Inspection of HVAC systems through continuous monitoring and benchmarking

www.iservcmb.info

Benchmarking HVAC system energy performance – the European iSERV project

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Content of talk

- History of HVAC energy efficiency and legislation
- Energy use in HVAC systems
- A practical procedure for Benchmarking energy use in HVAC systems
- Reporting energy use and ECO's in HVAC systems
- Participating in iSERV

What are the problems to solve?

- ➔ Owners want HVAC energy efficiency, but the market lacks independent proof of likely performance in use for various solutions
- ➔ Establishing energy efficient HVAC solutions that work in practice for specific activities served.
- ➔ To demonstrate clearly what energy performance is being achieved for a given activity served, and what is practically possible.
- ➔ Creating a common approach to demonstrating energy efficiencies achievable from HVAC components
- ➔ Create legislation that supports energy managers better

HISTORY OF HVAC ENERGY EFFICIENCY AND LEGISLATION

Legislative requirements

- The UK's Part L comes from local transposition of the requirements of the 2002 European Energy Performance of Buildings Directive (EPBD). The EPBD was recast in 2011 and the forthcoming Part L will reflect the changes made.
- The EPBD arose because the market was not delivering the savings needed in the buildings sector to help meet long-term energy and environmental security concerns in Europe.
- The EPBD, and its recast, is the primary legislation affecting all EU Member States' legislation aimed at reducing the energy used in Buildings

Implementation of the EPBD

➔Introduced 2002, the EPBD became law on 04/01/2006

➔The recast EPBD becomes law between 01/01 and 01/07/2013

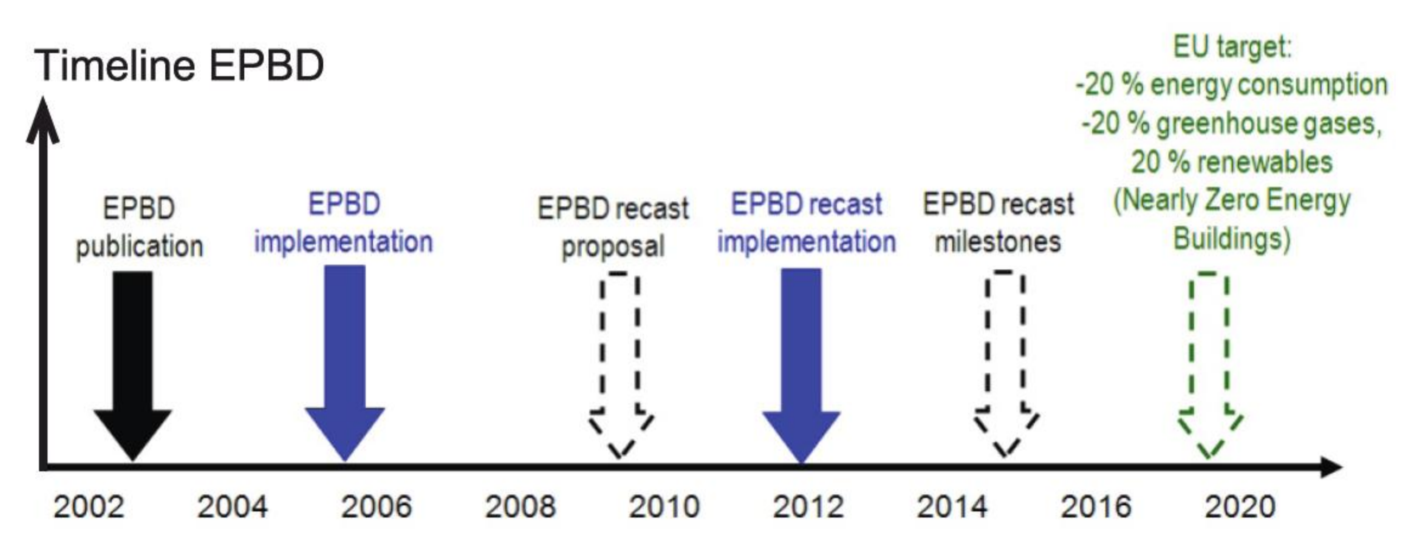


Figure 1. Timeline of the Energy Performance of Buildings Directive and its implementation.

- Taken from the REHVA Journal – March 2012

Which parts of the EPBD affect HVAC systems?

- ➔The EPBD has specific requirements for the treatment of HVAC systems within EU MS.
- ➔They are referred to as Technical Systems within the EPBD and have specific requirements for Inspection
- ➔There is also a requirement within the recast EPBD for all new buildings to be nZEB by 30/12/2020. This will have a major impact on HVAC systems, which will have a key role to play in achieving these targets.

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

Equipment	Electrical consumption as % of total EU use in 2007
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 in the EU
- EU GDP in 2007 ~ €13,500Bn. Electricity costs ~ €1,300 – 2,600Bn.
- A 10% HVAC saving is worth ~ €15 - 30Bn at €0.1 – 0.2 per kWh, or 0.1 – 0.2% of GDP, therefore primary motive for savings is improved energy security though the boost to GDP would be welcome.
- Does NOT include savings from reducing fossil fuel energy use.

Reducing energy use in HVAC systems – a practical approach

- ➔ So how do we achieve nZEB non-domestic buildings in practice?
- ➔ The rest of this talk examines a practical approach to reducing HVAC system energy use being trialled across Europe, and the history behind it.
- ➔ Whilst energy efficiency is primarily driven by monetary issues at present, paradoxically there is not a lack of money or will to invest. Rather there is a lack of understanding of where to invest to achieve long-term savings

AUDITAC: 2005 - 2007

→ AUDITAC was the first European project to look at the impact of the first EPBD on HVAC systems – specifically the inspection of AC systems aspect

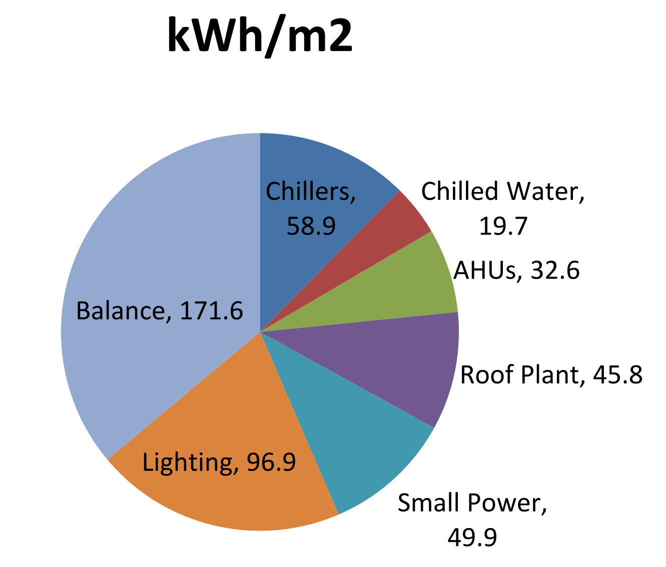
→ AUDITAC reviewed the audit and inspection process for AC systems as required by the original EPBD

→ It concluded that:

- There was little independent information on the energy consumption of AC systems in use, or what affected it
- There were insufficient high quality inspectors to undertake all the Inspections required in Europe.
- Inspections were unlikely to achieve the savings predicted or needed

HARMONAC: 2007 - 2010

- ➔ A follow-on European project, HARMONAC, obtained sub-hourly information on energy use in HVAC systems from 42 Systems in the EU
- ➔ It showed the electrical energy use of HVAC systems is typically 30 – 40% of the building total electrical use.
- ➔ HVAC generally accounts for > 90% of non-electrical energy use
- ➔ Produced data on in-use energy consumption in HVAC components
- ➔ All findings at: www.harmonac.info



Annual energy balance – One Wood Street, London

The crux of the issue…

- ➔ The two UK HQ Office buildings monitored in HARMONAC were very close in terms of occupancy type and activities.
- ➔ One was new at the start of monitoring and used the very latest ‘advice’ on trying to achieve a low energy design (variable speed drives, low fresh air rates, chilled beams, low energy daylight linked lighting, etc)
- ➔ The other was a 1988 building with that era plant and controls.
- ➔ They both used a nearly identical amount of HVAC energy per m^2.
- ➔ The benefits of 'energy efficient' HVAC **components** can potentially be negated by poor design and operating decisions.

➔ **Poor design choices can be locked into HVAC system energy performance for decades**

Operating HVAC systems efficiently

- Even when well designed, HVAC systems are often complicated and not explained well to operators.
- Sometimes they cannot be explained in a way that an operator can interpret with control actions should problems arise e.g. some are tied into the theoretical building demands and involve time lags. They therefore require faith that the building will stabilise.
- Result is that actions taken to rectify immediate complaints can have significant impacts on the actual energy use achieved.
- nZEB requirements run the risk of further complicating HVAC system design and operation

Current advice on achieving energy efficiency in HVAC systems

- ➔ With little information available on what makes an HVAC installation energy efficient in practice, then professional advice naturally tends to be based on theoretical considerations
- ➔ The history of HVAC systems until recently has been about providing the ‘right’ conditions, not reducing energy use, so we are starting from a low evidence base when trying to improve energy use.
- ➔ Many HVAC system configurations are possible. How to provide advice?
- ➔ For an HVAC system to work **efficiently** the interactions between the heating, cooling, humidification and ventilation components are crucial, as are their interactions with the climate, building fabric and occupancy.
- ➔ HARMONAC showed that a major contributor to poor energy consumption was a lack of meaningful feedback on performance.

