Ulster University

Industrial Heat Pumps in the UK Current Constraints and Future Possibilities

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#1

NI UNIVERSITY FOR STUDENT SATISFACTION

(National Student Survey, 2018)

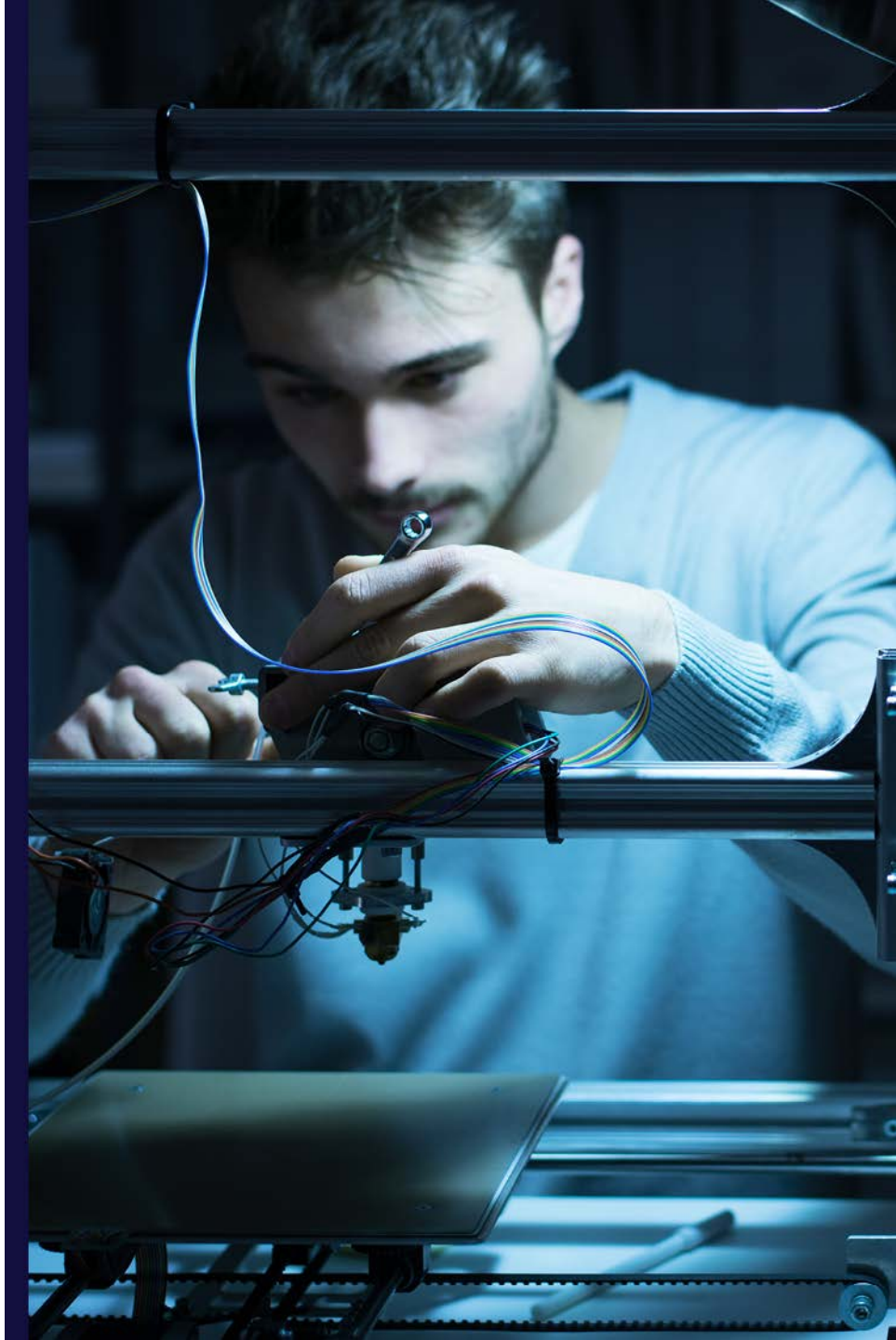
lonely planet

BELFAST & CAUSEWAY COAST

NUMBER ONE REGION IN THE WORLD TO VISIT 2018

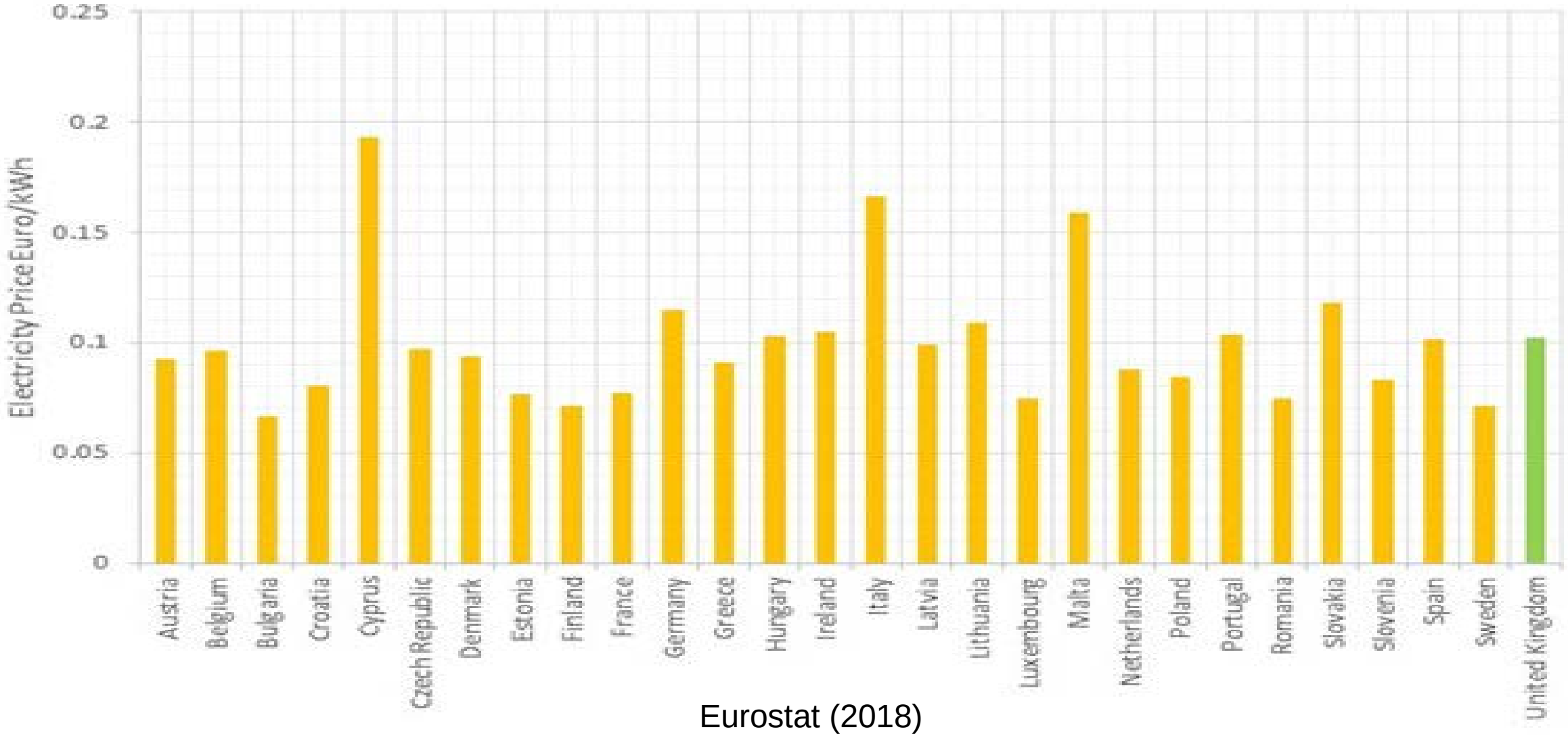
4

CAMPUSES ACROSS NORTHERN IRELAND



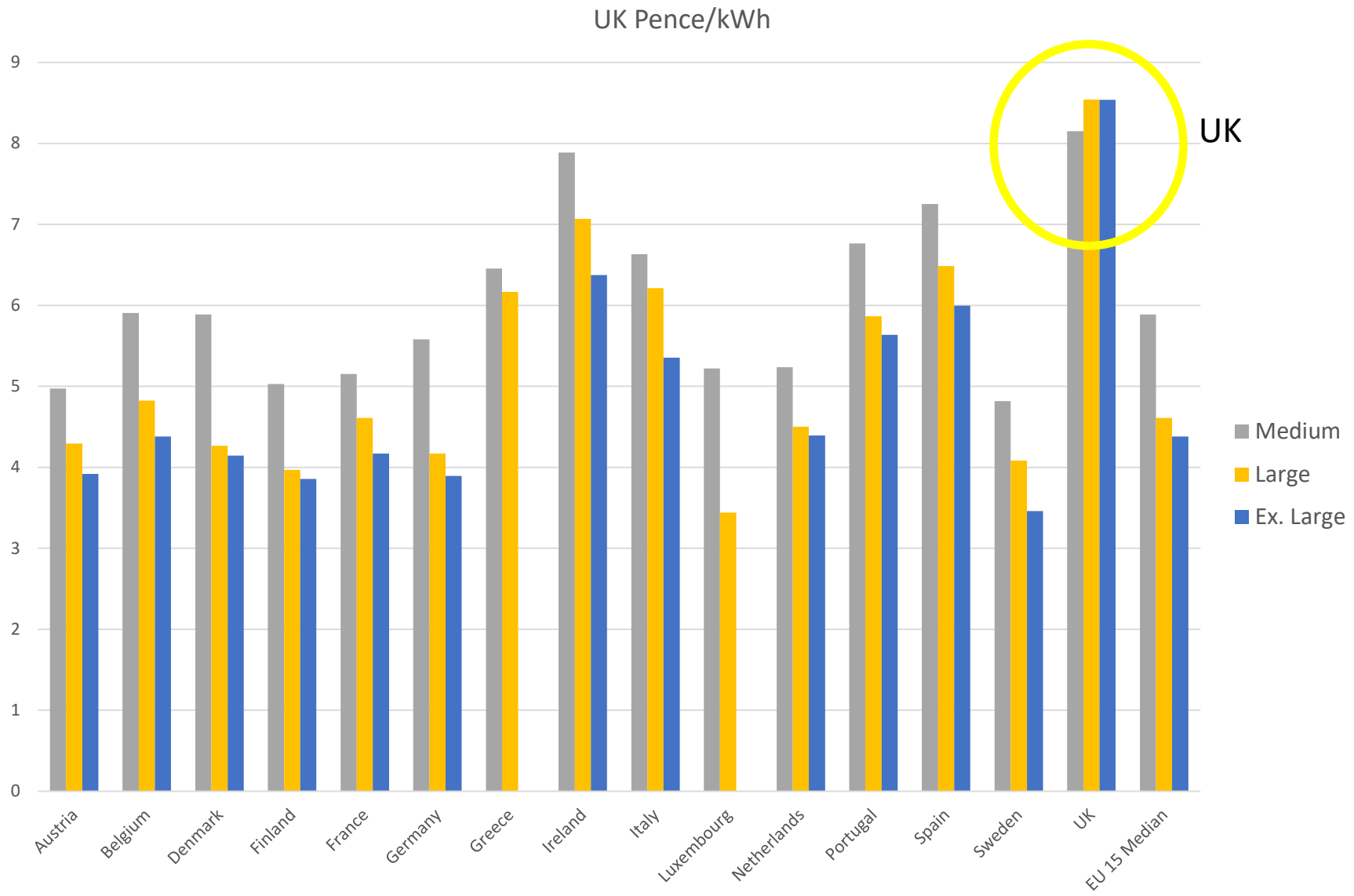
Energy Pricing in the UK

Energy Pricing in the UK - Electricity

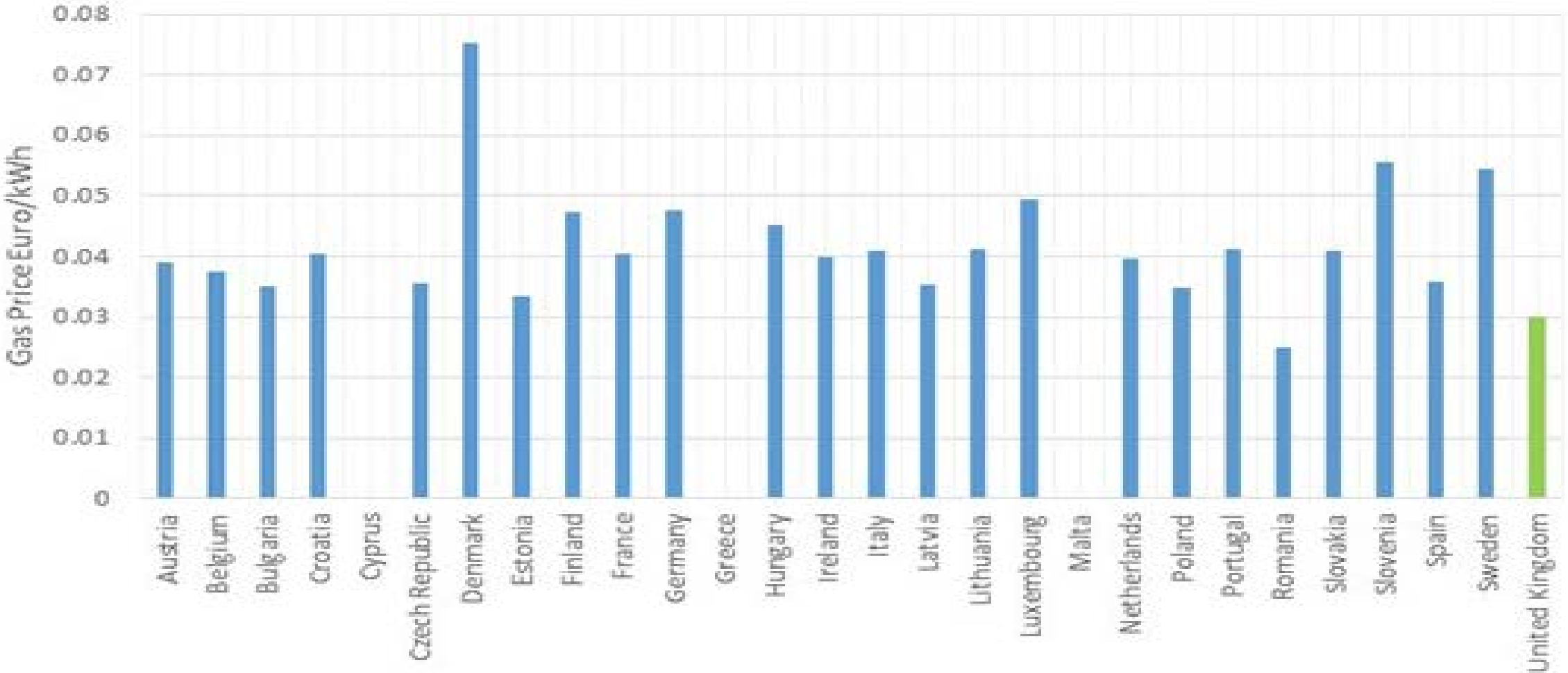


Eurostat (2018)

Electricity in the UK

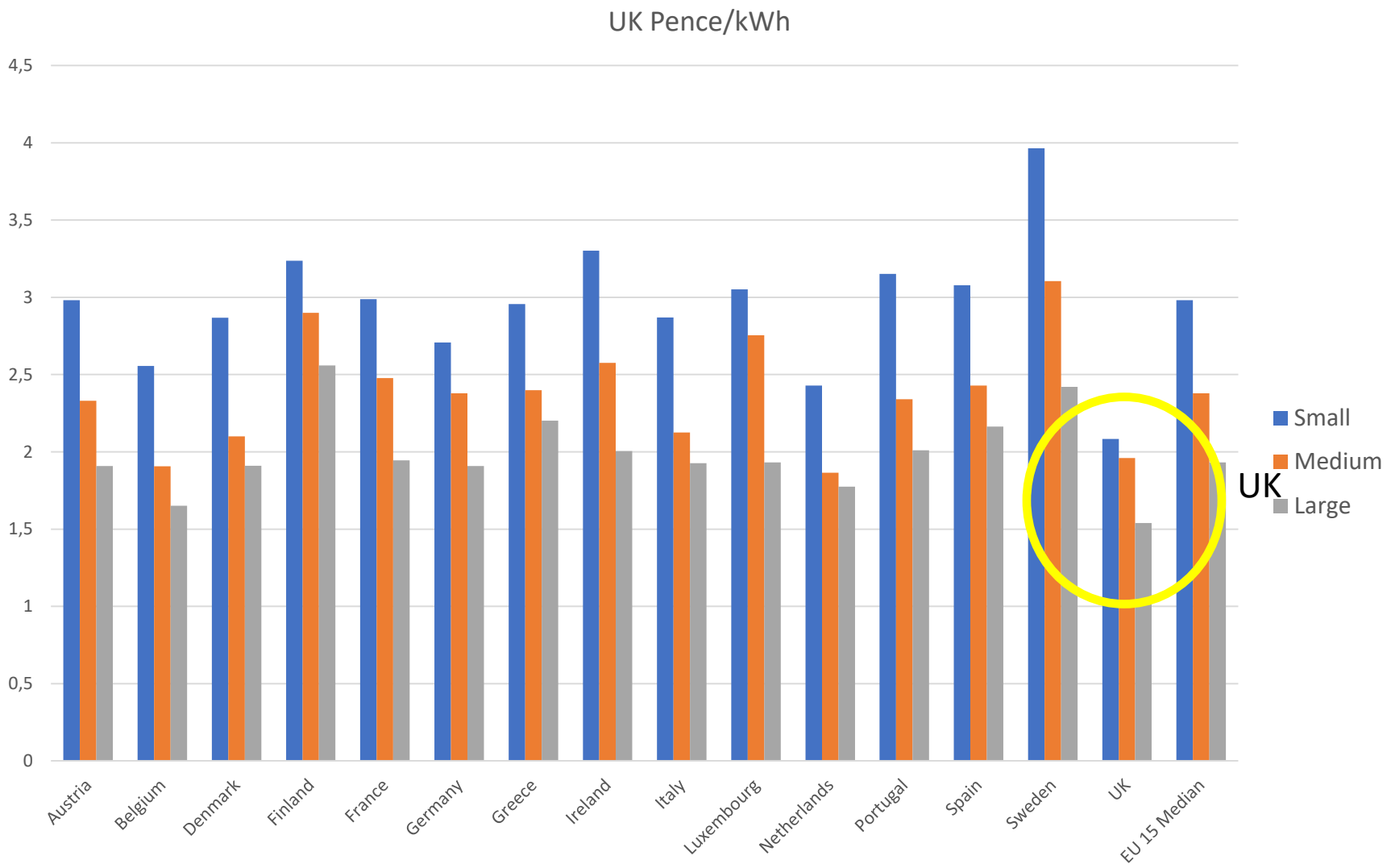


Energy Pricing in the UK - Gas



Eurostat (2018)

Energy Pricing in the UK - Gas



Energy Pricing in the UK

