UNIVERSITY OF BATH

How could big smart grid and smart metering data reduce our energy bills?

Professor Furong Li

Chair in Electrical Power Systems

11th November (1111) 2014

?

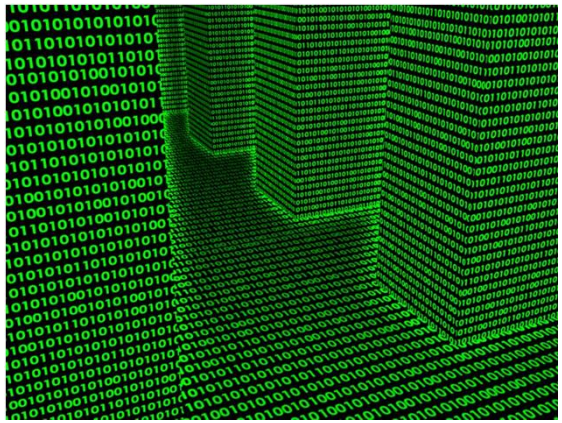
Big Data Facts

90% of the world data were generated in the past 2 years

£1 trillion invested on data related research

54% of data resources could not be identified or verified

80% of datasets are lost after 20 years

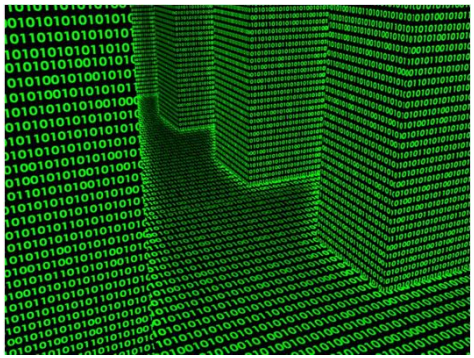


Big Data in Smart Grid

This is more so for the electrical supply system

£200bn

£19bn



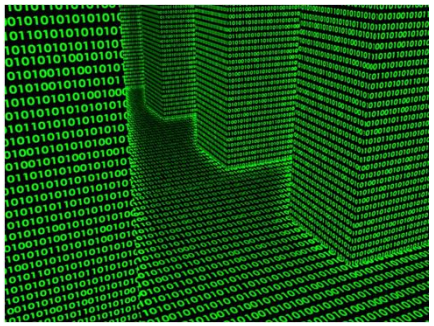
What are they for?

What does this mean to our energy bills?

Value in Big Data

Understanding others is intelligence

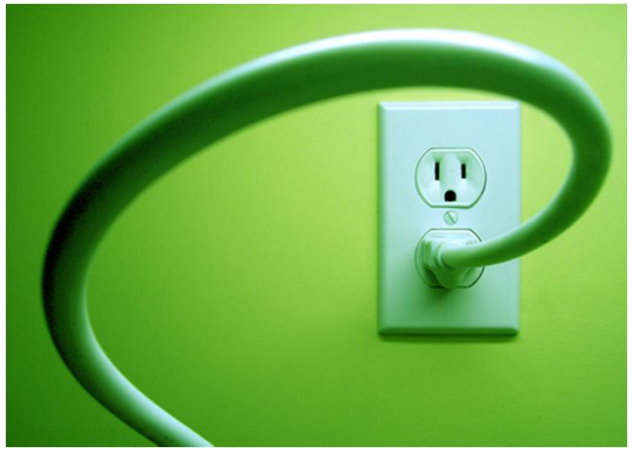
Understanding self is wisdom



Cheap, fair and transparent bills

知人者智, 知己者明

Where Electricity Comes From?



Behind the wall?

From Power Station?

WESTERN POWER DISTRIBUTION
Serving the South West and Wales

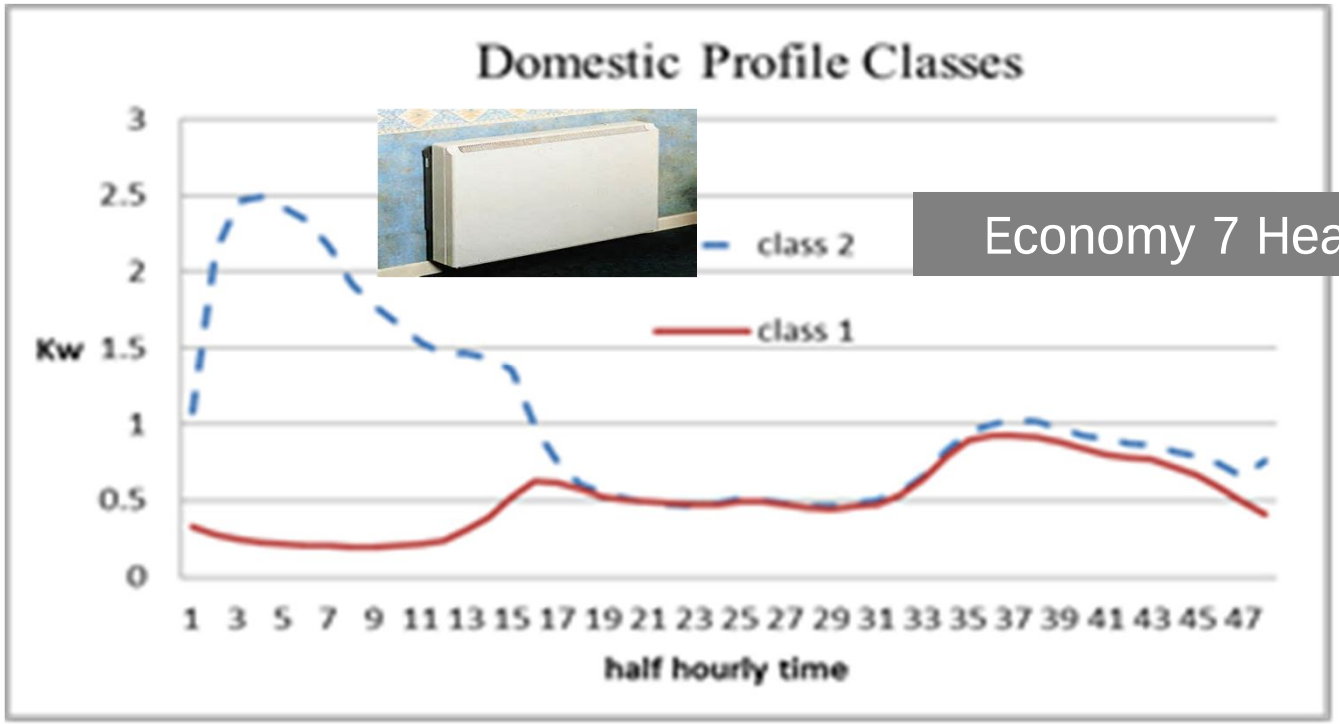
? or

npower

?

nationalgrid ?

What the Grid Knows About Us



Economy 7 Heater

Consumers are differentiated only by technology

98% mass consumers are assumed to be the same

What Grid Knows About Themselves

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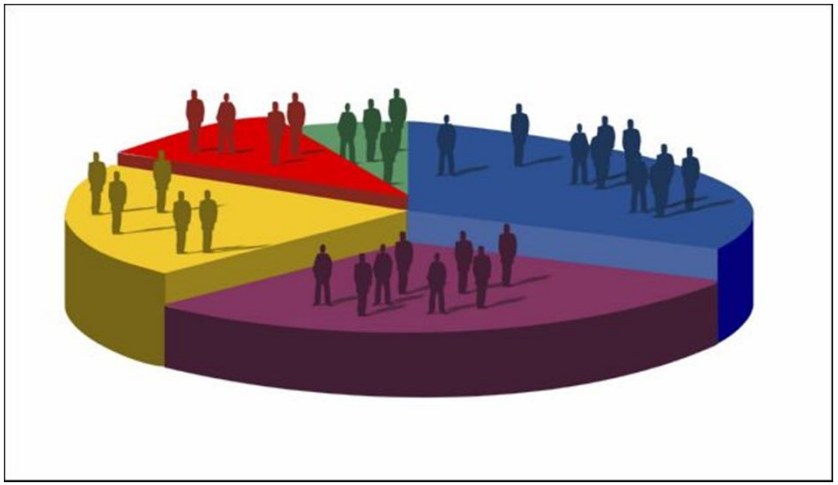
Last Mile: 1 million Low Voltage substations, 27 million households

