The iSERVcmb project – achieving HVAC energy savings in operational buildings

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SWEGON Air Academy Talk

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Inspection of HVAC systems through continuous monitoring and benchmarking

www.iservcmb.info

Supported by INTELLIGENT ENERGY EUROPE

iSERV Partners and Steering Group

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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		**Eurovent Certification** Certification Body	

Focus of talk

➔ The purpose and operation of iSERV

➔ Savings arising from monitoring

➔ The relative benefits of Inspection, Monitoring and Advice

Value at stake

Potential electrical savings for the EU appear to be 6+ Bn EUR/a or 60+ TWh

Background to iSERVcmb

- ➔ IEE HARMONAC Project -> AC Inspection not as effective at identifying ECOs (Energy Conservation Opportunities) as detailed energy monitoring
- ➔ This finding supported change in the recast EPBD – 'Intelligent Metering' (IM) systems now encouraged
- ➔ Energy savings in individual HVAC systems were shown by HARMONAC to be significant (up to 60%)
- ➔ No precedents exist for implementing IM at a large scale

The aims of iSERVcmb

➔Simplify understanding of energy use in HVAC

➔Produce a process to:

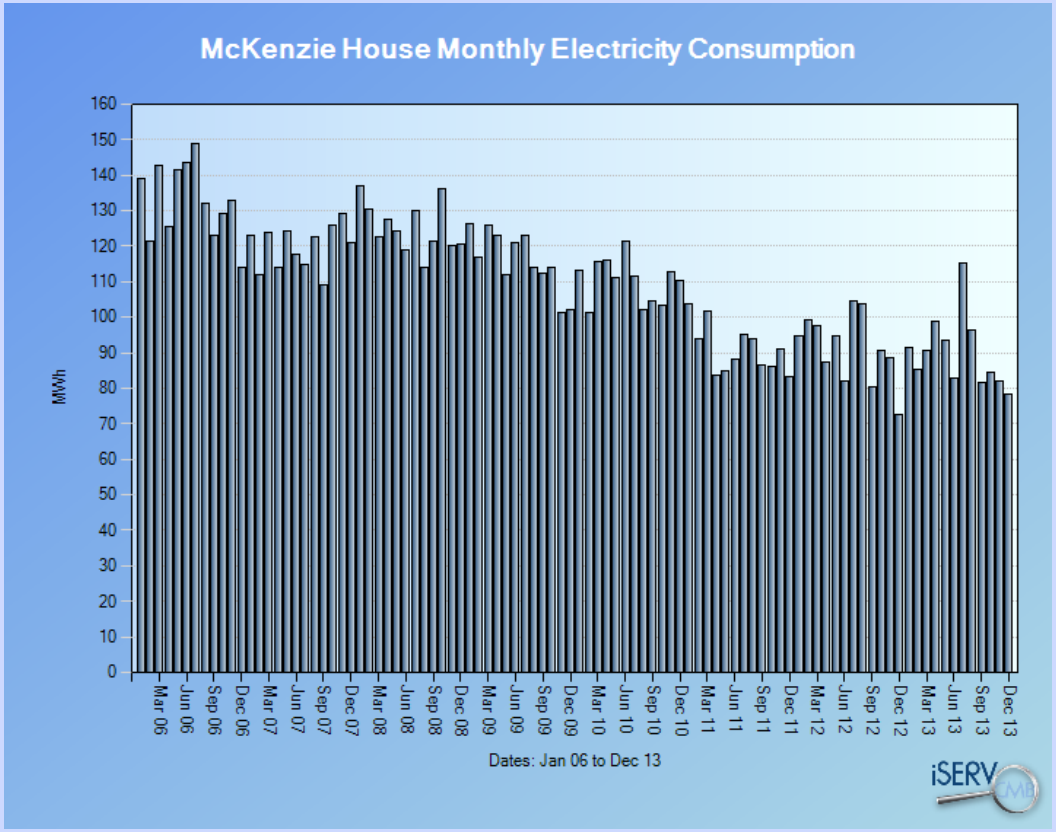
- Collate meters, activities, spaces, HVAC components and HVAC systems within buildings
- Record sub-hourly energy data for these systems
- Produce bespoke energy benchmark ranges for HVAC systems in operational buildings serving given activities
- Provide reports and guidance to HVAC system operators

