people
~~technology~~
It's the ~~economy~~, stupid

Socio-Technical Transitions for Net Zero – MT2023

Phil Grunewald

Why are we here?

Climate change

→ Sustainability

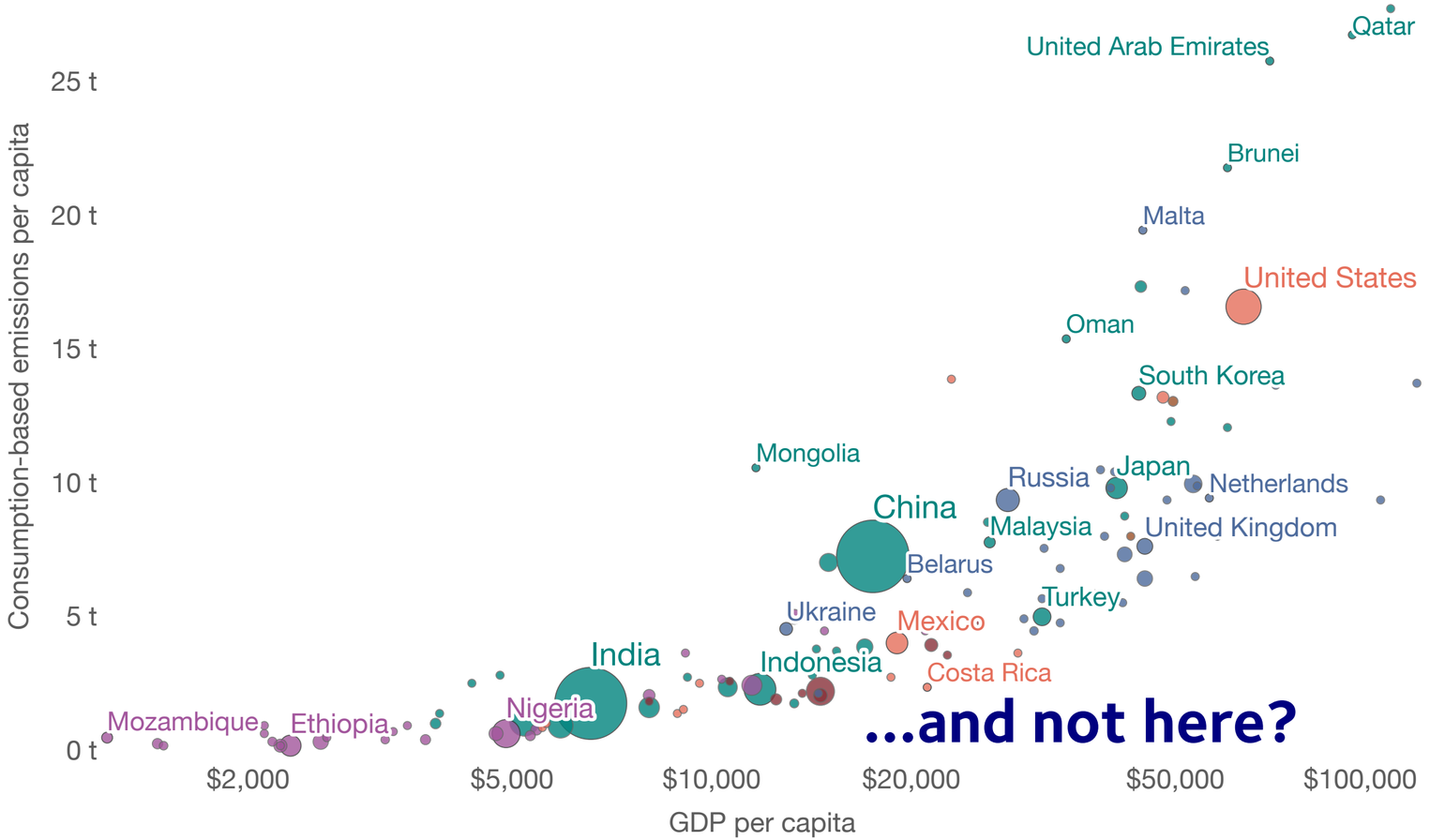
→ Energy

→ Generation

→ Demand

→ Energy service

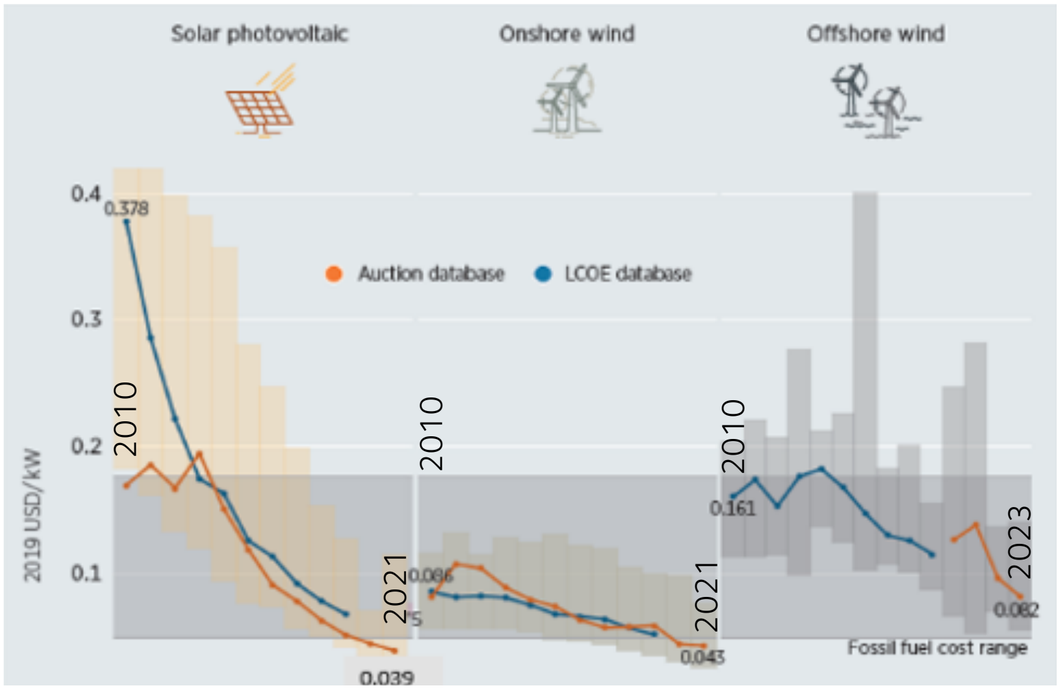
Why are we here...?



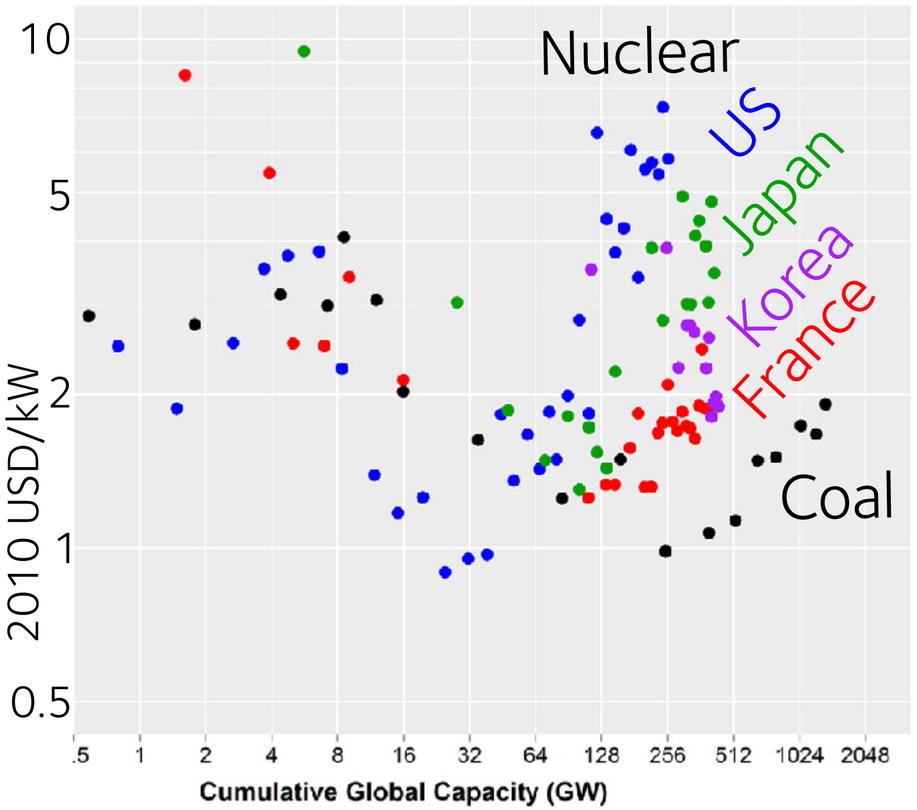
Data source: Global Carbon Budget (2023); Population based on various sources (2023); World Bank (2023)
OurWorldInData.org/co2-and-greenhouse-gas-emissions | CC BY

Supply matters: it's the economy (after all)

Winners



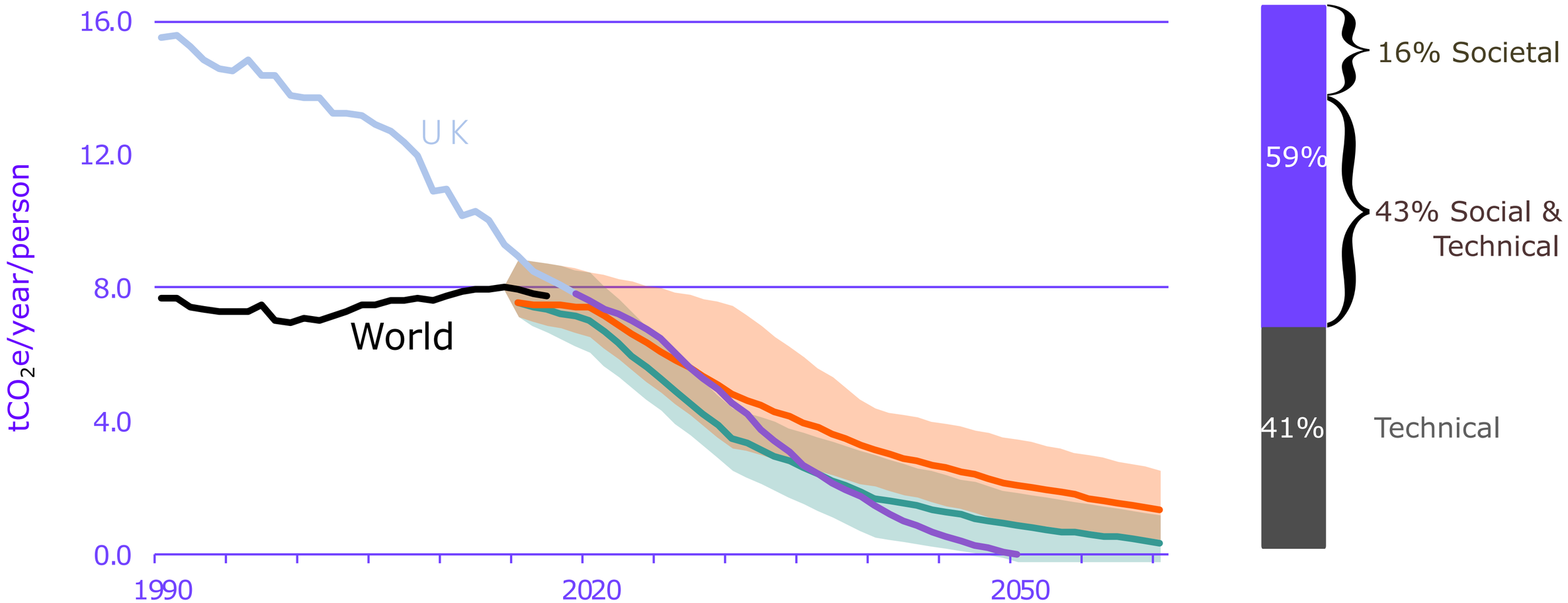
Losers



Irena (2020)

http://dx.doi.org/10.1016/j.enpol.2016.01.011

The transition becomes more socio-technical



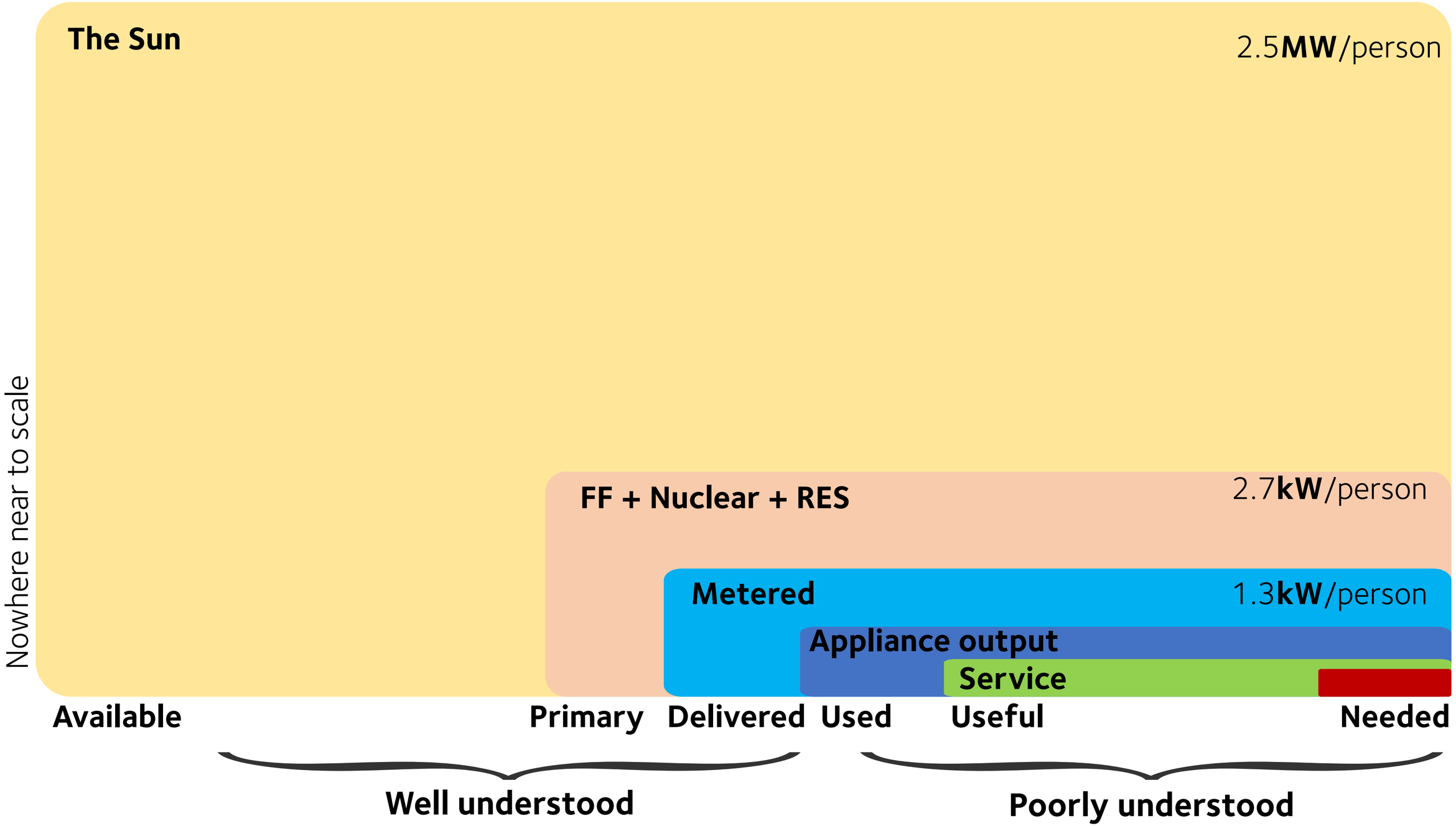
Source: Climate Change Committee. The UK's path to net zero. The sixth carbon budget, Climate Change Committee, December 2020

Changing a socio-technical system: systematically

Goals/paradigm	GDP, net zero, use less
	Meet needs
Rules/structure	Pay per kWh
	Pay for energy service
Feedbacks	Bills, In-home-displays (IHD)
	Analytics, needs met
Parameters	Network operators, supplier, generator
	Distributed systems (fractal grids)


WHSmith
WHSmith
No Service

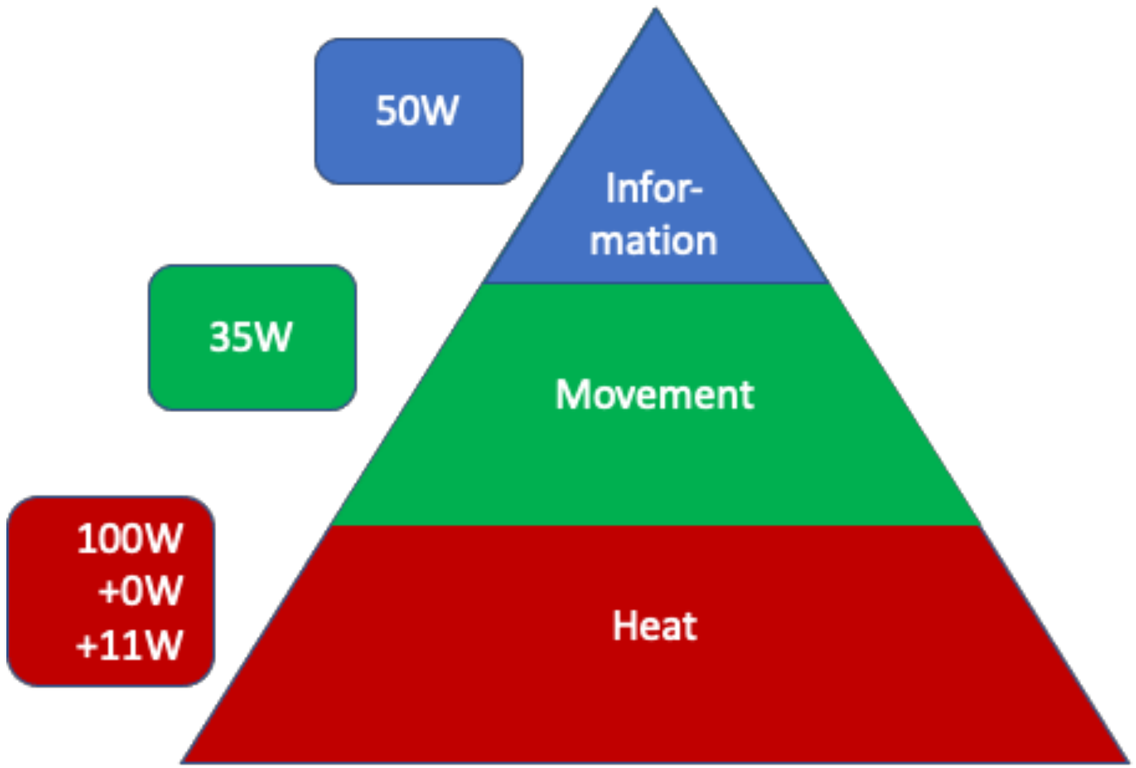

Pedal
Powered
Phone
Charging
£4 Per hour
£1.50 if you pedal!



