

DEPARTMENT OF
**ENGINEERING
SCIENCE**



Understanding and accelerating changes in energy use

Oxford Energy Seminar
7 November 2023
Phil Grünewald

edol.uk



Where we left off last week...



"GB demand will be **assumed to be 570 TWh/year** in 2050, although some results will also be reported based on simple models of demands of 440 TWh/year and 700 TWh/year."



Imperial College
London

Strategic Assessment of the Role and Value of Energy Storage Systems in the UK Low Carbon Energy Future

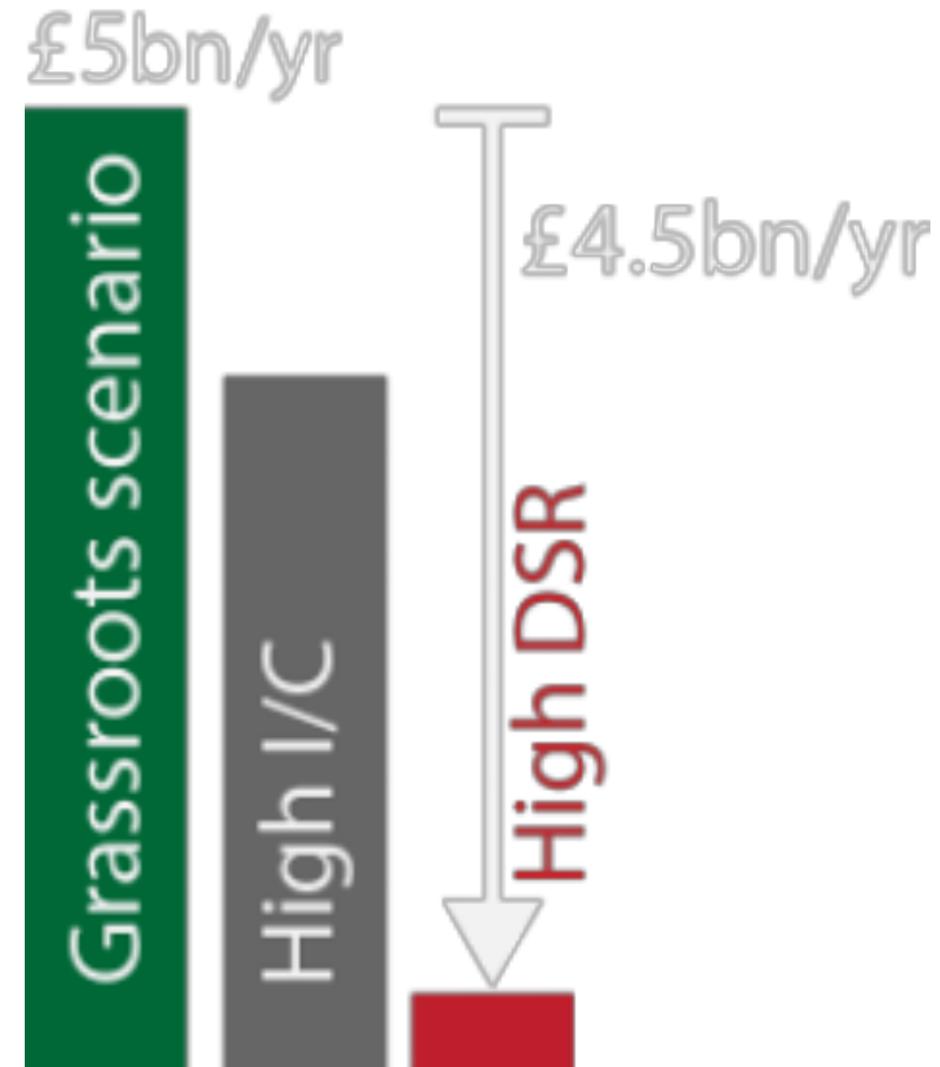
Report for the Carbon Trust

June 2012

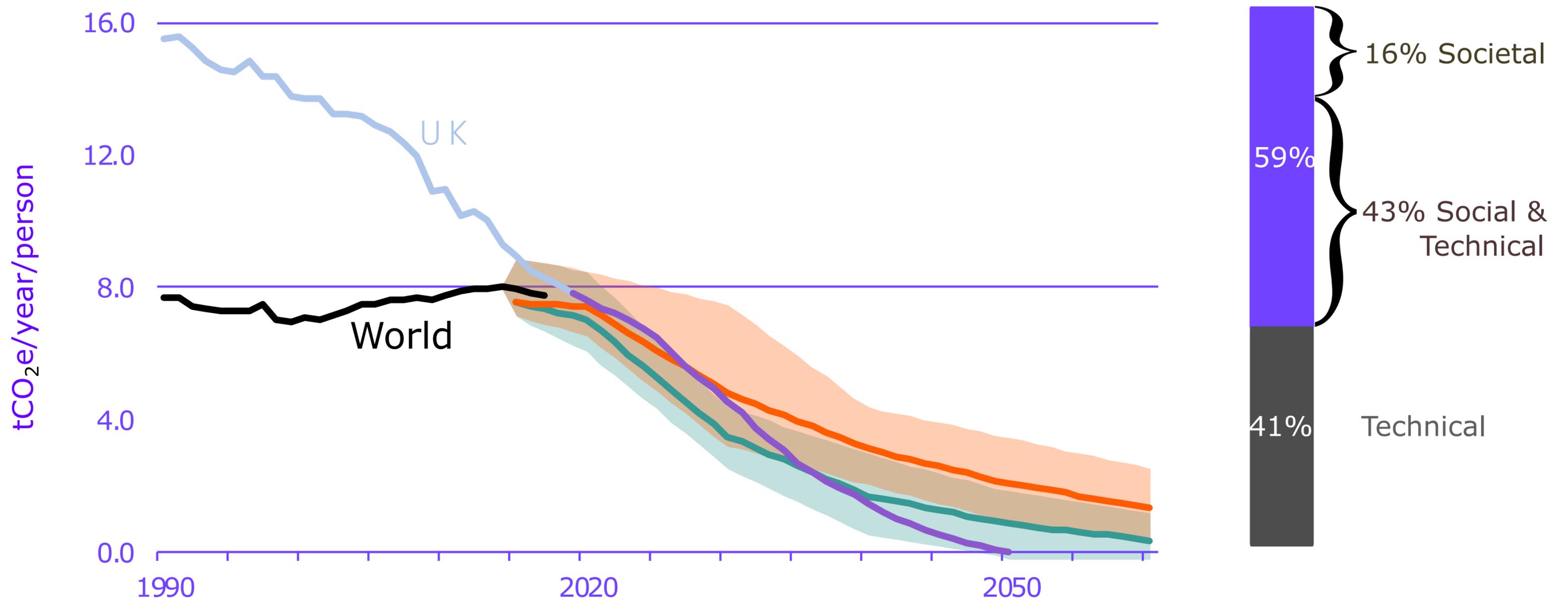
Goran Strbac, Marko Aunedi, Danny Pudjianto, Predrag Djapic, Fei Teng,
Alexander Sturt, Dejvise Jackravut, Robert Sansom, Vladimir Yufit, Nigel Brandon

*Energy Futures Lab, Imperial College
EDF UK R&D Centre*

Demand matters



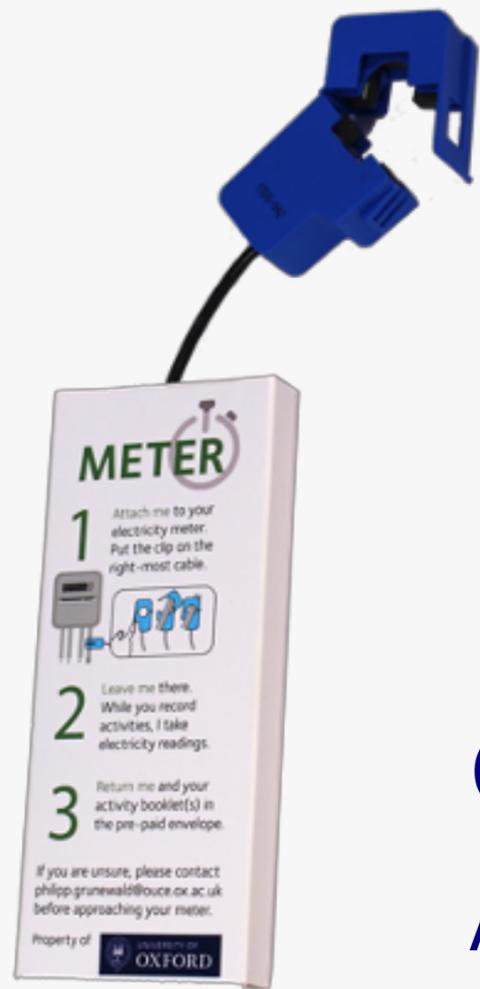
Demand matters: it's the society, stupid



Source: Climate Change Committee. The UK's path to net zero. The sixth carbon budget, Climate Change Committee, December 2020

Understanding demand the hard way

JoyMeter.uk



Current clamp



EDDI



App



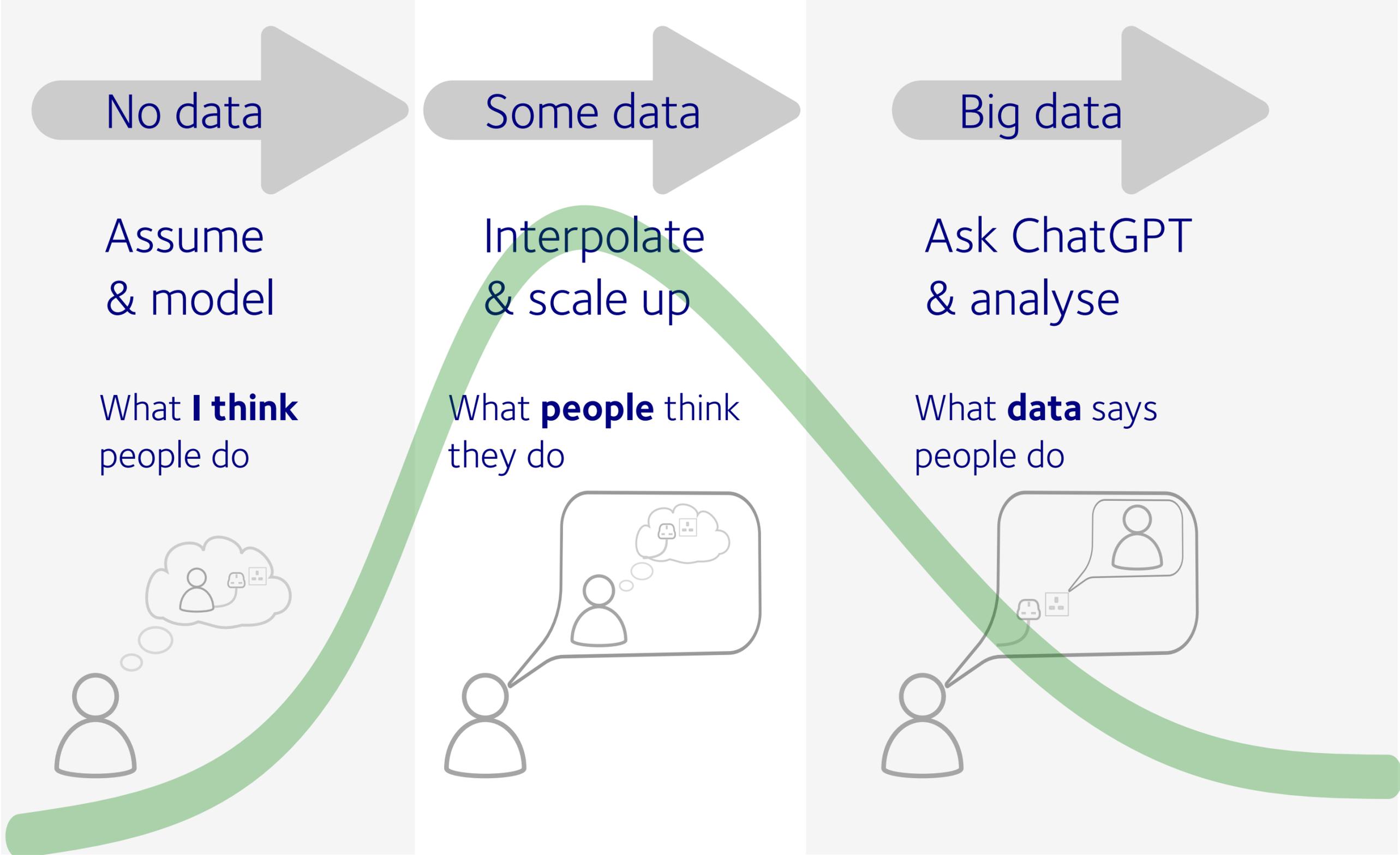
CAD (Consumer Access Device)

Diary



Energy demand research is evolving

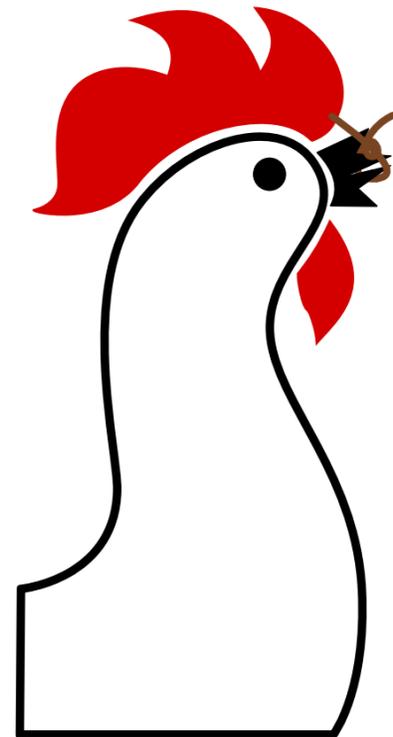
Effort
Understanding Demand



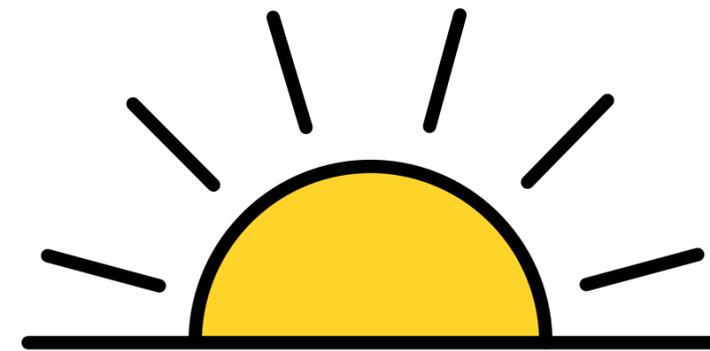
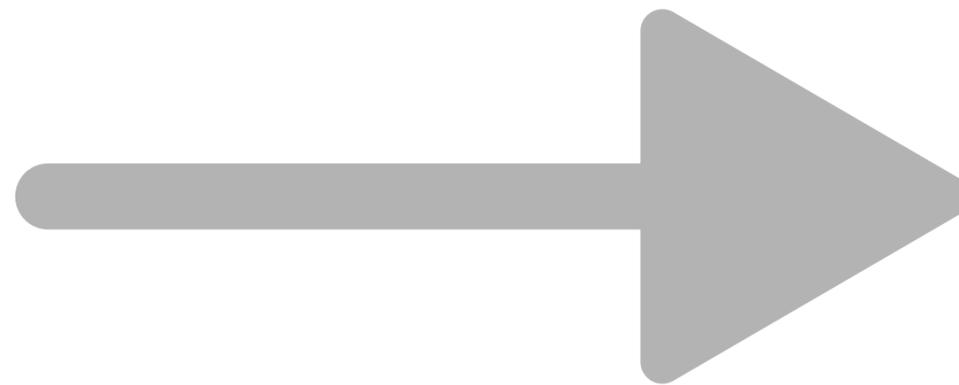


Judea Pearl

What **causes** the sun to rise?

