Why energy monitoring and feedback is essential to achieve sustained energy efficiency in EU buildings

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Simplifying a problem

The EU has produced The Energy Efficiency Directive [1], the original and recast Energy Performance of Buildings Directives [2,3], and the Eco-design of Energy-Related Products Directive [4] amongst other legislation all designed to achieve one end – the reduction of **unnecessary** energy use within the EU.

This paper proposes that achieving low energy consumption buildings across Europe could be significantly simplified for all actors by making **all legislation** revolve around more detailed measurements, analysis and feedback of energy end use – energy efficiency being the ultimate target of the legislation and also an accurately quantifiable parameter based on existing technologies.

The paper supports this hypothesis by presenting a brief look at the emerging results from iSERVcmb (www.iservcmb.info), a European Commission funded IEE project that examines the achieved impact from trialling such an approach in Buildings and Heating, Ventilating and Air Conditioning (HVAC) Systems across the EU Member States. The iSERVcmb project implements a detailed Monitoring, Feedback and Benchmarking system for energy use in buildings, but the principles of measure, record, analyse, benchmark and feedback, could equally be applied to the Industrial and Transport sectors.

Predicting Energy Efficiency in Buildings

The actors and parameters affecting power demands and energy use within buildings are well known, but we are aware from predicted and measured performance data for recent buildings that there is often still a significant performance gap between modelled energy predictions and reality.

There is, however, now a practical and affordable alternative approach to the use of computer models alone for predicting the in-use energy performance of buildings. This alternative approach has arisen in recent years from the rapid reduction in the cost of detailed energy submetering along with the almost universal embedding of intelligence and connectivity into even the smallest electronic component. For building services this manifests itself in the form of internet connected Air Handling Units, Pumps, Cold Generators, etc.

The ready availability of data on the actual energy consumption of individual items of equipment, along with other useful parameters such as temperatures, flow rates, etc., means that we can now use statistical information to help predict the likely energy performance ranges for buildings. The reliability of such an approach still depends on accurate characterisation of the main parameters which contribute towards this energy use but the time demands appear considerably less onerous than for modelling. The approach also allows for frequent feedback on performance being achieved.

A 'measured data' based approach at this level of detail also has the critical advantage of using actual operational data for specific items in specific buildings serving specified activities. This means the end user can understand not only what is being used but can also pinpoint where it is being used. The IEE HARMONAC [5] and iSERVcmb projects have observed that this type of data

Table 1. iSERV estimates and measurements of costs and benefits for recast EPBD compliance options.

Topic	Inspection	Monitoring	Advice
Cost	**100 – 250 EUR** (Compliance) **0.5 – 2.5 EUR/m²** (EPBD)	**0.1 to 2.0 EUR/m²** setup **0.1 to 3.0 EUR/m²** ongoing	Not known
Savings	Estimate (HARMONAC): **2.0 to 3.2 EUR/m²** at best	Measured (small sample): **9.0 – 14.0 EUR/m²/a** (electrical) Up to 33% building elec use	Not known
Net savings	**-100 to -250 EUR or -0.5 to 2.7 EUR/m²**	**1.0 to 13.0 EUR/m²/a**	**Not known**
Impact assessment	No feedback route	Data allows precise 'before' and 'after' impact studies	No feedback route
Comments	– Difficult to show impact. – 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.

appears critical in persuading the end user to undertake action when it can be shown to lead to a likely useful energy saving.

The IEE iSERVcmb project is based on the above alternative approach and its impact is being trialled in operational buildings in at least 20 EU Member States.

Operation of a Monitoring and Feedback Benchmark scheme at Member State level

The iSERVcmb project has been undertaken to explore the impact on energy use of implementing a metering and feedback system at building services component level across the EU Member States as encouraged by the recast EPBD in Articles 8, 14 and 15:

"Member States shall encourage the introduction of intelligent metering systems whenever a building is constructed or undergoes major renovation … Member States may furthermore encourage, where appropriate, the installation of active control systems such as automation, control and monitoring systems that aim to save energy."

Strictly speaking iSERVcmb is an intelligent use of Metering Systems to provide Feedback to Actors to enable energy savings. At this stage of implementation it was considered neither sensible nor desirable to provide active automatic control of systems via the project – though this would have been feasible.