RHI **Commercial** paid over **20 years**	p/kWh from 1 Jan 2015	p/kWh from 1 Apr 2015	p/kWh from 1 Jul 2015	p/kWh from 1 Oct 2015	p/kWh from 1 Jan 2016	p/kWh from 1 Apr 2016	p/kWh from 1 Jul 2016	p/kWh from 1 Oct 2016	p/kWh from 1 Jan 2017	p/kWh from 1 Apr 2017	p/kWh from 1 Jul 2017	p/kWh from 1 Oct 2017	p/kWh from 1 Apr 2018
Solar thermal	10.0	10.16	10.16	10.16	10.16	10.28	10.28	10.28	10.28	10.44	10.44	10.44	10.75
GSHPs	8.7	8.84	8.84	8.84	8.84	8.95	8.95	8.95	8.95	9.09	9.09	9.09	9.36
ASHPs	2.5	2.54	2.54	2.54	2.54	2.57	2.57	2.57	2.57	2.61	2.61	2.61	2.69
Biomass[1]	6.8[1]	5.87[1]	4.40[1]	4.18[1]	3.76[1]	3.62[1]	3.26[1]	3.10[1]	2.91[1]	2.85[1]	2.71[1]	2.96[1]	3.05[1]

RHI rates published by Ofgem – rates change with inflation each year from April.