➔ It is not yet possible to say “Just do this” and achieve an energy efficient HVAC system

HARMONAC Conclusions

- “HARMONAC… …reinforced what was already considered to be ‘good practice’, … …**necessary to have good operation, maintenance and control** of an AC system, as well as **good record-keeping** and **choice of the correct type and design of system for the end use activity**.”
- “The **key to increased long-term energy efficiency… …rests with making it cheaper for the owner to run their systems efficiently**… . This implies… …there should be a clear financial reward for good energy management e.g. by allowing systems to avoid inspection if they achieve certain standards.”
- “…there is **no real understanding in the market of the effect of AC system choice and design on the actual energy efficiency achieved** in practice”

Automatic monitoring – prospects for savings

- ➔ HARMONAC established, via metered EU Case Studies on 'real' AC systems, how many of the potential energy savings available in the systems studied were actually identified by Inspection procedures
- ➔ HARMONAC showed **Inspections identified about 37% of the energy savings shown to be present by the more detailed sub-hourly monitoring**
- ➔ The overall **average energy savings possible in the Case Study AC systems investigated were assessed as being between 35 – 40%**, or around 10% of the primary energy use of the buildings in which they were located
- ➔ Automatic monitoring allows **continuous feedback** on performance, thereby **achieving savings and, hopefully, maintaining them**.

HARMONAC Impact

- ➔ HARMONAC's results led to HVAC Inspection requirements changing from Article 9 in the original EPBD to Articles 15 and 16 in the recast EPBD. These new articles allow alternatives to physical Inspection based on automatic monitoring. The project also led to a more general emphasis on automatic monitoring and control systems in the recast EPBD as a whole
- ➔ This transfer of emphasis from 'reacting' to legislation to 'actively' demonstrating efficiency is likely to be reinforced as we move towards 2020.
- ➔ HARMONAC and iSERV account for over €5M of funding and are the two largest projects ever funded under the EC's IEE funding stream. They carry a great deal of weight.

ENERGY USE IN HVAC SYSTEMS

Confidence!

- The key to investment in, and achieving, increased HVAC energy efficiency, is to provide confidence that any proposals will deliver the required savings ‘in use’.
- Recent experience with design predictions have shown that the predicted energy efficiency is rarely achieved in practice.
- To provide this confidence we need to provide up-to-date examples of how the required energy efficiency is being achieved in real buildings, so that this information in turn can inform and improve the modelling process.
- A framework and procedure which allows us to capture, compare and continuously update information from diverse activities and servicing solutions is also required.

iSERVcmb – the continuous monitoring and benchmarking of HVAC systems

- ➔ www.iservcmb.info At €3.3M iSERV is the largest EC project ever funded under the IEE funding stream
- ➔ iSERVcmb's philosophy can be summarised as:
- ➔ **You can't manage what you don't measure**
  - We need data to understand HVAC system operation
- ➔ **You can't control what you don't understand**
  - Often, little information exists on the HVAC system components, where they serve, the system design intent or the expected energy performance
- ➔ **Data should lead to decisions, not graphs**
  - Energy management systems are producing so much data that we struggle to see the picture. Insight is needed.

HVAC energy efficiency - practice

➔ The basic question that iSERV tries to answer is:

‘Is the energy being consumed by an HVAC system reasonable for the activities it serves?’

iSERV aims

➔iSERV end goals:

- Establish a European framework for describing, monitoring and benchmarking HVAC system components against the activities they serve on a continuous basis
- Establish a first version of these benchmarks
- Highlight HVAC solutions that achieve low energy in use
- Allow the HVAC sector and end users to take responsibility for reducing HVAC energy use long-term.
- Reward good behaviour by reducing the legislative burden on HVAC systems and buildings which meet bespoke benchmarks

Anticipated iSERV project outputs and impacts

- ➔ Establish iSERV approach as a complement to Inspection
- ➔ Allow end users to access ECOs specific to their HVAC systems
- ➔ Reward good system design and operation
- ➔ Electricity savings of between 5 – 60% per system anticipated
- ➔ Electricity savings of between 5 – 15% on average
- ➔ Savings expected to be maintained c.f. Inspection reductions
- ➔ Establish that end users and manufacturers can help meet energy reduction goals when allowed to participate in setting targets to be achieved
- ➔ CIBSE and REHVA to use this information to produce professional guidance.

Background to iSERV

Energy Efficiency – Accountability, Responsibility and Engagement

- How do we account for it?
- Whose responsibility is it to achieve it?
- How do we engage with it practically?

What are buildings for?

- ➔ We construct environments (buildings) in which to undertake activities. Energy use is a direct effect of these activities.
- ➔ Energy efficiency is therefore always bound by the requirements of these activities. Providing the wrong environment needed for the activities is counterproductive to the wider needs of the organisation
- ➔ Energy efficiency can therefore only be properly evaluated when put into the context of the activities served

What we need to know therefore is:

‘How much energy is it appropriate to use for a given activity?’

What affects energy use? Role of the occupant

➔ A number of studies (IEE Projects including HARMONAC, Carbon Trust, etc) have shown that engaging end users can achieve significant savings (up to 30%) in electricity use.

➔ The energy balance equation discussed in the forthcoming slides clearly shows the importance of the internal gains, and hence activities, in the overall building energy demands.

➔ Any good energy management system must therefore provide Responsibility and Accountability for energy use, along with ongoing Engagement of the people responsible for this use.

What affects energy use?
Building energy losses and gains

- Energy use in buildings arises as a result of the continuous interactions between the following energy components:

$$Q_i + Q_s \pm Q_c \pm Q_v \pm Q_{st} \pm Q_{lat} \pm Q_m = 0$$

- **Q_i** – internal gains
- **Q_s** – solar gains
- **Q_c** – conduction losses or gains
- **Q_v** – ventilation losses or gains
- **Q_{st}** – energy stored or released from the fabric
- **Q_{lat}** – latent energy losses or gains, and
- **Q_m** – mechanical energy used to make up any overall energy losses or gains to achieve required internal conditions

New and Near Zero Energy Buildings

→ New and nZEB need a design balance to be struck between the energy components to minimise energy consumption

→ Q_c and Q_{st} in non-domestic new and nZEB are usually negligible compared to Q_v and Q_i (and Q_s if not well handled). Q_{lat} can be significant dependent on location and activities.

→ Assuming Q_c, Q_{st} and Q_{lat} can usually be ignored, minimising Q_m requires good control of Q_v to balance Q_i where possible

$$\mathbf{Q_i \pm Q_v \ (+ \ Q_s) = \pm \ Q_m}$$

→ Demand Controlled Ventilation (DCV) and other techniques for controlling Q_v are therefore becoming a major focus for reducing energy use in new buildings

The transition to nZEB

- ➔ The reality check of what it is actually possible to achieve in operational buildings is crucial for the transition to nZEB as clearly some activities cannot be zero energy by their nature.
- ➔ It is important we do not have inappropriate legislation for meeting ‘nZEB’ status that does not recognise these issues, otherwise the legislation becomes impossible to implement.
- ➔ iSERVcmb intends to provide a first version of these ‘in-use’ benchmarks as part of the transition to nZEB buildings.
- ➔ The CIBSE Technical Committee met on the 12th July 2012 to formulate a definition of nZEB buildings for consideration by the EC.

Definition of nZEB?

➔ CIBSE's proposed definition of a nZEB is:

'Technically and reasonably achievable energy use of > 0 kWh/(m^2 a) primary energy, achieved with a combination of energy efficiency measures and renewable energy technologies.'

