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Centre for Doctoral Training in Energy Demand

Vision and leadership for a sustainable built environment

GAS BOILERS & BEYOND: DYNAMICS OF HEATING SYSTEMS

Understanding domestic heating system dynamics to improve performance of gas boilers and inform future heating system legislation and development.

George Bennett
(Supervisors: Prof R.Lowe, Prof Tadj Oreszcyn, Dr C.Elwell

LoLo Annual Colloquium 2017

9 November 2017

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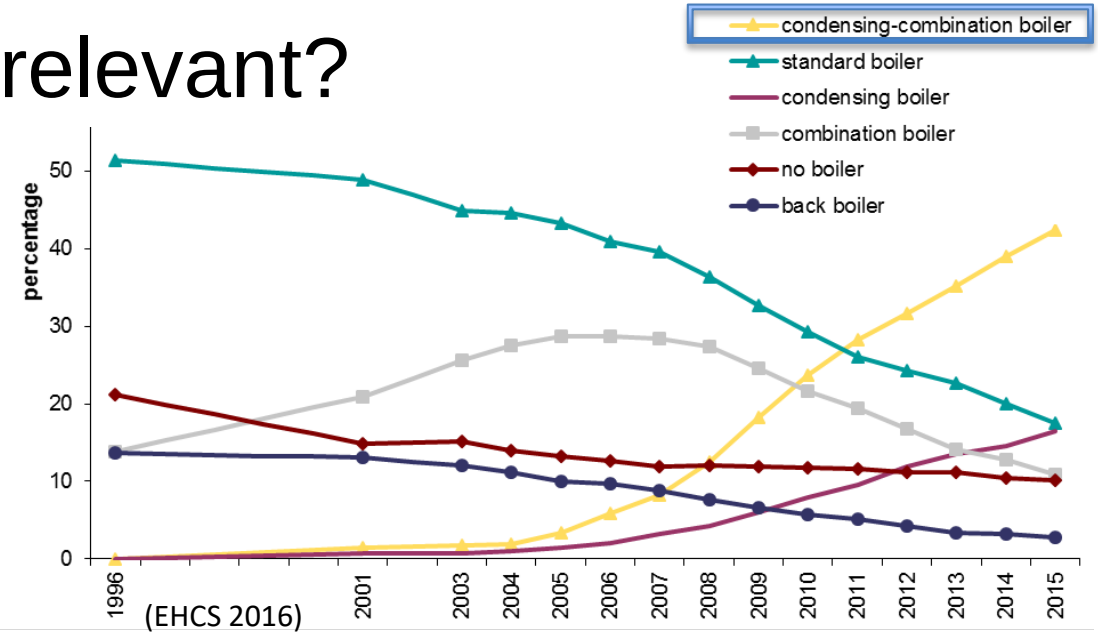
#lolocdt

Why are boilers still relevant?

Majority of heating systems in the UK

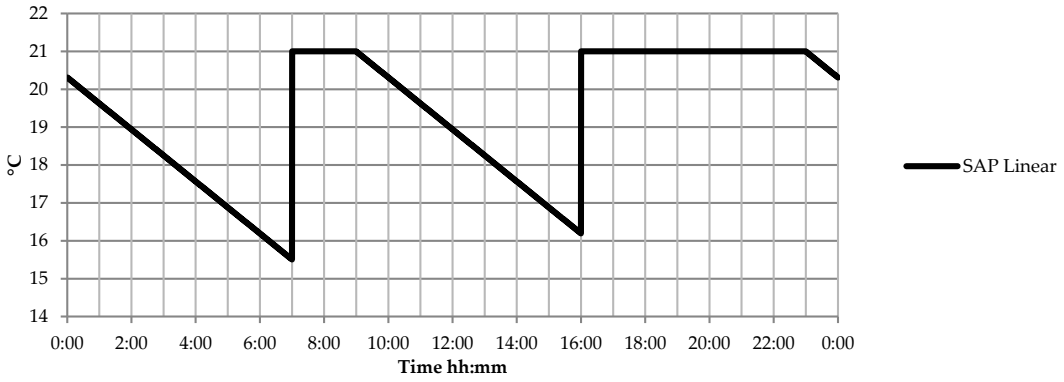
Boiler underperformance in buildings contributes to the performance gap



How is performance defined in standards?

SAP: heating schedules
fixed room temperatures
single efficiency values

Boiler efficiency standards:
steady state
maximum load & 30% load



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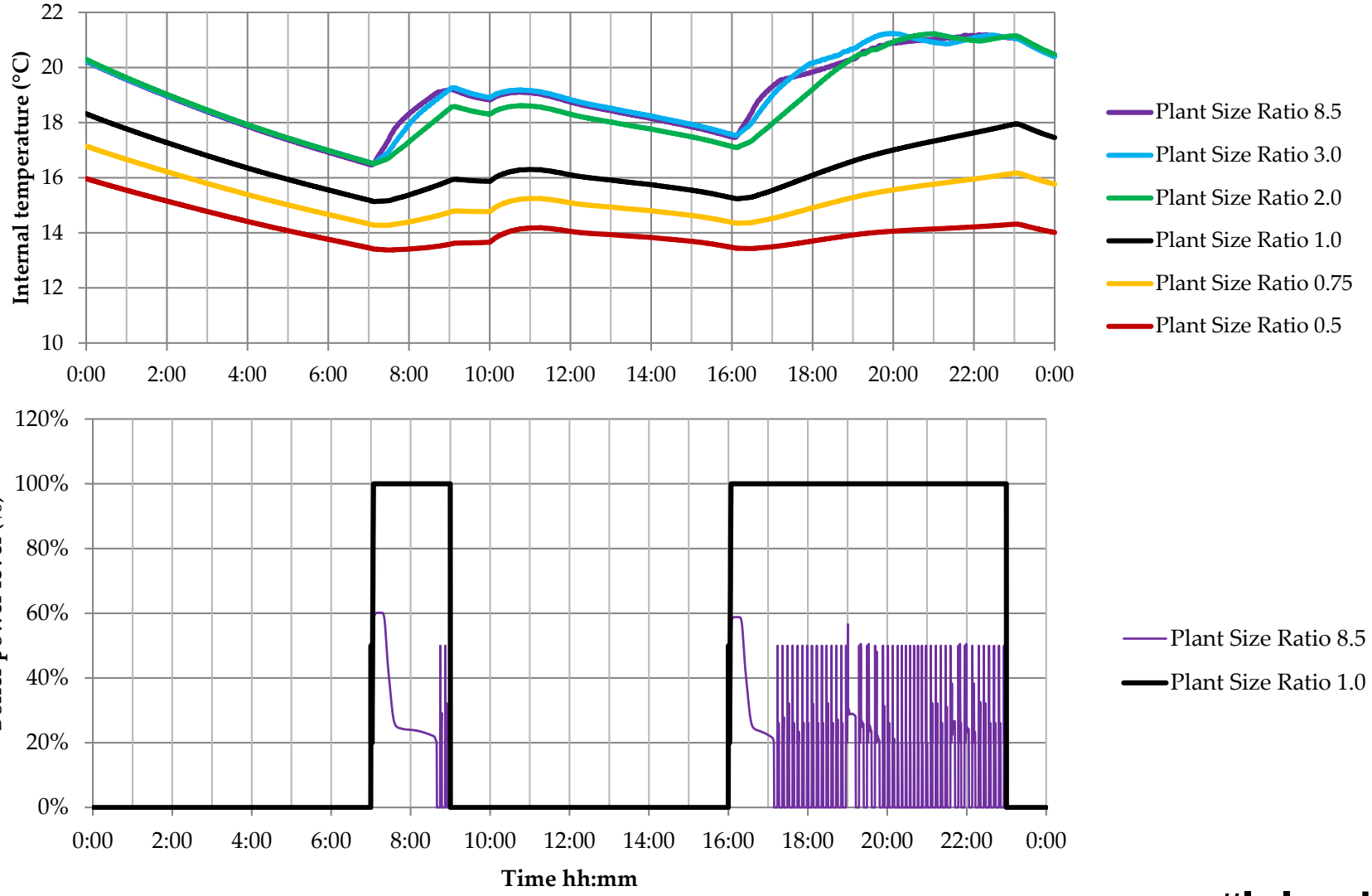
Simulation Results



