REHVA

Budapest University of Technology and Economics

Federation of European Heating, Ventilation and Air-conditioning Associations

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Energy saving of HVAC system with continuous monitoring

iSERV CMB

Supported by INTELLIGENT ENERGY EUROPE

REHVA Seminar, Aqua-Therm, Praha, 5 March, 2014

Acknowledgements

iSERV Inspection of HVAC systems through continuous monitoring and benchmarking

www.iservcmb.info

Co-ordinator: Prof. Ian Knight

Cardiff University, UK

2012 - 2014

iSERV CMB

Supported by INTELLIGENT ENERGY EUROPE

iSERV Partners and Steering Group

Welsh School of Architecture, Cardiff University Building energy use experts	CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD	**K2n Ltd** Energy database experts	
MacWhirter Ltd Installation, Maintenance and Energy Inspections	MacWhirter	**National and Kapodistrian University of Athens** Indoor Air Quality experts	
University of Porto HVAC and Engineering experts	U.PORTO FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO	**Politecnico di Torino** HVAC and Engineering experts	
Université de Liège HVAC and Modelling experts	Université de Liège	**Univerza v Ljubljani** HVAC and Engineering experts	
University of Pecs HVAC and Engineering experts		**Austrian Energy Agency** Dissemination and Legislation	
REHVA HVAC Professional Body	REHVA	**CIBSE** HVAC Professional Body	CIBSE
SKANSKA Building Developer	SKANSKA	**Camfil Farr** Filter manufacturer	camfil FARR
SWEGON AHU System manufacturer	Swegon		

EU Directives

- Energy Performance of Building Directive
  EPBD 2002/91/EC

- Ecodesign of Energy Using Products Directive
  2009/125/EC

- Energy Labelling Directive 2010/30/EU

- EPBD „recast” 2010/31/EU

- Energy Efficiency Directive EED 2012/27/EC

Outline/Agenda

- Long-term energy savings in buildings
- iSERV process
- Potential savings, results

Why is Europe interested in the energy use of HVAC systems?

Equipment	Electrical consumption as % of total EU 2007 Elec use
Air conditioning units and chillers	0.75
Fans in ventilation systems	3.34
Pumps / circulators	1.81
Space and Hot Water Heating	5.23
TOTAL	**11.13%**

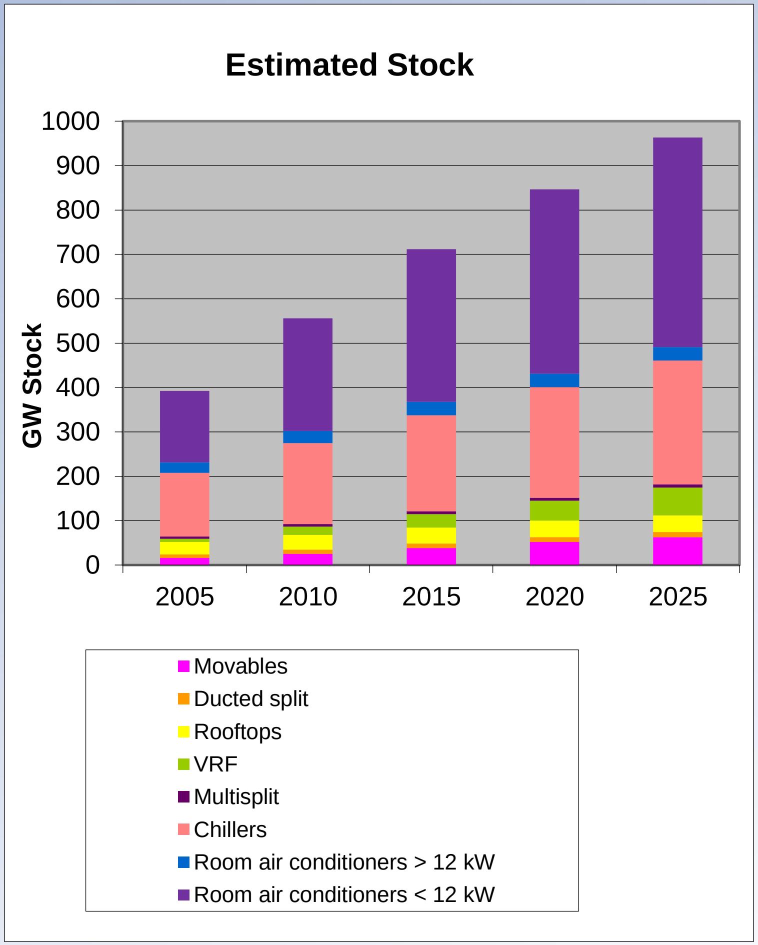
EC Joint Research Centre, Institute for Energy, 2009

At this level of energy consumption, HVAC systems must be a key contributor towards energy savings being sought in the EU

Context: European A/C Market

- European ownership of air conditioning is increasing
- This trend is expected to continue as Europe is currently well below US levels of ownership for similar climates

Reference: Roger Hitchin, Christine Pout, Philippe Riviere "Assessing the market for air conditioning systems in European buildings", Energy and Buildings, Volume 58, March 2013.



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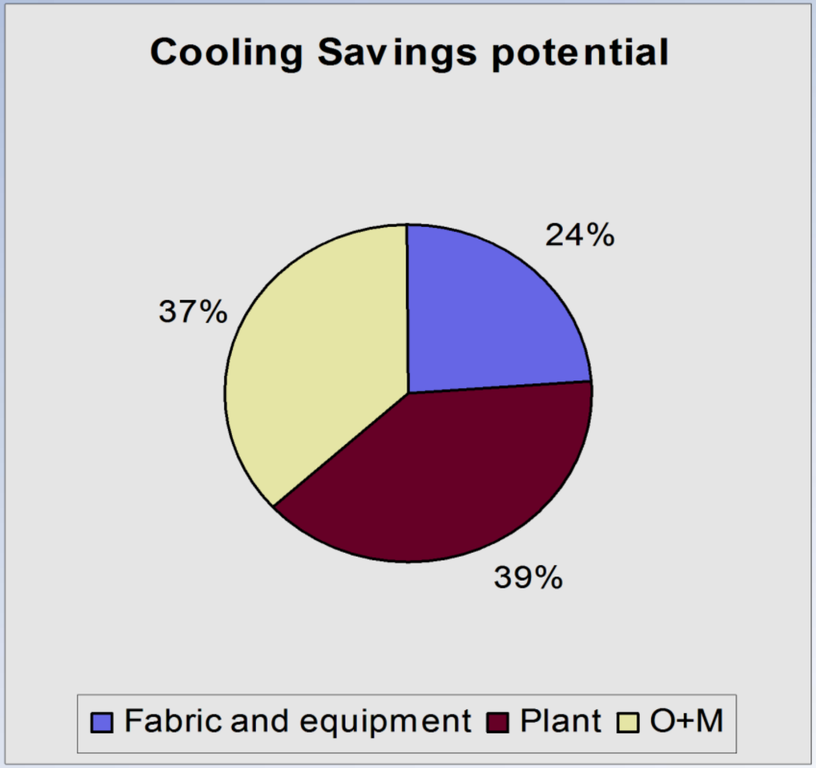
Context: Potential Energy Saving

Potential for savings through:

