IMPERIAL

HeatNet Alpha

Task 4.4 Whole-System Benefits and System Impacts

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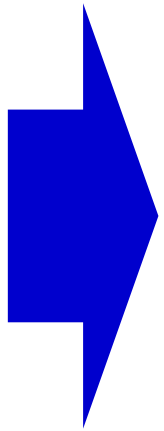
WP 4: Whole system benefits

Potential benefits of coordinated HP control on whole system investment and operation

Task 4.1 Analysis of system configurations
- Analysis of the peak demand contributions and maximum diversity factors from heat pump (HP) system configurations, both with and without HeatNet.

Task 4.2 Analysis of voltage-driven reinforcement
- Analysis of the reductions to voltage-driven reinforcement from using HeatNet across the three LV use cases and scaled for the UKPN and GB networks

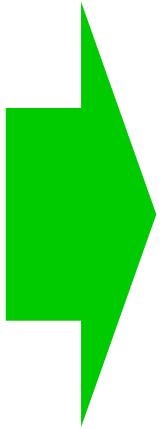
Task 4.3 Review of alternative approaches
- Review and development of alternative approaches for integrating HeatNet technologies into distribution network planning



D4.1.1 Review of alternative approaches (week 25; 17 Feb)

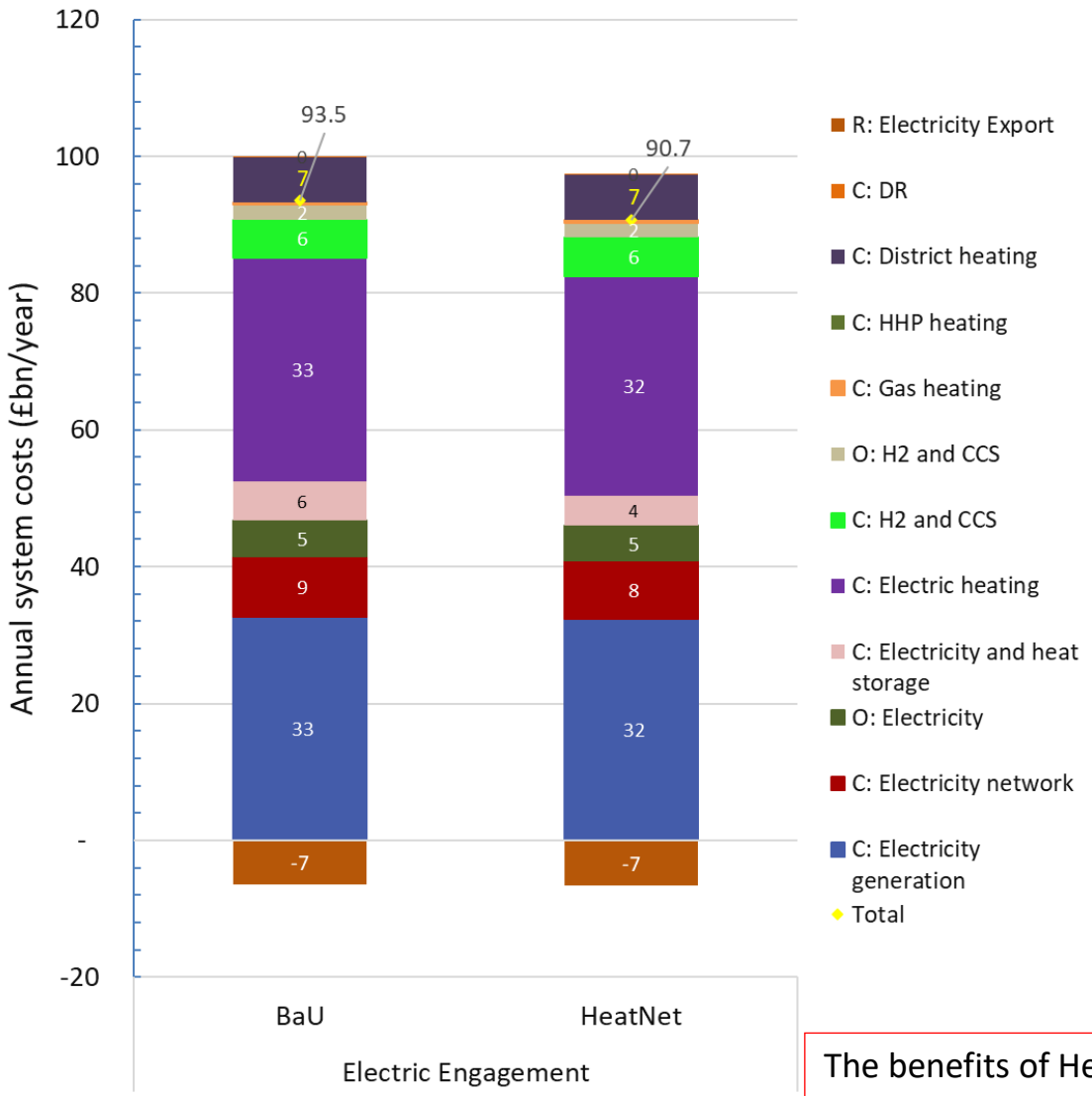
Task 4.4 Summary of the whole-system benefits
- **Evaluation of the whole-system benefits of applying HeatNet, looking at competition with other flexibility technologies like demand response and battery storage.**

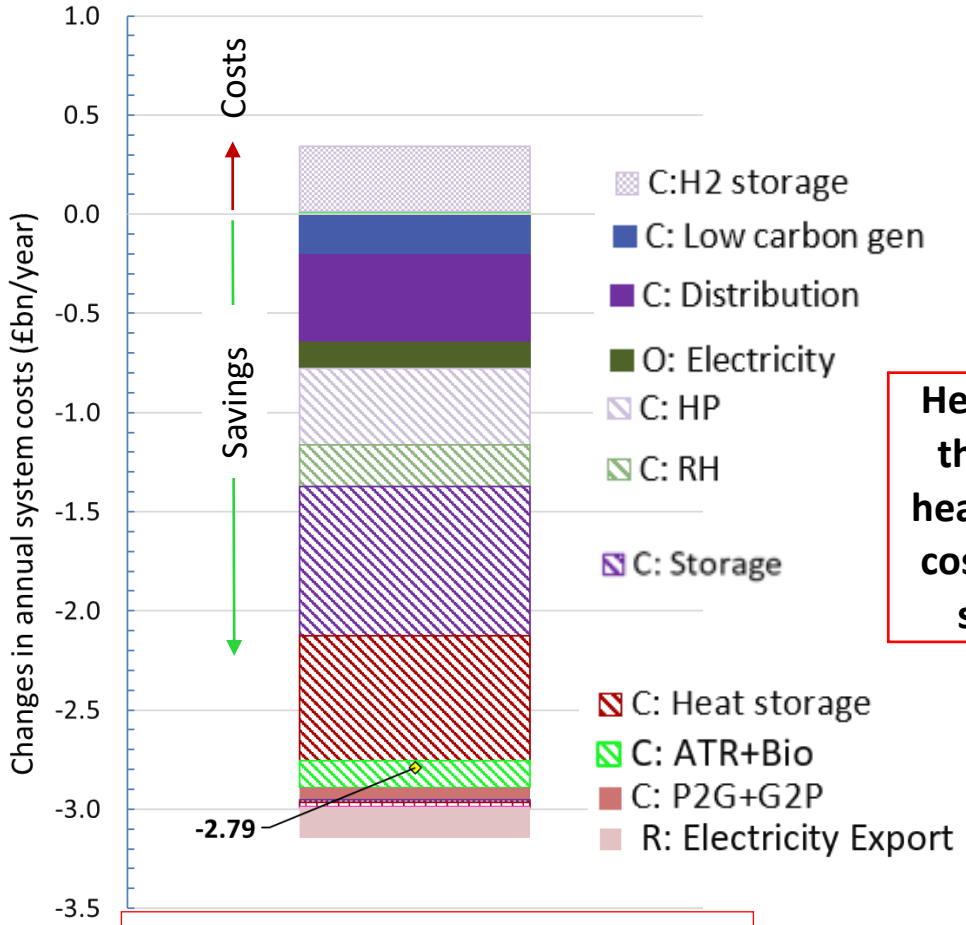
Task 4.5 Whole-system evaluation of HeatNet
- Development of a cross-cutting report analysing the impact of the HeatNet method on the UKPN's distribution network and across the GB energy system under different future scenarios



D4.2.1 Whole System Evaluation of HeatNet (week 29; 17 Mar)