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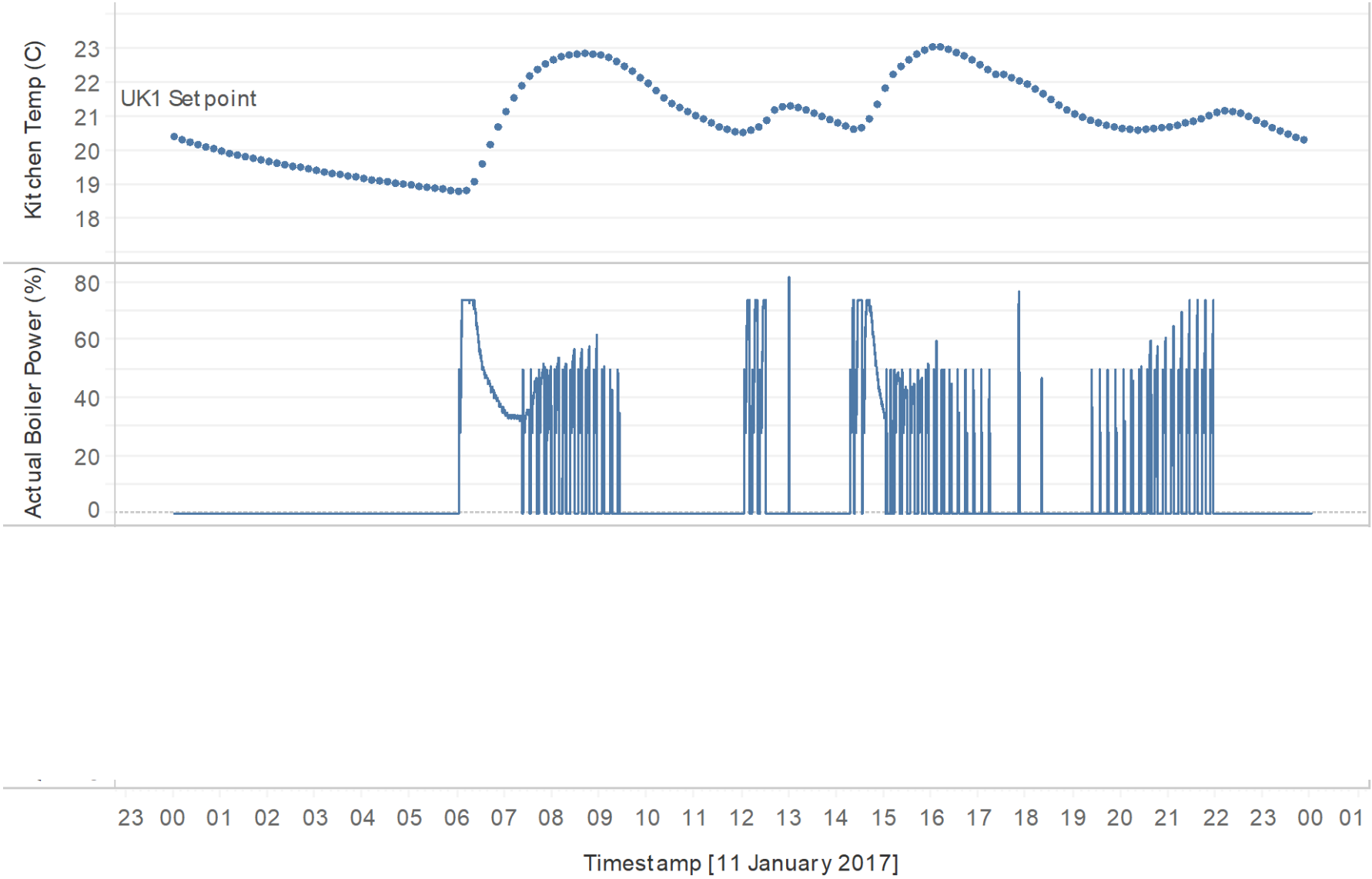
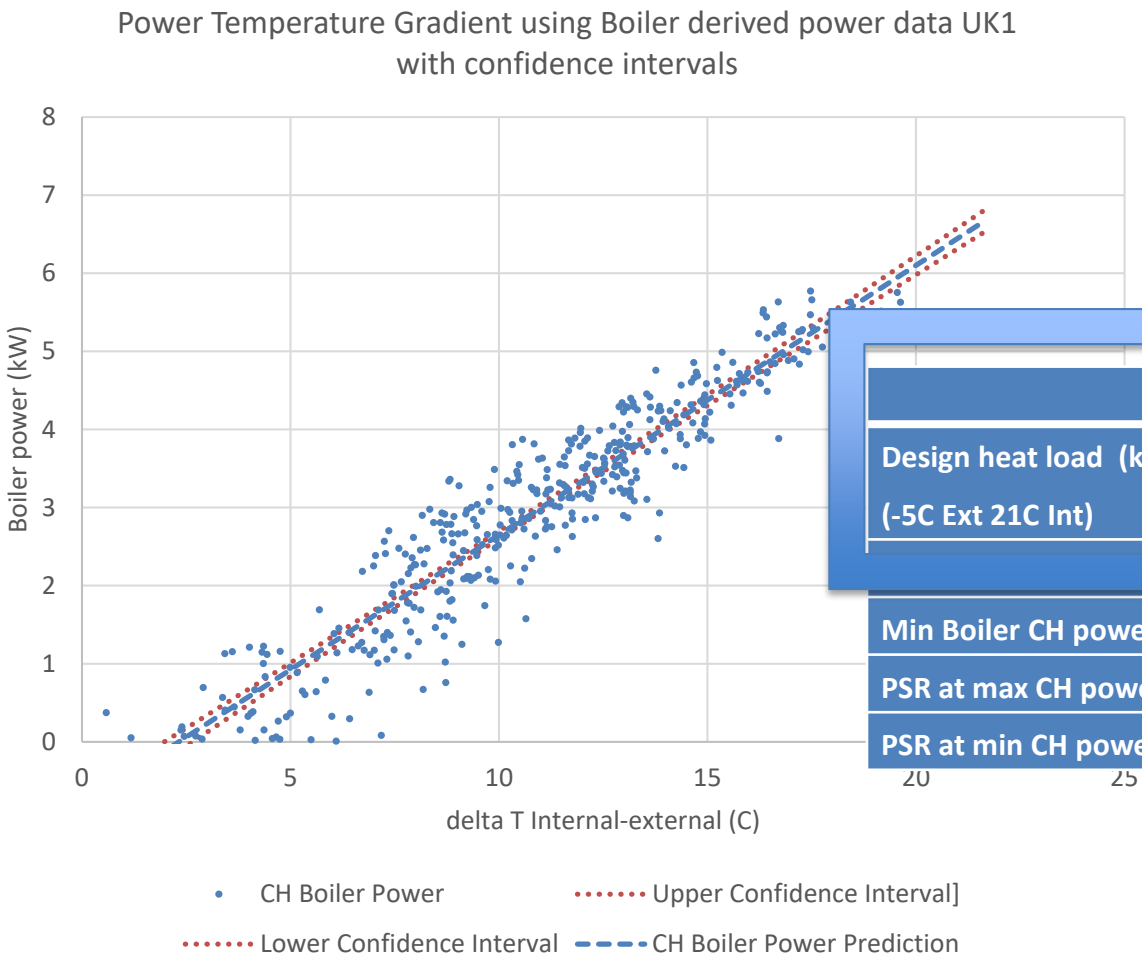