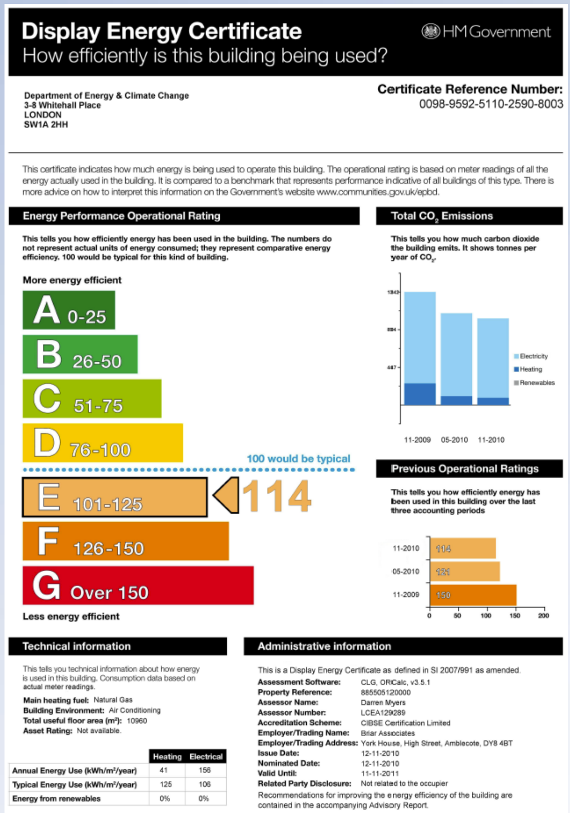
- Load reduction (24%)
- Improved efficiency (39%)
- Better operation (37%)

Source: HarmonAC project results. http://www.harmonac.info/



A 20th Century approach to a 21st Century problem

- Most EU MS Legislation aimed at reducing energy use looks at whole buildings and annual energy use due to the availability of billing meters for most buildings.
- So we know WHAT we are using, but not WHY we are using it.
- Current processes do not show what is possible to achieve with our actual existing building and activity mixes.
- Most organisations JUST comply with legislation, i.e. they spend time and money on compliance exercises but not improving their energy use in a robust manner.



Display Energy Certificate
How efficiently is this building being used?
HM Government

Department of Energy & Climate Change
3-8 Whitehall Place
LONDON
SW1A 2HH

Certificate Reference Number:
0098-9592-5110-2590-8003

This certificate indicates how much energy is being used to operate this building. The operational rating is based on meter readings of all the energy actually used in the building. It is compared to a benchmark that represents performance indicative of all buildings of this type. There is more advice on how to interpret this information on the Government's website www.communities.gov.uk/epbd.

Energy Performance Operational Rating

This tells you how efficiently energy has been used in the building. The numbers do not represent actual units of energy consumed; they represent comparative energy efficiency. 100 would be typical for this kind of building.

Total CO_2 Emissions

This tells you how much carbon dioxide the building emits. It shows tonnes per year of CO_2.

Previous Operational Ratings

This tells you how efficiently energy has been used in this building over the last three accounting periods

Technical information

This tells you technical information about how energy is used in this building. Consumption data based on actual meter readings.

Main heating fuel: Natural Gas
Building Environment: Air Conditioning
Total useful floor area (m²): 10960
Asset Rating: Not available.

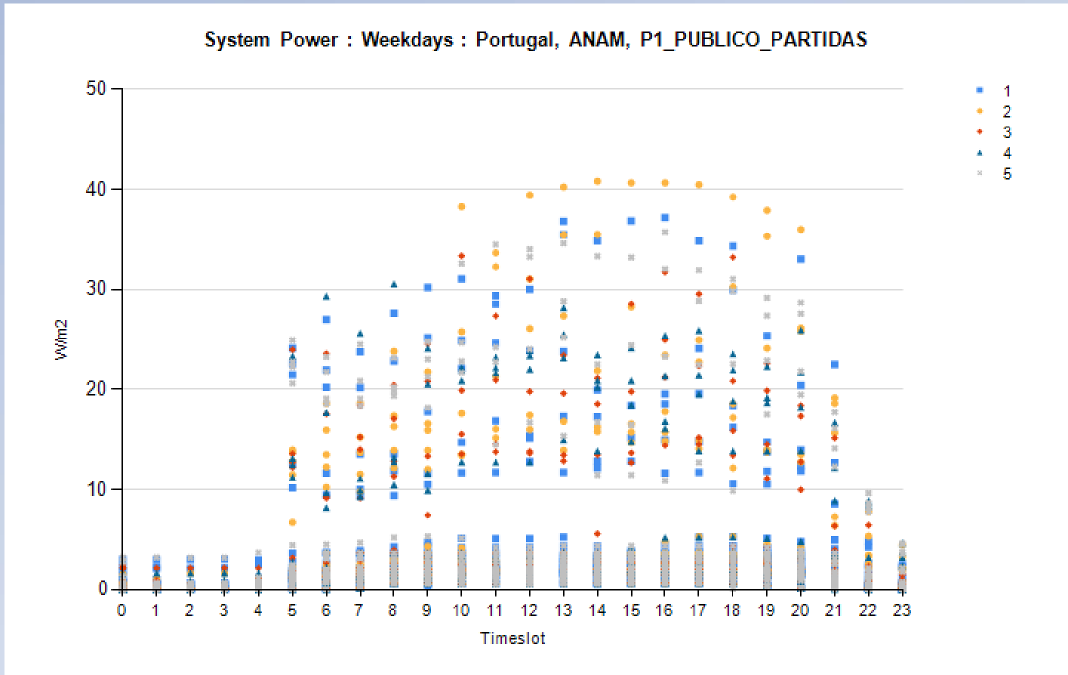
	Heating	Electrical
Annual Energy Use (kWh/m²/year)	41	156
Typical Energy Use (kWh/m²/year)	125	106
Energy from renewables	0%	0%

Administrative information

This is a Display Energy Certificate as defined in SI 2007/991 as amended.
Assessment Software: CLG, ORCalc, v3.5.1
Property Reference: 885505120000
Assessor Name: Darren Myers
Assessor Number: LCEA129289
Accreditation Scheme: CIBSE Certification Limited
Employer/Trading Name: Briar Associates
Employer/Trading Address: York House, High Street, Amblecote, DY8 4BT
Issue Date: 12-11-2010
Nominated Date: 12-11-2010
Valid Until: 11-11-2011
Related Party Disclosure: Not related to the occupier
Recommendations for improving the energy efficiency of the building are contained in the accompanying Advisory Report.

A 21st Century approach to a 21st Century problem

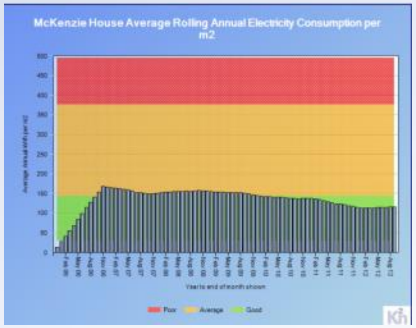
- New data sources now allow us detailed insights into how energy is used at sub-hourly intervals and by end uses.
- This level of detail is sufficient to provide confidence in what needs to be done to reduce energy use.



- iSERV utilises these new data sources to show how such a new approach might work - from defining the buildings through to how it might work with legislation.

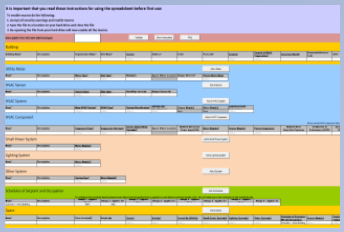
iSERV

- A way to show owners of real buildings the energy savings possible FOR THEIR BUILDINGS, by comparing their use with the performanceof other real buildings using the same equipment to service the same activity and floor area.
- iSERV uses an empirical process based on physical items that can be measured and found in all buildings.
- This means that reports can refer to actual items in a building.
- Gives confidence to the owner/operator that the information is relevant to them.
- Reduces RISK – therefore enables INVESTMENT.

