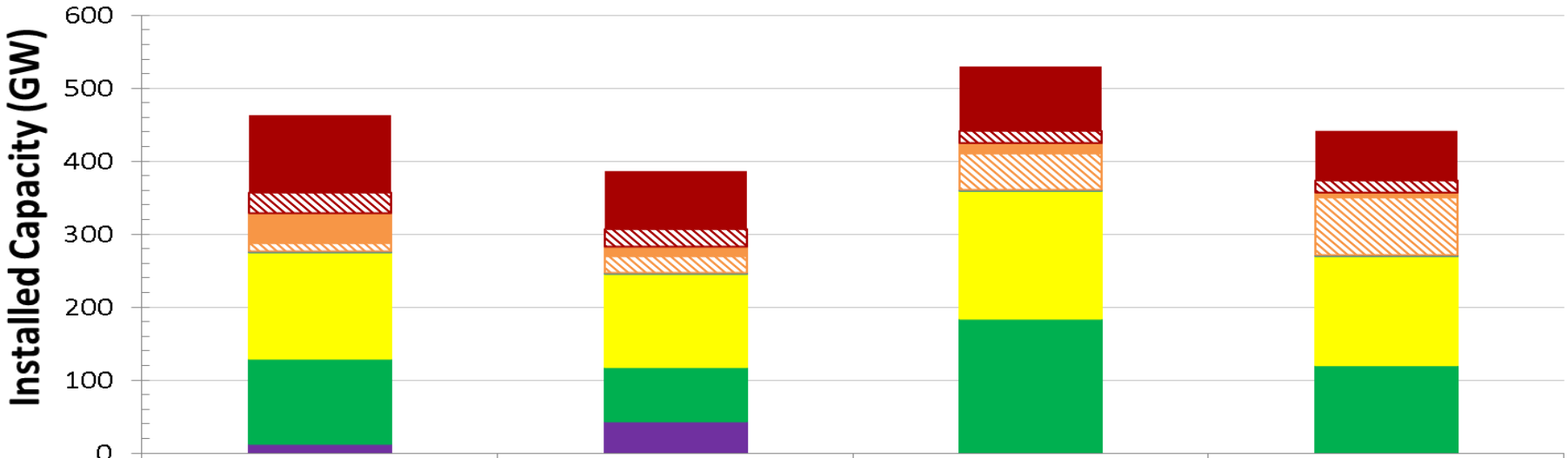

	Elec [30]	Elec [0] Core scenario	Elec [0] No nuclear, high RES	Elec [0] No nuclear, with H2 import
OCGT	106	79	88	68
H2 OCGT	27	24	16	17
CCGT	41	13	14	7
H2 CCGT	12	23	51	79
Hydro	1	1	1	1
PV	146	129	175	150
Wind	117	74	185	120
Nuclear	13	43	0	0

Required UK's RES potential by 2050

Assumed max RES capacity by 2050

Deep decarbonisation requires firm low-carbon capacity (nuclear, H2-fired gen) [less case for RES and other firm capacities]

RES can substitute nuclear in a flexible system with large storage and H2-fired generation

Alternatively, H_2 based power generation can be used with H_2 import. This reduces the need for RES in the UK.

Note:
- In 0 Mt, CCGT and OCGT will run on biogas (carbon-neutral)
- Source: G.Strbac (2018) Analysis of Alternative UK Heat decarbonisation Pathways. A report for Committee on Climate Change.

