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Smart energy performance indicators

for live historical and normative feedback systems

https://www.dora.dmu.ac.uk/handle/2086/10174

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smartspaces

ICTPSP
ICT POLICY SUPPORT PROGRAMME

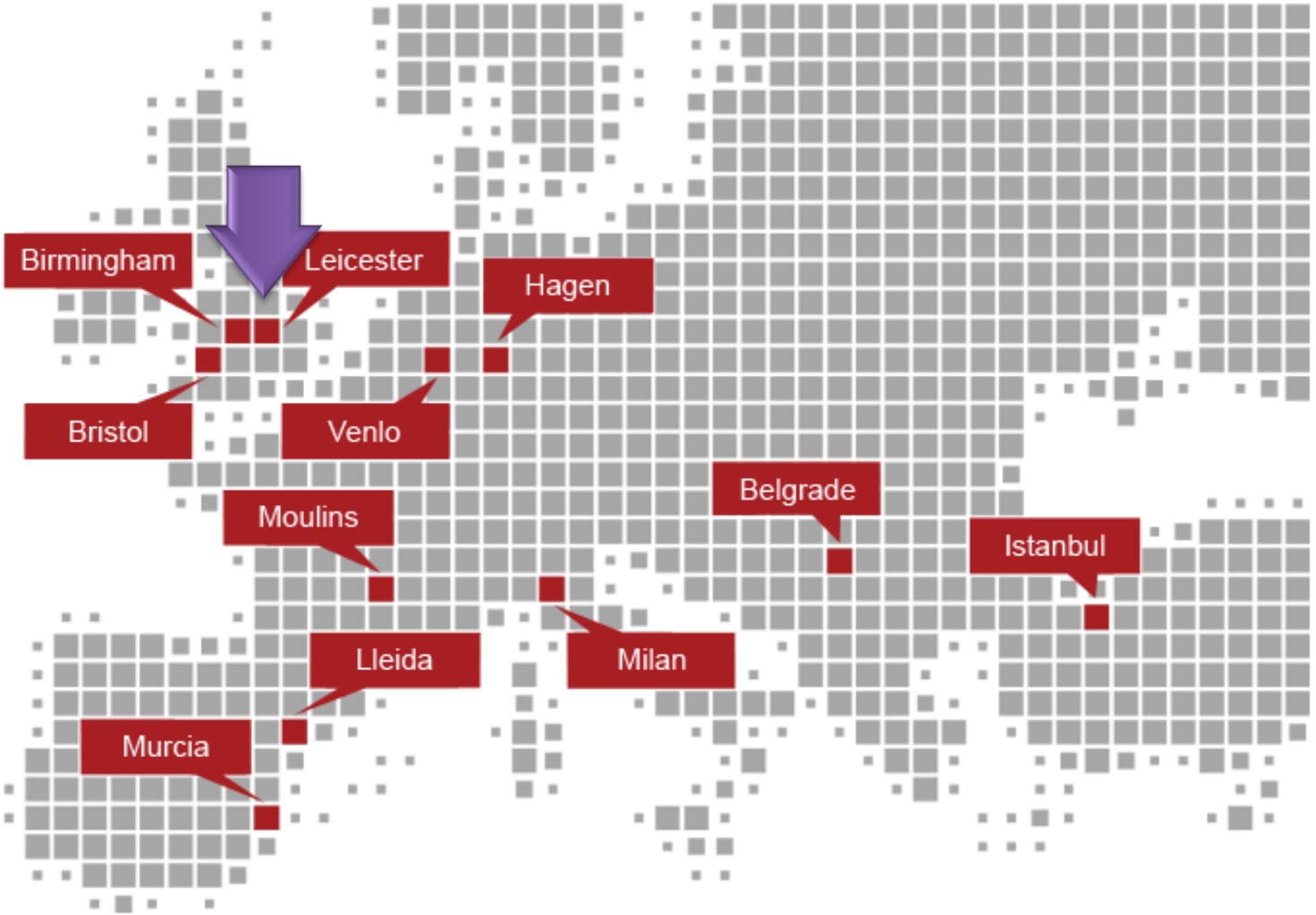
DE MONTFORT UNIVERSITY LEICESTER

- Saving Energy in Europe's Public Buildings Using ICT
- 01/2012 – 12/2014
- 11 pilot cities in 8 countries – 26 partners
  - United Kingdom, France, Germany, Italy, Spain, Netherlands, Turkey, Serbia