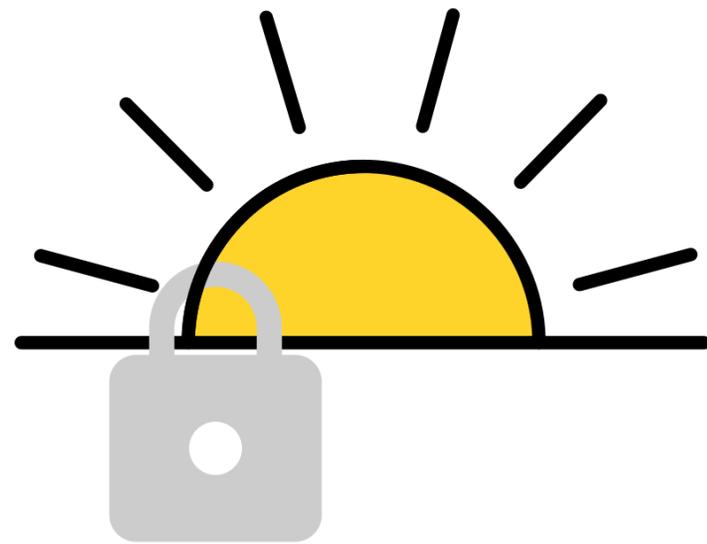


$P(\text{Sun} \mid \text{Crow})$

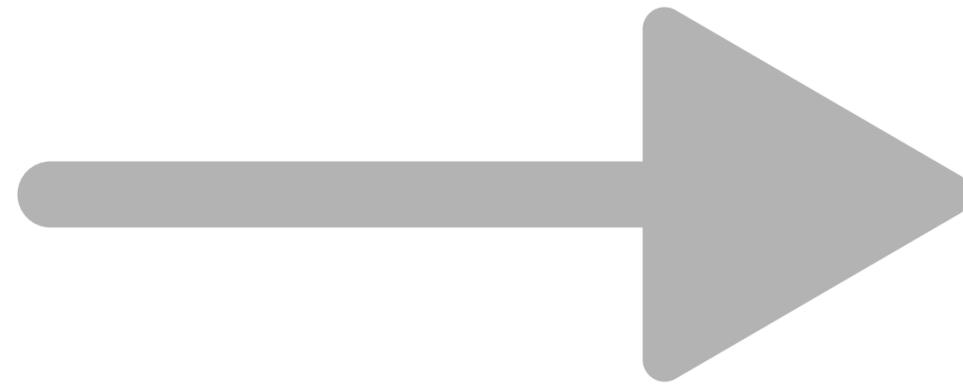


$P(\text{Sun} \mid \text{do not (Crow)})$

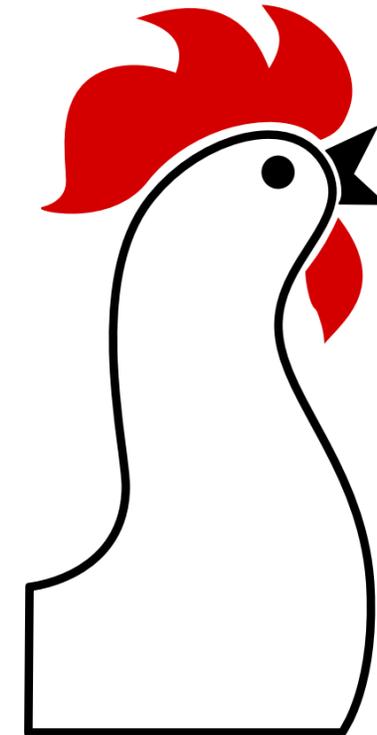
What **causes** the the cockerill to crow?



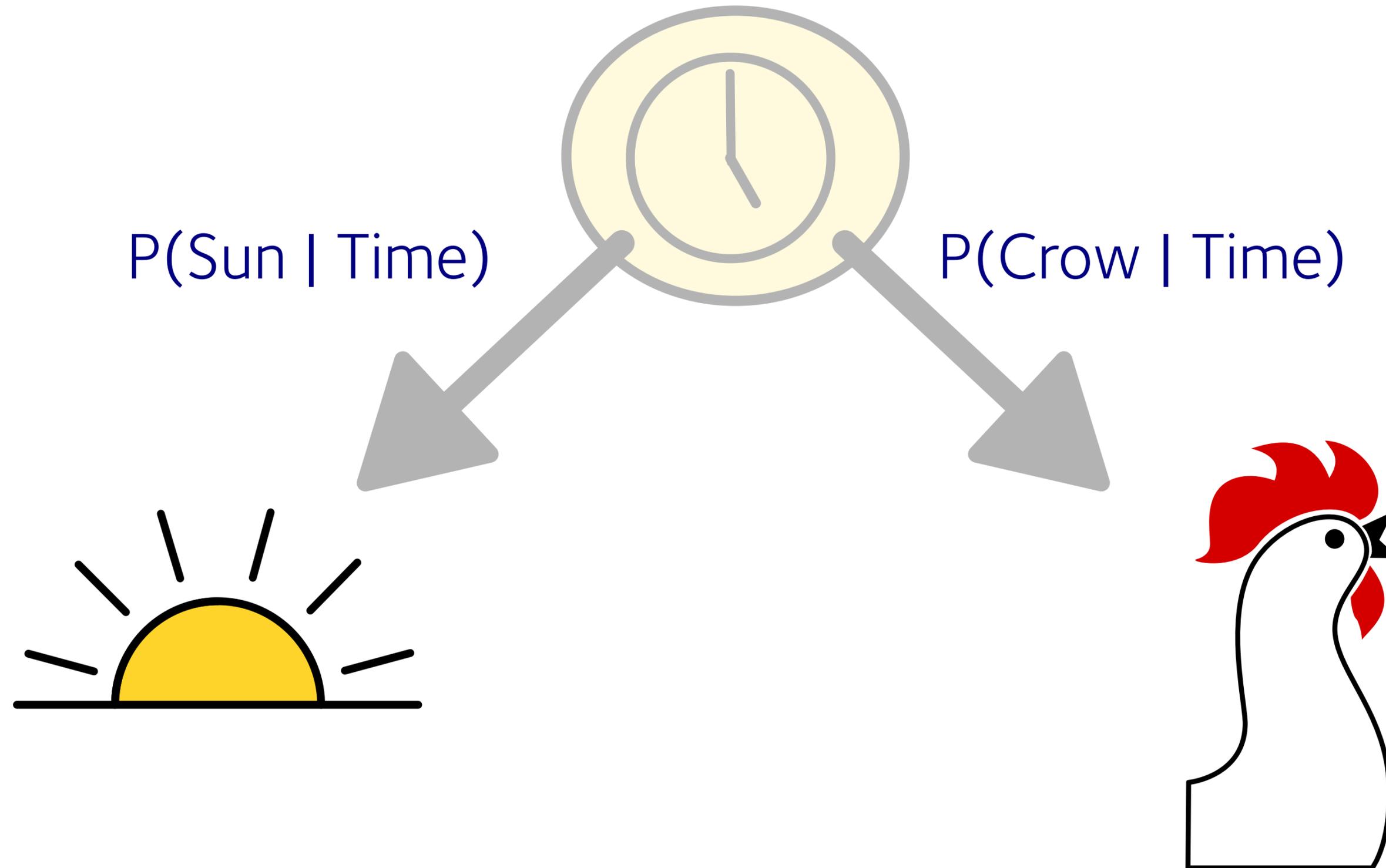
$P(\text{Crow} \mid \text{Sun})$



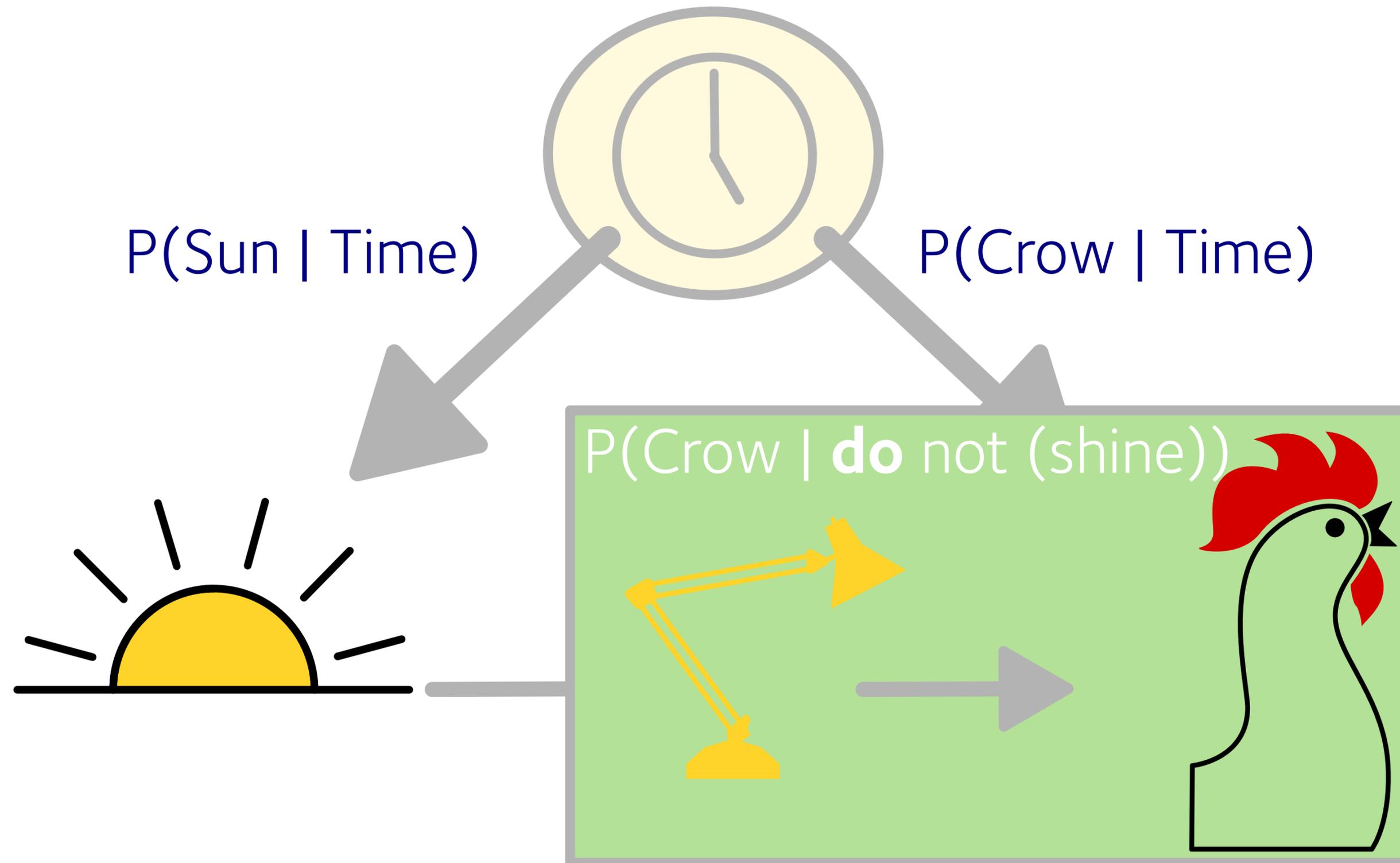
$P(\text{Crow} \mid \mathbf{do} \text{ not } (\text{Sun}))$



How to eliminate confounders?



How to eliminate confounders?