RHI rates for ground source heat pumps fall to 2.79p for use over 15% of the full rated annual capacity.

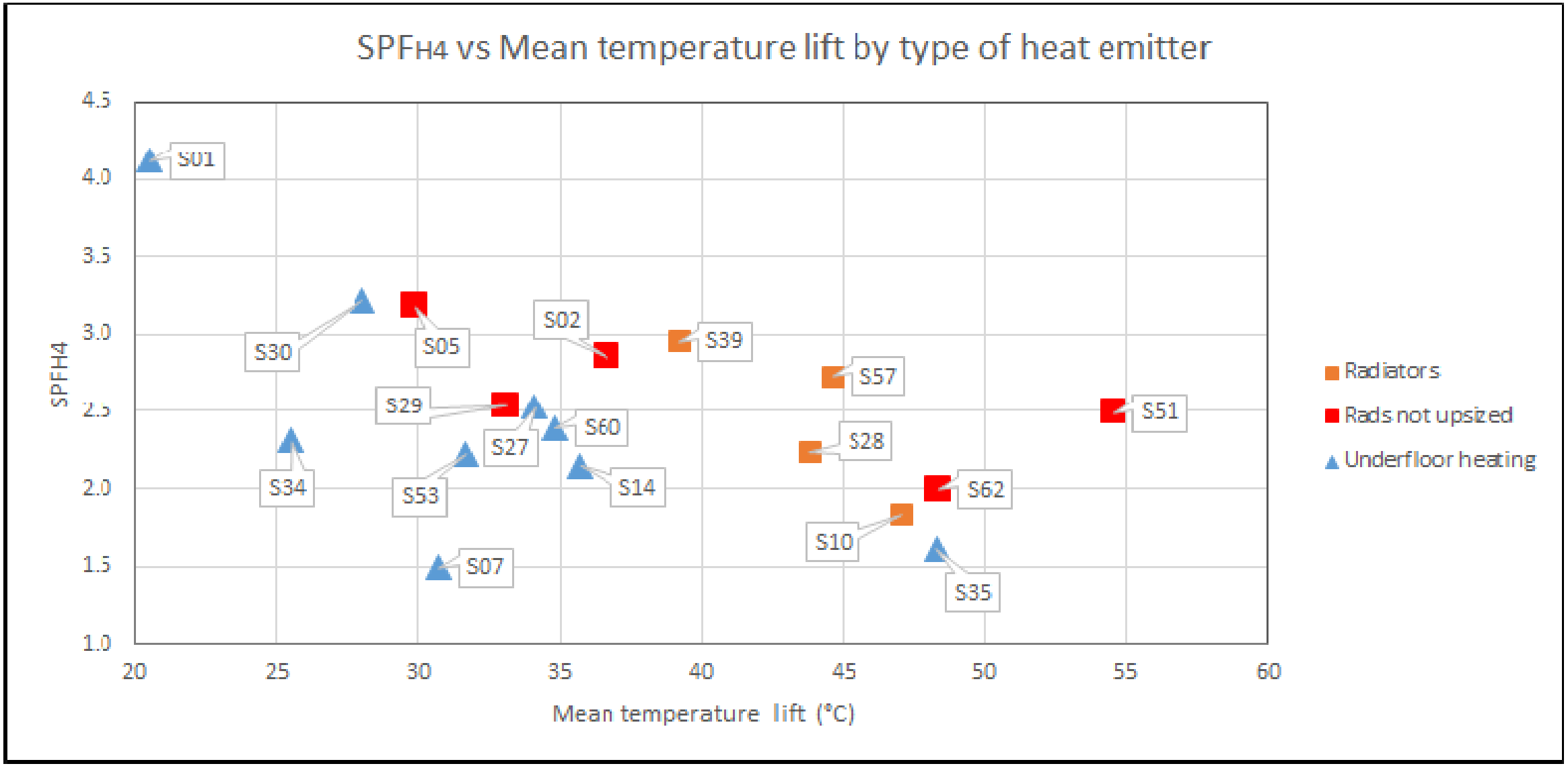
[1] RHI rates for biomass fall to 2.14p for use over 35% of the full rated annual capacity.

[1] RHI tariff for biomass has fallen from 8.8 in June 2014 down to 3.05p from 1 April 2018.

UK Industrial Heat Pump Performance

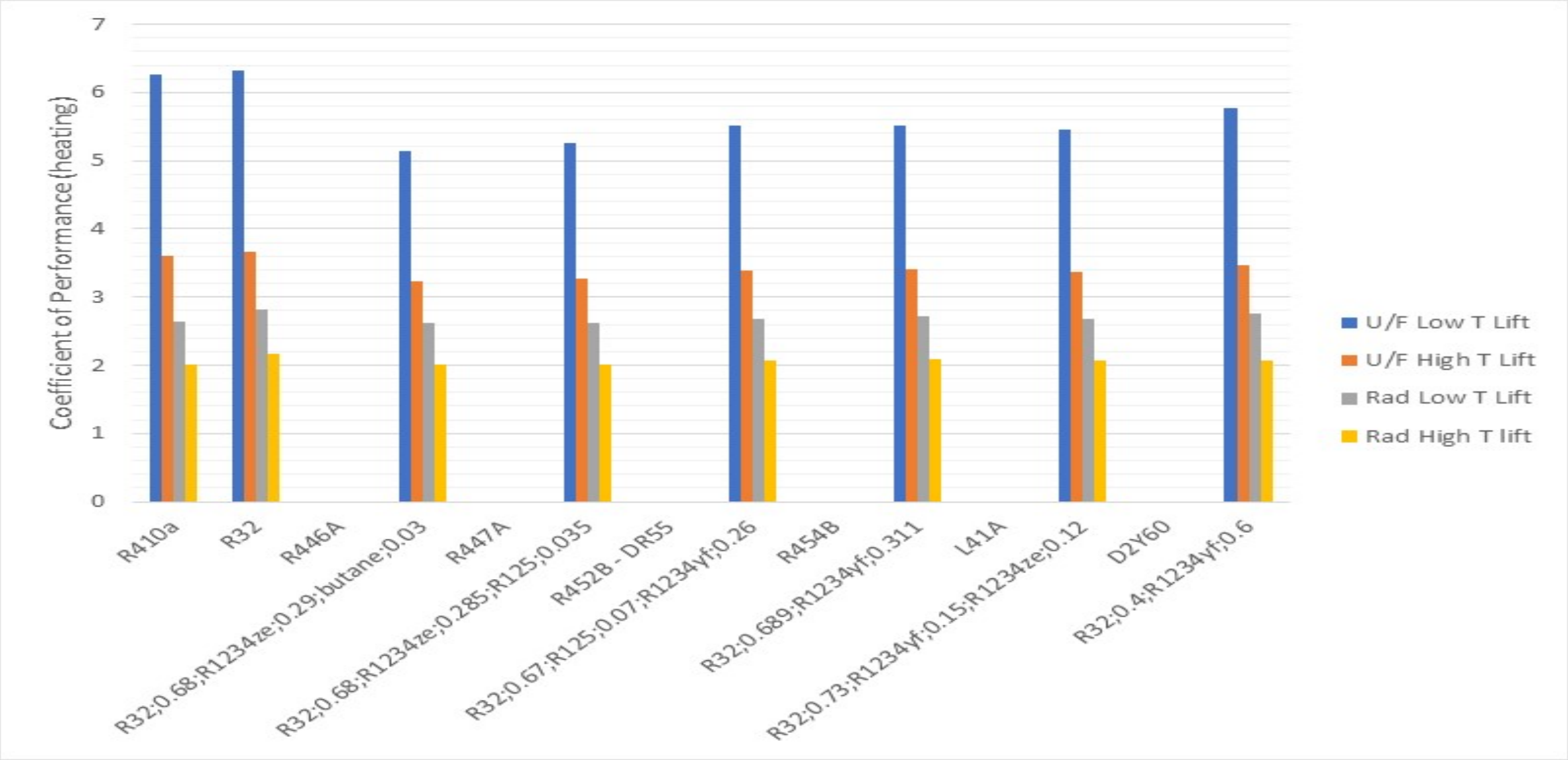
Seasonal Performance (Hughes, 2018)

Seasonal Performance (Hughes, 2018)