data: worldbank.org, iea.org

Maslow's Hierarchy of Needs

Energy service needs



Information

- 60W / GB (IEA)
- Streaming at 1.25 GB 16 hours per day

Movement

- $E = m (v^2/2 + g\ h)$
- m=100kg, v=100km/h, h=100m
- 5 trips per day: 830Wh

Heat (100W ~2,000kcal)

- $E = -k\ \Delta T\ A$
- Inside 36°C, outside 0°C, surface $2m^2$, E=100W
- k = -1.4 W/mK

Coolth

- Inside 36°C, outside 40°C, k = -1.4W/mK

Energy service needs

2.5**MW**/person

Efficiency requirement ~1 in 10,000

(Yes we can meet everyone's needs sustainably)

200 **W**/person

Energy service needs

Over the past 30 years

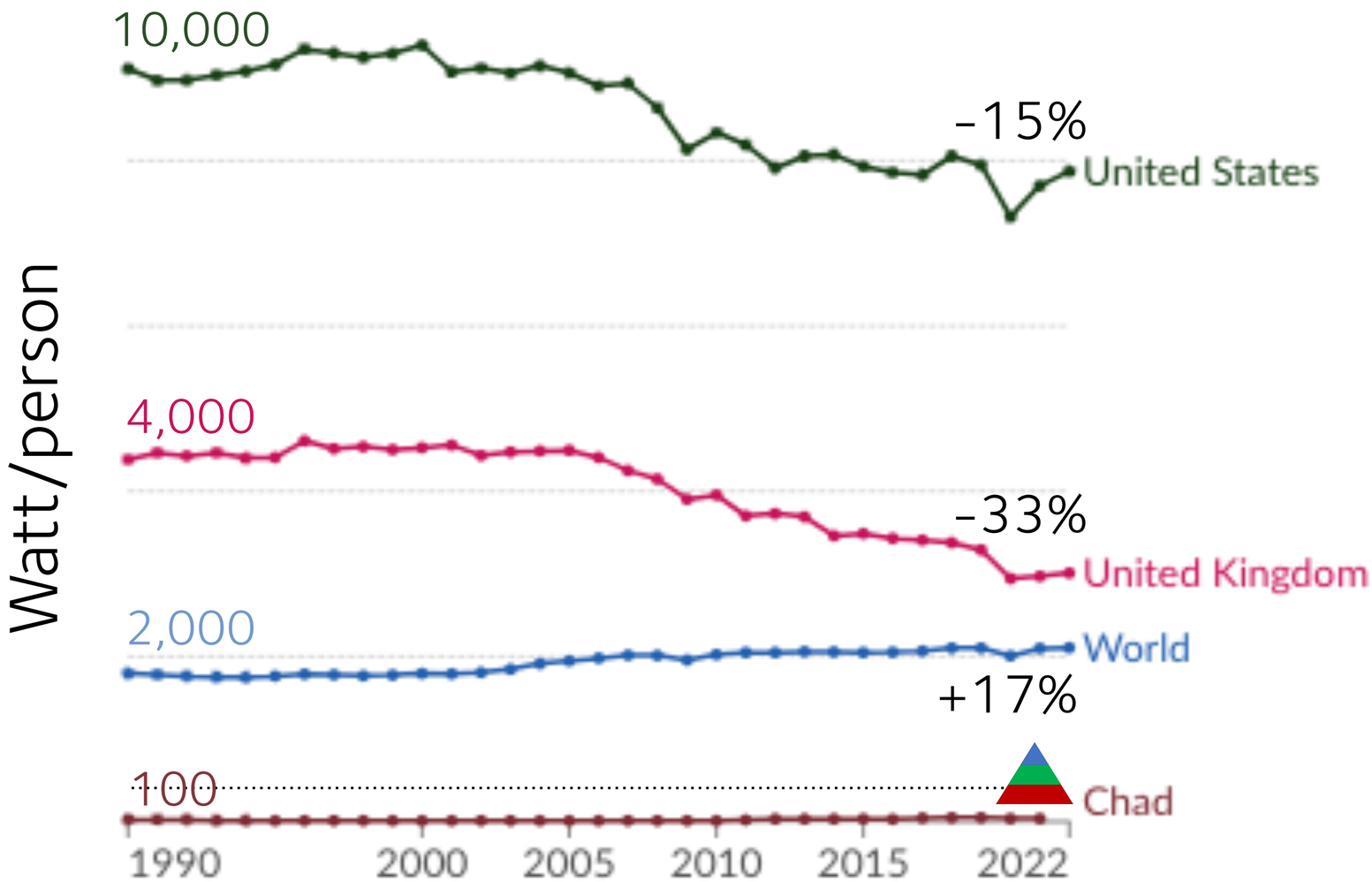
Energy use in the UK

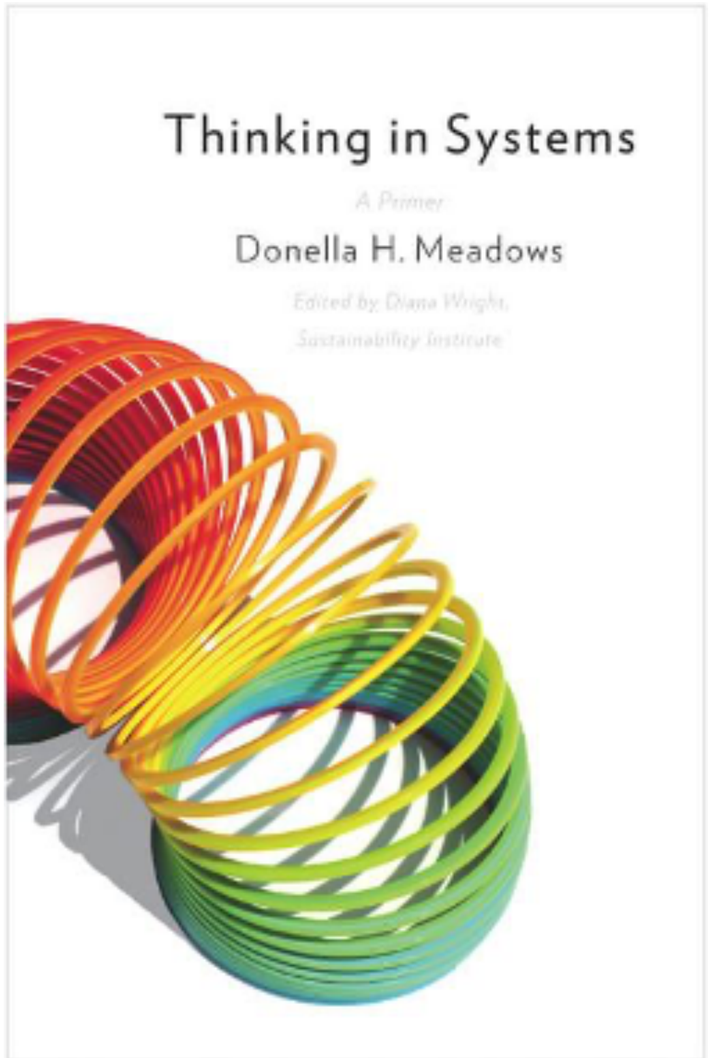
a) Increased 50%

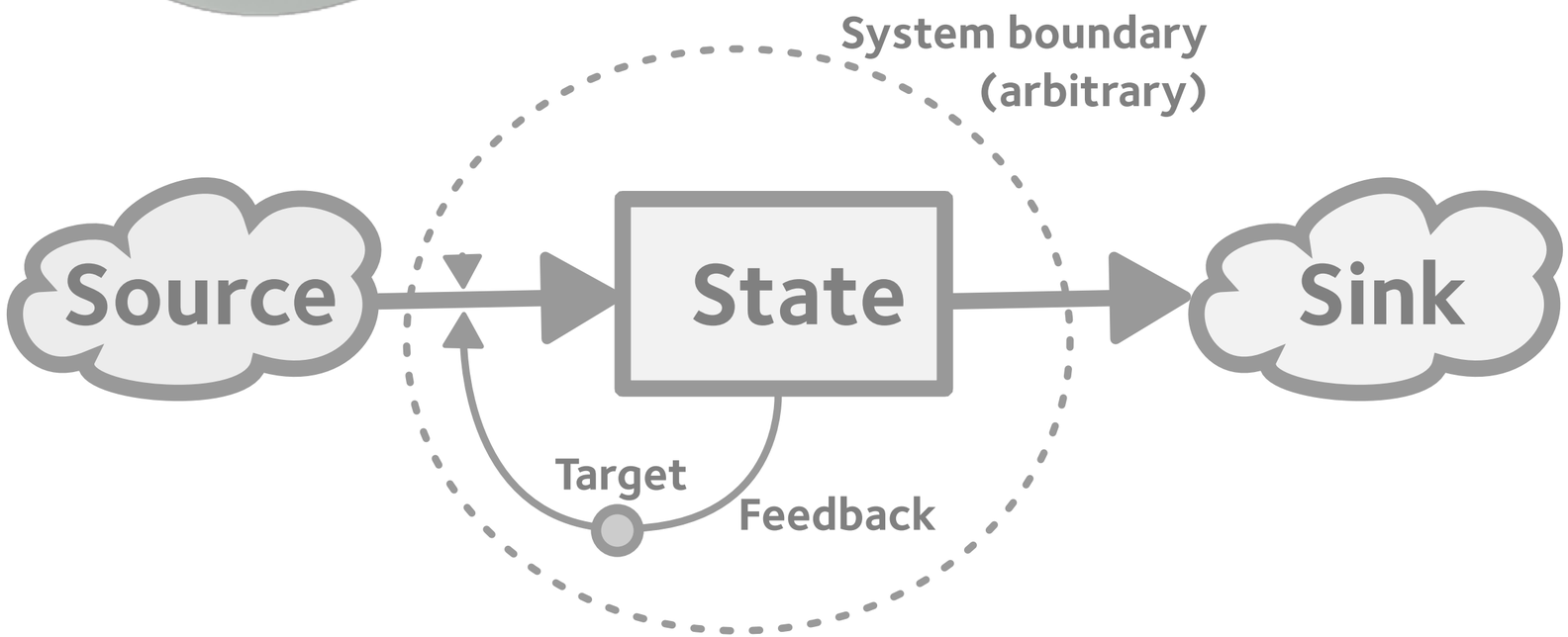
b) Increased 20%

c) stayed the same

d) reduced by 20%



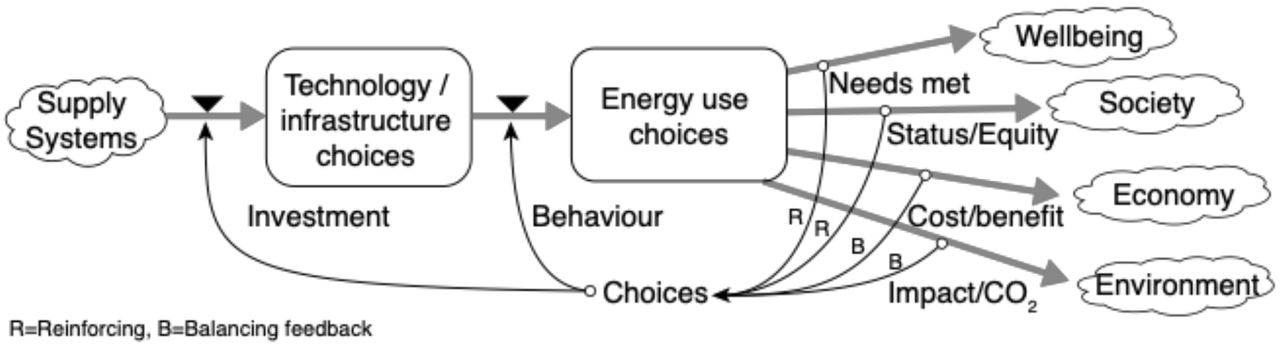

Thinking in Systems
A Primer
Donella H. Meadows
Edited by Diana Wright
Sustainability Institute


System boundary
(arbitrary)
Source
State
Sink
Target
Feedback

Energy feedback

Good feedback is:

- Timely (not just fast)
- Accurate
- Relevant to system goals

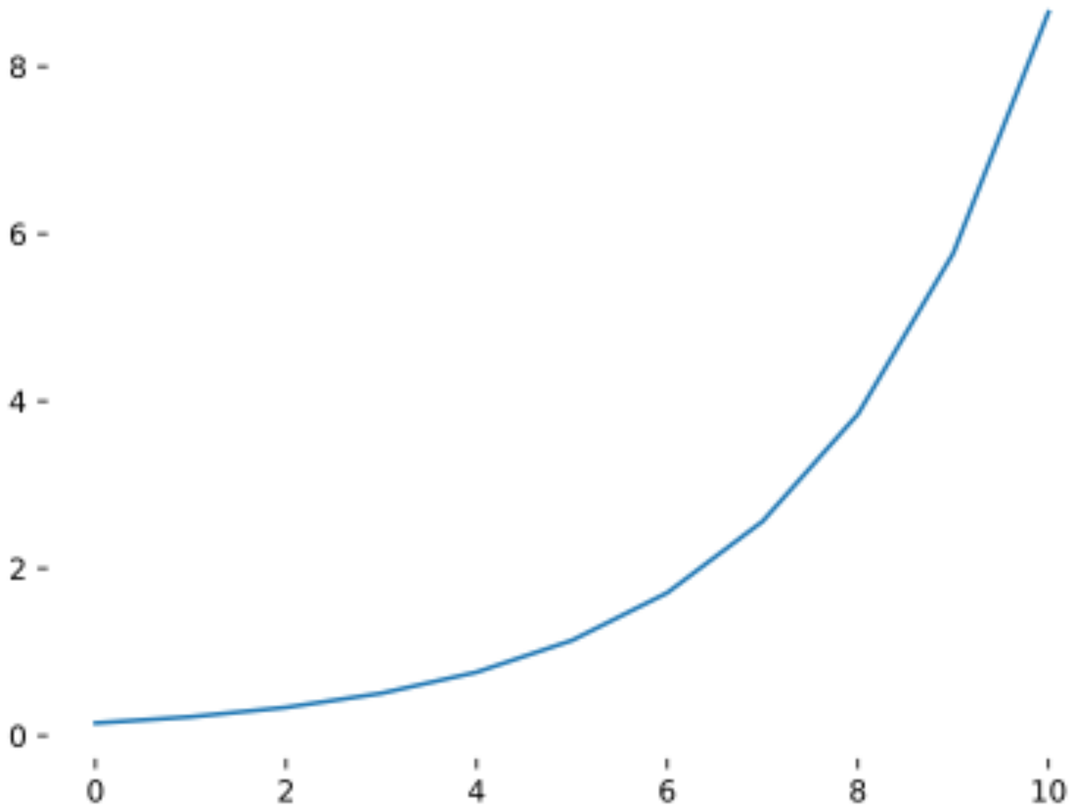


The power of feedback

$$S_{t+1} = S_t \times r$$

$S_t = \text{State at time } t$

$r = \text{growth rate}$

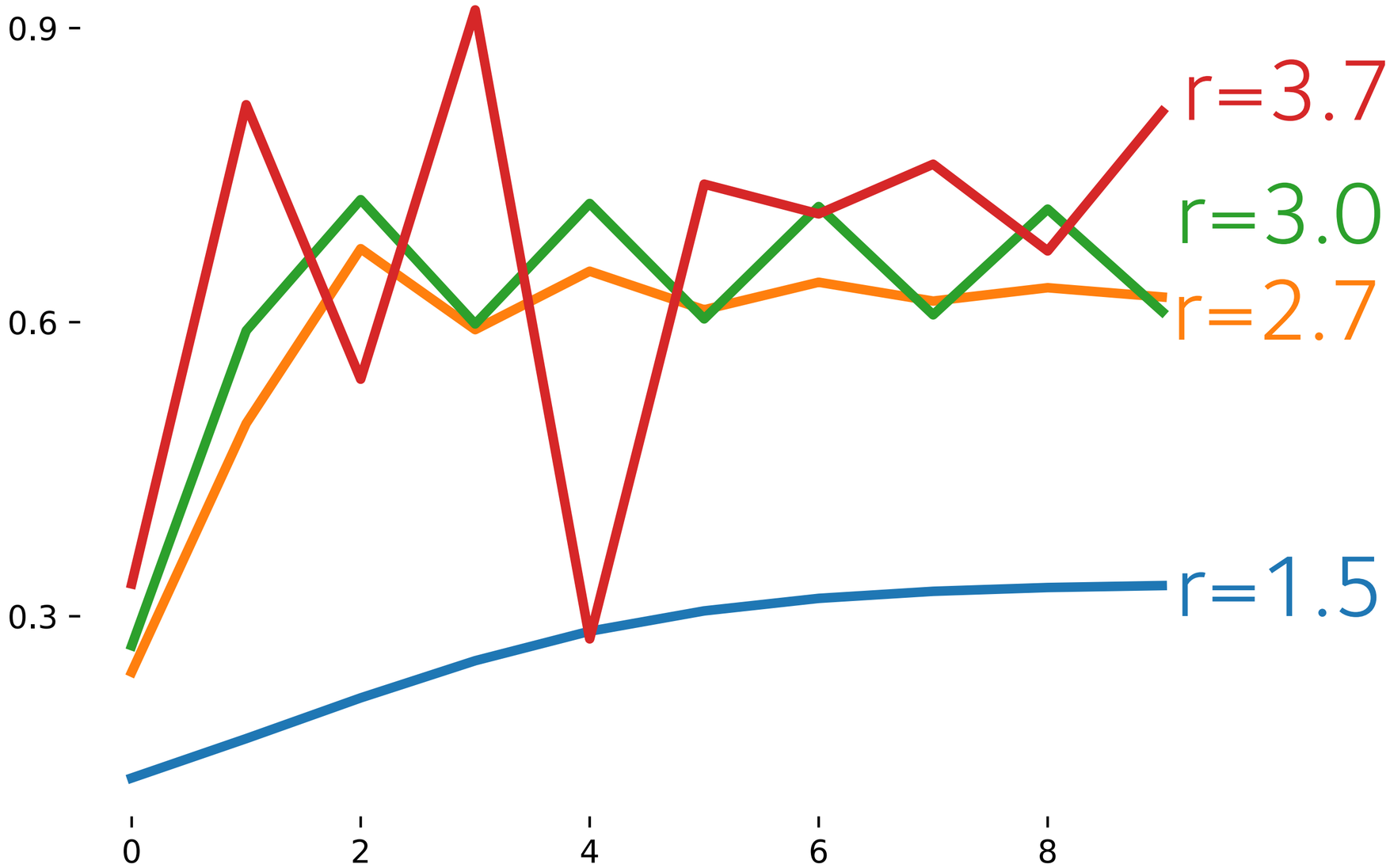


The power of feedback

$$S_{t+1} = S_t \times r(1 - S_t)$$

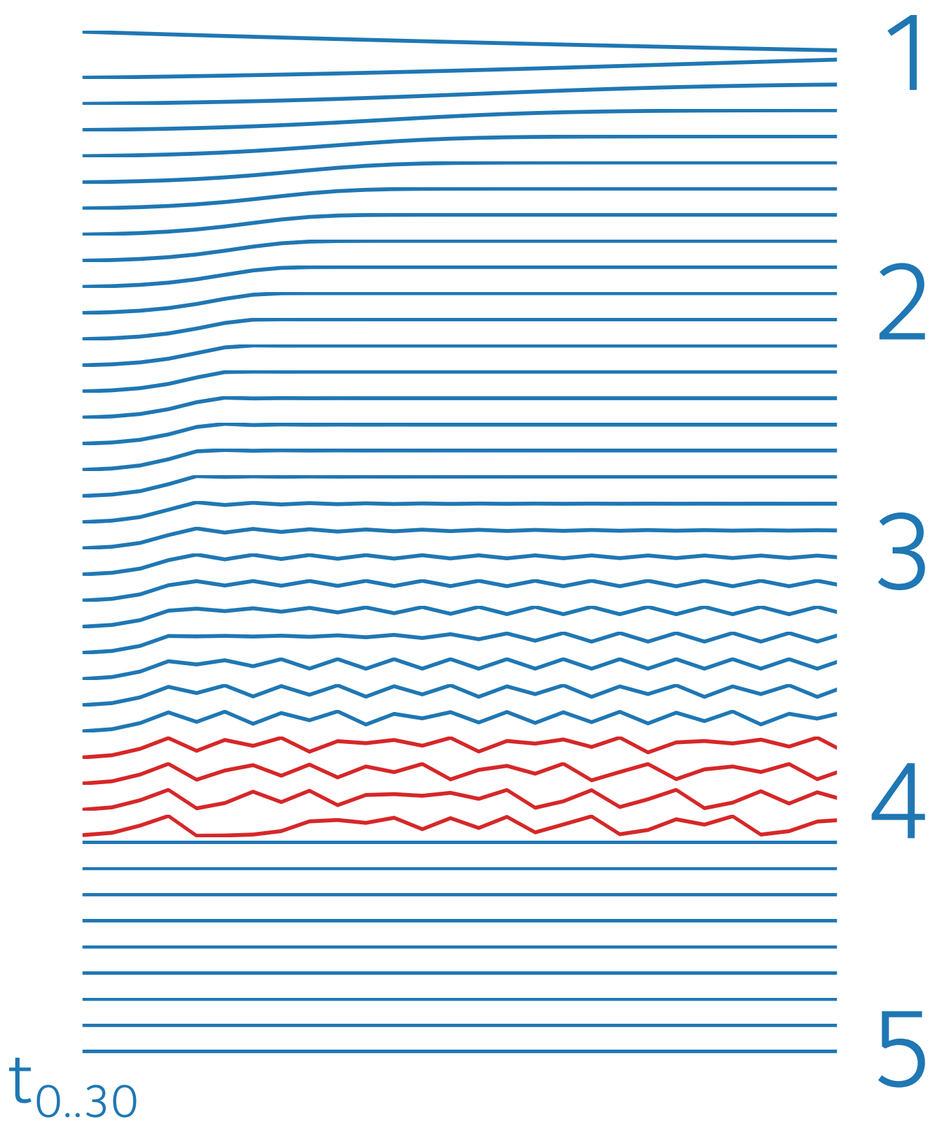
S_t = State at time t

r = growth rate



The power of feedback

$$S_{t+1} = S_t \times r(1 - S_t)$$



To **change** energy use we need to **understand** energy use **(as a system)**

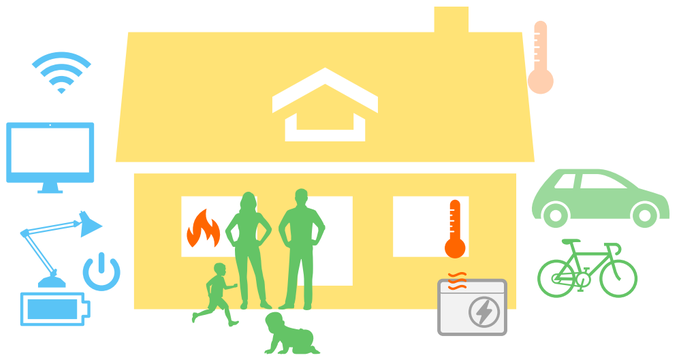
How much?

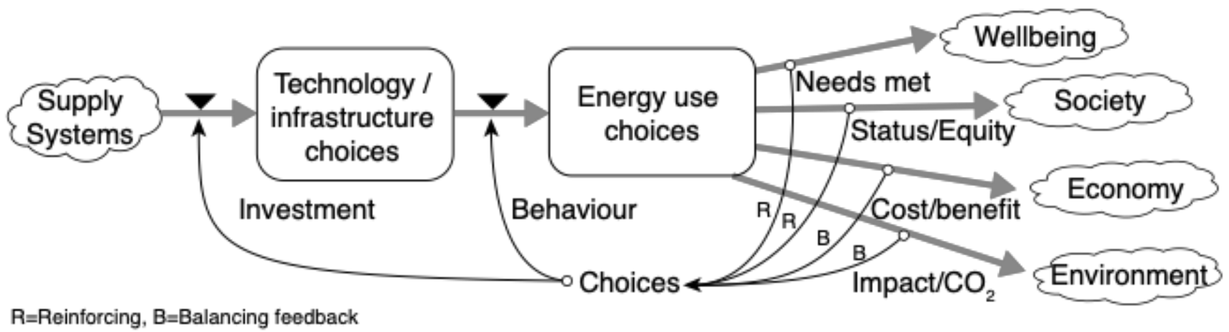
What?

Why?

Gas
Wood
Coal
Oil
H_2

Sun (light)
Air (temp)
Wind





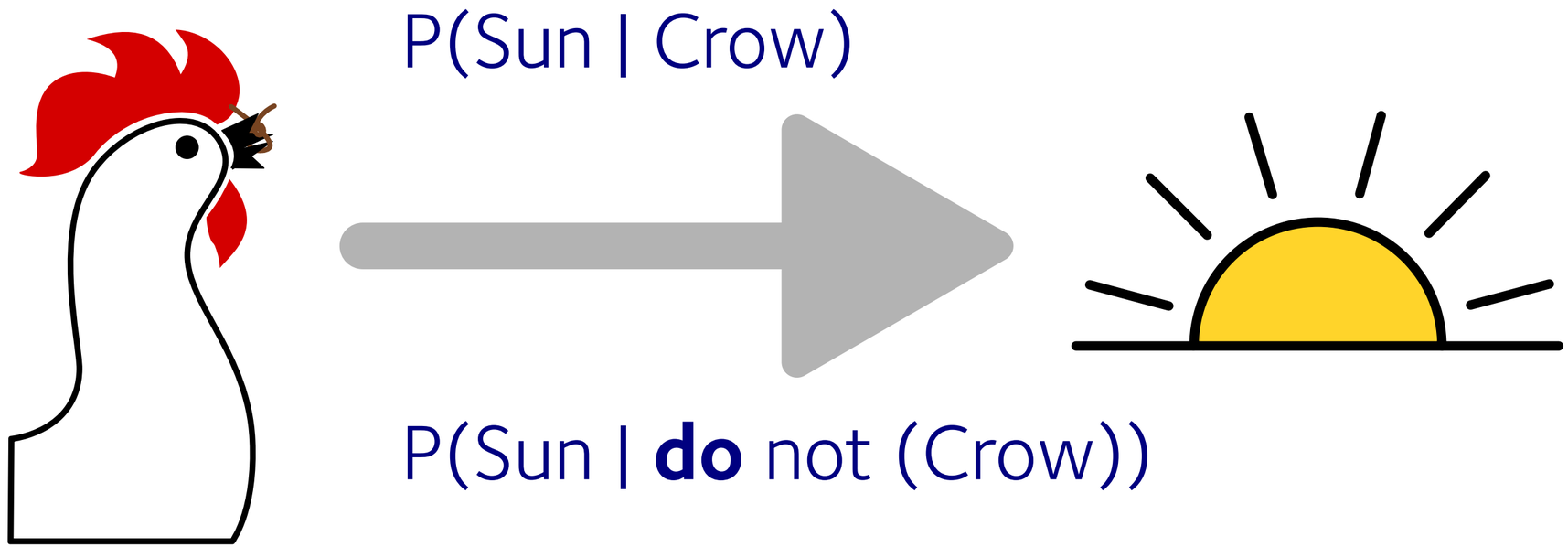
R=Reinforcing, B=Balancing feedback

Good feedback is:

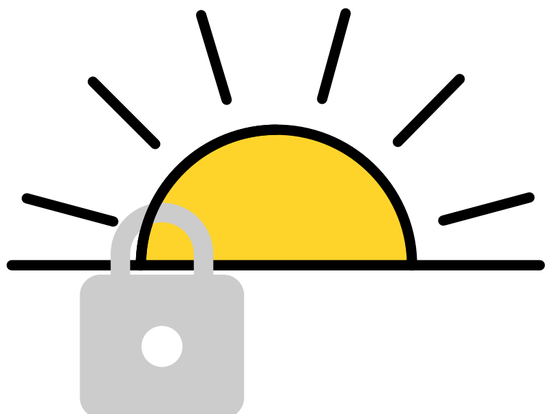
- Timely (not just fast)
- Accurate
- Relevant to system goals

Judea Pearl

What **causes** the sun to rise?

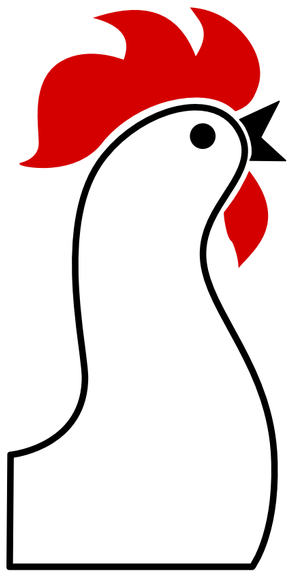


What **causes** the the cockerill to crow?

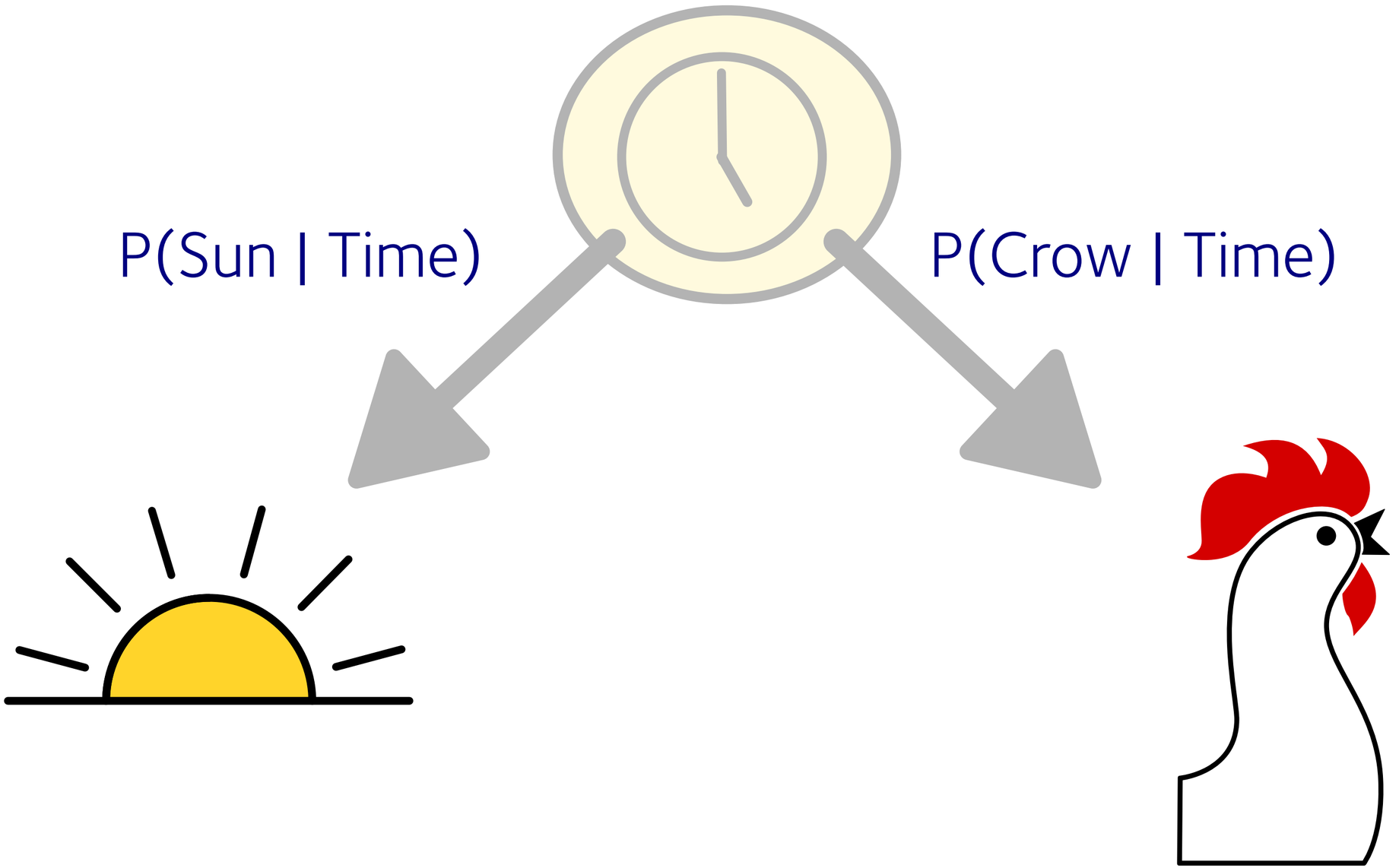


P(Crow | Sun)

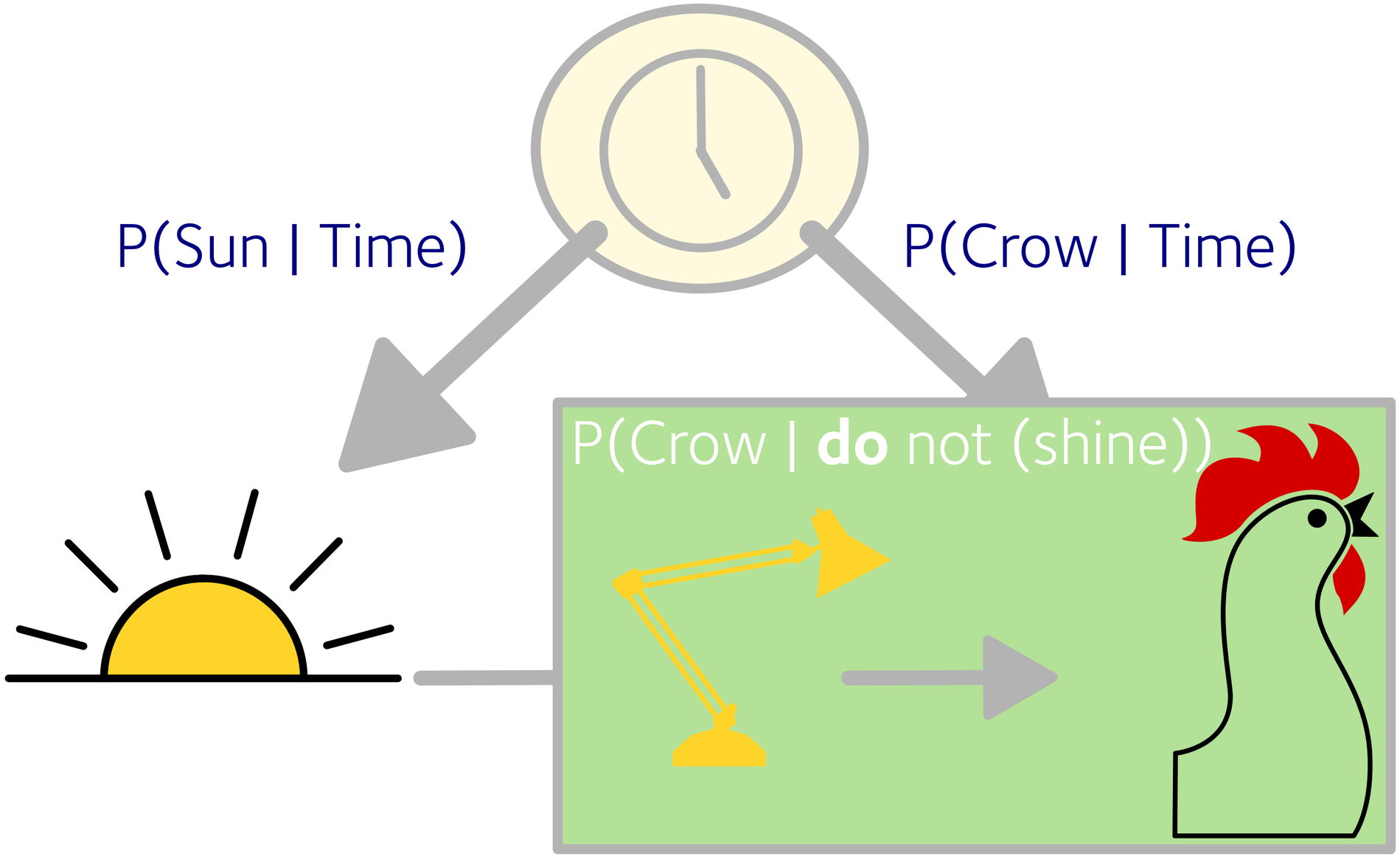
P(Crow | **do** not (Sun))



How to eliminate confounders?



How to eliminate confounders?