Comparison between the Annual System Cost of BaU and HeatNet





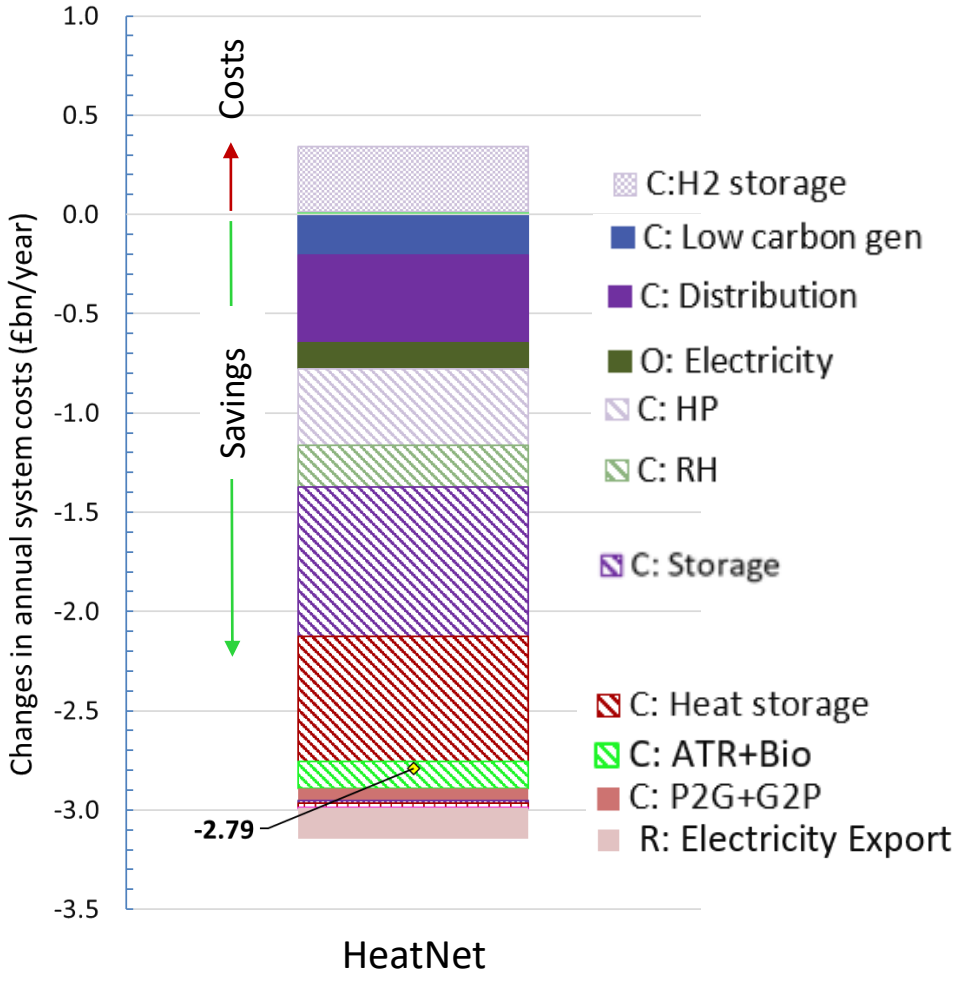
HeatNet reduces the customer's heating appliance costs and energy system costs

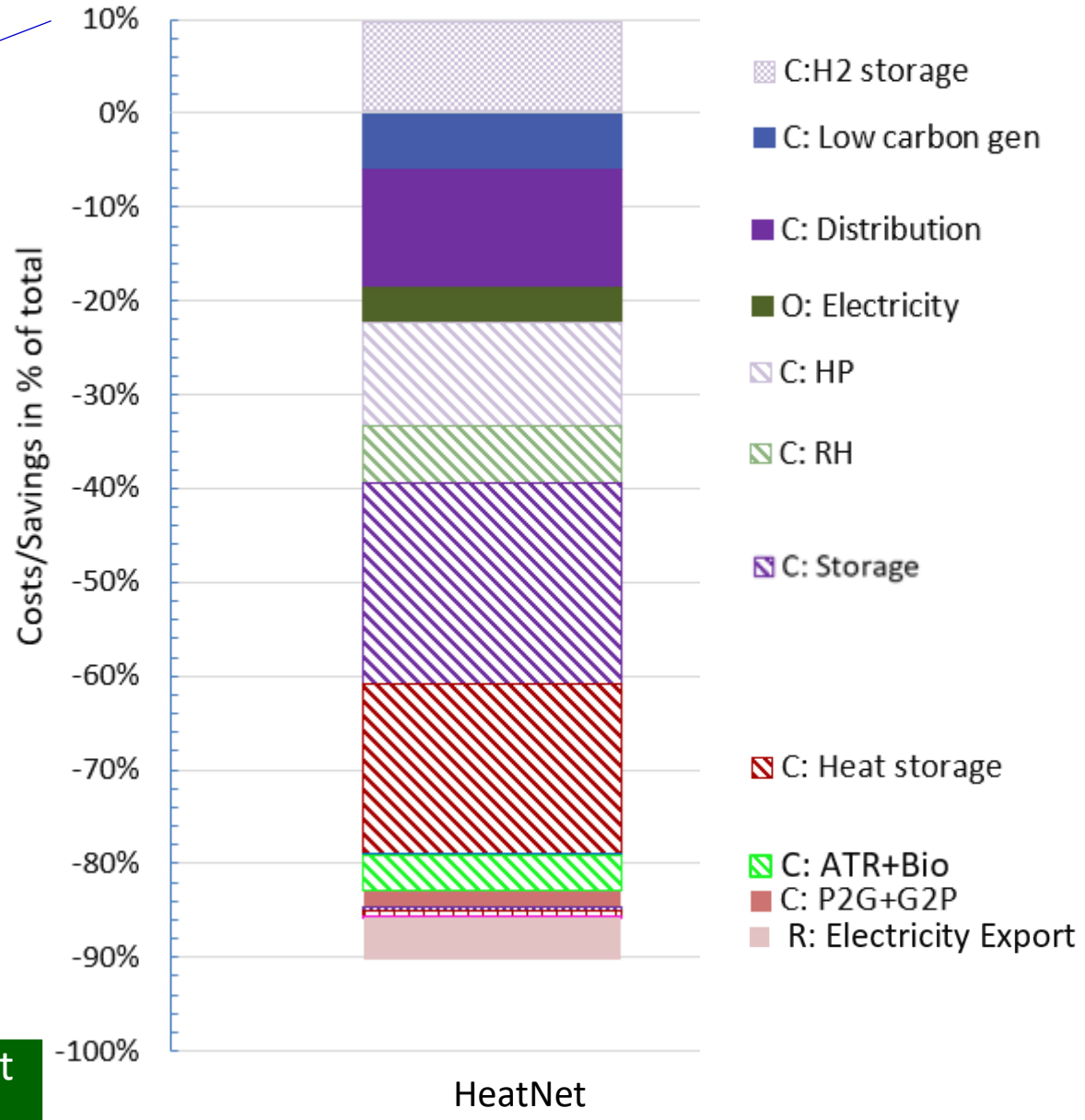
Savings: £2.79 bn/year

The benefits of HeatNet include savings in the investment cost of low-carbon generation technologies, distribution network reinforcement cost, OPEX of electricity, end-user heating appliance costs, and other flexibility technologies such as batteries, heat storage, hydrogen production capacity including electrolysers. It also enables more electricity exports.
The changes in the system are supported by investment in hydrogen storage.

System Benefits of HeatNet

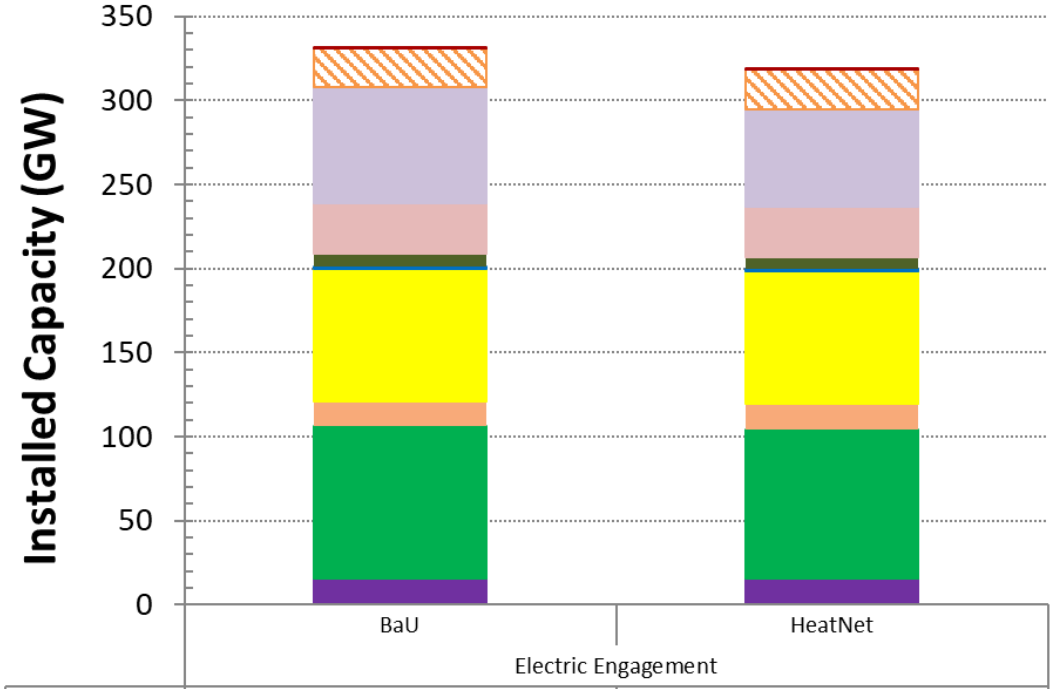
Distribution network savings are less than 16% of the total benefits.
The whole-system benefits of HeatNet are 7 times its benefits to distribution.