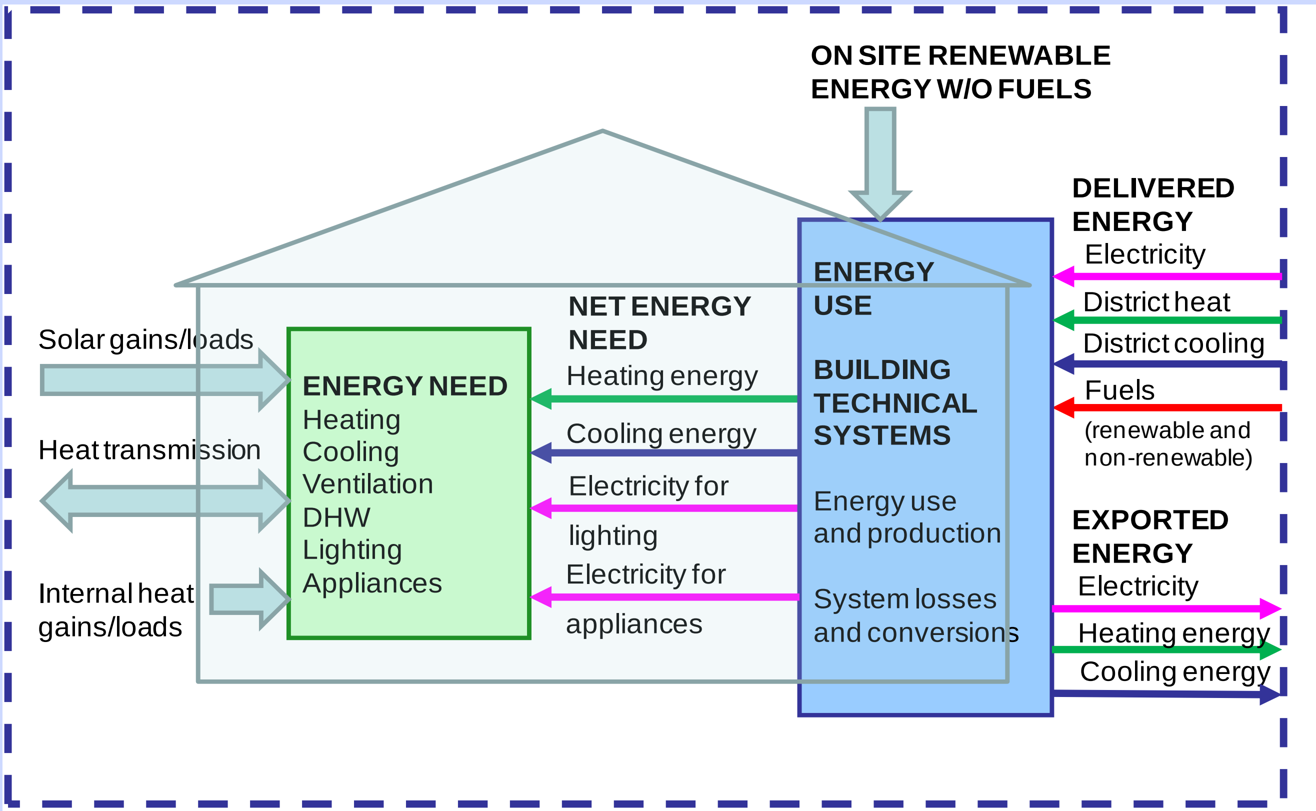
'Footnote: 'reasonably achievable' means by comparison with national energy use benchmarks appropriate to the activities served by the building, or any other metric that is deemed appropriate by each EU Member State.'

➔ As a full Partner in iSERVcmb, CIBSE intends to use the benchmark ranges derived from iSERV as part of its professional guidance to its members of what is 'reasonably achievable'. Guidance should arrive from 2014 onwards.

nZEB from Jan 2019 onwards

➔ Near Zero Energy Buildings (nZEB) will be required from 2019

➔ Still not clear what the final legal definition of nZEB will be



Building site boundary = system boundary of delivered and exported energy

- taken from REHVA proposals for nZEB definition June 2012

Are nZEB feasible?

➔ German housing energy use trends appear to suggest 'Yes'

➔ Not yet clear how far we can reduce energy use in non-domestic buildings due to the wide variety of activities, but iSERV should help provide achievable target ranges

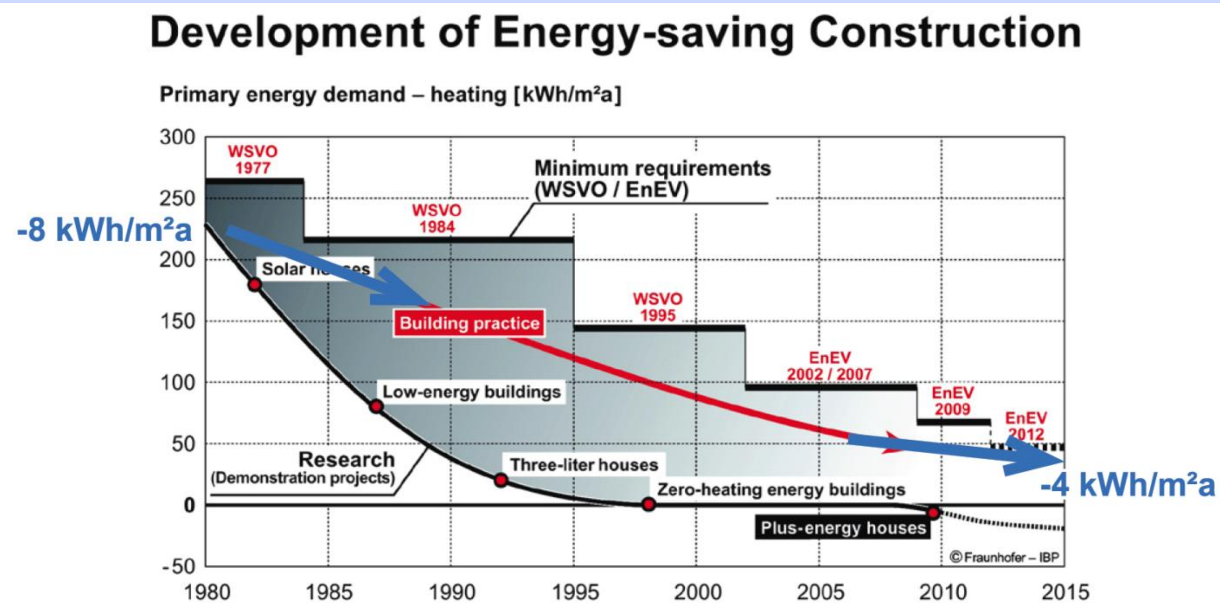


Figure 2. The development of the energy-saving construction in Germany showing the minimum energy performance requirements (upper line), the high performance pilot projects (lower line) and the innovative building practice (middle line) over the last 35 years.

- Source: REHVA Journal March 2012

Building Information Modelling (and Management)

- BIM(M) is inevitably how building information will be organised in the future, and will be useful in many aspects of Facilities Management.
- However, modelling is not yet a good way of predicting energy use in buildings as the input parameters needed for accurate prediction are too difficult to obtain once you put people into buildings e.g. actual ventilation rates achieved.
- Real ‘in-use’ data is required to enable prediction techniques to move forward using statistically valid datasets which enable us to fill in some of the ‘input’ gaps.
- As noted later, this data should distinguish between activity and services use.

A PRACTICAL PROCEDURE FOR BENCHMARKING ENERGY USE IN HVAC SYSTEMS

Appropriate benchmarks of energy performance

- ➔ Past energy benchmarks have been vague to reflect the difficulty of obtaining energy use data as well as the relative unimportance of energy in the operation of an organisation
- ➔ This situation no longer exists and, as we move towards requiring nZEB buildings in the near future, it is time to revisit the benchmarks needed to achieve this target.
- ➔ The equation shown previously clearly implies that any benchmark system should relate energy use to the activity undertaken in a space, along with an indicator of the overall 'size' of the activity – usually floor area.
- ➔ Weather conditions may also be required, but the building itself is considered part of the efficiency opportunities

Existing Buildings

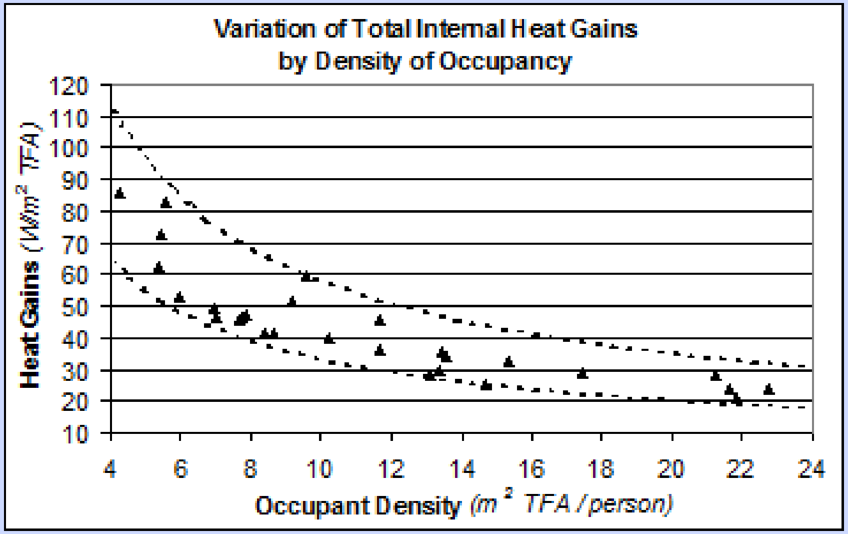
- Existing Buildings are already being required to improve insulation levels and many have done so within the constraints imposed by the building.
- However, while insulation is still a valuable tool, in many cases it is establishing control over solar gains, ventilation and infiltration in existing buildings which will now provide the greatest energy efficiency rewards.
- A new approach to the building regulations is also needed to achieve low energy buildings in practice, as single issue policies are no longer appropriate as the energy balance equation shows.

