



**iSERV Project – November 28<sup>th</sup> 2013, Lisbon**



**Inspection of  
HVAC systems  
through  
continuous  
monitoring and  
benchmarking**

**[www.iservcmb.info](http://www.iservcmb.info)**

# **iSERV – how to achieve long-term energy reductions in buildings**

**Professor Ian Knight  
EFRIARC Talk  
Lisboa, November 2013**

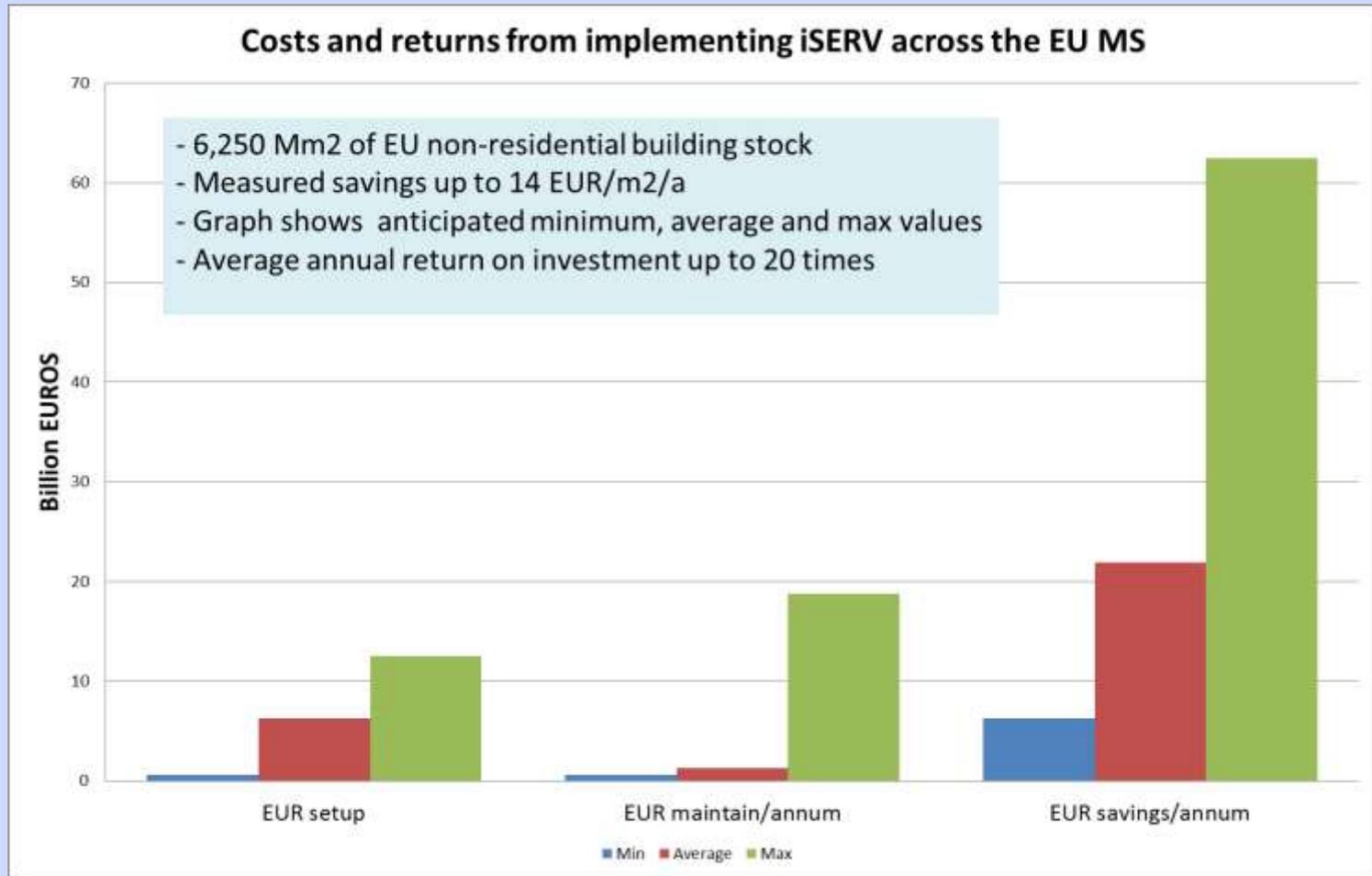
**[knight@cf.ac.uk](mailto:knight@cf.ac.uk)**

# Content of talk



- ➔ **Long-term** energy savings can be achieved through a process.
- ➔ This process needs to be in legislation for full impact
- ➔ The process needs to know:
  - What activities the buildings contain
  - How the services are arranged
  - The sub-hourly energy use in the building and services
  - Energy benchmarks for buildings and components servicing activities
- ➔ There is a strong commercial case for monitoring buildings

# Value at stake at EU scale



Fossil fuel and water savings are not included in this figure.

# End User interests



→ LEGISLATION COMPLIANCE – What MUST be done

→ RISK – Money, business continuity

→ EFFORT – Time, cost

→ REWARD – Business continuity, money, energy, marketing

If all the above show there is a strong case:

→ HOW to implement

# A 20<sup>th</sup> Century approach to a 21<sup>st</sup> Century problem



- ➔ Most EU MS Energy Legislation looks at whole buildings and annual energy use
- ➔ So we know WHAT we are using, but not WHY we are using it.
- ➔ Most organisations JUST comply with legislation
- ➔ We lack DETAIL on benefits and savings
- ➔ Therefore RISK increases

## Display Energy Certificate HM Government

How efficiently is this building being used?

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](http://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.

**More energy efficient**

- A** 0-25
- B** 26-50
- C** 51-75
- D** 76-100
- E** 101-125
- F** 126-150
- G** Over 150

**Less energy efficient**

### Total CO<sub>2</sub> Emissions

This tells you how much carbon dioxide the building emits. It shows tonnes per year of CO<sub>2</sub>.

