



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



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

Acknowledgements

iSERV

Inspection of HVAC systems through continuous monitoring and benchmarking <u>www.iservcmb.info</u> Co-ordinator: Prof. Ian Knight Cardiff University, UK 2012 - 2014



iSERV Partners and Steering Group

MacWhirter Ltd Installation, Maintenance and Energy InspectionsMacional and Kapodistrian University of Athens Indoor Air Quality expertsMacional and Kapodistrian University of Porto Image and Engineering expertsMacional and Kapodistrian University of Porto Image and Modelling expertsMacional and Kapodistrian University of Perse Image and Engineering expertsMacional and Kapodistrian Image and Kapodistrian Image and Engineering expertsMacional and Kapodistrian Image and Kapodistrian Image and LegislationMacional and Kapodistrian Image and KapodistrianMacional and Kapodistrian Image and Kapodistrian<	Welsh School of Architecture, Cardiff University Building energy use experts	PRIFYSGOL CAERDYD	K2n Ltd Energy database experts	K'n
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- 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%

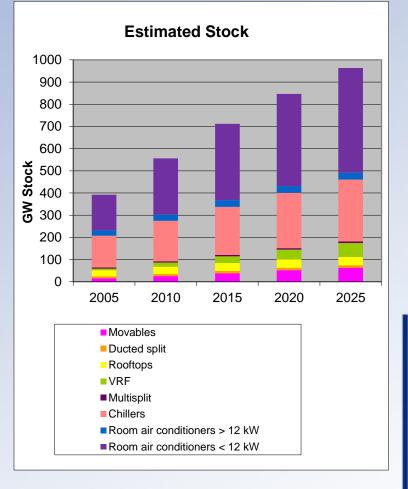
EC Joint Research Centre, Institute for Energy, 2009

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.

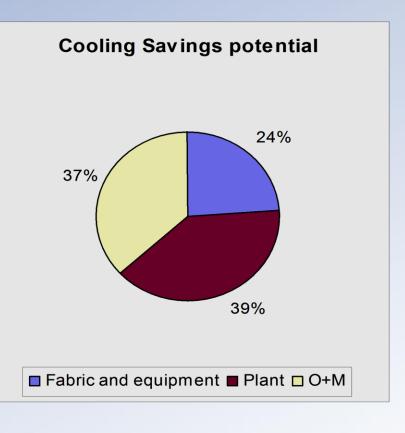


Context: Potential Energy Saving

Potential for savings through:

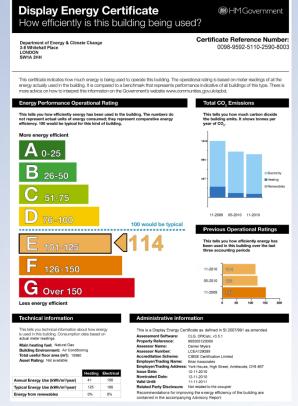
- Load reduction (24%)
- Improved efficiency (39%)Better operation (37%)

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



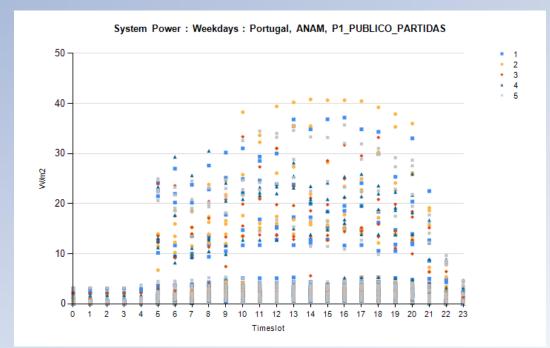
A 20th Century approach to a 21st Century problem

- 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.



A 21st Century approach to a 21st Century problem

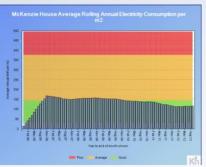
- New data sources now allow us detailed insights into how energy is used at sub-hourly intervals and by end uses.
- This level of detail is sufficient to provide confidence in what needs to be done to reduce energy use.



 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 performance of 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.