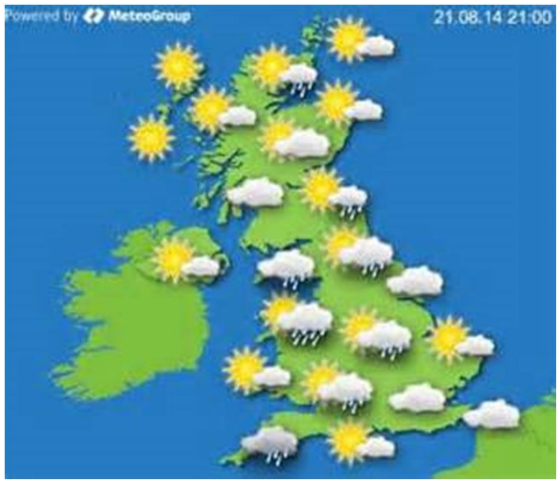
Account Number: 1234 5678 100
For period: 9/03/09 to 01/07/09

Balance on your account before this new bill	£0.00
Your gas charges	£153.67
Your electricity charges	£137.24
Other charges	-£10.62
Discounts	-£2.87
VAT	£13.87
Your total now due is	**£291.29**

Value in Smart Grid Big Data



Energy Usage Habits/Demographics



Weather

Condition of the supply System

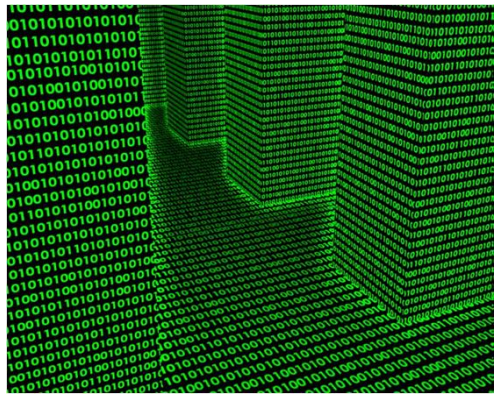
Economy

Measures to Reduce Electricity Bills

3000kWh/yr x 17pence/kWh = **£500/yr**

Energy Efficiency

Lifestyle Change



Topics

Electric Supply System

History of Supply

Big Data for Supply Efficiency

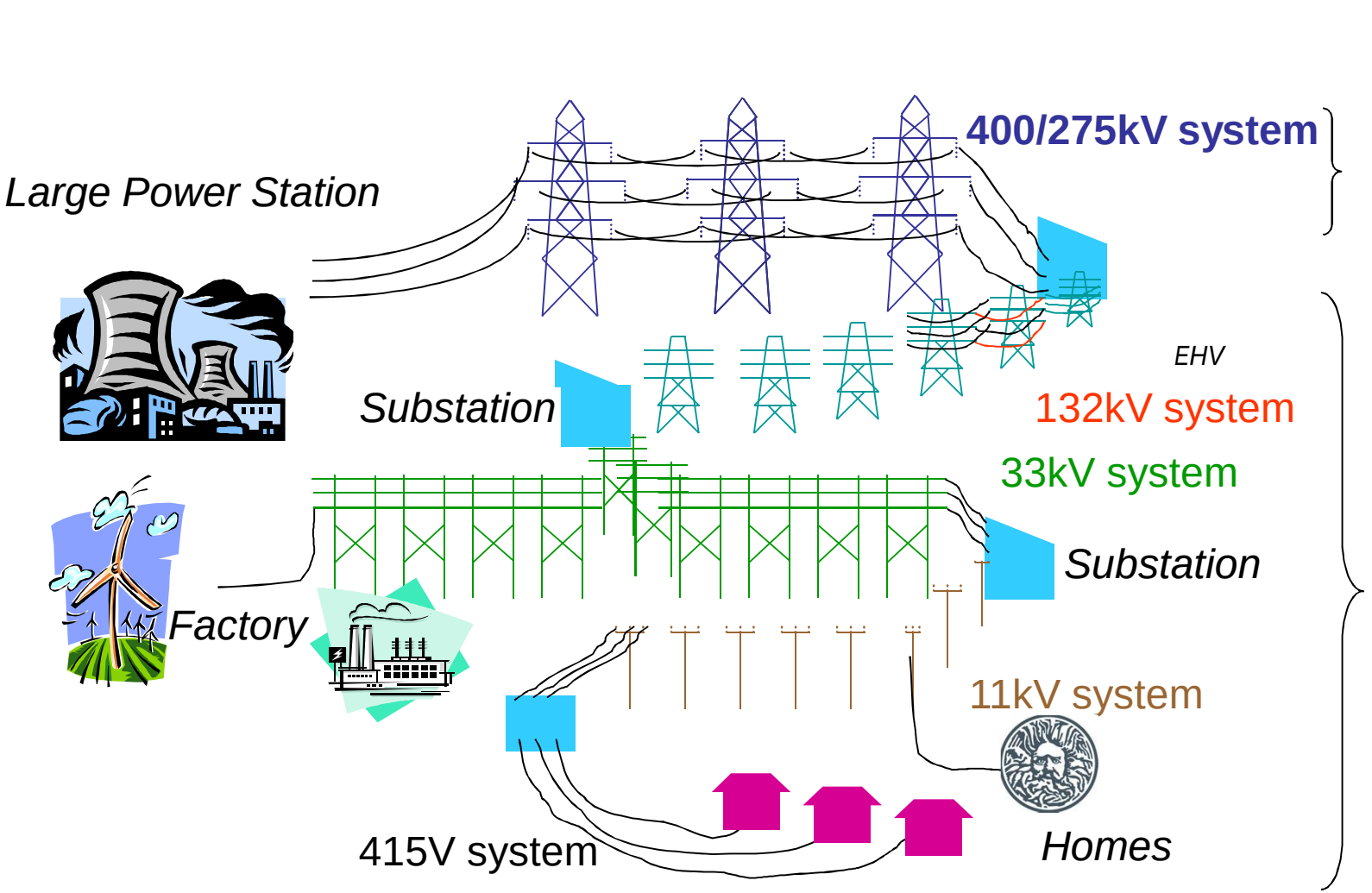
Topics

Electric Supply System

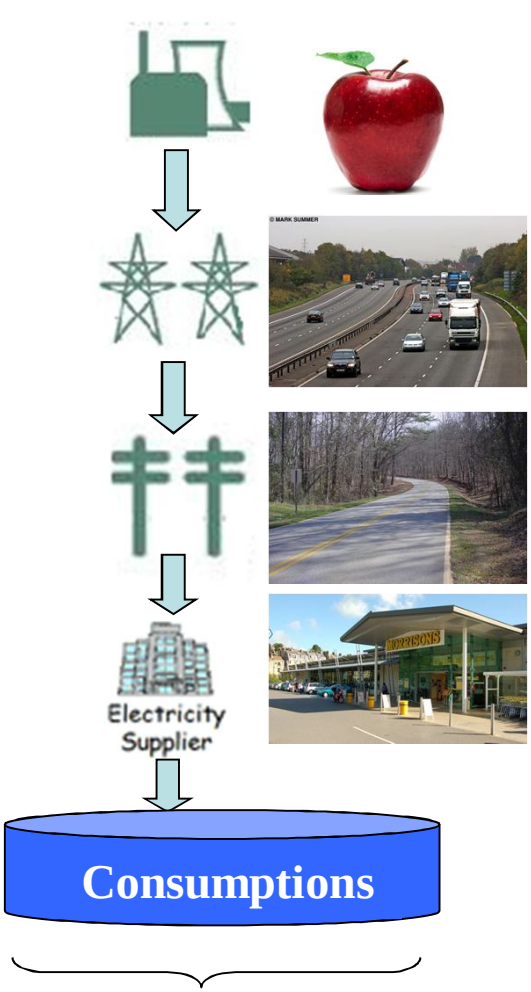
History of Supply

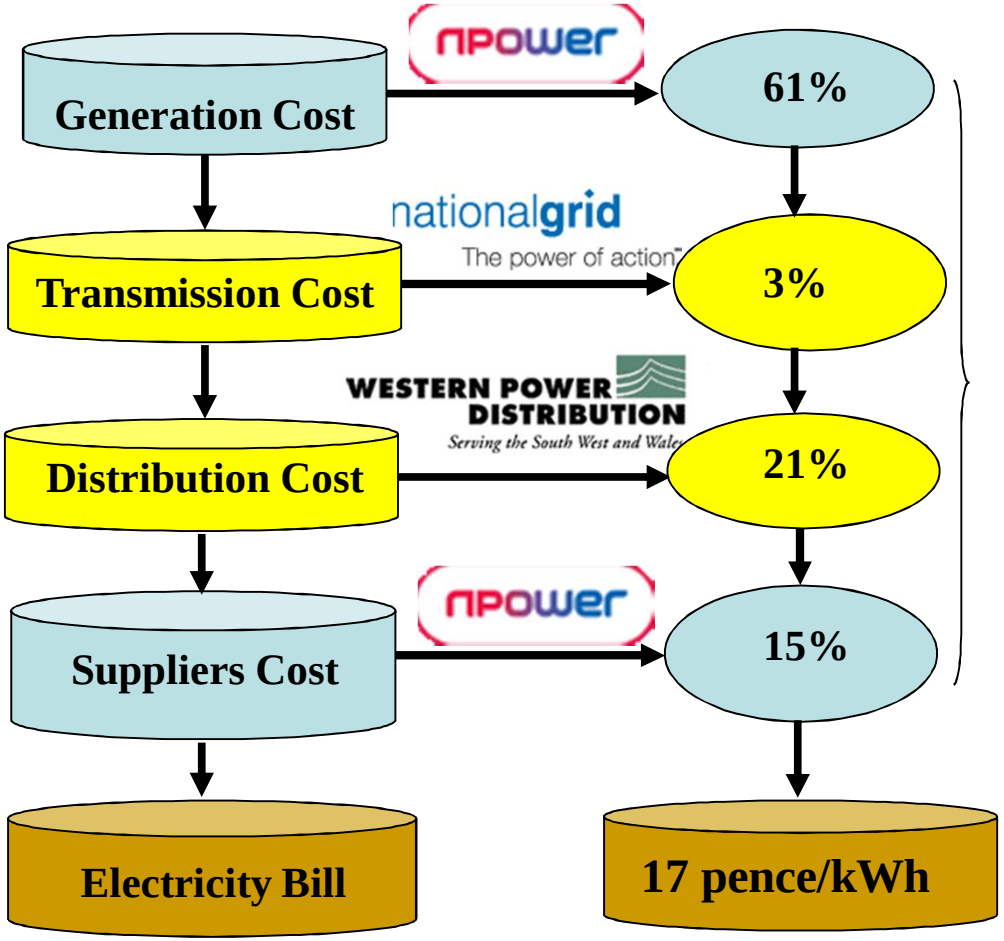
Big Data for Supply Efficiency

Electric Supply Chain



Cost Breakdown of Our Electricity Bill





Our Annual Electricity Consumptions

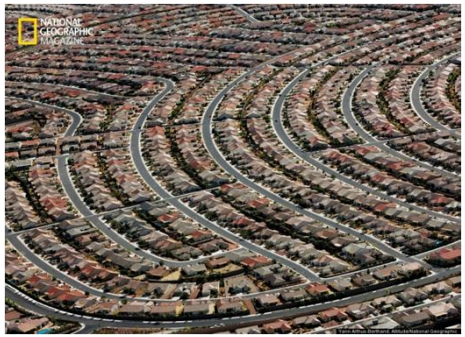
3,000kWh/yr

£500/yr

33000

27, 000, 000 kWh/yr
(27 GWh/yr)

£2.28 million/yr



9000 houses

300, 000, 000,000 kWh/yr
(300TWh/yr)