Cross-energy system flexibility is required to maximise the use of RES

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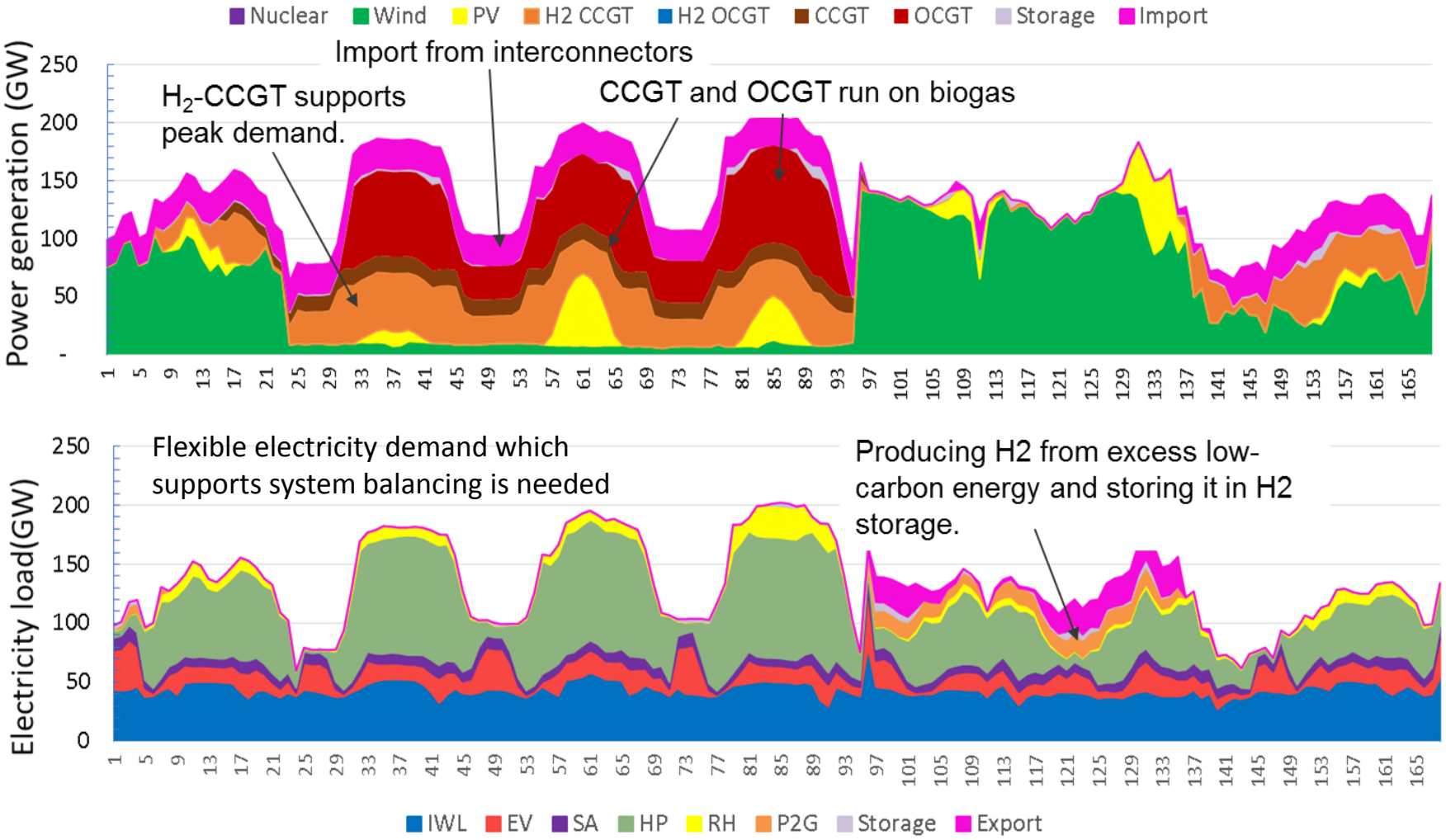
Elec [0] no nuclear, high RES