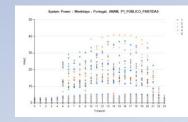


The iSERV recipe

A Spreadsheet



Sub-hourly data



+ A database

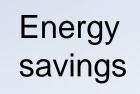


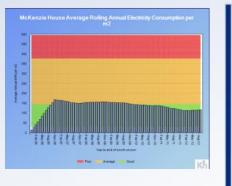
Component benchmarks



+ Targeted reports

www.iservcmb.eu		Energy Conser	vation Opportuni
Cooling Equipment / Fi	ree Cooling : Replace or Up	grade cooling equipment and	Theat pumps
	and efficiency. This is verified	ion of the chilled water pumps. I by examining the equipment's r	
Annati Savings*	Annual KWIh Savings	Annual Energy Savings	Annual CO2 Savings



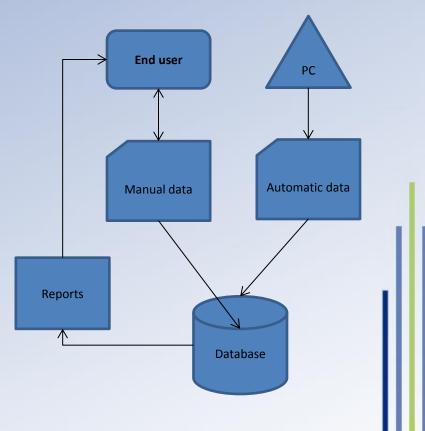


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What iSERVcmb is doing

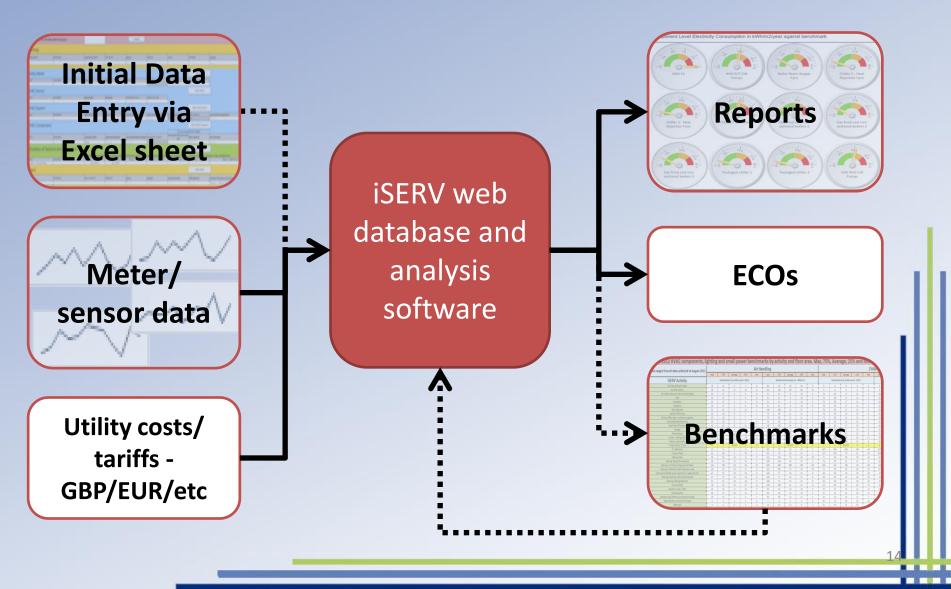
Remotely monitoring HVAC systems across Europe

- 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 easyto-add monitoring.
- Collating and analysing all data in a web-based database.



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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

Data applies from this date	(dd/mm/yyyy):			Validate	Show Instructions	FAQ	Import from CSV					
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Database