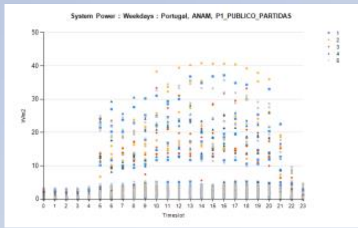


The iSERV recipe

A Spreadsheet

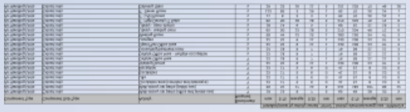


\+ Sub-hourly data

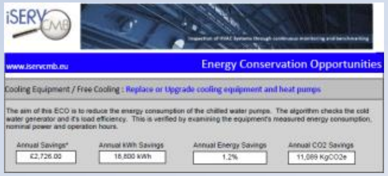


\+ A database

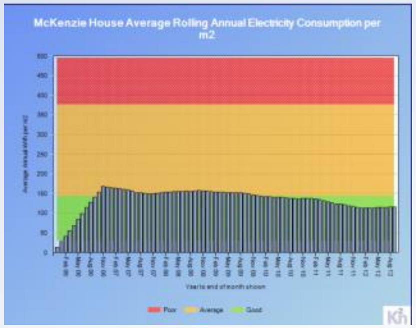
\+ Component benchmarks



\+ Targeted reports



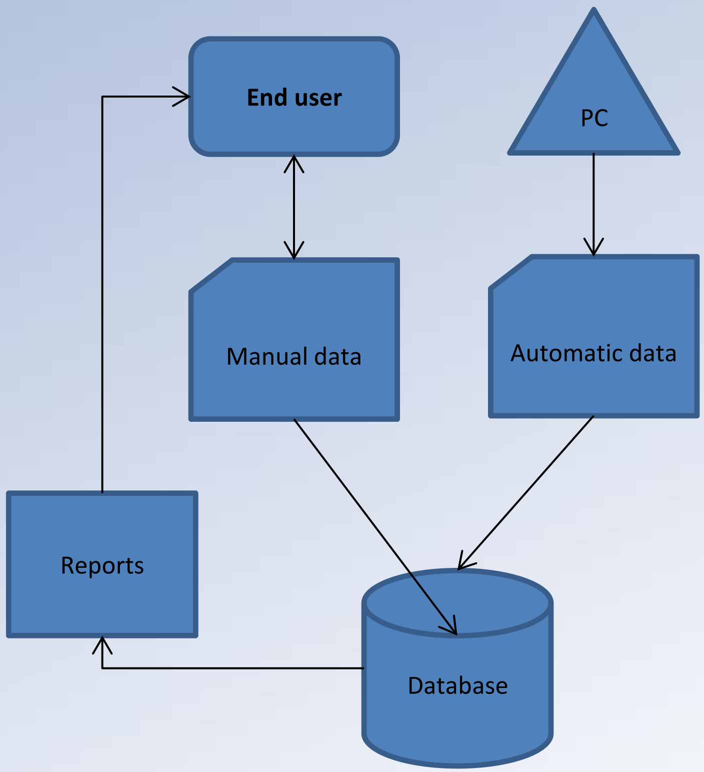
= Energy savings



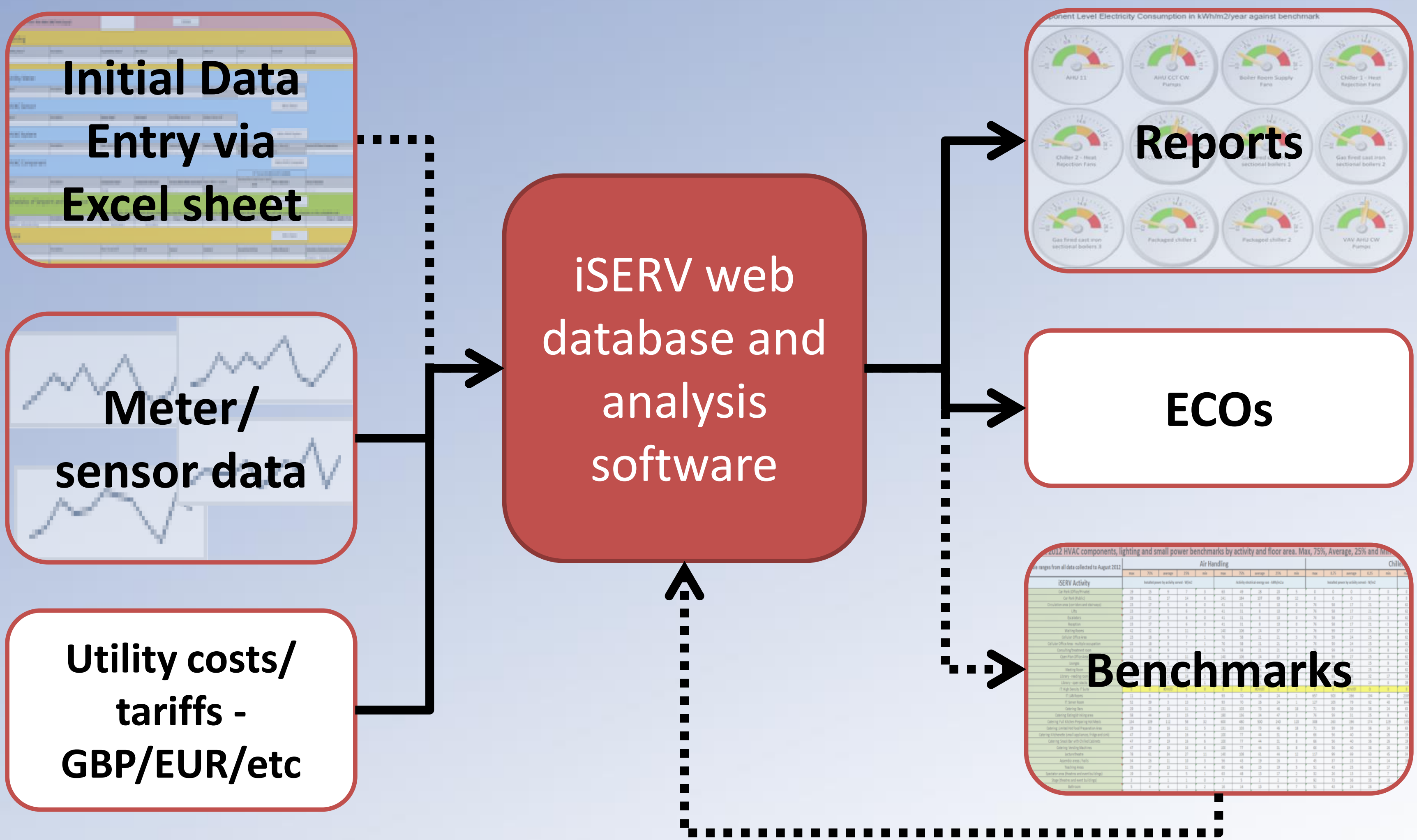
What iSERVcmb is doing

Remotely monitoring HVAC systems across Europe

- Target 1600 HVAC systems of all types in EU countries.
- Range of building sectors.
- Sub-hourly data for individual HVAC components.
- Mostly using existing or easy-to-add monitoring.
- Collating and analysing all data in a web-based database.