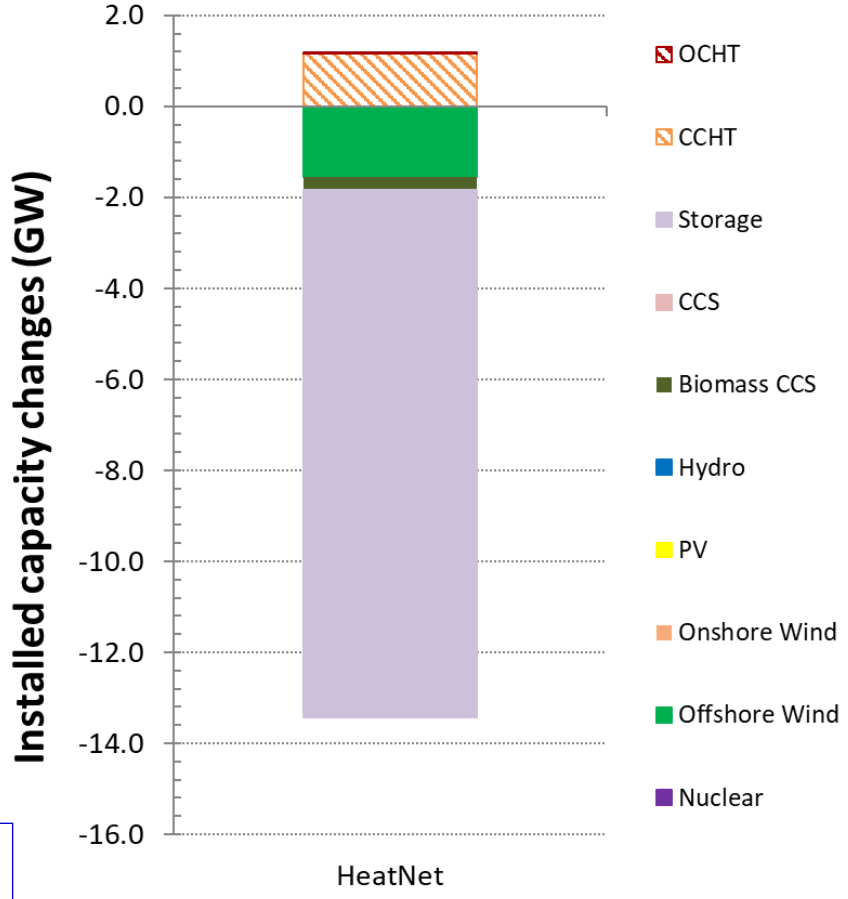


Value of HeatNet is in its flexibility services to support system needs and improve system efficiency.

Impact of HeatNet on the optimal power generation and electricity storage portfolio



	BaU	HeatNet
OCHT	0.2	0.2
CCHT	22.6	23.8
Storage	69	58
CCS	30	30
Biomass CCS	7	7
Hydro	1	1
PV	79	79
Onshore Wind	15	15
Offshore Wind	90.1	88.6
Nuclear	16	16



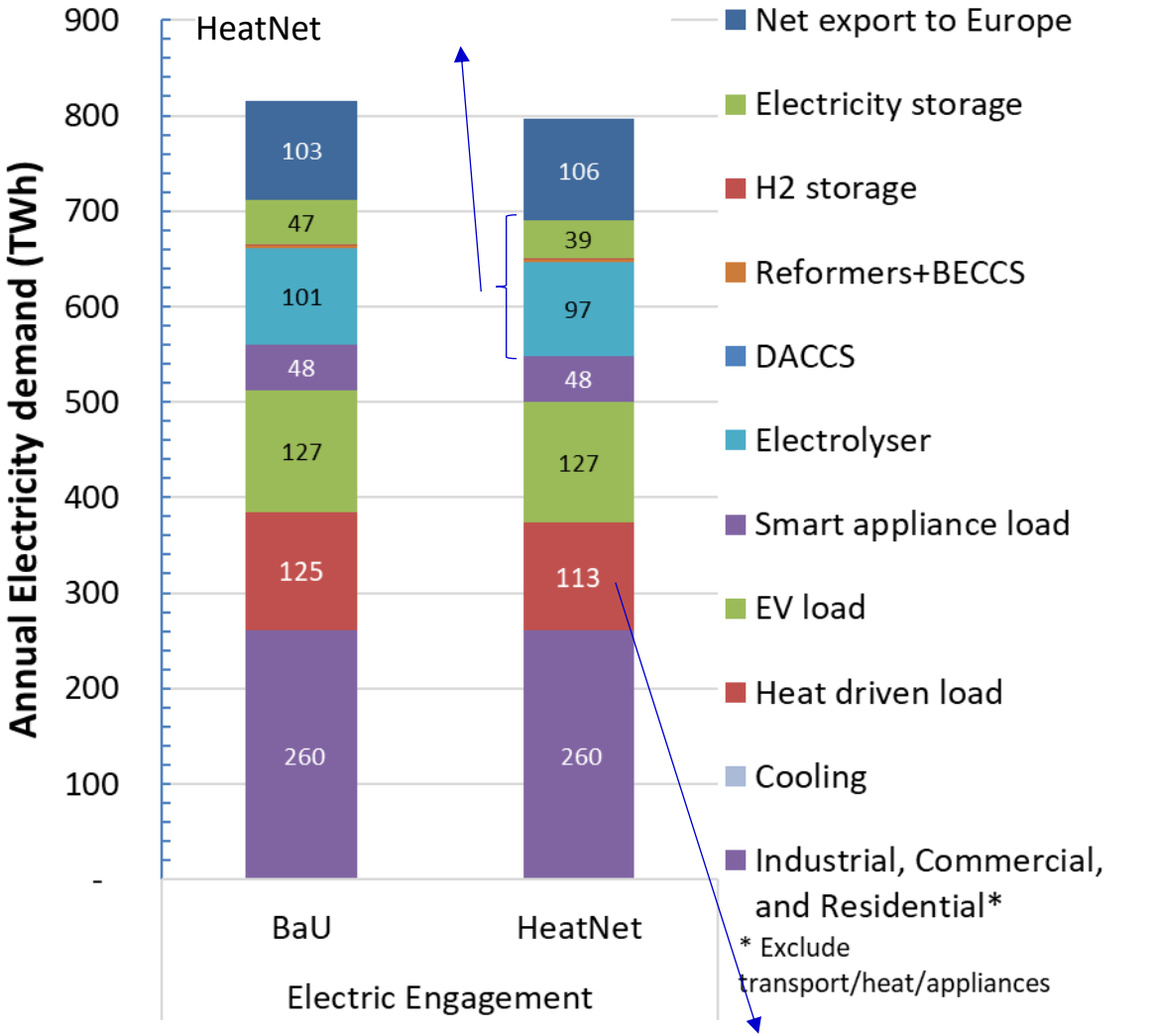
HeatNet ➡ Less investment needed in low-carbon generation technologies such as offshore wind and biomass CCS and in flexibility technology such as battery storage.

HeatNet influences how the optimal power generation portfolio will be and increase the CCHT to offset the impact of reduction in wind, biomass and storage.

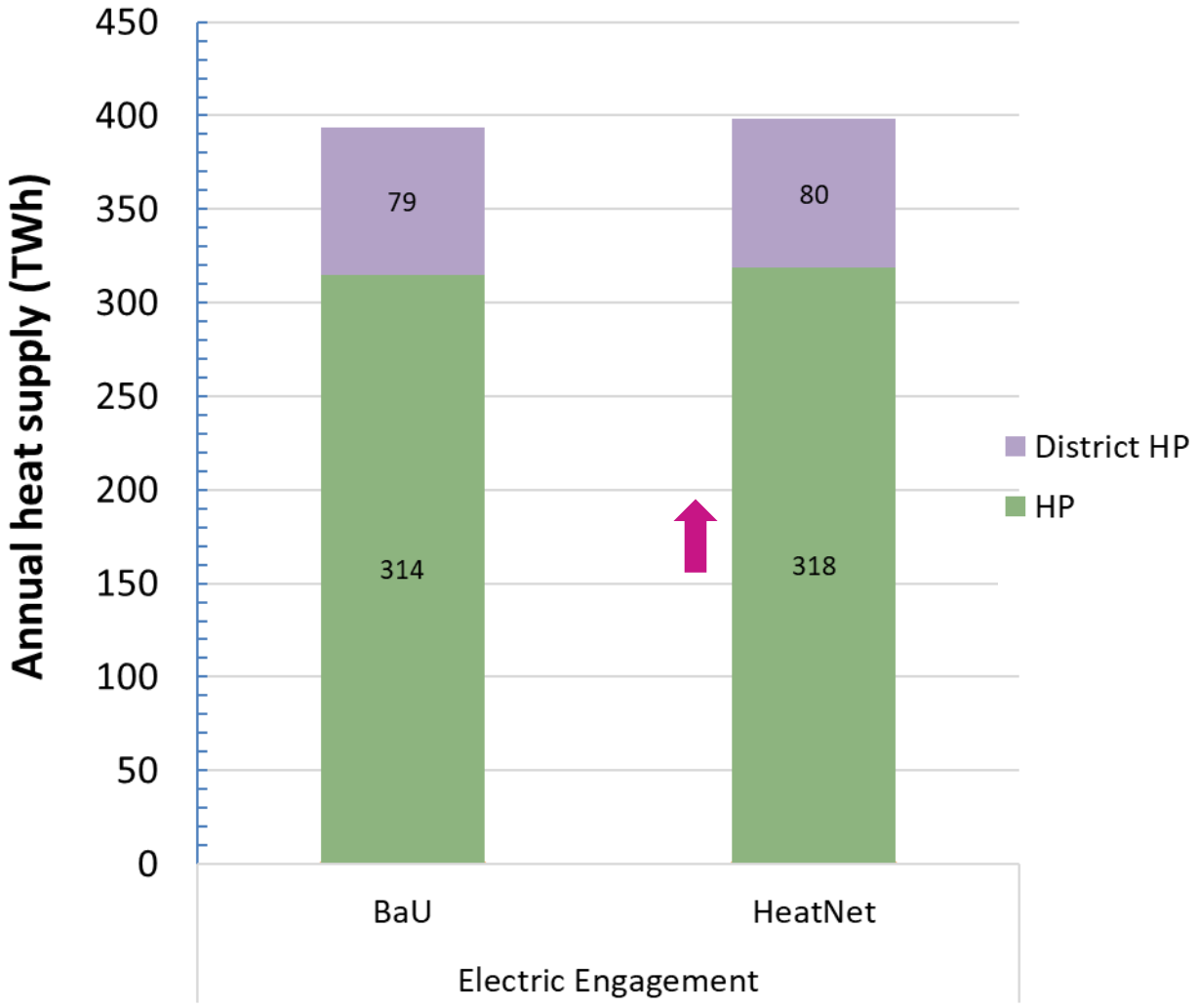
11 GW reduction in electricity storage capacity as HeatNet utilises building thermal storage, it also reduces the need for electricity storage.