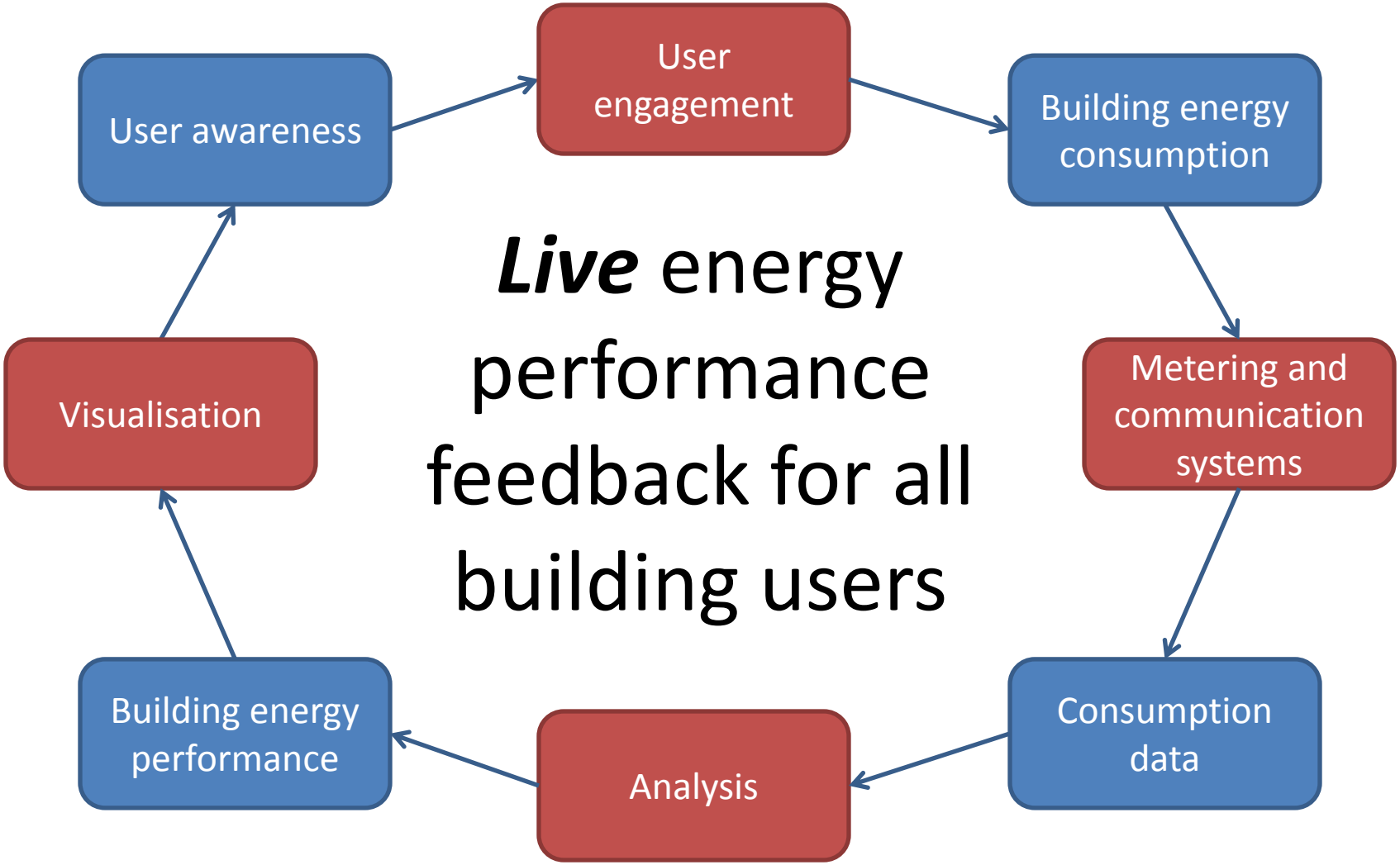
http://www.smartspaces.eu

SMARTSPACES in Leicester

De Montfort University + Leicester City Council



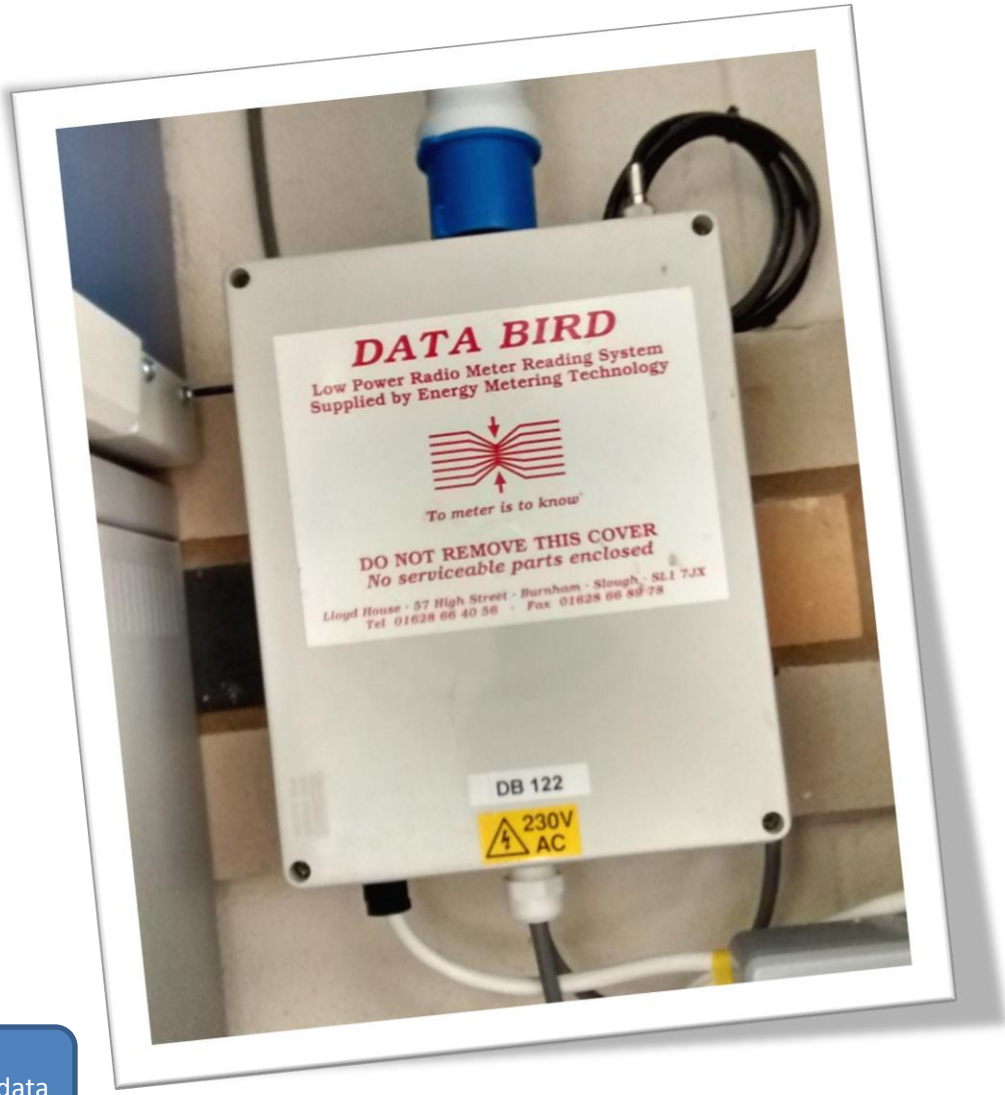
The vision



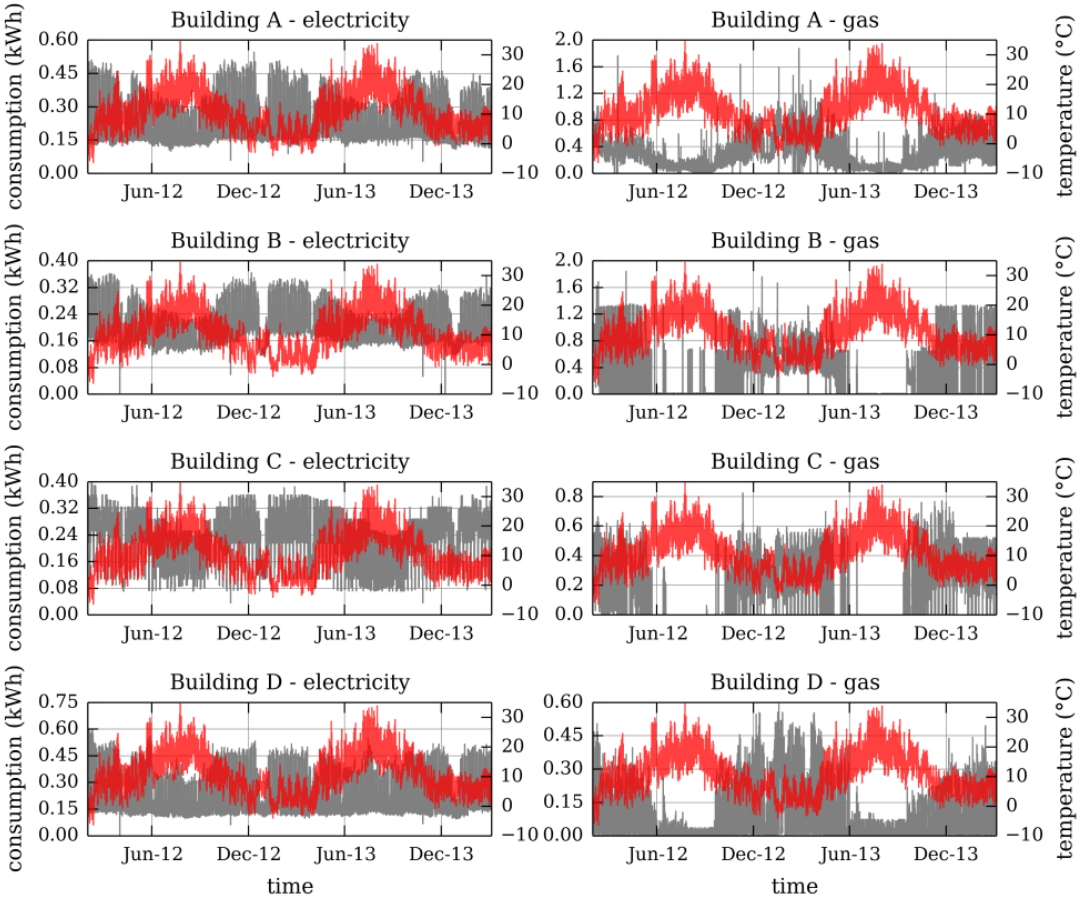
Live energy performance feedback for all building users

Metering and communications

- Prerequisite technology
  - Automatic Meter Reading (AMR)
  - Half-hourly
  - Electricity/Water/Gas
  - Outside air temperature
  - Communication to a central database
- Quite common these days



The raw data carry lots of information



These data are from four university buildings used as examples throughout this presentation

This is all the raw material necessary for the analysis that follows

For most people, energy is **not** an important issue

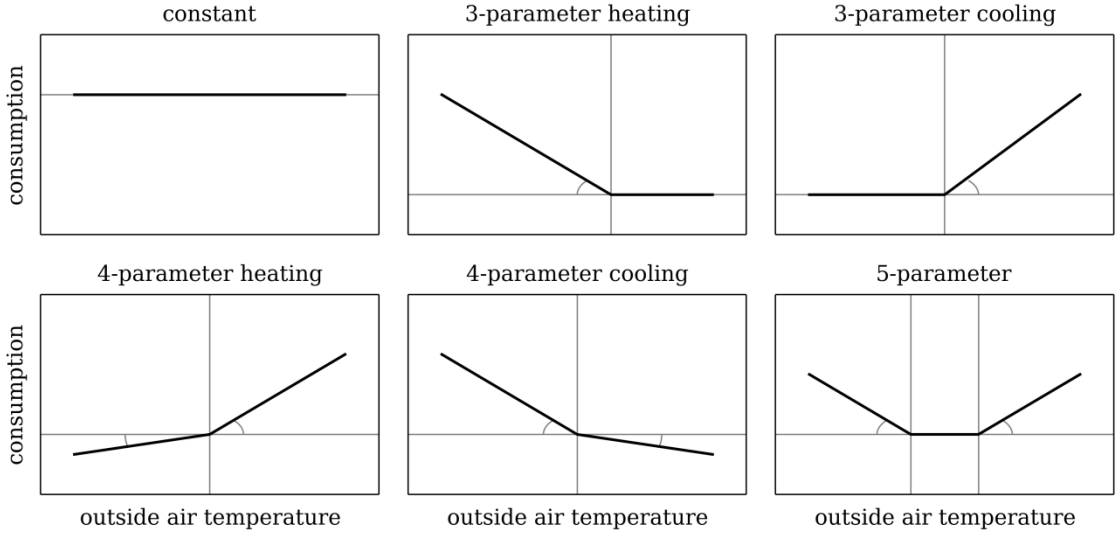
It takes **too much effort** to interpret this

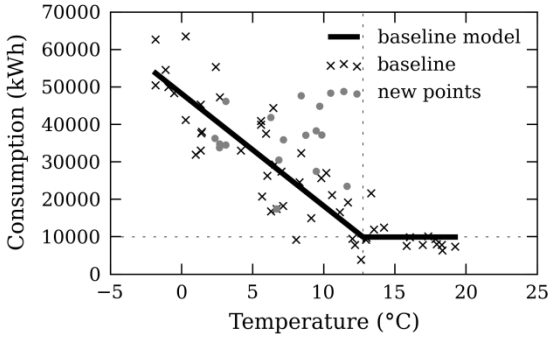
Normal people don't like graphs anyway

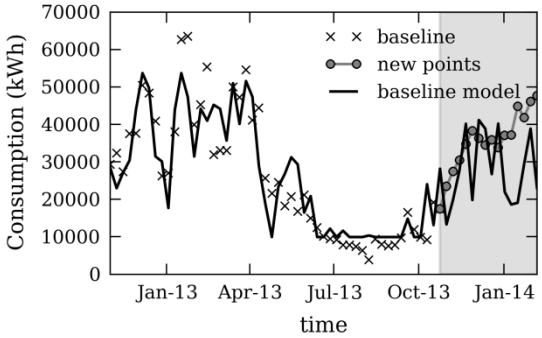
What information is useful?