Overview of basic process

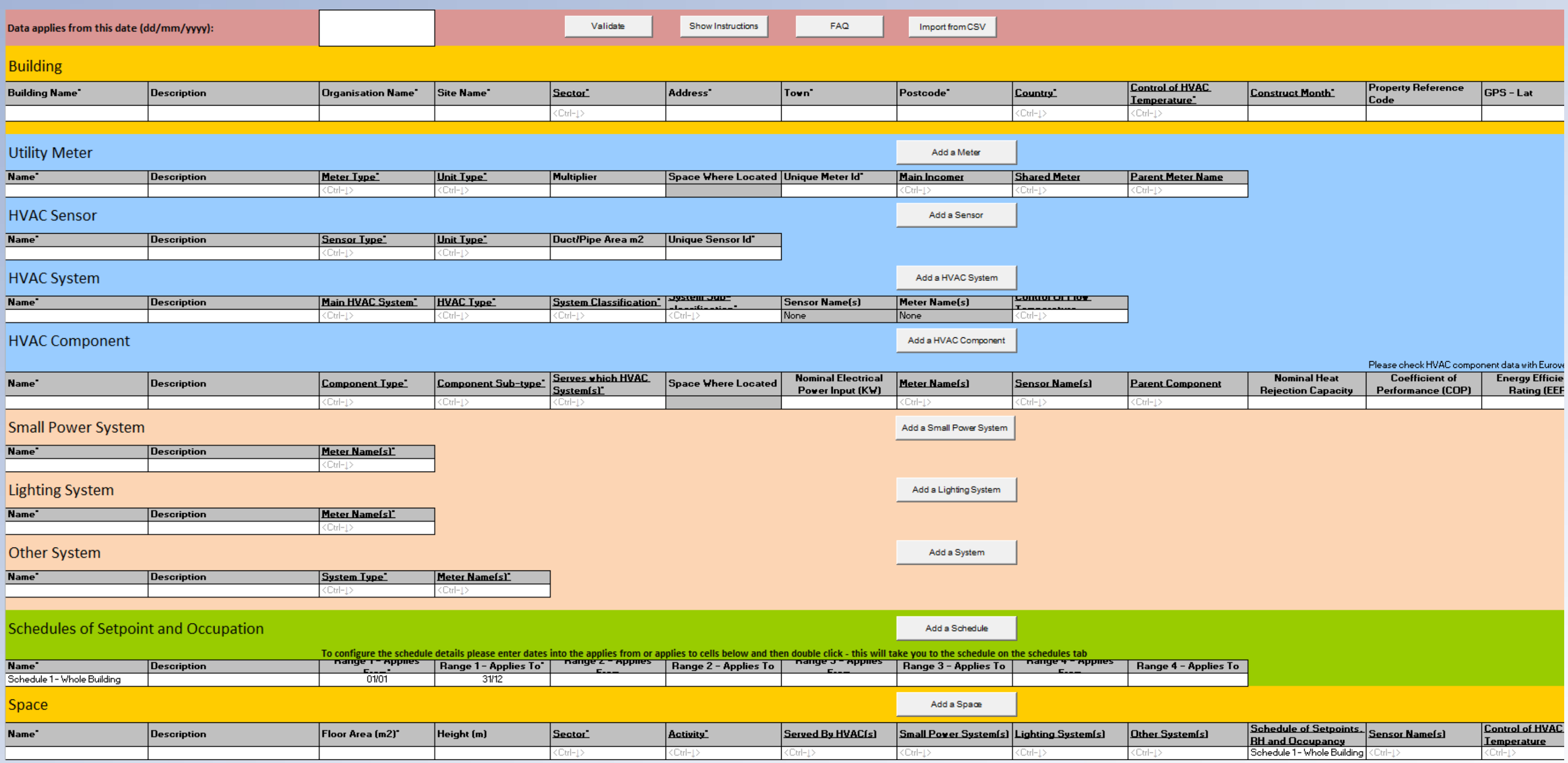


Collect information on the building

- Floor area and activity for each space in the building
- Networked utility meters and sensors, and where they serve
- Unique Identifiers for the sub-hourly data to be collected from these meters and sensors
- All HVAC Components and where they serve

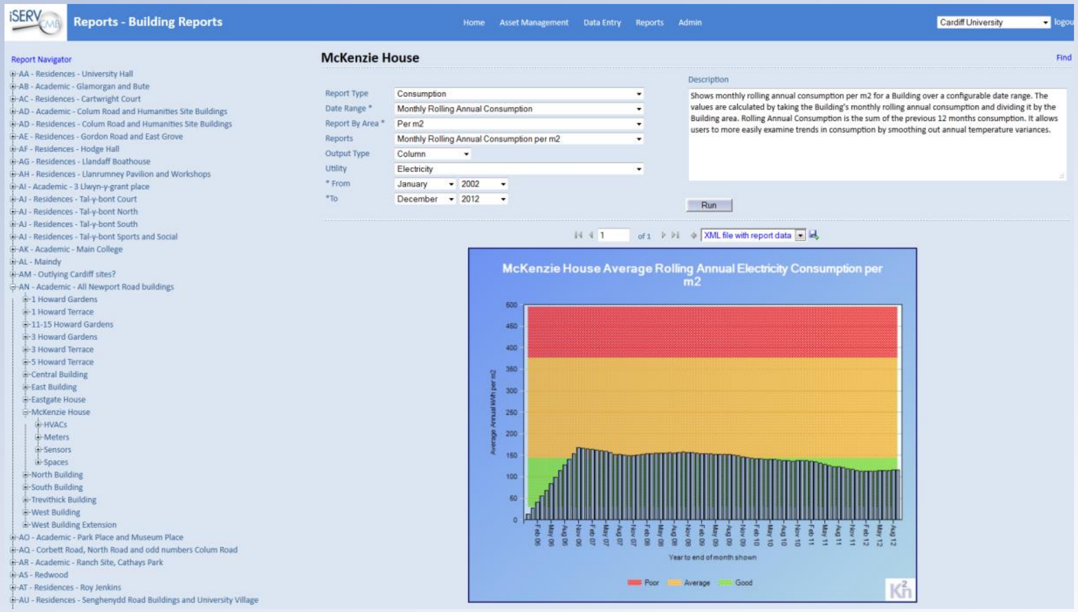
Collate information on the building

- iSERV has set up a spreadsheet to act as a data collection focus for the building, meters and services physical elements
- The spreadsheet also acts as a means of **connecting** all the elements together



