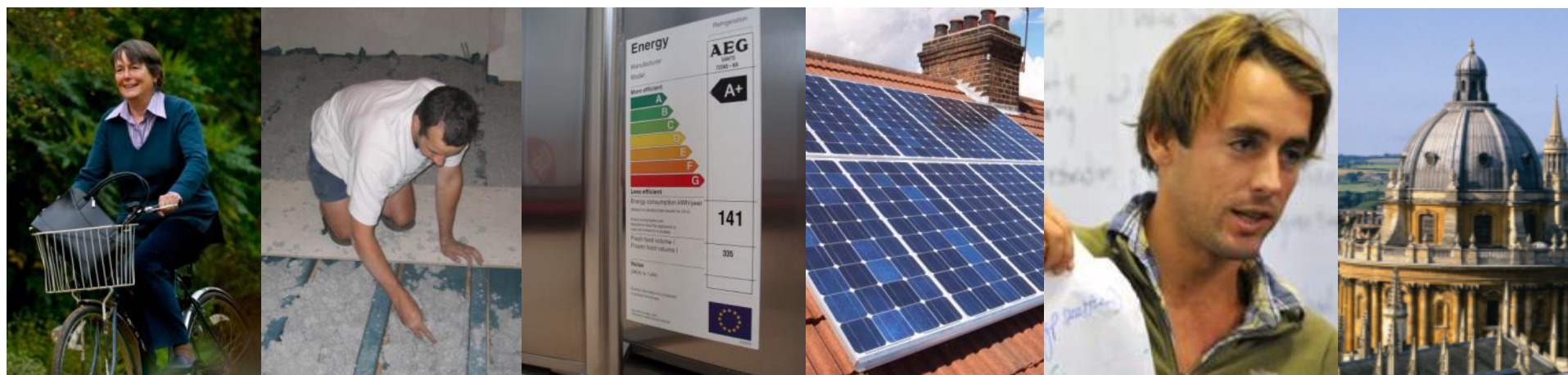


Environmental *Change* Institute



# Measuring and Evaluating Time- and Energy-use Relationships (METER)

Philipp Grunewald



February 4, 2015

Why don't we know  
what's going on during peak demand?