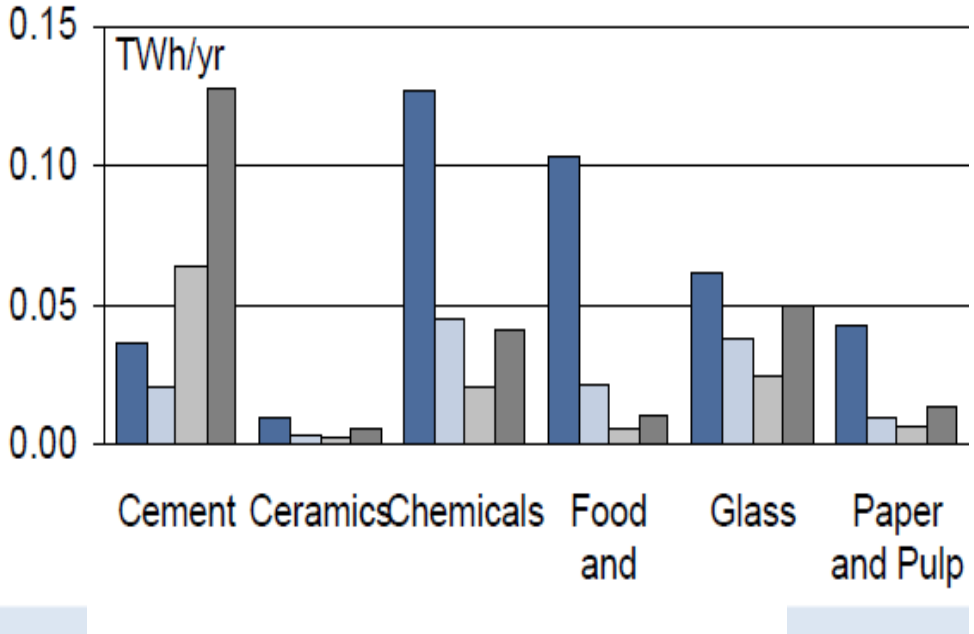
Replacing R410A

R410A Replacement

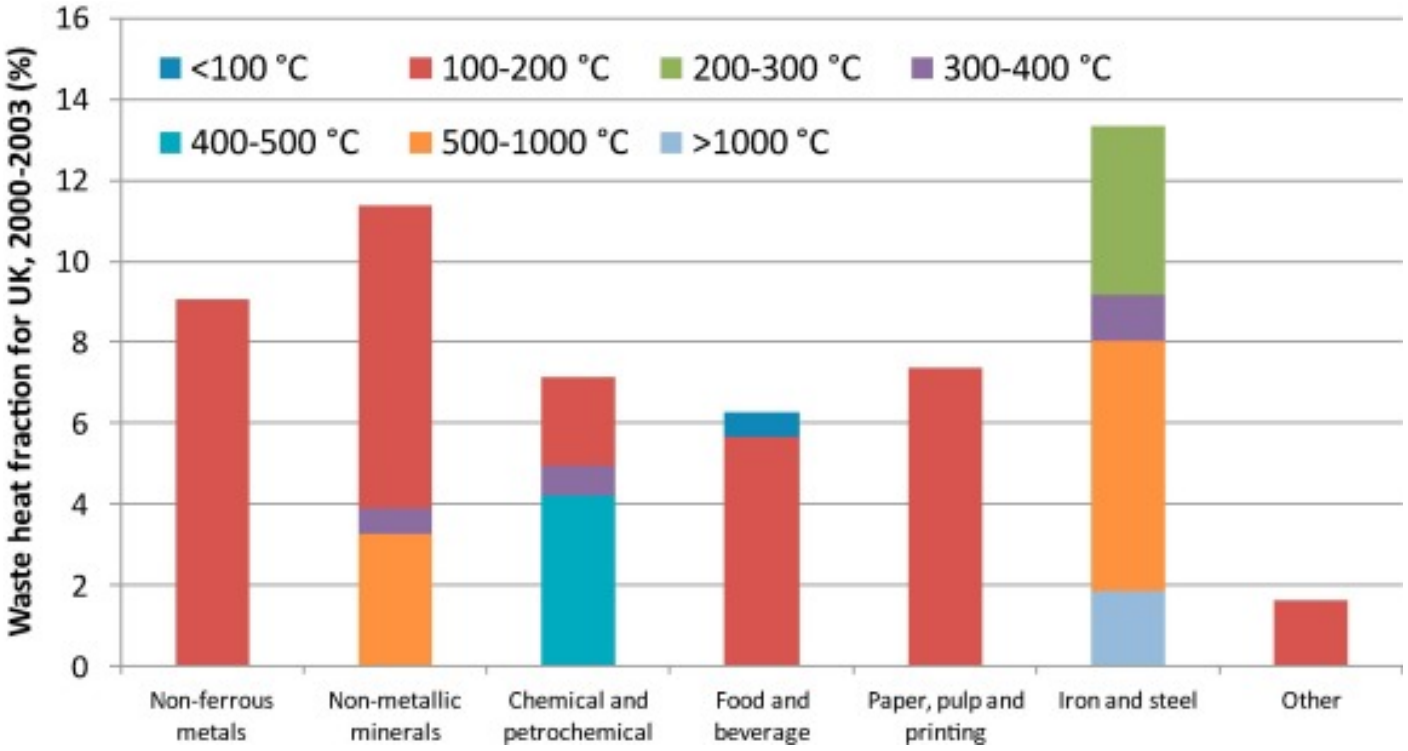


And Waste Heat?

Waste Heat Potential in the UK



McKenna et al., Energy Policy 38, 5878 (2010)



The potential for recovering and using surplus heat from industry Final Report for DECC 05/03/2014 Led by Element Energy Limited

Waste Heat Potential in the UK

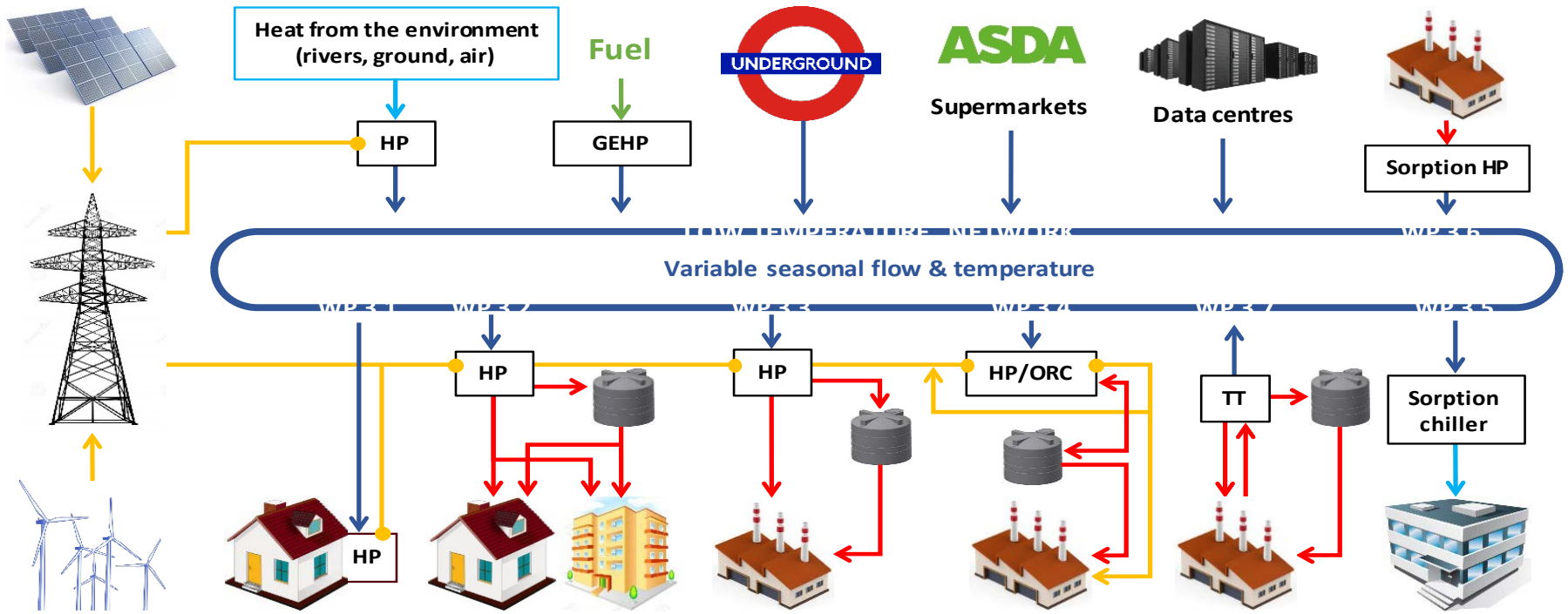
However there are disparities in the capacities….

Element Energy 300 TWh of industrial heat with 1/6 wasted	= **50 TWh/y**
Element Energy state that for district heating	= **28 TWh/y**
Element Energy state that ¼ of this heat is recoverable	= **12.5 TWh/y**
Cooper et al state that max. recoverable energy in DH	= **7.5 TWh/y**

Limitations identified by Cooper et al (2015) include temperature, distance of networks, heat losses, seasonal needs and economics.