Database

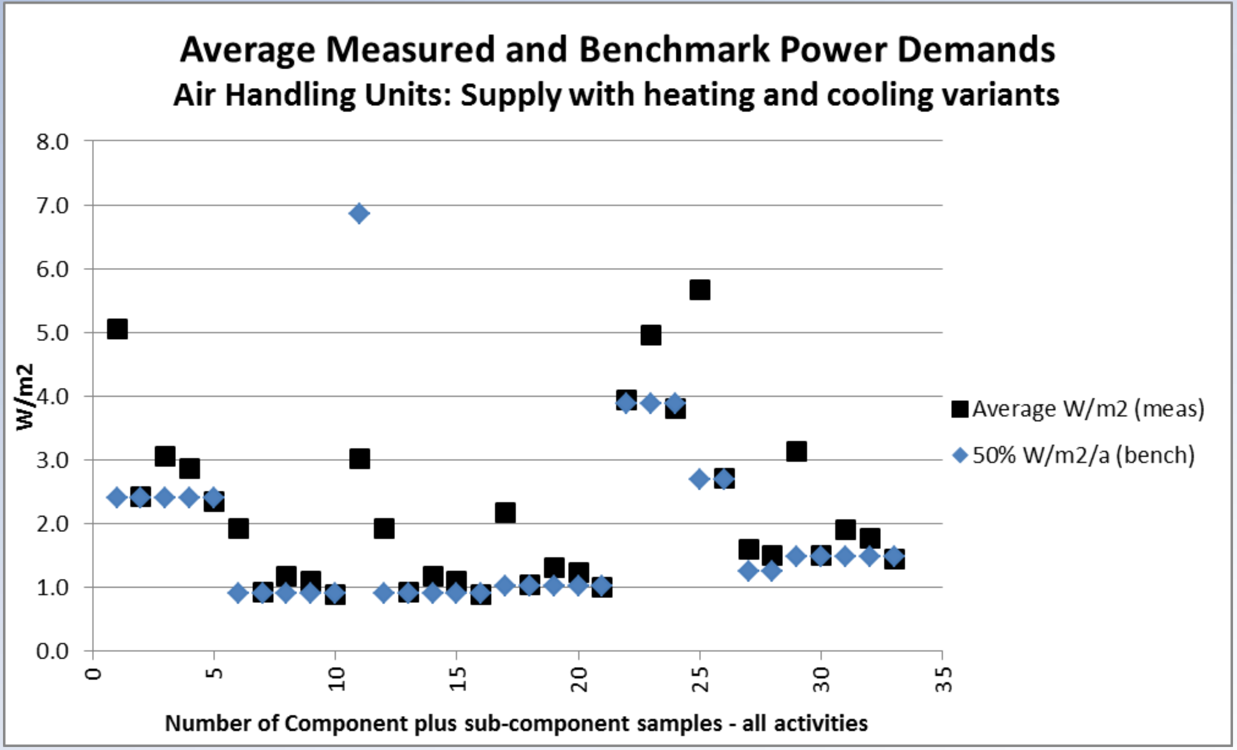
- A bespoke database has been written for the project
- Based on a commercial product
- Acts as the focus for the iSERV project elements:
  - Data collection
  - Benchmark use
  - Benchmark generation
  - Reports
  - Energy Conservation Opportunity algorithms



Benchmarks

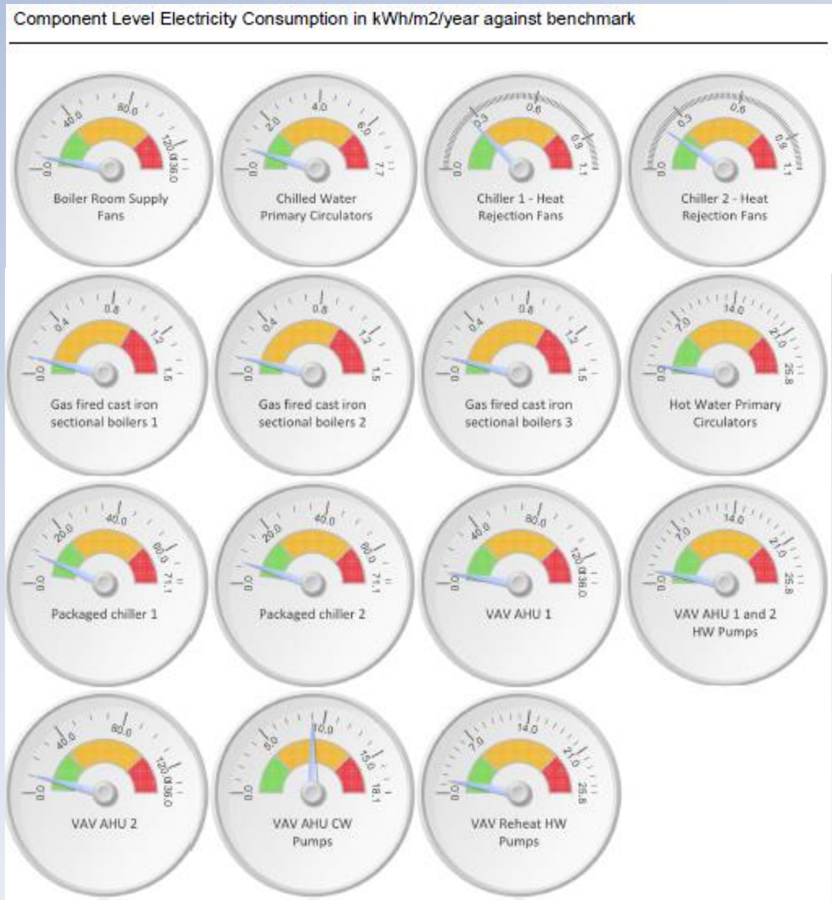
Three types of benchmark being produced and explored:

- Annual energy/m² – kWh/m².a
- Monthly energy/m² – kWh/m².month
- Power demands/m² – W/m²