Kitchen Temp (C)
23
22
21
20
19
18
UK1 Set point
Actual Boiler Power (%)
80
60
40
20
0
23 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00 01
Timestamp [11 January 2017]



	UK1	UK2	UK3	DE1
Design heat load (kW) (-5C Ext 21C Int)	9	9.5	8.4	4.8
Min Boiler CH power	8	7	7	2.5
PSR at max CH power	3.4	2.5	3.2	5.2
PSR at min CH power	0.9	0.7	0.8	0.5

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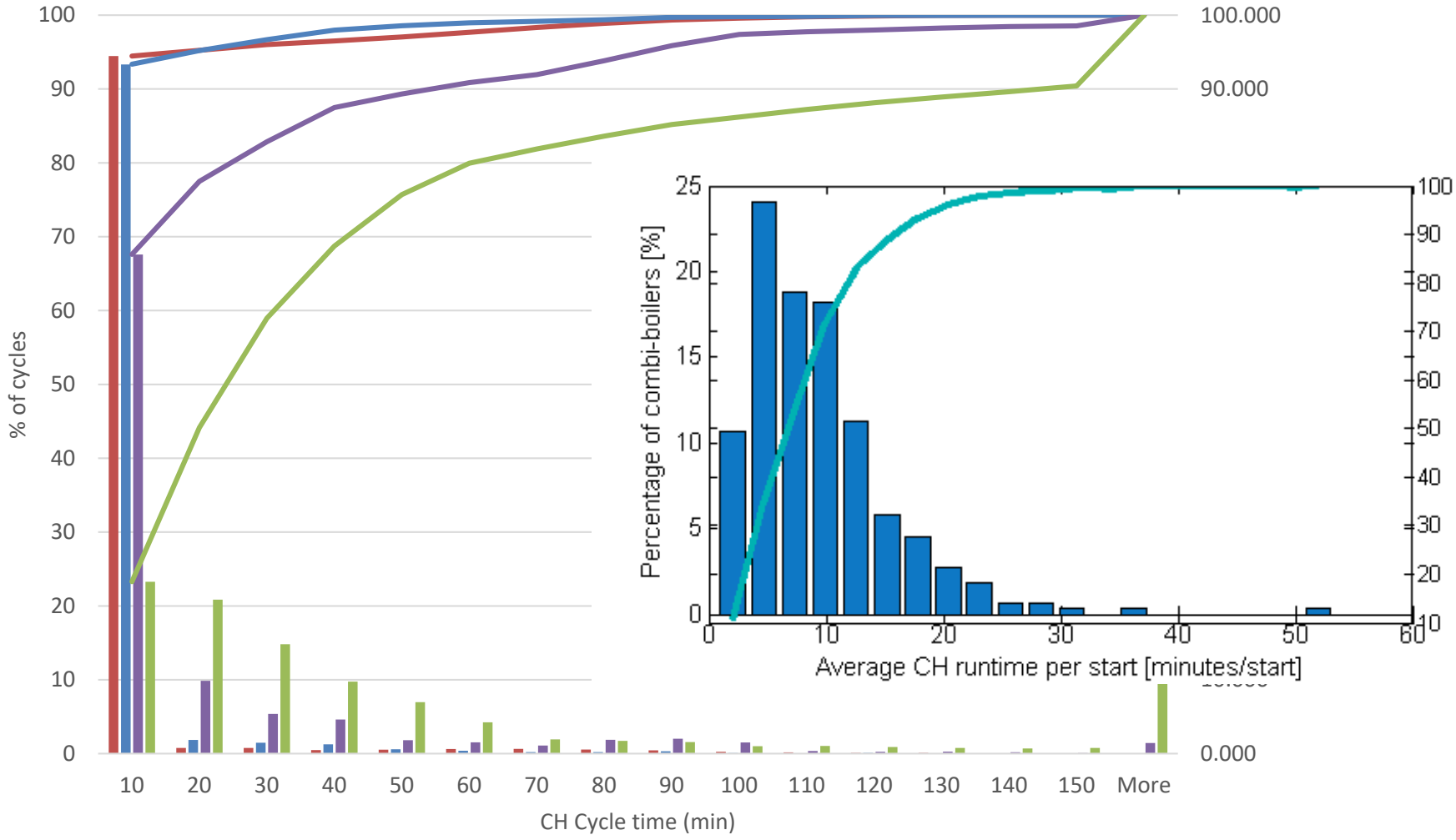
% of cycles
CH Cycle time (min)
100.000
90.000
0.000
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
More
Percentage of combi-boilers [%]
Average CH runtime per start [minutes/start]
UK1
UK2
UK3
DE1
UK1 cumulative
UK2 cumulative
UK3 cumulative
DE1 cumulative

Implications and impact

Building level: Energy Performance Certificates, SAP & installers

- Improvement of SAP correction factors for internal temperature (overshoot) and efficiency

- Fair representation of installations
  - Plant Size Ratio as factor in heating efficiency (not just common boiler efficiency decrease)
  - incentive for higher quality heating installations: benefit HP installations

- Fairer representation of controls
  - incentivise manufacturers and consumers

Implications and impact

Heating appliance level: Testing & developing

- representative dynamic testing addressing ‘underperformance’ in the field
- include hidden emissions, unburnt methane from start/stop
- boost innovation through visibility
  - wider modulation ranges
  - improved boiler dynamic controls
- lessons learned apply to future technologies