## 20<sup>th</sup> century

- It didn't matter
- It's expensive to find out

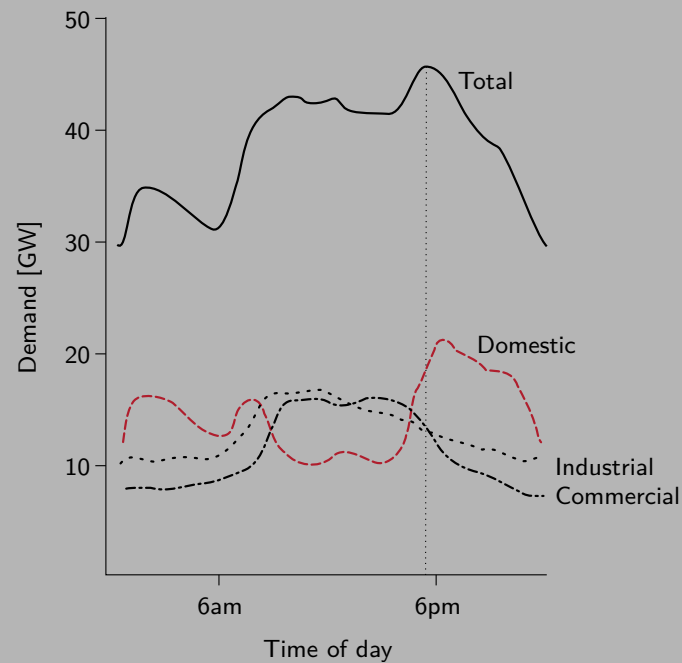
## 21<sup>st</sup> century

- It matters greatly
- It could be much cheaper

# Household contribution to system peak

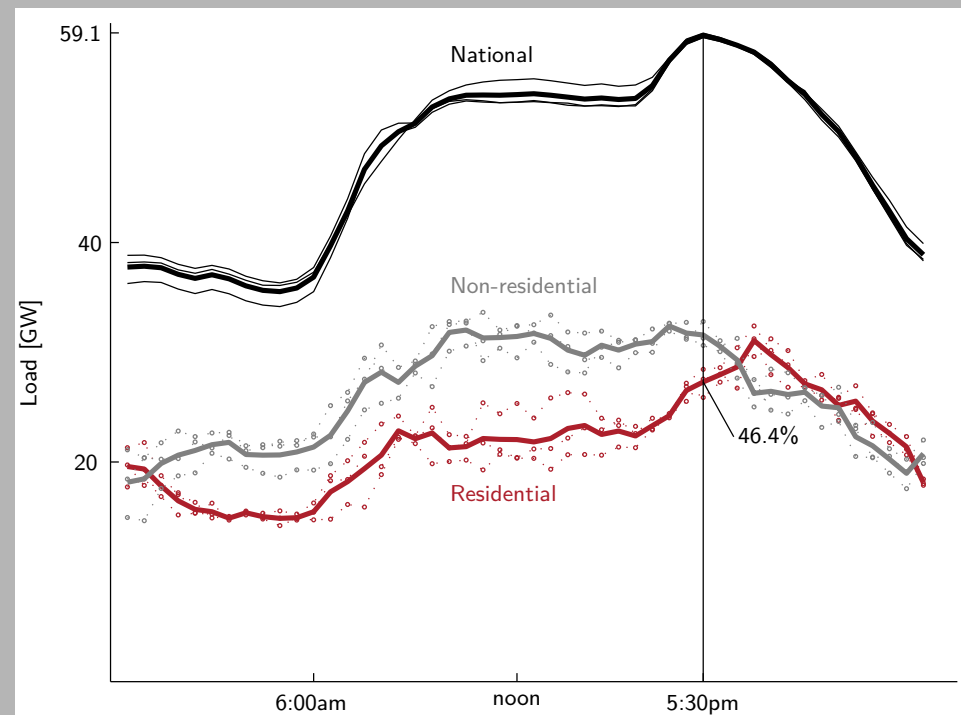
20<sup>th</sup> century

31%



21st century

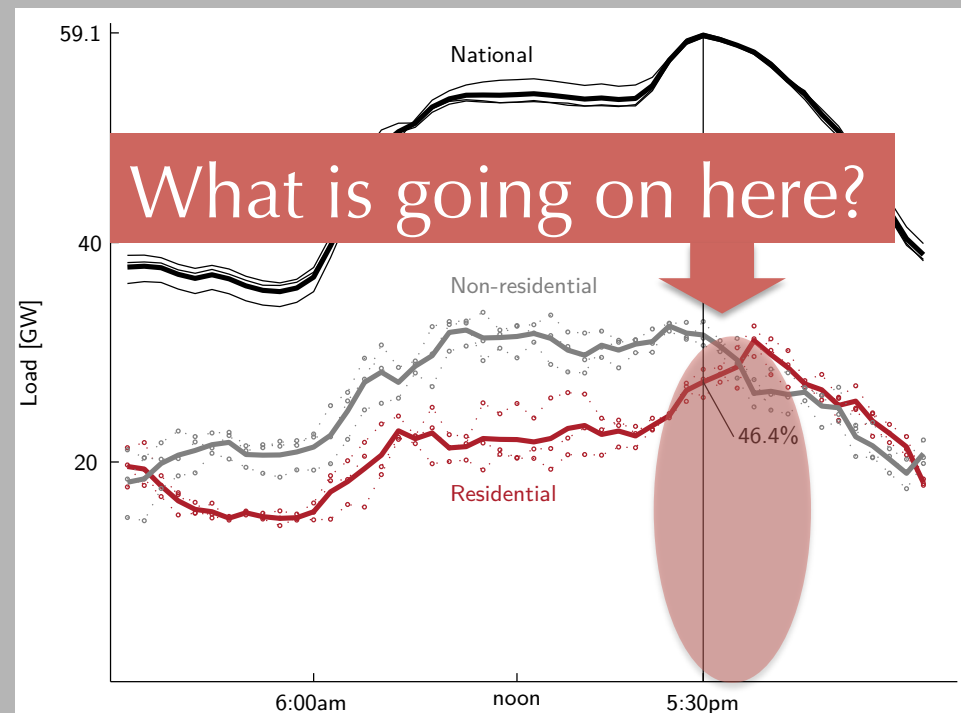
45% + EV + Heat Pumps



# Household contribution to system peak

21st century

45% + EV + Heat Pumps



# State of the Art

## Energy-use

- High instrumentation

Appliance level

- High resolution

Seconds-minutes

- Long duration

Months-Years

- High cost

£1000s per home



## Time-use

- Low instrumentation

Paper diary

- Medium resolution

10 minutes

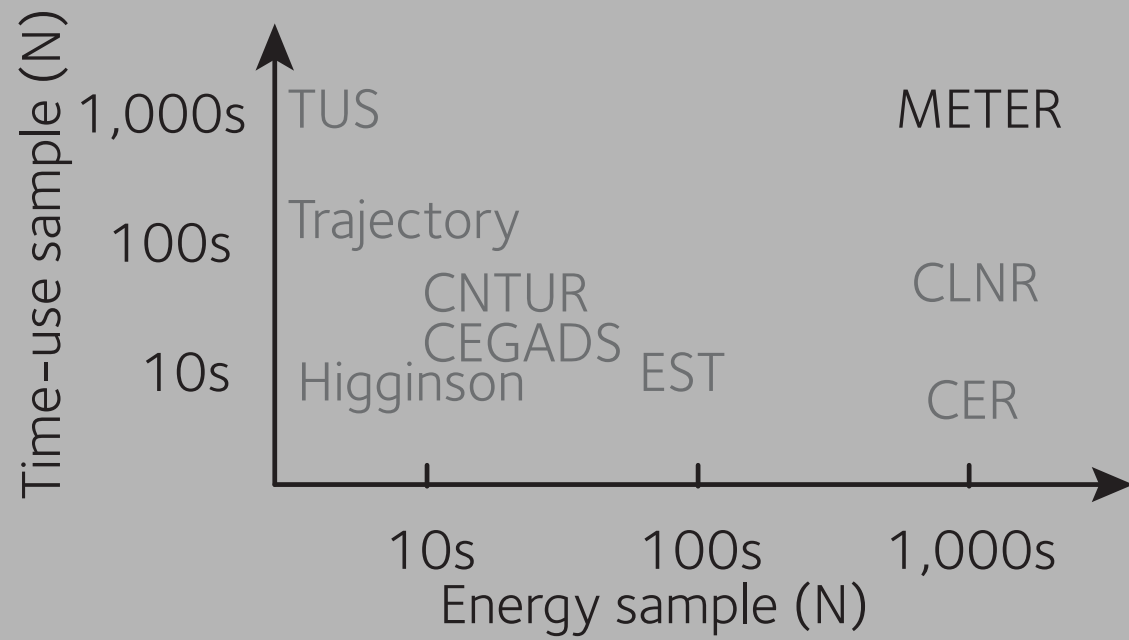
- Short duration

1 day

- Low cost

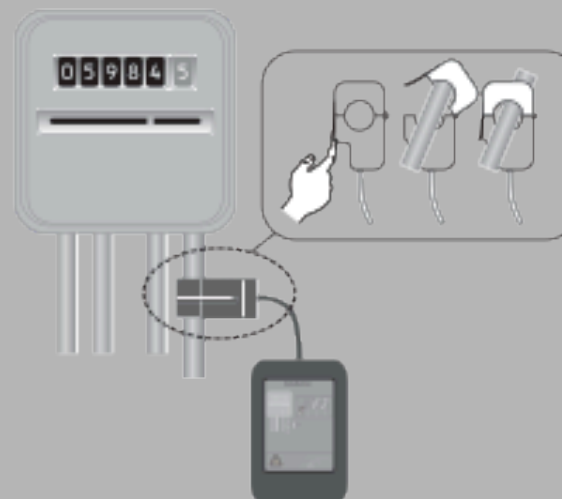
£s per household







## Installation



**Do not touch**  
cables with signs  
of damage!



# Phase 1





Day 1  
Time: 7am – 10am  
Morning

Time 7am–10am Morning (am)	What were you doing? Please write down one main activity.	If you did something else at the same time, what else did you do?	Did you use a smartphone, tablet, or computer?	Where were you? Location, or mode of transport	Were you alone or with somebody you know? Mark all relevant boxes								How much did you enjoy this time? 1 = not at all, 7 = very much
					People who live with you								
					Alone	Spouse / partner	Mother	Father	Child aged 0-7	Other person	Others you know		
7am–7:10	Woke up the children		<input type="checkbox"/>	At home	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5	
7:10–7:20	Had breakfast	checked emails	<input checked="" type="checkbox"/>	↓	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	6	
7:20–7:30	" "	Talked with my family	<input type="checkbox"/>		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5		
7:30–7:40	Cleared the table	Listened to the radio	<input type="checkbox"/>		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4		
7:40–7:50	↓	↓	<input type="checkbox"/>		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	↓		
7:50–8am	Helped the children dressing	Talked with my children	<input type="checkbox"/>	↓	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	↓	
8am–8:10	" "		<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	↓	
8:10–8:20	Went to the day care centre	↓	<input type="checkbox"/>	on foot	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	

Use an arrow or quote marks to record that an activity lasted longer than 10 minutes.

Shower  
Breakfast  
Getting children ready  
Clothes washing  
Builders in the attic  
[...]