11-2009 05-2010 11-2010

114

100 would be typical

### Previous Operational Ratings

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

11-2010 05-2010 11-2009

### 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 Envelope:** Air Conditioning  
**Total useful floor area (m<sup>2</sup>):** 1380  
**Asset Rating:** Not available

	Heating	Electrical
Annual Energy Use (kWh/m <sup>2</sup> /year)	41	198
Typical Energy Use (kWh/m <sup>2</sup> /year)	128	198
Energy from renewables	0%	0%

### Administrative information

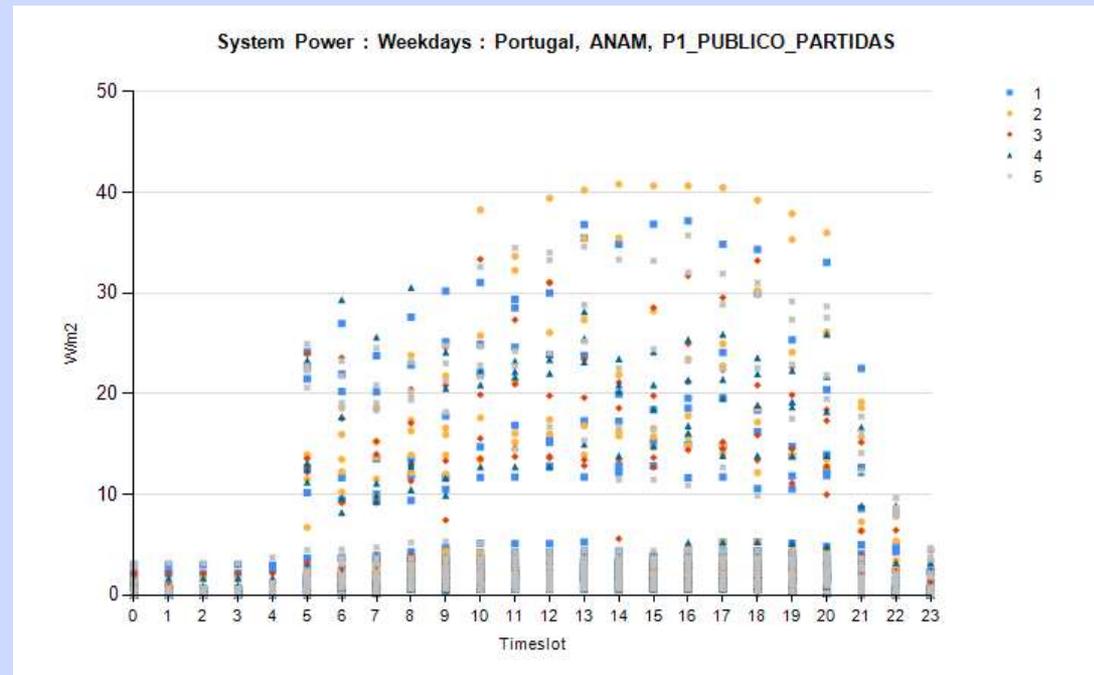
This is a Display Energy Certificate as defined in SI 2007/661 as amended.

**Assessment Software:** CLS ORCAS, v2.5.1  
**Property Reference:** 8880812000  
**Assessor Name:** Darren Myers  
**Assessor Number:** LCEA129289  
**Accreditation Scheme:** CEMC Certification Limited  
**Employer/Trading Name:** One Associates  
**Employer/Trading Address:** York House, High Street, Andover, DT19 4BT  
**Issue Date:** 12-11-2010  
**Nominated Date:** 12-11-2010  
**Valid Until:** 15-11-2011  
**Related Party Disclosure:** Not stated in the occupier  
**Recommendations for improving the energy efficiency of the building are contained in the accompanying Advisory Report.**

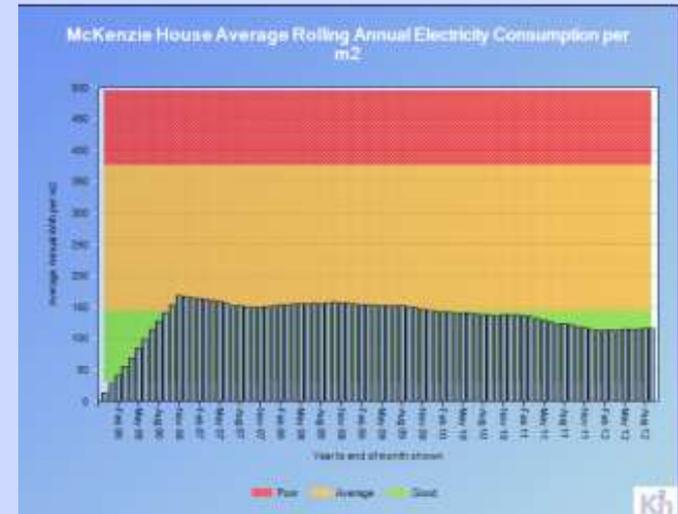
# A 21<sup>st</sup> Century approach to a 21<sup>st</sup> Century problem



- New data sources allow us detailed insights
- This level of detail reduces RISK
- iSERV utilises these new data sources to propose a new practical approach to achieving long-term energy reductions



- Shows the energy savings possible for REAL BUILDINGS
- 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
- Reduces RISK – therefore enables INVESTMENT