- I want to know if my building is performing OK or not
- I need context-free information
  - I don't know what is ***normal*** for my building
  - I don't know (or care) what a ***kWh*** is
- Context = How much energy do we expect to consume?
  - Is it normal?
  - Is it high?
  - Is it low?
- Energy ***Saving*** Performance
  - Assume fixed demand for energy services
  - Increase in consumption = more waste (bad)
  - Decrease in consumption = less waste (good)

Baseline model and forecast

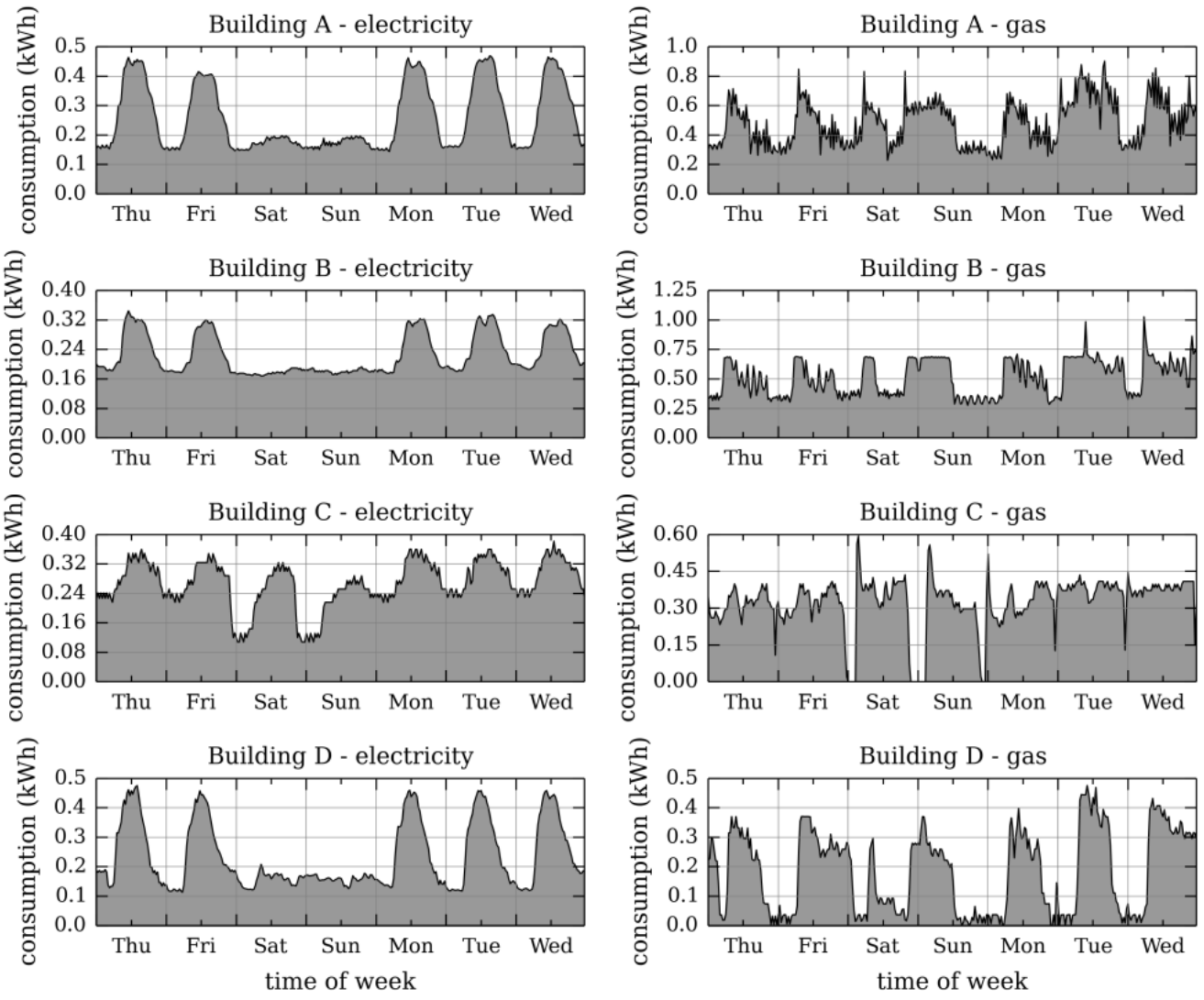






Test period = current week (Sunday to Saturday)
Baseline = previous 52 weeks

Sub-daily patterns are problematic



52 weeks per year
336 time slots per week
17,520 data points per year

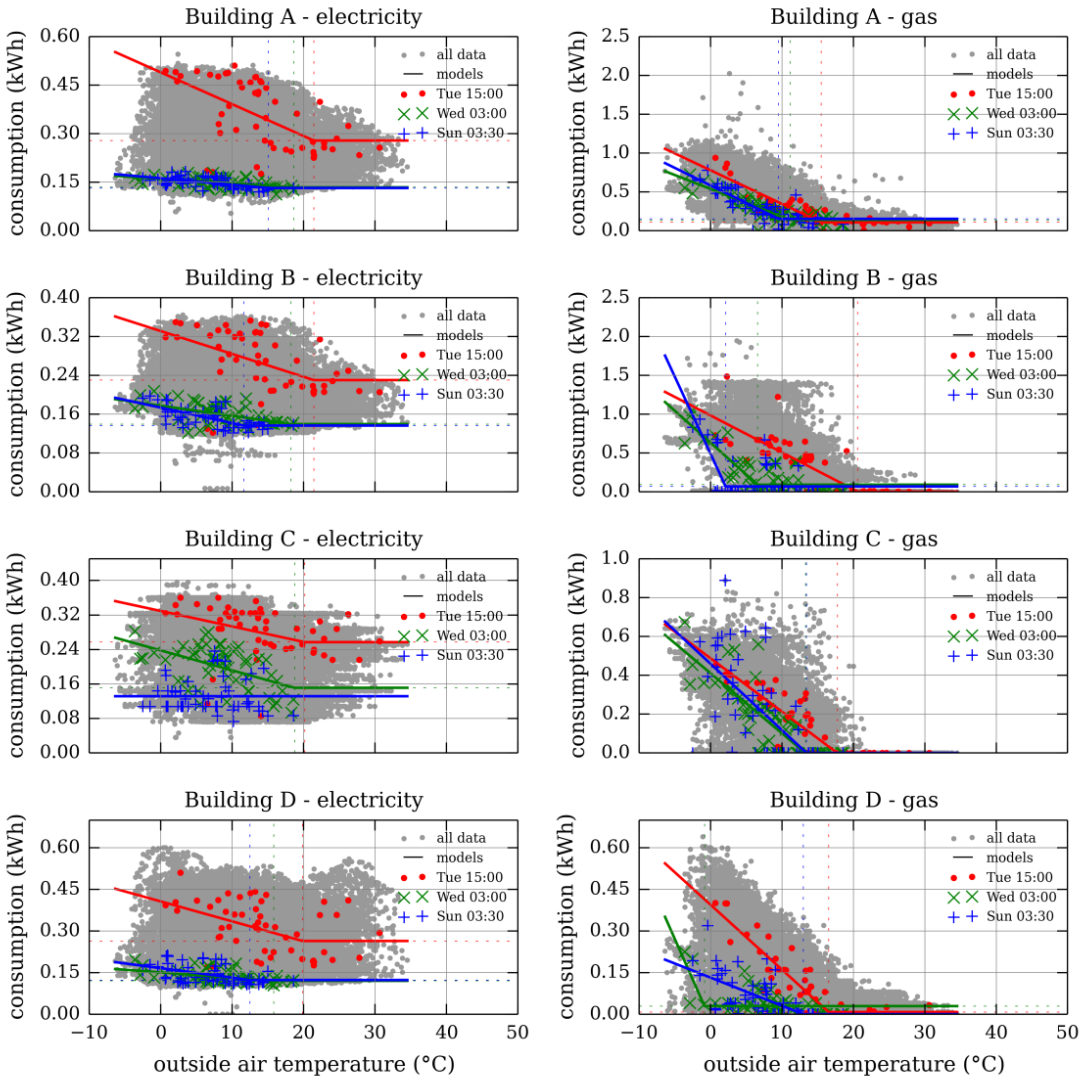
We need a prediction for each data point.

Thermostatic set points change on a ***time of week*** basis.

Occupancy patterns determine internal gains and much of electricity use.

Patterns are pretty stable, can we use this?