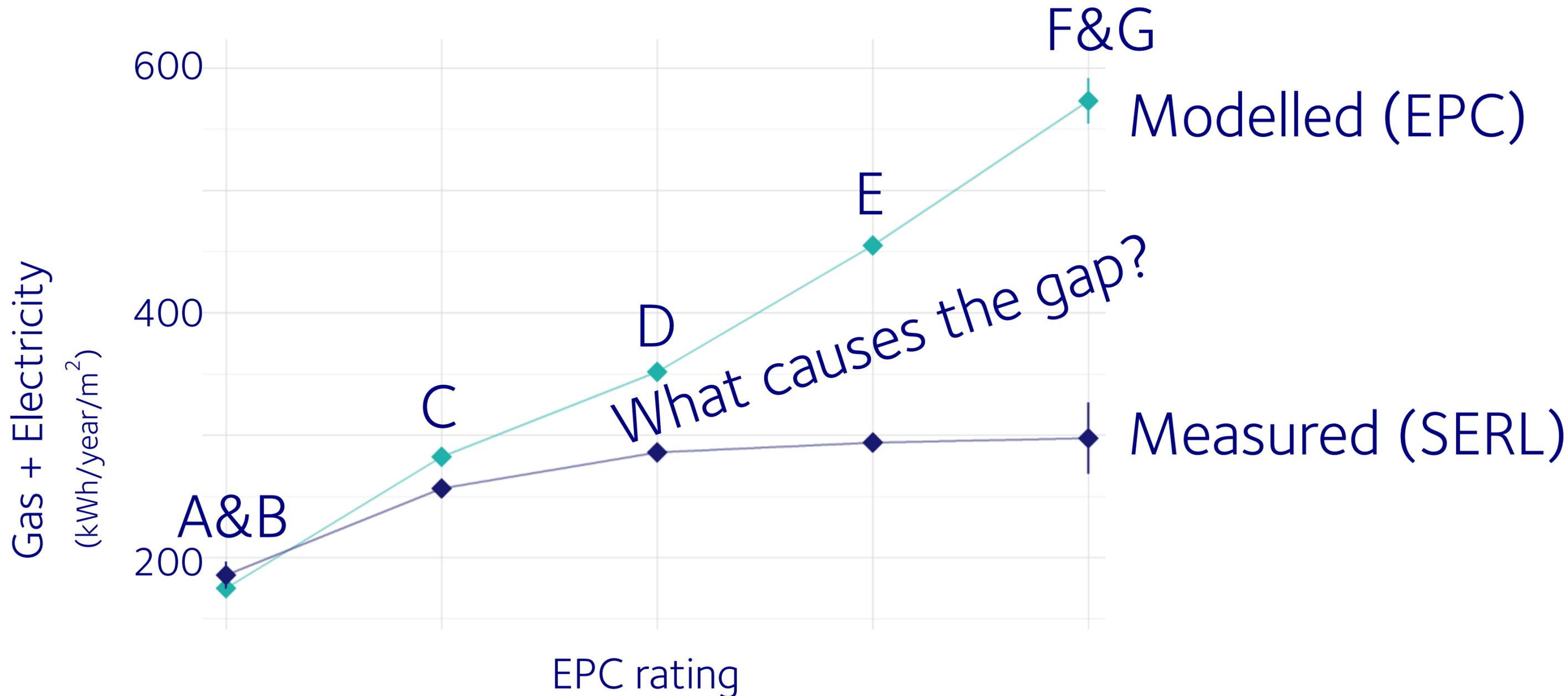
To understand causes we need (up to) three things

Causal model

Observation

Do something

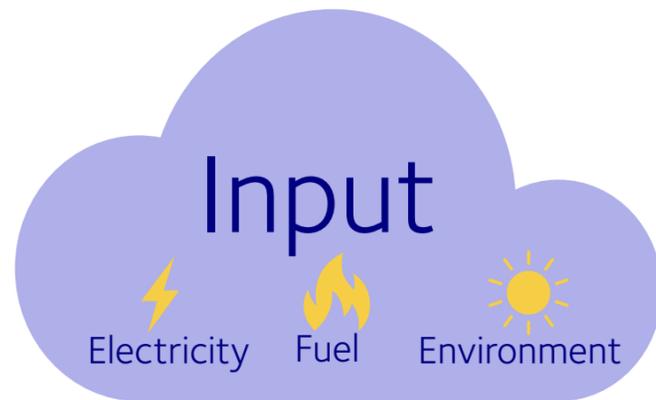
Model vs Reality: EPCs are poor predictors of demand





To change energy use we need to understand energy use

How much?

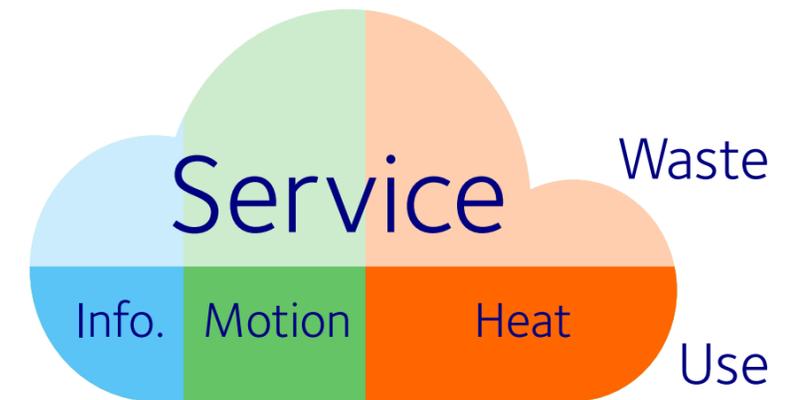


- Gas
- Wood
- Coal
- Oil
- H₂
- Sun (light)
- Air (temp)
- Wind

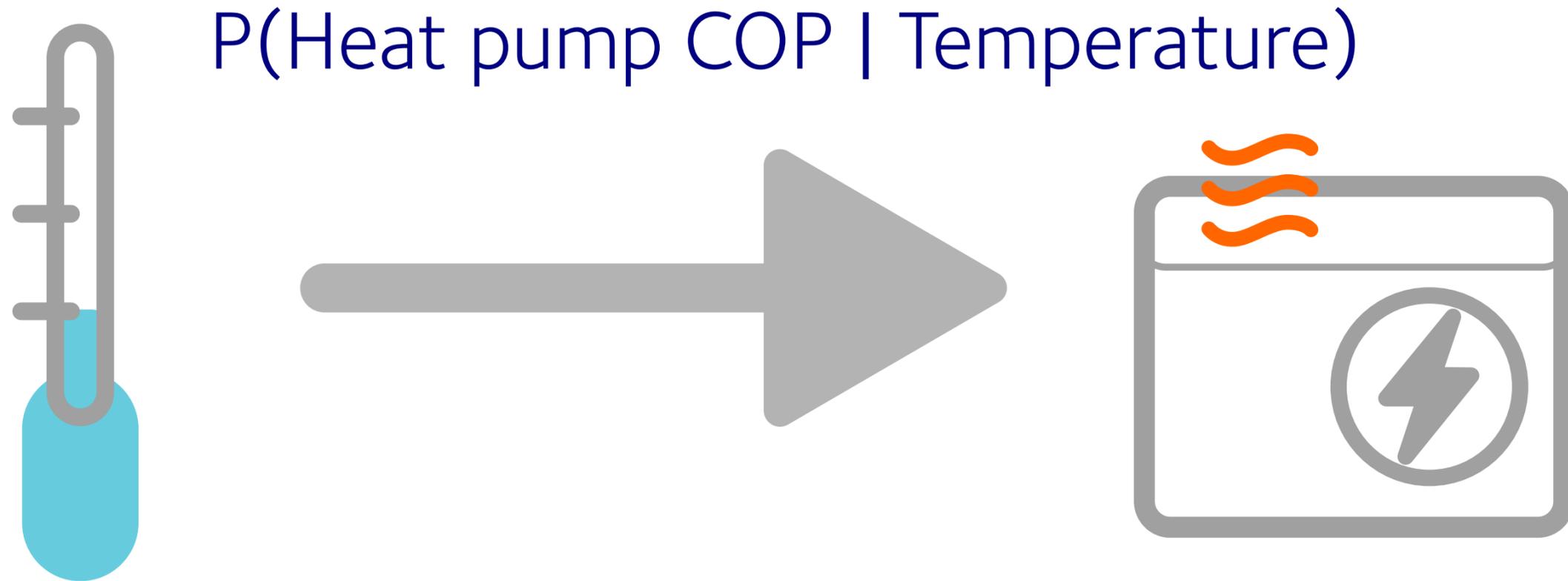
What?



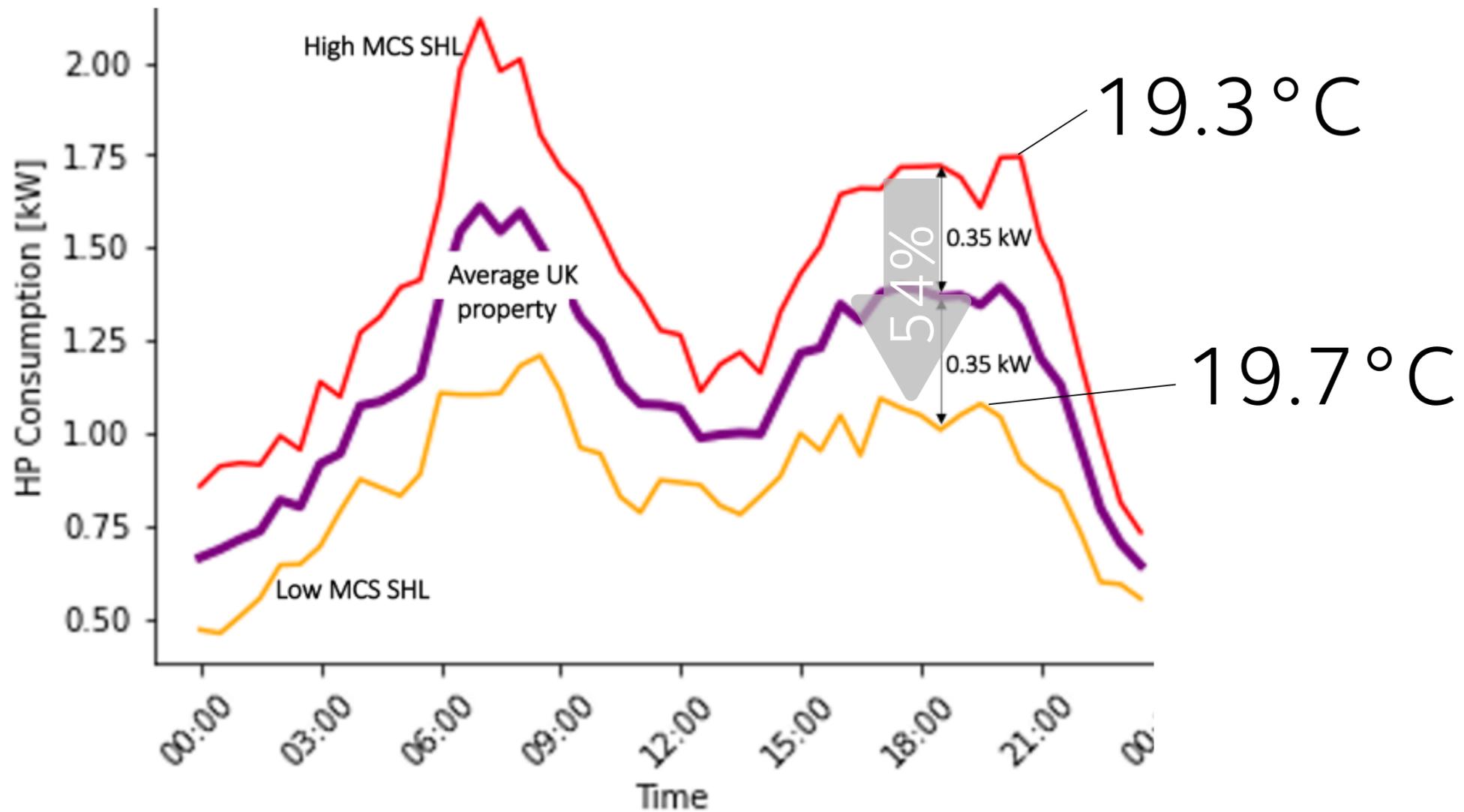
Why?



No data: I think... heat pumps don't work on cold days

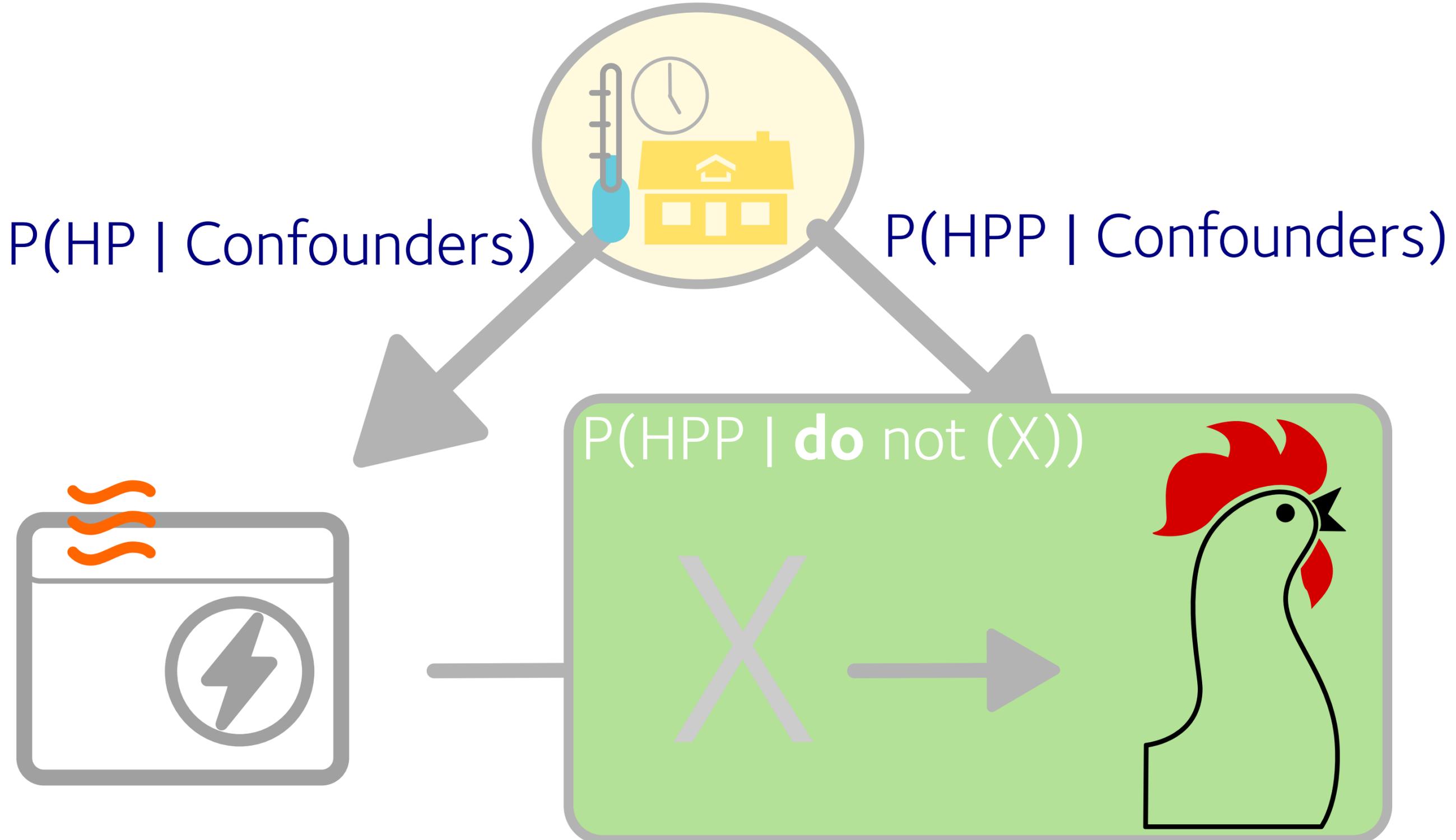


Some data: heat pumps work on cold days and even better in efficient homes



Credit: Sofia Perelli-Rocco, Energy Systems MSc 2022/23 and ChatGPT

Big data: What improves heat pump performance?