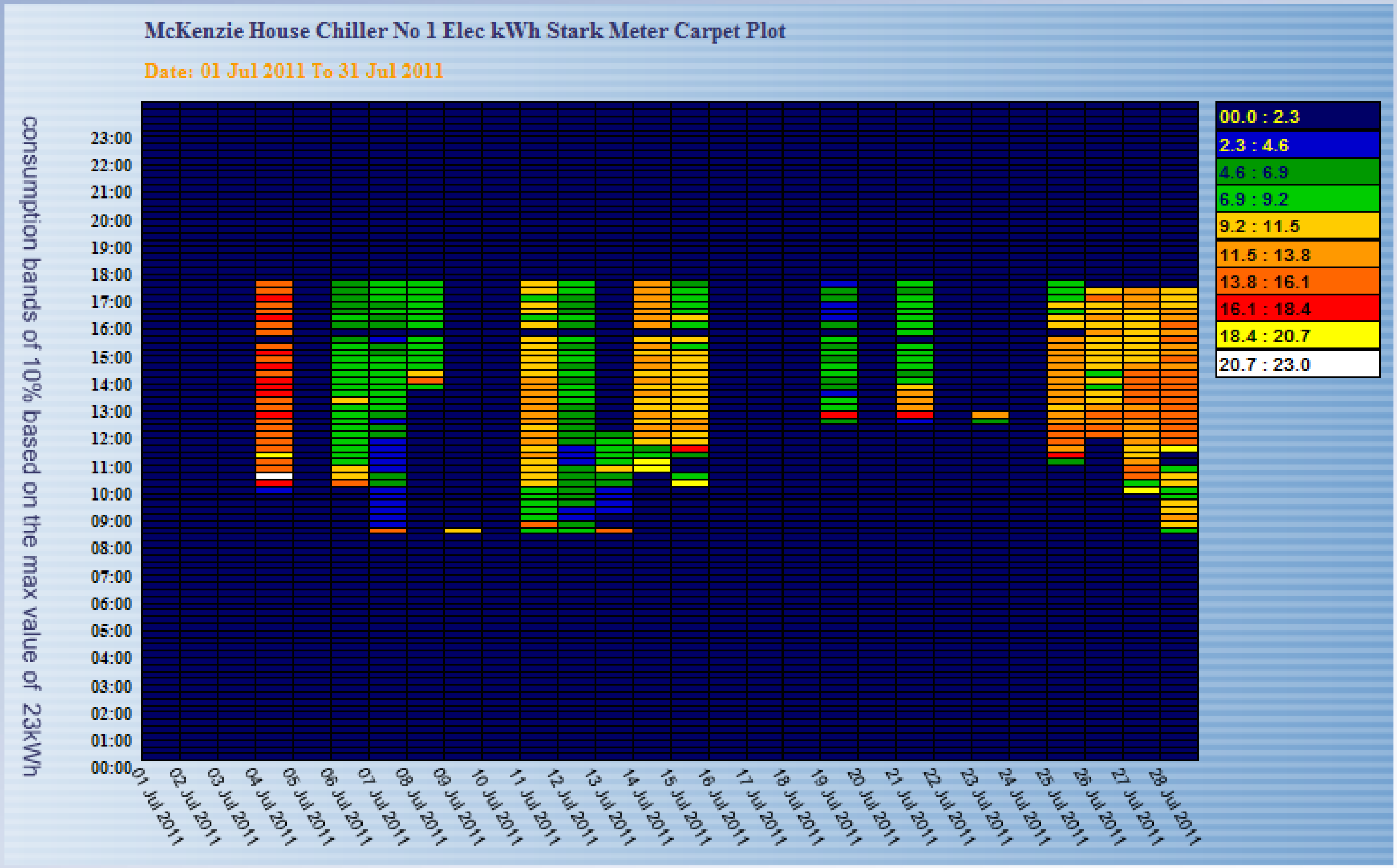


Three ways to save energy – regularly show performance

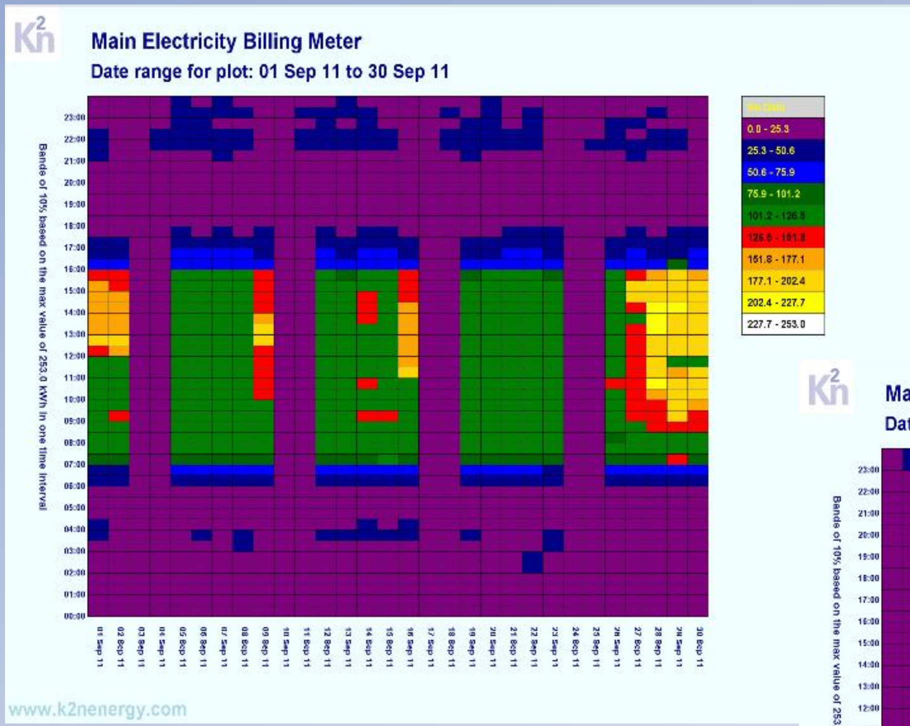
- Regularly show performance against benchmarks derived from the spreadsheet description of the building and services
- Benchmarks will evolve over time as the buildings / components providing data change their performance – so benchmarks always reflect current practice



Identification of Energy Conversation Opportunities (ECOs)

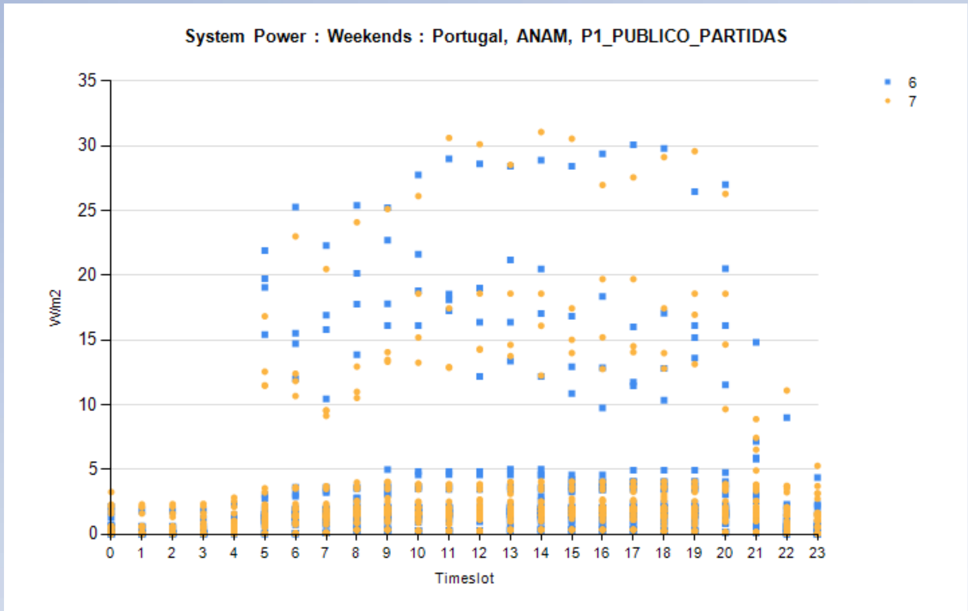


Carpet Plots – McKenzie House



Three ways to save energy – better control of existing plant

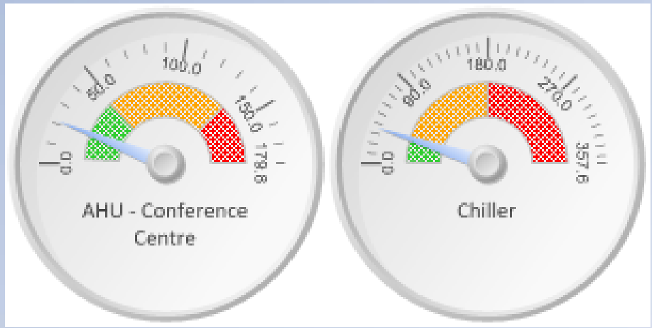
- Better control of what you already have e.g. use of ECO algorithms or scatter graphs/carpet plots to identify when systems and components are running outside of expected hours

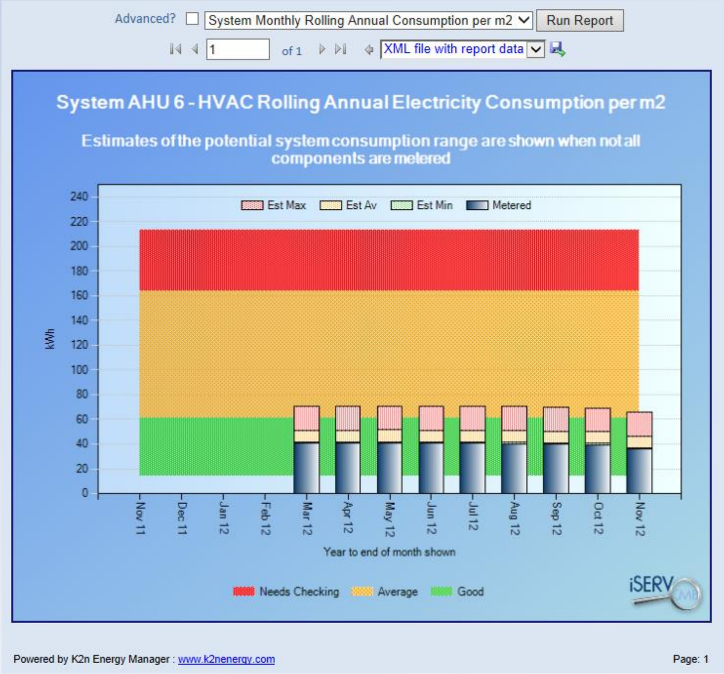


- Clearly shows what could be controlled better
- Can use the data directly to calculate potential savings