Implications and impact

Advice for future research & field trials

- be careful of black box thinking
- take advantage of boiler/heater diagnostic data
  - power temperature gradients
  - disaggregation of heating and hot water
  - high frequency and quality
  - cost effective

“You can teach an old dog new tricks”

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COLLABORATING WITH INDUSTRY DURING THE PHD

Tom Needld and Chris Gibbs

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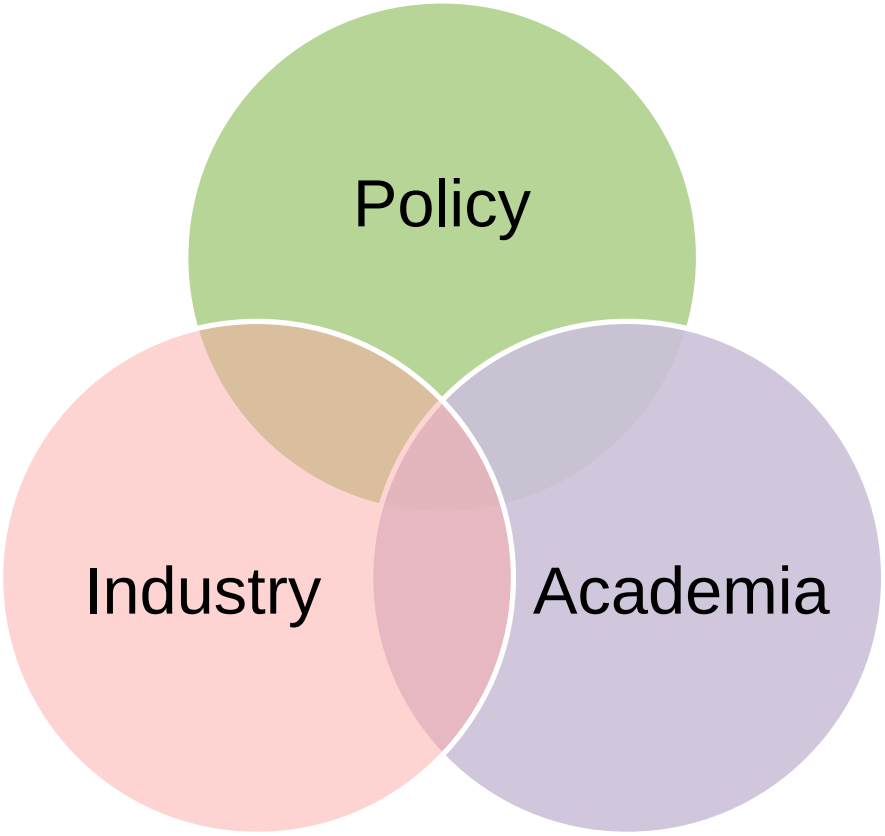
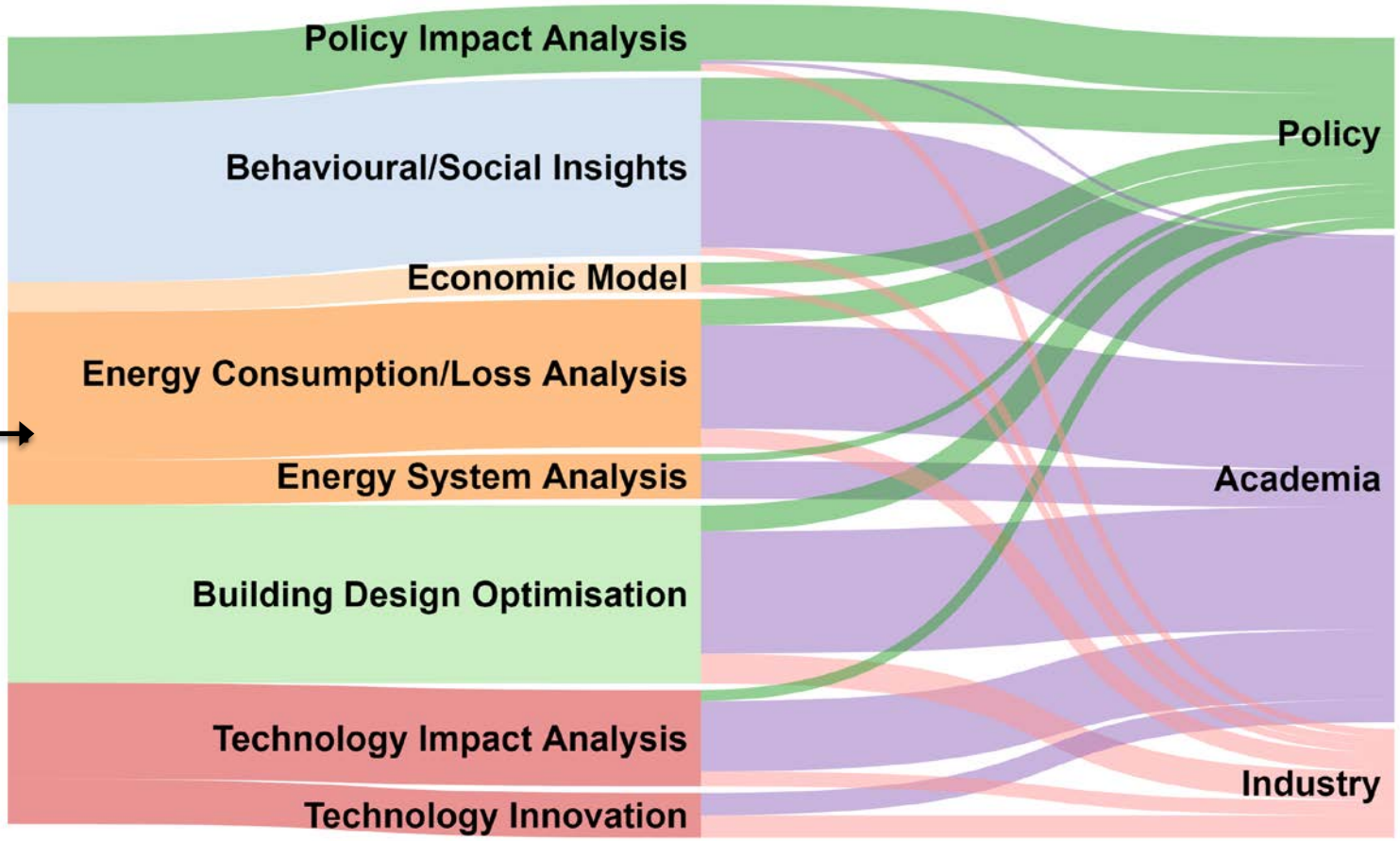
Research Aims and Impact Areas

To meet challenges associated with global warming and energy security



Research and Impact Areas

53 Lolo Students /Alumni →



N.B. Opinion of presenter

Challenges to impacting industry

- Information in general is not in the public domain
- Expertise and experience is within industry
- Equipment and technology not accessible
- Apprehensions of commercial bodies
- Uncertainty of IP ownership