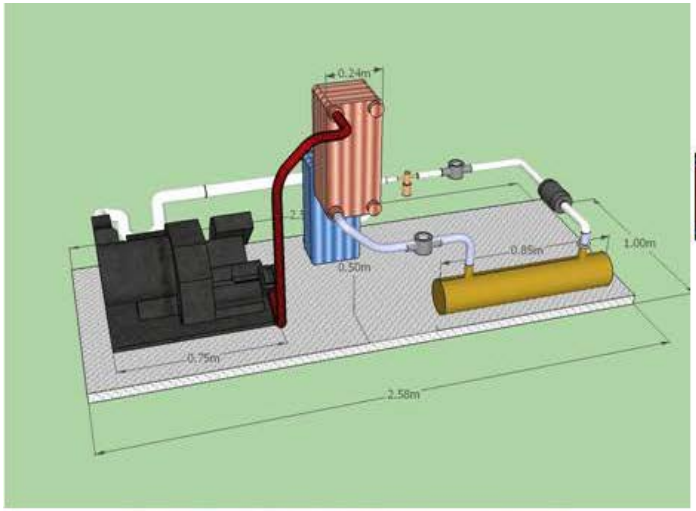
Booster Heat Pumps

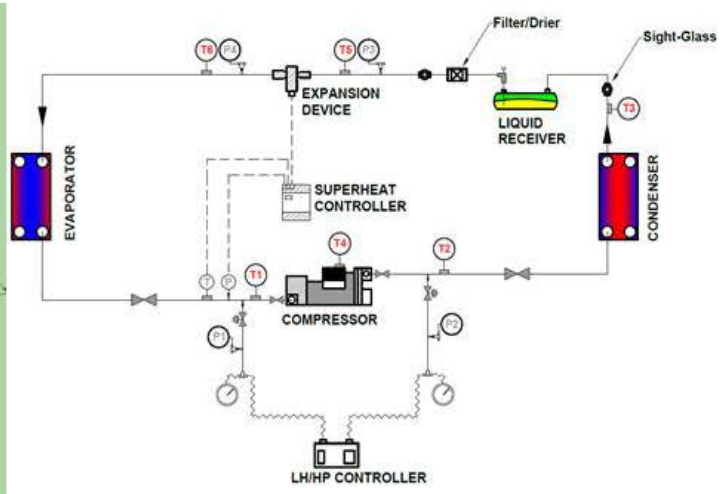
For upgrading low grade heat



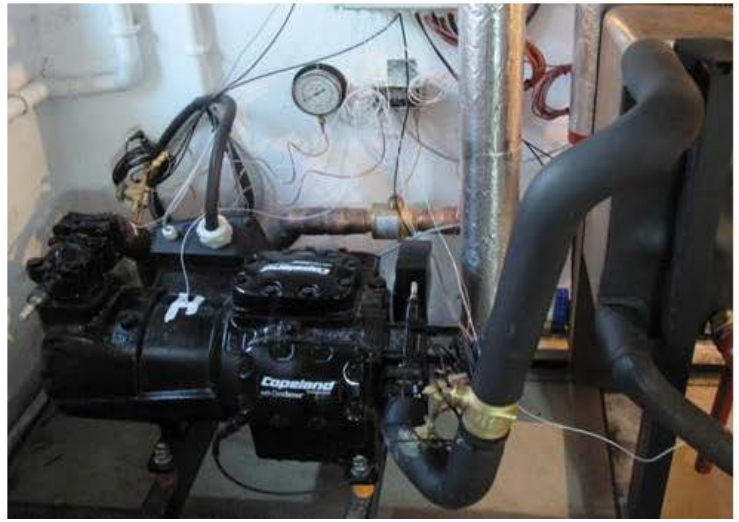
LoT-NET

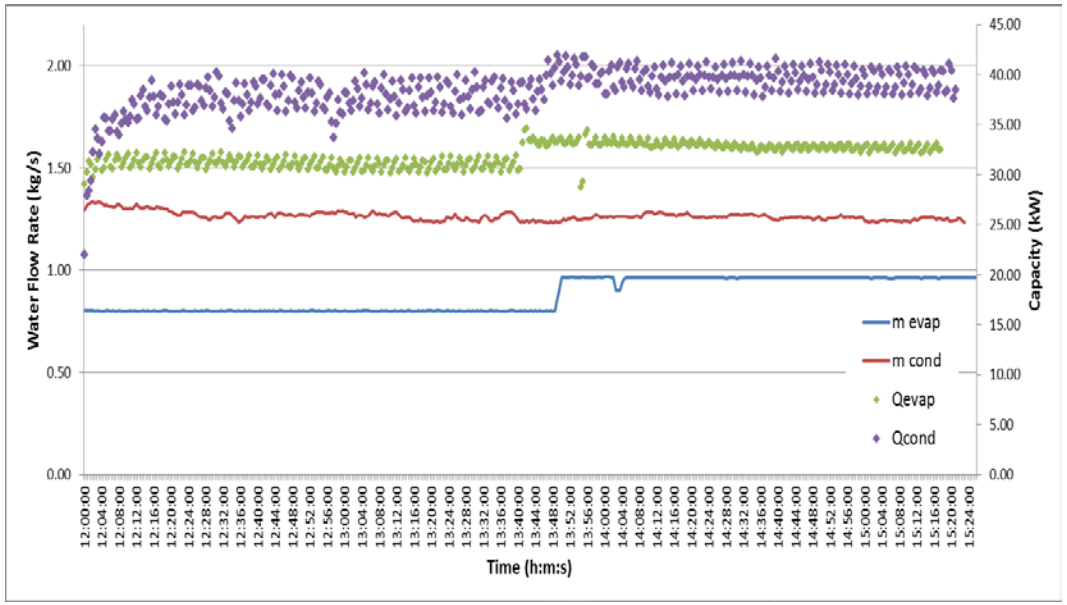
R245fa Booster HP Research



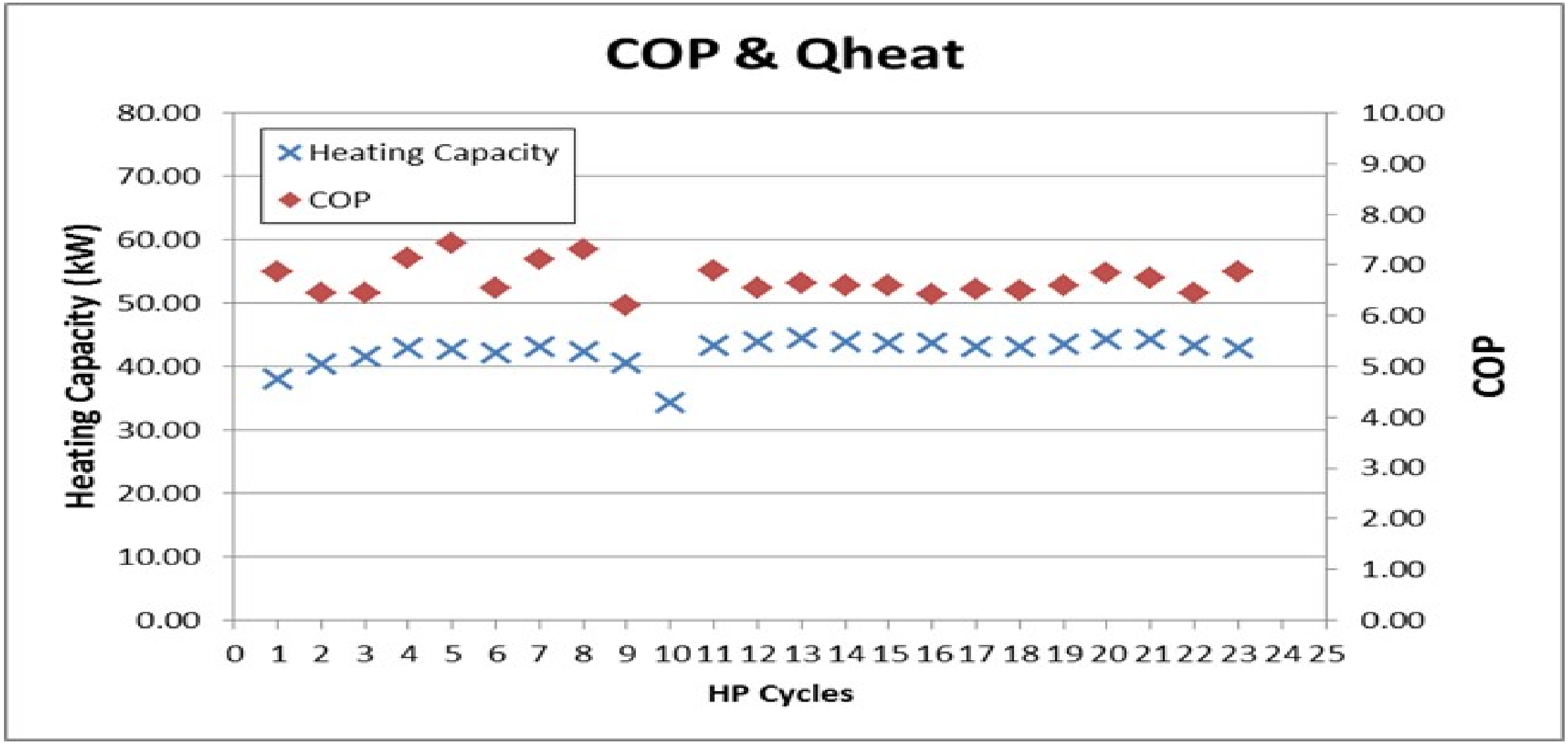


Evaporator		Condenser		POWER	Heat Cap.	COP
M	ΔT	M	ΔT	Win	Qcond	
kg/s	K	kg/s	K	kW	kW	kW/kW
0.8	9.26	1.26	7.16	6.93	37.75	5.45
0.96	8.18	1.26	7.52	7.12	39.58	5.56