Observation is not enough - make a change

No data

Little data

Big data

Understanding
Demand

What do **I think**
people do

What do **people** think
they do

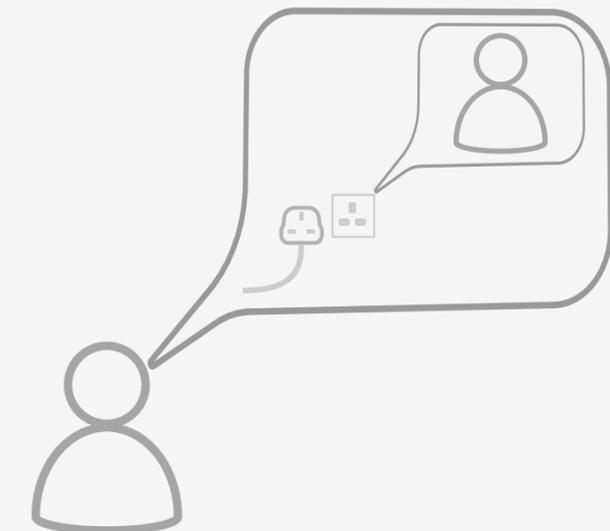
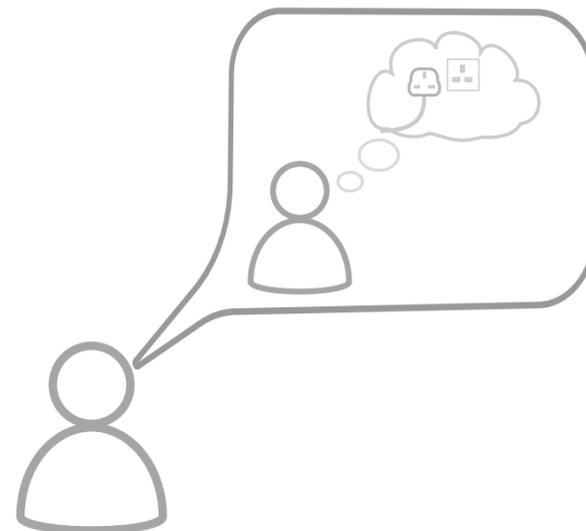
What does **data** say
people do

Changing
Demand

What **I think**
people **would do**, if...

What **people** think
they **would** do, if...

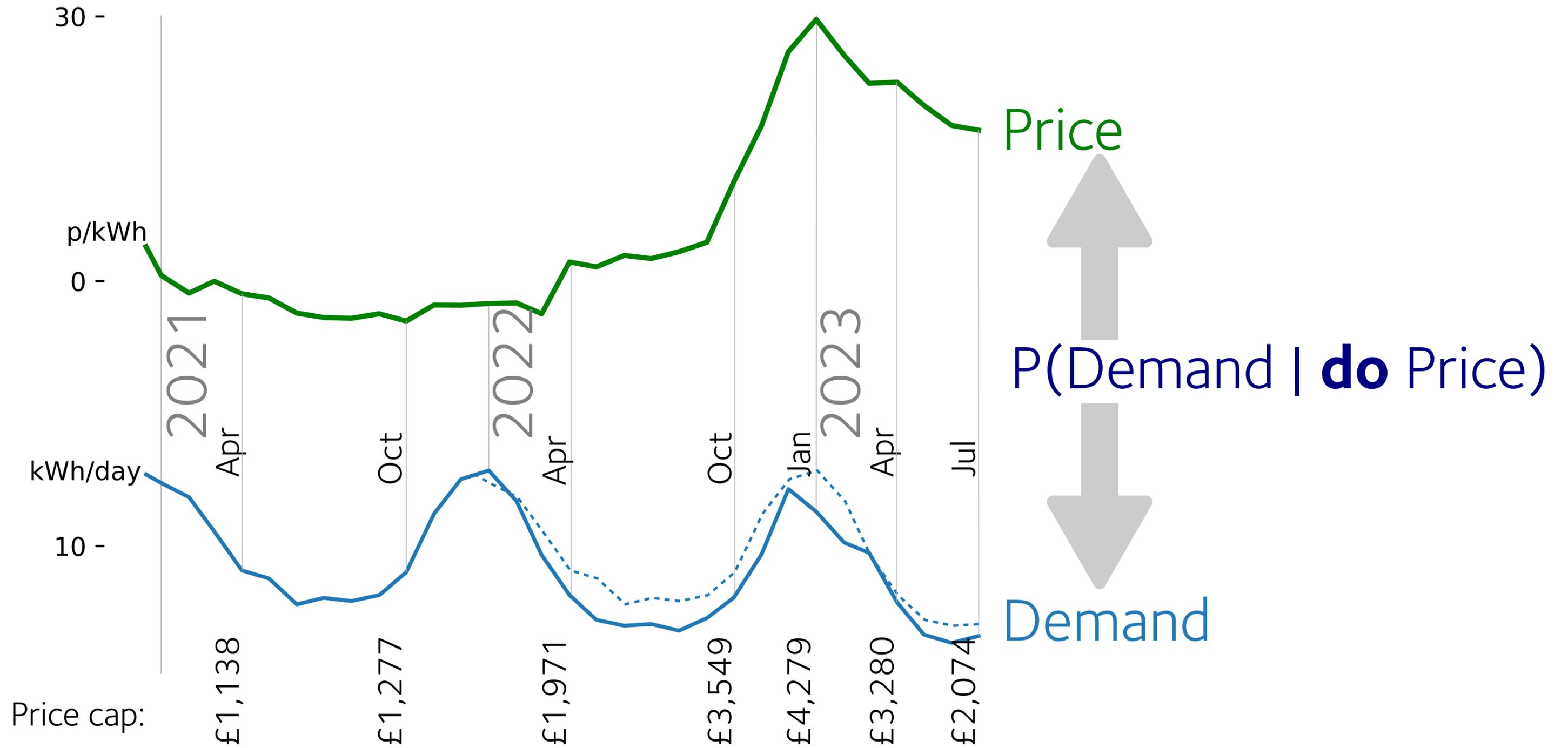
What **data** says
people **did do**, when...



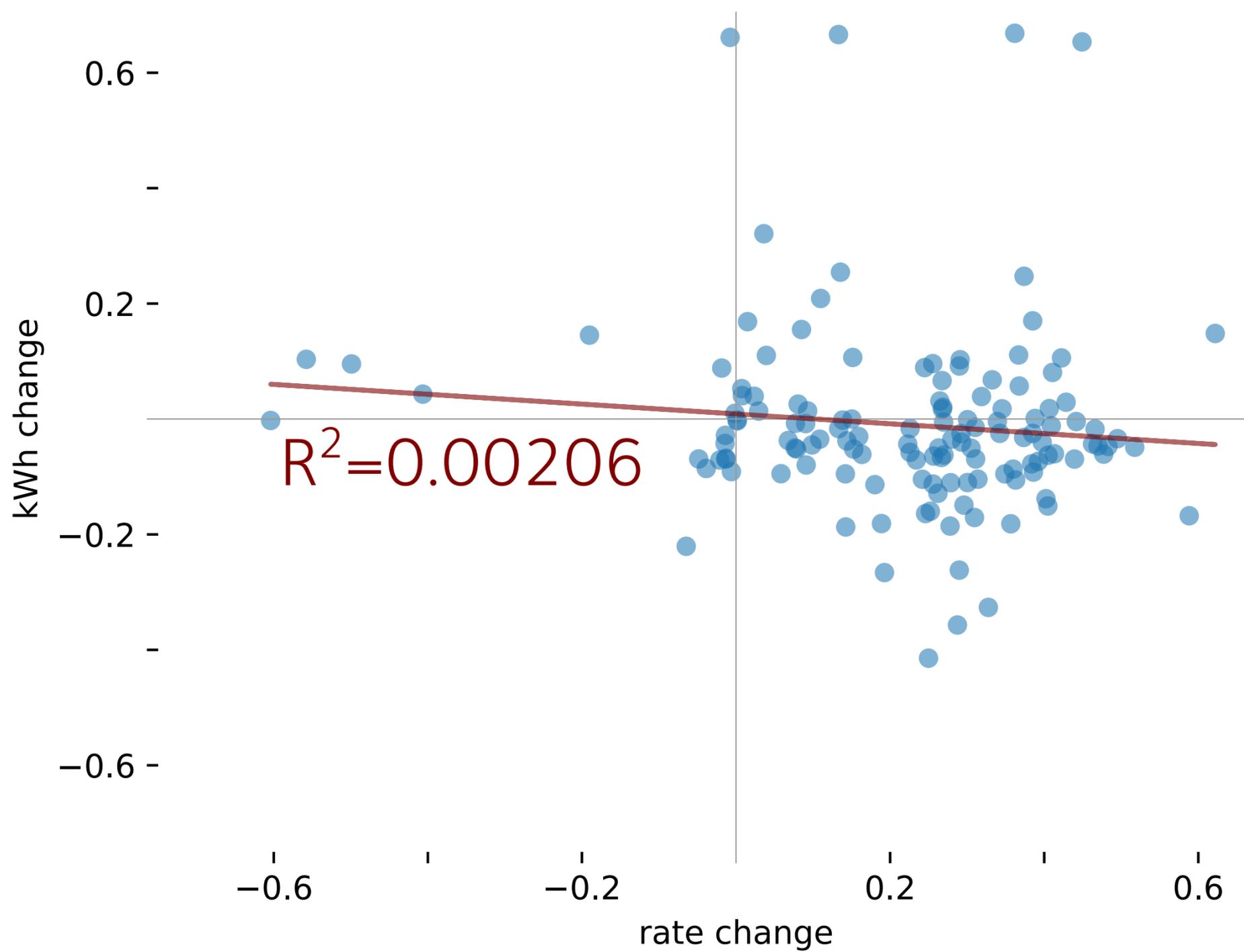
No data: I think... demand falls when prices rise