Accounting for Energy Use - Assigning Responsibility

➔ Energy use in buildings splits logically into two areas:

- The energy use consumed and required by the occupants of the building when undertaking the activities for which the building is operated
- The consequent energy use of these activities i.e. energy consumed by the services to provide the conditions required for the activities.

➔ Practically therefore we need to assess the energy use in buildings from these two viewpoints



Practical benchmarks

- ➔ Legislative drivers and signals are important in affecting energy use in practice as they require compliance.
- ➔ What we struggle with at present is providing practical, 'legislation friendly' benchmarks for the energy efficiency possible in buildings **with a specific mix of end use activities**
- ➔ If we cannot provide this information then widespread nZEB 'in use' buildings will not be realisable by 2019.
- ➔ Discussions are underway with the EU on how iSERV will contribute to these benchmarks.

The iSERVcmb process

➔ In a previous slide we noted that energy management and energy accounting should logically be split into two areas:

- Energy used by the occupants and their activities
- Energy used by the building 'services'

➔ This requires benchmark ranges for:

- The energy consumed by the activities undertaken in the spaces i.e. small power, lighting and process load benchmarks
- The HVAC services in meeting the requirements of those activities i.e. HVAC component benchmark by activity

➔ iSERVcmb provides a process and procedure for describing the spaces/activities plus meter and services arrangements in a building to acquire some of these benchmarks across the EU

iSERV Partners and Steering Group

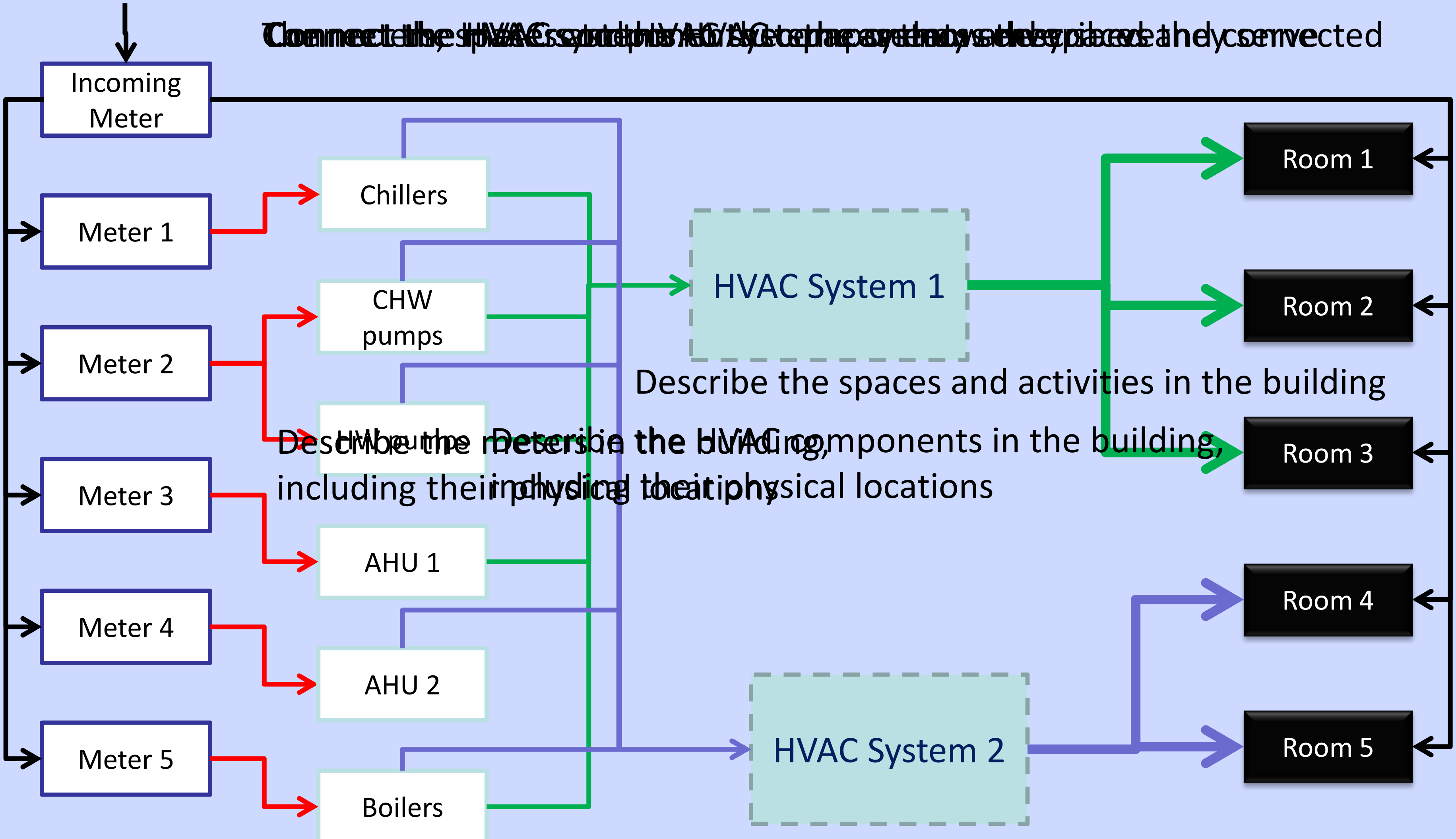
Welsh School of Architecture, Cardiff University Building energy use experts		**K2n Ltd** Energy database experts	
MacWhirter Ltd Installation, Maintenance and Energy Inspections		**National and Kapodistrian University of Athens** Indoor Air Quality experts	
University of Porto HVAC and Engineering experts		**Politecnico di Torino** HVAC and Engineering experts	
Université de Liège HVAC and Modelling experts		**Univerza v Ljubljani** HVAC and Engineering experts	
University of Pecs HVAC and Engineering experts		**Austrian Energy Agency** Dissemination and Legislation	
REHVA HVAC Professional Body		**CIBSE** HVAC Professional Body	
SKANSKA Building Developer		**Camfil Farr** Filter manufacturer	
SWEGON AHU System manufacturer			

iSERV data basics

➔iSERV collates information in a way that is rarely done for HVAC systems at present:

- It catalogues the HVAC components, meters and sensors
- It describes the spaces, areas and activities served by the HVAC systems
- It links all these elements together to describe the HVAC system components in terms of areas and activities served
- It provides a web-based system to collate all this information and to receive the sub-hourly metered data to describe the HVAC systems’ on-going performance.

The iSERV setup process



iSERV data entry sheet

- Part of the iSERV Excel-based data entry sheet is shown below
- The sheet is endorsed by CIBSE and REHVA as an accepted means of recording information about HVAC systems

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

Building

Building Name*	Description	Organisation Name*	Site Name*	Sector*	Address*	Town*	Postcode*	Country*
				<Ctrl-↓>				<Ctrl-↓>

Utility Meter

Add a Meter

Name*	Description	Meter Type*	Unit Type*	Multiplier	Space Where Located	Unique Meter Id*	Parent Meter Name
		<Ctrl-↓>	<Ctrl-↓>				<Ctrl-↓>

HVAC Sensor

Add a Sensor

Name*	Description	Sensor Type*	Unit Type*	Duct/Pipe Area m2	Unique Sensor Id*
		<Ctrl-↓>	<Ctrl-↓>		

HVAC System

Add a HVAC System

Name*	Description	Main HVAC System*	HVAC Type*	System Classification*	System Sub-classification*	Sensor Name(s)	Meter Name(s)	Control Of Flow Temperature
		<Ctrl-↓>	<Ctrl-↓>	<Ctrl-↓>	<Ctrl-↓>	None	None	<Ctrl-↓>

HVAC Component

Add a HVAC Component

						Or* but preferably both if available		
Name*	Description	Component Type*	Component Sub-type*	Serves which HVAC System(s)*	Space Where Located	Nominal Electrical Power Input (KW)	Meter Name(s)	Sensor Name(s)
		Pumps	<Ctrl-↓>	<Ctrl-↓>			<Ctrl-↓>	<Ctrl-↓>

Schedules of Setpoint and Occupation

Add a Schedule

To configure the schedule details please enter dates into the applies from or applies to cells below and then double click - this will take you to the schedule on the schedules tab

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
Schedule 1 - Whole Building		01/01/2012	31/12/2012					