£32 billion/yr

KWh	10^3
MWh	10^6
GWh	10^6
TWh	10^{12}

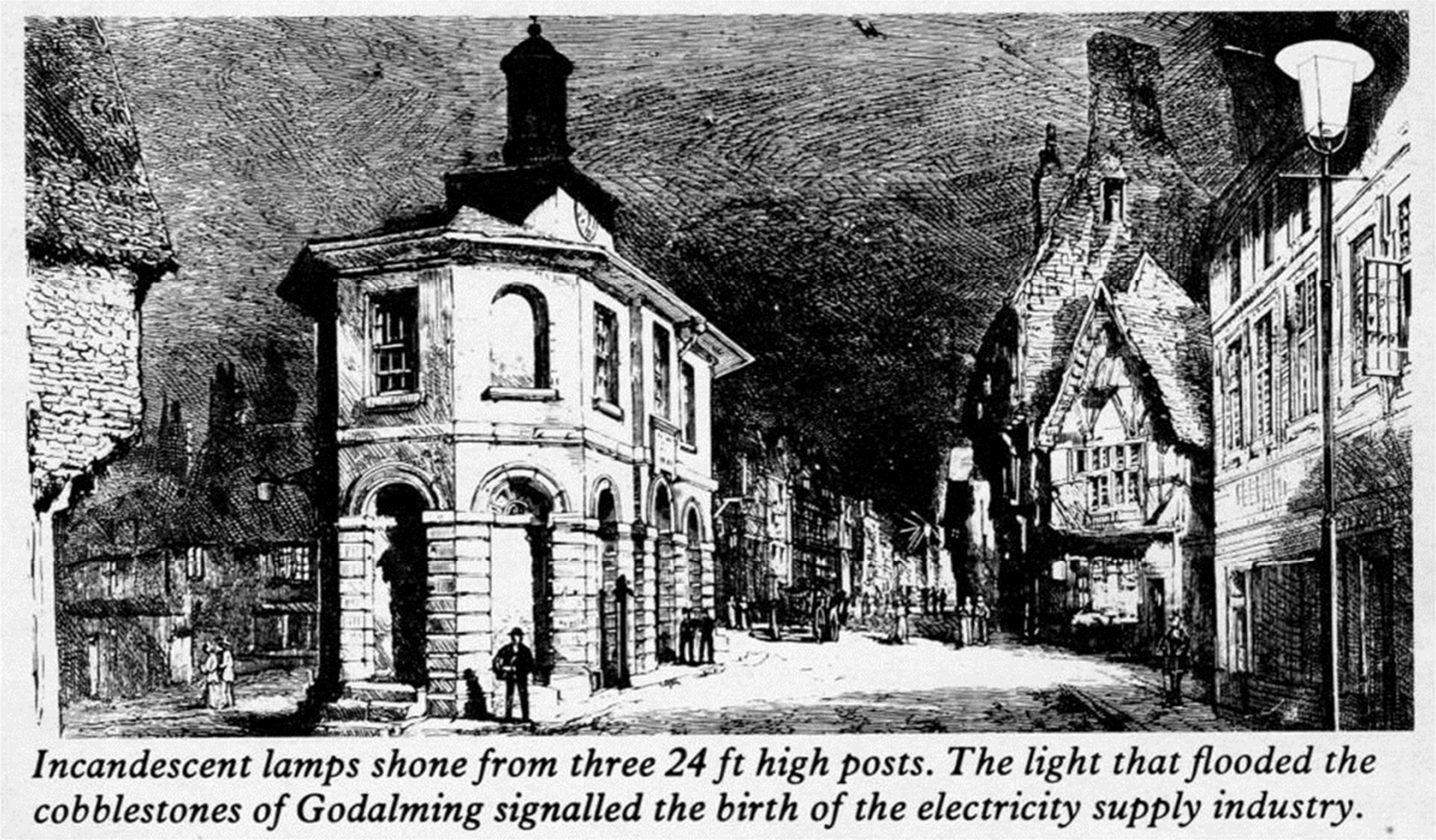
Topics

Electric Supply System

History of Supply

Big Data for Supply Efficiency

First Public Electricity Supply Industry

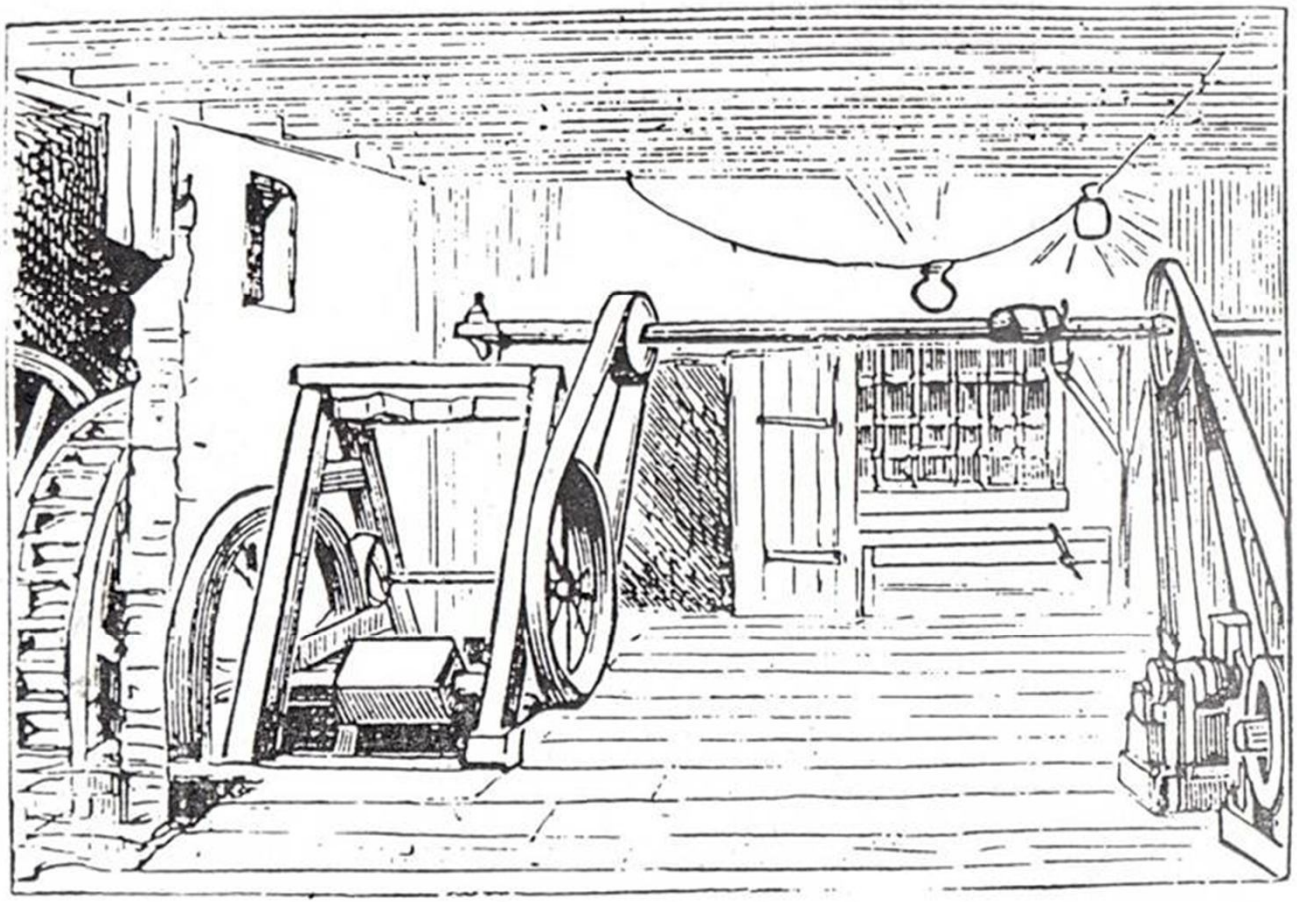


Incandescent lamps shone from three 24 ft high posts. The light that flooded the cobblestones of Godalming signalled the birth of the electricity supply industry.

Street lighting by gas costed £238/yr

Three electric lights installed in October 1881 at £195/yr

First Public Electricity Generation



Generating equipment at the Westbrook Mill, Godalming, from The Graphic *21 November 1881*

Water wheel the power source

Siemens generator converted water power to electricity

Replaced by steam generator, because it was neither adequate nor reliable

Transition was not a Plain Sailing

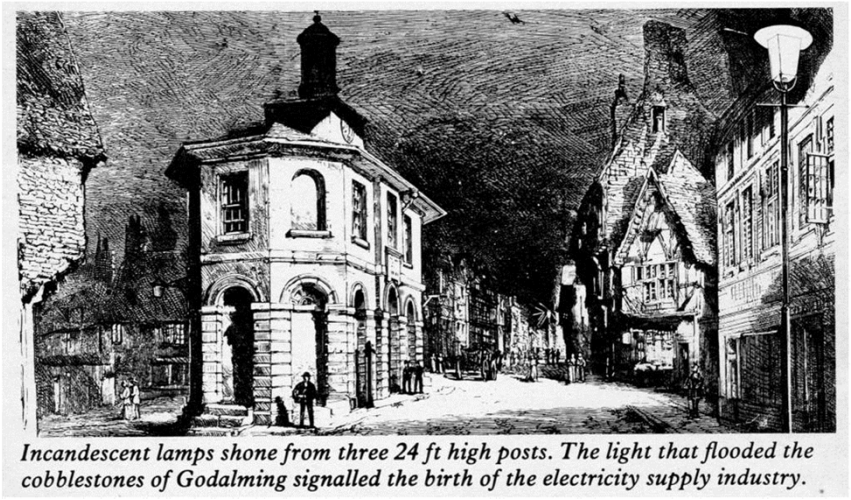
Supply cost very high

Small number of customer

Short duration of supply (6pm-11pm)