Collaboration Agreement

Confidentiality

- Data protected during and a period after project

Limitations on Academic Publication

- Company can delay publication if required (~3months)
- Confidential data can be blocked from publication

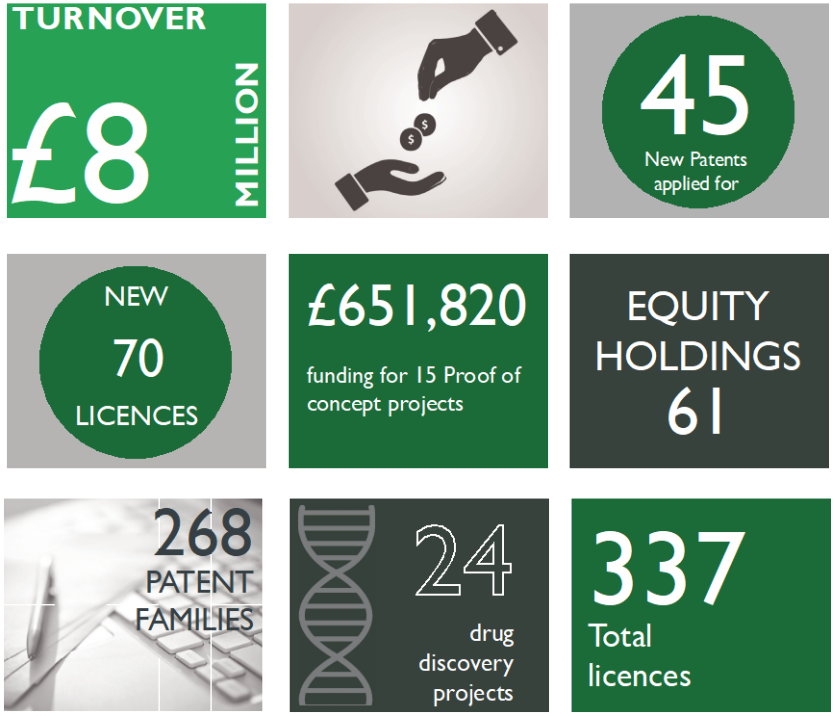
Exploitation of Intellectual Property

- In general generated IP is shared (depends on relative input)
- Both parties responsible to inform of patentable results

Who assisted me drafting a collaboration agreement and is continuing to assist beyond the PhD … ?

UCL Business Overview

- Technology Transfer Office
- Realise the ‘value’ of UCL’s IP
- Raise UCL’s ‘impact’
- Provide service to UCL
- Mitigate UCL’s risk
- Make money



Developing new IP from basic research

- UCLB has 16 Business Managers and Directors covering the range of faculties and embedded into the Institutes and Departments
- Work with academics and clinicians to identify new technologies developed at UCL and evaluate for patenting / registering
- Variety of services to help collaborations with industry
- Commercialisation = realisation of technology in the market, returns to inventors & departments.

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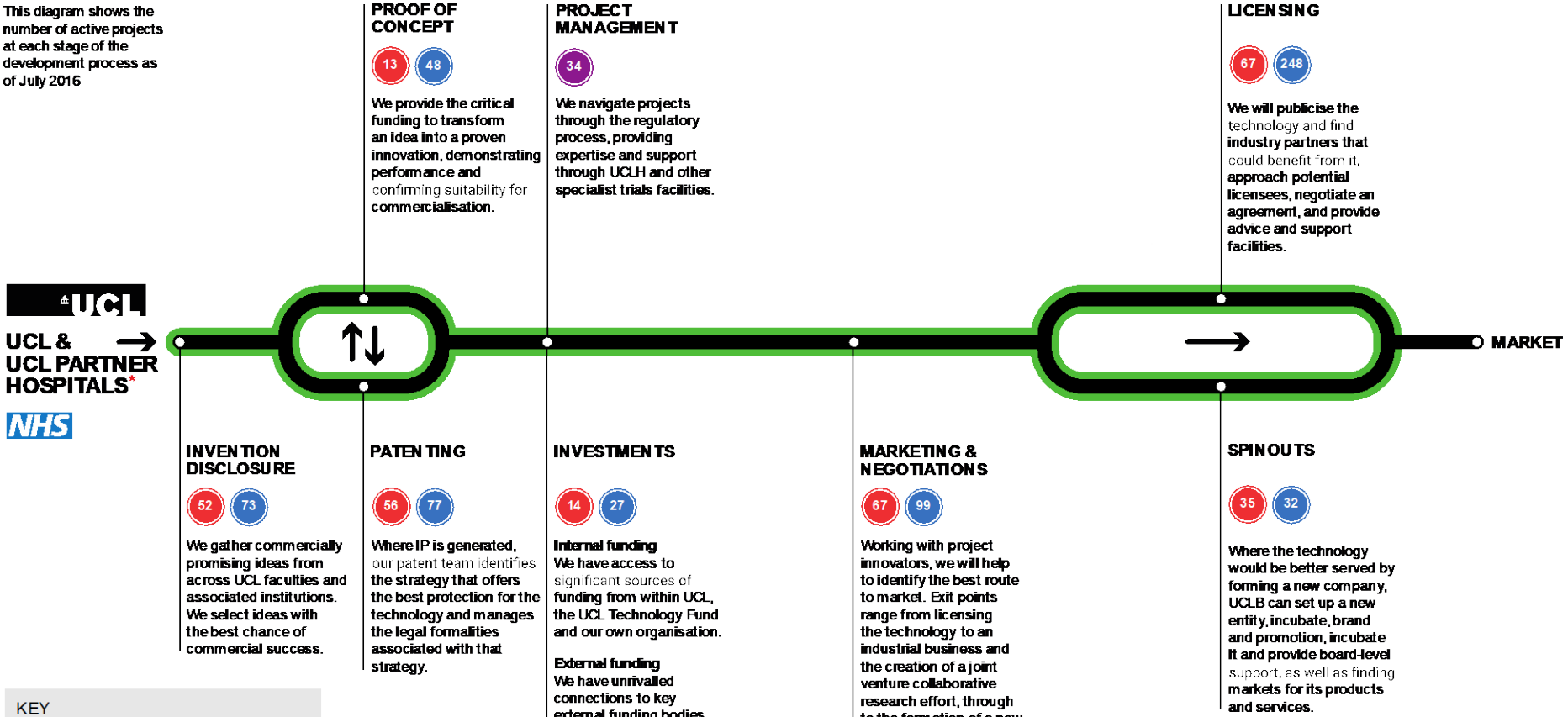
OUR ROUTE TO MARKET

This diagram shows the number of active projects at each stage of the development process as of July 2016



INVENTION DISCLOSURE

52 73

We gather commercially promising ideas from across UCL faculties and associated institutions. We select ideas with the best chance of commercial success.

PATENTING

56 77

Where IP is generated, our patent team identifies the strategy that offers the best protection for the technology and manages the legal formalities associated with that strategy.

PROOF OF CONCEPT

13 48

We provide the critical funding to transform an idea into a proven innovation, demonstrating performance and confirming suitability for commercialisation.