Impact of HeatNet on Electricity Demand and Heat Supplied

Lower electricity storage and electrolyser demand indicating some flexibility displaced by HeatNet

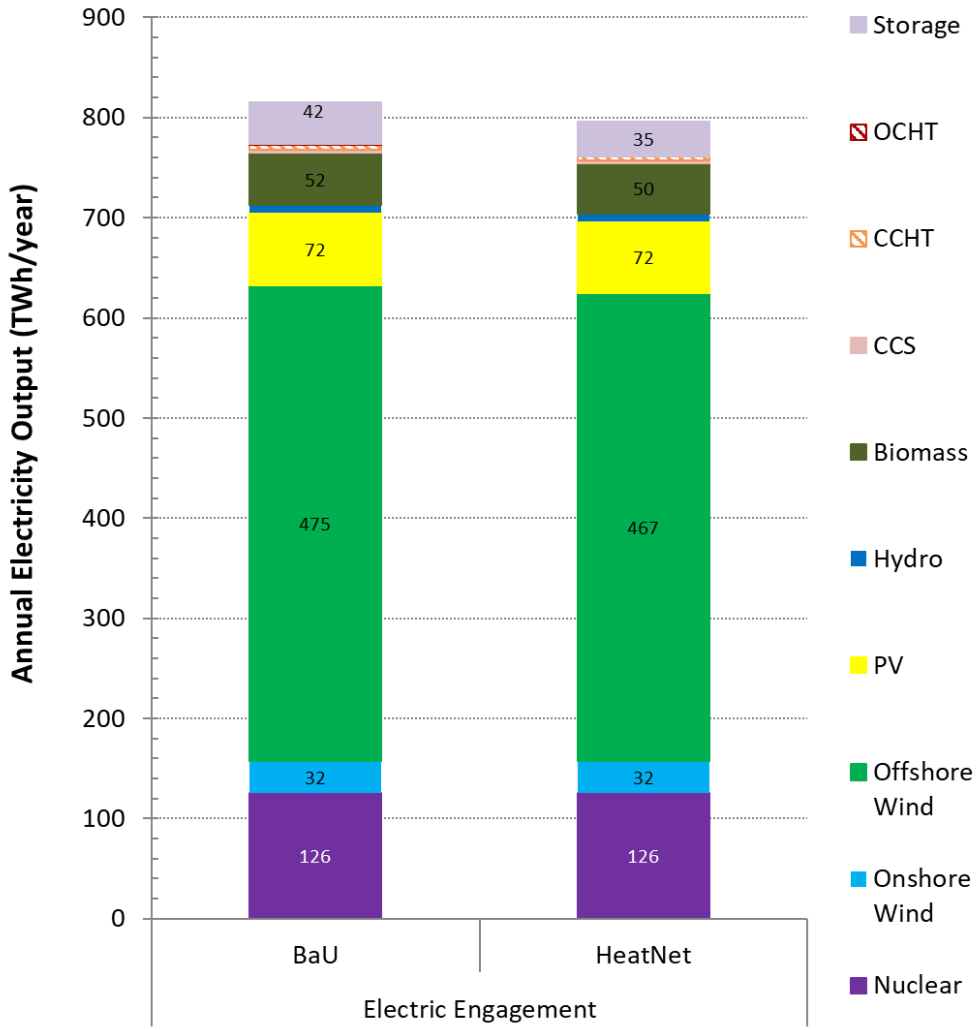


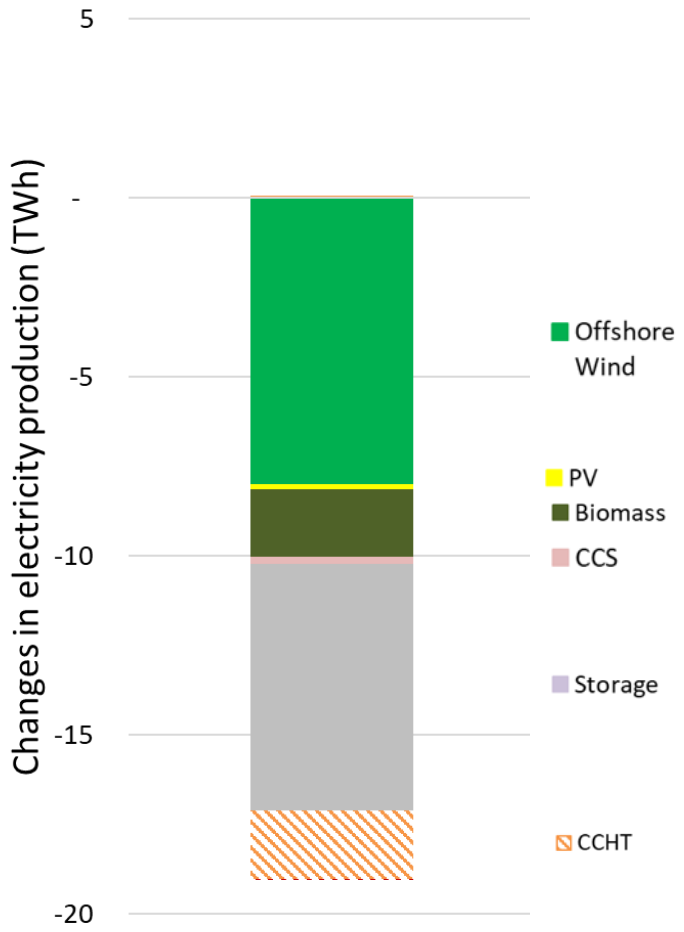
Energy savings: 10%



Heat pumps produce slightly (1.3%) more heat to compensate for increased thermal storage losses.

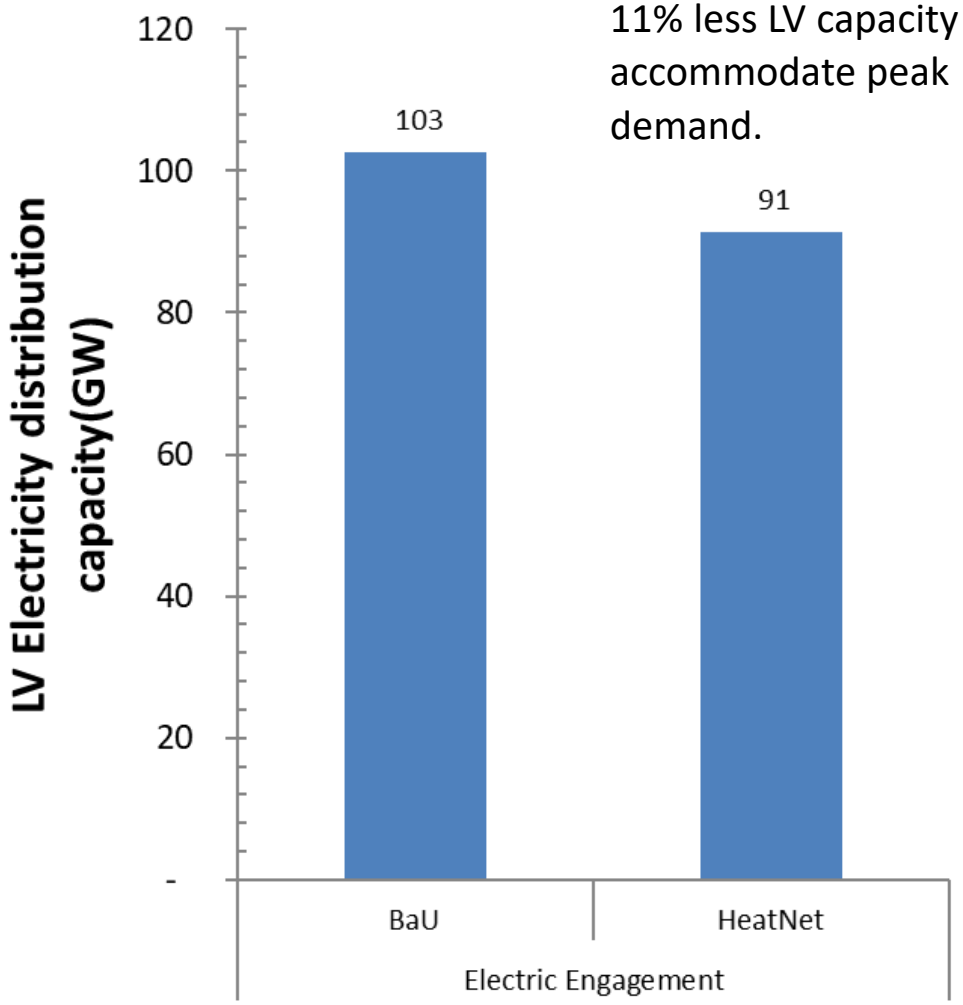
Impact of HeatNet on Electricity Production Mix





HeatNet reduces the overall electricity demand and low-carbon generation capacity needed.
Less electricity production reduces electricity OPEX.