Nimby (not in my backyard)

"They cause the houses to vibrate like ships at sea."



Incandescent lamps shone from three 24 ft high posts. The light that flooded the cobblestones of Godalming signalled the birth of the electricity supply industry.

Set Backs

Economics required 400~500 private customers

The lighting company only secured 100

Contract did not renew

Revert to gas lighting in 1884

Chesterfield in Derbyshire 1881-1884

Edison station in London 1882 - 1886

Incandescent lamps shone from three 24 ft high posts. The light that flooded the cobblestones of Godalming signalled the birth of the electricity supply industry.

How did Victorian reintroduced electric supply system back to the society?

Innovations for Supply Efficiency

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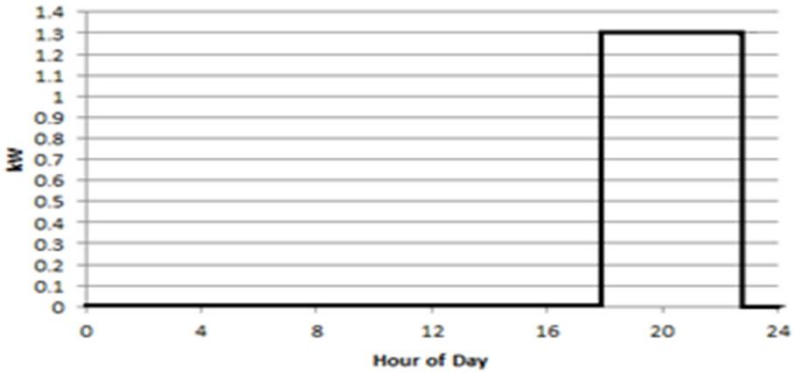
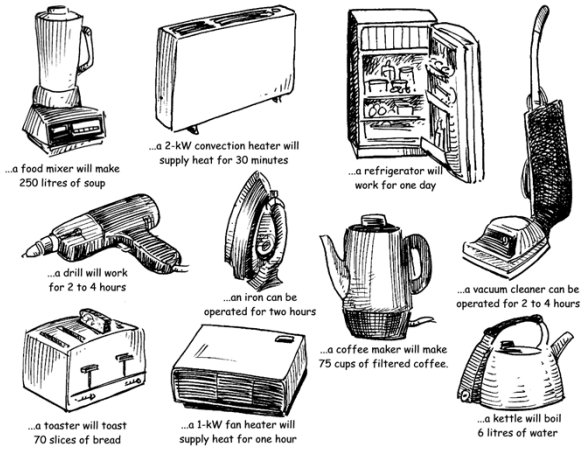
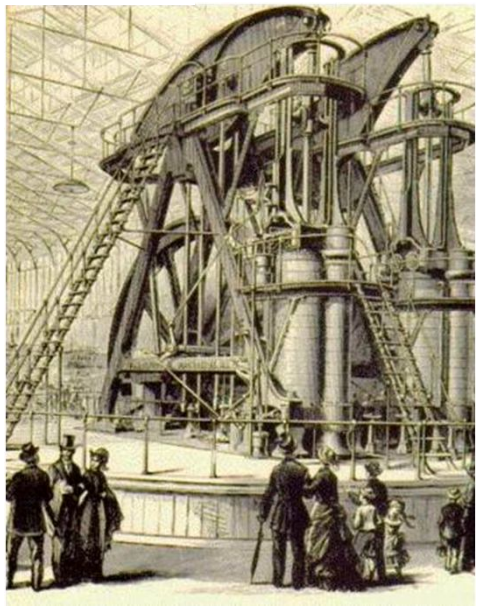
Technical Innovations