➔Demonstrate savings achieved through this process

➔Adoption of Intelligent Metering by EU MS

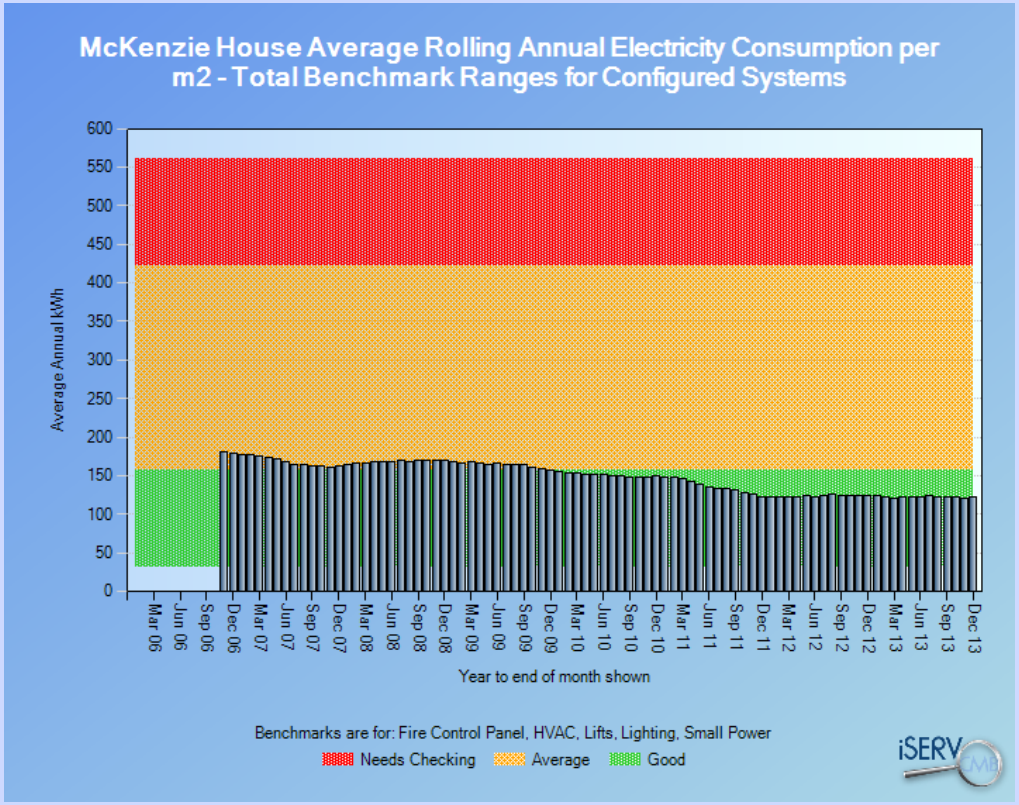
Moving from data collection…

- So, how does the process work?
- Typical monitoring systems tell us what we are consuming, and when
- They don't let us know whether this is good or not



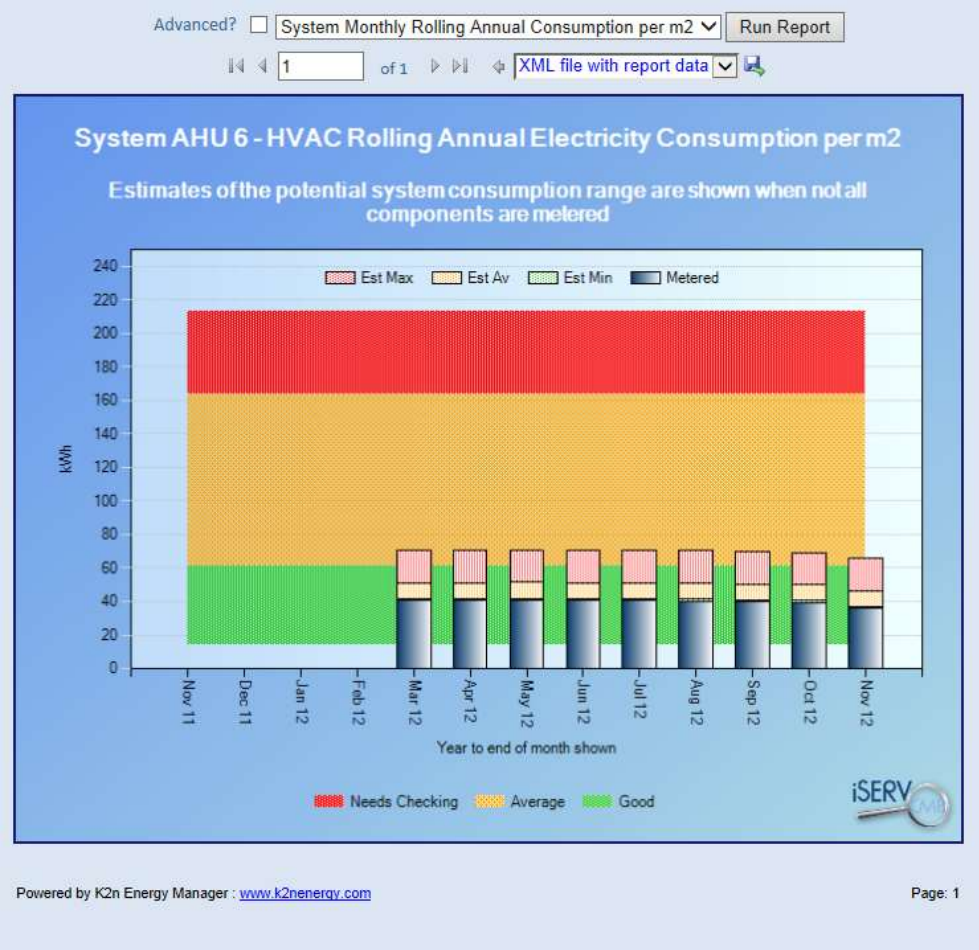
…to data understanding

- Benchmarking ranges derived from a Building's Floor Area, Activities, HVAC, Lighting and Small Power systems allows bespoke targets
- Can now see if we should be taking action to reduce energy use