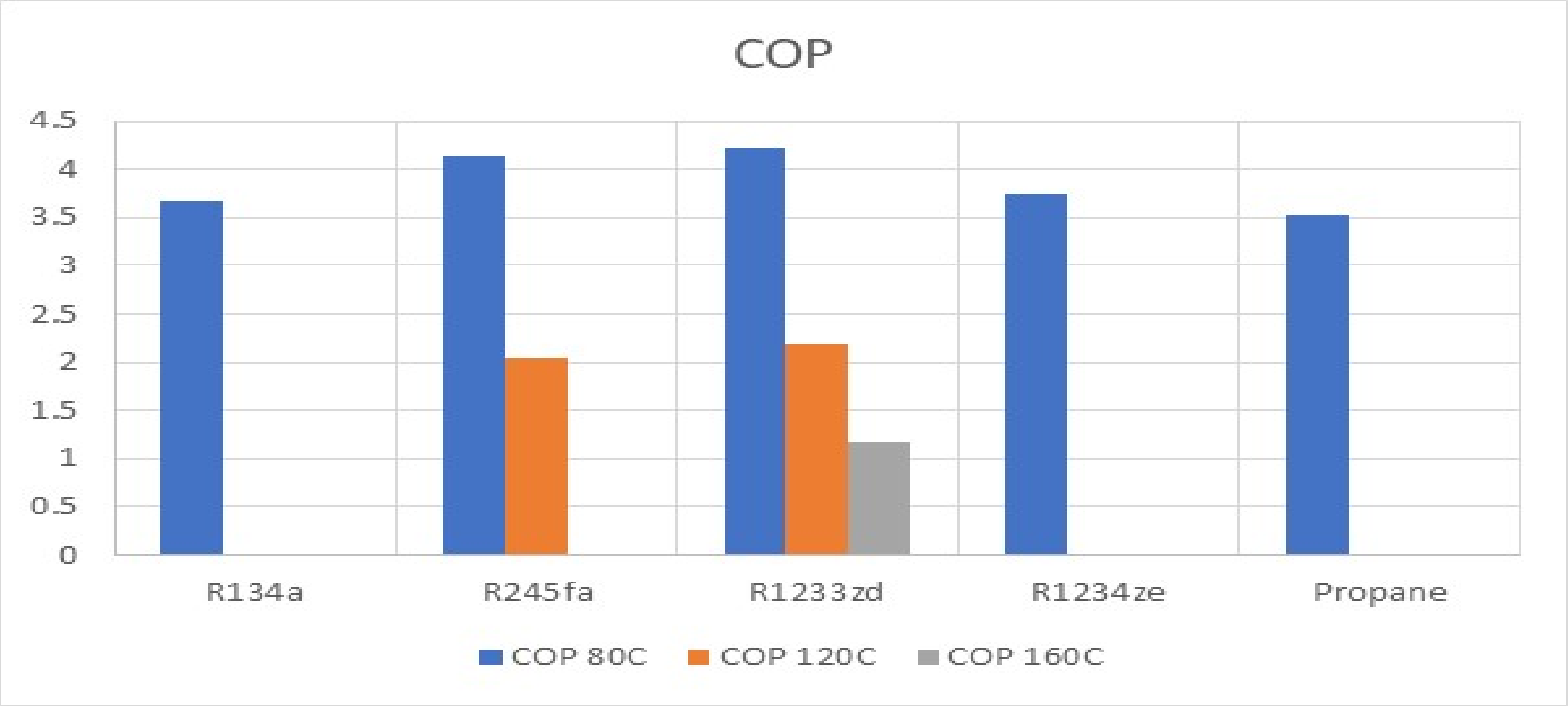




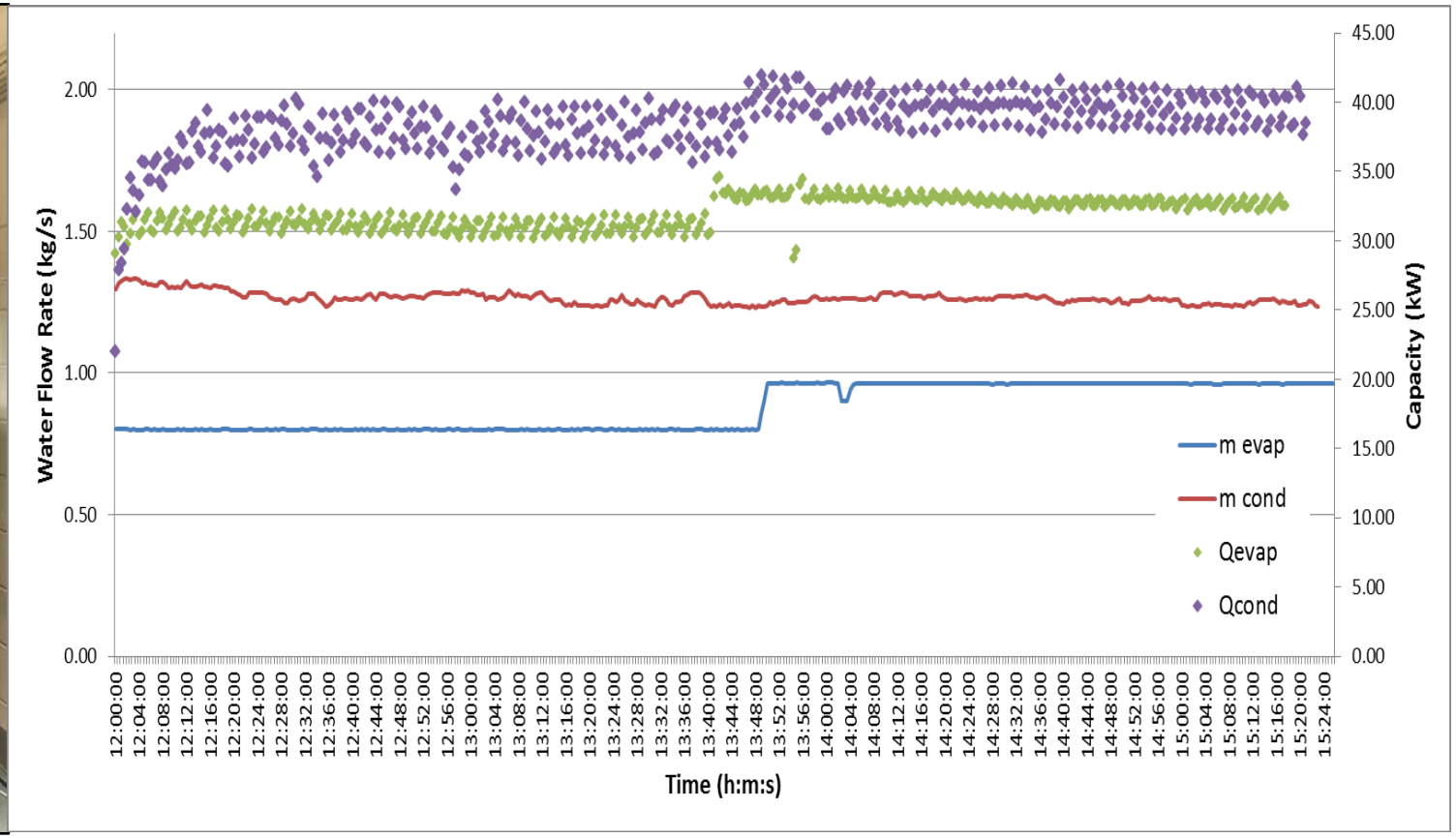
R245fa Booster HP Research



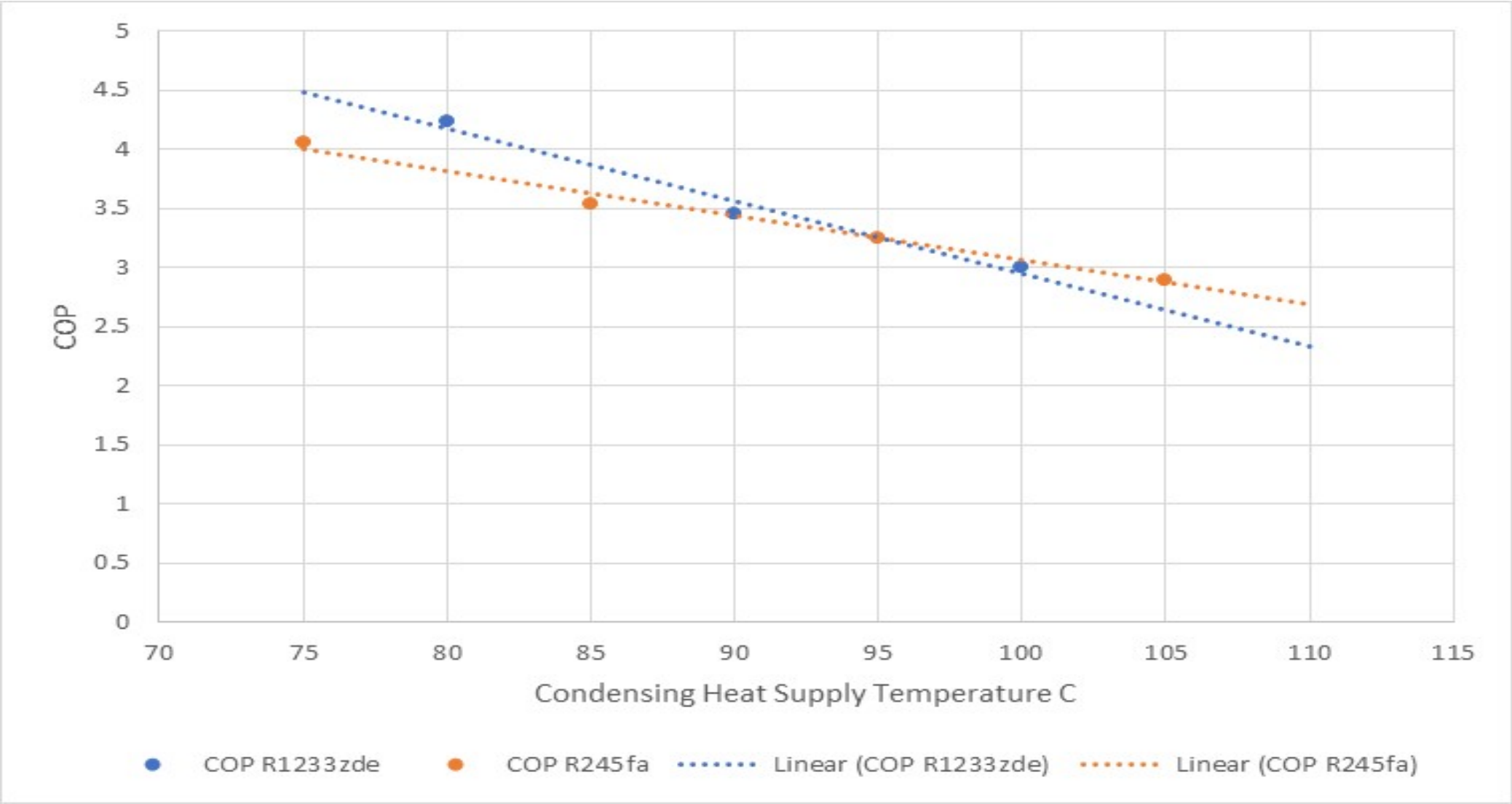
Replacing R245fa



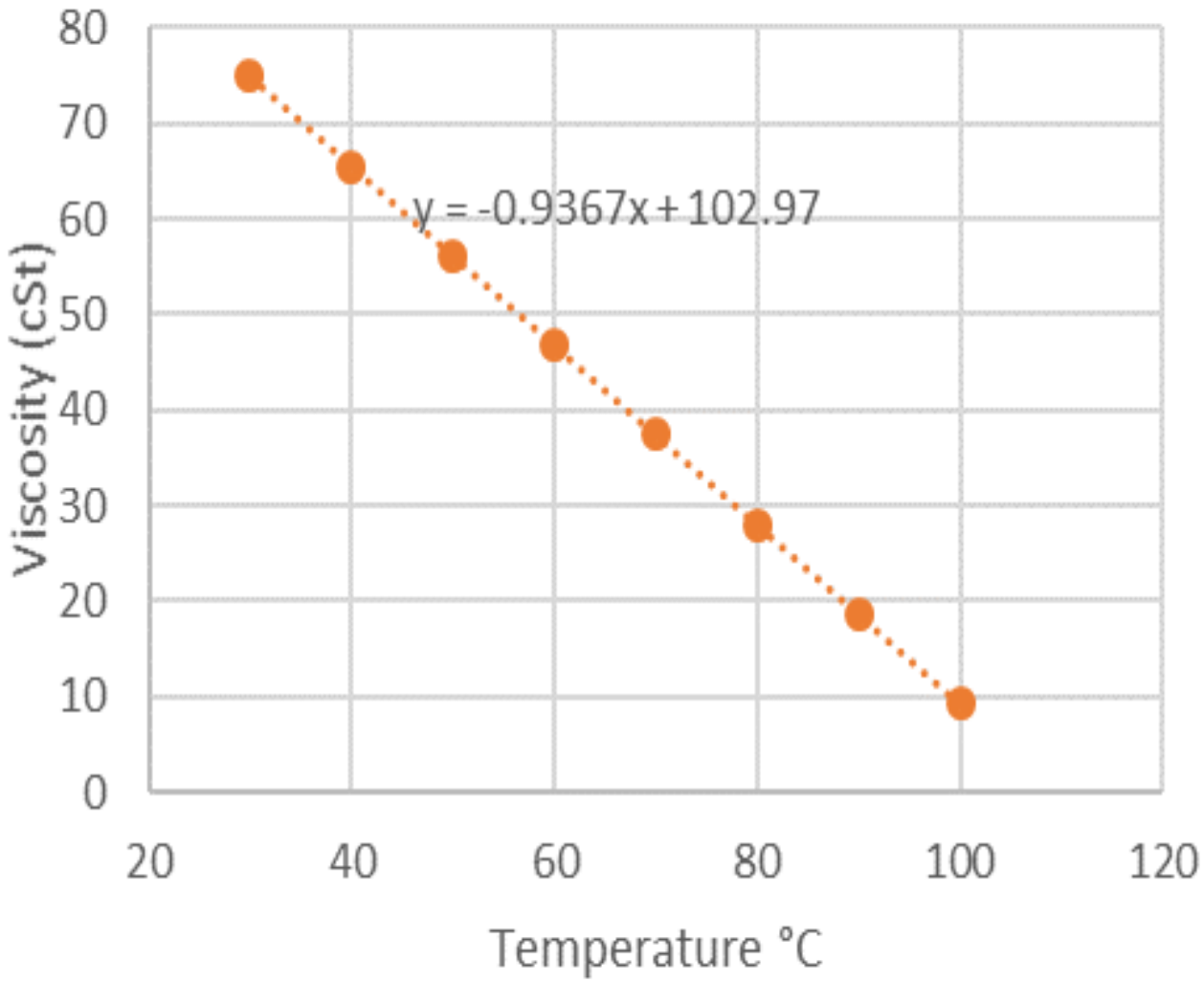