Three ways to save energy – install more efficient equipment

- **Install more efficient equipment**. Even if equipment is well controlled it may well require more power when in use than more modern equipment
- Benchmarks based on power demands when in use can help show this difference and when equipment might benefit from being upgraded

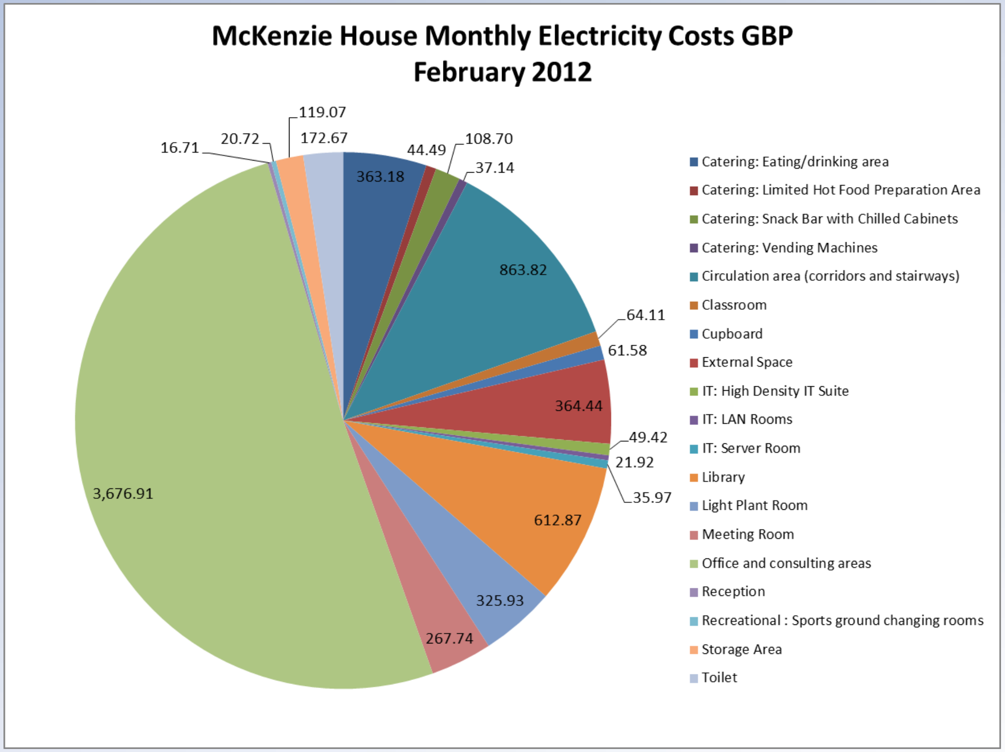




Energy cost by activity

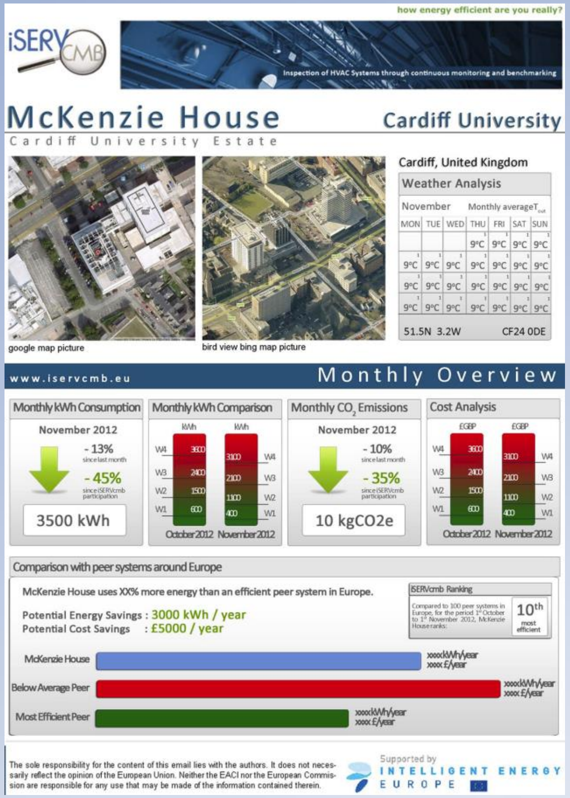
- Energy cost by activity can be calculated from the whole building energy consumption (monthly cost shown here)
- This can also be broken down into HVAC and Occupant costs by activity per month

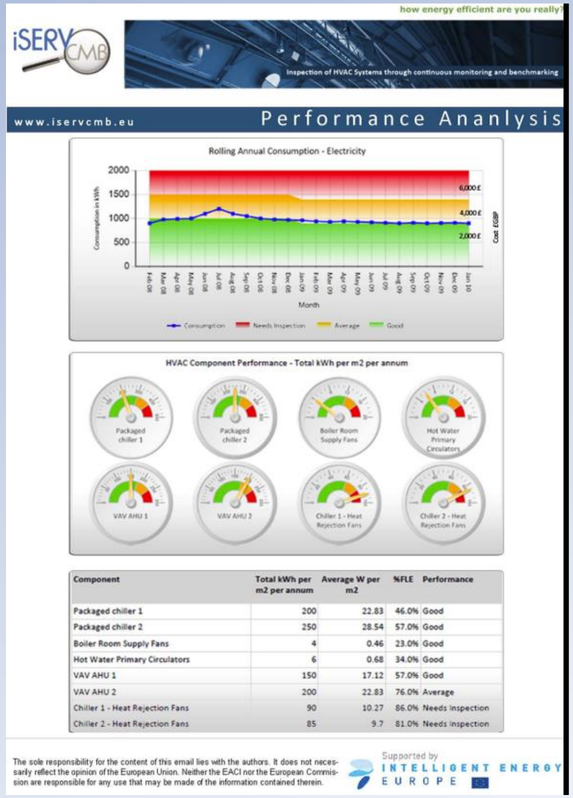
The graph shows the estimated electricity costs in February 2012 for the activities undertaken in the building



Reports

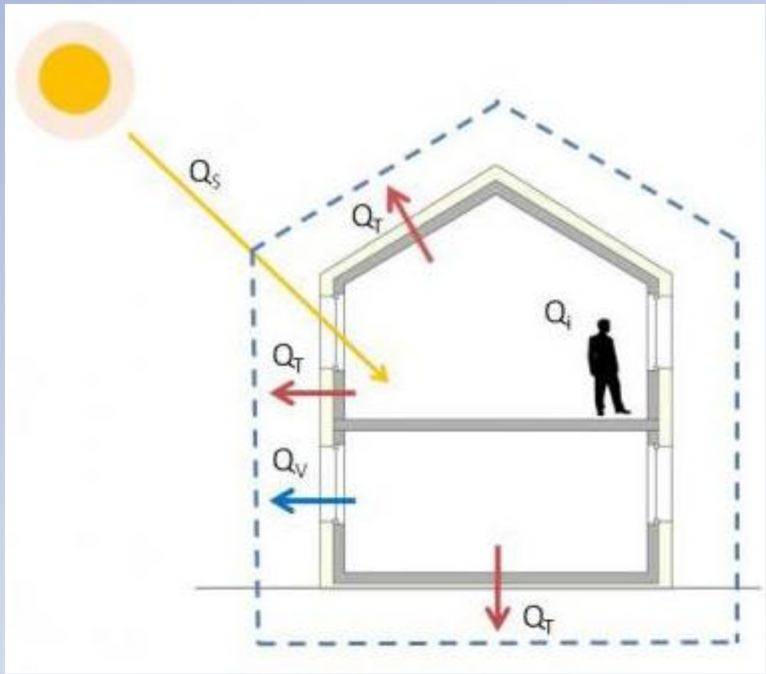
- The key is to not just present meter data but to interpret it with respect to the situation in the real building
- A number of report sets are being trialled to see which provide the information in the best form to allow