A ***live*** (i.e. half-hourly) baseline model

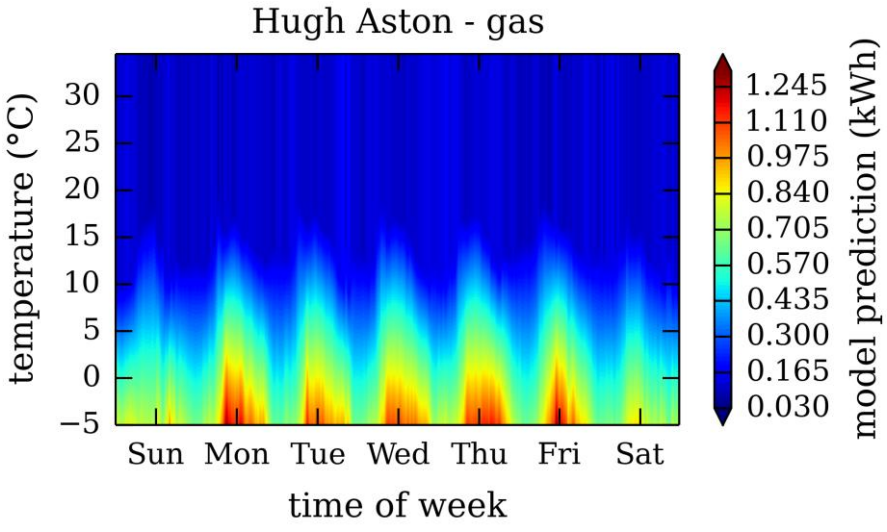


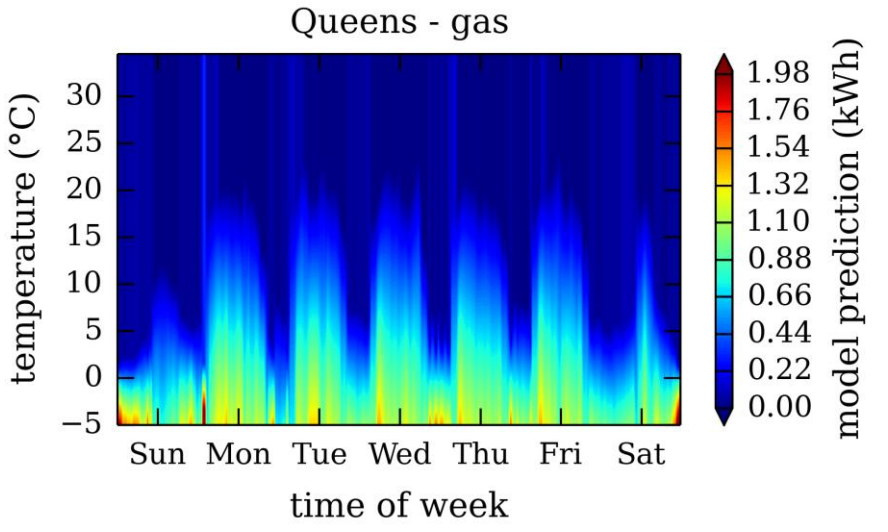
Applying these simple models to each half-hourly slot in a week produces a composite model of consumption. Fitting the model generates 336 sets of model parameters.

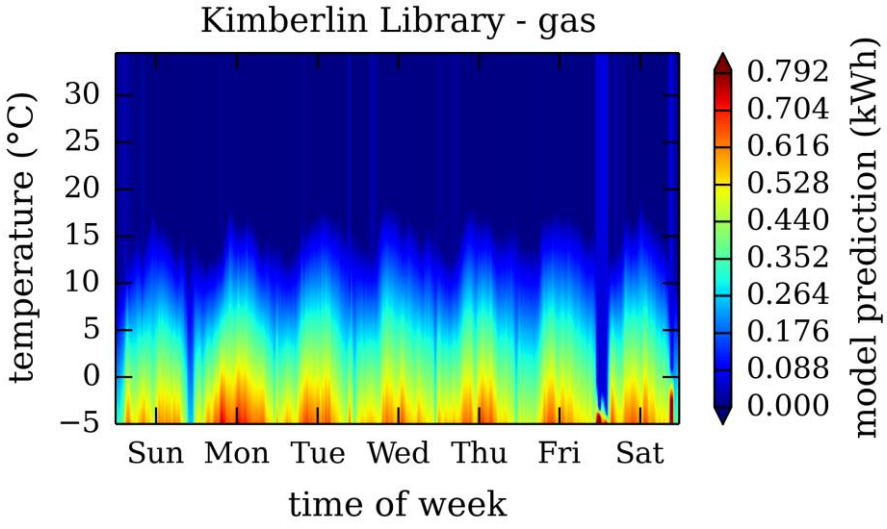
The model takes into account both outside air temperature and time of week, as a proxy for occupancy. Each sub-model is fitted to 52 data points.

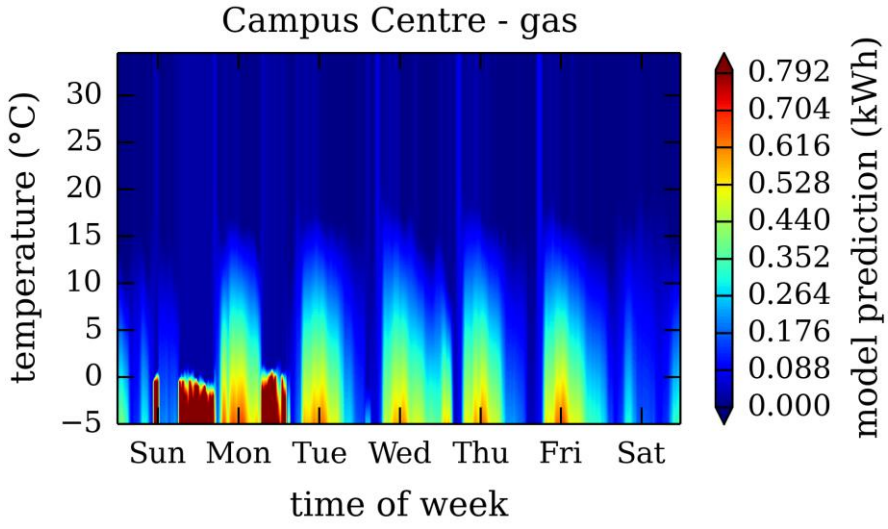
Given an outside temperature and a time of week value it is possible to generate a prediction for expected consumption for any half hour.