Replacing R245fa - Baseline



R1233zd(e) Performance



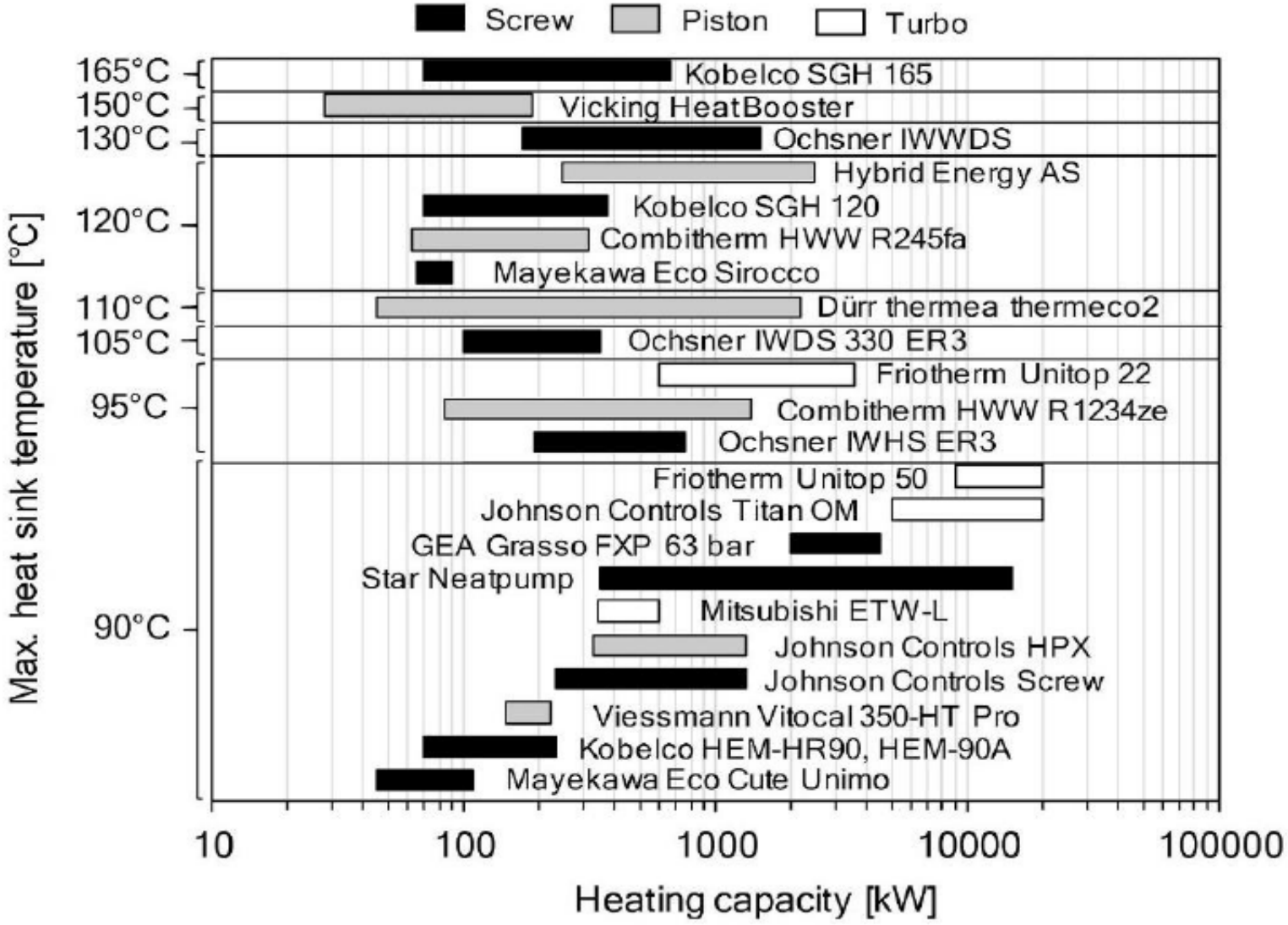
And Compressor Lubrication



POE68

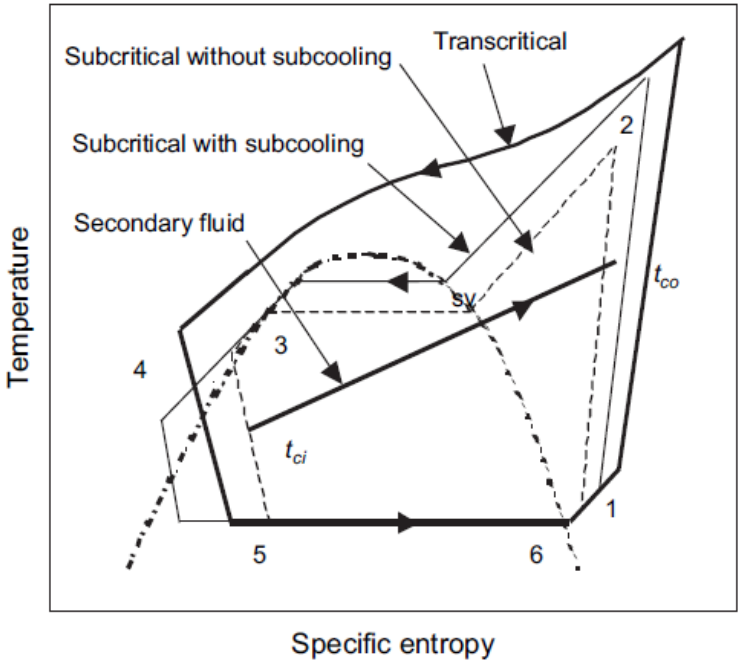
Oil Solubility and Transport Observations