Day Time ‘off-peak’ Electric Use



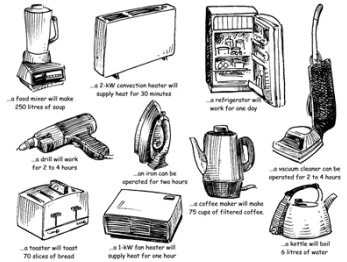
Usage: 6pm-11pm





Innovations for Supply Efficiency

Commercial Innovations



Incentivising electricity use at the right time

Domestic Tariffs in 1916

Lighting	Peak Demand	2 pence/KWh
Heating Cooking	Off-Peak Demand	0.6 pence/KWh
Vehicle charging	Super Off-Peak Demand	0.2 pence/KWh

Topics

Electric Supply System

History of Supply

Big Data for Supply Efficiency

Measures to Reduce Bills

3000kWh/yr	17pence/kWh
Reducing quantity	Reducing supply cost

Energy Efficiency

Lifestyle Change

Supply Efficiency

Big Data for Supply Efficiency

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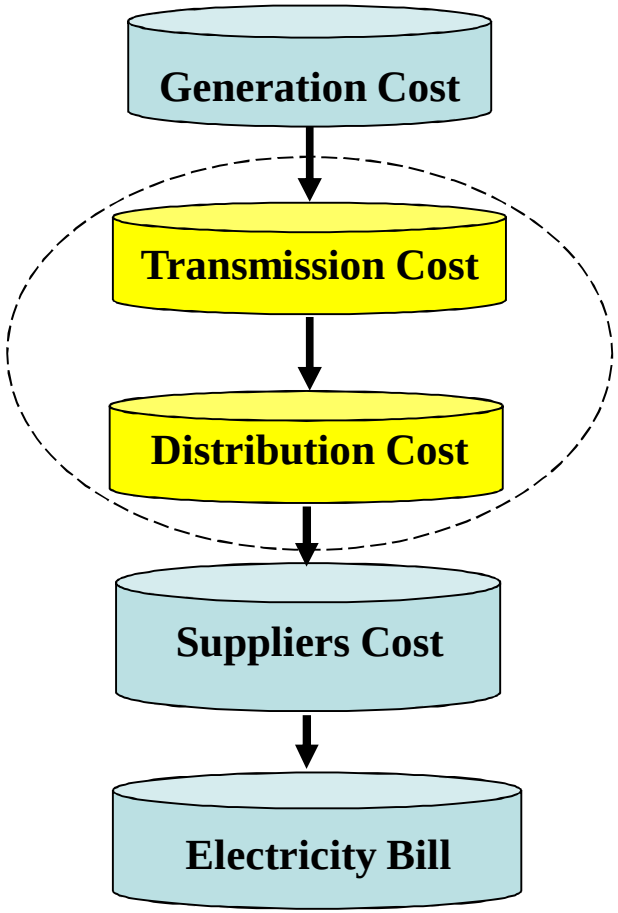
1. Innovations in generation development

2. Innovations in network development

3. Innovations in supply

4. Innovations in consumptions

Big Data for Supply Efficiency

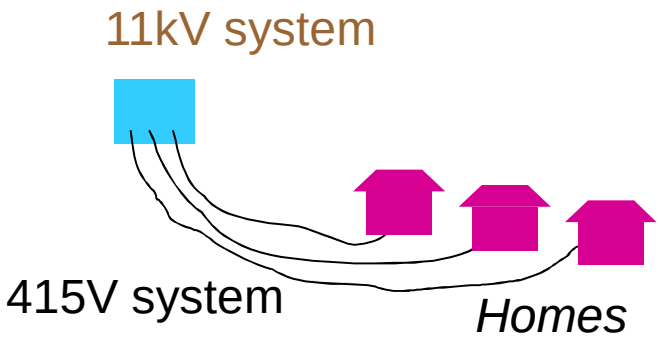


2. Innovations in network development

Old

Inefficient

Low Visibility - Where is the Trough?



1,000,000 LV Substations

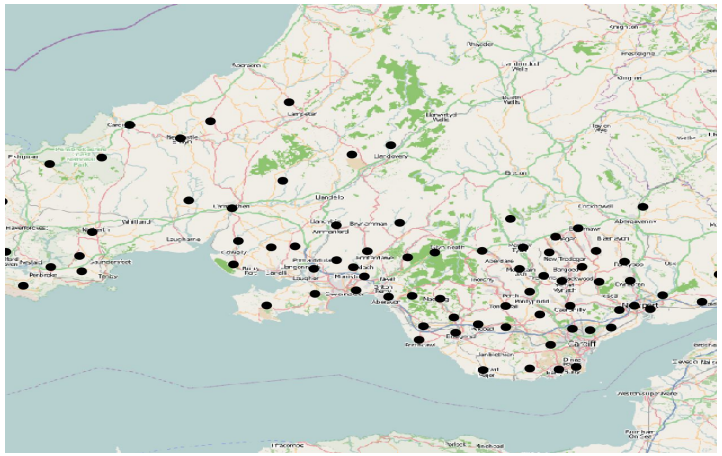
£2,000 for Each Monitoring

£2 Billions for full visibility

From Big Data to Smart Data

UNIVERSITY OF BATH

Low Voltage Network Templates - £32m



800 HV/ LV substations
Less than 1%

1. *Do we need to monitor every single substation?*
2. *Are there common patterns?*
3. *Can we use the common patterns to estimate a substation load without expensive monitoring*

Gu, Li (R), Yan, Zhao,
Martin, Shaddick, Walker

npower
An RWE company
WESTERN POWER DISTRIBUTION
Serving the South West and Wales
ofgem

From Big Data to Smart Data

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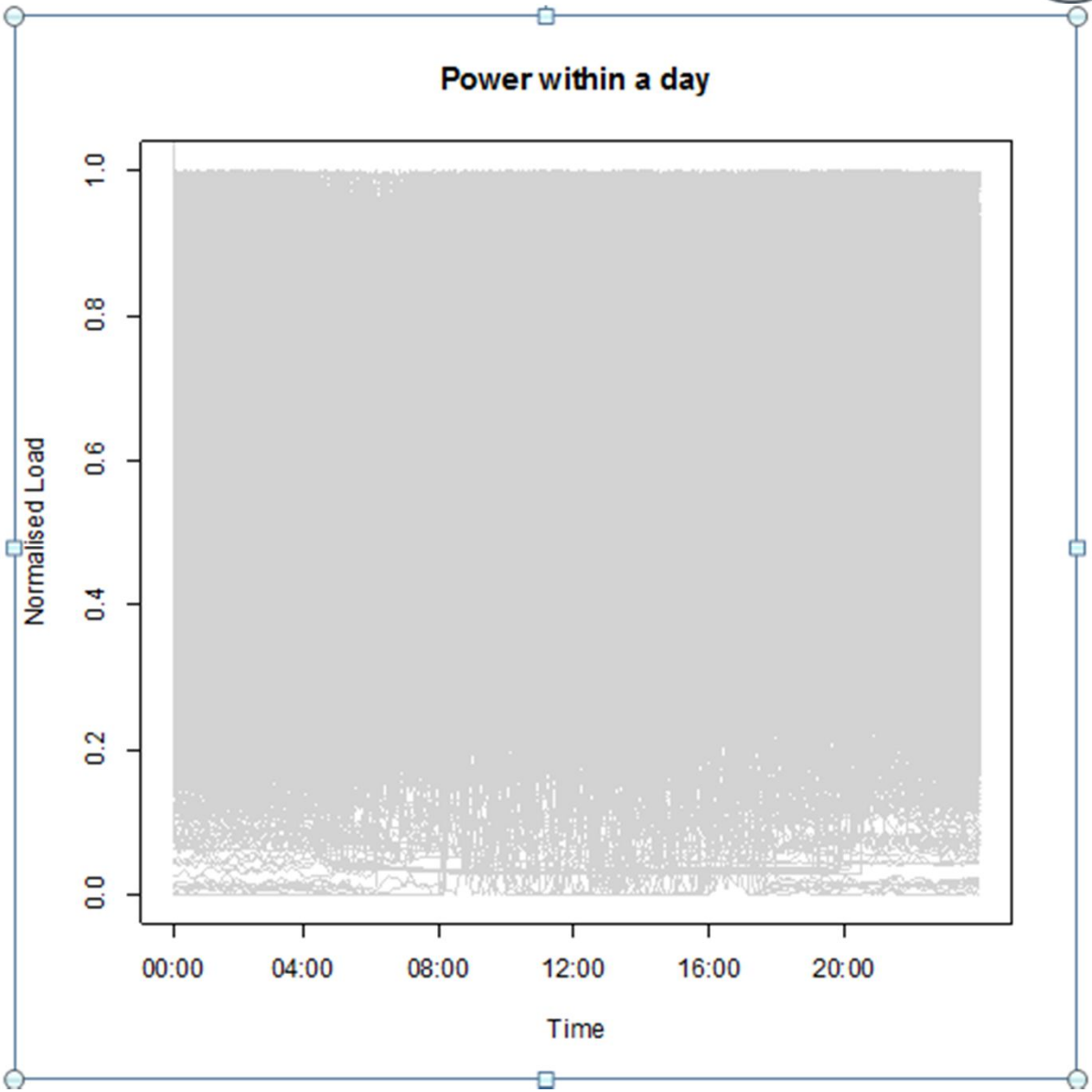