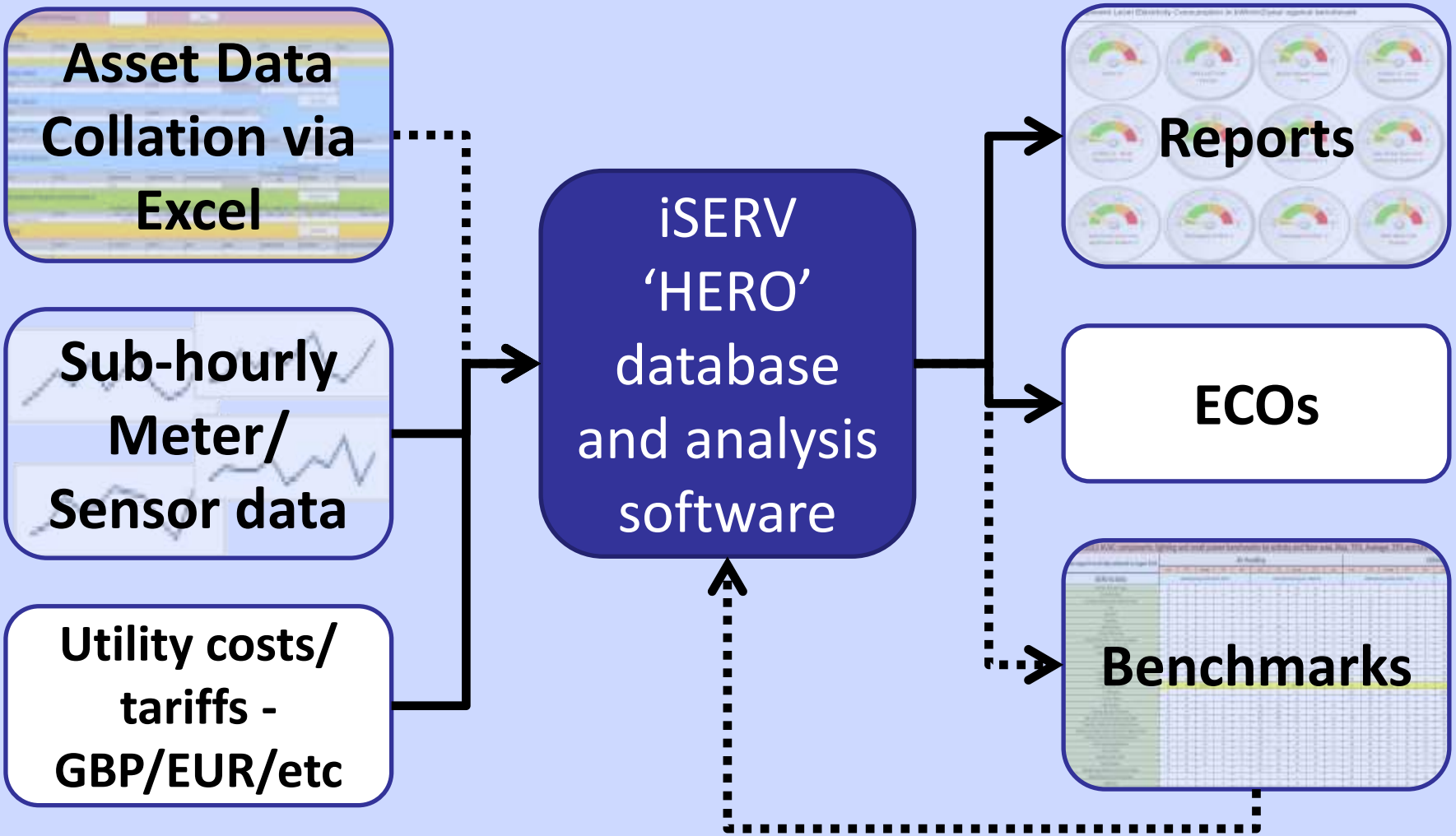


Building, System and Component

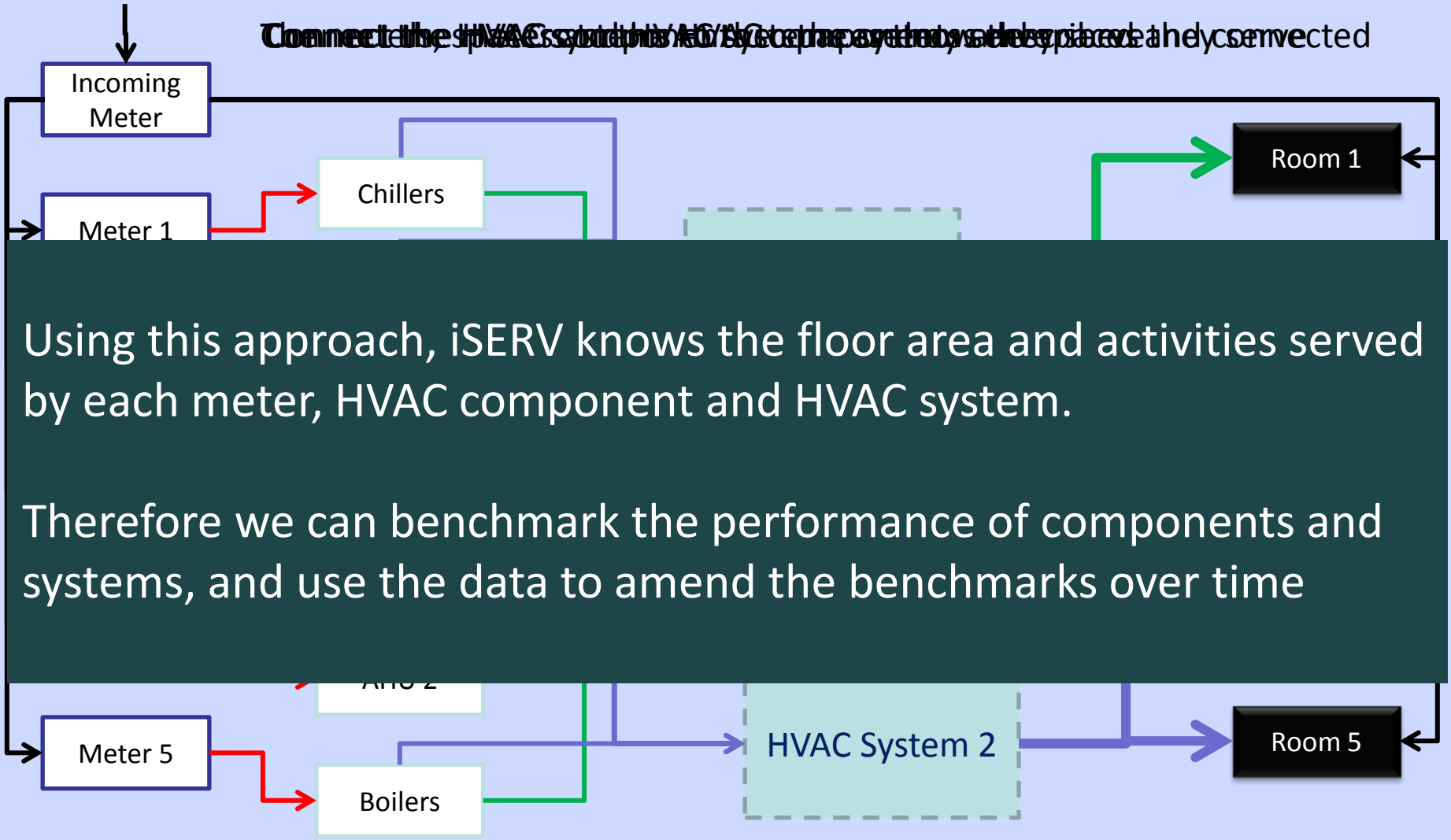
- iSERVcmb provides insight into achieved real-world energy **performance** - from the Building to the HVAC component level
- For example, it can provide a bespoke benchmark performance range to be expected for a specific mix of HVAC components (a System) servicing a specific set of activities and areas
- Over this range it can then show the recorded energy consumption from the sub-meters serving the HVAC components, or estimate ranges from the recorded data where specific meters are not installed



Overview of basic process



The iSERV setup process



Using this approach, iSERV knows the floor area and activities served by each meter, HVAC component and HVAC system.