Impact of HeatNet on electricity peak demand and capacity requirement at LV



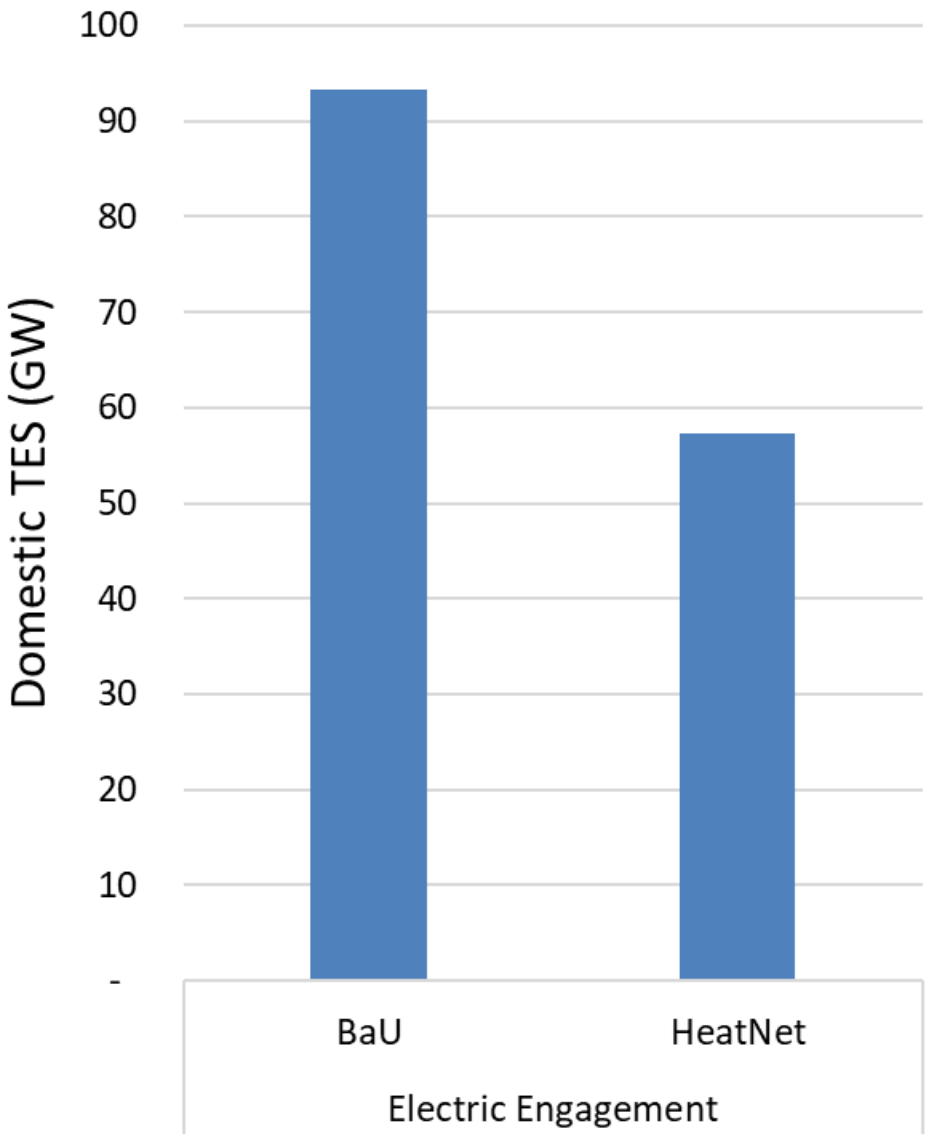
11% less LV capacity to accommodate peak demand.

LV electricity distribution network capacity (MW)

Region	BaU	HeatNet	Savings (%)
North Scotland	4,522	3,943	12.8%
South Scotland	7,447	6,581	11.6%
North-West England	10,502	9,741	7.2%
North-East England	2,843	2,843	0.0%
North Wales	7,833	7,550	3.6%
Yorkshire	6,620	5,651	14.6%
South Wales	3,806	3,216	15.5%
West Midlands	7,693	6,454	16.1%
East Midlands	11,032	10,095	8.5%
South-West England	6,378	5,567	12.7%
South England	8,677	7,291	16.0%
London	12,923	12,005	7.1%
East England	7,421	6,195	16.5%
South-East England	5,021	4,275	14.9%
Total	102,717	91,406	11.0%

HeatNet can reduce the LV distribution network capacity needed for faster heat electrification.

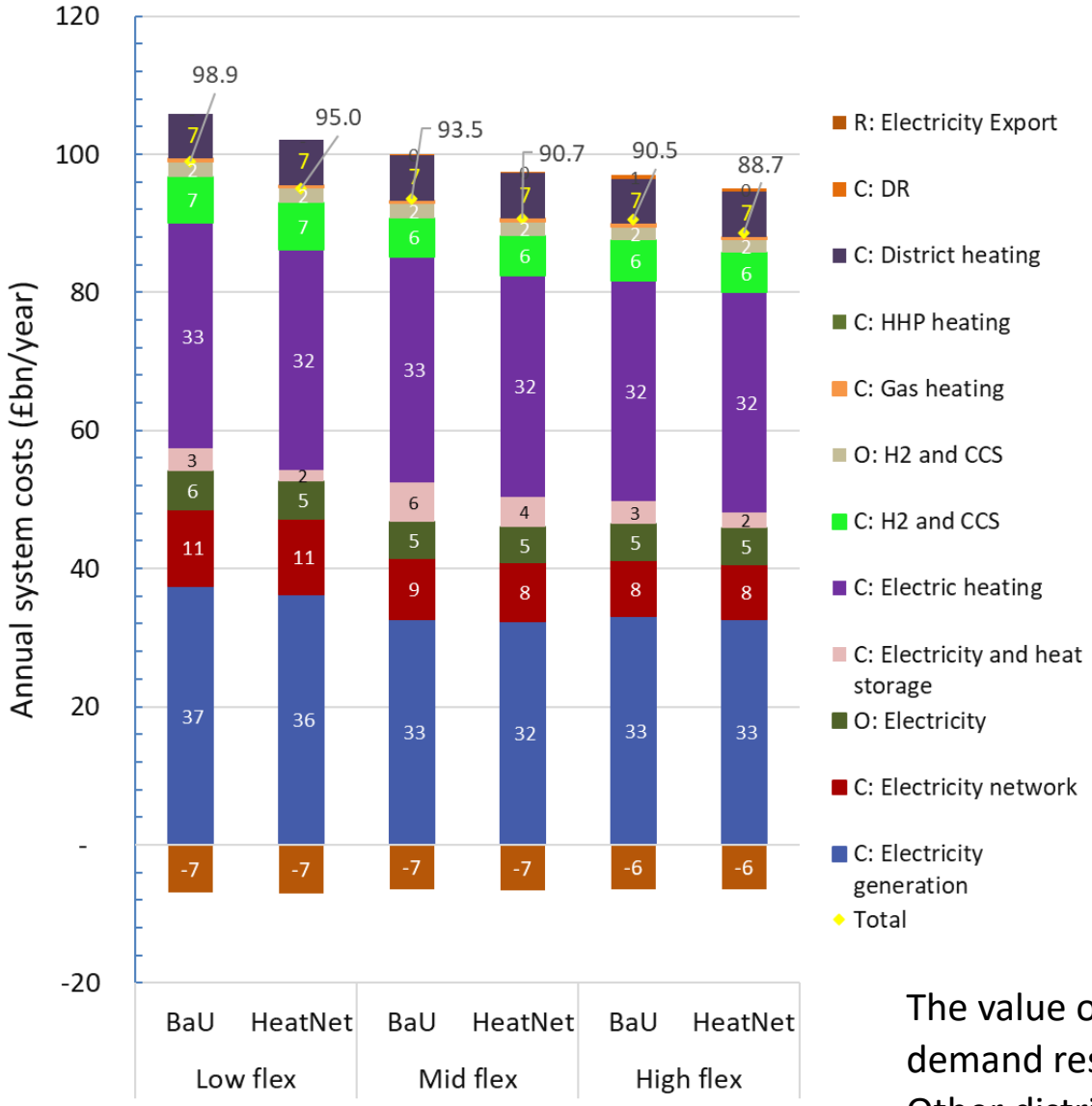
HeatNet reduces the need for dedicated Thermal Energy Storage