To understand causes we need (up to) three things

Causal model

Observation

Do something

Energy demand research is evolving

Effort

Understanding Demand

No data

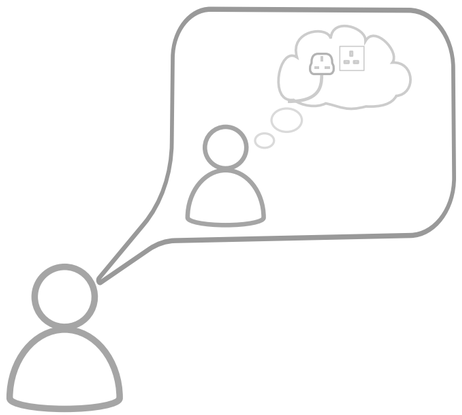
Assume & model

What **I think** people do

Some data

Interpolate & scale up

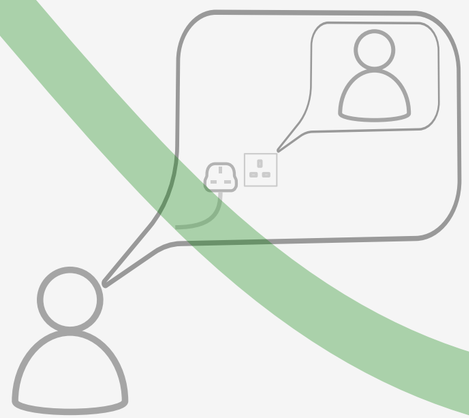
What **people** think they do



Big data

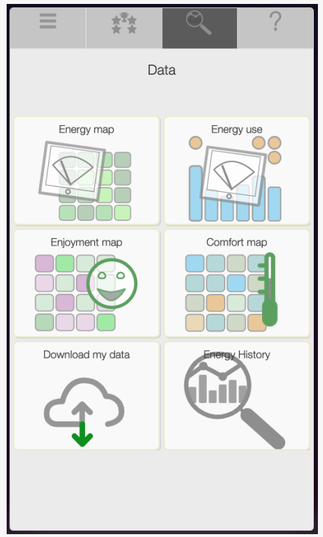
Observe (intervene) & analyse

What **data** says people do



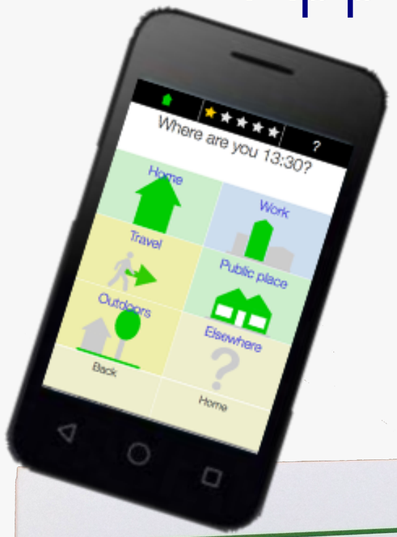
Understanding demand the hard way

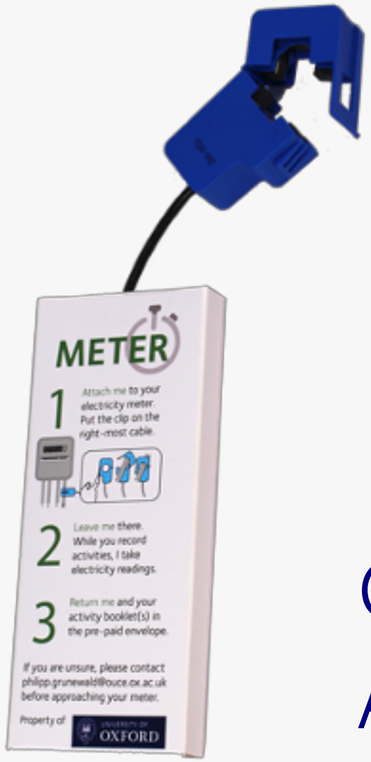
JoyMeter.uk



EDDI

App



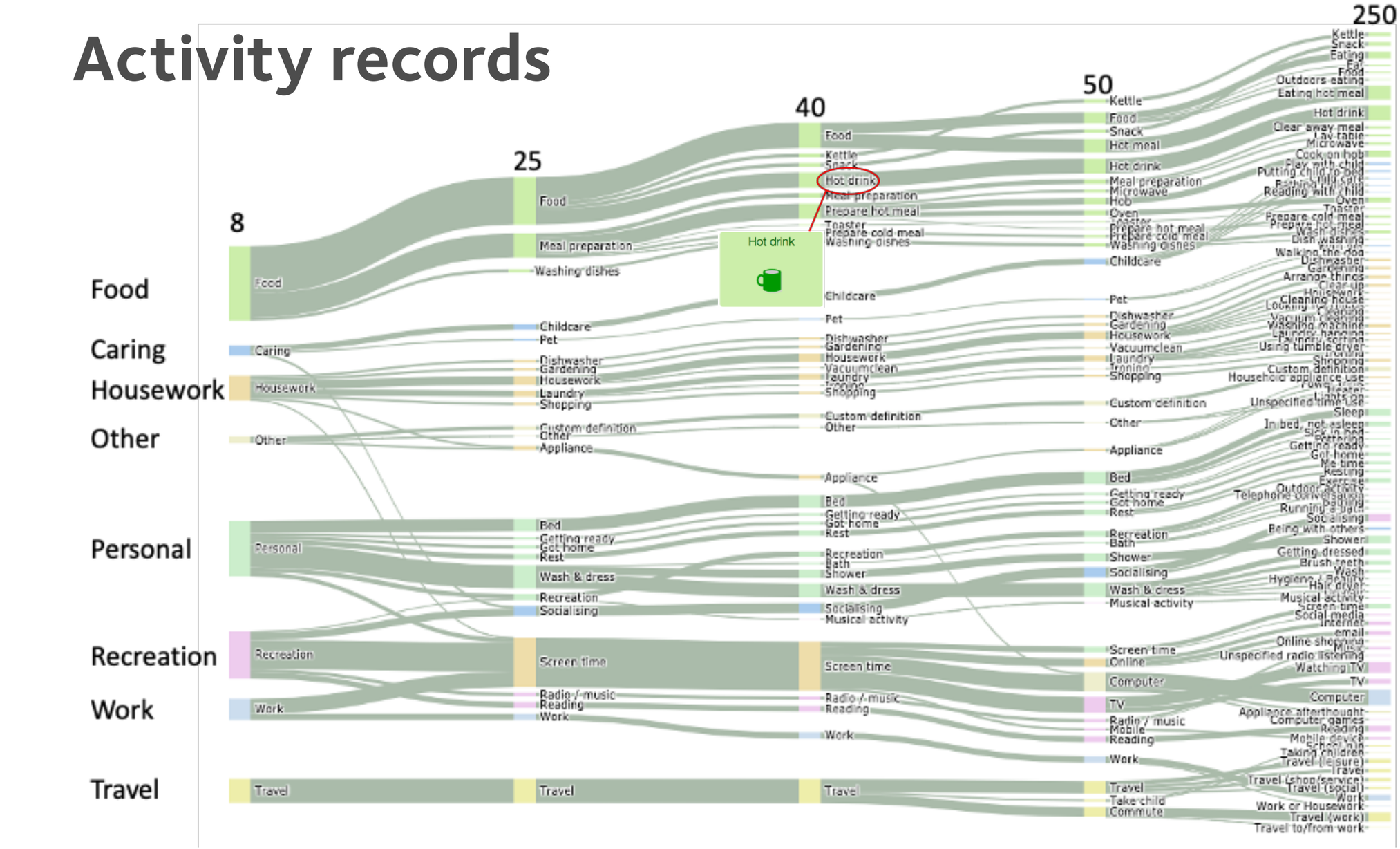


CAD (Consumer Access Device)

Current clamp

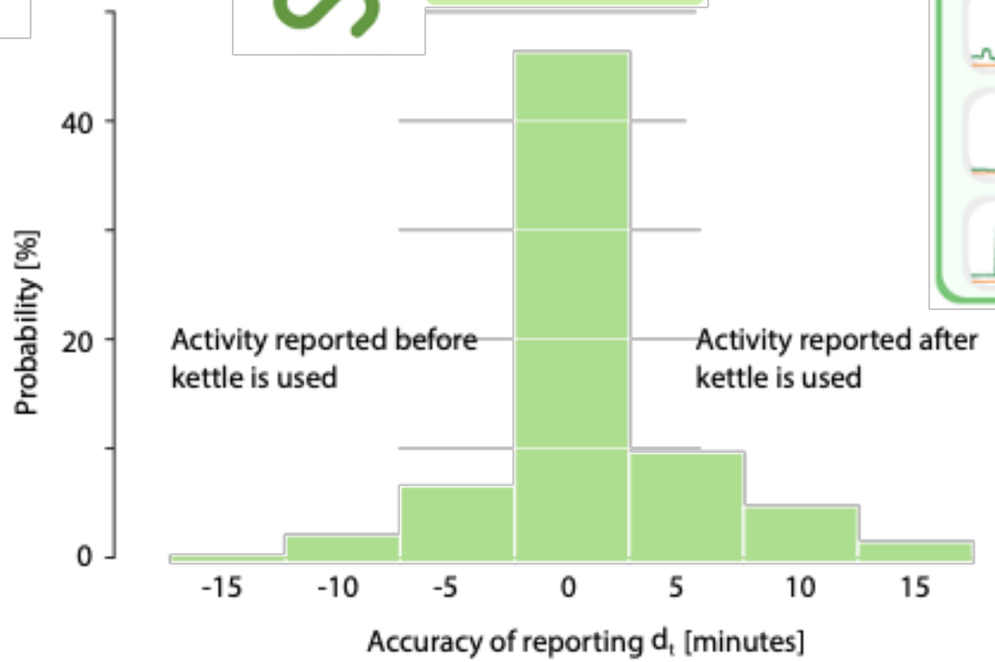
Diary

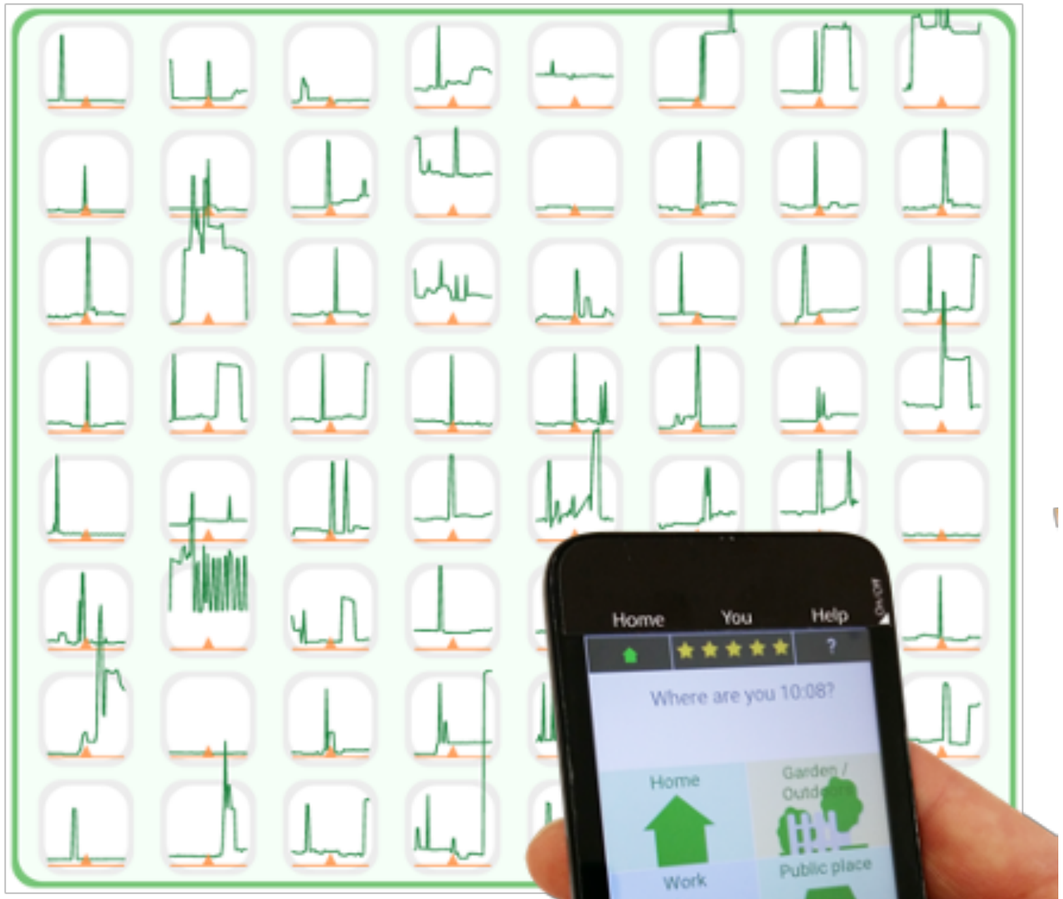
Activity records



Tea-test

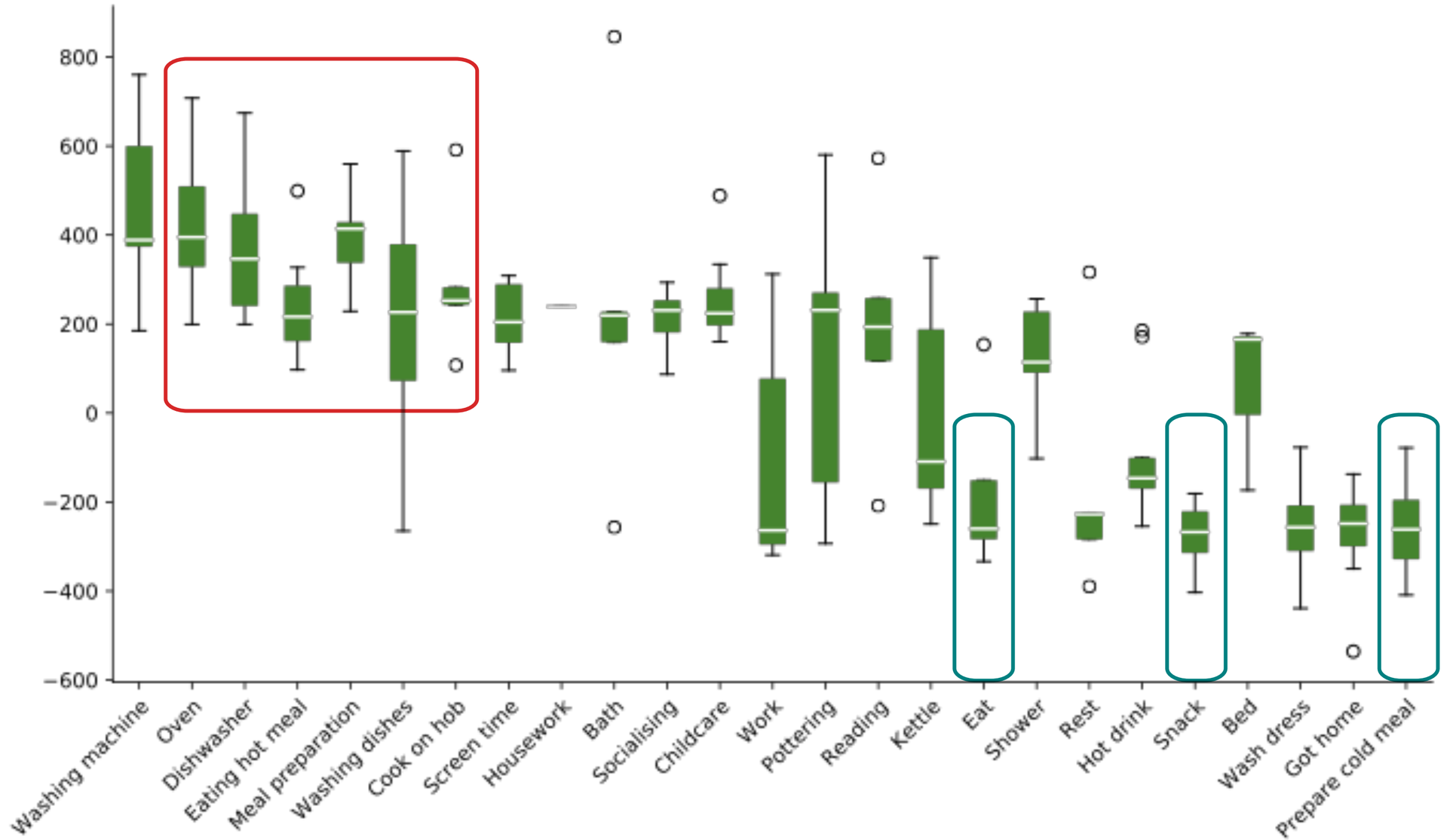

Hot drink


40
20
0
Probability [%]
Activity reported before kettle is used
Activity reported after kettle is used
-15
-10
-5
0
5
10
15
Accuracy of reporting d_t [minutes]



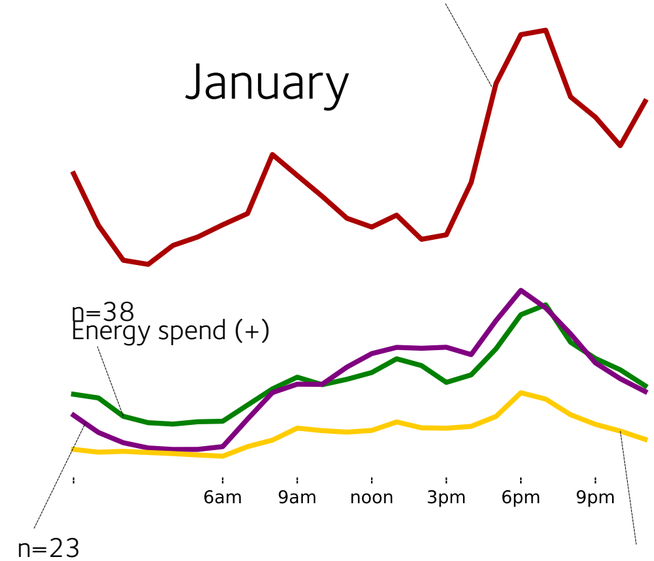

Home
You
Help
Where are you 10:08?
Home
Work
Public place
Travel
Back
Home
METER

Marginal contribution of activities to demand



Enjoyment of activities and demand

DTW clusters

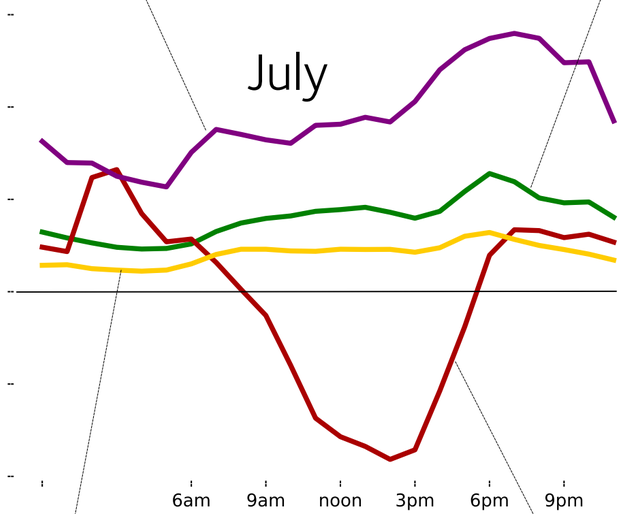


n=11
Average electricity use (+)
Have an electric heat pump (+)
Average electricity use at 6pm (+)
How much do you spend on energy? (+)
Dog owner (+)
House type (+)
Social grade (+)

n=38
Energy spend (+)

n=23
El. quantile 50 (-)
El. quantile 25 (-)

n=59
Agerage electricity use (-)
Average electricity use at 6pm (-)
How much do you spend on energy? (-)
How many adults? (-)
What type of property do you live in? (+)