Hydrogen storage requirement in different scenarios

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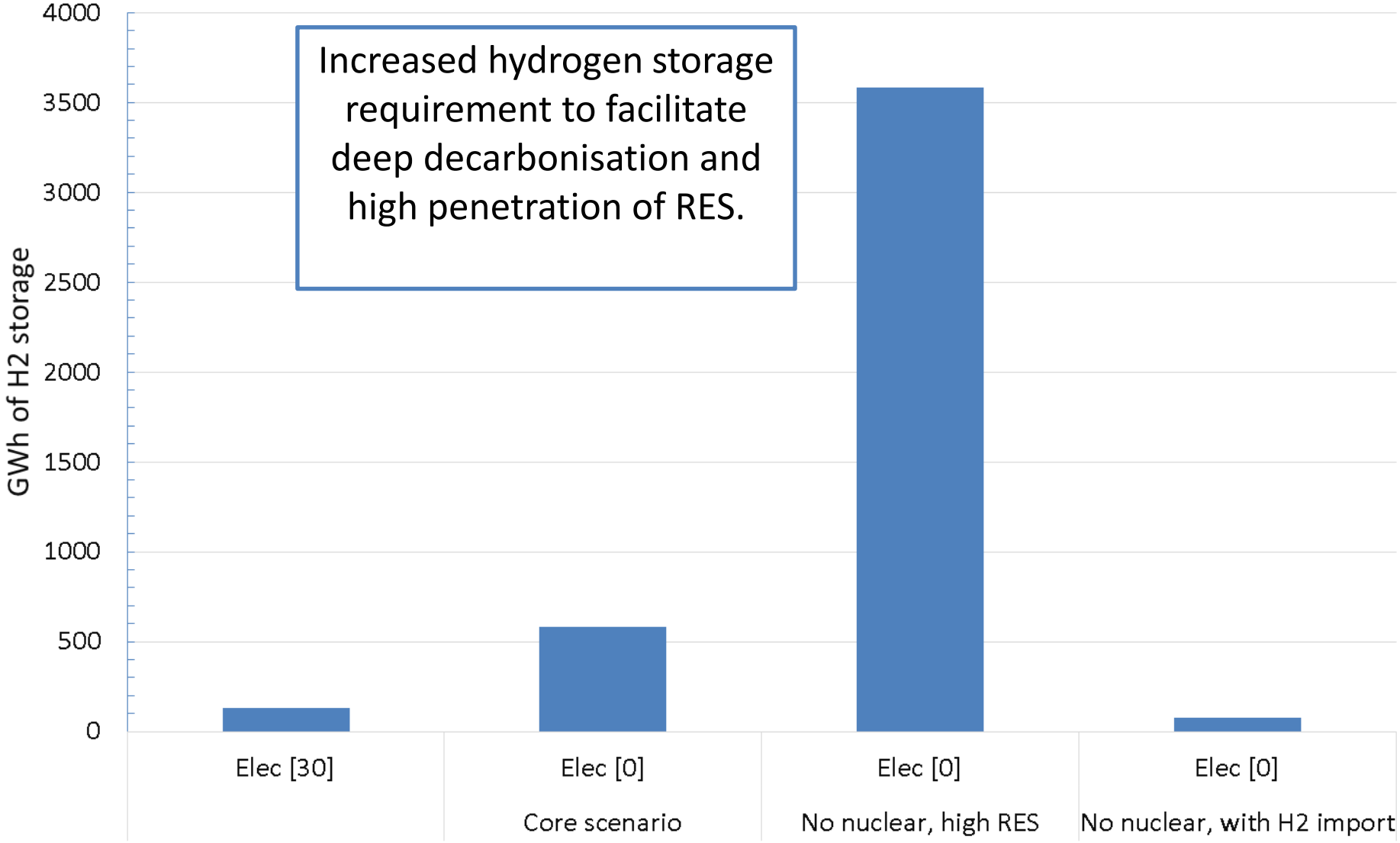

Thermal storage or electricity storage ?