Therefore we can benchmark the performance of components and systems, and use the data to amend the benchmarks over time

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*

Utility Meter — Add a Meter

Name*	Description	Meter Type*	Unit Type*	Multiplier	Space Where Located	Unique Meter Id*	Parent Meter Name

HVAC Sensor — Add a Sensor

Name*	Description	Sensor Type*	Unit Type*	Duct/Pipe Area m2	Unique Sensor Id*

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
						None	None	

HVAC Component — Add a HVAC Component

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

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
								Schedule 1 - Whole Building

HERO database

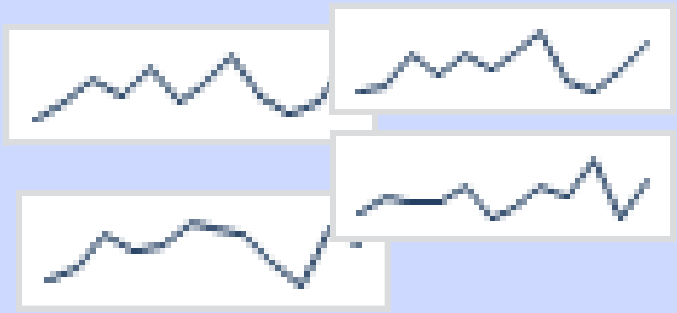
➔ The role of HERO is to collect, collate and analyse the data input to produce reports which show the performance of the building and HVAC systems:

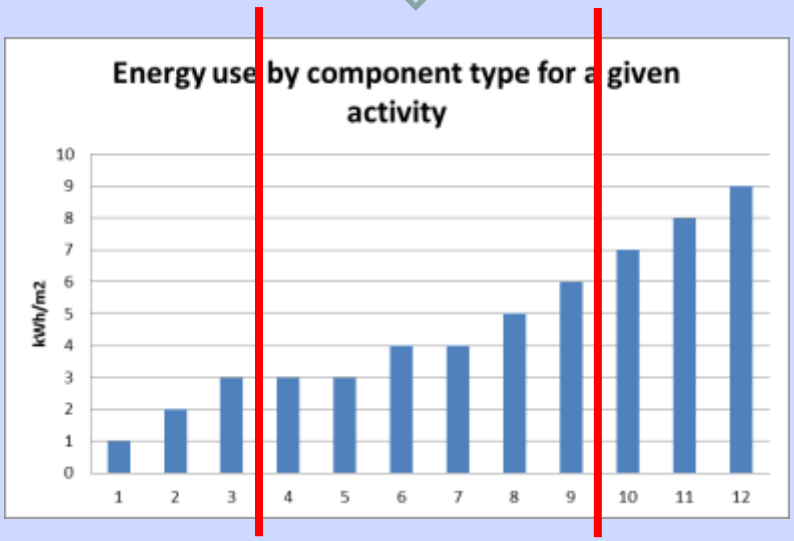
- Against tailored benchmarks derived from the building, services and space descriptions
- Via algorithms which use the input building and sub-hourly meter data to identify specific Energy Conservation Opportunities (ECOs) for that building and systems

➔ HERO uses the same data to update its benchmarks on a regular basis, so that they remain current and useable for investment decisions

Deriving benchmarks

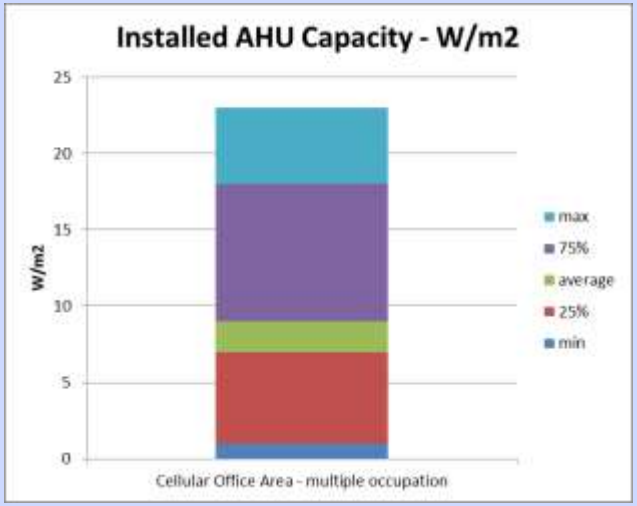
- iSERV derives benchmarks by collecting and collating energy use data from HVAC component types servicing the same activity, usually normalised for floor area
- This data then provides ranges of achieved performance/m^2 **by HVAC component** and **activity**
- Benchmark thresholds are initially set at the upper and lower quartiles of this data for iSERV

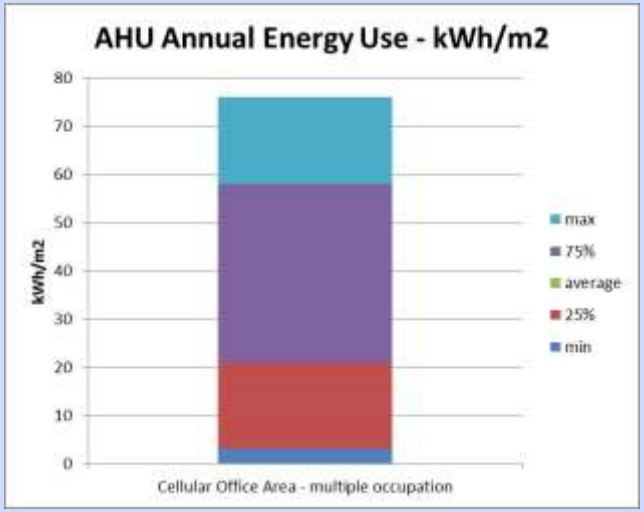




Makeup of a benchmark for an activity

- The graphs show ranges of installed capacity and monitored energy use for AHU's used in cellular offices in multiple occupation
- Adding together the ranges of all the components of an HVAC system servicing an activity and area, we can produce a tailored HVAC system benchmark range for a space.
- The tailored benchmark for a building is then simply the assembly of the benchmarks for a collection of spaces





iSERV benchmark types

- ➔ iSERV is investigating the feasibility of producing 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 ($kWh/m^2.month$)
  - Maximum, minimum 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 annual energy use/m^2 is likely to be the main benchmark for legislation
- ➔ The monthly energy use/m^2 and the power/m^2 benchmarks are needed 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 HVAC components, lighting and small power benchmarks