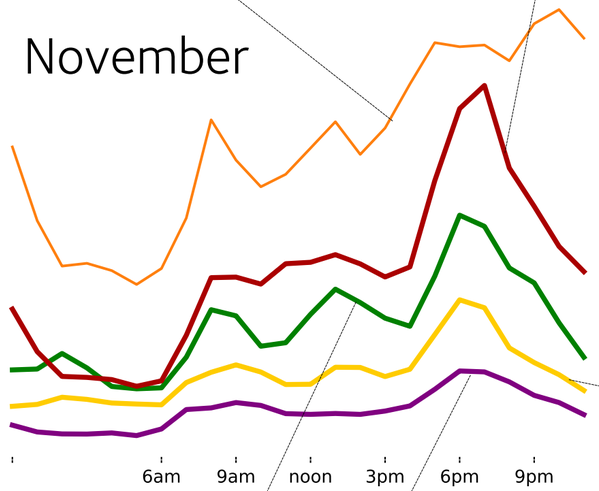


n=7
(+) Average electricity use
(+) Average electricity use at 6pm
(+) Energy spend
(+) Living rent free
(-) In employment

n=52
Average electricity use (-)
Average electricity use at 6pm (-)
How many rooms? (-)
What type of property? (+)
How many adults? (-)
How much do you spend on energy? (-)
How many rooms does your home have? (-)
Would buy an electric vehicle (-)
Would install an electric heat pump (+)
Universal Credit (+)

n=74
(+) How many rooms does your home have
(+) Average electricity use at 6pm
(-) How many rooms does your home have
(+) How much do you spend on energy?
(-) What type of property?
(-) House type
(+) How many adults?
(+) Average electricity use

n=5
(+) Standard tariff
(+) Heat pump
(-) Load response in intervention
(+) Number of rooms
(+) Very likely to buy an EV
(+) Detached house
(+) Southern England



n=6
(+) Average electricity use
(+) Energy spend
(+) Average electricity use at 6pm
(+) Detached house
(+) Unsure about heat pump
(+) Bungalow
(-) Reduce water consumption

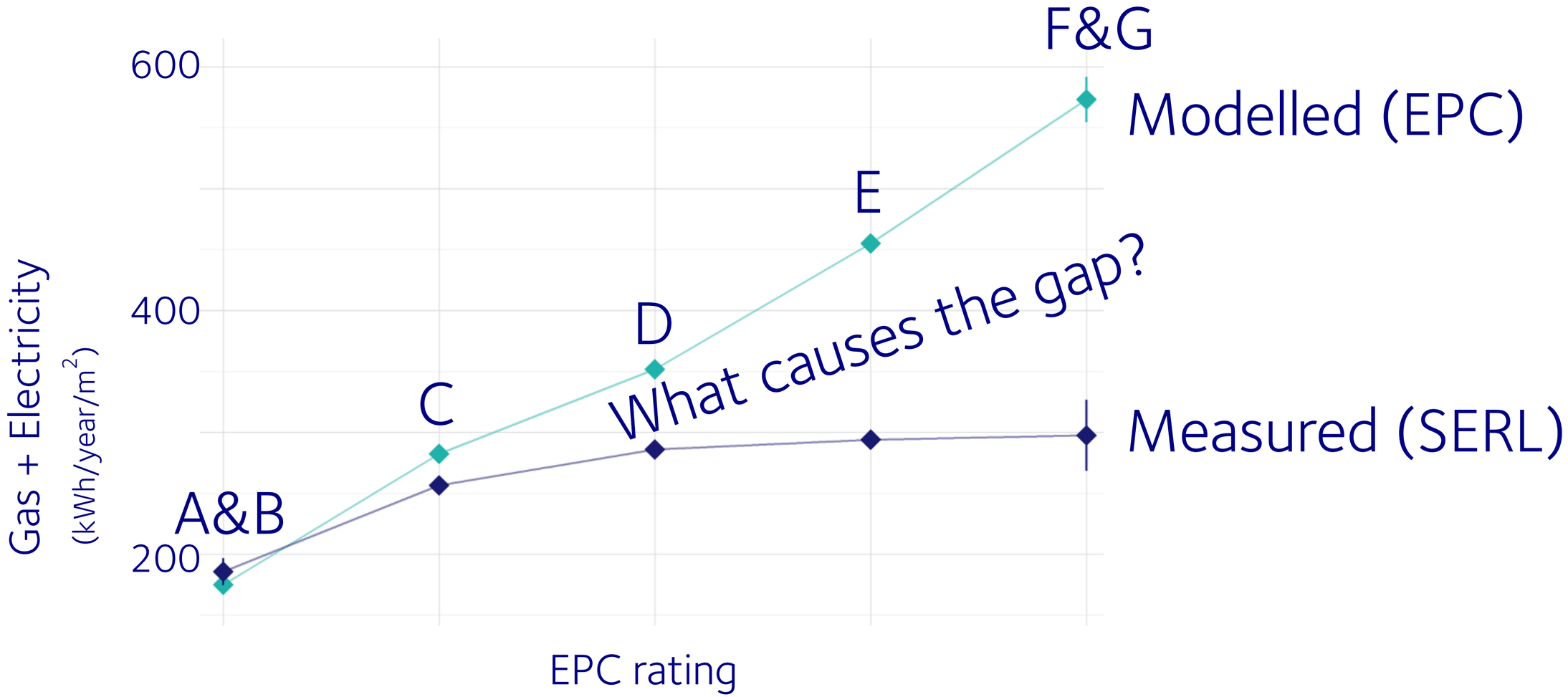
n=14
(+) Average electricity use at 6pm
(+) How much do you spend on energy?
(+) Average electricity use
(+) How many rooms?
(+) Unlikely to buy an electric vehicle
(-) Would install an electric heat pump

n=49
(-) Energy spend
(+) Dog owner
(+) Universal Credit

n=29
(-) Average electricity use at 6pm
(-) How much do you spend on energy?
(-) Average electricity use
(-) How many adults?
(+) No energy saving behaviours
(+) Type of energy tariff

n=42
(+) How many rooms?
(+) How much do you spend on energy?
(-) Type of property
(+) Average electricity use at 6pm

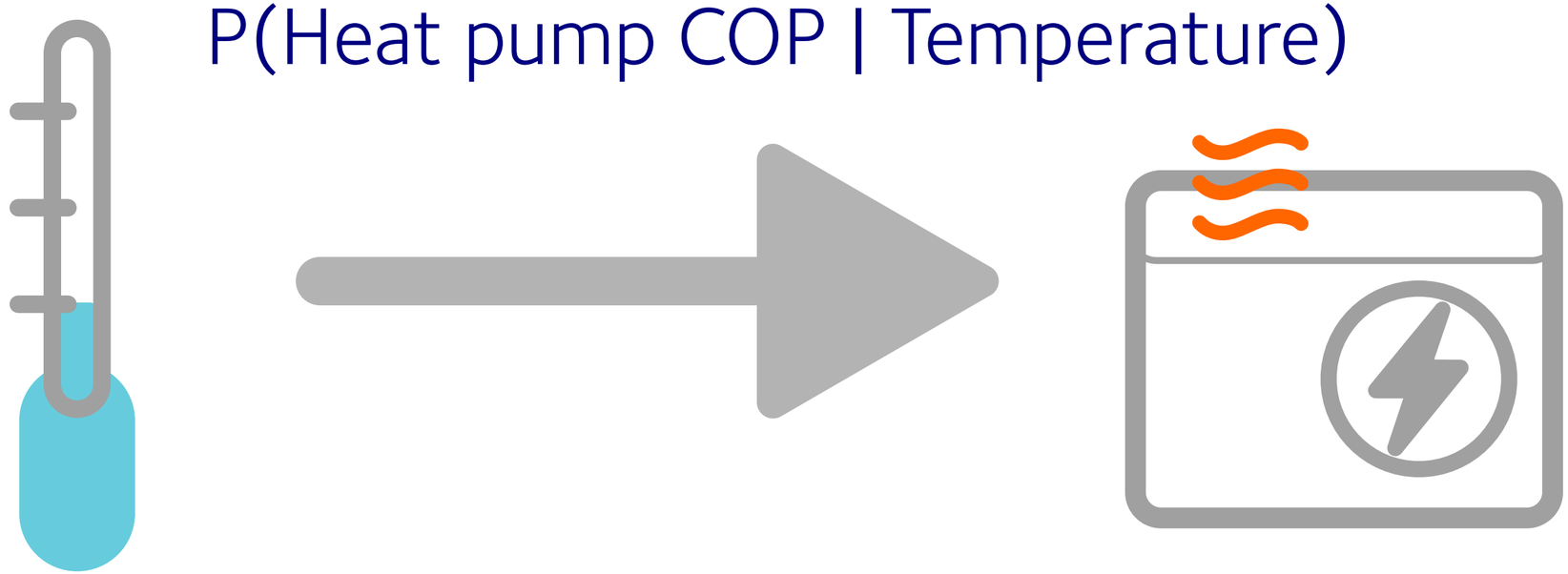
Model vs Reality: EPCs are poor preditors of demand



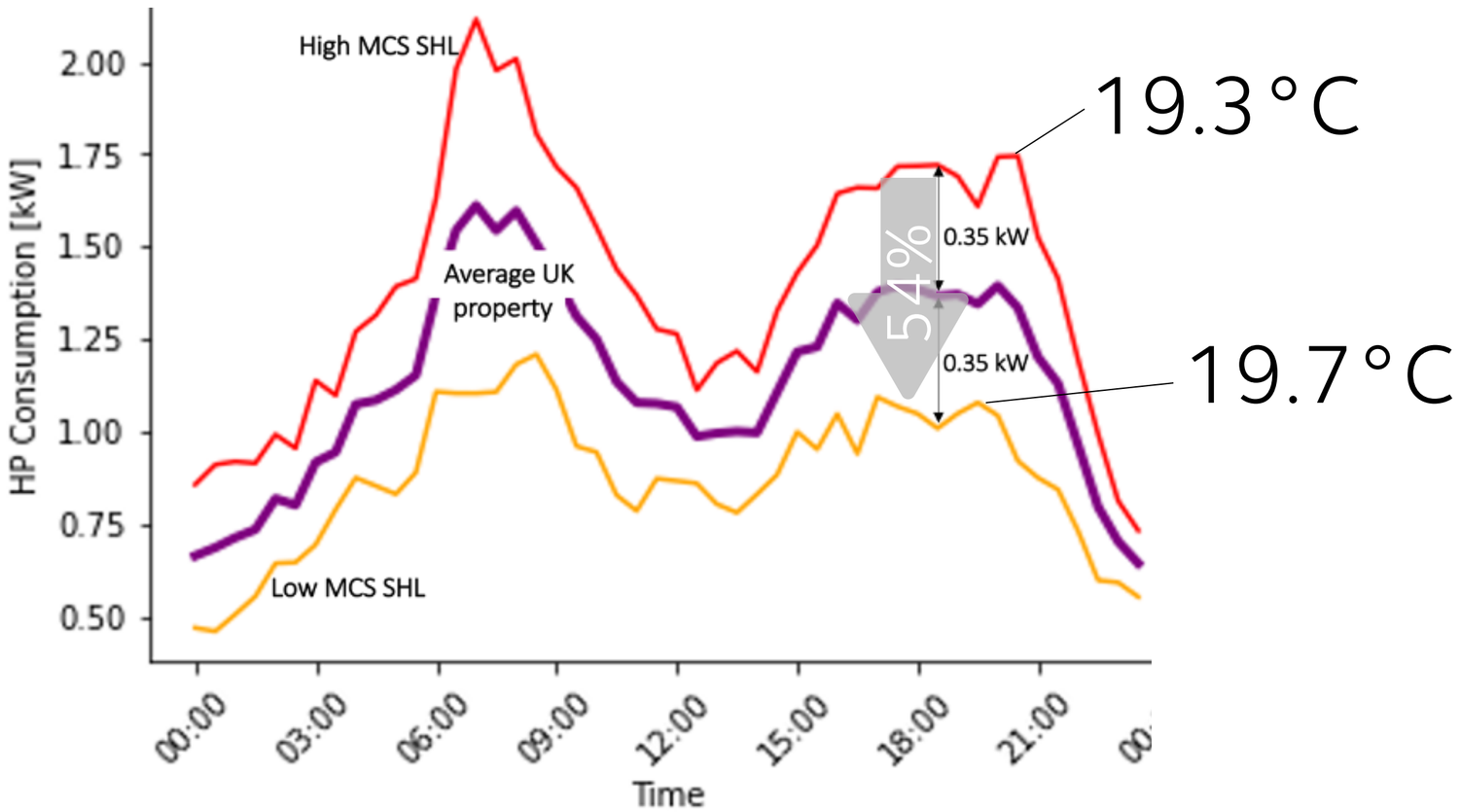
https://doi.org/10.1016/j.enbuild.2023.113024

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

P(Heat pump COP | Temperature)

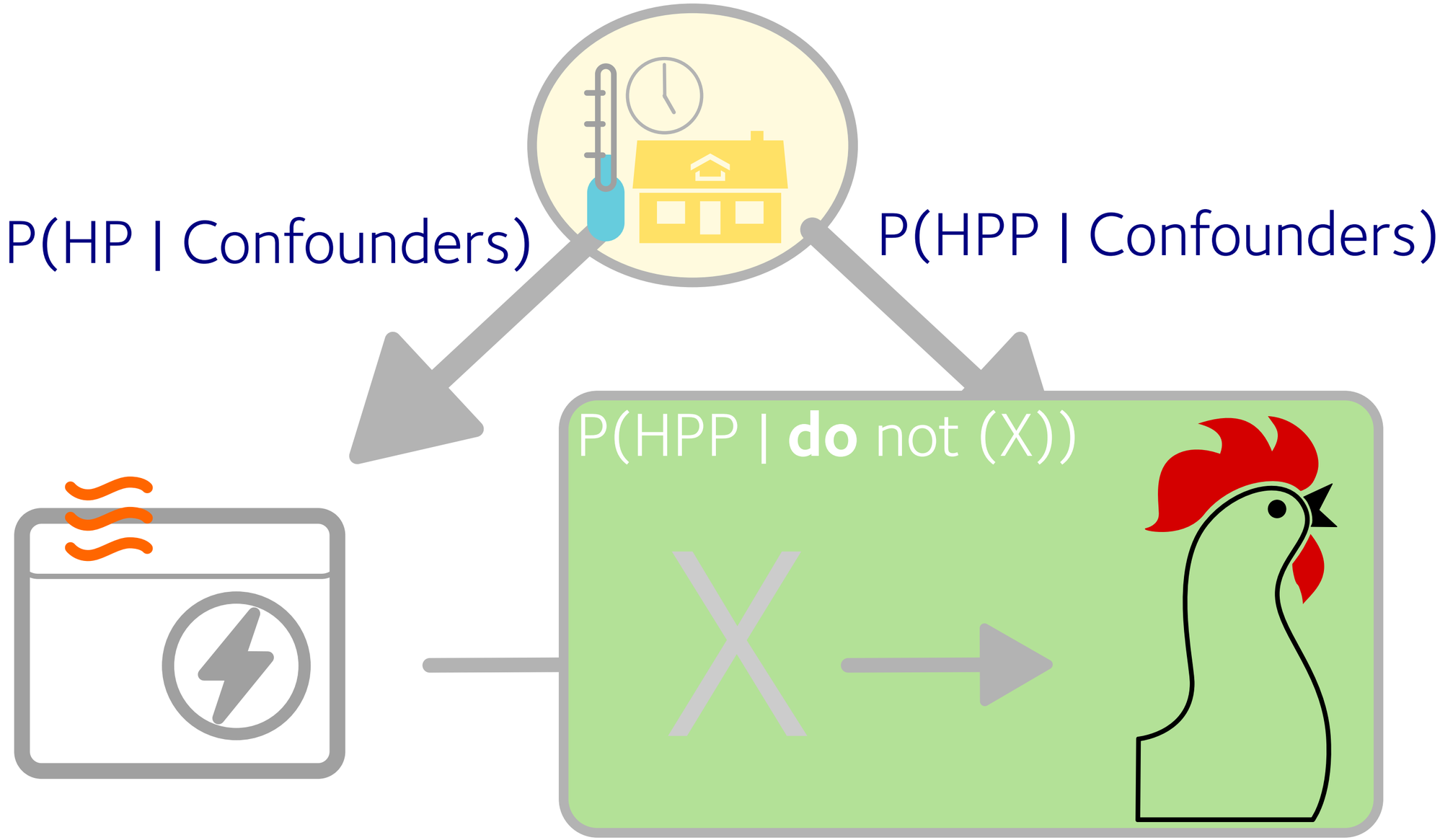


Some data: heat pumps work on cold days and even better in efficient homes



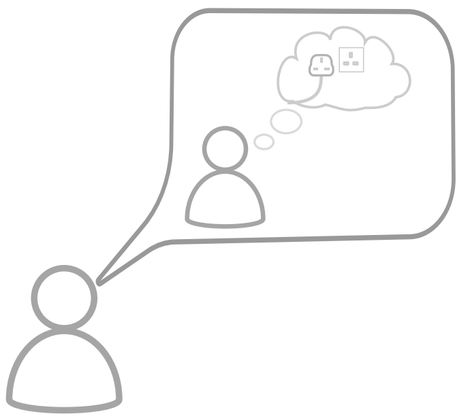
Credit: Sofia Perelli-Rocco, Energy Systems MSc 2022/23 and ChatGPT

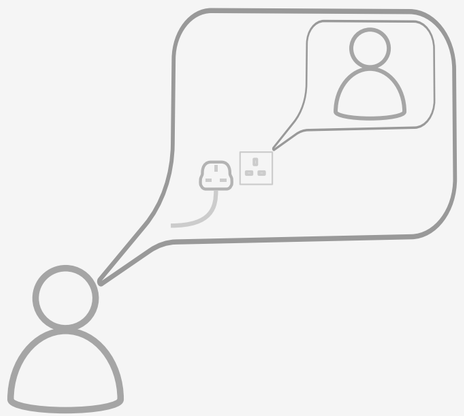
Big data: What improves heat pump performance?