The near future

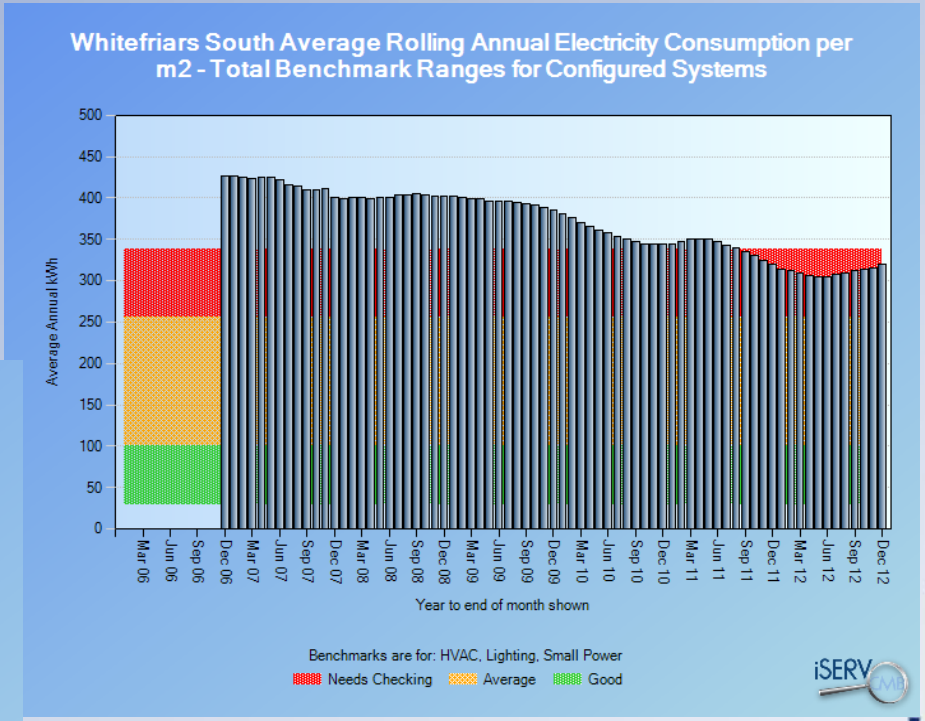
- Near zero energy buildings will require us to BALANCE the energy loads in a building with minimum NET use of energy
- With highly insulated structures this balance is mainly about how Solar Gains, Internal Gains and Ventilation energy needs interact with each other

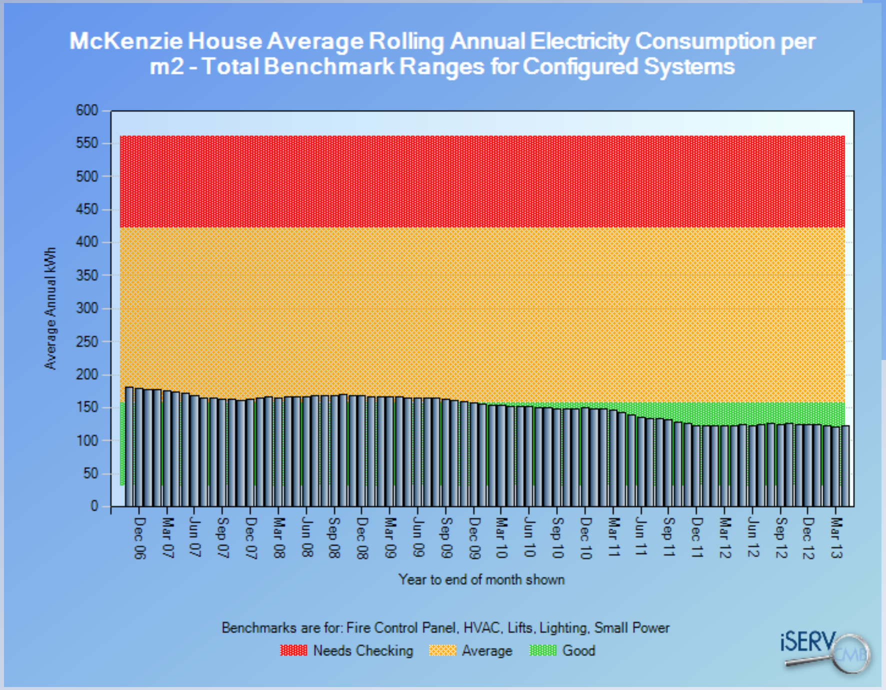


- The most controllable parameter is Ventilation
- In both hot and cold climates energy efficiency can be achieved by MINIMISING ventilation rates, with the attendant potential for IAQ problems and Health

Savings in real buildings

Two buildings showing their electrical savings achieved since first participating in HARMONAC





Monitoring savings: Case Studies

- Building electrical savings of between 19% to 33% p.a.
- Building electrical savings/m^2 between 61 to 100 kWh/m^2/a
- In economic terms:
  - Measured recurrent savings of 9 to 14 EUR/m^2/a
  - Recorded ‘one-off’ setup costs between 0.1 to 2 EUR/m^2
  - Estimated 0.1 – 3 EUR/m^2/a to maintain.
  - Net returns between 7 – 13 EUR/m^2/a
- The savings actually achieved in these 3 buildings indicate more significant ACTUAL savings could be achieved in the wider building stock.
- Success in reducing HVAC energy use is providing the confidence and finance (from savings) to tackle other electrical use as well

Cost comparison of acceptable recast EPBD approaches

Topic	Inspection	Monitoring	Advice
Cost	**100 – 250 EUR** (Compliance) **0.5 – 2.5 EUR/m²** (EPBD)	**0.1 to 2.0 EUR/m²** setup **0.1 to 3.0 EUR/m²** ongoing	Not known
Savings	Estimate (HARMONAC) : **2.0 to 3.2 EUR/m²** at best	Measured (small sample): **9.0 – 14.0 EUR/m²/a** (electrical) Up to 33% building elec use	Not known
Net savings	**-100 to -250 EUR** or **-0.5 to 2.7 EUR/m²**	**1.0 to 13.0 EUR/m²/a**	**Not known**
Impact assessment	No feedback route	Data allows precise ‘before’ and ‘after’ impact studies	No feedback route
Comments	Savings not likely to be sustainable where intervention is needed. Savings difficult to maintain.	Initial setup can be costly. Requires more attention than inspection or advice. Provides detailed understanding of energy use. Reduces investment risk. Proven real energy savings. Helps maintain savings Provides data for design decisions	Difficult to show impact. No mechanism for drawing attention to energy use. Not clear how it will help maintain energy savings.

Proposal on implementing monitoring as a complement to Inspection

- iSERV proposes Monitoring and Inspection are complementary processes as DETAILED Inspections are the obvious route to improving buildings with poor benchmarks.
- **Monitoring requires the iSERV spreadsheet be completed first. (Whether or not a Monitoring scheme exists this step should be required by legislation as it informs both Inspection and Advice).**
- Second step is the accreditation of monitoring schemes. These schemes required to report key data to MS legislators.
- Set regular benchmarks from the data to ensure benchmarks continue to reflect best practice being achieved.

Monitoring - Conclusions

- Monitoring brings:
  - Clarity and Certainty;
  - Proven energy and cost savings to the end user and MS;
  - End user engagement and ability to contribute to 2020 targets;
  - Proof of impact achieved;
  - Increased use of energy efficient products;
  - Reduced Risk;
  - Ability to use Smart Metering data which is coming

- As a commercial prospect monitoring makes sense already.

Questions?

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