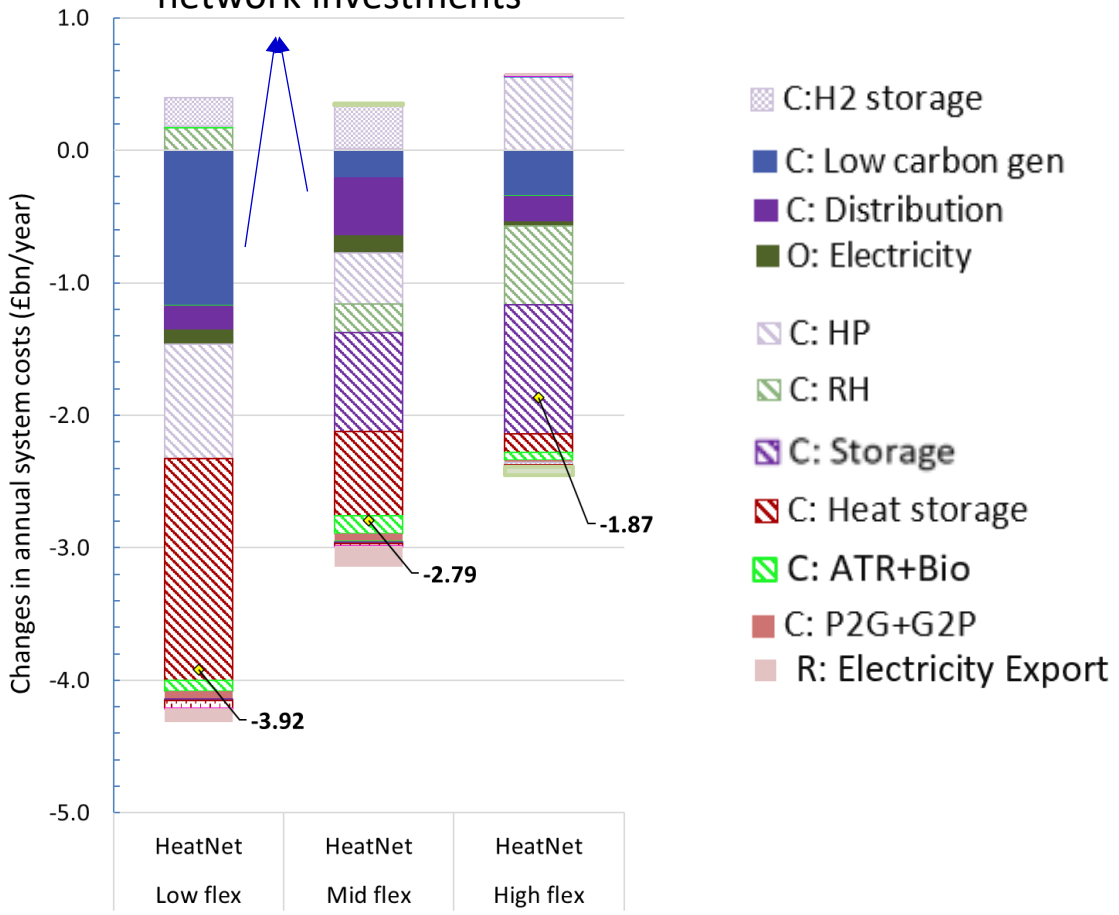
Well-insulated buildings' thermal storage can be used for preheating and shifting the heat-led electricity load, reducing electricity peak demand and network peak load.

Building thermal storage reduces the need for dedicated domestic TES.

Value of HeatNet in systems with different level of distributed flexibility technologies

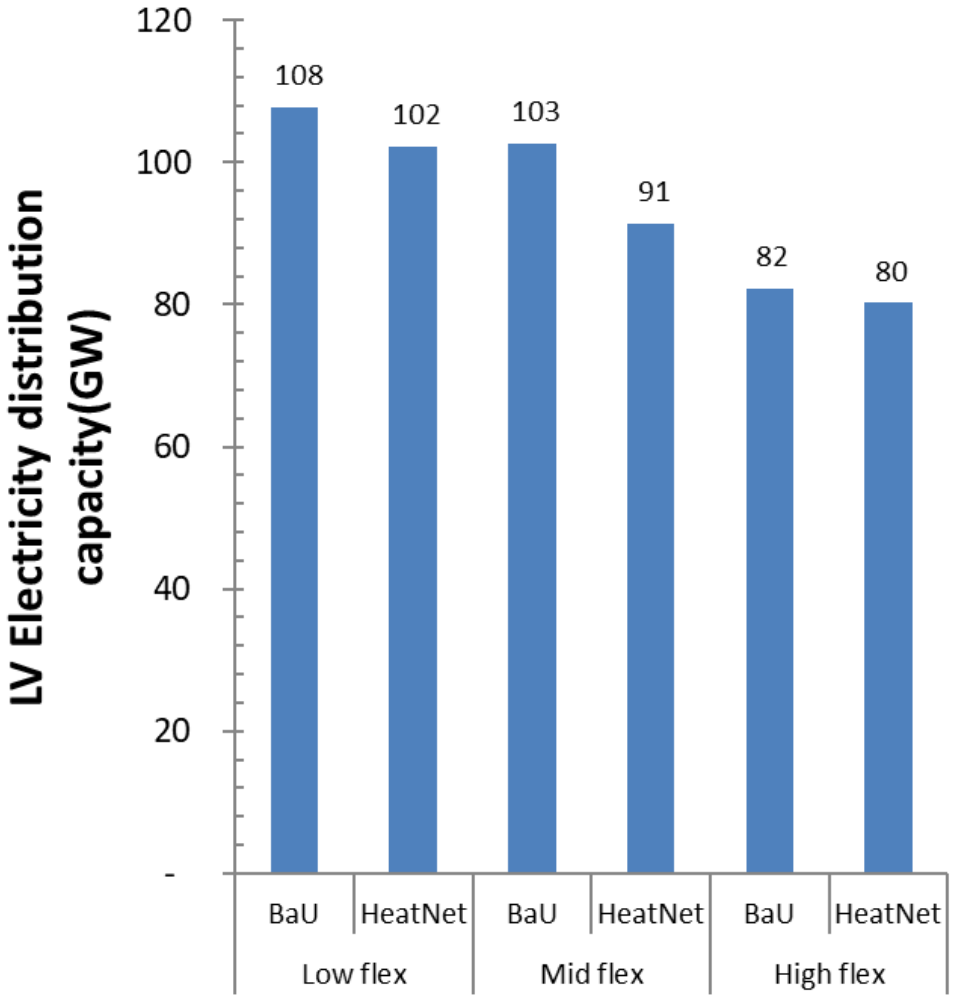


A trade-off between the use of flexibility in HeatNet to save low-carbon gen with distribution network investments



The value of HeatNet is high if the system does not have sufficient flexibility from other demand response technologies or distributed electricity storage.
Other distributed flexibility resources reduce the value of HeatNet's flexibility services.

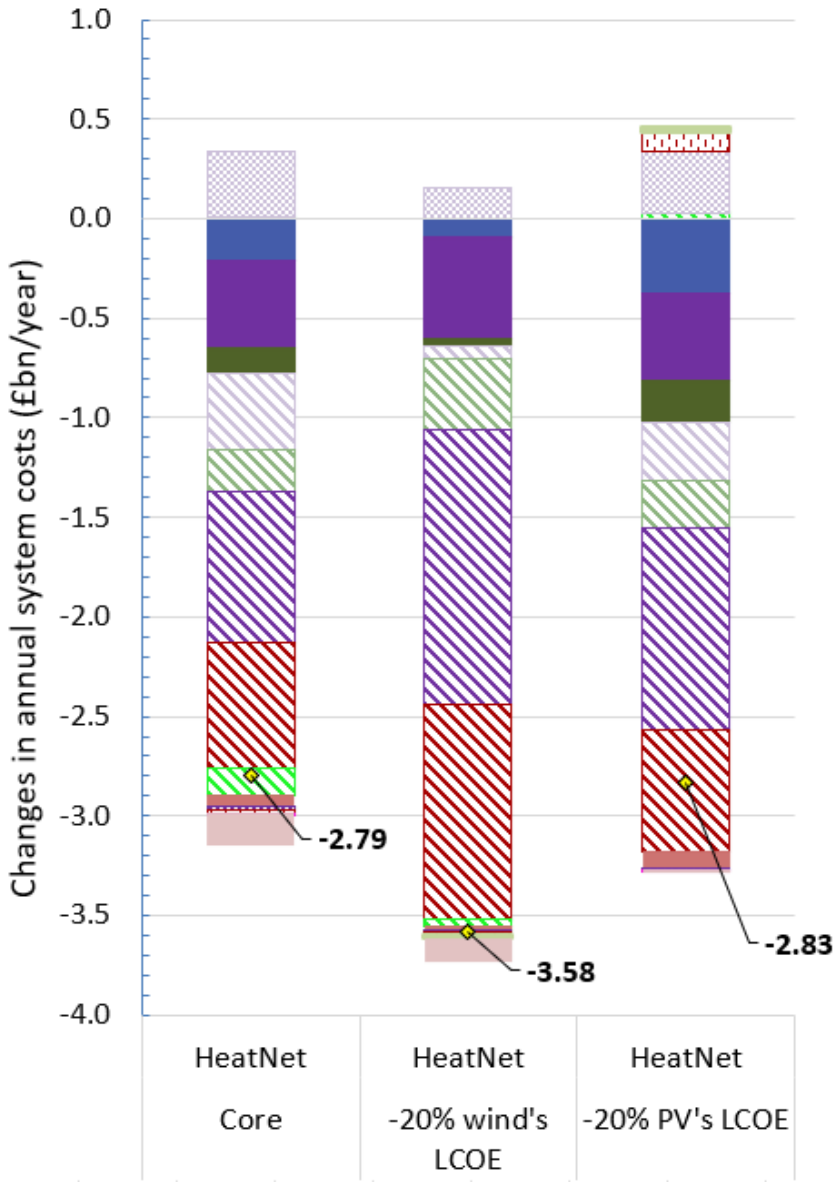
Impact of HeatNet on the peak electricity demand in systems with different flexibility from demand response and distributed storage technologies



HeatNet’s distribution network flexibility services are more significant in the system, with limited flexibility provided by other demand response and distributed storage technologies.