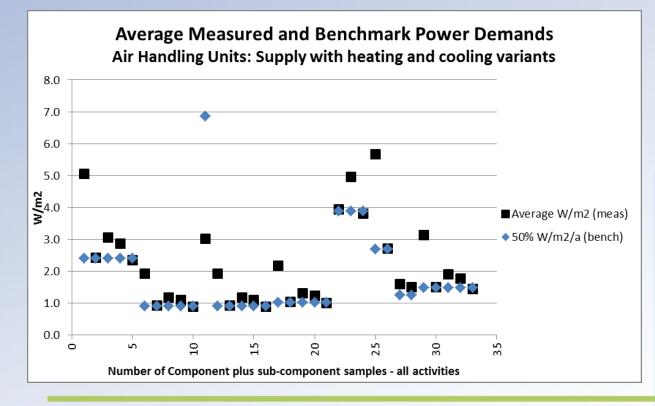
- A bespoke database has been written for the project
- Based on a commercial product
- Acts as the focus for the iSERV project elements:
 - Data collection
 - Benchmark use
 - Benchmark
 - generation
 - Reports
 - Energy
 Conservation
 Opportunity
 algorithms

Reports - Building Reports		Home				Cardiff University •
port Navigator	McKenzie H	ouse				
AA - Residences - University Hall					Description	
AB - Academic - Glamorgan and Bute	Report Type	Consumption				2 for a Building over a configurable date range. The
AC - Residences - Cartwright Court	Date Range *		Annual Consumption -			
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AI - Academic - 3 Llwyn-y-grant place	* From	January • 2002	•			
AJ - Residences - Tal-y-bont Court	*To	December • 2012	-			
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AJ - Residences - Tal-y-bont South						
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M - Outlying Cardiff sites?				use Average No	m2	PCI -
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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

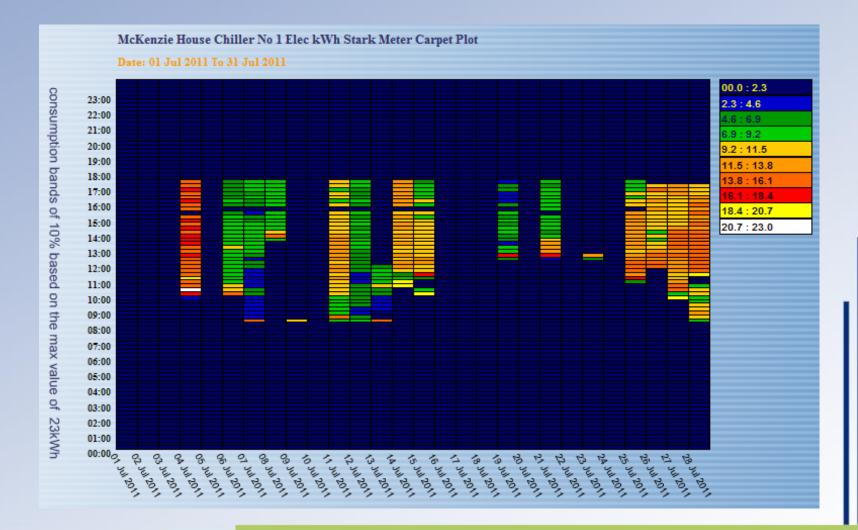


Three ways to save energy – regularly show performance

- 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

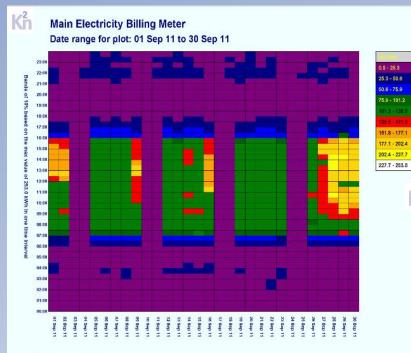


Identification of Energy Conversation Opportunities (ECOs)