PROJECT MANAGEMENT

34

We navigate projects through the regulatory process, providing expertise and support through UCLH and other specialist trials facilities.

INVESTMENTS

14 27

Internal funding
We have access to significant sources of funding from within UCL, the UCL Technology Fund and our own organisation.

External funding
We have unrivalled connections to key external funding bodies, such as research councils and venture capitalists, and an enviable track record in matching funds to projects.

MARKETING & NEGOTIATIONS

67 99

Working with project innovators, we will help to identify the best route to market. Exit points range from licensing the technology to an industrial business and the creation of a joint venture collaborative research effort, through to the formation of a new company.

LICENSING

67 248

We will publicise the technology and find industry partners that could benefit from it, approach potential licensees, negotiate an agreement, and provide advice and support facilities.

SPINOUTS

35 32

Where the technology would be better served by forming a new company, UCLB can set up a new entity, incubate, brand and promotion, incubate it and provide board-level support, as well as finding markets for its products and services.

KEY

UCLB activity

Total number of active projects per phase

- Engineering, Physical Sciences, Arts & the Built Environment
- Biomedical Sciences
- Project Management

* Great Ormond Street Hospital for Children NHS Foundation Trust
Moorfields Eye Hospital NHS Foundation Trust
Royal Free London NHS Foundation Trust
University College London Hospitals NHS Foundation Trust

Case Studies

- Autolus
  - T-cell cancer therapies pioneered Dr Martin Pule @ UCL Cancer Inst.
  - UCLB spin-out formed in 2014
  - Raised $80M Round C Sep-2017
- Amalyst
  - External catalyst development company
  - Spin-in, spin-out with Dr Dan Brett, Chemical Engineering
  - Crossing valley of death
- Bartlett and Bosch
  - Innovative control system
  - Joint IP developed between UCL and Bosch
  - Negotiation for Knowledge Transfer Project to commercialise tech
  - License deal

Summary

- Lolo PhDs can often align with industry
- Close collaborations optimise outputs
- Collaboration agreements should be established to avoid ambiguity
- UCLB provide students' with support and representation
- Reaching market can maximise impact

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QUESTIONS

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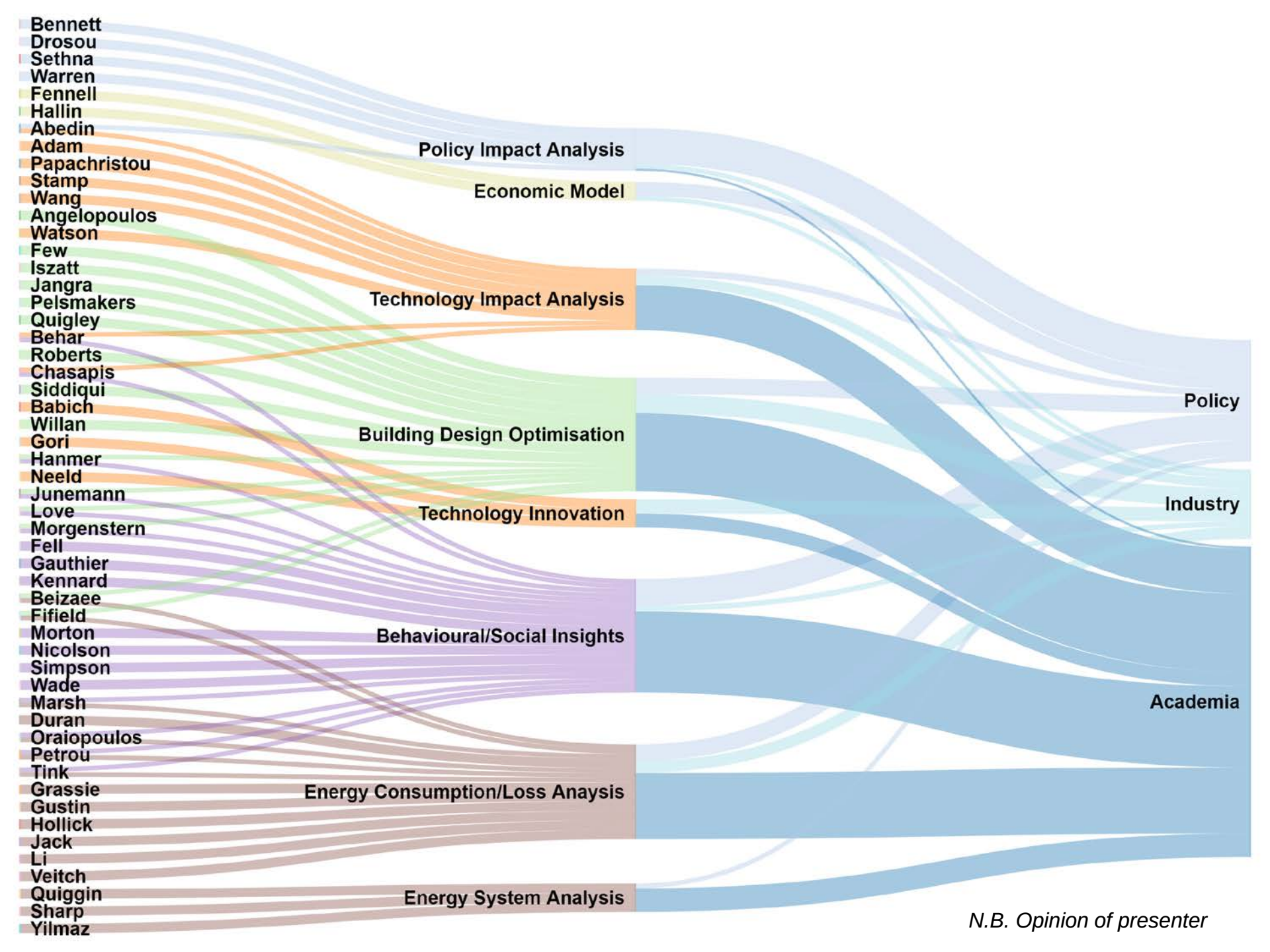