Observation is not enough – make a change

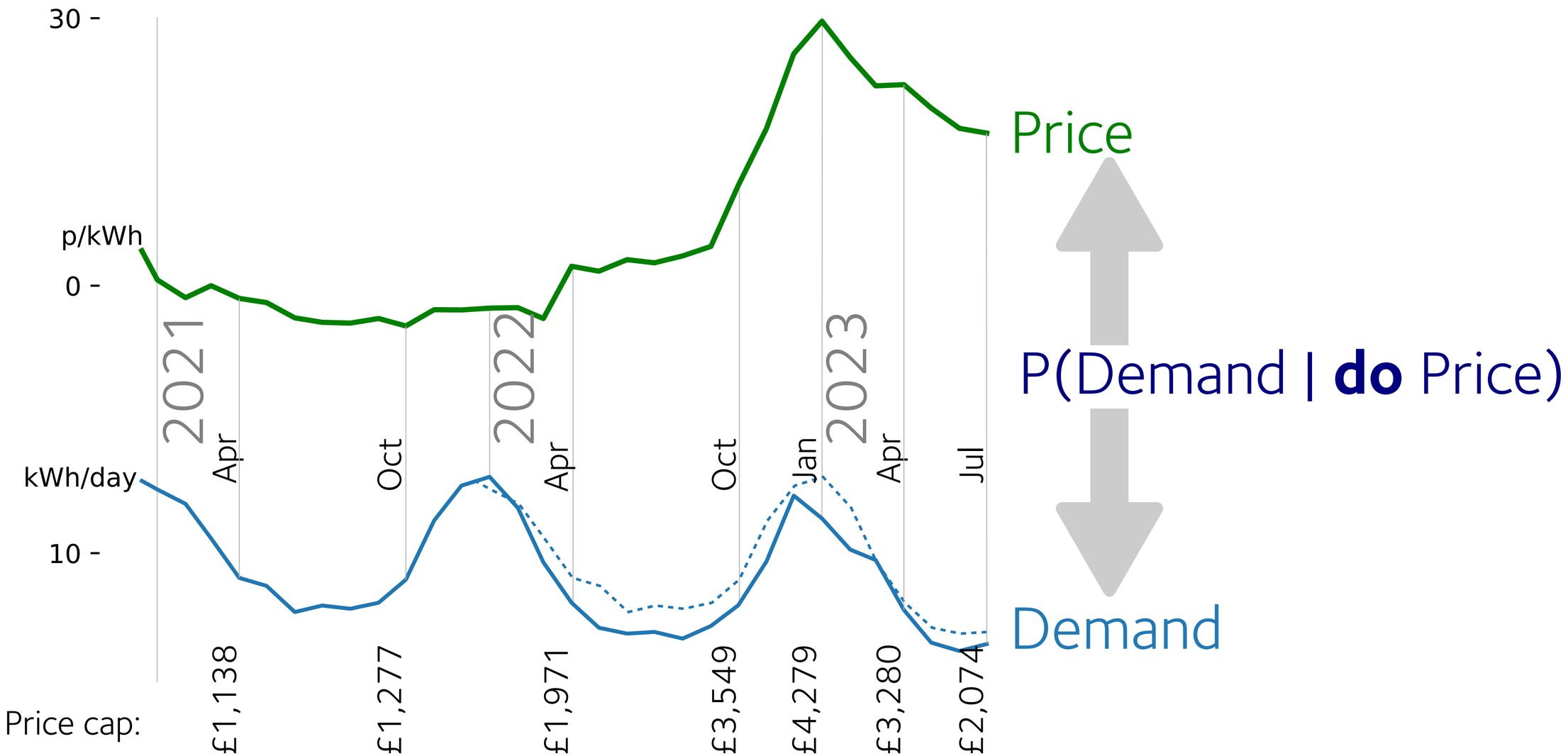
	No data	Little data	Big data
Understanding Demand	What do **I think** people do	What do **peope** think they do	What does **data** say people do
Changing Demand	What **I think** people **would do**, if…	What **peope** think they **would** do, if…	What **data** says people **did do**, when…



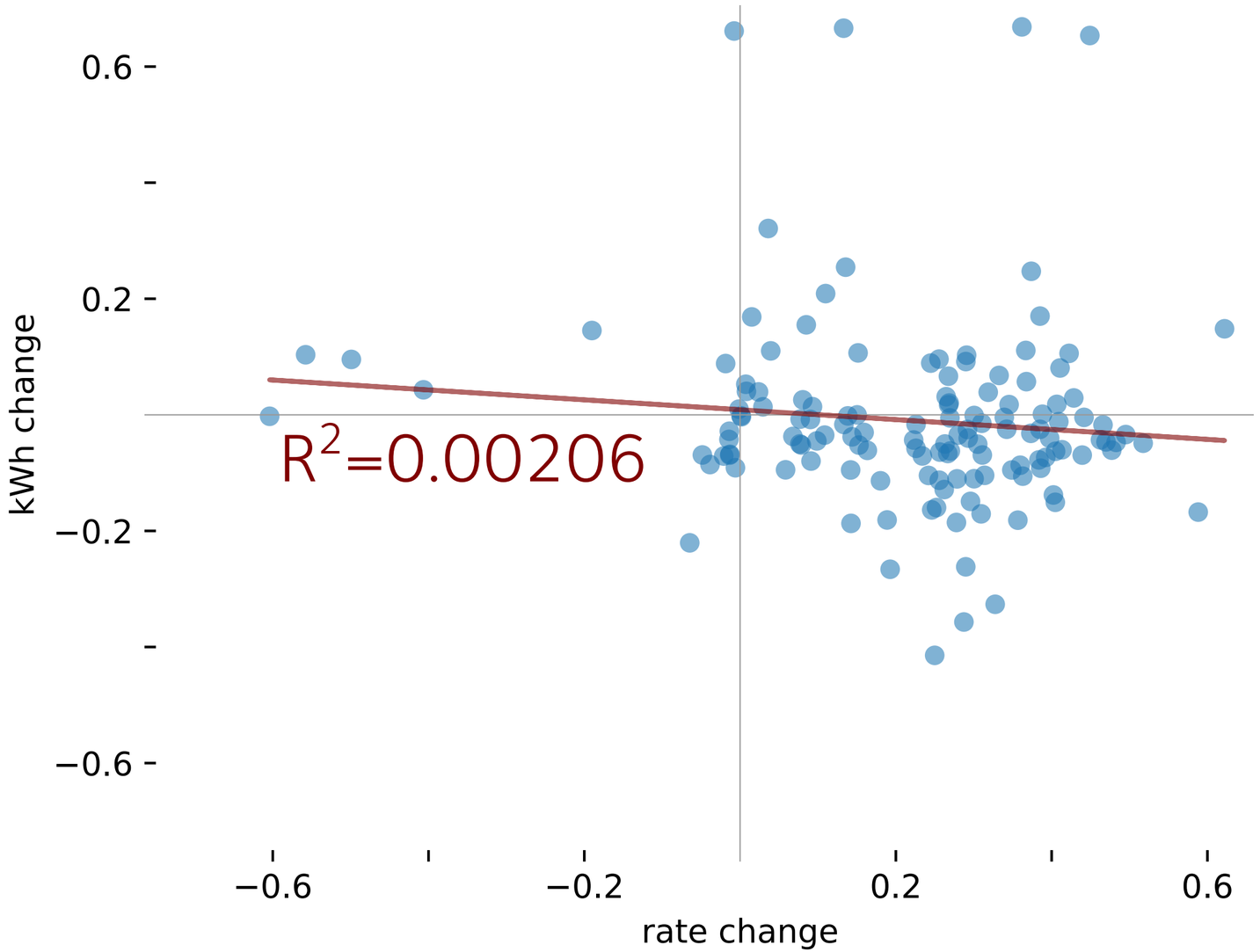


No data: I think… demand falls when prices rise

Little data: demand falls when prices rise



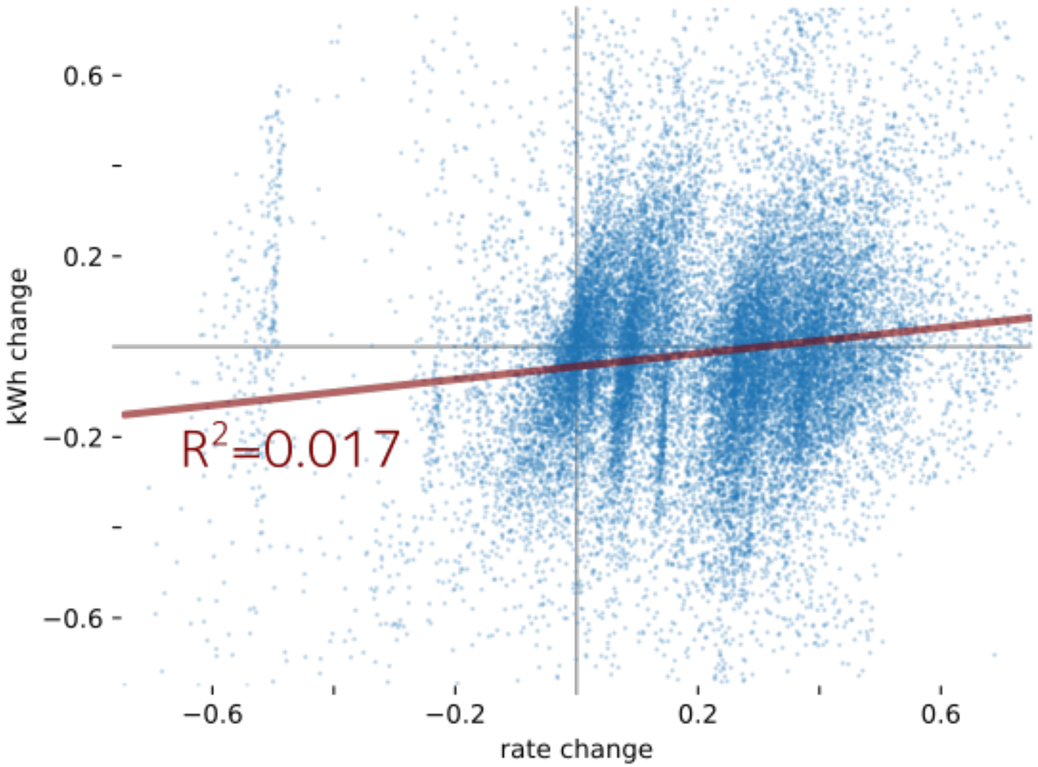
Medium data: negative price elasiticity?

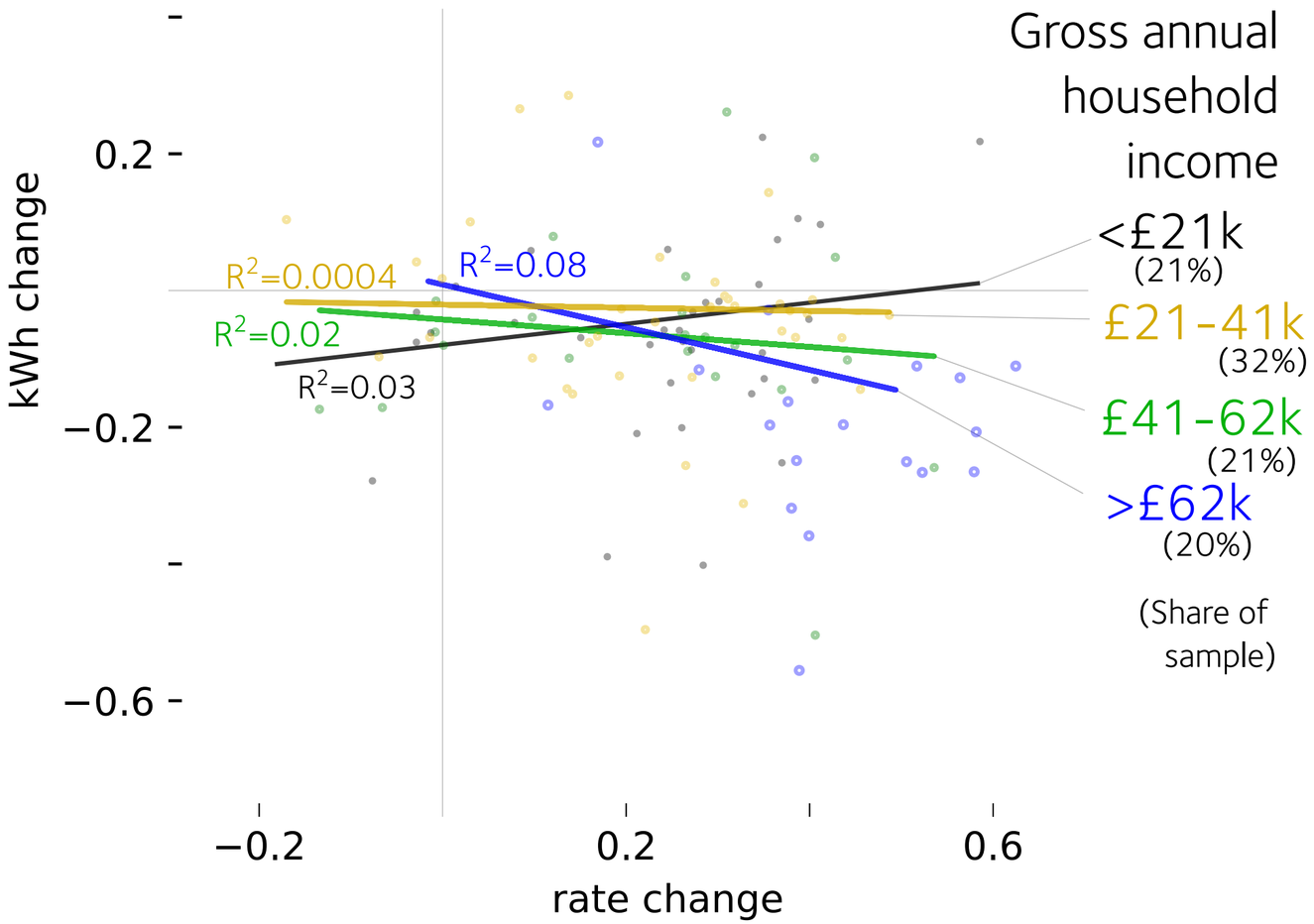


Jan 2022
vs.
Jan 2023

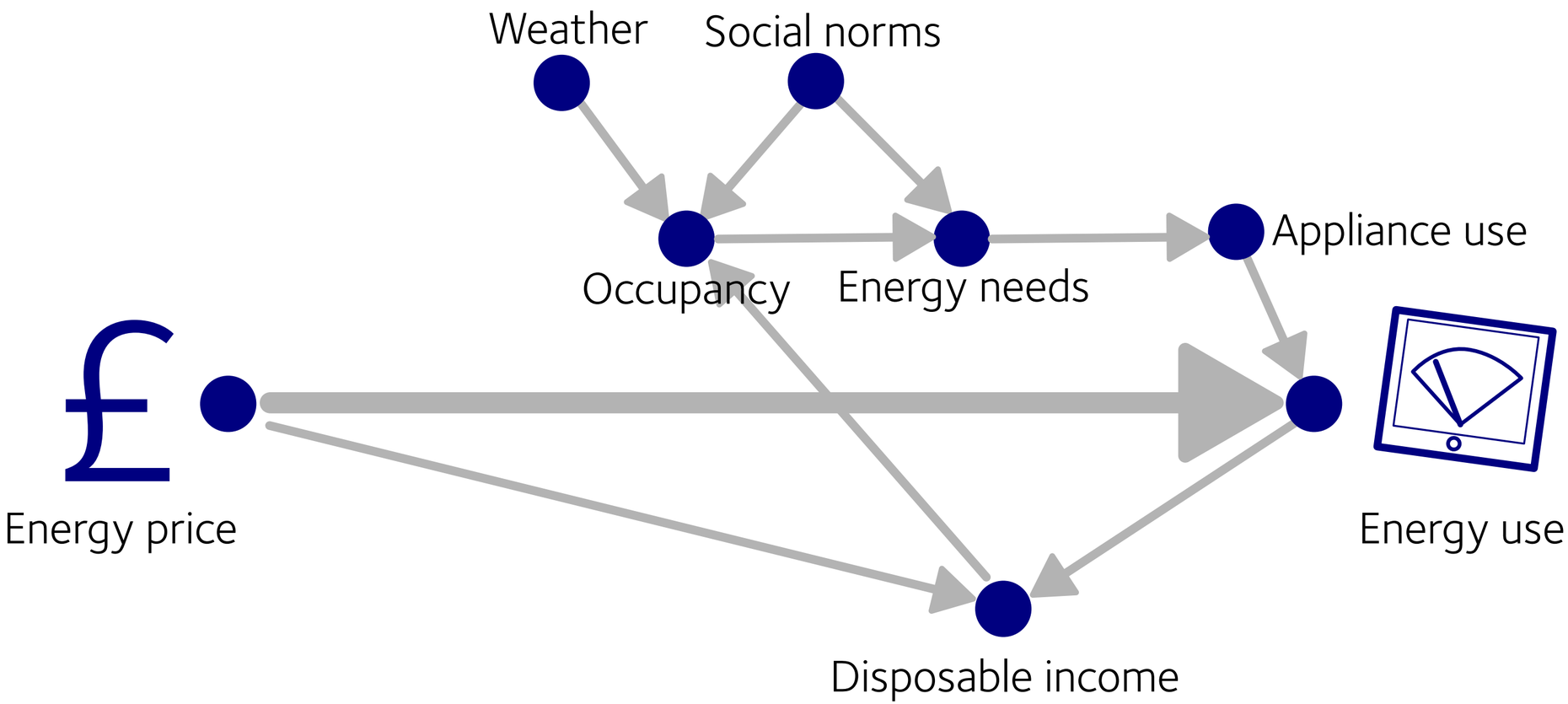
Big data: … it depends

Price elasticity is weak and depends on circumstances





Causal model: What **causes** energy demand to change?