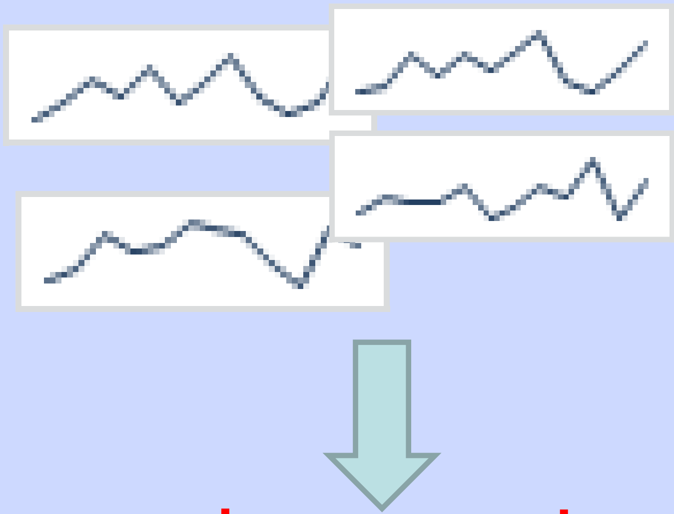
Space

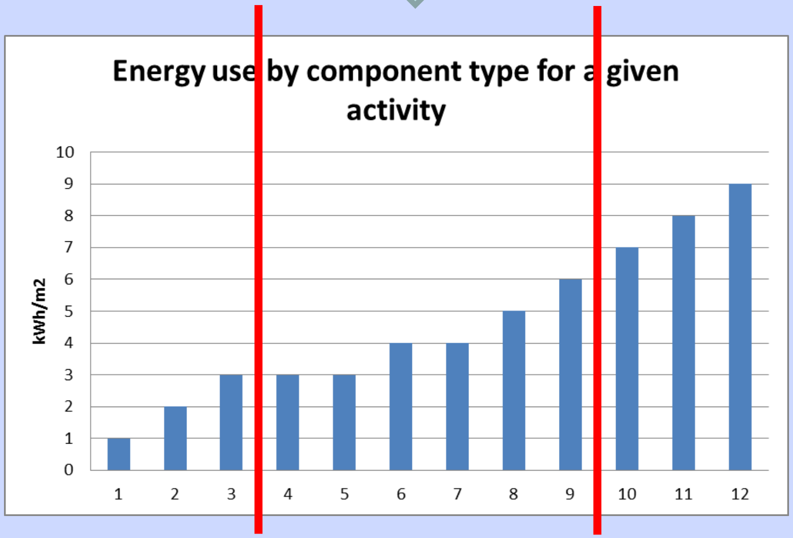
Add a Space

Name*	Description	Floor Area (m2)*	Height (m)	Sector*	Activity*	Served By HVAC(s)	Utility Meter(s)	Schedule of Setpoints, RH and Occupancy
				<Ctrl-↓>	<Ctrl-↓>	<Ctrl-↓>	<Ctrl-↓>	Schedule 1 - Whole Building

Deriving benchmarks

- ➔ iSERV derives benchmarks by collecting and collating energy use data from HVAC component types servicing the same end use activity in different buildings and areas
- ➔ This data then provides ranges of achieved performance by a component for a given activity
- ➔ Benchmark thresholds are initially set at the upper and lower quartiles of this data





iSERV benchmark types

➔ It is intended to produce ranges of benchmarks by activity at the levels of:

- Annual energy consumption per m^2 ($kWh/m^2.a$)
- Monthly energy consumption per m^2 ($kWh/m^2.month$)
- Peak and average power consumptions in use (W/m^2)

➔ Initially, range boundary figures for the upper and lower quartiles of the measured data will represent the boundaries between 'good':'average' and 'average':'needs inspection' energy performance

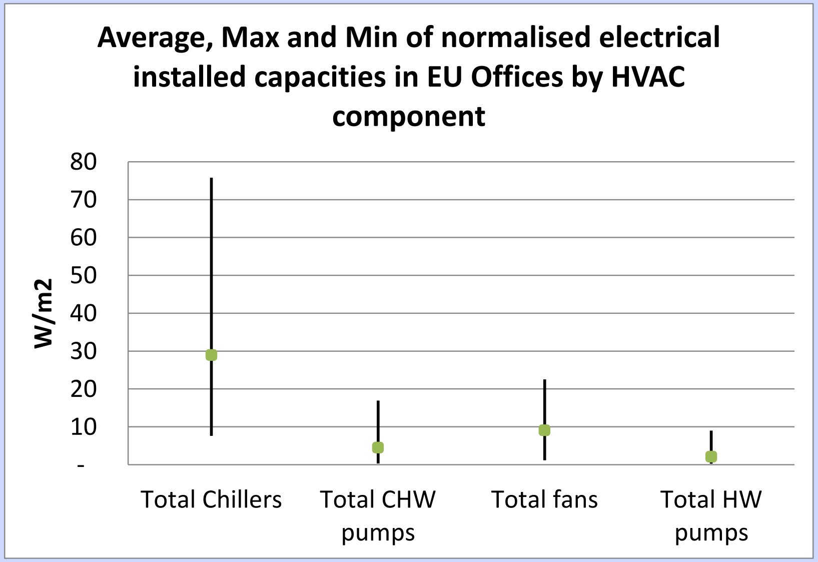
➔ The wording of the performance 'achieved' may change to reflect actions needed

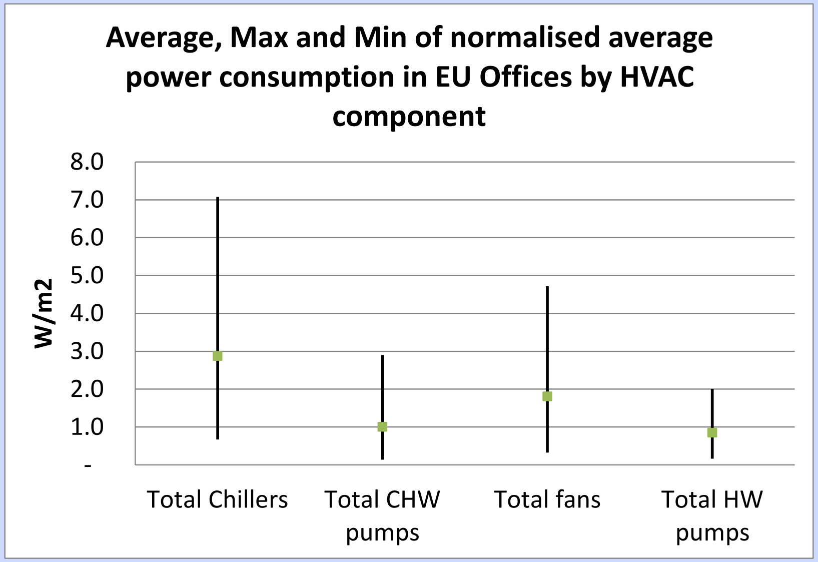
Use of benchmarks

- ➔ These 3 different benchmarks cover various possibilities for assessing energy use from the recorded data
- ➔ The normalised annual energy use is likely to be the benchmark for legislation
- ➔ The monthly energy use and power benchmarks are the most useful for diagnosing Energy Conservation Opportunities
- ➔ As these benchmarks are obtained from buildings in use from around Europe they represent what can be **achieved** in buildings at this moment in time.
- ➔ This makes them powerful in terms of setting realistic legislation standards for expected performance of HVAC system energy use in 'as-built' buildings

Initial energy use ranges by HVAC component - HARMONAC

- ➔ HARMONAC (2007 – 2010) produced data on the European ranges of installed HVAC component loads per m^2, and the consumptions per m^2 recorded in the offices studied.
- ➔ The activities served in the Offices were not recorded in detail
- ➔ The data shows that average power demand by component was between 10 – 20% of Full Load Equivalent over a year





Initial HVAC components, lighting and small power benchmarks

- An initial set of installed power and annual energy use benchmarks by activity for AHU's, Chillers, CHW Pumps, HW Pumps, DHW Pumps, Humidifiers, Boilers, Lighting and Small Power is being assembled from existing sources and collected data.
- Complete by mid-September 2012, this data will be used to obtain the first bespoke benchmark ranges for those buildings and HVAC systems supplying data to iSERV

August 2012 HVAC components, lighting and small power benchmarks by activity and floor area. Max, 75%, Average, 25% and Min table