N.B. Opinion of presenter

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DOMESTIC CONSUMER ADOPTION OF DEMAND-SIDE RESPONSE

Using behavioural science to increase adoption of time of use tariffs

Moira Nicolson, supervised by Gesche Huebner, David Shipworth

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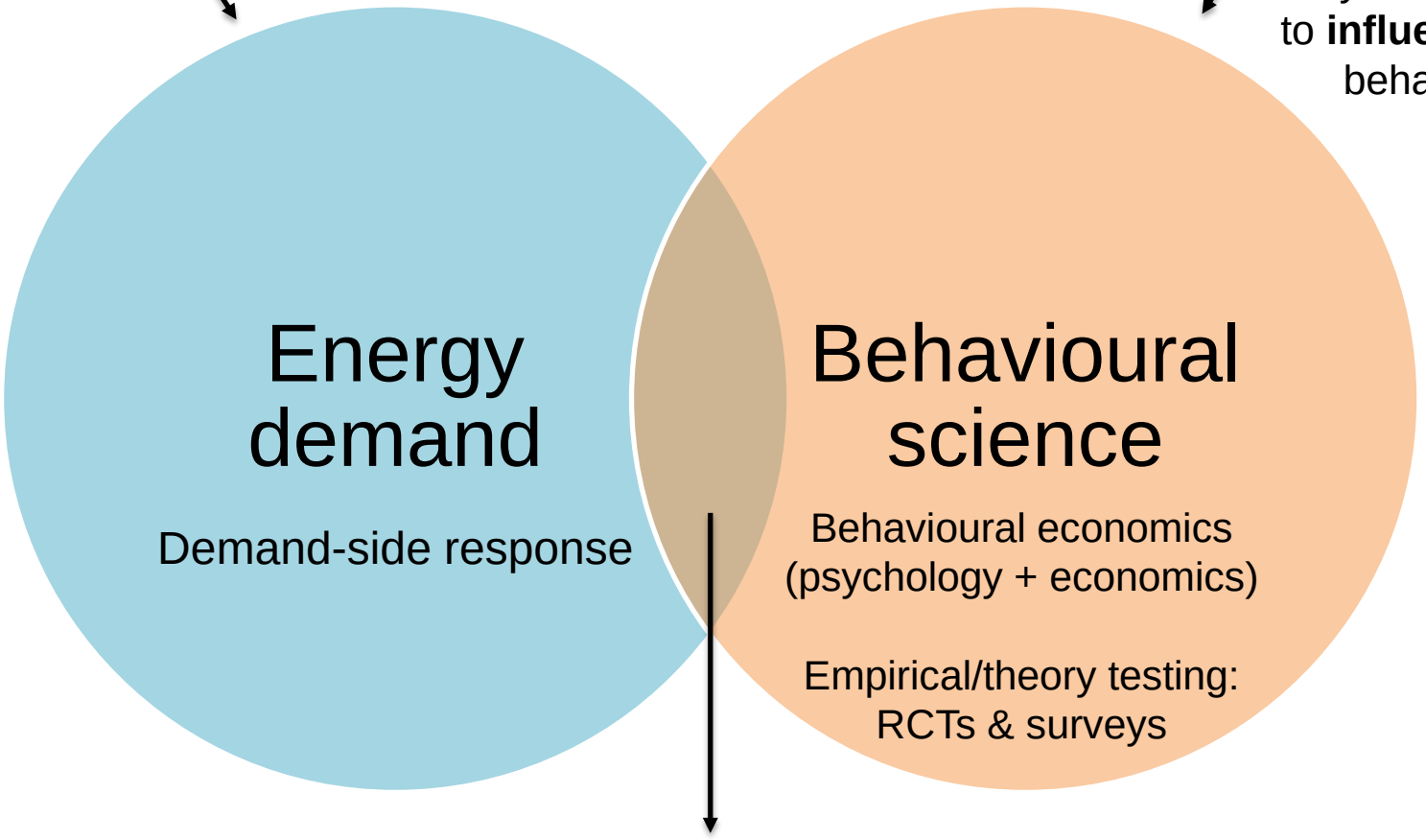
Merging energy and behavioural science

Activities we want people to engage in

Theoretical and empirical evidence on **why** people behave as they do and how to **influence** that behaviour



Can we use **behavioural science** to increase domestic consumer adoption of **time of use electricity** tariffs?

Research design choices

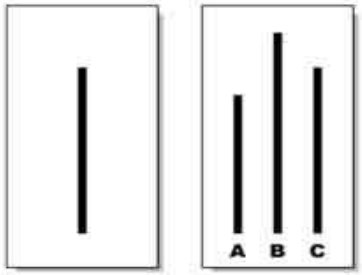
In the lab

In the field

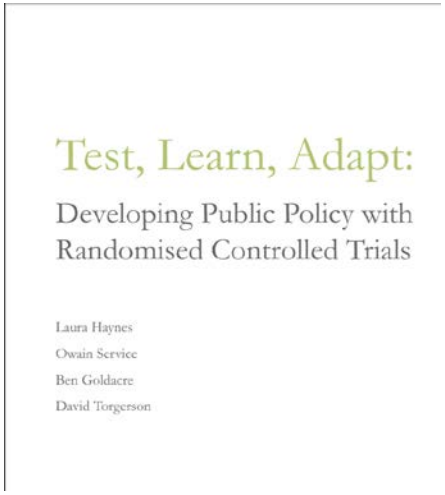
Natural sciences

Behavioural/social sciences

Asch conformity experiment (1951)



Sample = 50 male US university students



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Opt-in versus opt-out recruitment

"One of the primary advantages of green defaults is that they can have beneficial effects while maintaining freedom of choice and hence respect for heterogeneity.

Suppose…people are facing serious economic difficulty… and if green energy is more expensive than the alternative, it may…be important to allow consumers to opt out"

Sunstein and Reisch (2013, p5)

This presentation will present four studies, undertaken across 16,000 British energy bill payers, to show:

- Why opt-out enrolment may not be the best enrolment strategy for time of use tariffs (or other forms of DSR)
- That tailored marketing is a promising alternative strategy that possesses the advantages of opt-outs (higher enrolment than opt-in) without its disadvantages (passive decision making, unwitting consent)

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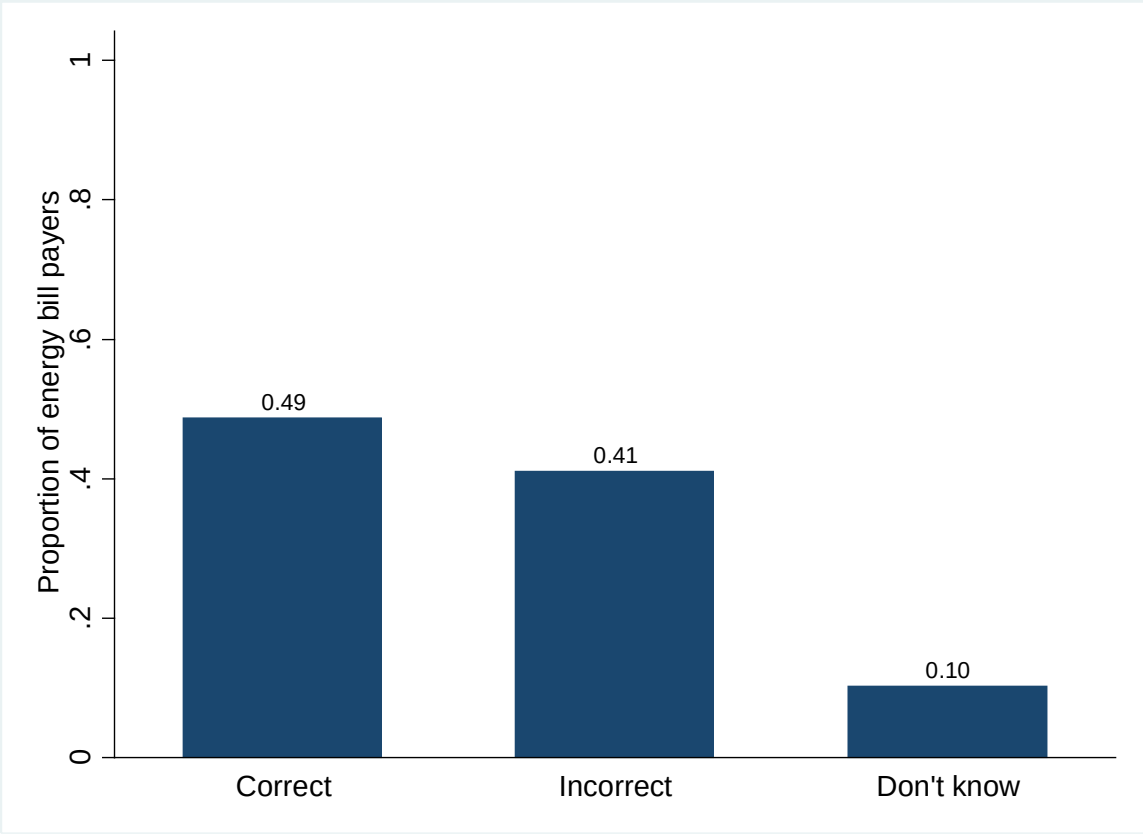
Study 1: energy tariff decision making