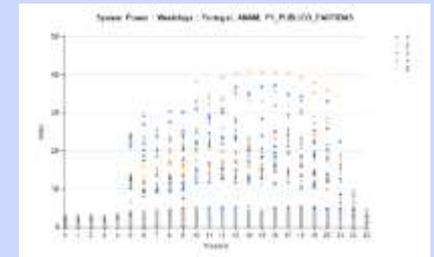
# The iSERV recipe



A Spreadsheet



+ Sub-hourly data



+ A database



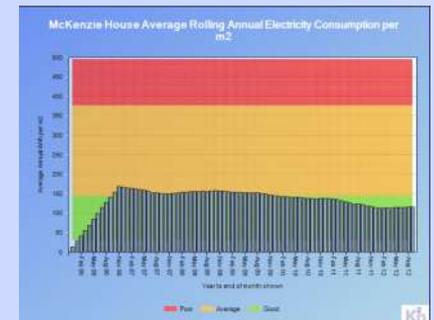
+ Component benchmarks



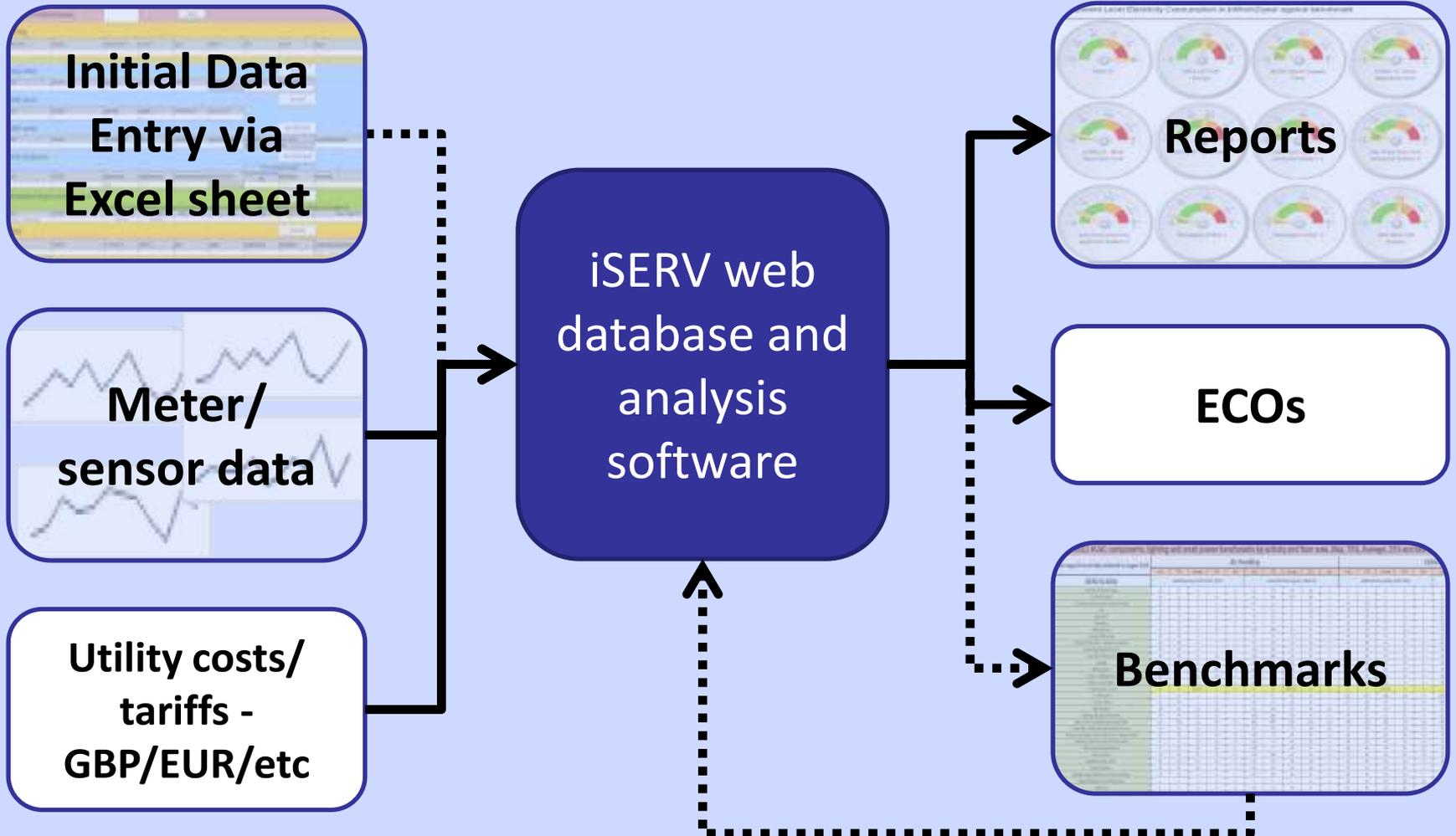
+ Targeted reports



= Energy savings



# Overview of basic process



# Collect information on the building

- Floor area and activity for each space in the building
- Networked utility meters/sensors
- Unique Identifiers for the sub-hourly data collected
- 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

Data applies from this date (dd/mm/yyyy):

### Building

Building Name*	Description	Organisation Name*	Site Name*	Sector*	Address*	Town*	Postcode*	Country*	Control of HVAC Temperature*	Contractor Name*	Property Reference Code	GPS - Lat
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>									

### Utility Meter

Name*	Description	Meter Type*	Unit Type*	Multiplex	Space Where Located	Unique Meter ID*	Main System	Shared Meter	Parent Meter Name
<input type="text"/>									

### HVAC Sensor

Name*	Description	Sensor Type*	Unit Type*	Duct/Pipe Area m2	Unique Sensor ID*
<input type="text"/>					

### HVAC System

Name*	Description	Main HVAC System	HVAC Type*	System Classification	Manufacturer	Sensor Name(s)	Power Name(s)	Commission Date
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>				

### HVAC Component

Please check HVAC component data with iSERV

Name*	Description	Component Type*	Component Sub-type*	Sensors which HVAC System(s)	Space Where Located	Nominal Electrical Power Input (kW)	Meter Name(s)	Sensor Name(s)	Parent Component	Nominal Heat Rejection Capacity	Coefficient of Performance (COP)	Energy Efficiency Rating (EER)
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>				

### Small Power System

Name*	Description	Meter Name(s)
<input type="text"/>	<input type="text"/>	<input type="text"/>

### Lighting System

Name*	Description	Meter Name(s)
<input type="text"/>	<input type="text"/>	<input type="text"/>

### Other System

Name*	Description	System Type*	Meter Name(s)
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

### Schedules of Setpoint and Occupation

To configure the schedule details please enter data into the applies from or applies to cells below and then double click - this will take you to the schedule on the spreadsheet tool.