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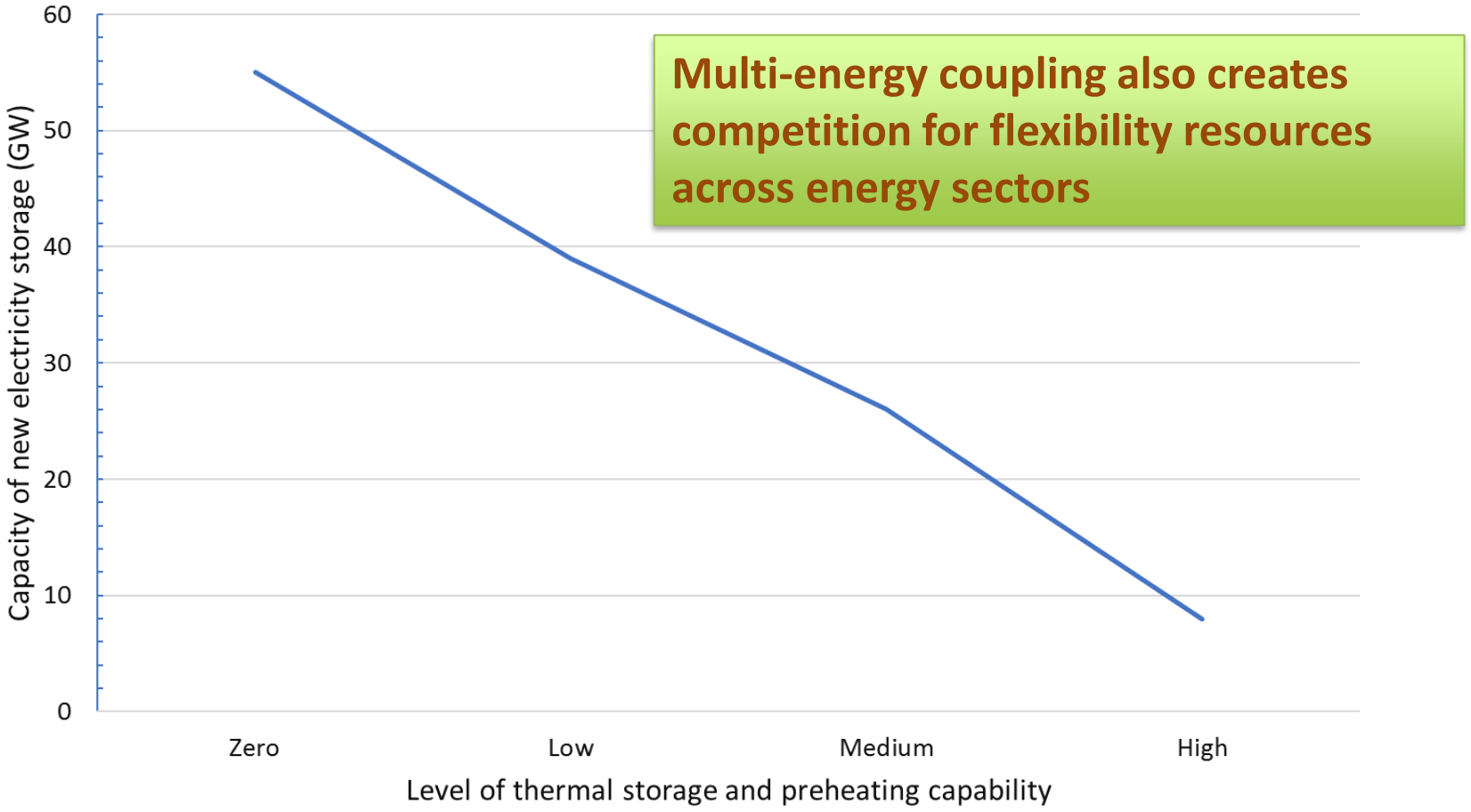