Little data: demand falls when prices rise



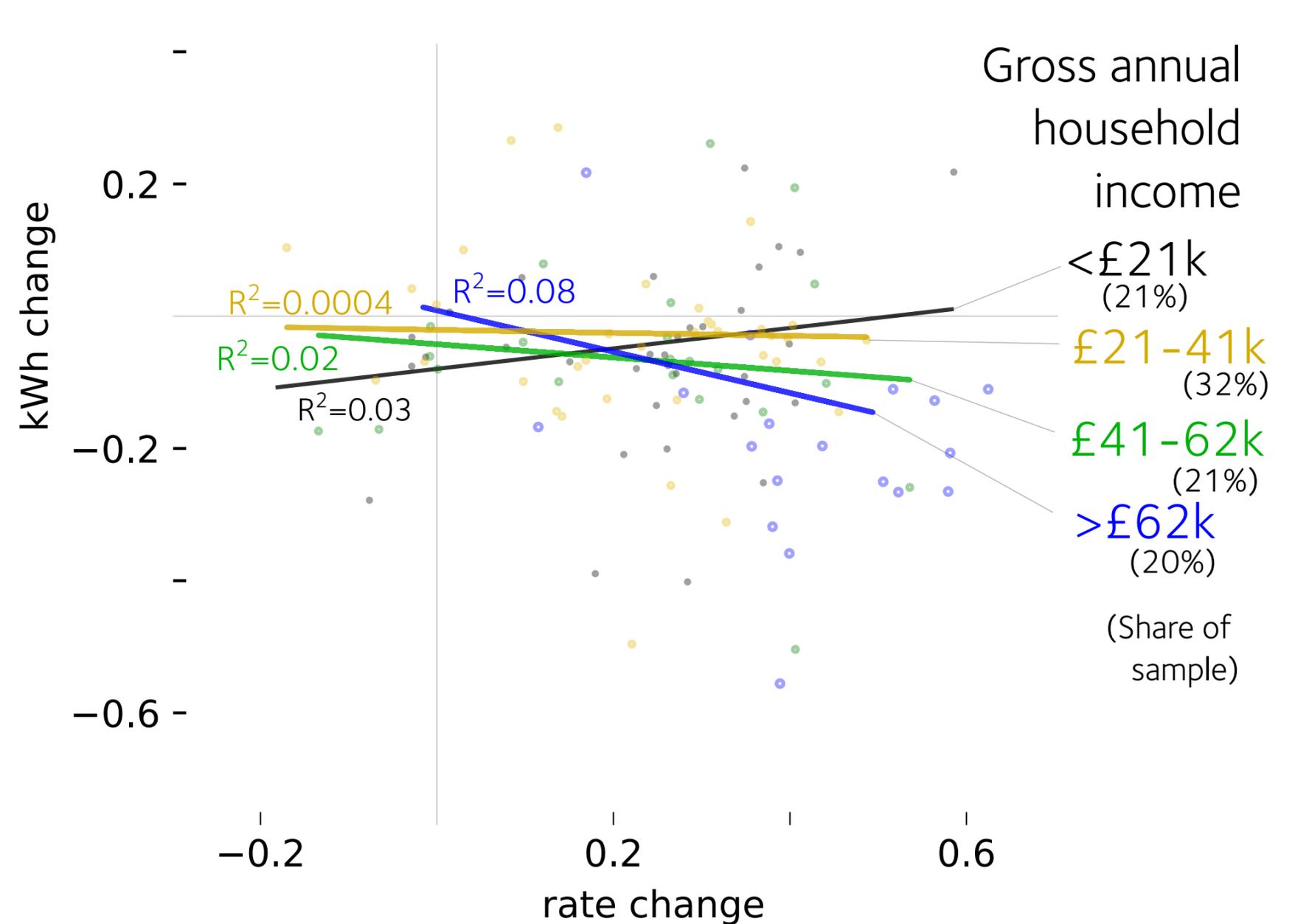
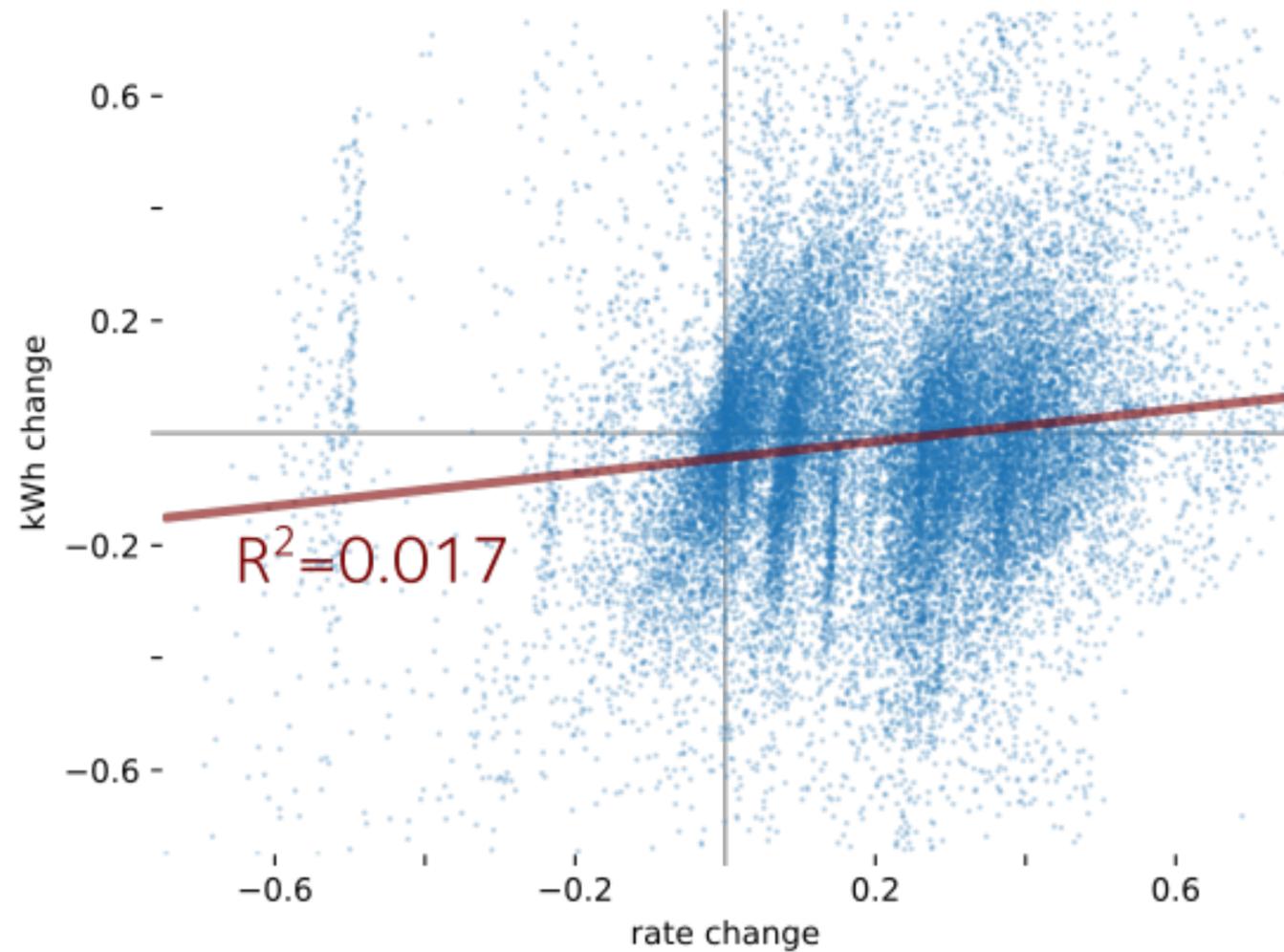
Medium data: negative price elasticity?



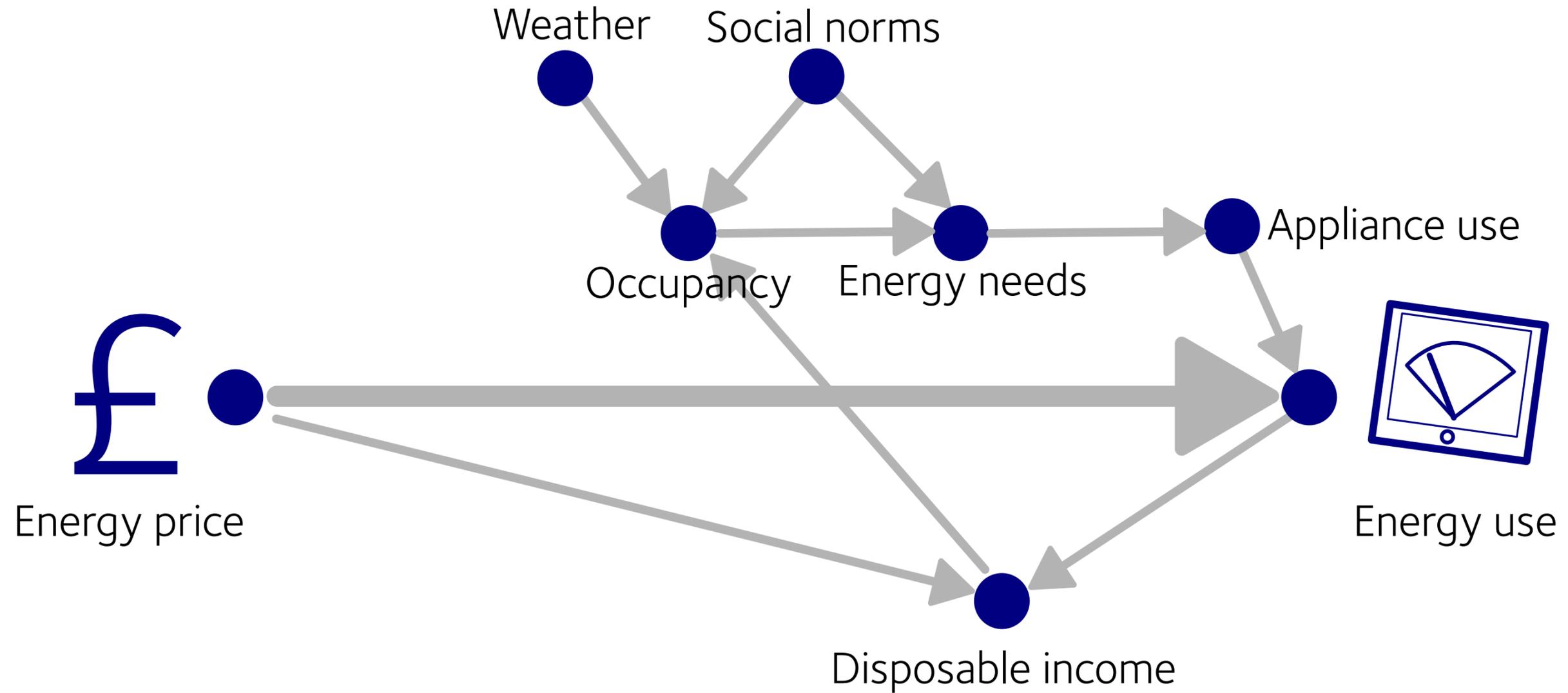
Jan 2022
vs.
Jan 2023

Big data: ... it depends

Price elasticity is weak and depends on circumstances



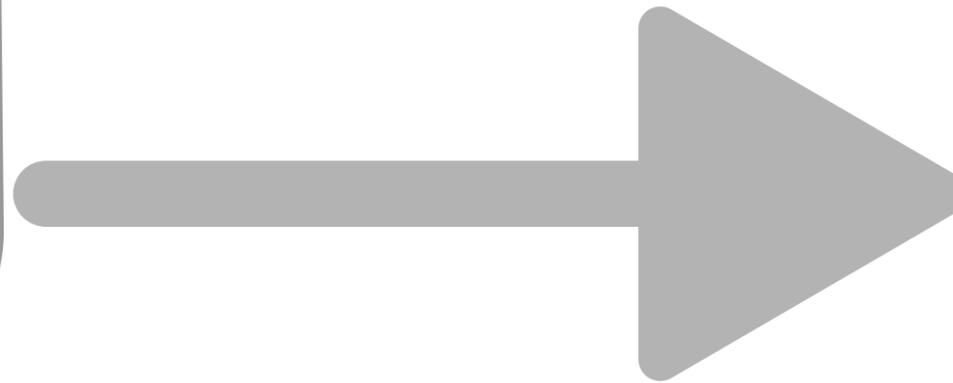
Causal model: What causes energy demand to change?



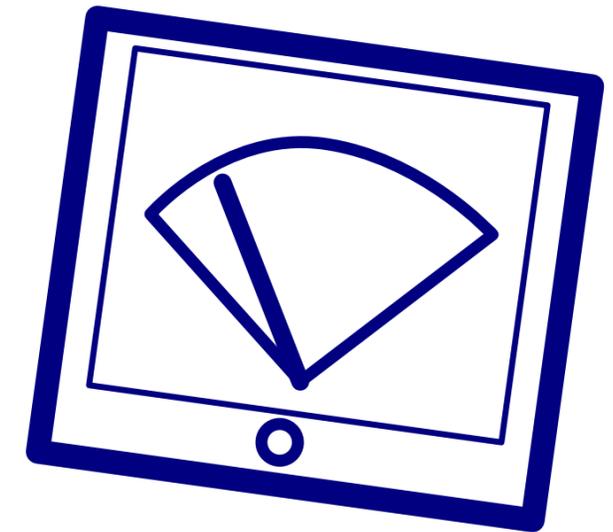
No data: I think... people will never give up dinner for DSR