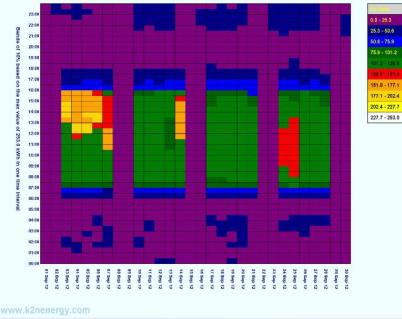
Carpet Plots – McKenzie House

K'n



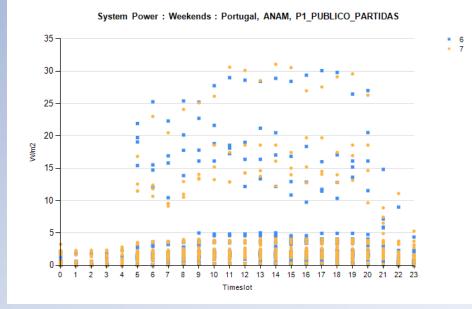
www.k2nenergy.com

Main Electricity Billing Meter Date range for plot: 01 Sep 12 to 30 Sep 12



Three ways to save energy – better control of existing plant

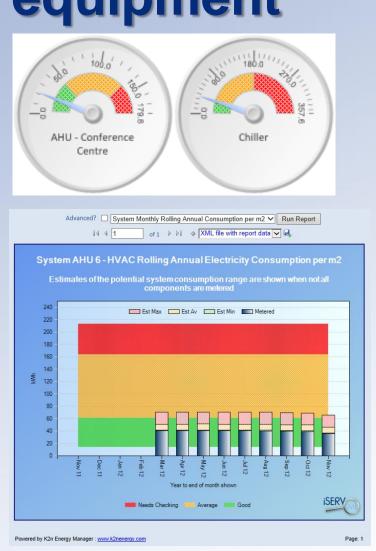
 Better control of what you already have e.g. use of ECO algorithms or scatter graphs/carpet plots to identify when systems and components are running outside of expected hours



- 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

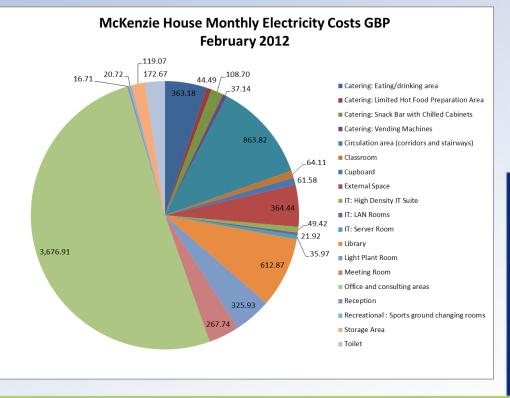
- Install more efficient equipment. Even if equipment is well controlled it may well require more power when in use than more modern equipment
- Benchmarks based on power demands when in use can help show this difference and when equipment might benefit from being upgraded



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



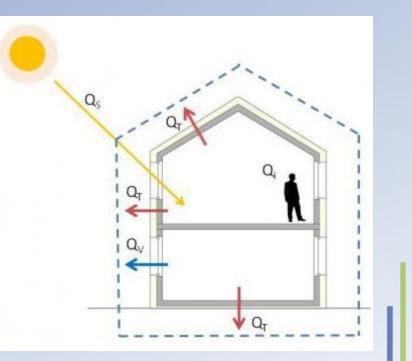


- The key is to not just present meter data but to interpret it with respect to the situation in the real building
- A number of report sets are being trialled to see which provide the information in the best form to allow