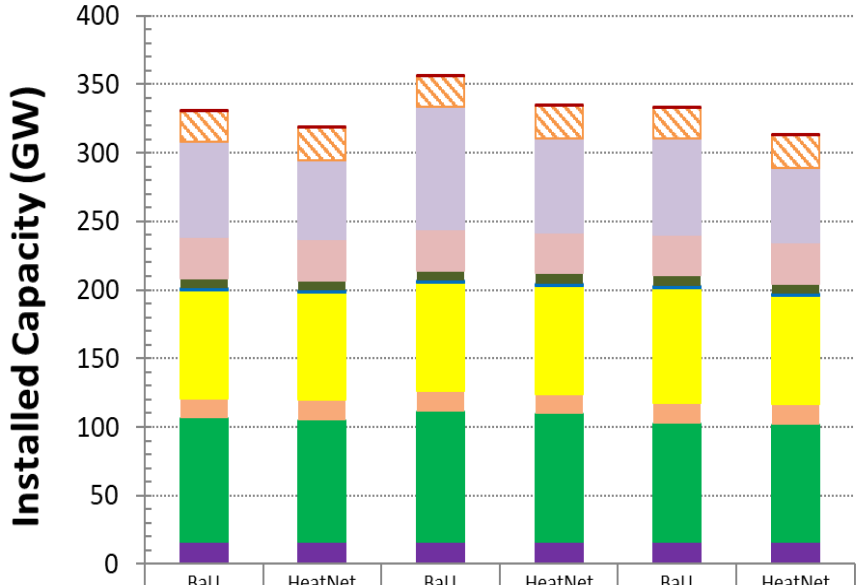
The high volume of demand response technologies, such as smart EVs, smart appliances, and BESS, limits HeatNet's impact on reducing the electricity peak demand at Low Voltage.

Sensitivity of HeatNet's system value to the changes in wind and PV's LCOE



- Lower cost of variable renewables tends to increase demand for system flexibility
- Improve the value of HeatNet's flexibility services

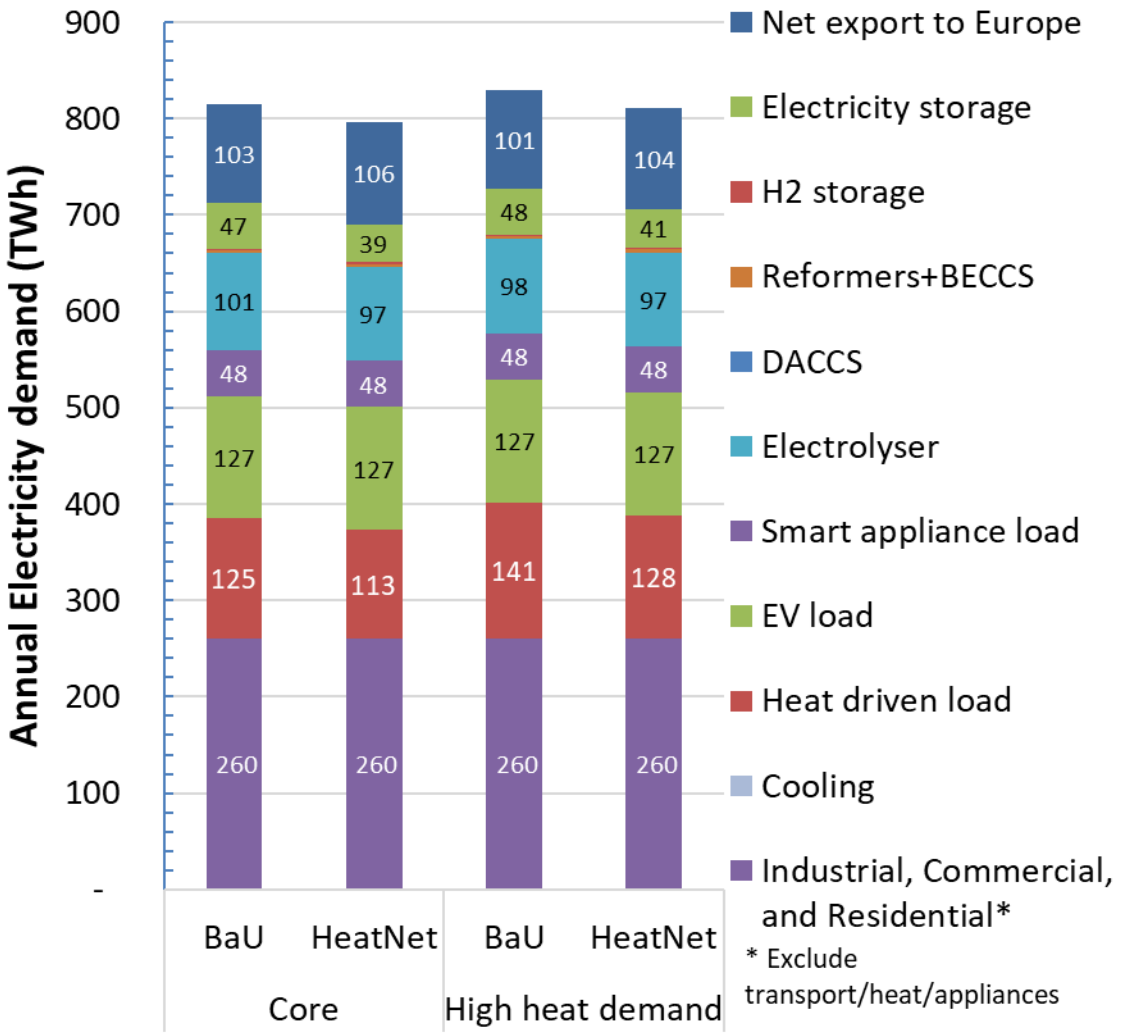
Most of the HeatNet's value comes from the savings in energy storage.

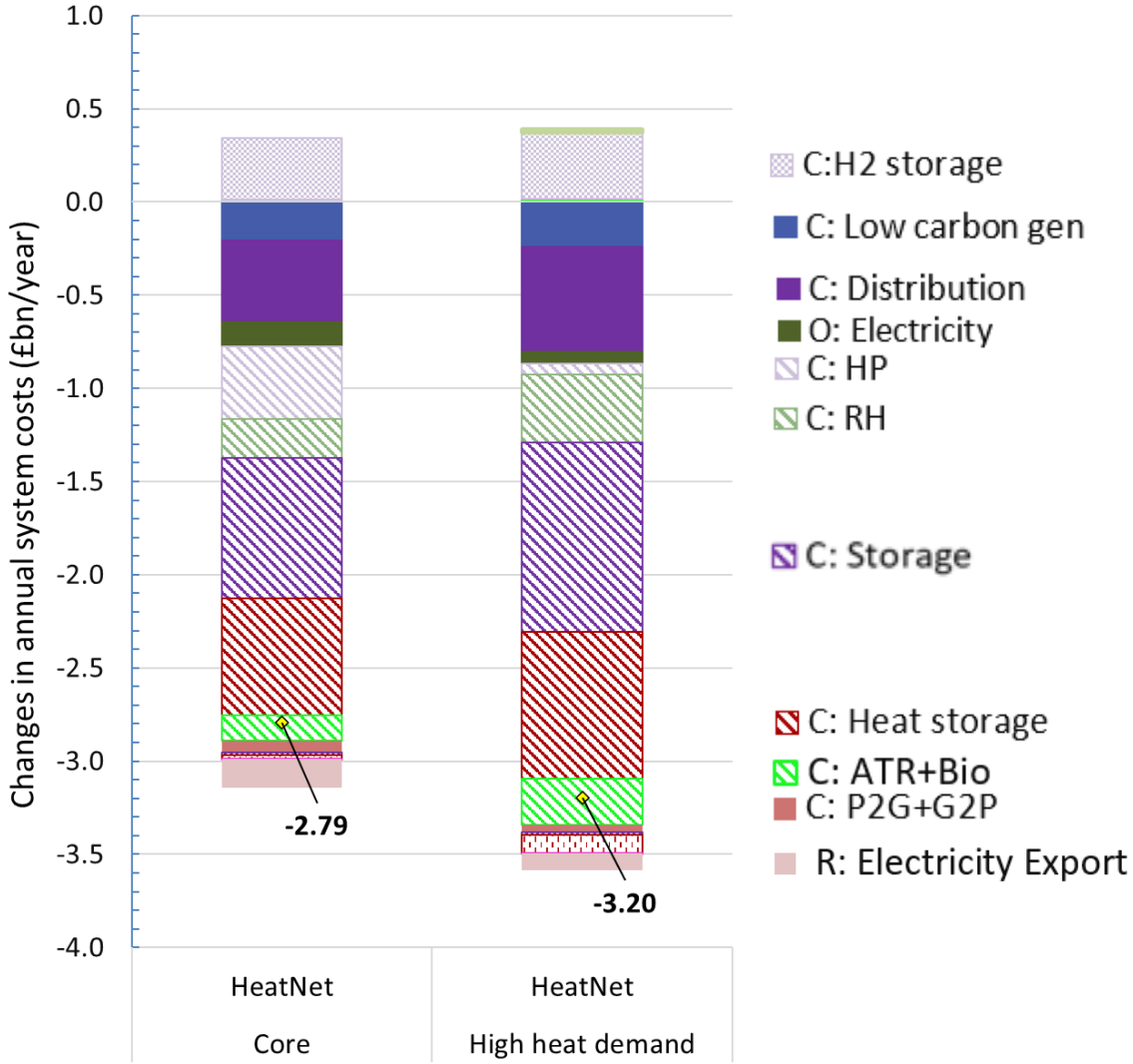


	Core		-20% wind's LCOE		-20% PV's LCOE	
	BaU	HeatNet	BaU	HeatNet	BaU	HeatNet
OCHT	0.2	0.2	0.2	0.1	0.1	0.1
CCHT	22.6	23.8	22.1	23.6	22.2	23.9
Storage	69	58	89	68	69.7	54.1
CCS	30	30	30	30	30	30
Biomass CCS	7	7	8	8	8	7
Hydro	1	1	1	1	1	1
PV	79	79	79	79	84	79
Onshore Wind	15	15	15.01	15	15	15
Offshore Wind	90.1	88.6	95	93	87	85
Nuclear	16	16	16.00	16	16	16