Please,
1) Keep a diary
2) Reduce demand
5pm to 7pm

$P(E \mid \text{Life})$

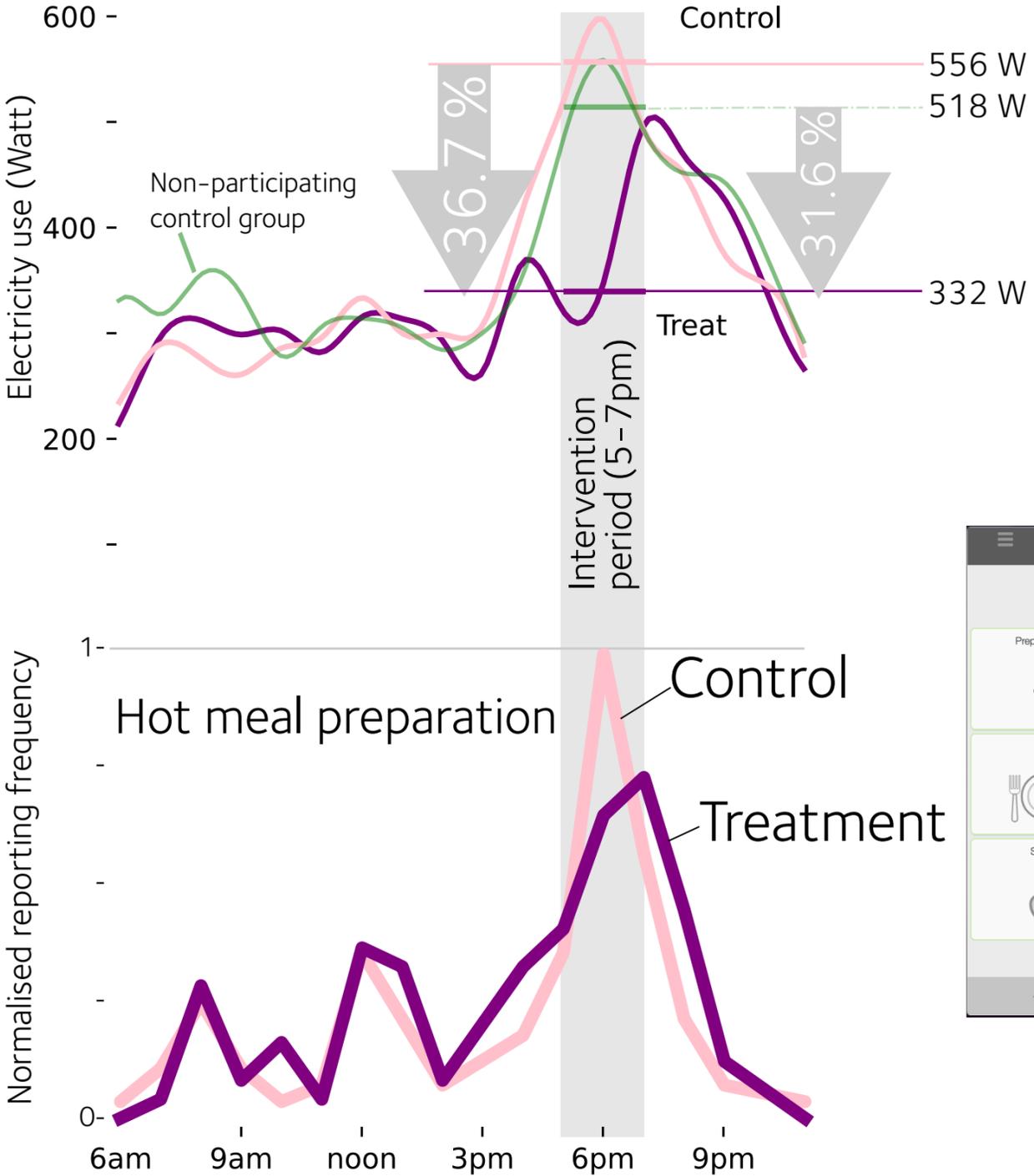


$P(E \mid \text{Life} + \mathbf{do} (\text{Ask}))$

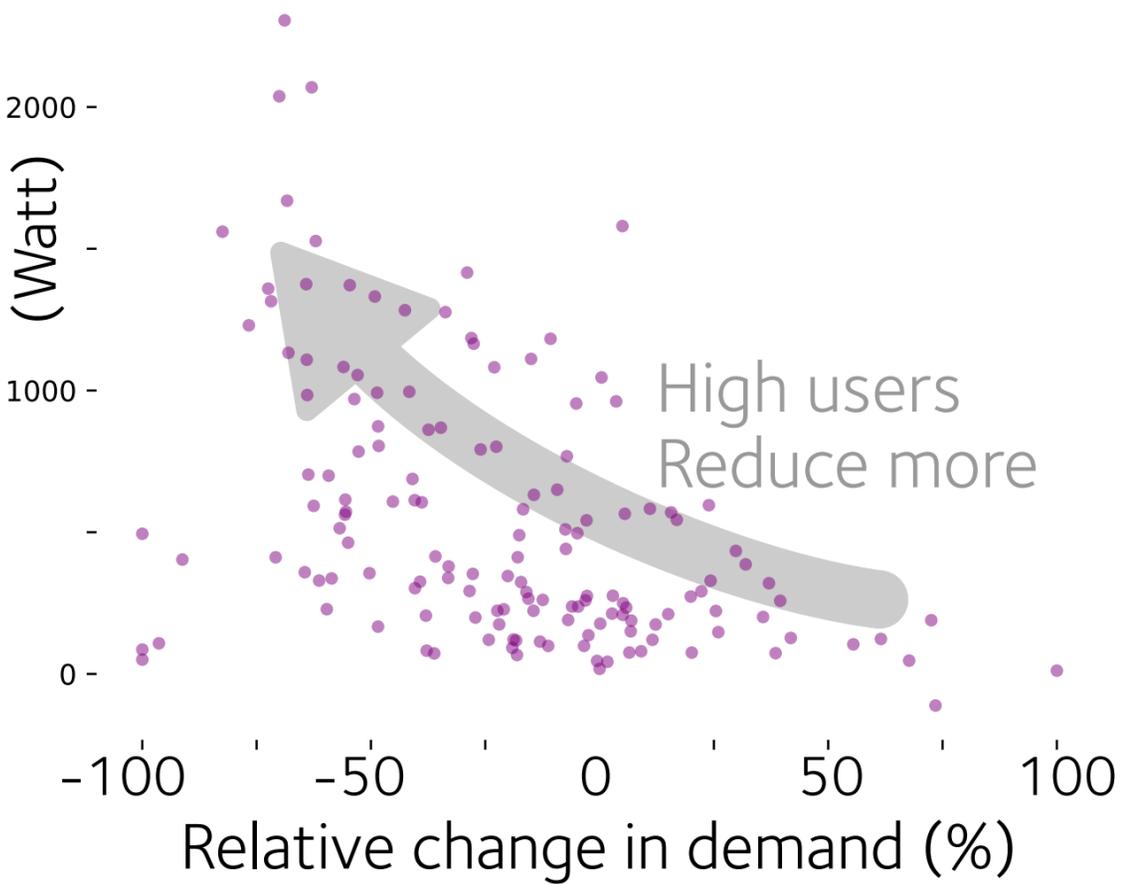


Little Data: Control and intervention:

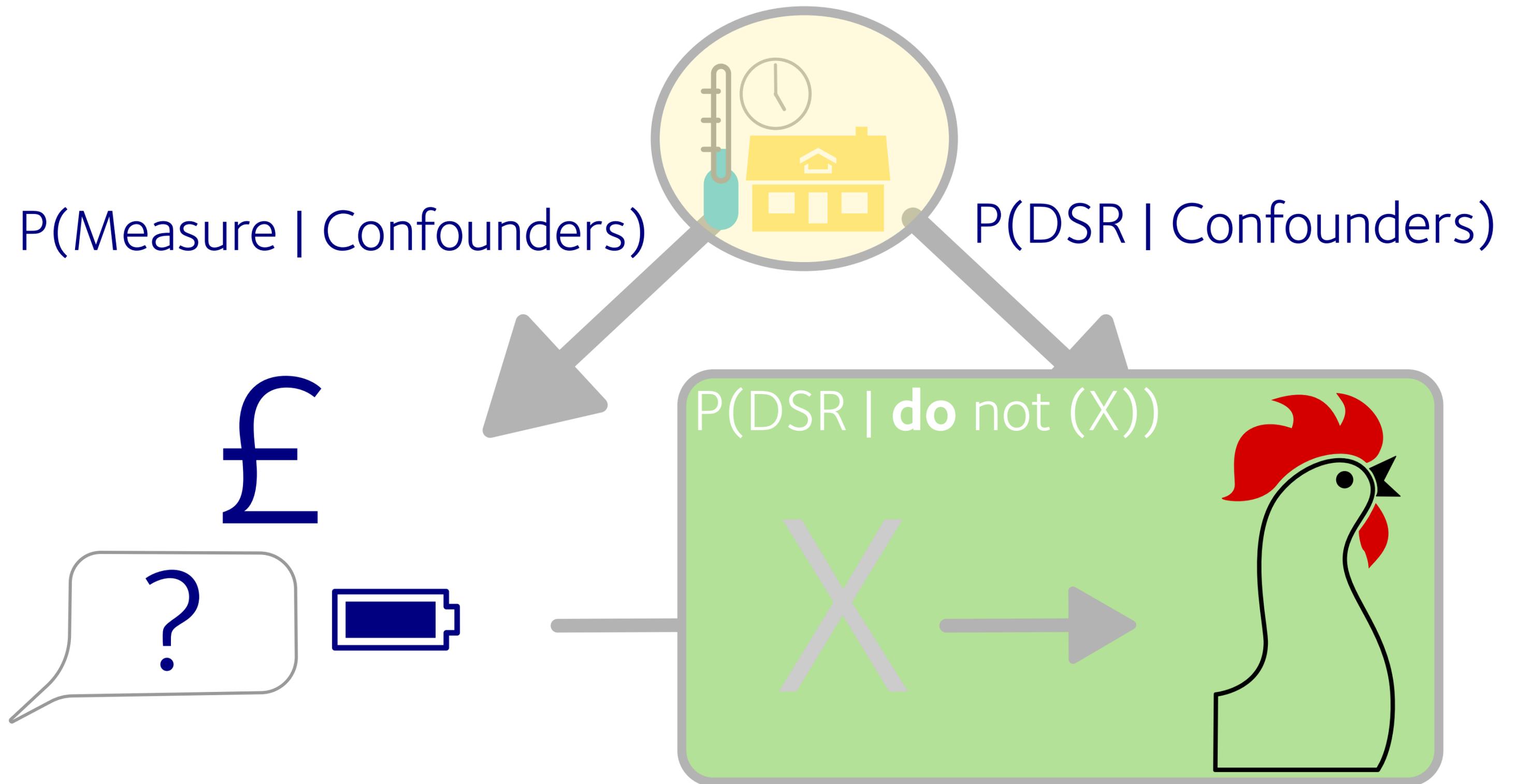
Responses are significant, repeatable and effective



Demand 5-7pm on Control Day



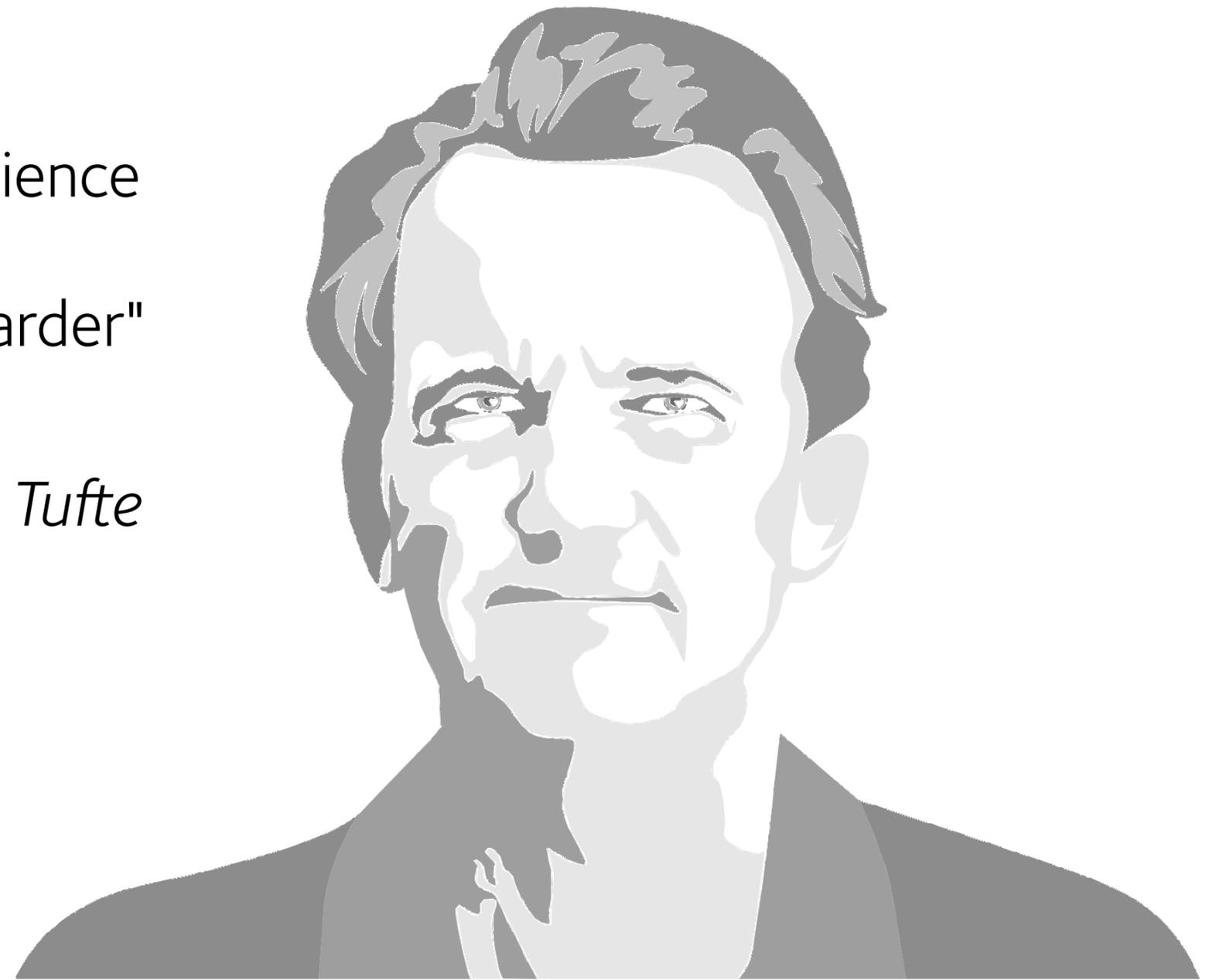
Big data: Who/what delivers demand side responses?