Gas consumption baselines

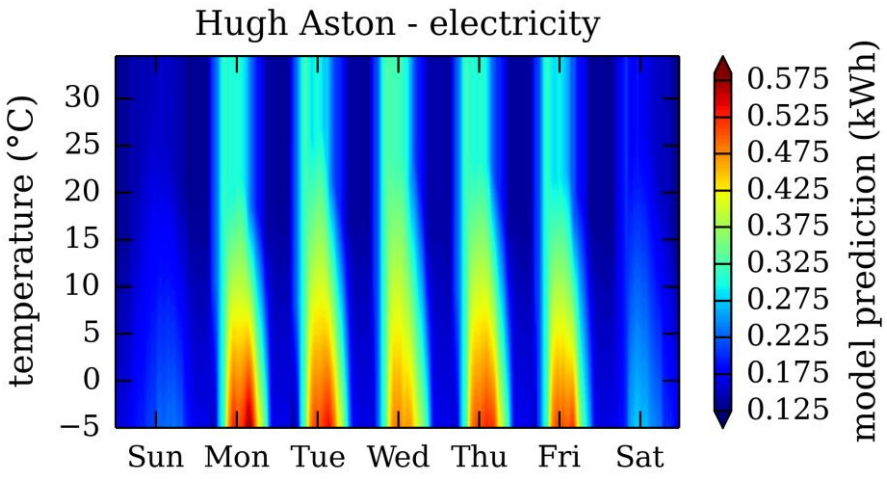


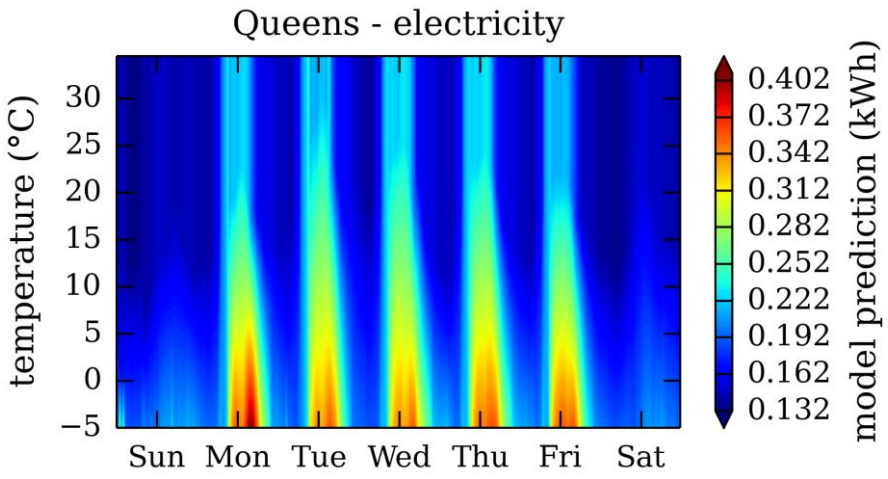


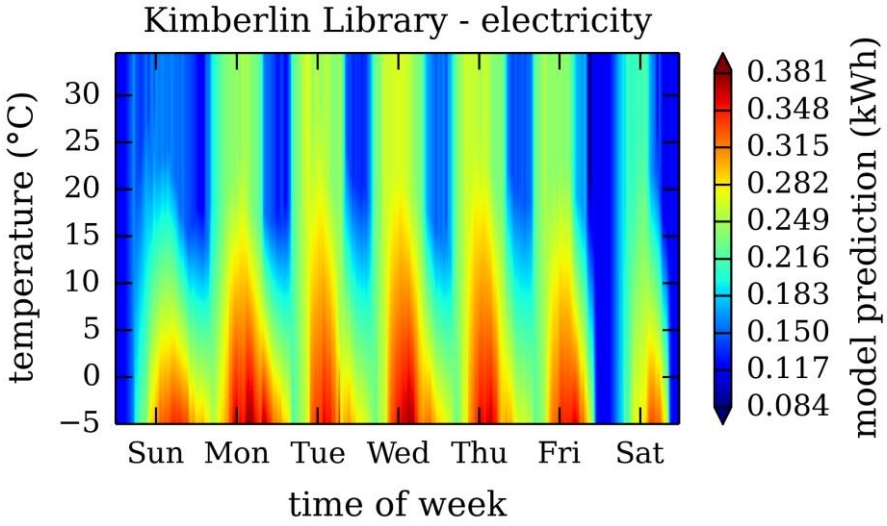


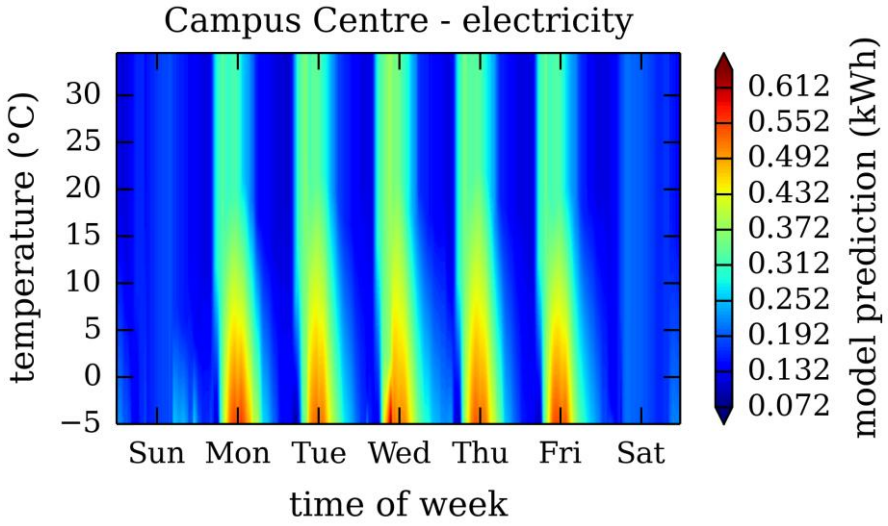


Electricity consumption baselines

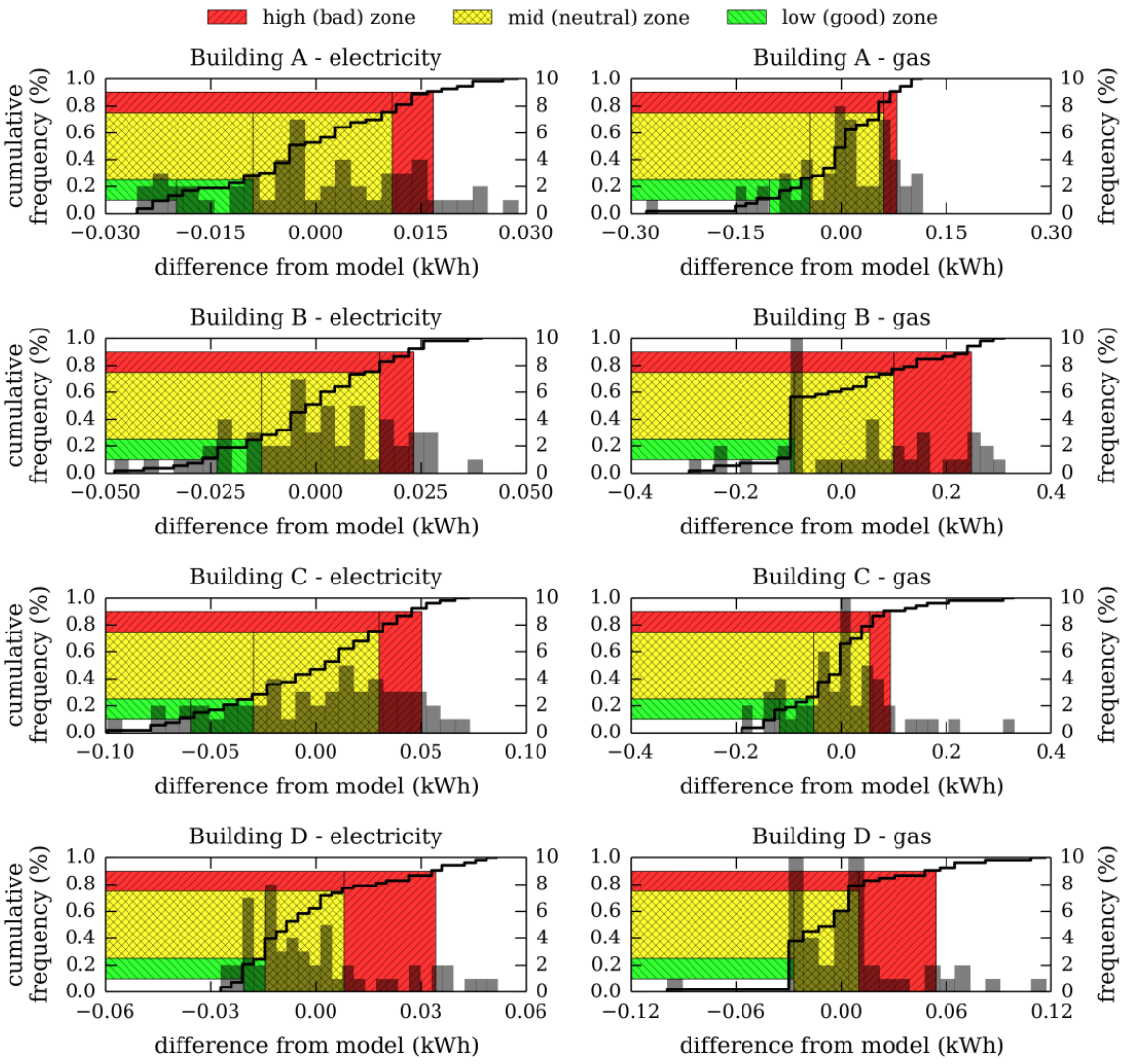








So what is ‘normal’?



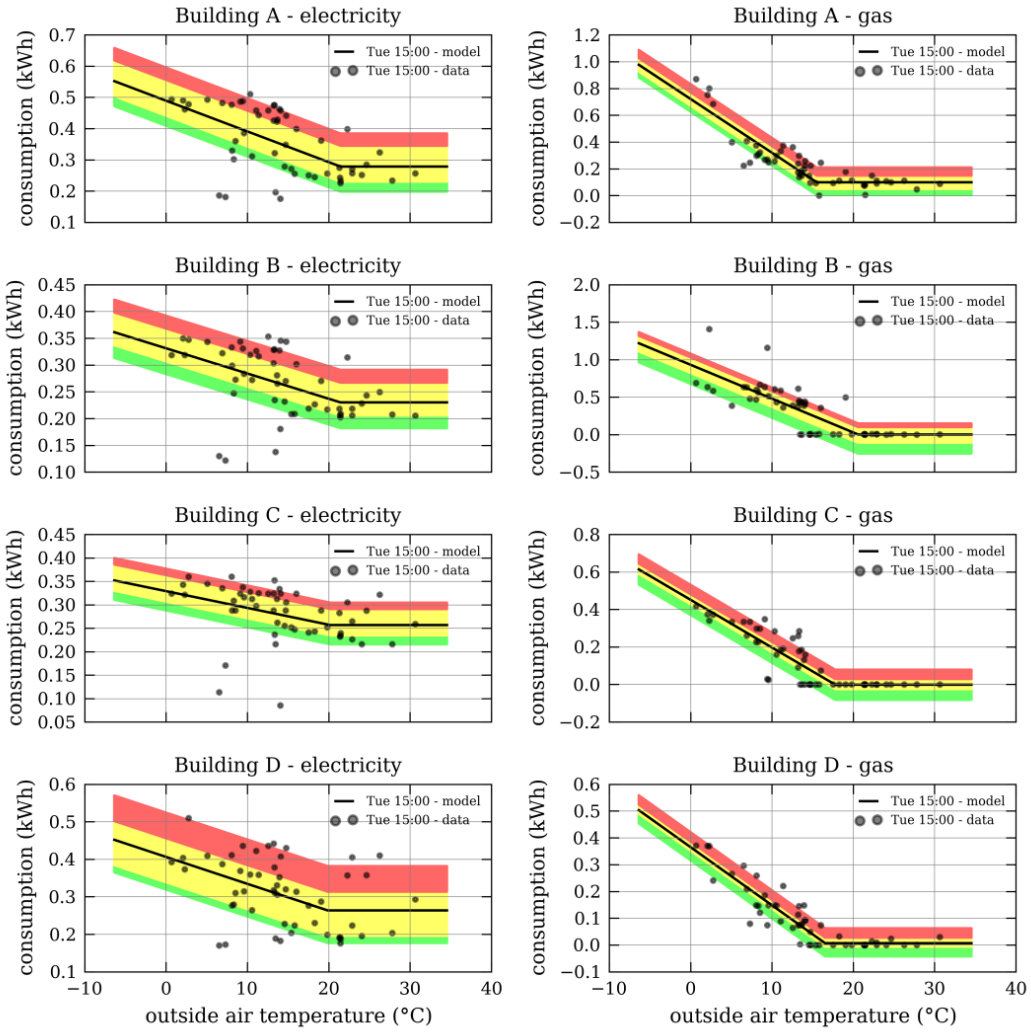
Model residuals (the scatter around the models) are used to calculate “zones” of consumption.

10^{th} – 25^{th} = “good zone”
25^{th} – 75^{th} = “neutral zone”
75^{th} – 90^{th} = “bad zone”

This provides building-specific ranges around the model prediction.