7439 W –

129 W

-730 W

Wed 03 00

Wed 09 00

Wed 15 00

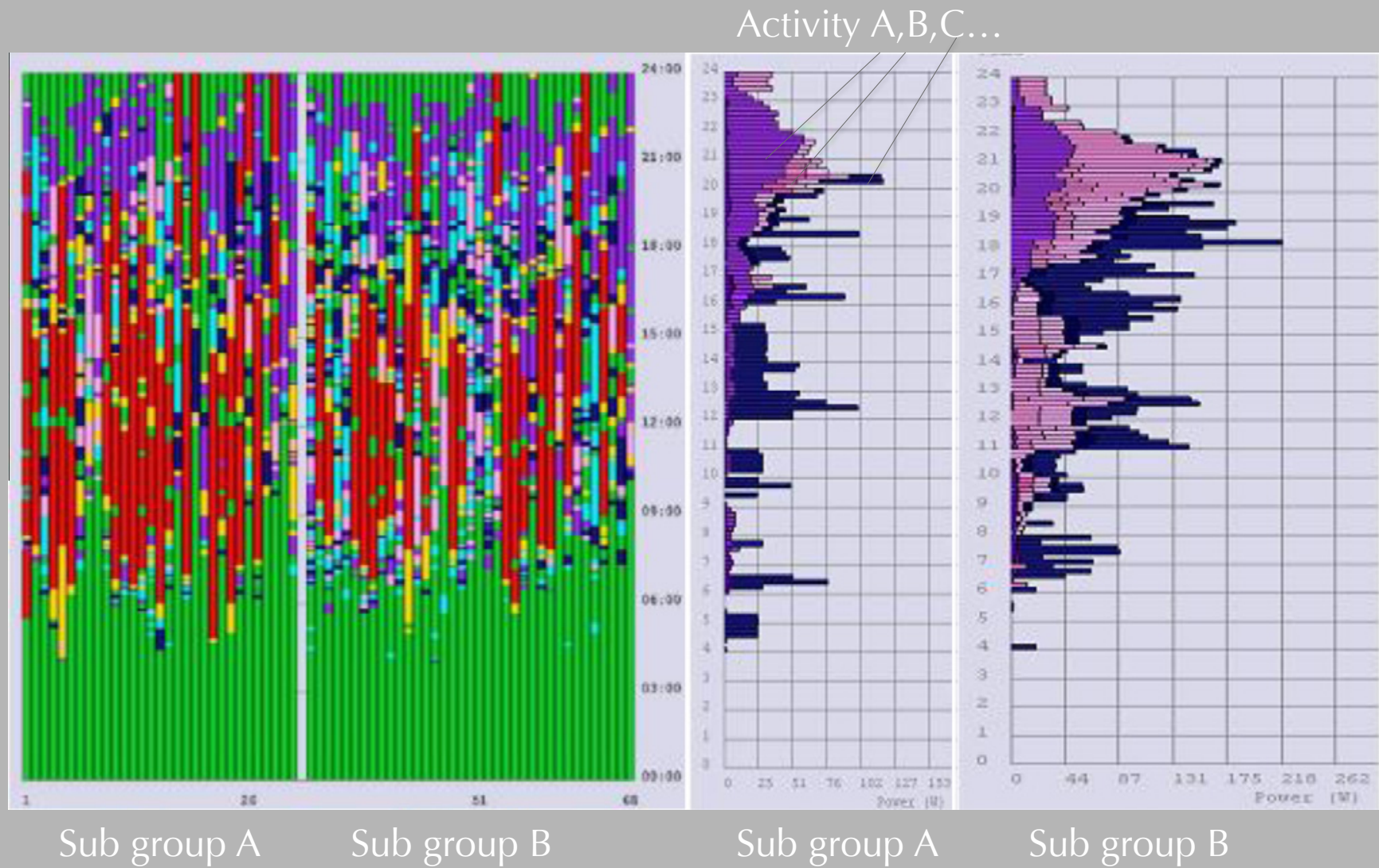
Wed 21 00

Thu 04 00

Added insight

- 1) Diary calibration
- 2) Energy use

# Mapping Energy to Activity



# The trouble with hand written diaries

- Labour intensive
  - for participant
  - for coding
- Indiscriminate
  - All day diary (incl. all the boring bits)
- Delayed recording
  - Post-hoc entries
- Inaccurate
- Biased



## Phase 2: Event triggered diaries



## Phase 2:

### Collect selectively at

- Random active times
- High load
- Uncertain load
- Peak demand



### Additional insight:

- Participant location / movement
- Activity levels
- Proximity to each other  
(joint activity?)

# Phase 3:

## Provide Feedback

Test different messages

- Money (classical economics)
- Social (behavioural economics)
- Event based (big brother)



Collect response

1. Message commitment
2. Profile response
3. Activity response

# Make it statistically significant

Sample target >2000

- One device + clamp + electronics + setup £80
- Reusability >10
- Set for 3 person household (4x80/10) £32
- Courier service (drop off, pick up) £10
- 2000 households (2000x42) **£84k**

# Summary

- **Novel approach** to combine time-use and electricity use
- **Statistically significant** data on the temporal relationship between electricity use and household activities
- **Fundamental evidence** base for load-shifting initiatives
- **Opportunities** for expansion

Heating, light levels, health, building fabric ...

...to be continued...





Thank you.

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