Table ranges from all data collected to August 2012	Air Handling										Chillers						
	max	75%	average	25%	min	max	75%	average	25%	min	max	0.75	average	0.25	min	max	0.75
iSERV Activity	Installed power by activity served - W/m2					Activity electrical-energy use - kWh/m2.a					Installed power by activity served - W/m2					Activity ele	
Car Park (Office/Private)	19	15	9	7	3	63	49	28	20	5	0	0	0	0	0	0	0
Car Park (Public)	39	31	17	14	6	241	184	107	69	12	0	0	0	0	0	0	0
Circulation area (corridors and stairways)	23	17	5	6	0	41	31	8	10	0	76	58	17	21	3	62	47
Lifts	23	17	5	6	0	41	31	8	10	0	76	58	17	21	3	62	47
Escalators	23	17	5	6	0	41	31	8	10	0	76	58	17	21	3	62	47
Reception	23	17	5	6	0	41	31	8	10	0	76	58	17	21	3	62	47
Waiting Rooms	42	32	9	11	1	140	106	24	37	3	76	59	27	25	8	62	47
Cellular Office Area	23	18	9	7	1	76	58	21	21	3	76	59	24	25	8	62	47
Cellular Office Area - multiple occupation	23	18	9	7	1	76	58	21	21	3	76	59	24	25	8	62	47
Consulting/treatment room	23	18	9	7	1	76	58	21	21	3	76	59	24	25	8	62	47
Open Plan Office Area	42	32	9	11	1	140	106	24	37	3	76	59	27	25	8	62	47
Lounges	42	32	9	11	1	140	106	24	37	3	76	59	27	25	8	62	47
Meeting Room	58	44	13	15	1	180	136	34	47	3	76	59	31	25	8	62	48
Library - reading room	65	50	13	18	3	270	204	49	72	6	78	63	38	32	17	58	44
Library - open stacks	18	14	6	5	1	69	52	21	19	2	78	60	29	24	6	39	30
IT: High Density IT Suite	0	0	#DIV/0!	0	0	0	0	#DIV/0!	0	0	0	0	#DIV/0!	0	0	0	0
IT: LAN Rooms	11	8	3	3	1	93	70	26	24	1	657	503	266	194	40	2335	1767
IT: Server Room	52	39	3	13	1	93	70	26	24	1	127	105	79	62	40	844	649
Catering: Bars	29	23	16	11	5	131	103	73	46	18	71	59	39	36	24	63	49
Catering: Eating/drinking area	58	44	13	15	1	180	136	34	47	3	76	59	31	25	8	62	48
Catering: Full Kitchen Preparing Hot Meals	134	109	112	58	32	600	480	500	240	120	308	263	196	174	129	165	132
Catering: Limited Hot Food Preparation Area	29	23	16	11	5	131	103	73	46	18	71	59	39	36	24	63	49
Catering: Kitchenette (small appliances, fridge and sink)	47	37	19	16	6	100	77	44	31	8	66	56	40	36	26	19	15
Catering: Snack Bar with Chilled Cabinets	47	37	19	16	6	100	77	44	31	8	66	56	40	36	26	19	15
Catering: Vending Machines	47	37	19	16	6	100	77	44	31	8	66	56	40	36	26	19	15
Lecture theatre	78	61	34	27	11	140	108	61	44	12	117	99	69	63	45	34	27
Assembly areas / halls	34	26	11	10	3	56	43	19	16	3	45	37	23	22	14	16	12
Teaching Areas	35	27	13	11	4	60	46	23	19	5	51	43	25	26	17	17	13
Spectator area (theatres and event buildings)	19	15	4	5	1	63	48	13	17	2	32	26	13	13	7	36	28
Stage (theatres and event buildings)	3	2	1	1	0	7	5	2	2	0	92	73	36	35	16	146	112
Bathroom	5	4	4	3	2	16	14	13	9	7	51	43	24	26	17	11	9
Toilet	5	4	4	3	2	16	14	13	9	7	51	43	24	26	17	11	9
Bedroom	25	19	11	9	4	210	165	90	76	31	43	36	22	22	15	43	34
Laboratory	71	54	28	21	5	155	121	65	53	18	120	96	64	48	23	59	49
Laboratory with fume cupboards	0	0	#DIV/0!	0	0	0	0	#DIV/0!	0	0	0	0	#DIV/0!	0	0	0	0
Laboratory - Sterile	0	0	#DIV/0!	0	0	0	0	#DIV/0!	0	0	0	0	#DIV/0!	0	0	0	0
Workshop	56	43	23	19	7	153	120	64	53	20	75	64	45	41	30	26	21
Retail Warehouse Sales area - chilled	19	15	6	6	1	80	61	27	22	3	36	29	20	14	7	26	20
Retail Warehouse Sales area - electrical	19	15	6	6	1	80	61	27	22	3	36	30	22	17	11	39	30
Retail Warehouse Sales area - general	19	15	6	6	1	80	61	27	22	3	36	30	22	17	11	39	30

REPORTING ENERGY USE AND ECOS IN HVAC SYSTEMS

Making sense of the data

➔ iSERV will process the information provided to the database by individual systems to produce:

- Bespoke benchmarks per HVAC component and system
- Clear reports – including benchmark and exception reports
- Suggestions for Energy Conservation Opportunities

➔ From analysing the data for the 1600+ HVAC systems iSERV will also:

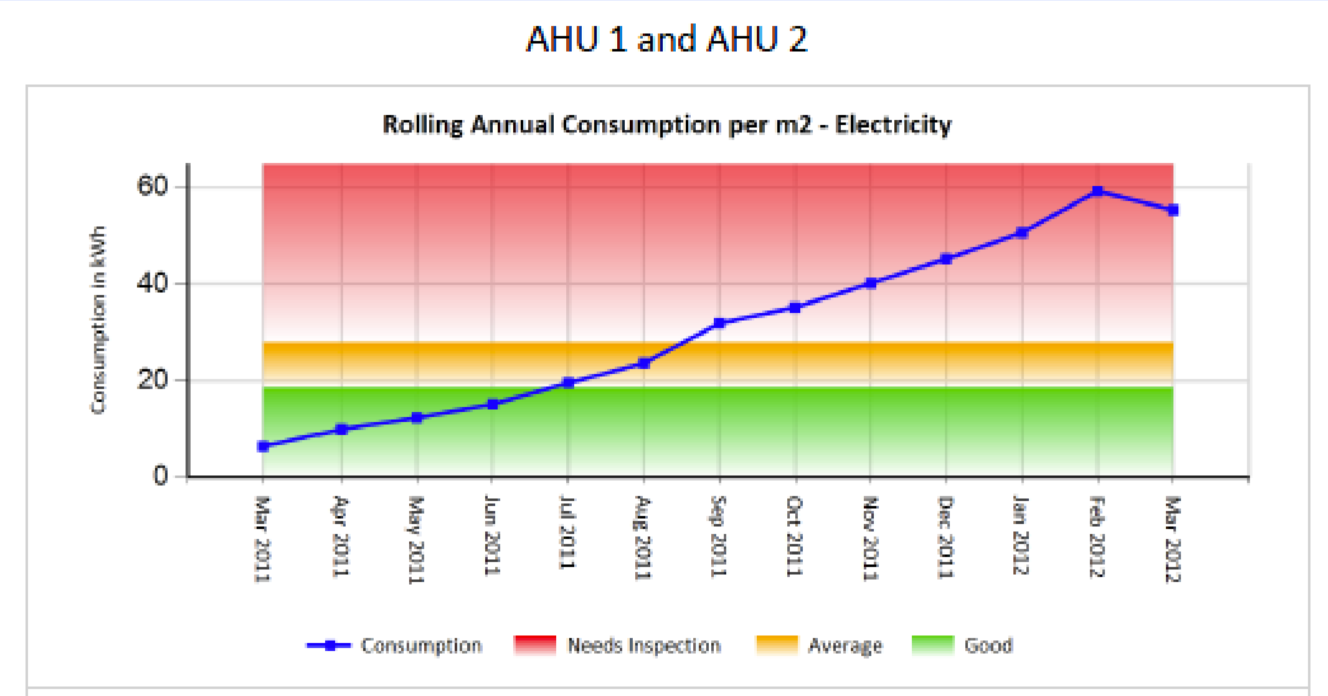
- Note what 'works' in practice – technology neutral
- Produce on-going benchmarks over time for use in legislation and professional guidance
- Update and add to the ECO's

Prototype reports

- ➔ The following 6 slides illustrate the types of report which can be derived from the iSERV system.
- ➔ These are prototype reports at present and further report types will emerge as the data analysis reveals how best to achieve efficiency in system operation
- ➔ In particular it is anticipated that the following report types will become available:
  - Separate reports aimed at the occupants and services operators.
  - Cost-based reports aimed at finance managers
  - Carbon-based reports for compliance purposes
  - Reports aimed at the EPBD Inspection process needs