This defines what is ***normal*** for each building

Looking at it another way



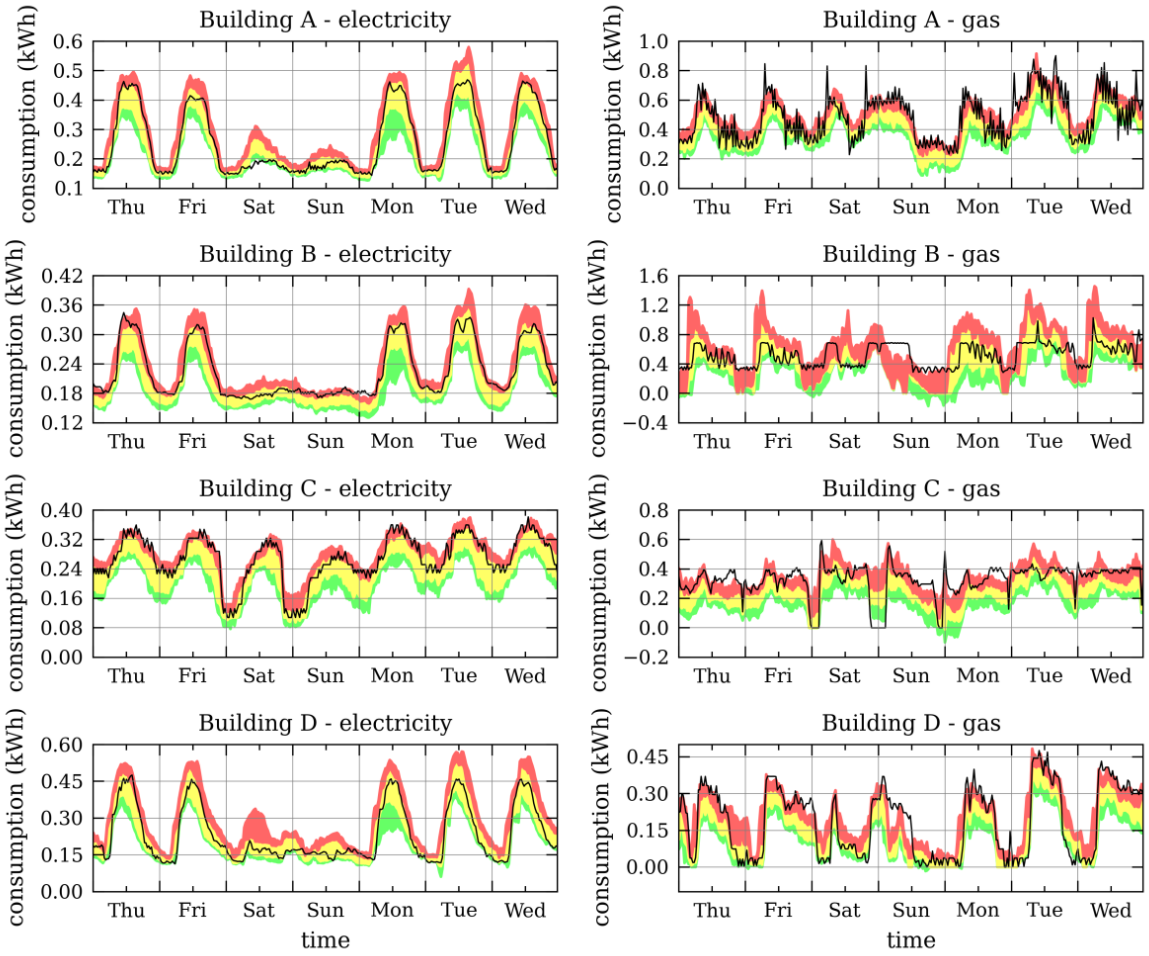
Every forecast value in the test period has an associated range of expected consumption values (for a given confidence interval)

Consumption can be visualised against the baseline zones.

This approach can be applied to any building no matter the size or configuration. Consumption falling in or above the “bad zone” is considered as high.

In this case there are 52 points per model so 5.2 points fall above the red zone and below the green zone. Exactly 26 points fall in the yellow zone.

Visualising consumption in context

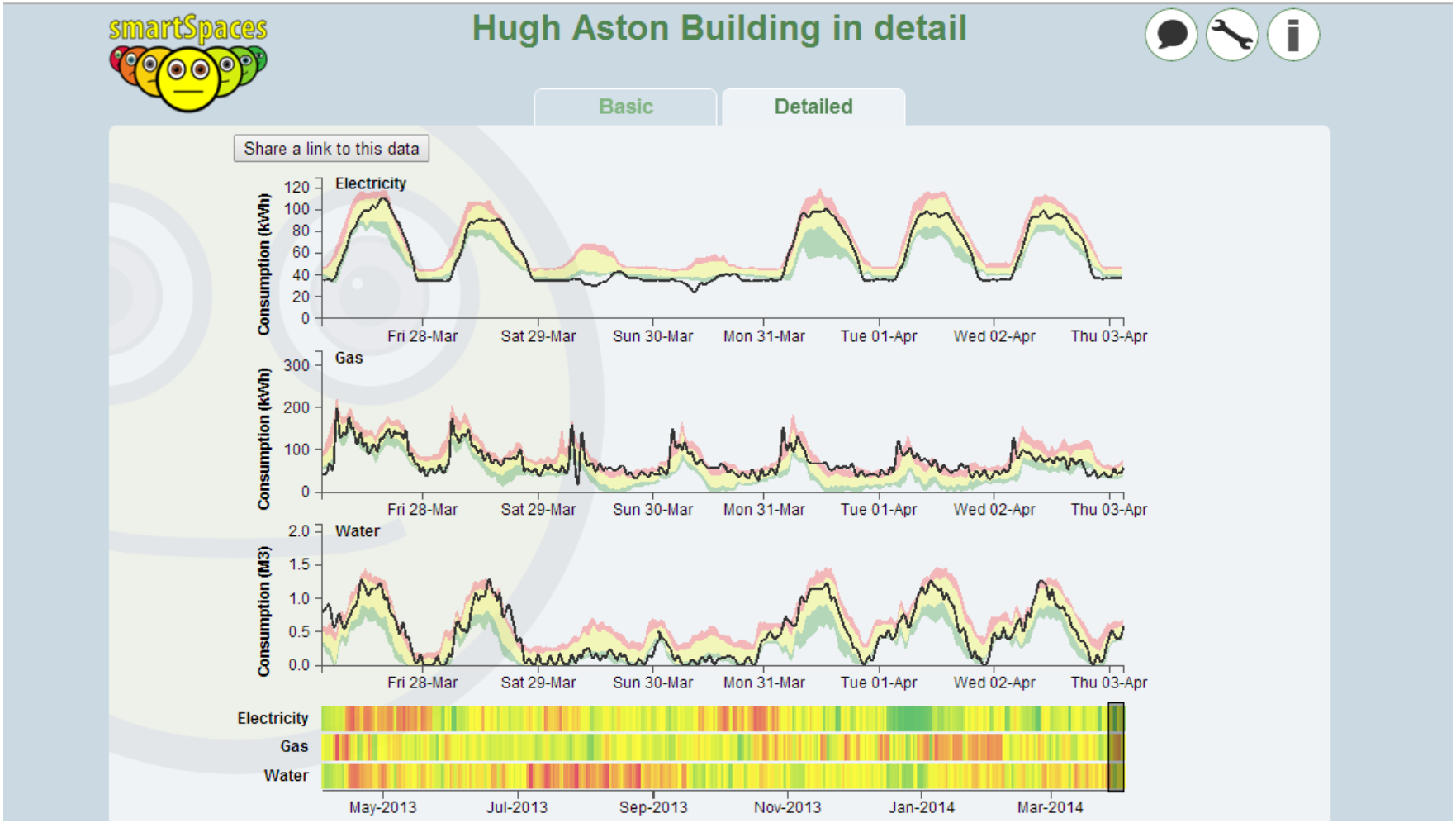


In the test period (one week) we can forecast the expected zones of consumption.

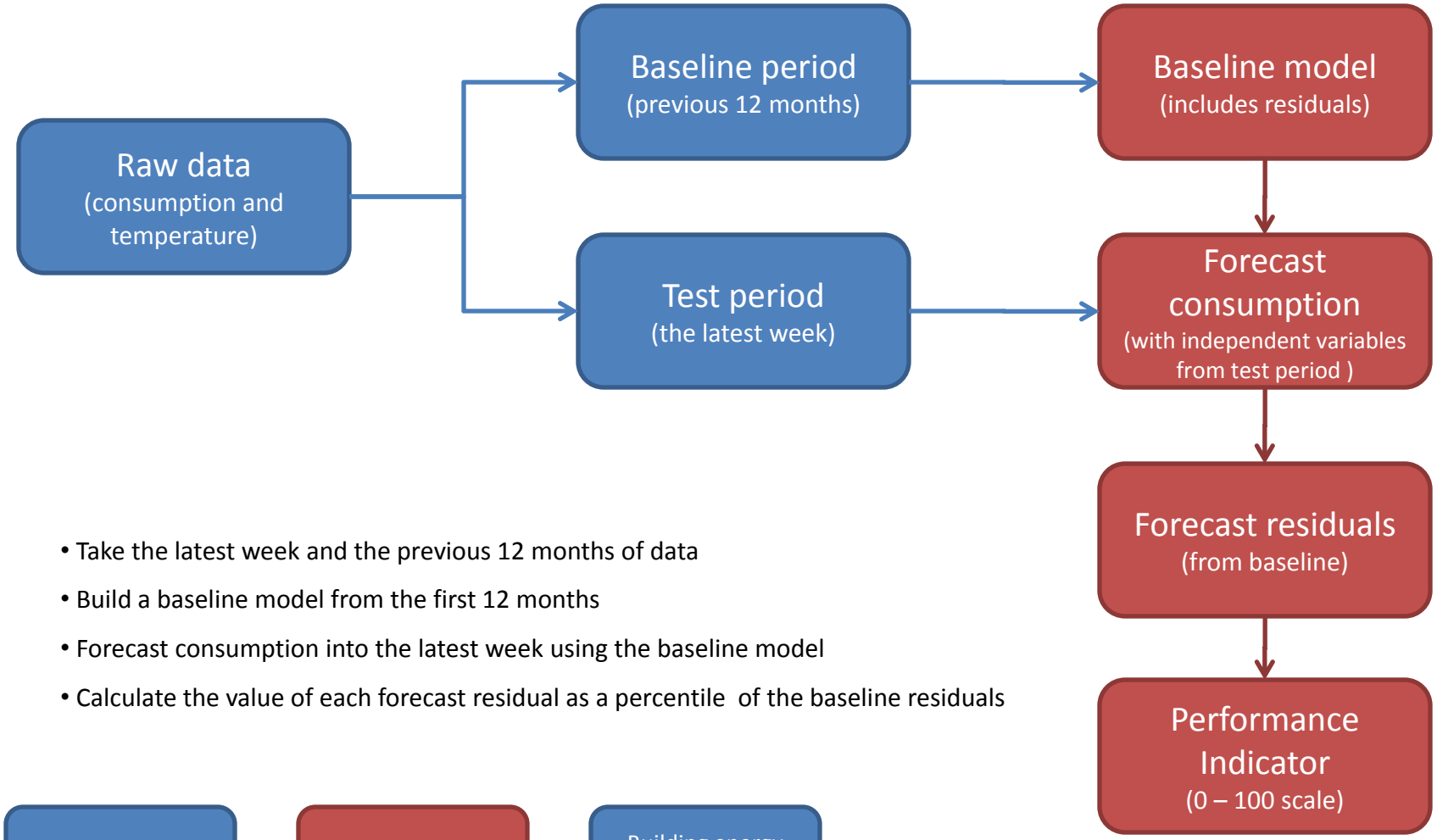
A percentile value can also be calculated for any consumption point. The residual of the value is compared to the residuals of the baseline model.