Name*	Description	Range 1 - Applies From	Range 1 - Applies To	Range 2 - Applies From	Range 2 - Applies To	Range 3 - Applies From	Range 3 - Applies To	Range 4 - Applies From	Range 4 - Applies To
Schedule 1 - Whole Building	<input type="text"/>	<input type="text"/>	<input type="text"/>						

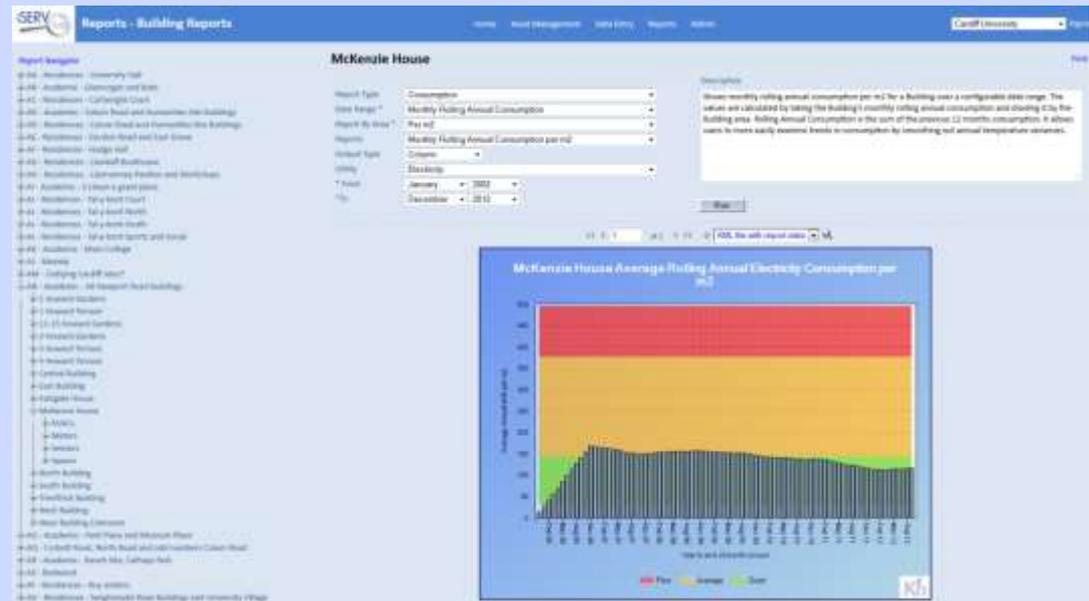
### Space

Name*	Description	Floor Area m2*	Height (m)	Sector*	Activity*	Served By HVAC(s)	Small Power System(s)	Lighting System(s)	Other System(s)	Schedule of Setpoints, BH and Occupance	Sensor Name(s)	Control of HVAC Temperature
<input type="text"/>	<input type="text"/>	<input type="text"/>	Schedule 1 - Whole Building	<input type="text"/>	<input type="text"/>							

# 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

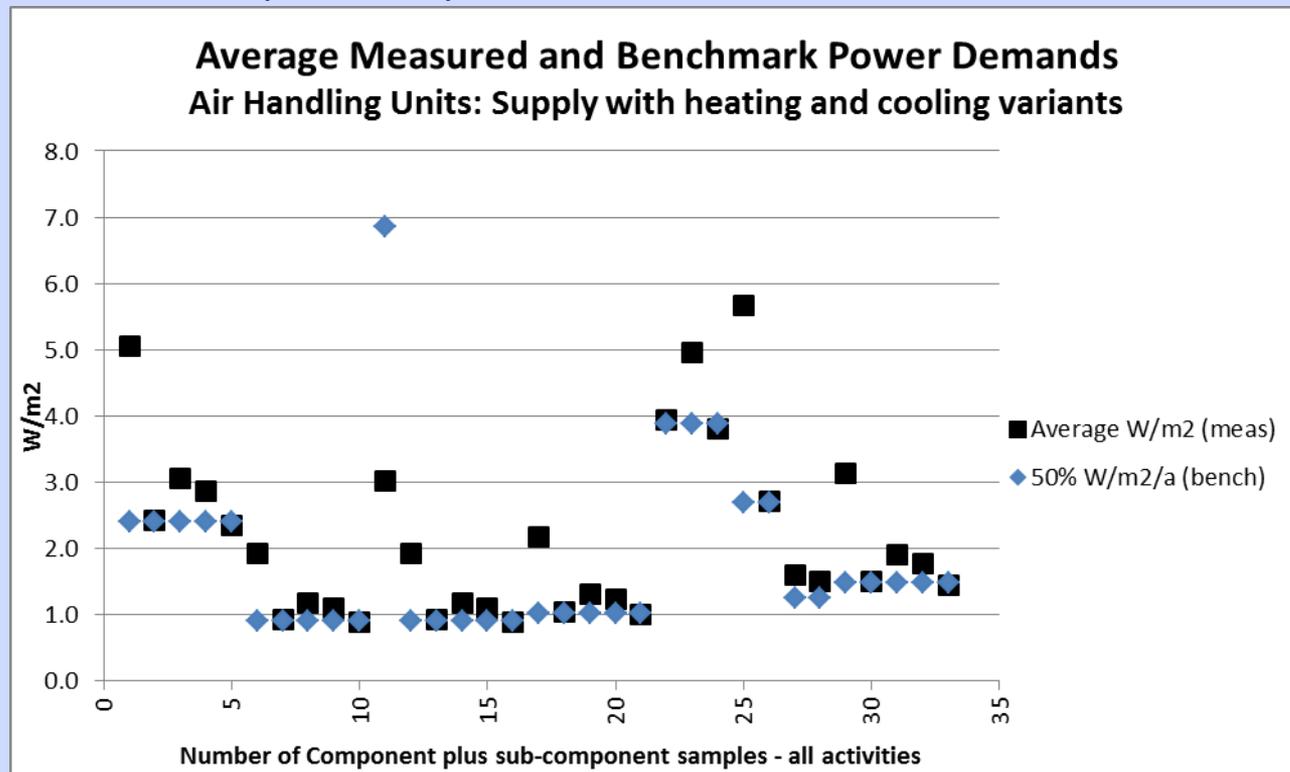


# Benchmarks



➔ Three types of benchmark being produced and explored:

- Annual energy/m<sup>2</sup> – kWh/m<sup>2</sup>.a
- Monthly energy/m<sup>2</sup> – kWh/m<sup>2</sup>.month
- Power demands/m<sup>2</sup> – W/m<sup>2</sup>



# Three ways to save energy – regularly show performance



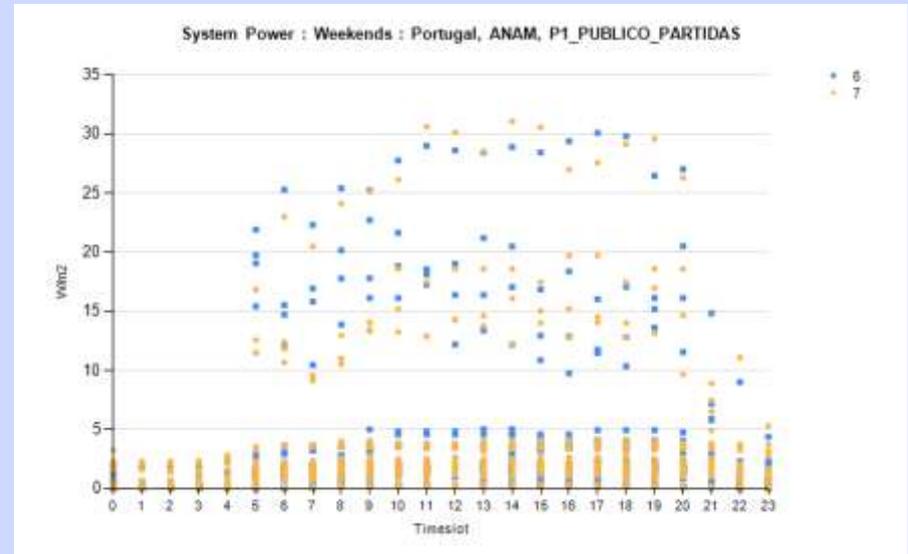
- ➔ Regularly show performance against benchmarks derived from the details of the building and services
- ➔ Monthly reports advised
- ➔ Benchmarks reflect current practice so reduce risk



# 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



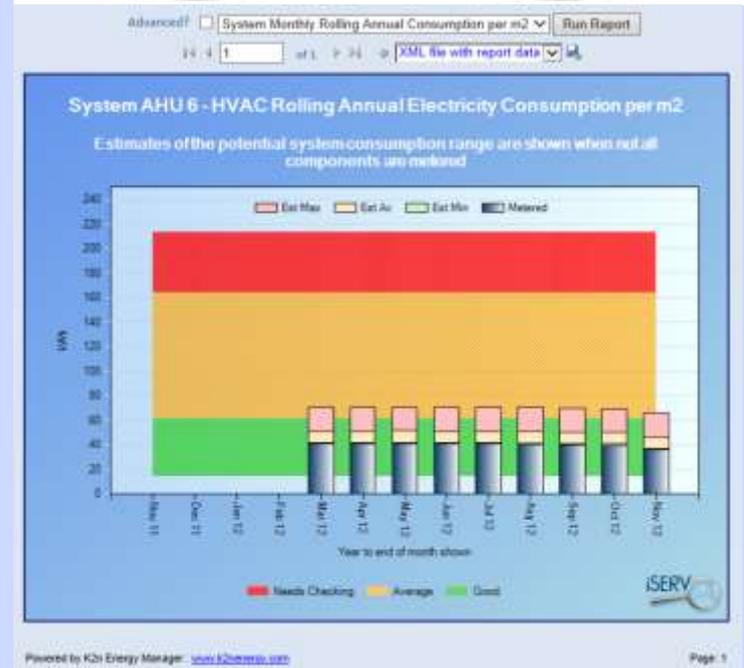
→ Can use the data directly to calculate potential savings, therefore reduced risk

# Three ways to save energy – install more efficient equipment



➔ **Install more efficient equipment.** Even if equipment is well controlled it may use more power in use than state-of-art kit

➔ **Benchmarks based on ‘in use’ power demands show this difference and again reduce risk from upgrading**



# Reports



- ➔ Reports should interpret data 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 decisions

How energy efficient are you really?

**McKenzie House** Cardiff University  
CARDIFF UNIVERSITY ESTABLISHED

Cardiff, United Kingdom

**Weather Analysis**

Reversion	Monthly average	WIND	WV	WDIR	WV2	WV3	WV4	WV5	WV6	WV7	WV8	WV9	WV10
1%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%

51.34 8.26 07/24/2012

**Monthly Overview**

Monthly kWh Consumption: November 2012 -13% (3500 kWh), October 2012 -45% (3500 kWh)

Monthly CO<sub>2</sub> Emissions: November 2012 -10% (10 kgCO<sub>2</sub>e), October 2012 -35% (10 kgCO<sub>2</sub>e)

Cost Analysis: October 2012 -£560, November 2012 -£560

Comparison with peer systems around Europe: McKenzie House uses 200% more energy than an efficient peer system in Europe. Potential Energy Savings: 3000 kWh / year, Potential Cost Savings: £5000 / year.

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How energy efficient are you really?