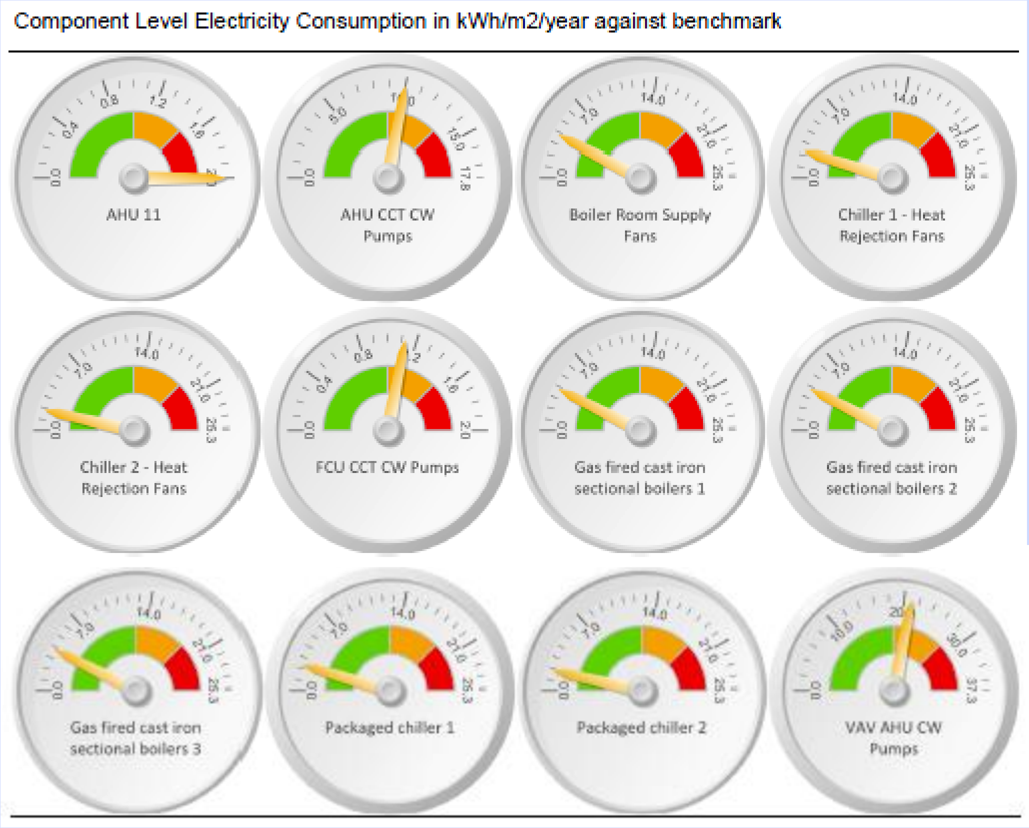
HVAC System Report

➔ Overview of whole HVAC system performance against bespoke benchmarks predicted for mix of activities served



HVAC Component Reports

- ➔ Individual HVAC component normalised annual energy use against energy use ranges predicted by component for the mix of activities served



Energy Conservation Opportunity (ECO) Reports

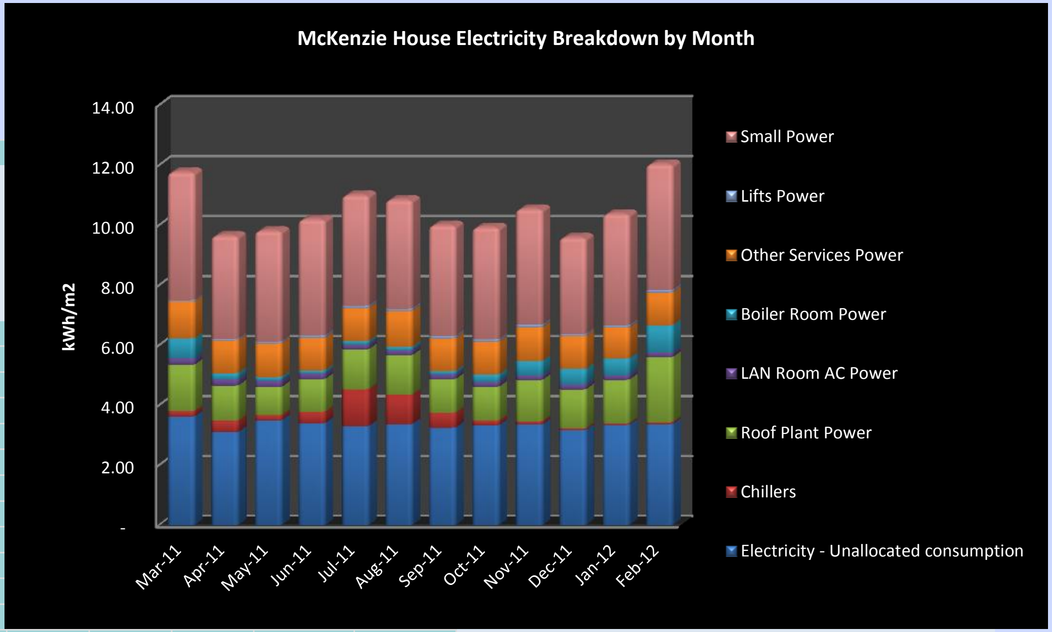
- Another unique feature of iSERV is its ability to take the measured data for the HVAC components along with other characteristics of the HVAC components and spaces, and suggest potential ECOs that could reduce the energy use of the specific HVAC system.
- iSERV will provide an indication of the likely energy, carbon and cost savings to be achieved for each ECO.
- ECO reports maximise the value of submeters, and help reduce the analysis time needed by the energy manager to understand his HVAC system.

Example outputs from iSERV data – monthly data

McKenzie House Conditioned Floor Area/m2 = 8434.93

All Figures in kWh/m2

Month	Electricity - Unallocated consumption	Chillers	Roof Plant Power	LAN Room AC Power	Boiler Room Power					
Mar-11	3.62	0.18	1.54	0.21	0.67					
Apr-11	3.10	0.38	1.17	0.21	0.21					
May-11	3.49	0.18	0.93	0.21	0.13					
Jun-11	3.39	0.39	1.09	0.18	0.11					
Jul-11	3.29	1.24	1.33	0.17	0.11					
Aug-11	3.36	0.98	1.32	0.17	0.11					
Sep-11	3.25	0.50	1.12	0.16	0.11					
Oct-11	3.33	0.15	1.13	0.17	0.25					
Nov-11	3.36	0.11	1.37	0.16	0.48					
Dec-11	3.17	0.06	1.30	0.17	0.52					
Jan-12	3.34	0.05	1.45	0.16	0.55					
Feb-12	3.37	0.07	2.16	0.16	0.90					
Total Mar-11 to Feb-12	**40.1**	**4.3**	**15.9**	**2.1**	**4.1**	**13.3**	**0.8**	**45.0**	**125.7**	**257.0**