State of the Art

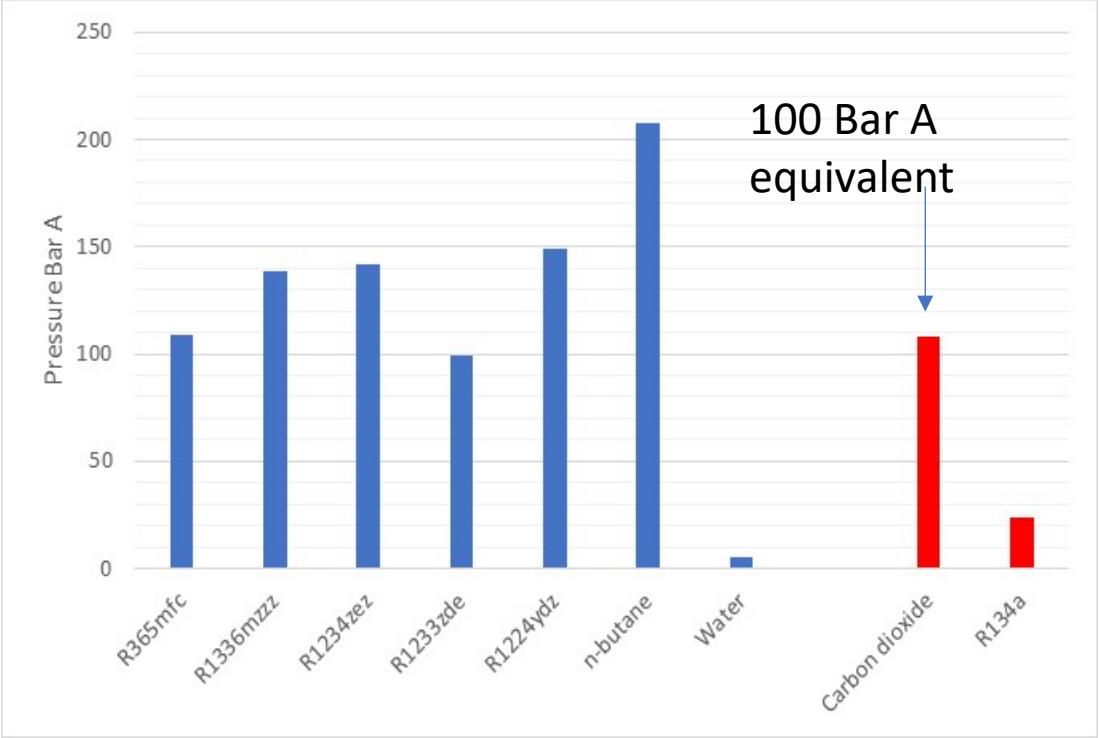


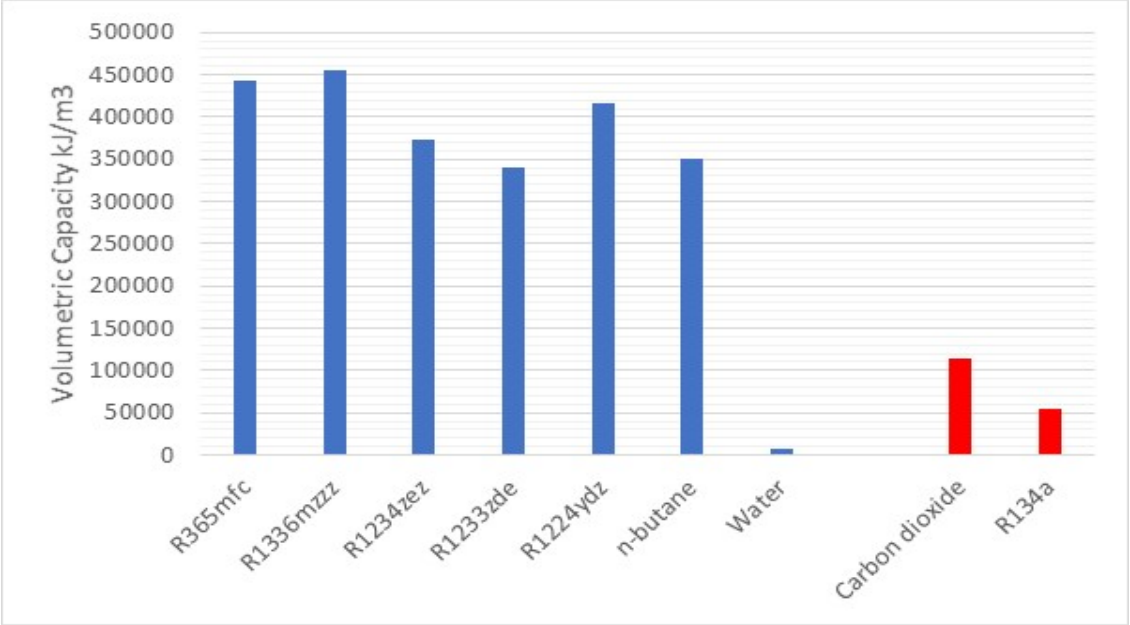
C. Arpagaus, F. Bless, M. Uhlmann, J. Schiffmann and S. Bertsch, “High temperature heat pumps: Market overview, state of the art, research status, refrigerants, and application potentials,” Energy, vol. 152, pp. 985-101, 2018.

And 200˚C?



Sarkar et al, 2007





And I have great help

Ulster University has been working with heat pumps since 1975 and in the last 10 years has attracted > £10M R&D funds

We have watched the COP grow from 2.0 to 7.0 (application dependent)

We have worked with many working fluids and their respective compressor lubricants

We work with energy markets i.e. demand side response while satisfying thermal comfort and hot water demands through thermal storage

We intend to push to 200˚C and more for industrial applications

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CAMPUSES ACROSS NORTHERN IRELAND

Heat Pump Team @ Ulster:

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Dr Chris Wilson
Dr Donal Cotter

Energy Markets & Networks
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Dr I Vorushylo
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PhD Scholars
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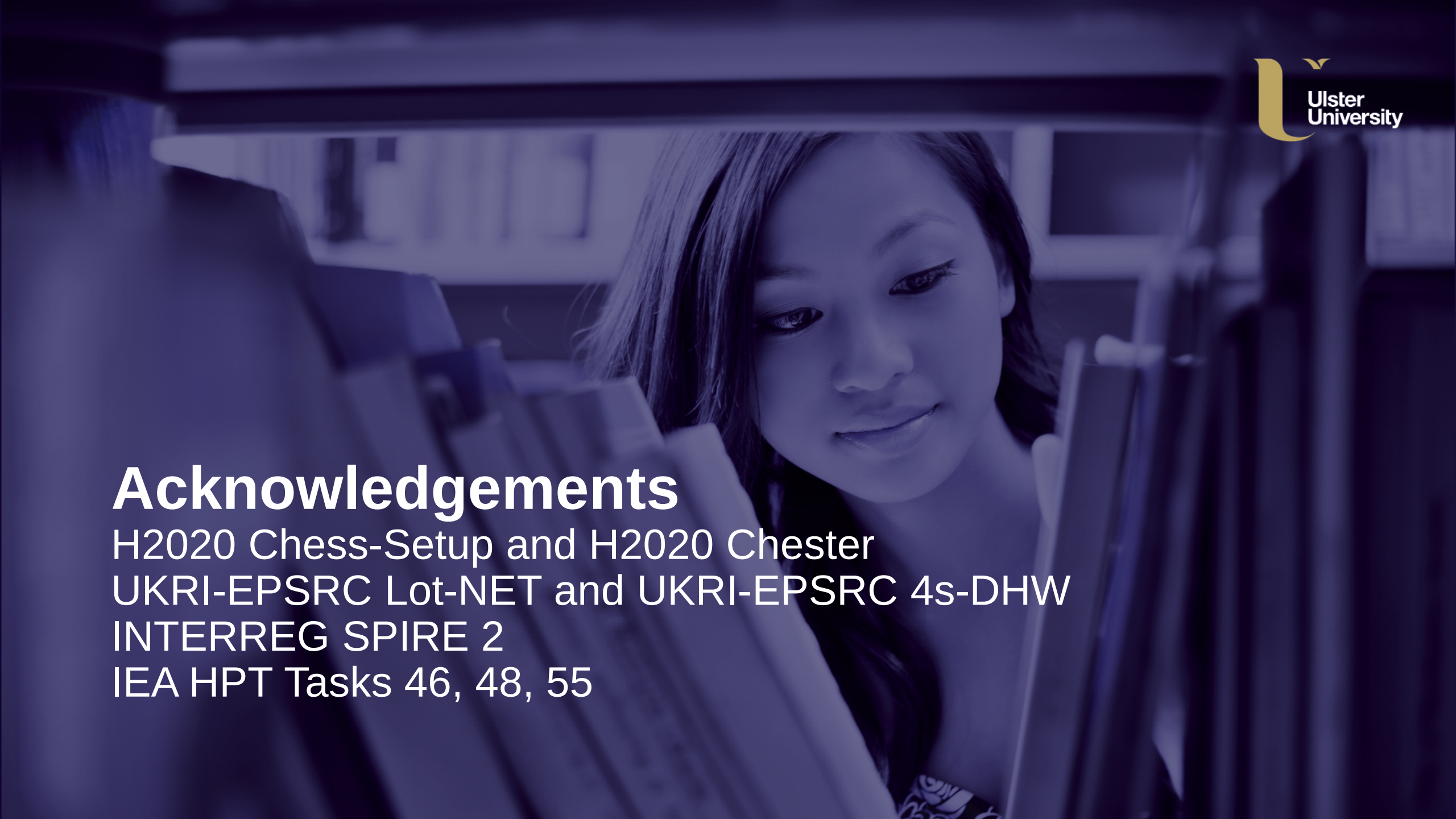
K Rahul
E Cao
C McKinstry



Acknowledgements

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INTERREG SPIRE 2
IEA HPT Tasks 46, 48, 55