**Performance Analysis**

Billing Annual Consumption: Electricity

Building Annual Consumption: Electricity

Building Performance - Total kWh per m<sup>2</sup> per annum

Component	Total kWh per m <sup>2</sup> per annum	Average W per m <sup>2</sup>	NHE Performance
Packaged chiller 1	200	22.83	46.0% Good
Packaged chiller 2	250	28.34	57.0% Good
Boiler Room Supply Fans	4	0.46	23.0% Good
Hot Water Primary Circulation	6	0.68	34.0% Good
HV ACU 1	180	17.13	57.0% Good
HV ACU 2	200	22.83	78.0% Average
Chiller 1 - Heat Rejection Fans	80	10.27	35.0% Thermal Inefficiency
Chiller 2 - Heat Rejection Fans	85	9.7	33.0% Thermal Inefficiency

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How energy efficient are you really?

**Energy Conservation Opportunities**

**BBIM control/Miscellaneous**

Reduce power consumption of auxiliary equipment (Description To reduce energy consumption of pumps and fans the algorithm checks the following: if it happens that HVAC components like fans and pumps work outside the schedule of building. The ECO algorithm checks if pumps and fans work according to the building schedule, thereby preventing energy over-consumption.

Annual CO <sub>2</sub> Savings	Annual kWh Savings	Annual Energy Savings	Annual CO <sub>2</sub> Savings
£560,00	3500 kWh	5.2%	800 tons

**Cooling equipment/Free cooling**

Consider cold storage applications (chilled water, water ice and other phase changing materials) (Description To reduce energy consumption of pumps and fans the algorithm checks the following: if it happens that HVAC components like fans and pumps work outside the schedule of building. The ECO algorithm checks if pumps and fans work according to the building schedule, thereby preventing energy over-consumption.

Annual CO <sub>2</sub> Savings	Annual kWh Savings	Annual Energy Savings	Annual CO <sub>2</sub> Savings
£560,00	3500 kWh	5.2%	800 tons

**Air handling/room recovery/Air dehumidification**

Apply variable flow rate fan control (Description To reduce energy consumption of pumps and fans the algorithm checks the following: if it happens that HVAC components like fans and pumps work outside the schedule of building. The ECO algorithm checks if pumps and fans work according to the building schedule, thereby preventing energy over-consumption.

Annual CO <sub>2</sub> Savings	Annual kWh Savings	Annual Energy Savings	Annual CO <sub>2</sub> Savings
£560,00	3500 kWh	5.2%	800 tons

**General HVAC systems**

Shut off HVAC equipment when not needed (Description To reduce energy consumption of pumps and fans the algorithm checks the following: if it happens that HVAC components like fans and pumps work outside the schedule of building. The ECO algorithm checks if pumps and fans work according to the building schedule, thereby preventing energy over-consumption.

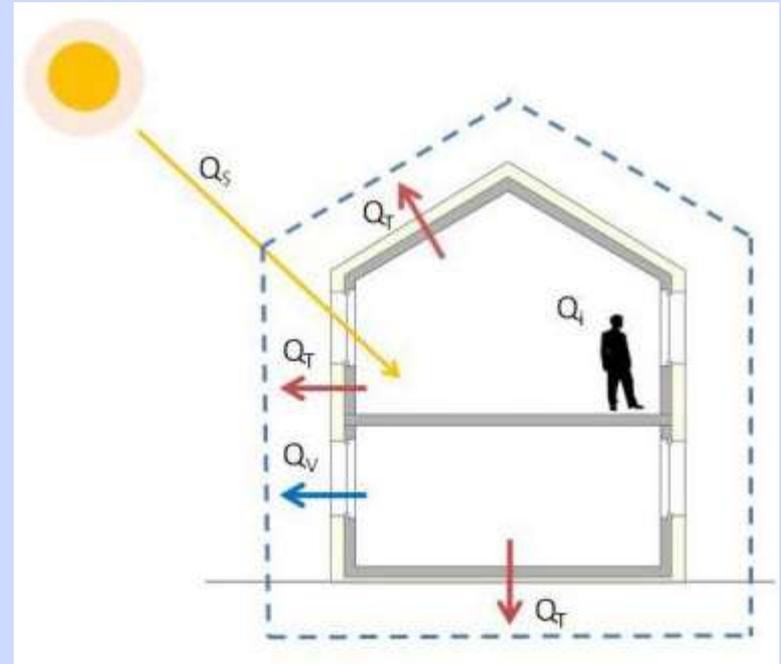
Annual CO <sub>2</sub> Savings	Annual kWh Savings	Annual Energy Savings	Annual CO <sub>2</sub> Savings
£560,00	3500 kWh	5.2%	800 tons

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# The near future



- Near zero energy buildings (nZEB's) will require us to understand building loads
- With highly insulated structures this balance is about Solar, Ventilation and Internal Gains
- The most controllable parameter is Ventilation
- RISK: energy efficiency can be achieved by MINIMISING ventilation rates. Potential for IAQ problems and Health



Ref: <https://www.educate-sustainability.eu/portal/content/thermal-balance-buildings>