Time-Series Clustering Analysis

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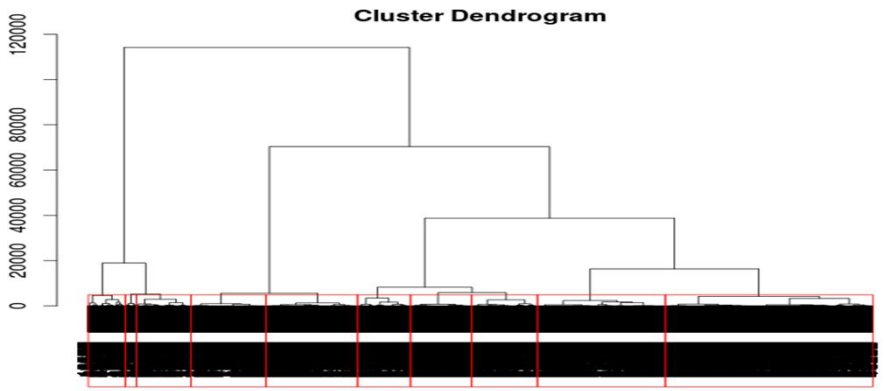
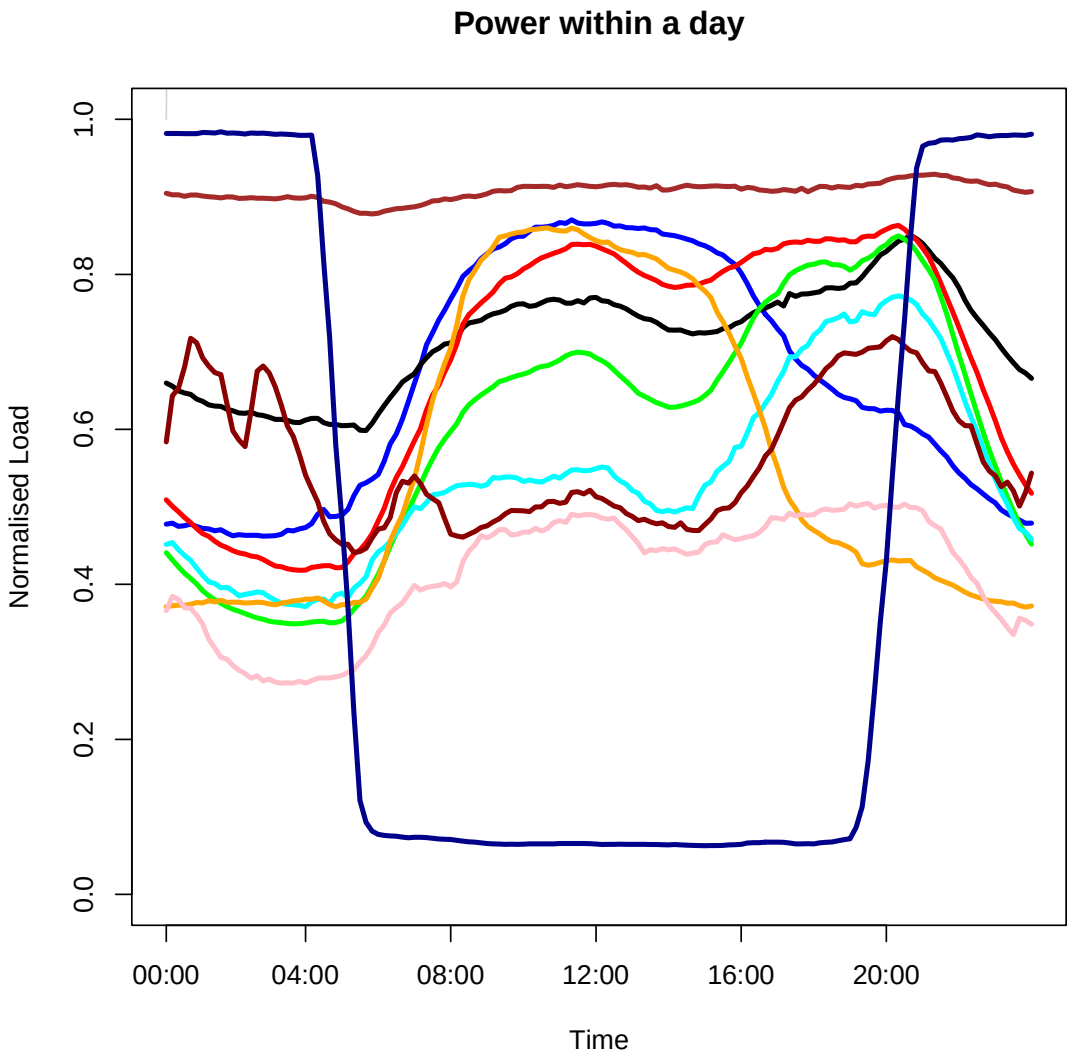
Aim: To reduce within-group variations

Solution: Increasing the number of load profiles

Methods: Statistical Clustering
- Create groupings within data
- Objects within a cluster are more similar than those in between clusters



