Smart energy performance indicators
for live historical and normative feedback systems

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• 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
The raw data carry lots of information

For most people, energy is not an important issue. It takes too much effort to interpret this. Normal people don’t like graphs anyway.

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

This is all the raw material necessary for the analysis that follows.
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
- 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?
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

Hugh Aston - gas

Queens - gas

Kimberlin Library - gas

Campus Centre - gas
Electricity consumption baselines

- Hugh Aston - electricity
- Queens - electricity
- Kimberlin Library - electricity
- Campus Centre - electricity
So what is ‘normal’?

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

10th – 25th = “good zone”
25th – 75th = “neutral zone”
75th – 90th = “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.
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

- Create baseline model
  - Includes residuals for each HH period in baseline

- Assess current consumption
  - Each data point includes
    - Temperature -> Prediction (baseline forecast)
    - Actual consumption -> Residual (from baseline)
  - Calculate residual as a percentile of baseline residuals
A unitless performance indicator

energy and water performance

Latest 24 hours (updated 2 hours ago)

Previous seven days

http://smartsaces.dmu.ac.uk
Live, half-hourly feedback

http://smartspaces.dmu.ac.uk
Comparable across buildings

http://smartspaces.dmu.ac.uk
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