Number of household: 34.3 M
Thermal storage: 1.7 kWth/household

Cost changes in core decarbonisation pathways under different scenarios

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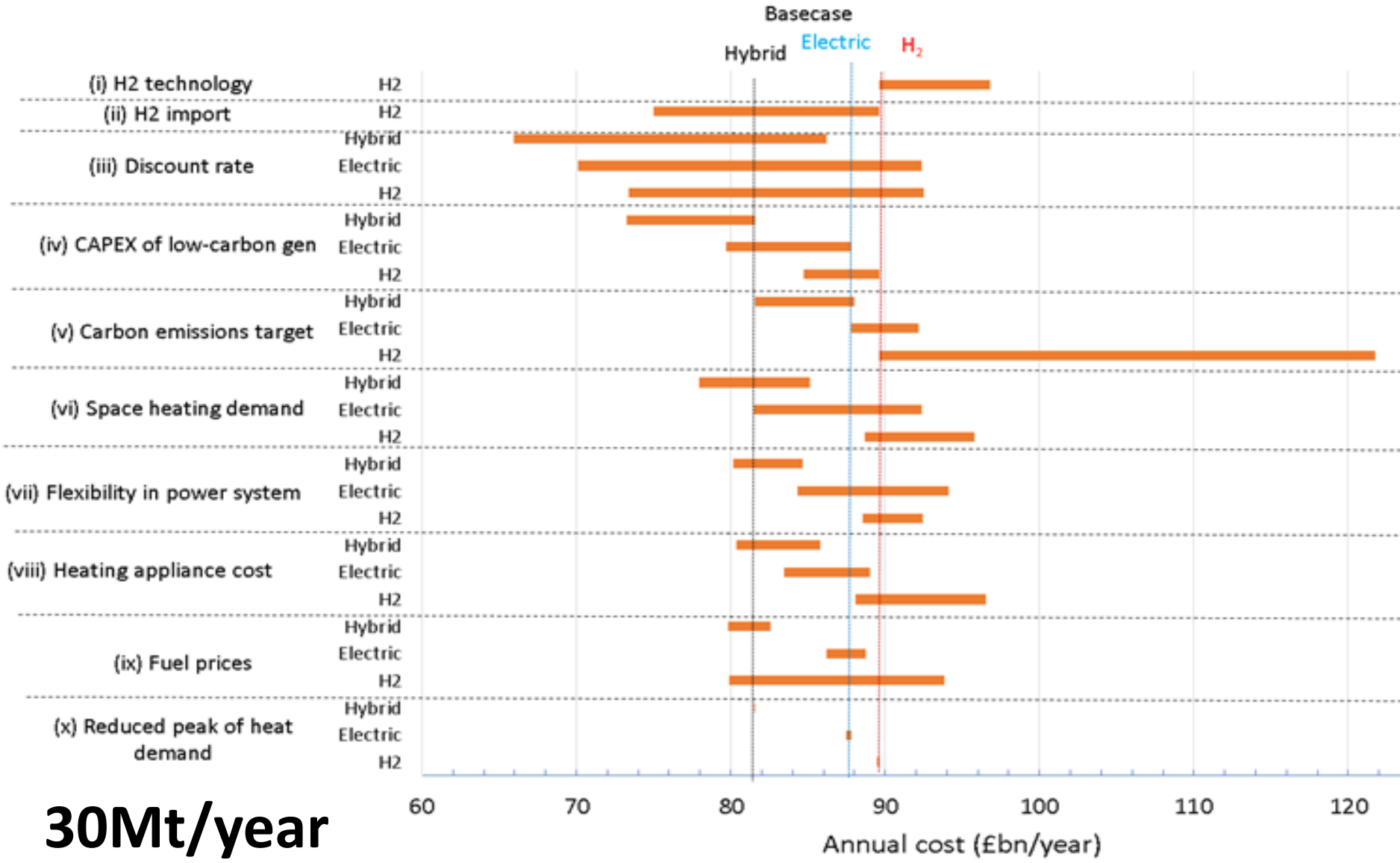

30Mt/year

Key findings

- Whole-system approach for integrating heat / cooling, gas, electricity, transport infrastructure is the key to minimise the overall cost of decarbonisation -
  - Need for high time and space resolution of multi-vector modelling
- Renewable sources based decarbonisation – role of long term / hydrogen storage
- Significant need for demonstration of innovative solutions
- Need for appropriate regulatory, market & business models