From Big Data to Smart Data

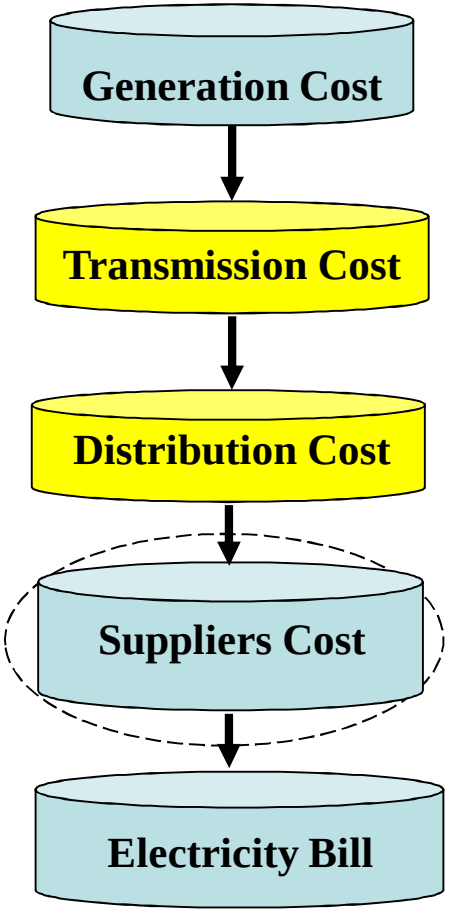


Estimating un-monitored substation achieved 85% accuracy

£32m at 85%

£2bn at 100%

Big Data for Supply Efficiency



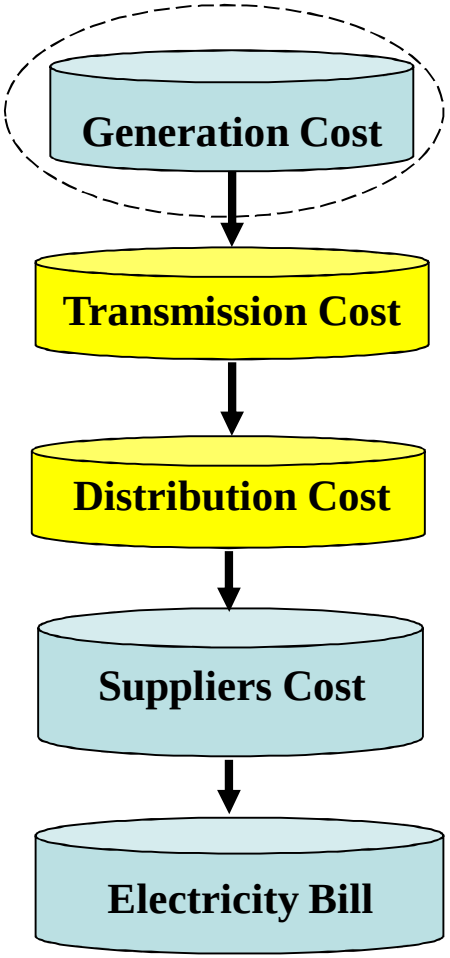
4. Innovations in supply

Status Quo - Retailers

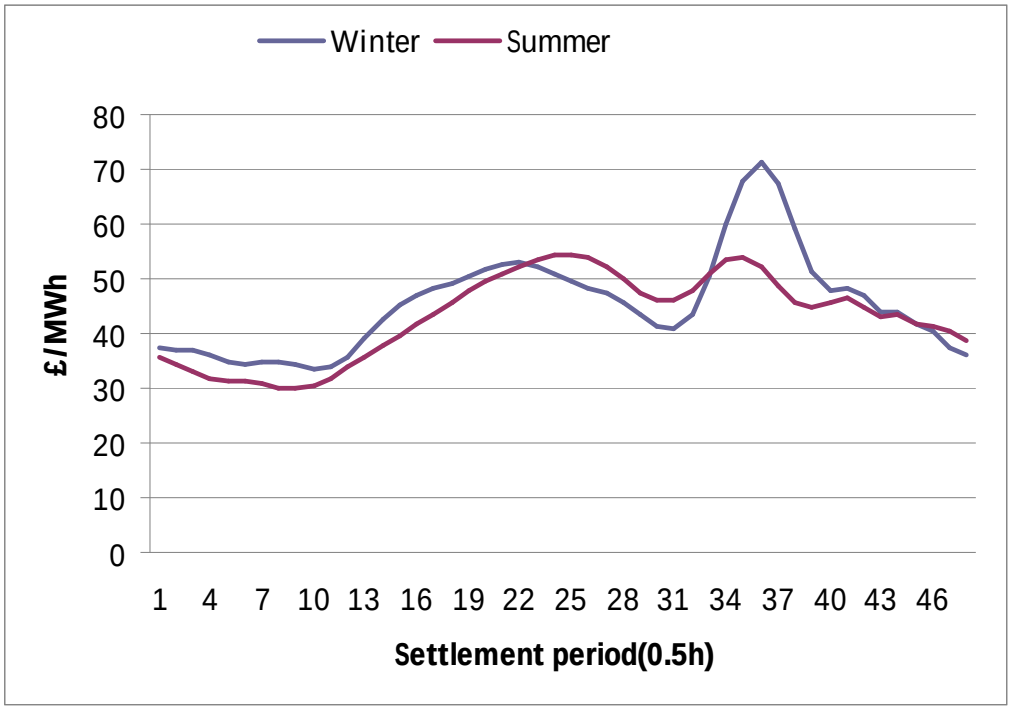
3000kWh/yr **x** 17pence/kWh **=** **£500/yr**