This generates a performance indicator ranging from 0-100 for each half-hour point of data.

Interactive interface



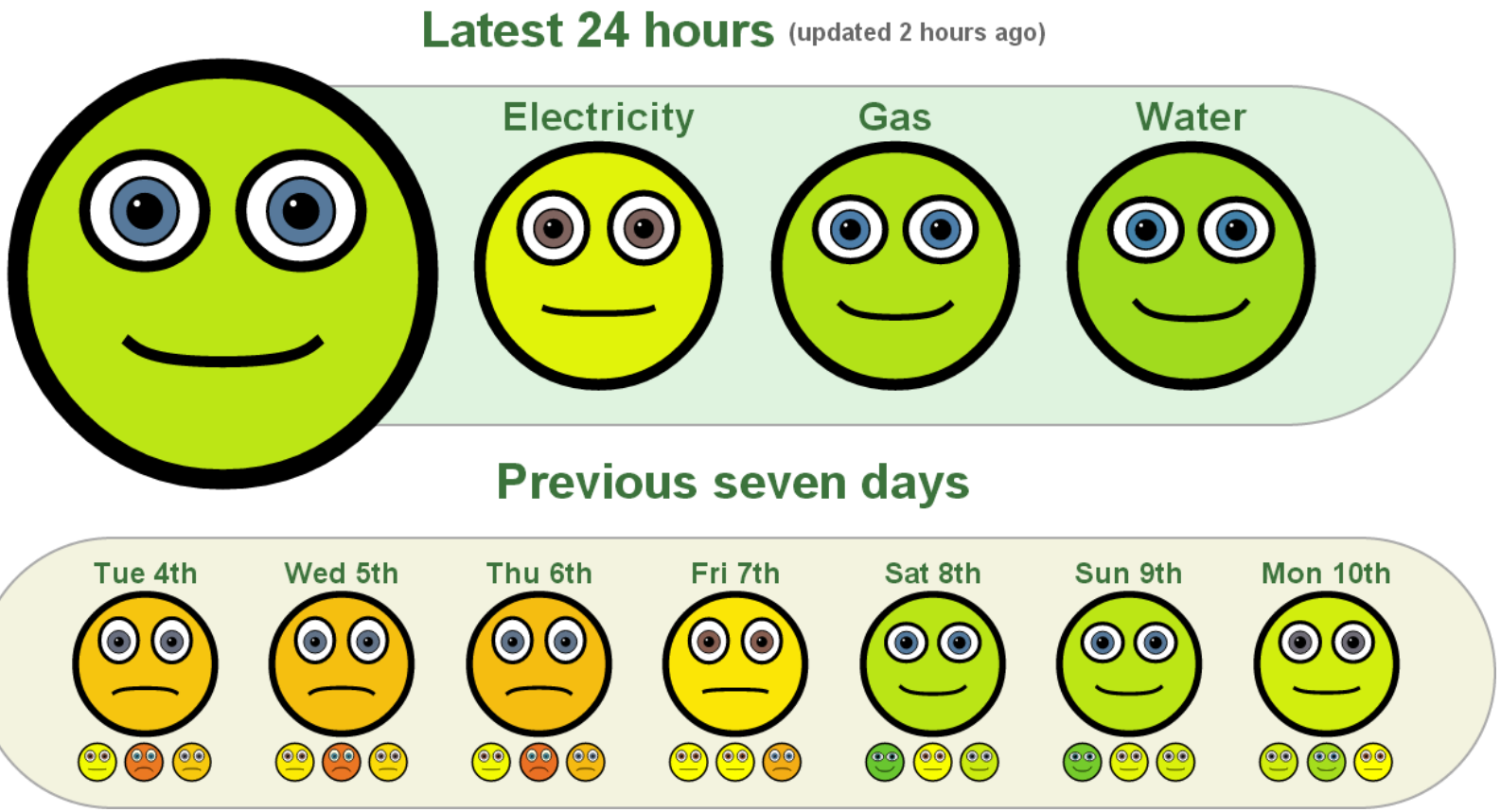
A unitless performance indicator



- Take the latest week and the previous 12 months of data
- Build a baseline model from the first 12 months
- Forecast consumption into the latest week using the baseline model
- Calculate the value of each forecast residual as a percentile of the baseline residuals

A unitless performance indicator

[redacted] energy and water performance



Building energy performance → Visualisation → User awareness

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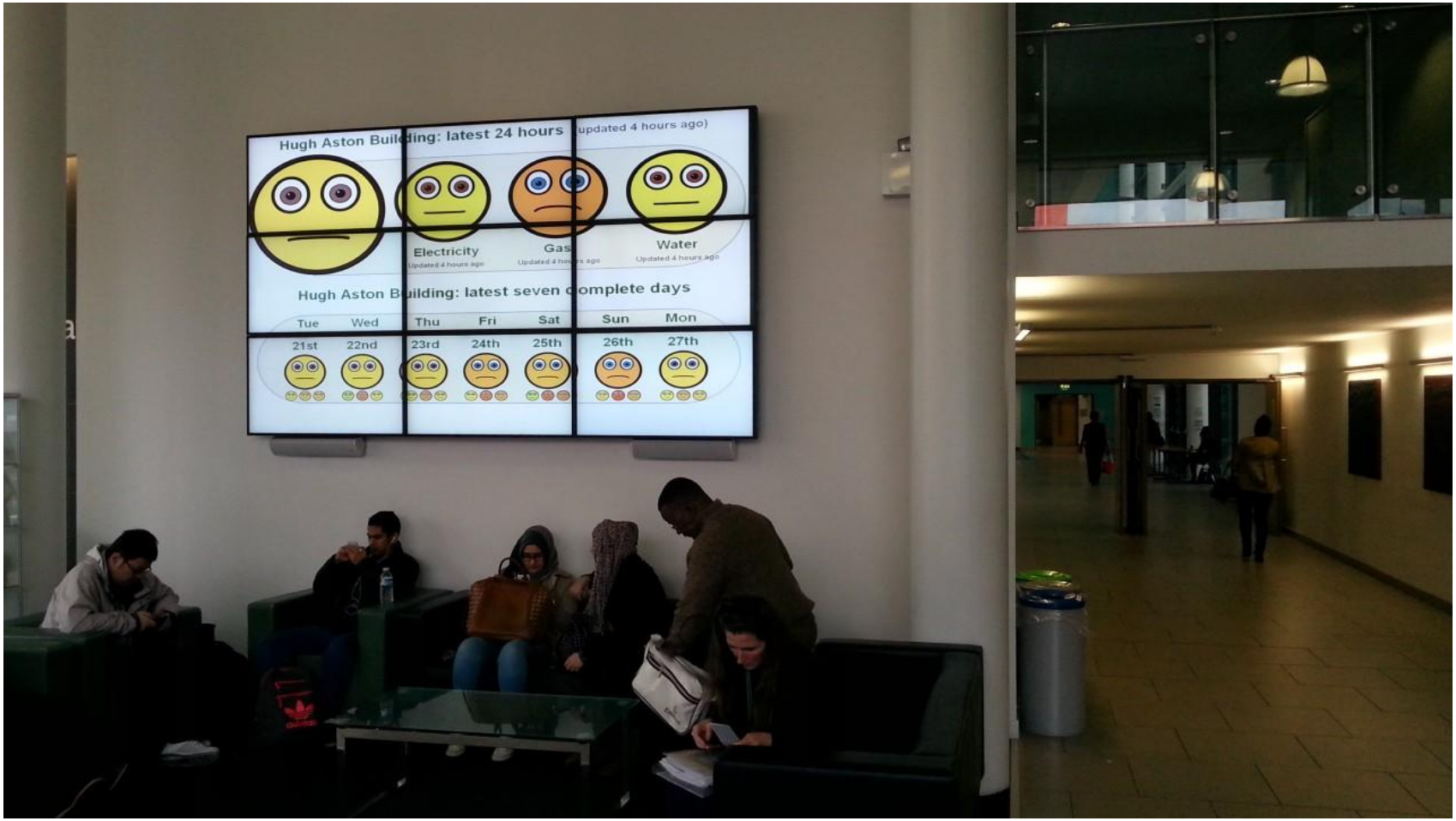
Live, half-hourly feedback