Do people have the energy literacy skills to know when to opt-out? *No: Consumers struggle to identify the cheapest tariff even when given all the information required.*



Note: Data from an online survey of 811 British energy bill payers who are members of an online market research panel.

Studies 2, 3 & 4: testing nudge

Is there an alternative to opt-outs for time of use tariffs and other forms of DSR? Tailored marketing is an "effective and selective" nudge.

Google UK

Compare All UK Tariffs - UKPower.co.uk
Ad www.ukpower.co.uk/Compare-Tariff
At UK Power We Compare All UK Energy ... One Search.
Services: Home Energy, Business Energy, ... ency
Great Energy Savings - No Paperwork -Ha... Free - ... Rate Energy Tariffs

N=6,000

- Control
- Price comparison
- Tailored

07 Opinium

N=3,000

- Control
- Tailored

SURVEY

Office for Low Emission Vehicles

N=7,000

- Control
- Tailored

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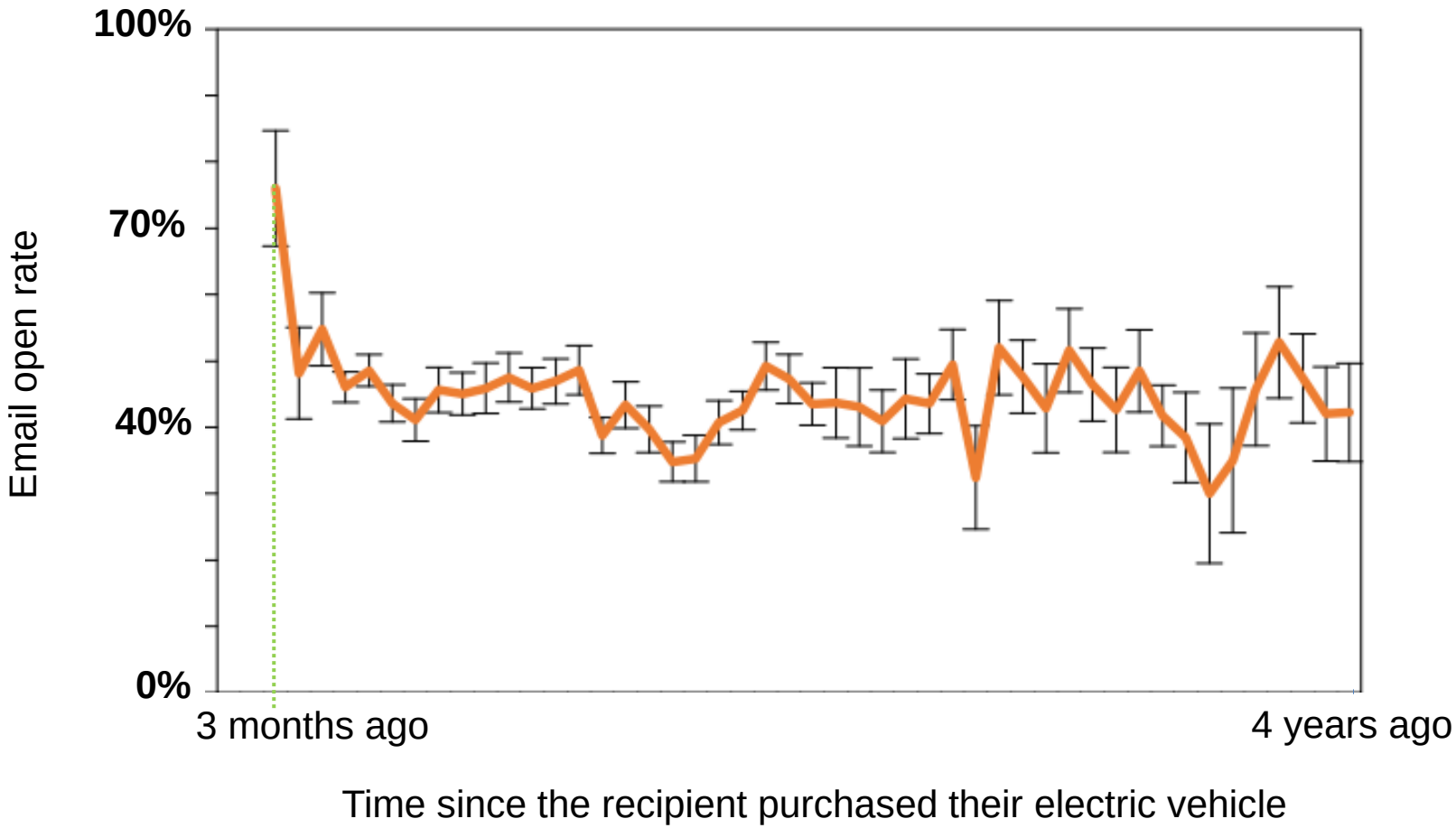
Study 4: the importance of early action

Email open rates declined from 70% to 40% for people who purchased their electric vehicle more than 3 months ago
("habit discontinuity" Verplanken et al. 2008, 2006)



Nicolson, M., Huebner, G., Shipworth D., Elam, S. (2017) "Tailored emails prompt electric vehicle owners to engage with tariff switching information". Nature Energy (2) 1703, p4.

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Three key insights from this research

Policy:

- Opt-out enrolment combined with automation may circumvent consumer inertia but it has downsides → informed consent; research into methods of obtaining explicit consent, that result in high uptake, is required.
- Cost-benefit analyses which rely on decisions of energy bill payers cannot just be based on classical economic models which do not account for the influence that framing has on decisions. How is this best achieved? More research needed.

Industry:

Exploit the window of opportunity when people adopt new low carbon technologies to prompt adoption of your new low carbon technologies and products → product bundles.

Academia:

The Internet offers a relatively low cost and quick method of conducting rigorous randomised control trials on real people. How can we reach people who are not online?