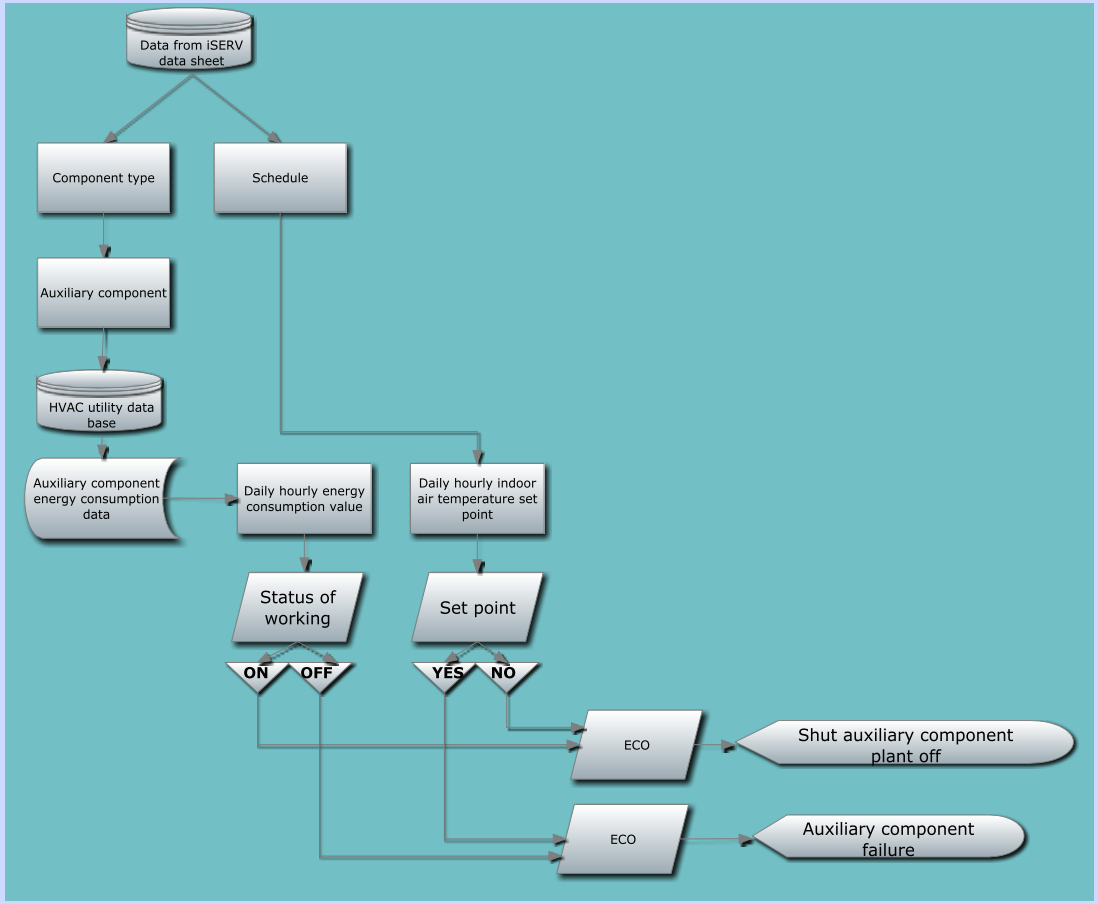
- An initial set of installed power and annual energy use benchmarks by activity for AHU's, Chillers, CHW Pumps, HW Pumps, DHW Pumps, Humidifiers, Boilers, Lighting and Small Power was assembled from existing sources and collected data in September 2012 to enable the iSERV process to be trialled

- These benchmarks are currently being evaluated against the 'live' data being collected from the iSERV project.

- A revised set of benchmarks derived from the iSERV data for European buildings will be published by iSERV in July 2014

Energy Conservation Opportunities (ECOs)

- A flowchart for an ECO which looks at the scheduled occupancy of the building and compares this with the measured sub-hourly consumption of various HVAC components
- The potential savings are obtained from summing the out-of-hours usage
- 22 ECOs are being automated in total