While the changes in renewable capacity in the UK are not very significant, low-cost renewables also affect the gen portfolio in Europe, affecting the energy exchange across GB-Europe interconnectors.

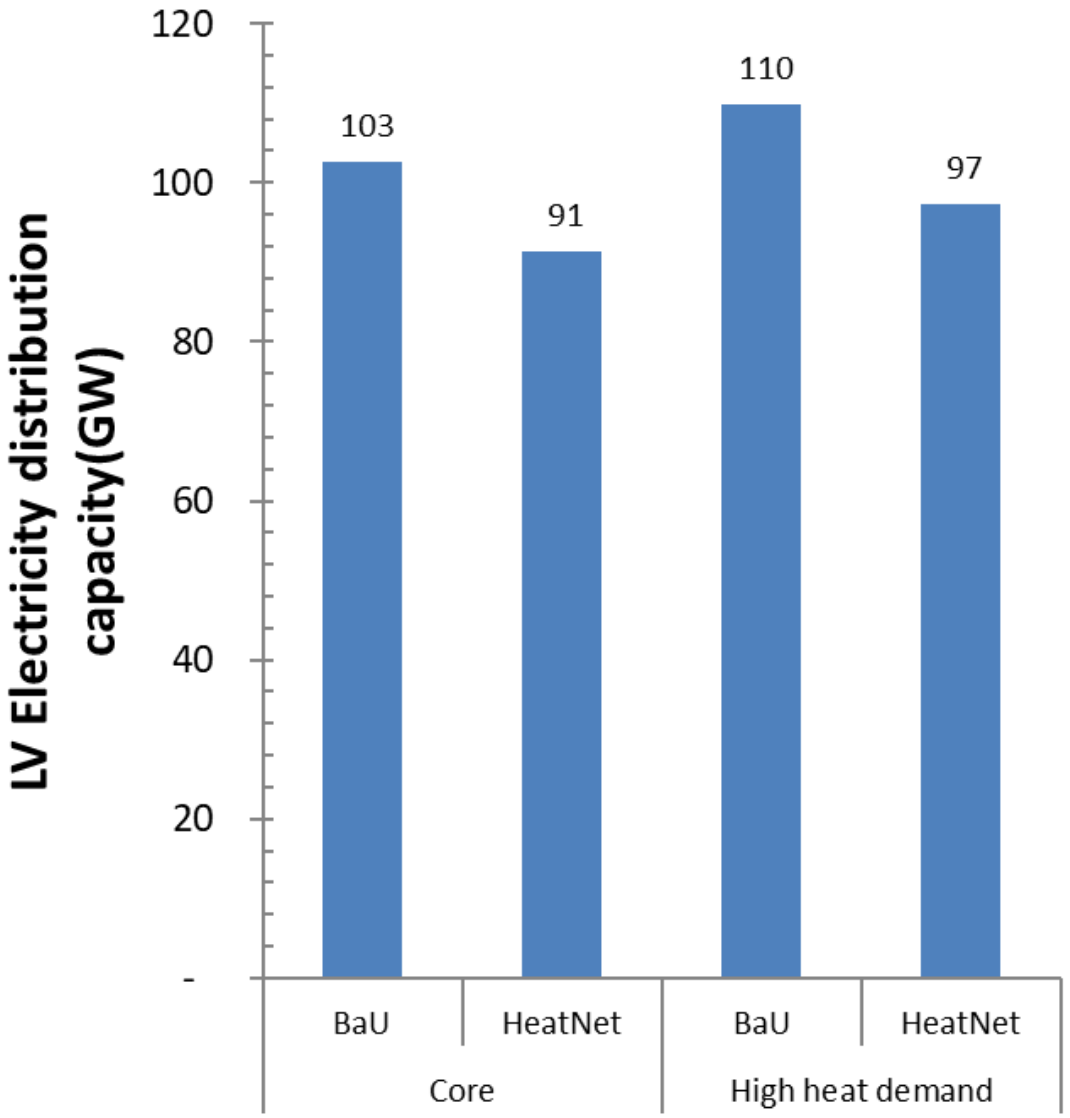
Impact of High Heat Demand on the Value of HeatNet



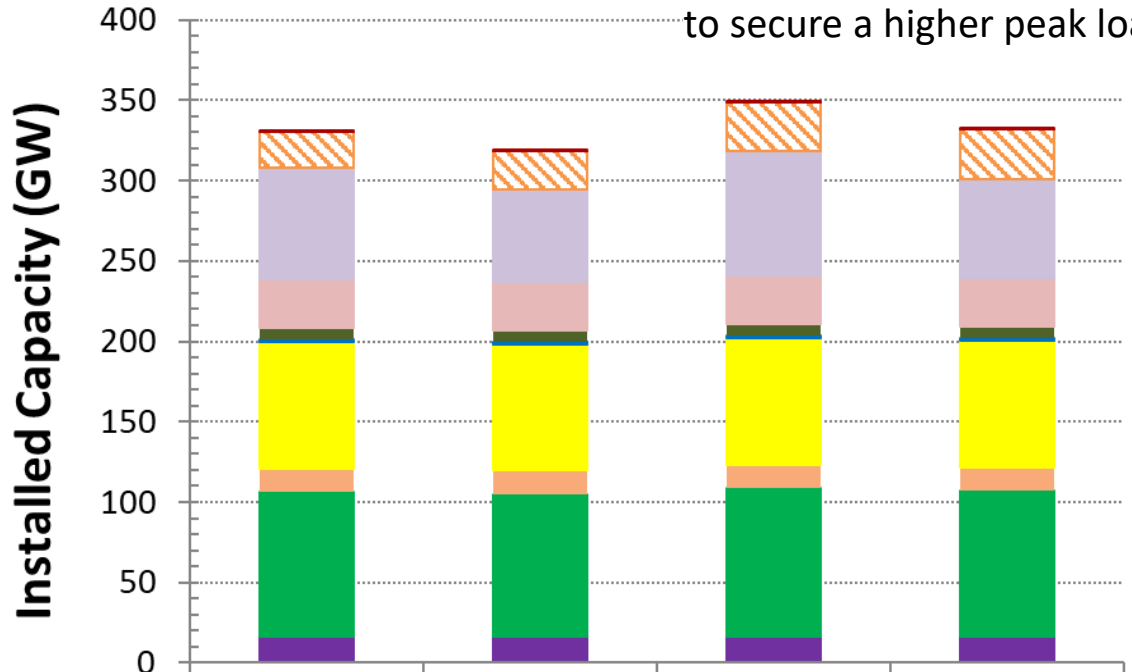


20% higher heat demand

High heat demand increases electricity peak load



More firm capacity is needed to secure a higher peak load.



	Core		High heat demand	
	BaU	HeatNet	BaU	HeatNet
OCHT	0.2	0.2	0.1	0.2
CCHT	22.6	23.8	30.3	30.6
Storage	69	58	77.8	62.1
CCS	30	30	30	30
Biomass CCS	7	7	7	7
Hydro	1	1	1	1
PV	79	79	79	79
Onshore Wind	15	15	15	15
Offshore Wind	90.1	88.6	92	91
Nuclear	16	16	16	16

Conclusions

- The whole-system benefit of HeatNet is up to £2.79bn/year by 2050.
  - Distribution network cost savings are only 16% of the total benefit.
  - HeatNet reduces the customer's heating appliance and energy system costs.
  - Less investment in low-carbon generation and flexibility technologies (such as energy storage)
  - Reduction in heat-led electricity annual demand (10%) and peak demand (11%)

- The value of HeatNet is in its flexibility services to support system needs and improve system efficiency
  - The flexibility from HeatNet is not always used to reduce distribution network reinforcement, but it is also used for system balancing and capturing renewables.
  - HeatNet also allows more heat pumps to be integrated faster than traditional control.

- System value of HeatNet depends on other flexibility technologies such as demand response and distributed storage
  - Low flexibility scenario:  £3.92bn/year (40% higher)
  - High flexibility scenario:  £1.87bn/year (33% lower)

- Value of HeatNet also increases in a system with:
  - Higher heat demand
  - Lower cost of renewables -> increasing demand for flexibility