# Understanding what is reasonable for existing buildings

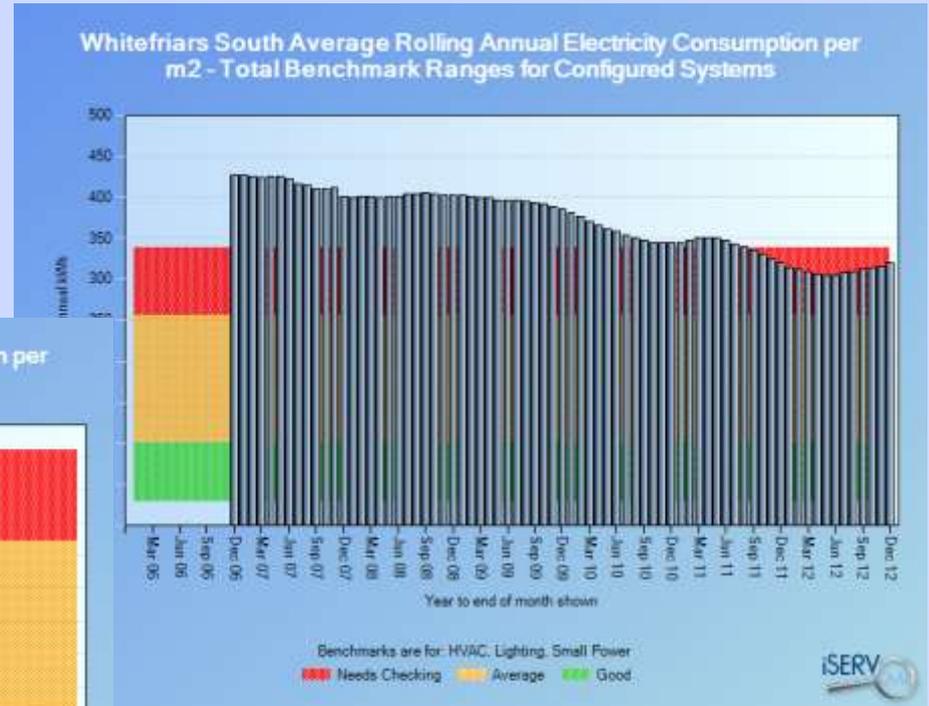
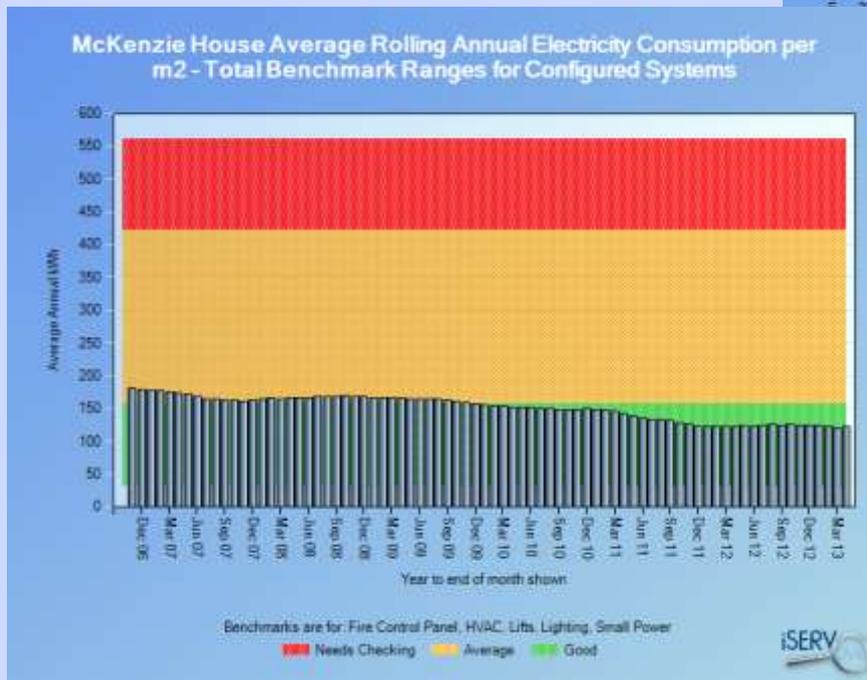


- ➔ The sunk resources in existing buildings are huge. There is rarely a justification for demolition on energy grounds alone
- ➔ What energy is it reasonable for HVAC system components to consume when servicing existing buildings?
- ➔ Targets for existing buildings are of little value if there is no information on how they are being achieved in the real world
- ➔ There are real, significant savings to be made – and lessons to be learnt for NEW buildings

# Savings in real buildings



➔ Two buildings showing the electrical savings achieved since first participating in HARMONAC



# Monitoring savings: 3 Case Studies



- ➔ **Building electrical savings of between 19% to 33% p.a.**
- ➔ **Building electrical savings/m<sup>2</sup> between 61 to 100 kWh/m<sup>2</sup>/a**
- ➔ **No Fossil Fuel figures yet**
  
- ➔ **In economic terms:**
  - **Measured recurrent savings of 9 to 14 EUR/m<sup>2</sup>/a**
  - **Recorded 'one-off' setup costs between 0.1 to 2 EUR/m<sup>2</sup>**
  - **Estimated 0.1 – 3 EUR/m<sup>2</sup>/a to maintain.**
  
  - **Net returns between 7 – 13 EUR/m<sup>2</sup>/a**
  
- ➔ **Exceeding the HARMONAC predicted building electrical savings of 1 – 5%**
- ➔ **These 3 buildings show significant ACTUAL savings achievable in practice.**

# Inspection vs Monitoring: Costs and Savings



- European MS Inspection costs are between **100 – 250 EUR**. Primarily for compliance i.e. a cost with no real benefit.
- The cost of a ‘proper’ Inspection appears **~0.5 – 2.5 EUR/m<sup>2</sup>**
- Savings from ‘proper’ Inspections are unclear. HARMONAC suggests **savings of 2.0 – 3.2 EUR/m<sup>2</sup> at best**. Without feedback, these savings expected to last ~ 6 months.
- Monitoring costs **~0.5 – 2 EUR/m<sup>2</sup>/a**
- **Annual** costs are less for Inspection than Monitoring.

# Costs and Savings for Monitoring



## Costs

- ➔ Energy monitoring welcomed by many organisations as a compliance route as they already do it. Extra costs from:
  - The cost of any additional metering needed
  - The cost of belonging to an accredited scheme
  - The initial costs of entering the scheme
- ➔ The cost of implementing Monitoring system recommendations