	how energy efficient are you really?	ISER CON	Insection of HVAC System	how energy efficient are you really:	ISER			energy efficient are you really
McKenzie House	Cardiff University	www.iservcmb.eu	Performa	nce Ananlysis	www.iservcmb.eu	Energy	Conservation	Opportunities
Cardiff University Estate		Rolli	ng Annual Consumption - Electricity		BEMS and controls / Miscellan	eous		
	Cardiff, United Kingdom Weather Analysis November Monthly averageT.	2000 1500		6,000 £	checks the following: It's happening	ng that HVAC components like fa	on To reduce energy consumption ns and pumps work outside the sch edule, thereby preventing energy	edule of building. This ECO algo-
A CONTRACT OF A CONTRACT	MON TUE WED THU FRI SAT SUN	§ 1000	*******	4,000£	Annual GBP Savings	Annual kWh Savings	Annual Energy Savings	Annual CO2 Savings
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google map picture bird view bing map picture	51.5N 3.2W CF24 0DE	- Consumption	- Needs Inspection - Average	f Goot	consumption of pumps and fans t	the algorithm checks the followin	d other phase changing material g: It's happening that HVAC compo nps and fans work according to the	onents like fans and pumps work
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					£560,00	3500 kWh	5.2%	800 tons
Comparison with peer systems around Europe McKenzie House uses XX% more energy than an efficient peer system in		Component	Total kWh per Average W pe m2 per annum m2	NFLE Performance				
Potential Energy Savings : 3000 kWh / year	Compared to 100 peer systems in Europe, for the period 2 th October to 3 th November 2002, McKlende	Packaged chiller 1		3 46.0% Good	General HVAC system			
Potential Cost Savings : £5000 / year	Housenariks. Housenariks efficient	Packaged chiller 2		4 57.0% Good	Shut off A/C equipment when	not needed: Description To rec	uce energy consumption of pump	is and fans the algorithm checks
Martine Contraction	xxxxkWhylear	Boiler Room Supply Fans		6 23.0% Good	the following: It's happening that checks if pumps and fans work ac	HVAC components like fans and cording to the building schedule	pumps work outside the schedule thereby preventing energy over-c	or building. This ECO algorithm ionsumption.
McKenzie House	x000c £/year	Hot Water Primary Circulators		8 34.0% Good	10000			
Below Average Peer	xxxxdWh/year	VAV AHU 2						Annual CO2 Savings
		Chiller 1 - Heat Rejection Fans		7 86.0% Needs Inspection	£560,00	3500 kWh	5.2%	800 tons
Most Efficient Peer	x000CE/yEEF	Chiller 2 - Heat Rejection Fans	85 9	7 81.0% Needs Inspection				
Bolow Average Poer Most Efficient Peer The sole responsibility for the content of this email lies with the authors. It does not necessary reflect the opinion of the European Commission are responsible for any use that may be made of the information contained therein.	xood&htyken xood&htyken xood £yken Supported by	Chiller 1 - Heat Rejection Fans	200 22.1 90 10: 85 9 the authors. It does not neces- ACI nor the European Commis-		Annual GBP Savings £560,00 The sole responsibility for the content o sally reflect the options of the European sion are responsible for any use that mu	f this email lies with the authors. It o Union. Neither the EACI nor the Eur	oes not neces-	

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

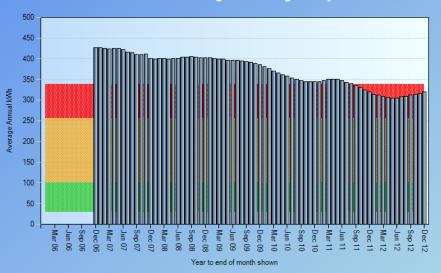
Savings in real buildings

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

McKenzie House Average Rolling Annual Electricity Consumption per m2 - Total Benchmark Ranges for Configured Systems 600 550 500 450 400 Annual kWh 350 300 250 200 150 100 50 80 0 0 0 0 0 8 8 = = ŝ = -12 -12 8 10 10 09 5 Year to end of month shown Benchmarks are for: Fire Control Panel, HVAC, Lifts, Lighting, Small Power **iSERV**

Needs Checking Average III Good

Whitefriars South Average Rolling Annual Electricity Consumption per m2 - Total Benchmark Ranges for Configured Systems



Benchmarks are for: HVAC, Lighting, Small Power Needs Checking Average IIII Good

iSERV

Monitoring savings: Case Studies

- Building electrical savings of between 19% to 33% p.a.
- Building electrical savings/m² between 61 to 100 kWh/m²/a
- In economic terms:
 - Measured recurrent savings of 9 to 14 EUR/m²/a
 - Recorded 'one-off' setup costs between 0.1 to 2 EUR/m²
 - Estimated 0.1 3 EUR/m²/a to maintain.
 - Net returns between 7 13 EUR/m²/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

Торіс	Inspection	Monitoring	Advice
Cost	100 – 250 EUR (Compliance) 0.5 – 2.5 EUR/m² (EPBD)	0.1 to 2.0 EUR/m ² setup 0.1 to 3.0 EUR/m ² ongoing	Not known
Savings	Estimate (HARMONAC) : 2.0 to 3.2 EUR/m ² 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/m ²	1.0 to 13.0 EUR/m ² /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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