17 pence/kWh

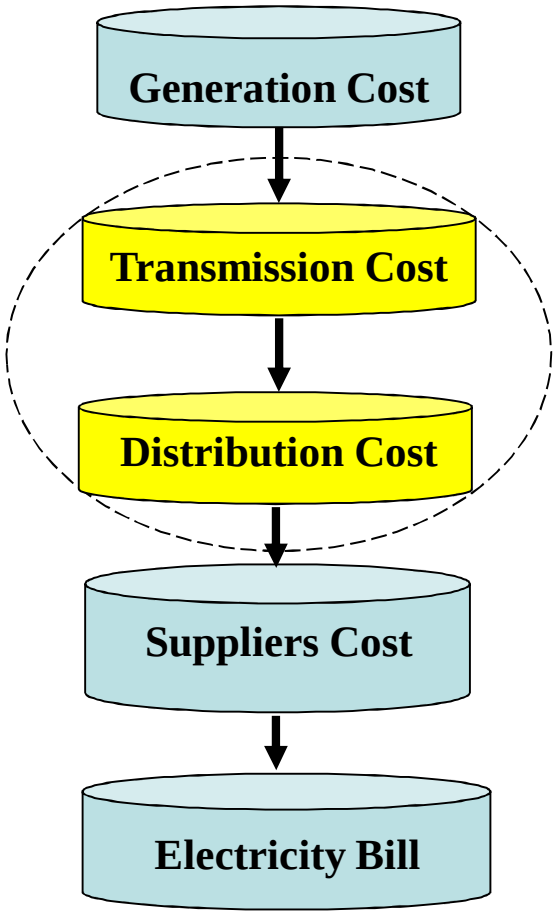
Price Variations in Generation



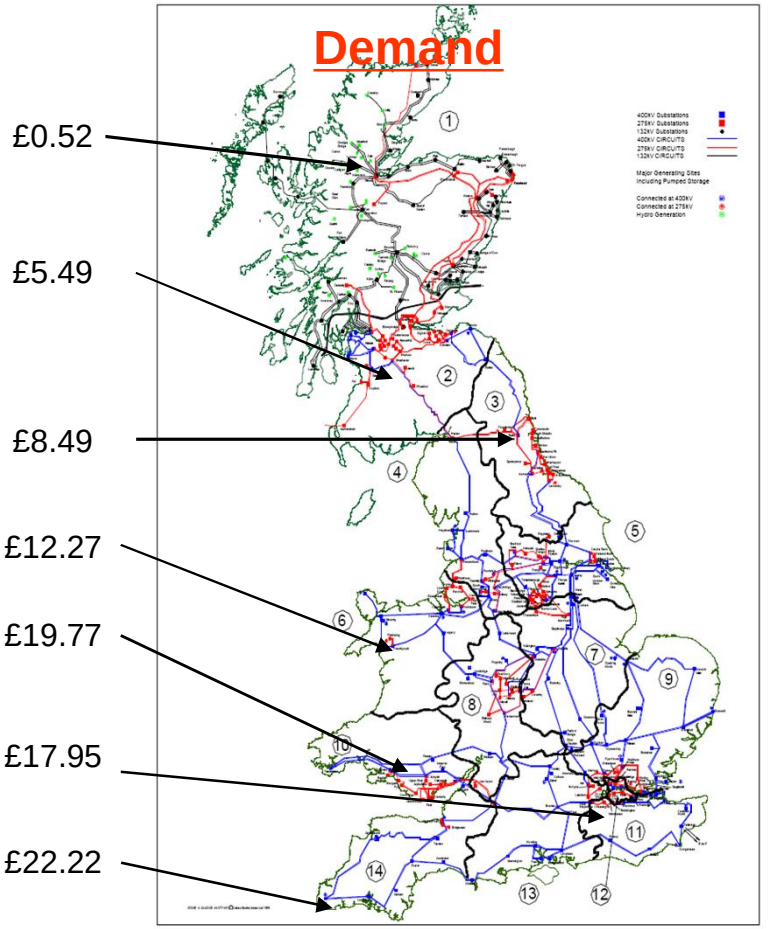
Vary with time



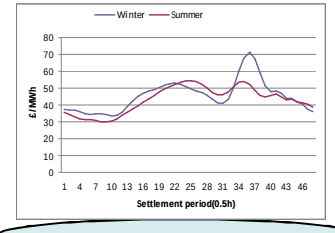
Price Variations in Networks



Vary with location



Tariffs for Domestic Consumers in 2012



Generation Cost

Transmission Cost

Distribution Cost

Filter out market information

Suppliers Cost

Electricity Bill

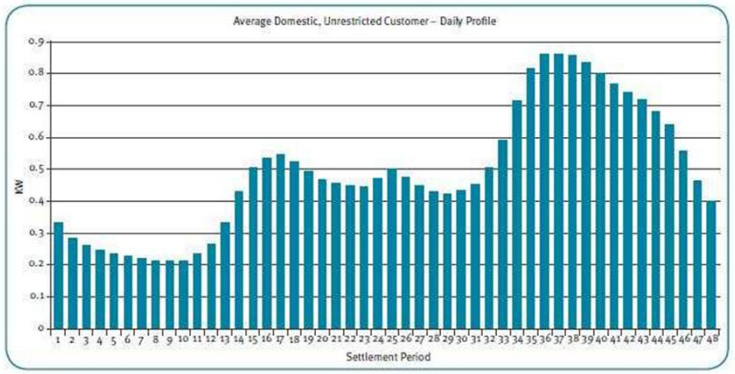
Domestic Consumers	17 pence/KWh

One-Rate Not Incentivise Change

3000kWh/yr **x** 17pence/kWh **=** **£500/yr**

No incentives for mass consumers to move to energy efficient ***behaviours***

One-Rate not Cost-reflective



Do not differentiate energy behaviours and their impact on the grid

From Big Data to Smart Data

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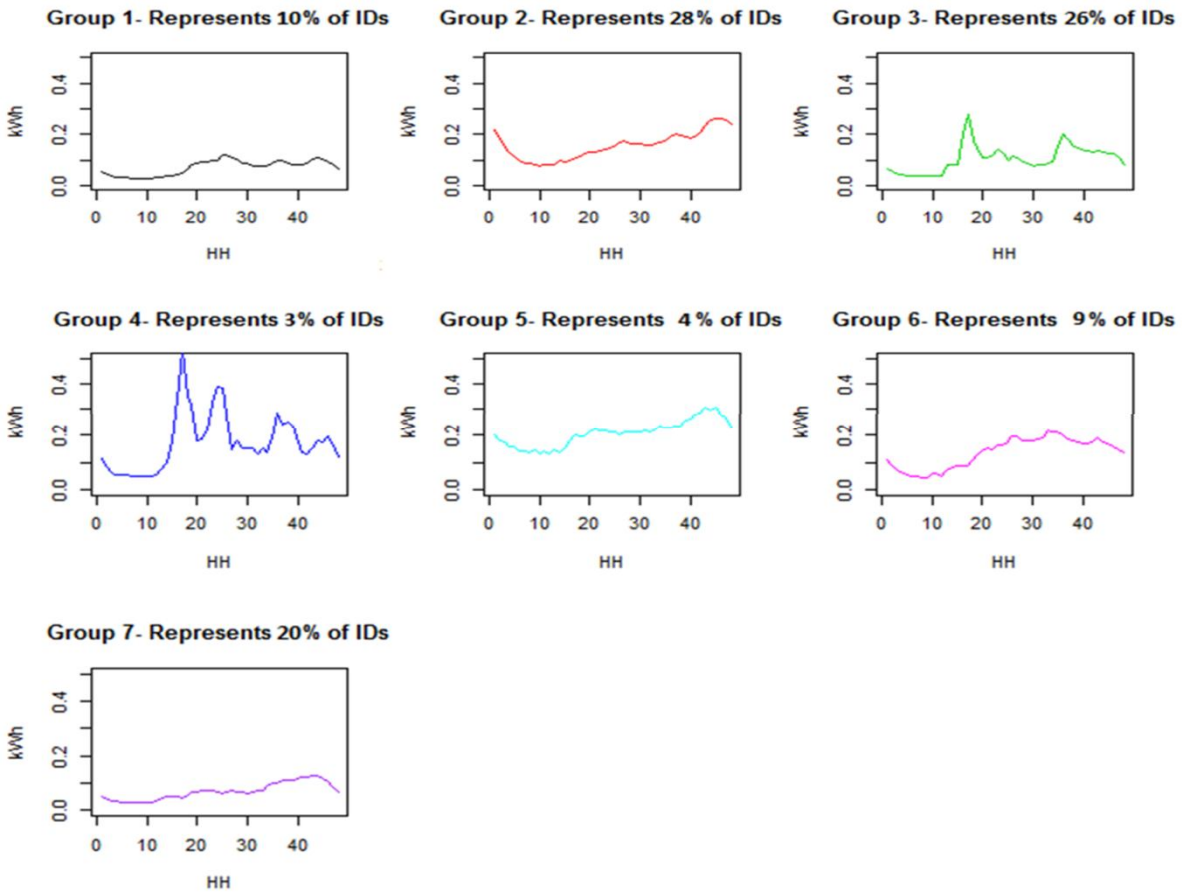
Representative load profiles based on 7 cluster groups



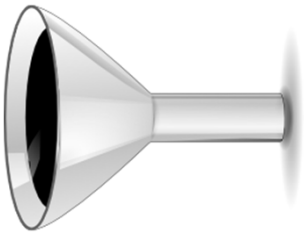
Role of Retailers

Charge consumer fairly
- *energy behaviours*
- *their impacts on the grid*

Remove cross-subsidies

Incentivise more responsive consumer behaviour

Role of Retailers



Filter through market some information

Big Data in Smart Grid

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Understanding others is intelligence
Understanding self is wisdom

Understand consumer ***energy behaviour***

Understand the ***impact*** to the grid from ***energy behaviours***

Understand the link between behavior and the grid to set ***incentives***

Class Calculator

Class Calculator

UNIVERSITY OF BATH

The Great British class calculator: What class are you?

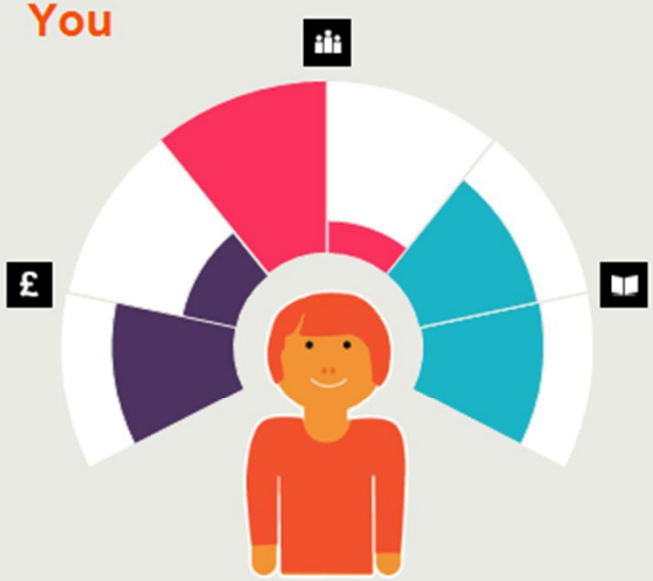
Middle class? | Class calculator | US view | Reader reactions | 'Huge survey' | The results | The methodology | Reliable results?

Traditional British social divisions of upper, middle and working class seem out of date in the 21st Century, no longer reflecting modern occupations or lifestyles.

The BBC teamed up with sociologists from leading universities to analyse the modern British class system. They surveyed more than 161,000 people and came up with a new model made up of seven groups. To find out where you fit in use this calculator below.

Economic £ | Social | Cultural | Your result ✓

You



Coloured wedges represent your details, select icons to find out more.

Result: the class group you most closely match is:

Technical middle class

This is a small, distinctive and prosperous new class group. According to the Great British Class Survey results, lots of people in this group:

- Mix socially with people similar to themselves
- Work in research, science and technical fields
- Enjoy emerging culture such as going to the gym and using social media

Reset

Share your result Share

Select the categories below to explore the class groups

Bless Kuri

Ji Wang

Vandad Hamidi

Girish Pudaruth

Bo Li

Hui Yi Heng

Chenghong Gu

Edwin Matlotse

Yan Zhang

Sterren Latsky

Andrew Issacs

Chenchen Yuan

Fan Yi

Zhanghua

Hidayat

Ran Li

Zhimin Wang

Jiangtao Li

Lin Zhou

Chen Zhao

Zhipeng Zhang