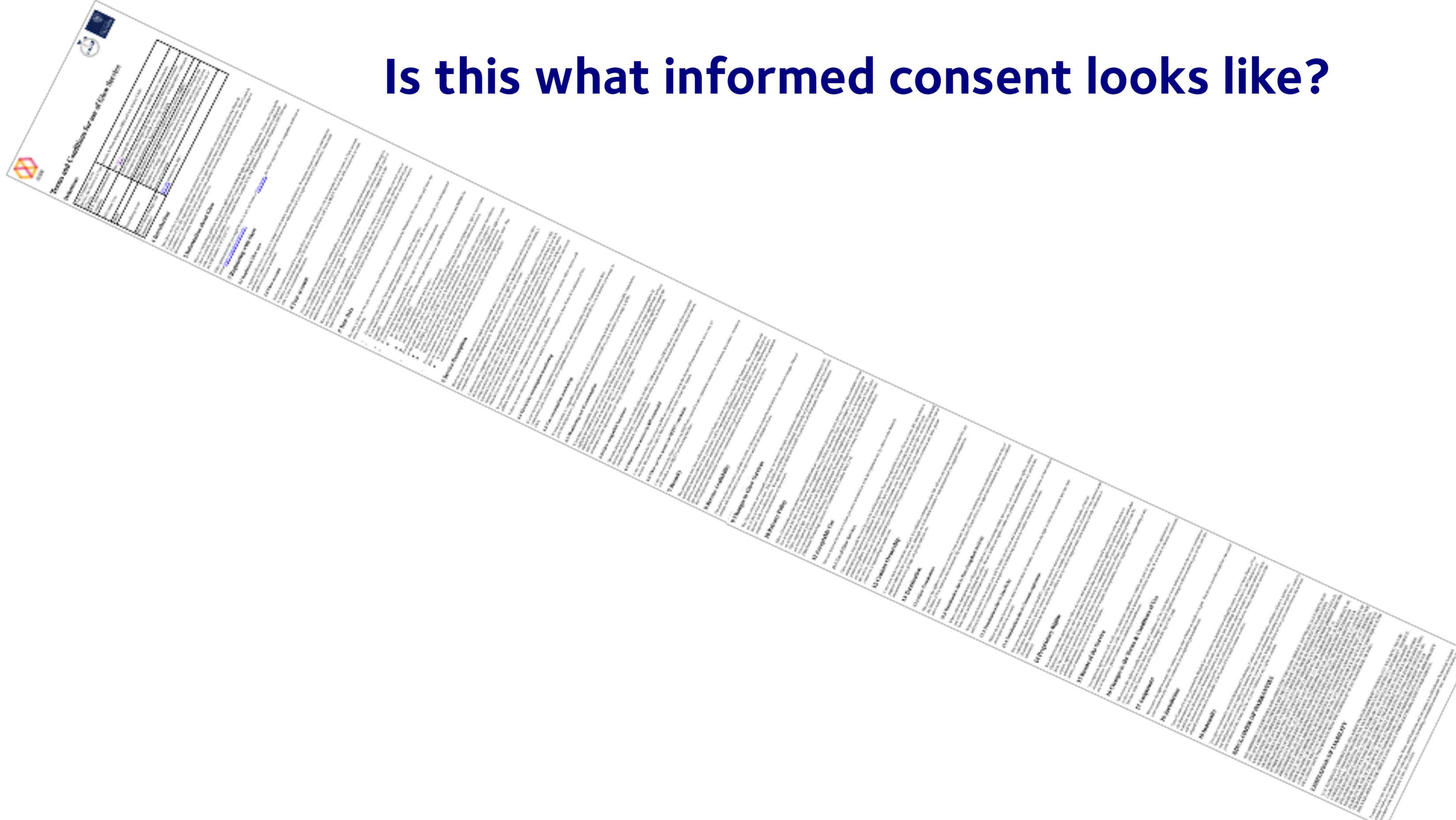
"Understanding human behaviour isn't rocket science

– it's harder"

Edward Tufte

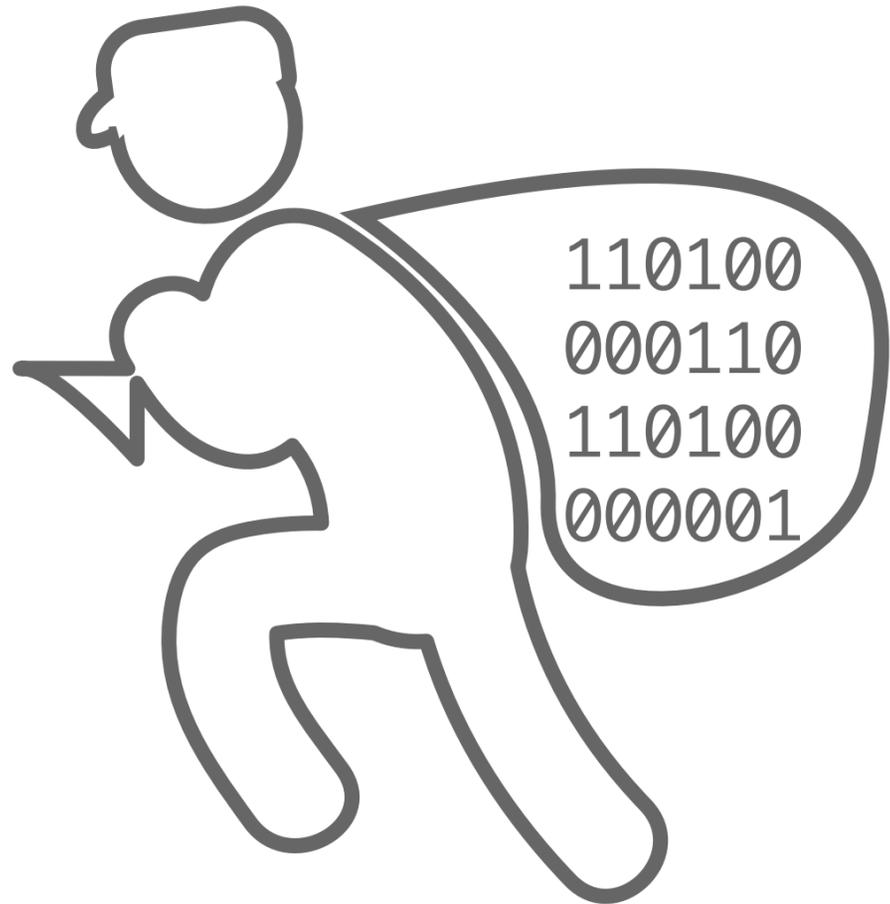


Is this what informed consent looks like?





It is unclear what is sensitive and why



Energy use?

EPCs are public

Occupancy?

Lights and windows
are visible to all

Privacy?

Spying spouses

Practices?

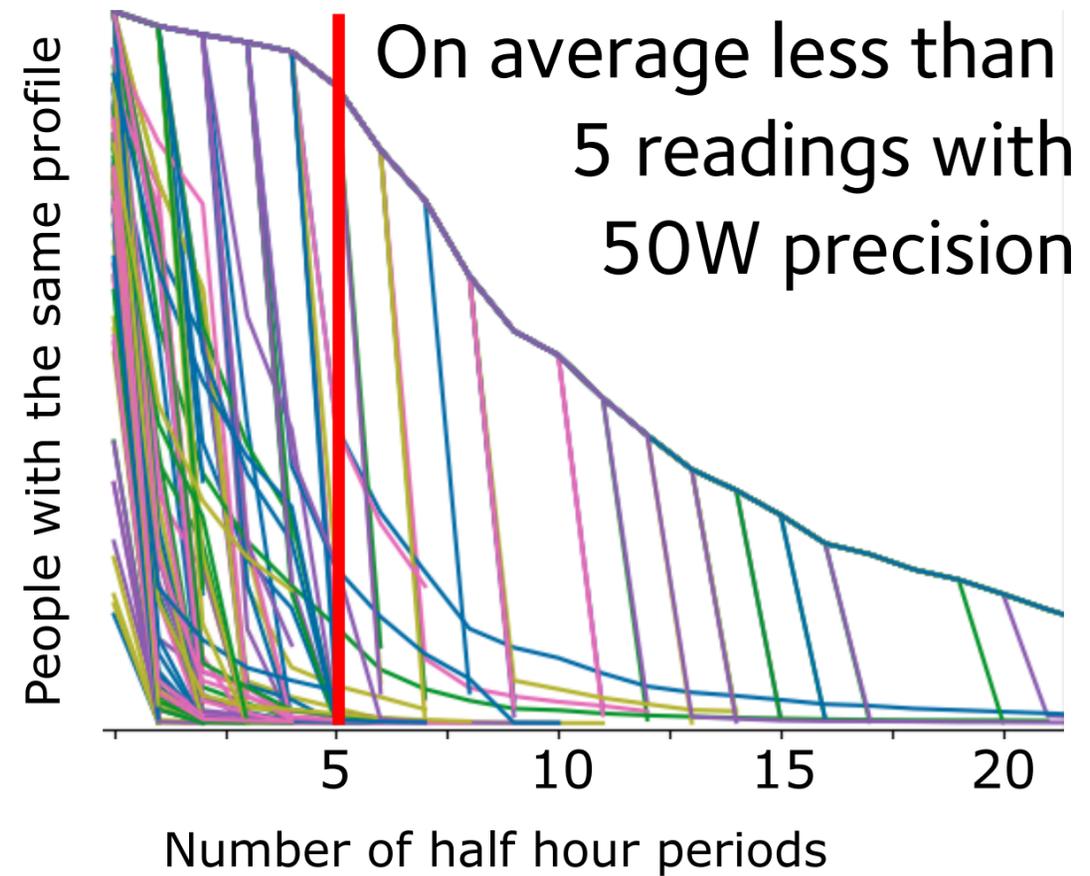
Profiles reveal faith

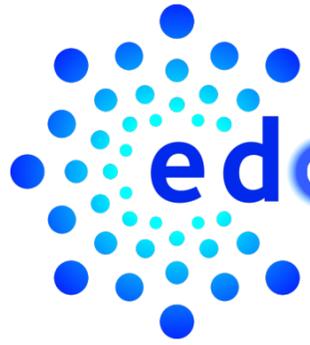
Identity?

How unique is the data

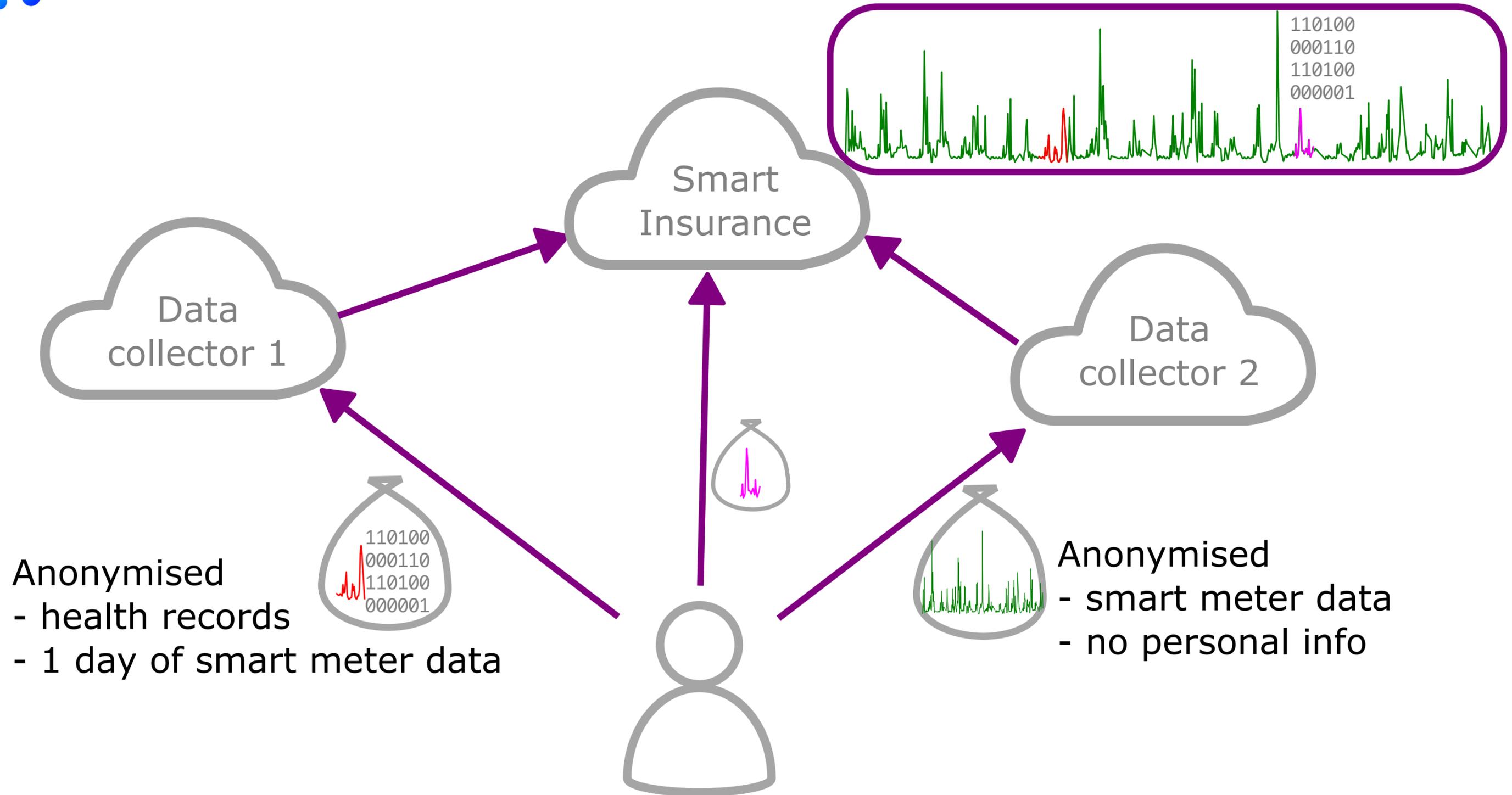


How much smart meter data does it take to uniquely identify *you*?





Linking can turn harmless data into revealing data





We need to de-identify data while maintaining data integrity

Approaches

- 1) Aggregate Rule of '10' (or 3?) – arbitrary, defusing and unreliable
- 2) Cluster Maintains some relevant features (e.g. heat pump cluster)
- 3) Synthesise Allows to generate even hypothetical profiles



Interested?

Get in touch!



Fully funded* DPhil in Energy Data Privacy

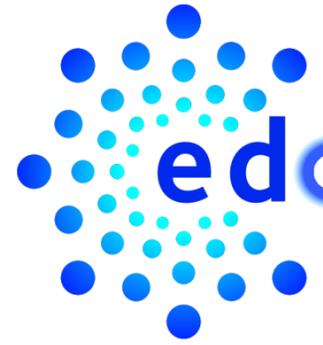
Energy equity, security and decarbonisation can benefit from ethical uses of personal data. Oxford has access to large personal data sets. Apply machine learning tools to synthesise and share them responsibly.