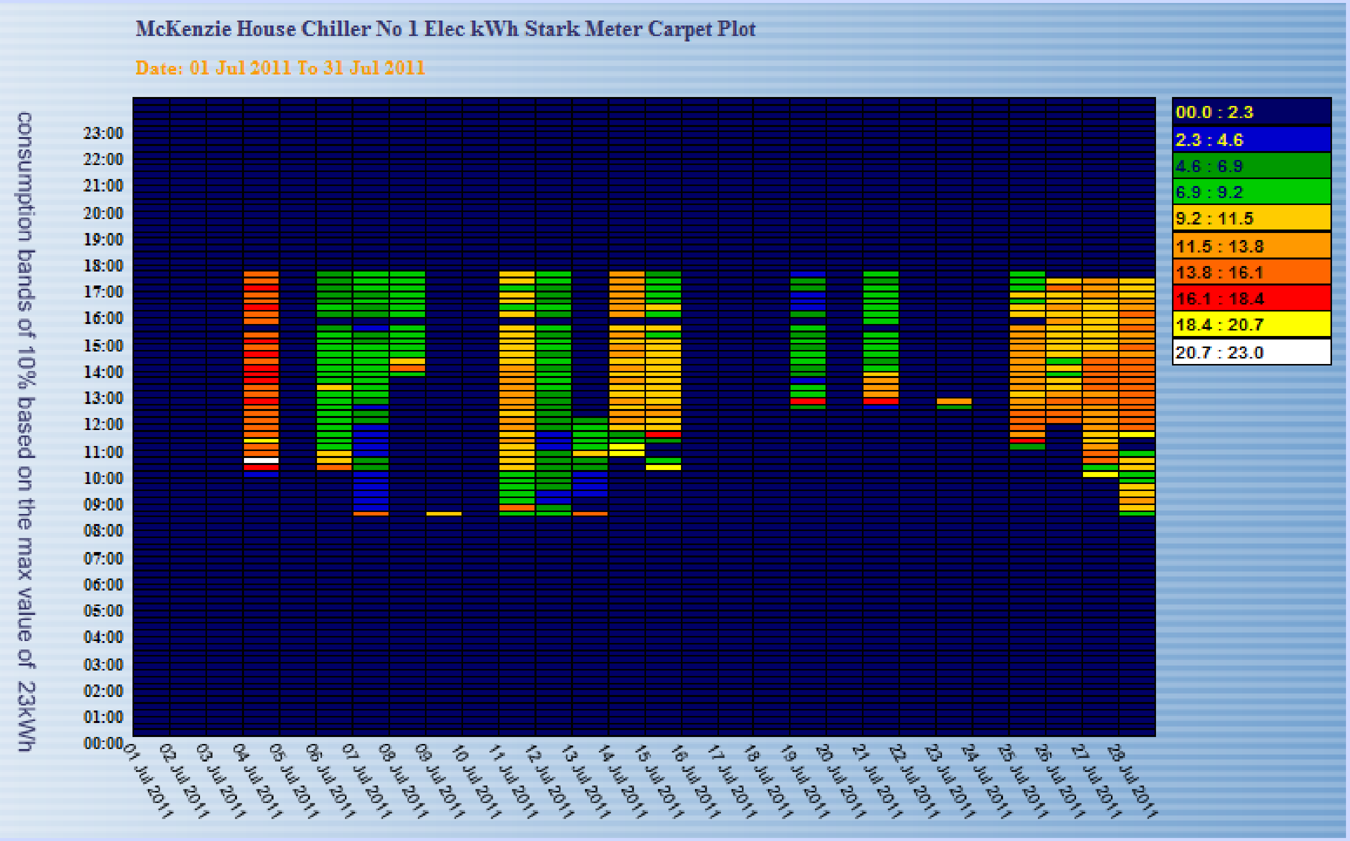


Sum of Std_Month_ Consumption

Month	Blr 1 Cumulative	Blr 2 Cumulative	Blr 3 Cumulative	Chiller 1 cum power	Chiller 2 cum power	Clean Supply DB cum power	DB Floor 2 cum power	DB Floors 1&3 cum power	DB Ground cum power	Fire Panel cum power	Lan Room AC cum power	Landlords DB cum power	Lift 1 cum power	Lifts 2&3 cum power	Main Incomer CP	MCP 4th Plant cum power	MCP Boiler Plant cum power	MCP Central services	MCP Dining cum power
Mar-11	5,956.81	316,373.75	9,614.31	986	561	37	-	10,993	-	1	1,792	-	206	253	99,253	207	5,623	567	622
Apr-11	2,919.58	18,340.97	3,903.47	1,846	1,374	47	-	9,154	-	1	1,734	-	1	412	81,365	177	1,772	534	628
May-11	791.39	3,443.61	1,058.75	1,042	464	49	-	9,661	-	1	1,792	-	24	490	82,732	188	1,062	561	859
Jun-11	-	-	-	1,868	1,382	12	-	9,904	-	1	1,543	-	249	416	85,947	176	907	574	559
Jul-11	-	-	-	5,326	5,092	22	-	9,299	-	2	1,400	-	276	388	92,747	185	930	537	488
Aug-11	-	-	-	4,555	3,730	1	-	9,455	-	-	1,401	-	259	371	91,448	182	961	560	548
Sep-11	224.58	224.58	-	2,561	1,651	13	-	9,341	-	2	1,356	-	270	382	84,318	177	935	542	529
Oct-11	2,481.11	246,988.19	3,443.61	806	498	17	-	9,422	-	1	1,403	-	272	378	83,722	185	2,079	536	514
Nov-11	4,320.56	73,631.25	6,523.61	561	354	10	-	10,019	-	1	1,358	-	282	403	88,882	179	4,018	541	523
Dec-11	242,218.47	294,749.58	12,533.89	288	189	110	-	7,816	-	2	1,402	-	217	305	80,854	198	4,373	522	556
Jan-12	71,075.28	266,901.25	10.69	261	190	145	-	8,854	-	1	1,359	-	252	364	87,521	215	4,628	498	515
Feb-12	277,756.11	76,197.92	225,684.86	316	234	109	-	10,176	-	2	1,362	-	277	407	101,491	248	7,620	510	534
Mar-12	19,378.33	20,982.50	19,378.33	93	58	46	-	3,337	-	-	454	-	89	133	30,778	63	2,577	165	175
Grand Total	627,122.22	1,317,833.61	282,151.53	20,509	15,777	618	-	117,431	-	15	18,356	-	2,674	4,702	1,091,058	2,380	37,485	6,647	7,050

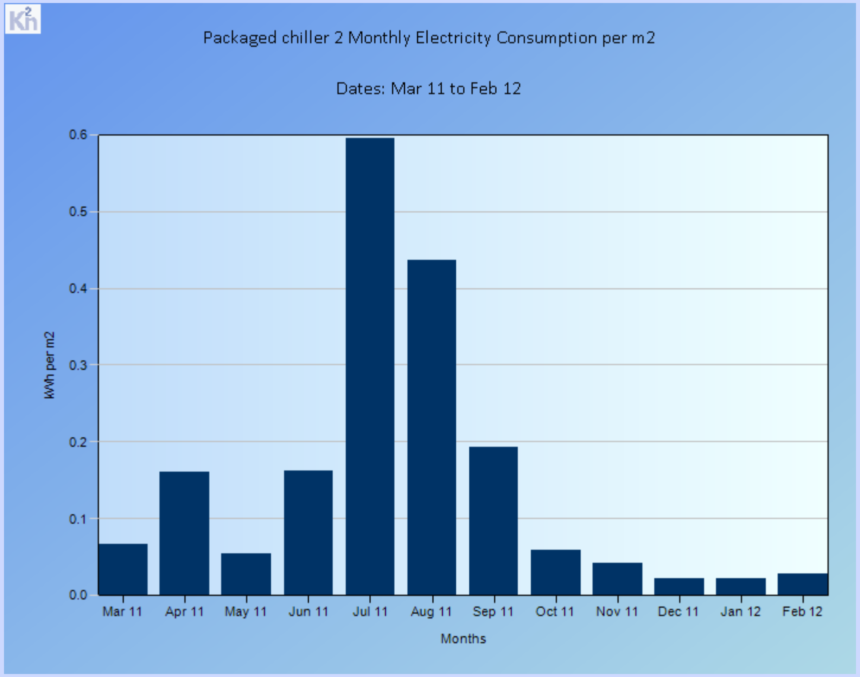
Example outputs from iSERV data – subhourly data

➔Example for Chiller 1 for July 2011 showing good time control compared to occupancy hours



Energy use by component

- iSERV will also calculate/estimate the consumption of individual HVAC components PER UNIT AREA SERVED and PER ACTIVITY where their supply meter is recorded.
- This information is the basis of the on-going benchmarks to be produced by iSERV



PARTICIPATING IN ISERV

Participation in iSERV

- iSERVcmb is an important opportunity for everyone involved in reducing the energy consumption of buildings to contribute towards setting these new standards.
- iSERV is recruiting around 1600 HVAC systems to participate in helping set these standards.
- Data is required for all types of activities and HVAC components.
- iSERV has an Excel template for entering the required data for a building to participate in iSERVcmb. This template is also endorsed by CIBSE for collating data about HVAC systems, meters and spaces for mandatory Inspection purposes.

iSERV – direct end user benefits

➔ Offers all HVAC system operators the opportunity to trial for free a monitoring and feedback approach to energy efficiency across their HVAC systems. iSERV:

- Deals with the data overload problem arising from trying to handle the outputs from many submeters in the building
- Links energy use @ HVAC component level to the activities served
- Provides regular feedback to help maintain savings achieved
- Provides analysis of monitored data and feedback on not only consumption achieved against benchmarks but also potential Energy Conservation Opportunities (ECOs).
- Reduces staff time spent analysing data freeing it up for implementing practical energy conservation regimes
- Will put monetary figures to all this data where possible

iSERV – indirect end user benefits

- ➔ CIBSE and REHVA will publish benchmarks produced from iSERV as professional guidance i.e. the approach should become the accepted way to operate HVAC systems in practice across the EU. Participation therefore enables early experience to be gained
- ➔ Ability to highlight participation as part of CSR
- ➔ Help establish the principle that a demonstrably good energy consumption for an HVAC system should be acceptable as an alternative to prescriptive legislation – with legislation only being invoked where performance does not meet bespoke standards

How to participate in iSERV

- Register on the iSERV website – www.iservcmb.info
- Notify the relevant iSERV Partner that you wish to participate, so that you have the latest information
- Download the iSERV spreadsheet and complete it for your HVAC system(s) by building.
- Validate the spreadsheet and send to iSERV for checking and entering to iSERV database
- Check and validate your data collection with iSERV
- Start using iSERV to help manage your HVAC system

Project period

➔ iSERVcmb runs until May 2014 and provides a free to use resource for building owners. At least one similar solution will be offered post-project to continue collating benchmarks

➔ Participation in iSERVcmb will:

- Provide bespoke HVAC benchmarks for the buildings entered,
- Allow participants to advertise their assistance in helping set UK and European standards in this area, as well as helping to influence future EU energy efficiency policy.
- Anonymity of data is provided unless otherwise required.

➔ We are looking for around 100 – 200 HVAC systems in the UK and have around 30 signed up at present. The project should appeal to well monitored Estates.

iSERV Summary

- ➔ iSERV will produce ‘benchmark’ figures at HVAC component and activity level for the professions
- ➔ iSERV is the only large-scale ‘open’ approach to this area at present in Europe
- ➔ ‘Blind’ to manufacturer and other potential bias
- ➔ Allows rapid verification of novel HVAC approaches in real buildings
- ➔ Allows owners to fully understand their systems
- ➔ Essential for understanding HVAC system energy use in time to allow an orderly transition to nZEB

Inspection of HVAC systems through continuous monitoring and benchmarking

www.iservcmb.info

Supported by INTELLIGENT ENERGY EUROPE

Thank you for your attention

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iSERV Coordinator

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