Building energy performance → Visualisation → User awareness

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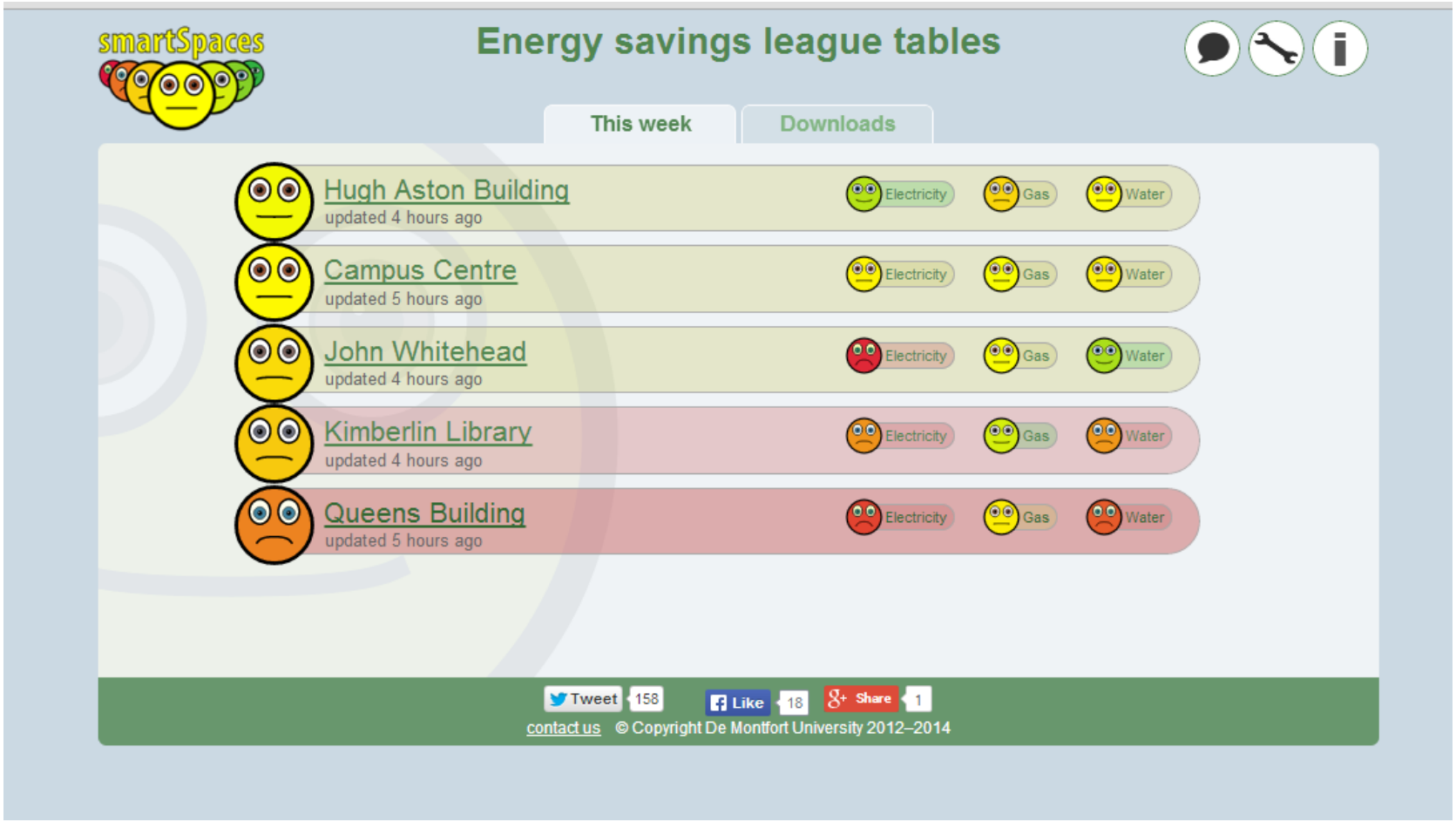
Comparable across buildings



Building energy performance → Visualisation → User awareness

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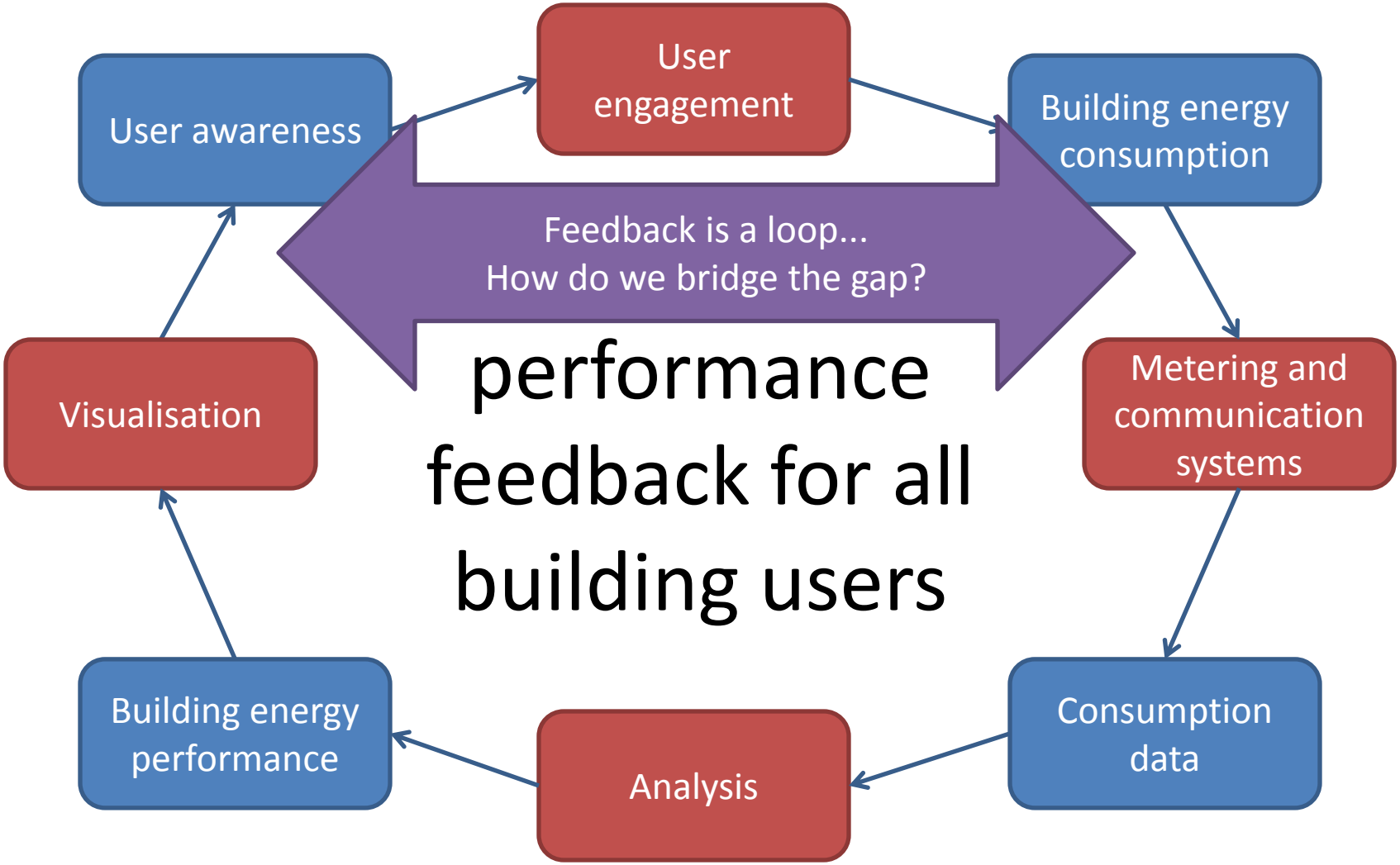
Remember the vision?



www.discourse.org

- A public knowledge base for energy efficiency
  - in simple, linked conversations
- Building users can communicate with energy professionals
  - report faults
  - ask for guidance
  - share best practice
  - coordinate collective action
- Bridges the gap, closes the loop
  - makes the connection between smiley faces and concrete actions

forum.smartspaces.dmu.ac.uk

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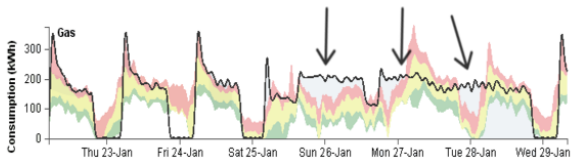
DMU buildings | Queens Building

Queens heating system

3 28 Jan

ggstuart
smartspaces Benevolent Dictator for Life

This is the Queen Building heating over the last few days. It looks like the heating was on constantly for three days (even overnight).



It seems the control has returned to normal. I wonder what happened?

I know the Queens building is often cold in the mornings (especially Monday mornings) but surely heating overnight and all weekend is not necessary?

Does anyone have any comfort issues in the Queens building? It would be useful to collect some reliable information on this.

Created	Last post	Posts	Views	Users	Links
28 Jan	21 Feb	6	183	4	2

12 Feb ← Queen's building temperature

snapey

I find my office becomes too hot fairly quickly (1.11)

I am also interested in where the new fan heaters show up in the stats. I presume they will introduce a new small but fairly constant electrical load - if so it doesn't seem significant. I would say that I am amazed they were installed. They are ugly, noisy, don't seem to achieve very much and seem to be at odds with our green policies. Are they controlled by a central BMS? Or just locally on a thermostat?

3 of 6

User awareness → User engagement → Building energy consumption

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