Start October 2024 - see edol.uk/dphil

*for home students



Engineering and Physical Sciences Research Council



EDOL The Energy Demand Observatory and Laboratory

EDOL is

- An EPSRC programme with
- Establishes a new energy data resource over 5 years
- Large scale (>2000 GB homes)
- Longitudinal (extend SERL, run until net-zero?)
- Un-intrusive and low cost
- Intrusive and expensive



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UNIVERSITY OF
OXFORD



Engineering and
Physical Sciences
Research Council

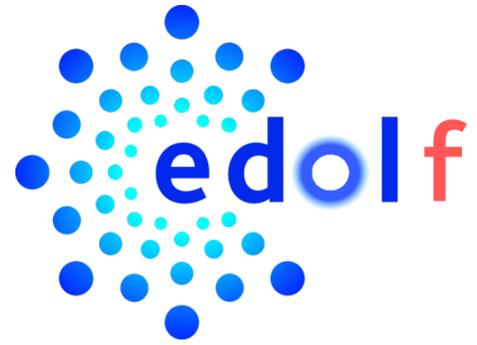


Deliver

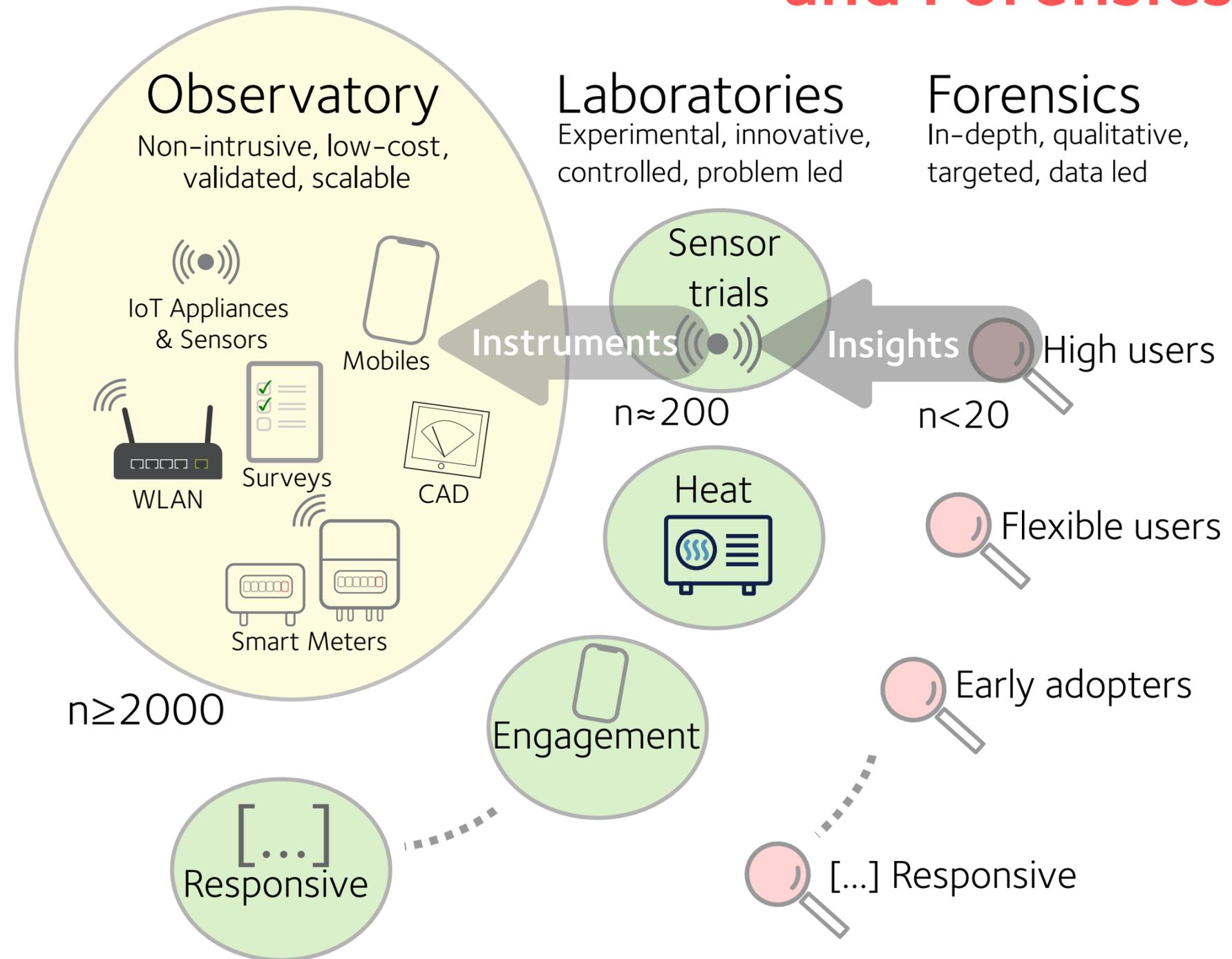
- 1) **sociotechnical research** for a scientific understanding of **energy use**
- 2) **responsive** research to a fast-moving technological and policy landscape
- 3) **make data available** to scientists, industry and policymakers
- 4) **data-driven approaches** to energy data collection, analysis and access
- 5) **innovate** new, cost-effective smart data solutions for collecting energy data at scale

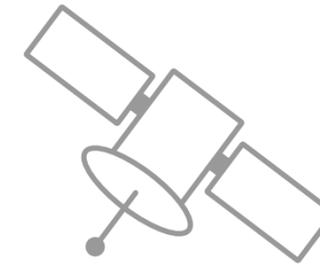
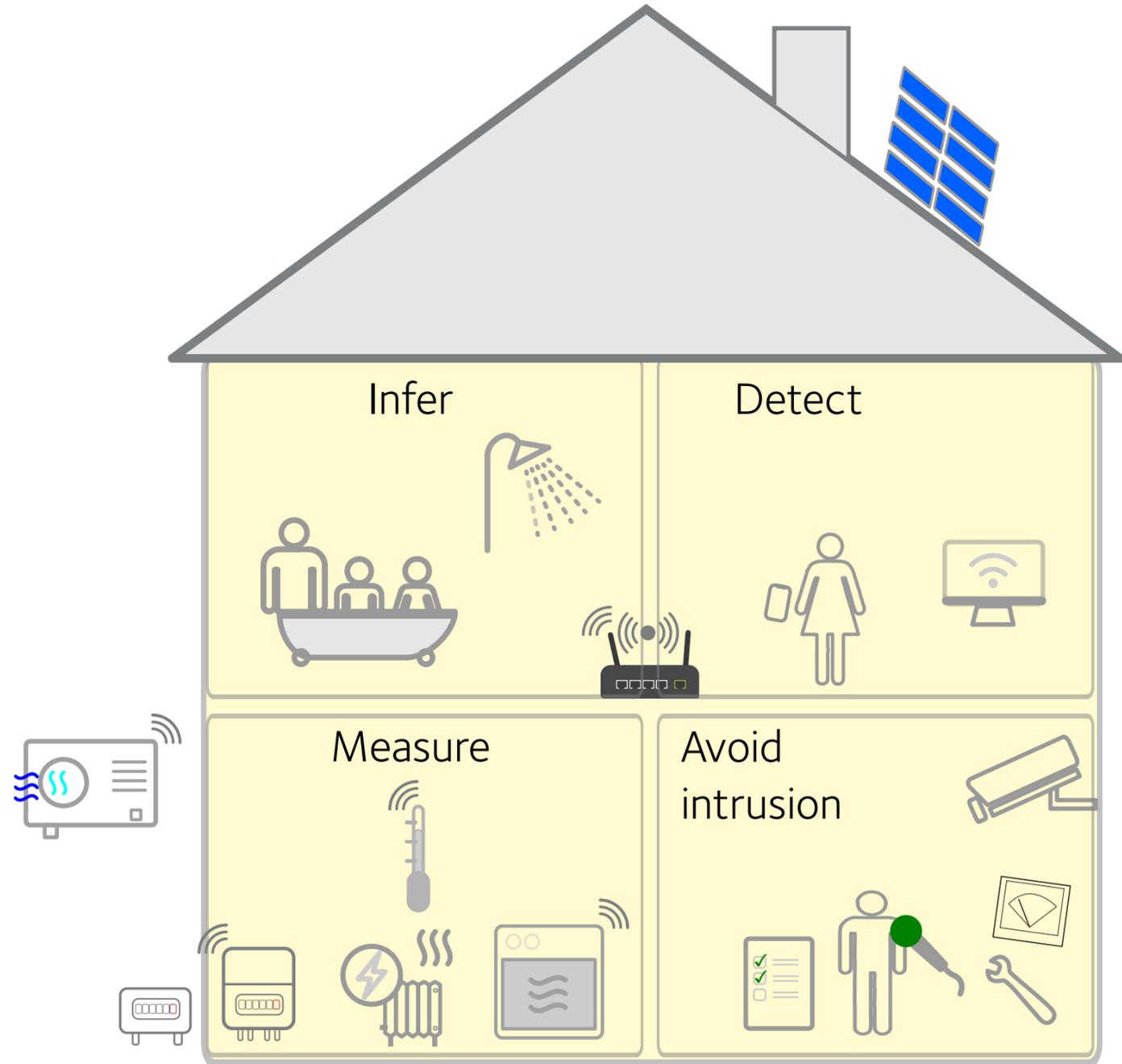
...and my own

- 1) **spend to save** drive down effort and cost per home (make EDOL2,3 & 4 no-brainers)
- 2) **share** - establish EDOL as the goto place for household energy data



Energy Demand Observatory and Laboratory and Forensics





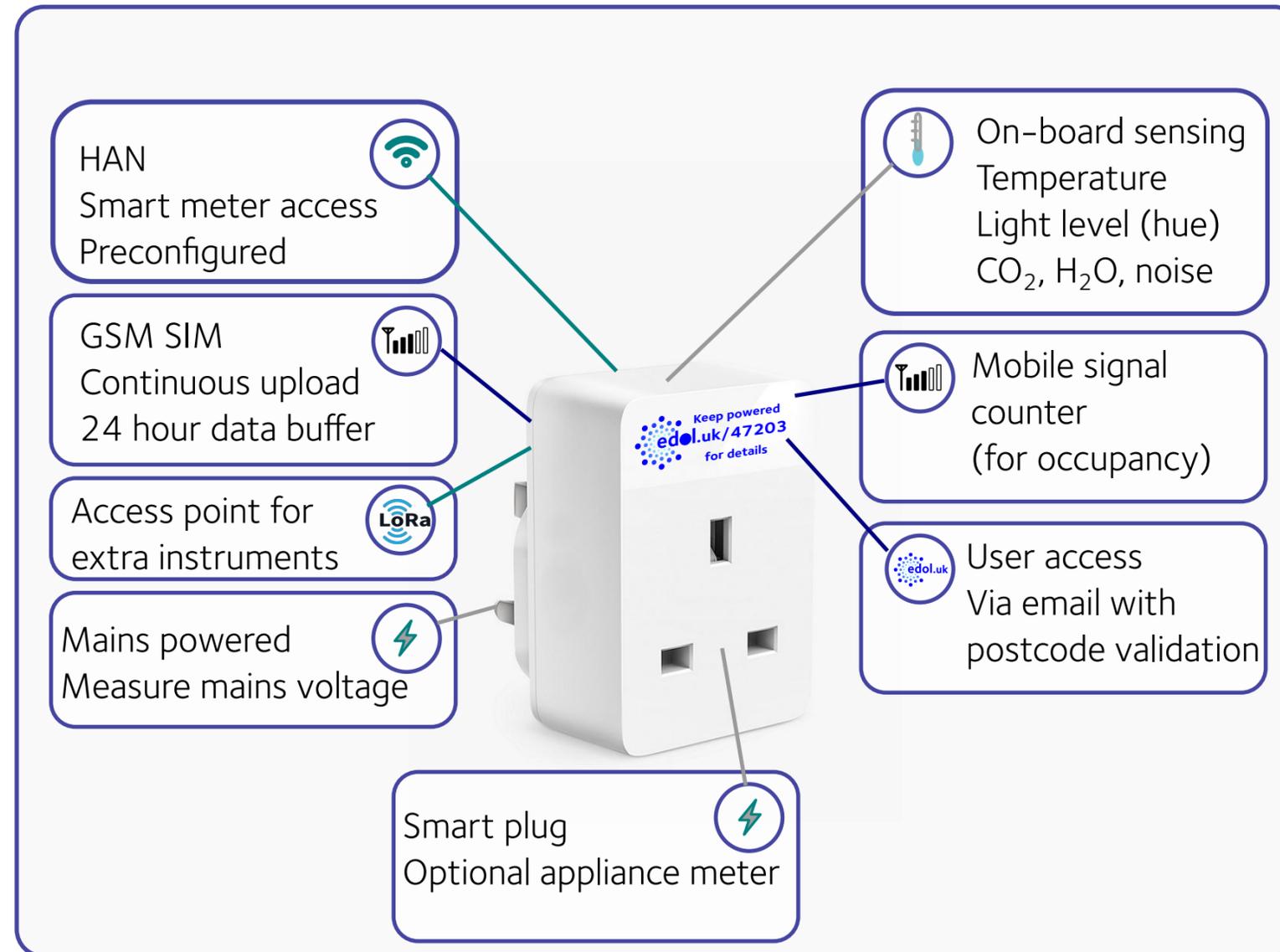
Key development steps

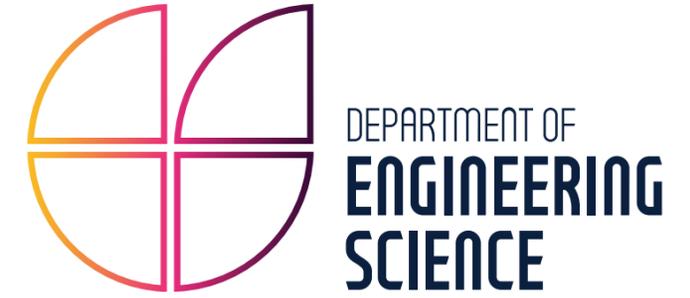
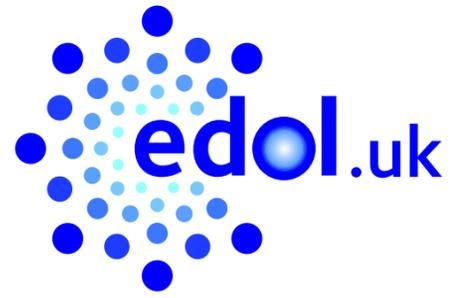
- 1) Identify and validate technology options
- 2) Minimise the need for hardware and intrusion
- 3) Use accessible sources of data





EDOL Dream Data Instrument (EDDI)





Thank you



**Dr Phil
Grünewald**



**Dr Tina
Fawcett**



**Dr Zeynep
Duygu Tekler**



**Dr Marina
Topouzi**



**Prof. Christian
Brand**



**Dr Dominic
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**Prof. Charlie
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