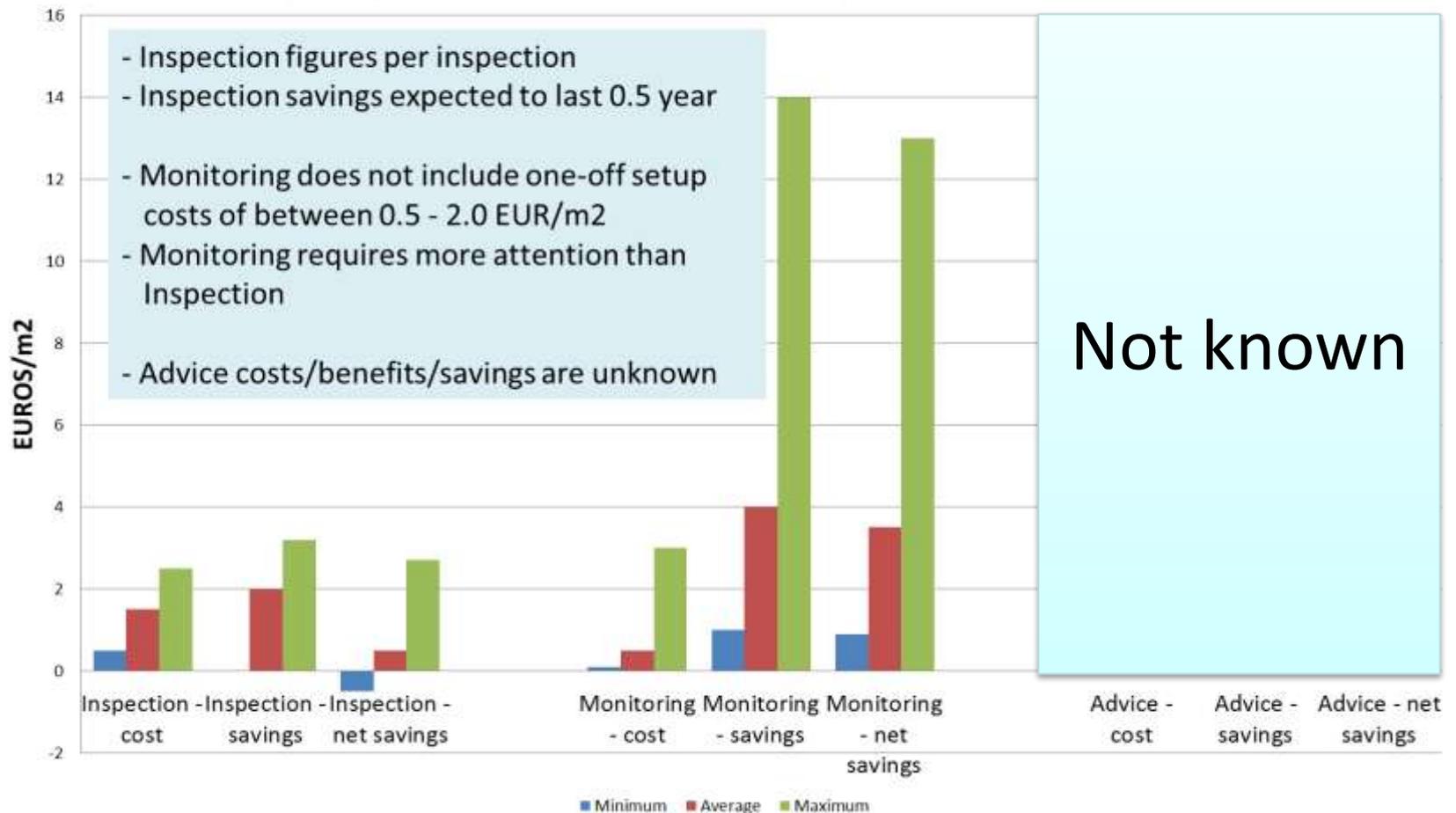
## Savings

- ➔ Savings achieved from focussed feedback
- ➔ Savings due to reduction of risk for investments
- ➔ Collateral savings from increased confidence in returns
- ➔ Savings from maintaining reductions achieved

# Cost comparison of 3 acceptable recast EPBD approaches



Comparing costs and benefits of EPBD approaches across the EU MS



# Benefit comparison of 3 acceptable recast EPBD approaches



Topic	Inspection	Monitoring	Advice
Impact assessment	No feedback route	Data allows precise 'before' and 'after' impact studies	No feedback route
Comments	<p>Difficult to show impact.</p> <p>Savings not likely to be sustainable where intervention is needed.</p> <p>Savings difficult to maintain.</p>	<p>Initial setup can be costly.</p> <p>Requires more attention than inspection or advice.</p> <p>Provides detailed understanding of energy use.</p> <p>Reduces investment risk.</p> <p>Proven real energy savings.</p> <p>Helps maintain savings</p> <p>Provides data for design decisions</p>	<p>Difficult to show impact.</p> <p>No mechanism for drawing attention to energy use.</p> <p>Not clear how it will help maintain energy savings.</p>

## Monitoring as a complement/alternative to Inspection and Advice



- ➔ Monitoring and Feedback is acceptable as an alternative route to compliance for recast EPBD Articles 14 and 15
- ➔ EC have funded iSERV and are aware of the savings found.
- ➔ Inspection and Advice are complementary processes
- ➔ **Monitoring requires the iSERV spreadsheet to be completed and, at a minimum, this data should be required by legislation as it informs both Inspection and Advice**

# Monitoring - practical aspects



- ➔ Are there schemes to which building owners can sign up now?
  - It is believed iSERV is the only scheme of its type at present.
  - iSERV can be still joined and used for free but will become a commercial service from April 2014 when funding ends.
  - iSERV will work with MS to provide a scheme if required
- ➔ How can monitoring services be formally recognised in legislation?
  - Legislation needs only refer to monitoring schemes meeting required criteria as being an acceptable alternative to mandatory Inspection. This does not preclude Inspection being required where performance benchmarks are not met.
  - iSERV will provide the outline working details for such a scheme.
- ➔ What are the main conditions for an owner to participate?
  - Completion of the iSERV spreadsheet and acceptable sub-metering

# 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

**→ So the real question is not ‘Should a MS use this route to compliance?’ but ‘Why would any MS not want to offer this as a route to compliance?’**

**→ As a commercial prospect monitoring makes sense already**



**Thank you**

Professor Ian Knight – iSERVcmb co-ordinator

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Talk available from: [www.swegonairacademy.com](http://www.swegonairacademy.com)