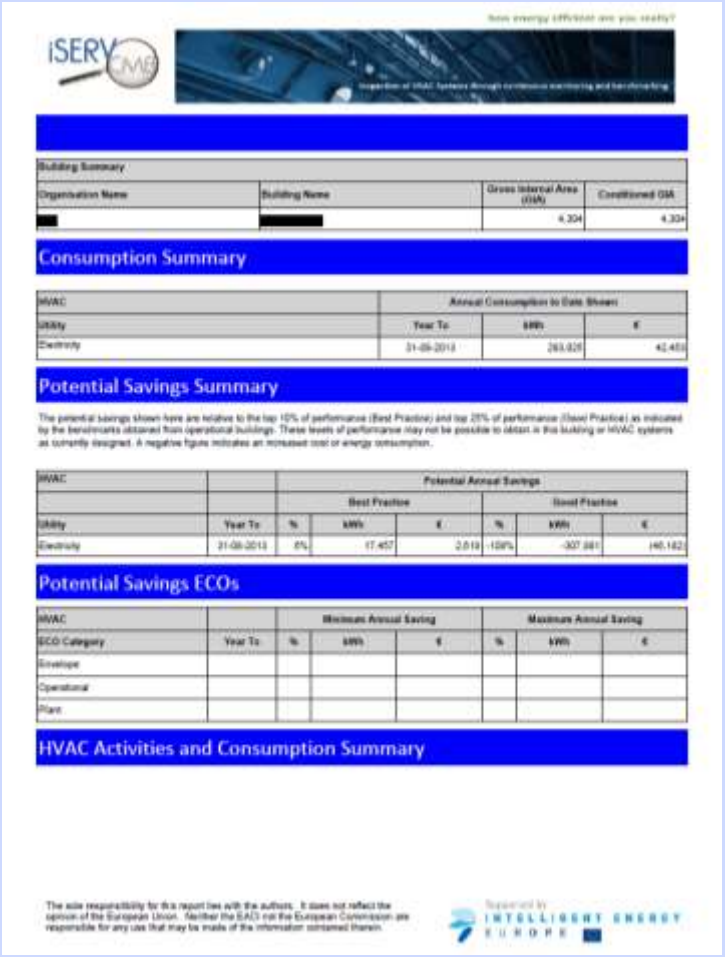
ECOs and benchmarks – accuracy and Indoor Air Quality (IAQ)

- ➔ To provide confidence that the benchmarks and ECOs produced from iSERV reflect reality, and do not come at the expense of poor IAQ, iSERV also undertook physical Inspections and IAQ tests in a sample of monitored buildings
- ➔ These Inspections and IAQ tests are currently being analysed separately from the iSERV data to try and ensure that their findings are not influenced by the measured data findings
- ➔ Initial IAQ findings are that the environment in the majority of EU Buildings is acceptable from an Air Quality viewpoint
- ➔ Initial Inspection findings show that maintenance of HVAC equipment could generally be better, with significant energy savings to be had from filter replacement and maintaining refrigerant levels in AC equipment.

Example report

➔ A report for an iSERV building showing it performing well

➔ Report shows healthy individual HVAC systems and meter data

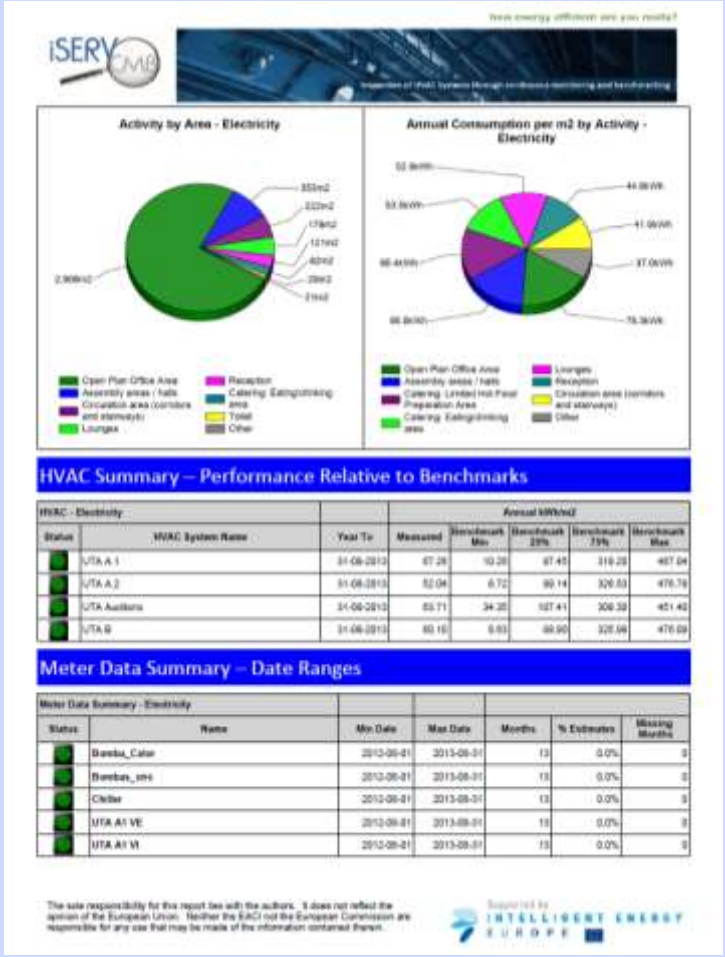


Consumption Summary

Potential Savings Summary

Potential Savings ECOs

HVAC Activities and Consumption Summary



HVAC Summary – Performance Relative to Benchmarks

Meter Data Summary – Date Ranges

Monitoring real buildings

➔iSERVcmb has achieved the following in buildings from across the EU:

- A process for the energy assessment of HVAC systems
- Recruitment of over 1700 systems across Europe
- A database to collect, analyse and report performance
- **Measured** total electrical energy consumption savings in real buildings **up to 33%**
- Indoor Air Quality Studies and Physical Inspections of selected systems
- Algorithms and Models for predicting HVAC component and system specific ECOs

3 long-term 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:
  - Recurrent savings of 9 to 14 EUR/m^2/a
  - Estimate 'one-off' setup up cost of 1 to 2 EUR/m^2
  - Estimate 0.5 – 4 EUR/m^2/a ongoing costs.
  - **Net returns between 7 – 12 EUR/m^2/a**
- ➔ HARMONAC anticipated average total building electrical savings of 1 – 5%.
- ➔ Appears success in reducing HVAC energy use is providing the confidence and finance to tackle other electrical use as well.

Intelligent Metering (IM) and legislation

➔ Why have no MS allowed IM as a route to compliance yet? There are a number of reasons, including:

- Insufficient evidence of impact of IM on energy use in practice
- Existing MS Inspection schemes, however poor, meet EPBD Legislative needs, and Advice appears cheaper to implement than IM
- Lack of precedents

➔ iSERV shows that to achieve sustainable energy reductions in operational buildings, IM must be part of the options available to building operators

➔ IM impacts more than energy use, it also clarifies where to invest first; the energy costs associated with various activities; and the cost per m^2 associated with utility use

End User interests

- ➔ Will I really save energy and costs? – RISK
- ➔ WHERE should I be looking to achieve savings?
- ➔ What effort must I put in to achieve and maintain savings?
- ➔ Will my efforts be recognised by legislation?
- ➔ Why can't my existing monitoring systems be used to reduce costs of compliance with legislation?
- ➔ Justifying monitoring systems if they are not required by legislation

Defining cost

- ➔ Cost of managing energy use depends on where the energy boundaries lie, and who pays:
- ➔ Scenario 1: Cost is defined by the capital and running costs paid to undertake Inspections, Audits and/or Monitoring
- ➔ Scenario 2: Cost is defined by the net cost of Scenario 1 including the cost savings made from any energy savings
  - This scenario is almost impossible to use without monitoring, so often Scenario 1 is used in the absence of evidence of savings
- ➔ Scenario 3: Cost is defined by the International perspective of energy security; whether a country is price competitive globally; and if we can afford the required energy supply networks
  - This scenario is used only at country level

Cost comparison of 3 EU options for managing building energy use

Comments	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	• Established approach. • Standards and bodies exist. • Savings not likely to be sustainable where intervention is needed. • Savings difficult to maintain.	• Framework needs establishing. • Initial setup can take time. • Requires more attention than inspection or advice. • Provides detailed understanding of energy use. • Reduces investment risk. • Proven real energy savings. • Helps maintain savings	• Framework needs establishing. • Difficult to show impact. • No mechanism for drawing attention to energy use. • Not clear how it will help maintain energy savings.

Cost of, and savings from, monitoring at MS scale

- ➔ BPIE reports 25,000 Mm^2 of EU27 + CH and N building stock (2011)
- ➔ 25% is non-residential i.e. 6,250 Mm^2. iSERV monitors ~0.01%
- ➔ Anticipated costs to implement iSERV at EU level are around 1.25 Bn EUR or about 45 M EUR/MS on average.
- ➔ Conservative net savings of 1 EU/m^2/a from monitoring returns around 6.25 Bn EUR/a or about 215 M EUR/MS on average
- ➔ A 500% Return on Investment
- ➔ iSERV suggests **real** savings from monitoring should be higher than this conservative figure. Fossil fuel and water savings are not included.
- ➔ **Achievable** average annual savings/MS of 215+ M EUR appear possible
- ➔ **Potential electrical savings for the EU as a whole appear to be 6+ Bn EUR/a or 60+ TWh**

Monitoring – Benefits found

➔ Monitoring brings:

- Clarity and Certainty
- Proven energy and cost savings to end user and MS
- End user engagement and ability to help 2020 targets
- Proof of impact achieved
- Increased use of energy efficient products
- Reduced Risk for investments
- Ability to use Smart Metering data which is coming

Summary

- ➔ iSERV: ‘Tailor made’ benchmarks
- ➔ Significant savings being achieved in operational buildings
- ➔ Understanding HVAC energy use provides confidence to address other energy use
- ➔ iSERV provides a platform for HVAC industry to demonstrate benefits of upgrading to more efficient equipment
- ➔ All actors involved with HVAC system energy use would benefit from the introduction of such an approach
- ➔ **With savings of this order being achieved, the question has to be ‘Why would anyone NOT want to do this?’**

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Thank you for your attention

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