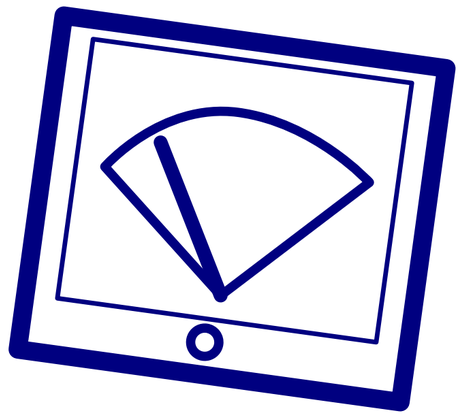


No data: I think… people will never give up dinner for DSR

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

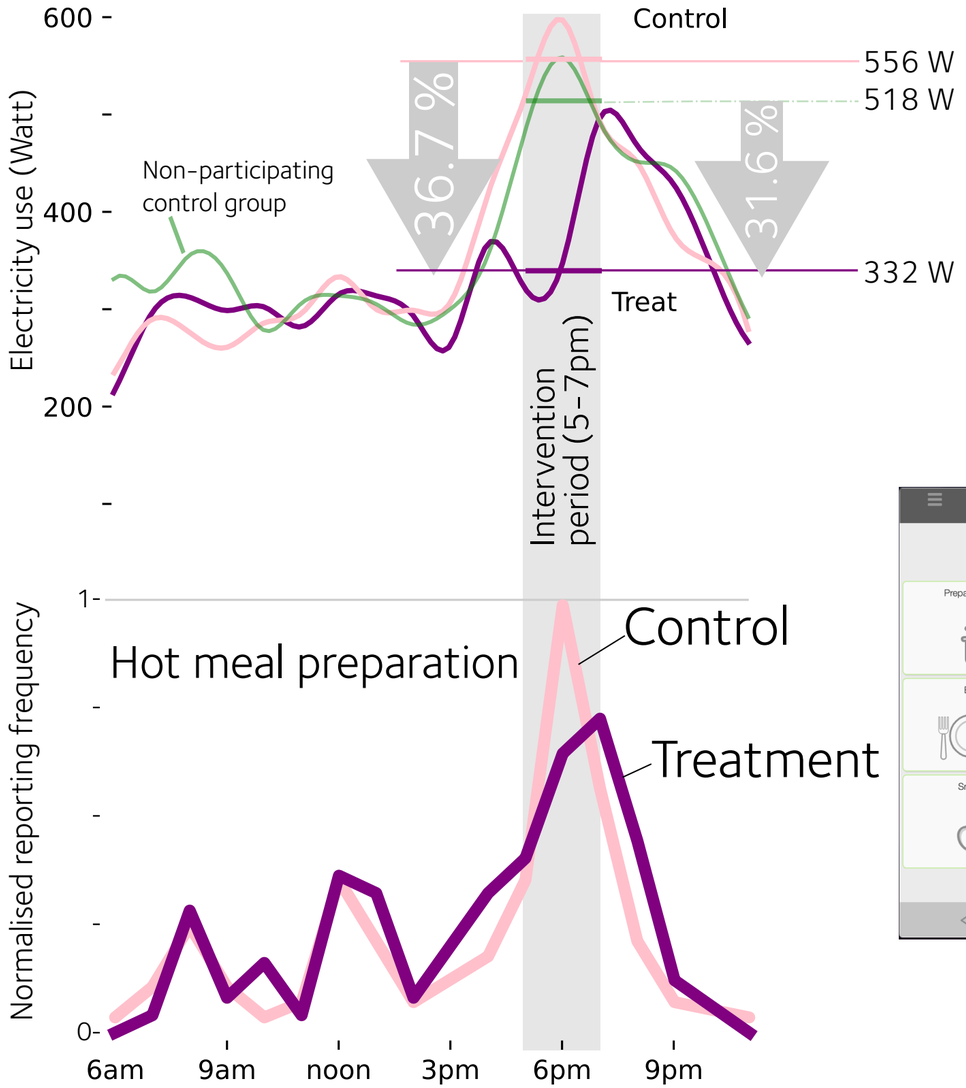
P(E | Life)

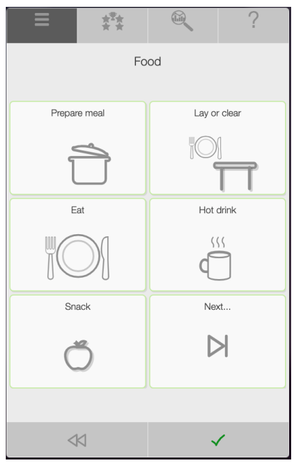
P(E | Life + **do** (Ask))

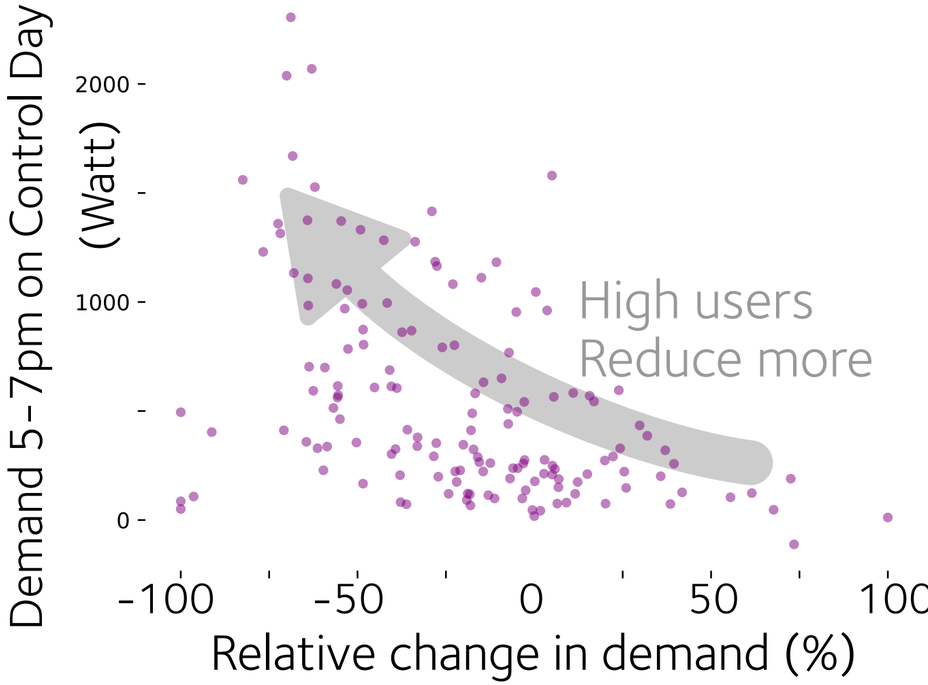


Little Data: Control and intervention:

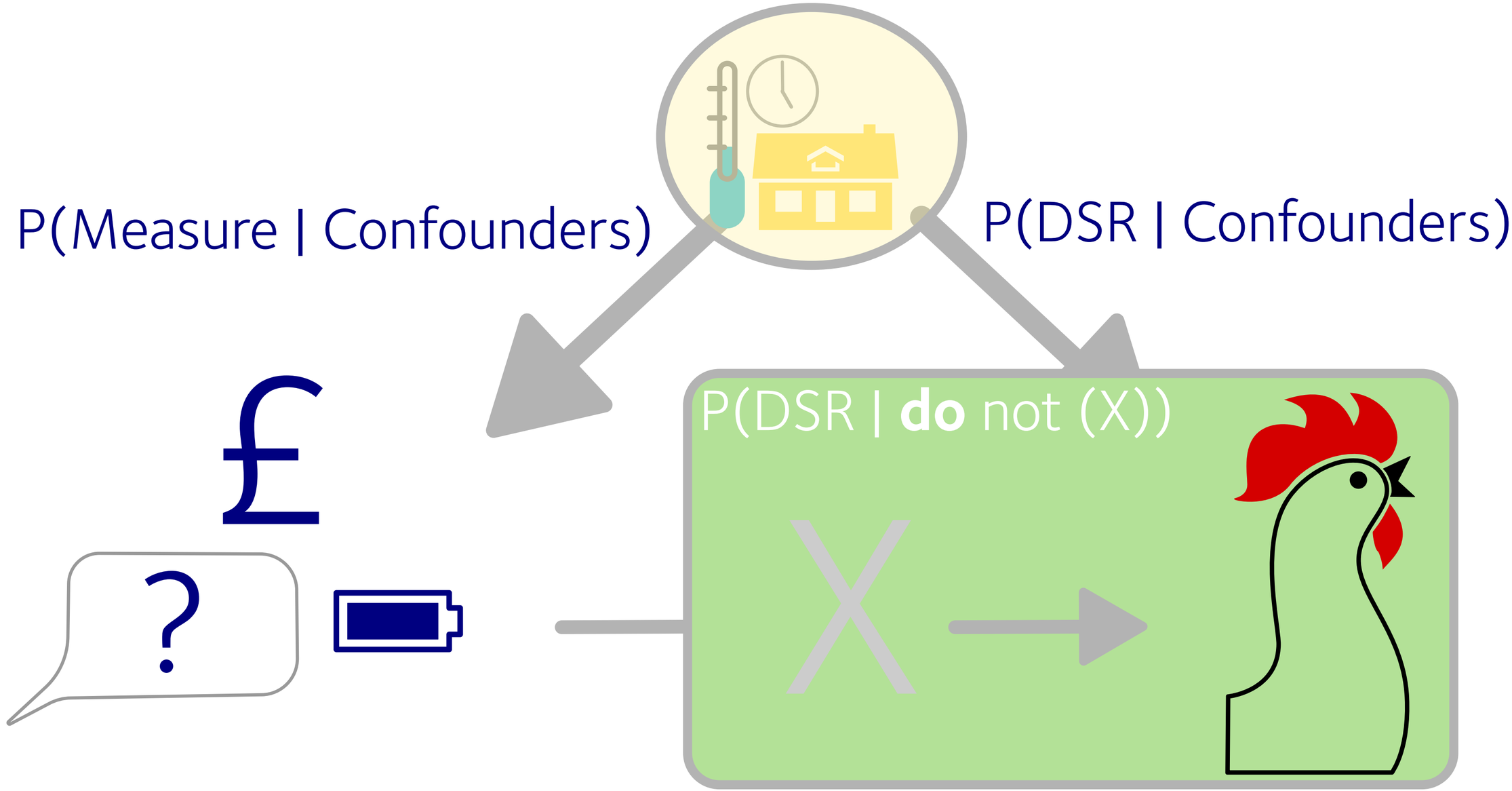
Responses are significant, repeatable and effective







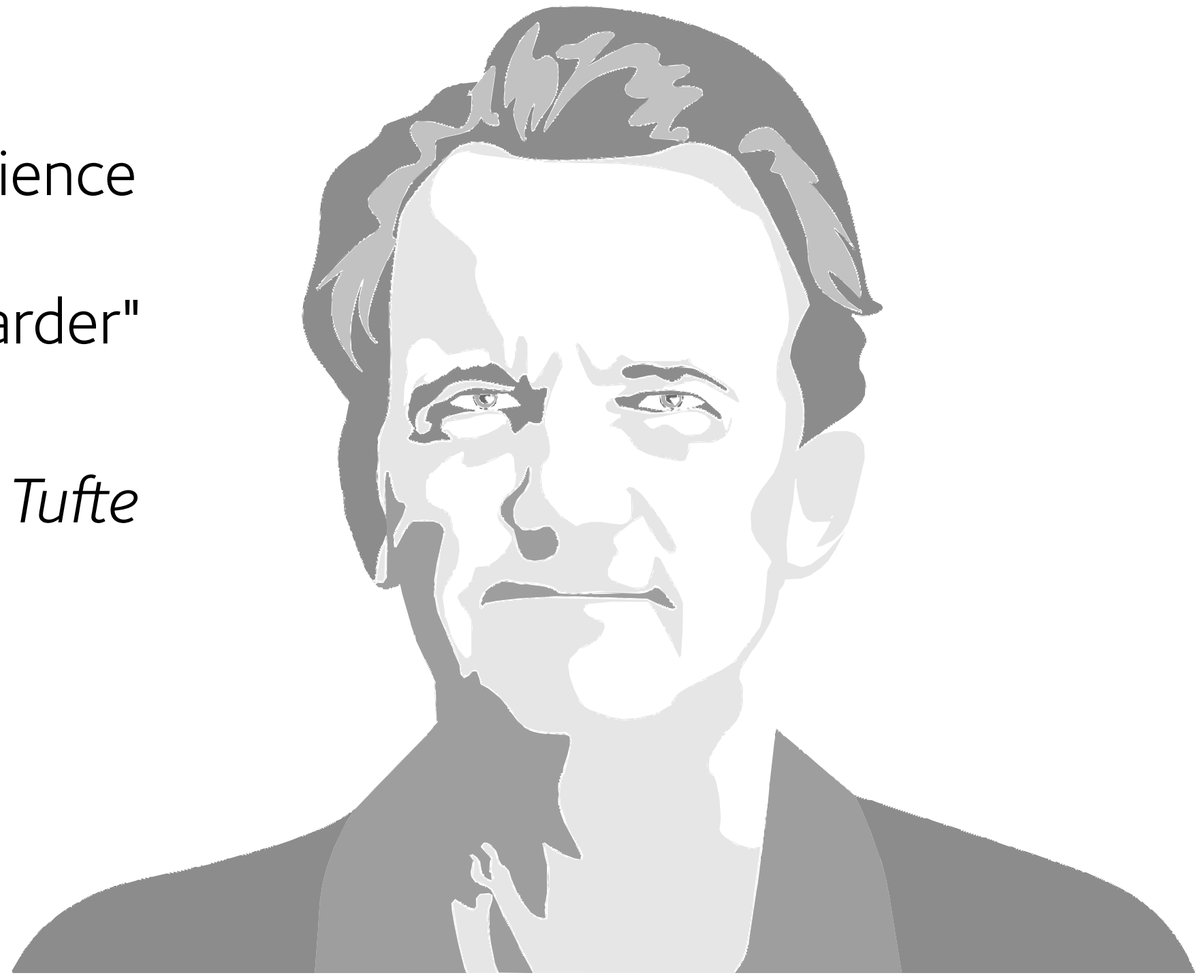
Big data: Who/what delivers demand side responses?



"Understanding human behaviour isn't rocket science

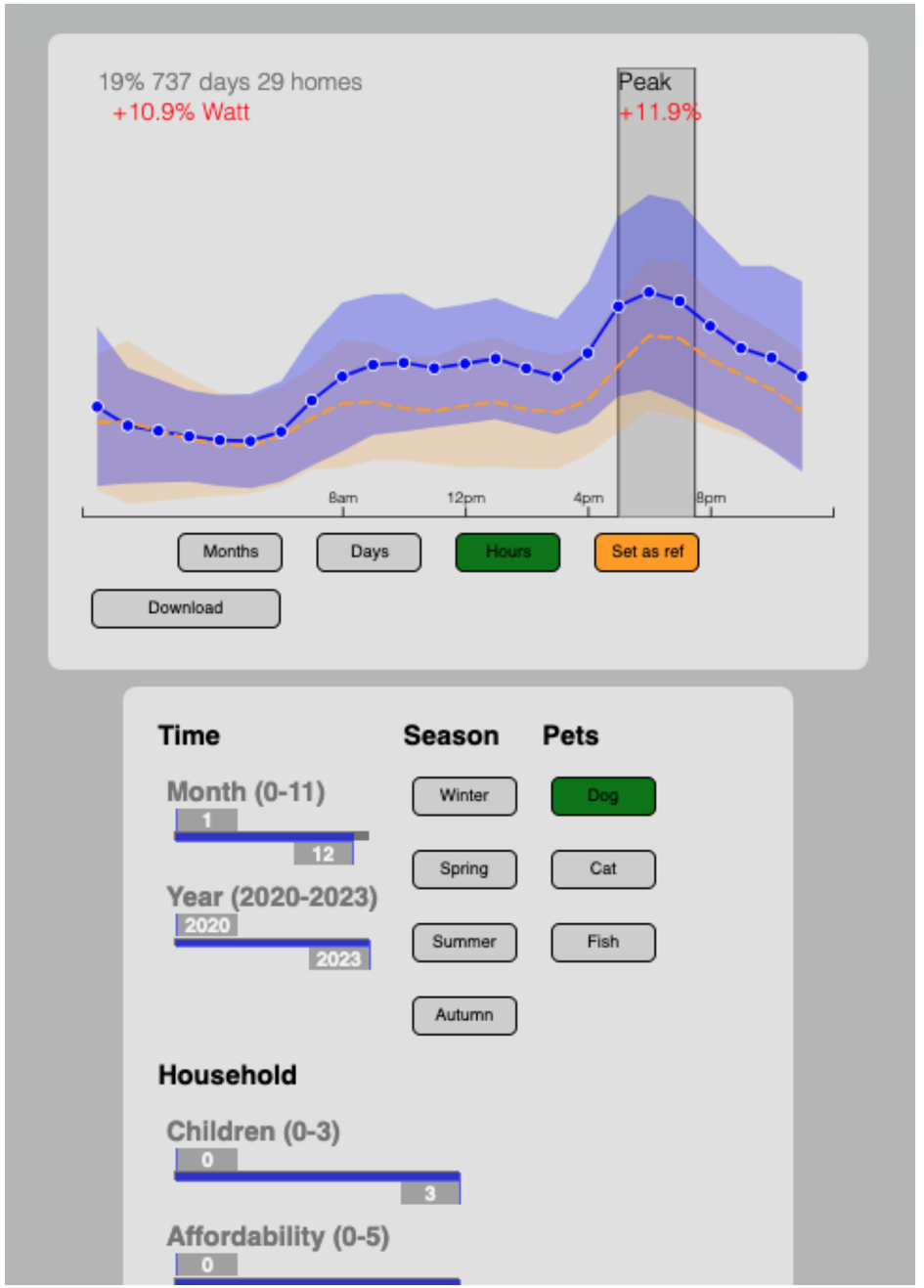
– it's harder"

Edward Tufte

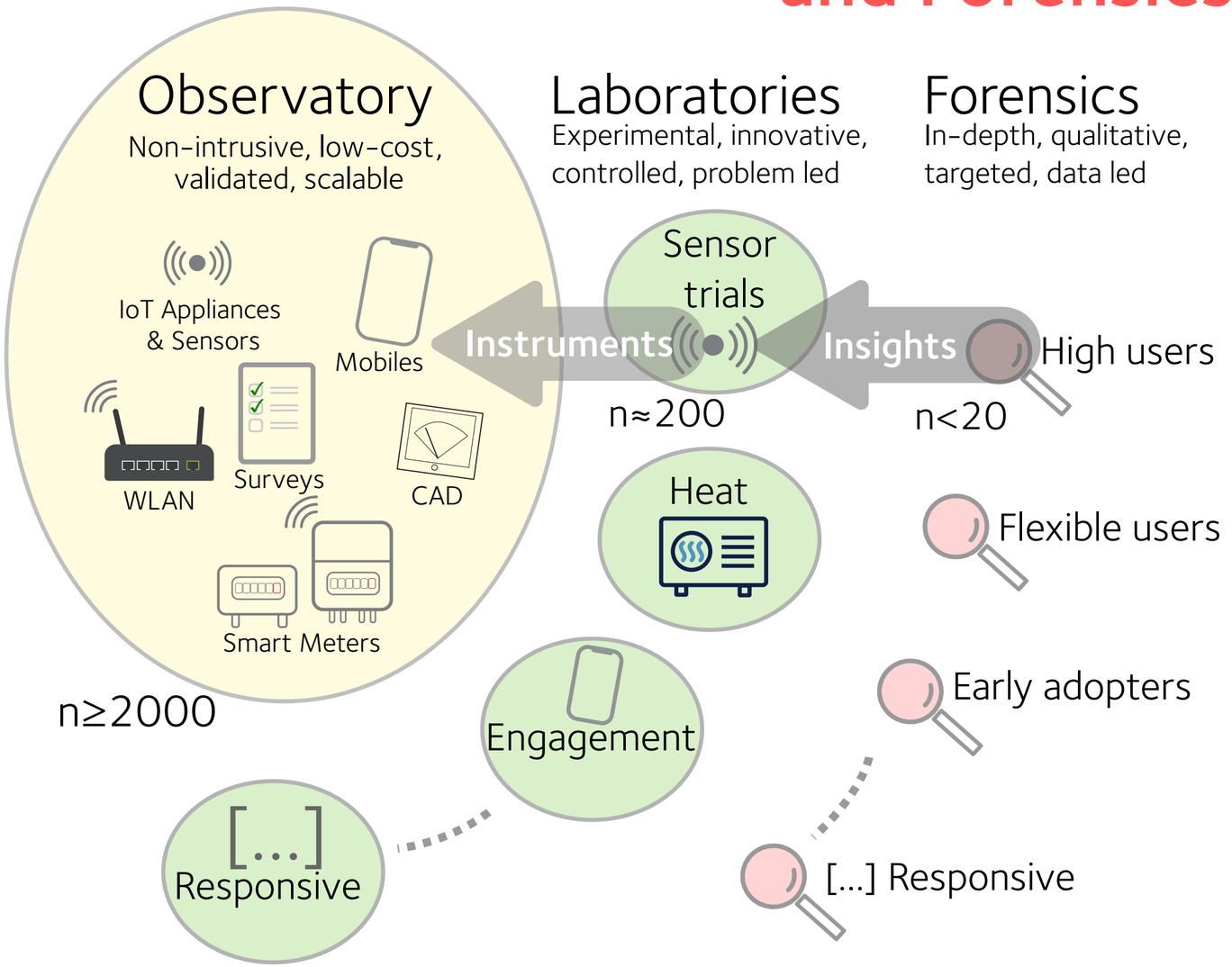


Power explorer:

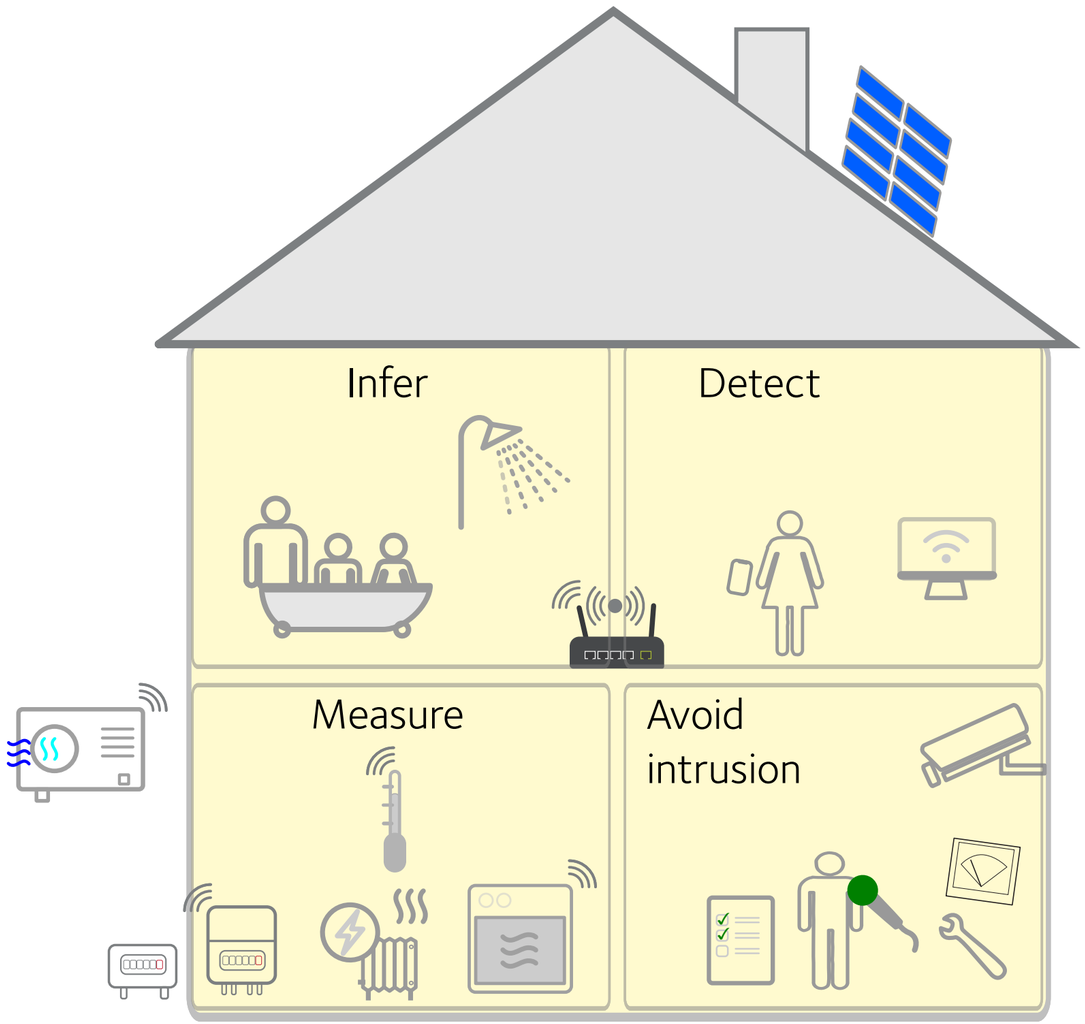
energy-use.org/data

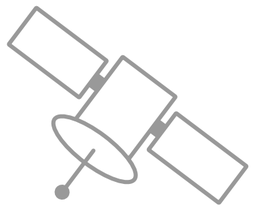


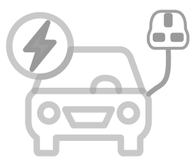
Energy Demand Observatory and Laboratory and Forensics



edol Observatory



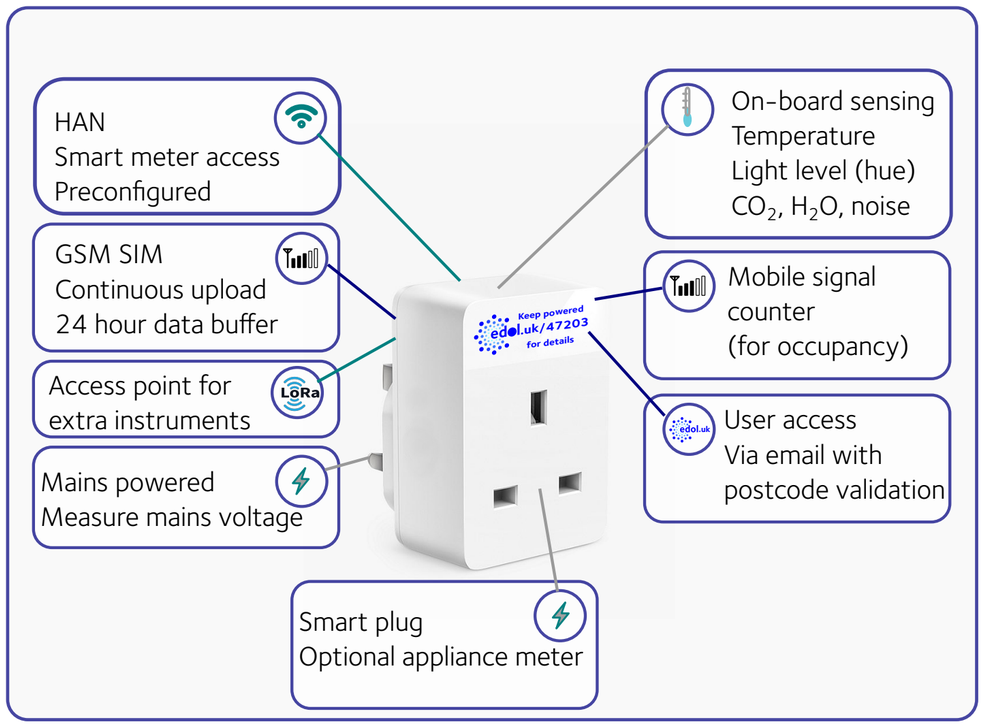


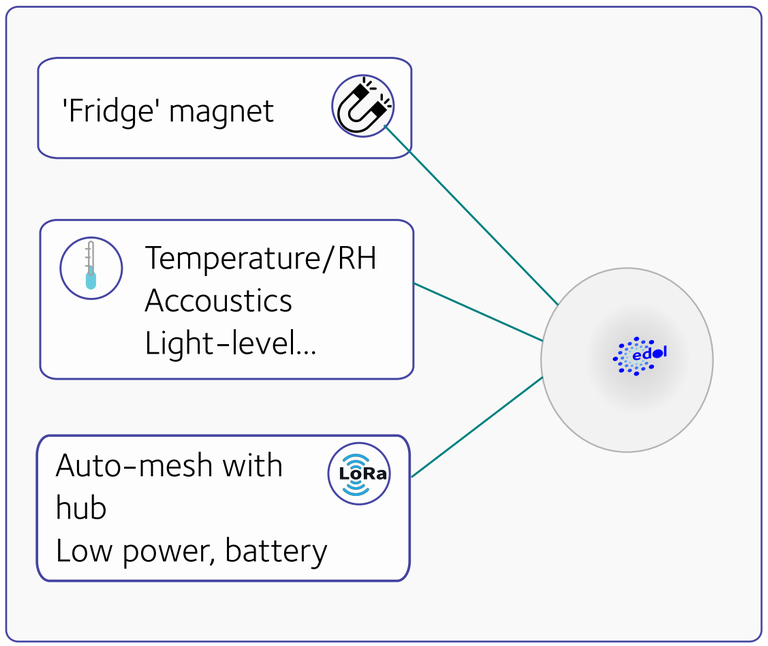


Key development steps

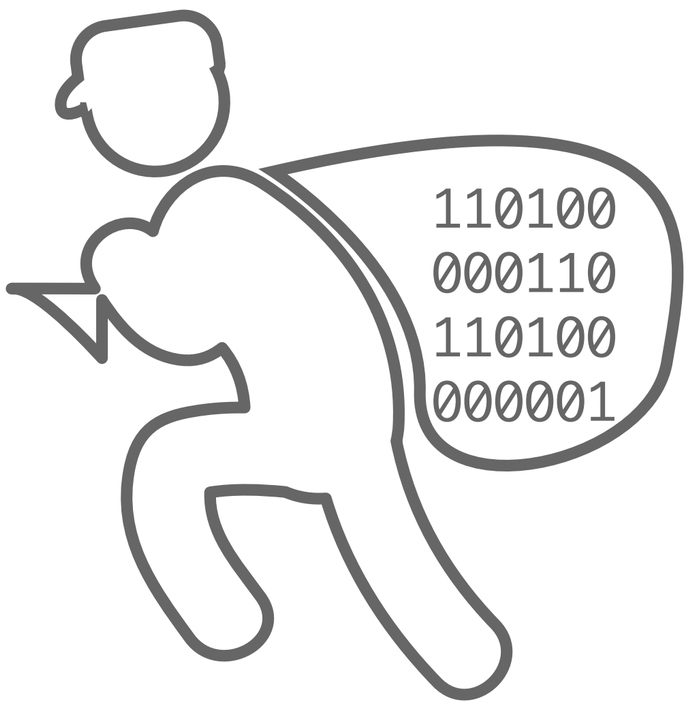
1) Identify and validate technology options
2) Minimise the need for hardware and intrusion
3) Use accessible sources of data

EDOL Dream Data Instrument (EDDI)



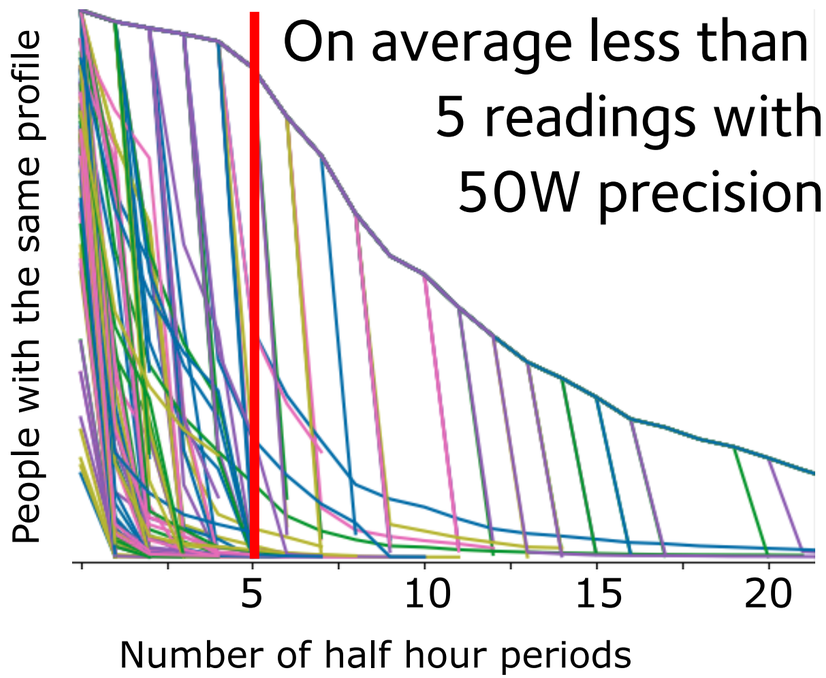


It is unclear what is sensitive and why

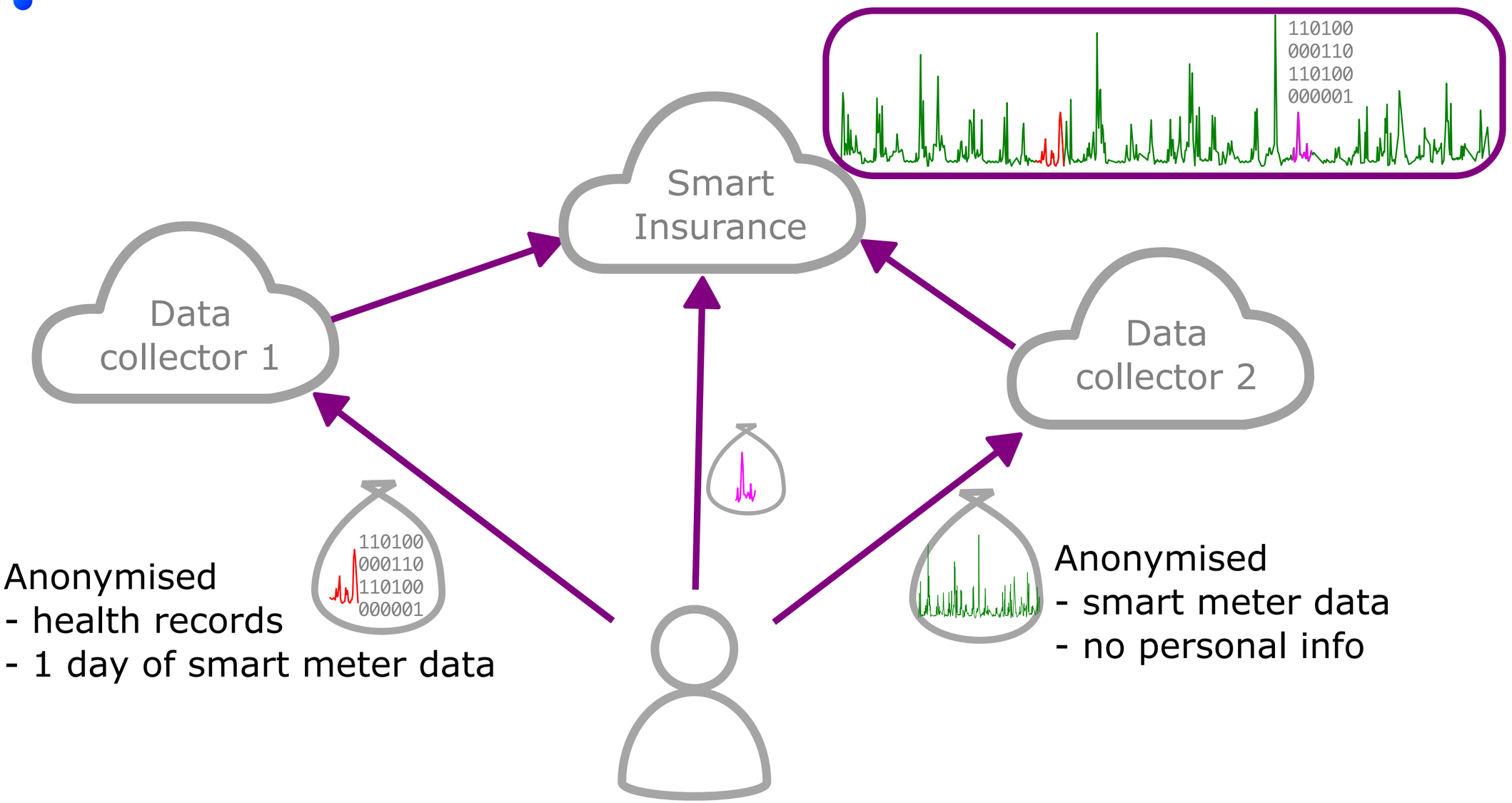


Energy use?	EPCs are public
Occupancy?	Lights and windows are visible to all
Privacy?	Spying spouses
Practices?	Profiles reveal faith
Identity?	How unique is the data

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!

Department of Engineering Science, University of Oxford

Turn energy data into a force for good

Fully funded*

DPhil in Energy Data Privacy

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Start October 2024 - see edol.uk/dphil

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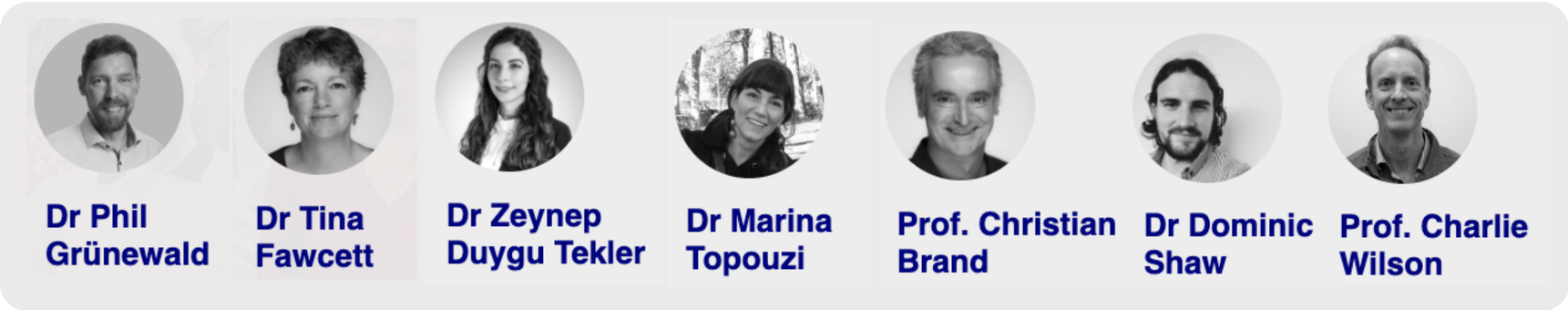
Thank you



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