The iSERVcmb project impact

The full details of iSERVcmb are available from the project website (www.iservcmb.info). For this paper only the measured or estimated costs and energy savings from iSERVcmb compared to acceptable recast EPBD legislative alternatives are presented in **Table 1**.

The Inspection costs presented are actual costs taken from a sample of EU MS's and cover the two types of Inspection that seem to be undertaken in practice – a 'compliance' Inspection cost and a 'proper' Inspection in the spirit of the EPBD intentions. The 'compliance' Inspection reports appear to be universally ignored by the recipients, so they are considered to be a net cost in the savings section. All other costs presented have been measured or calculated from operational buildings, except the net savings presented. Here the completed sample is too small at present to have confidence in the measured savings shown, so a conservative range of 1 to 13 Euros/m² has been presented based on expected final performance ranges to be obtained from the 1400+ systems in iSERV.

The table also shows the anticipated impact on energy use from each of the three compliance options offered by the EPBD. The new route of providing 'Advice' has not been able to be assessed but expectations based on observations during the HARMONAC and iSERVcmb projects suggest this will probably have less impact than hoped for, as there is no clear compliance requirement

and therefore owners are likely to react with little enthusiasm, as they have already reacted to Inspections.

Potential savings to accrue at EU level

From the figures shown in **Table 1** the ranges of calculated costs and potential saving values at stake from implementing an iSERVcmb-type approach at the EU level are presented in **Figure 1**. This calculation uses the non-residential floor area estimate from BPIE [6].

Figure 1, derived from the findings of the iSERVcmb and HARMONAC projects, shows that the risk of not achieving substantial annual energy and net cost savings across the EU MS would appear low. The EU's potential **annual** cost savings from energy reductions are calculated to be between 6 and 60 Bn Euros, with an average saving likely to be just over 20 Bn Euros. The estimated annual cost of maintaining the Monitoring system are anticipated to be below 1 Bn Euros across all EU MS, with most of these costs borne by the end users – who should also accrue most of the savings. It appears that annual returns on investment will be significantly greater than costs on average.

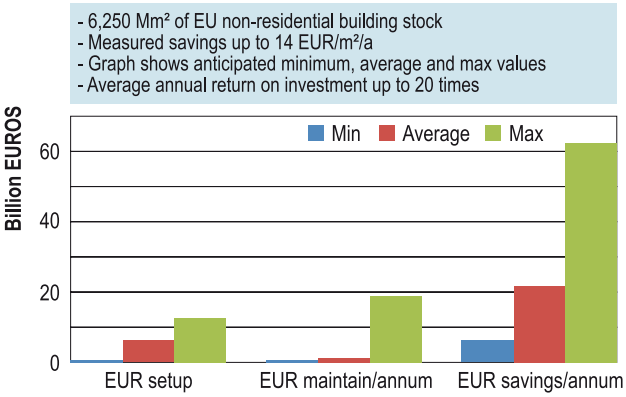

Figure 1. Potential maximum/minimum/average costs and returns from implementing iSERVcmb across the EU Member States.

Implementing an Automatic Monitoring & Feedback (aMF) system at EU MS level

The route to implementation of an iSERVcmb-type approach first needs legislation to permit aMF systems and benchmarking at the individual MS level, as already provided for in the recast EPBD.

However, the recast EPBD also now allows the provision of Advice as a means of compliance, as well as retaining the Inspection route, both of which appear easier for MS to enact. Therefore they are currently the more appealing route for many MS legislators.

It is anticipated that once iSERVcmb has shown the energy and cost savings possible from implementing a benchmark-type approach to achieving energy efficiency in buildings that a number of MS may be persuaded to implement such an approach as the third alternative for end users during their transposition of the recast EPBD or its future evolution. This would allow those organisations who wish to employ automatic monitoring as a means of controlling their energy use to also use the same data to help meet their compliance obligations.

Once an aMF benchmark system has been implemented at a Member State level then this is a win-win situation for both the MS and the organisations who adopt this approach to compliance.

Conclusions

This paper has provided a brief overview of why independent large-scale Energy Monitoring, Feedback and Benchmarking systems are likely to be the key to helping achieve significant energy reductions in existing and future buildings in the EU.

The main hurdles to achieving energy efficiency in real buildings that such an approach would help overcome include:

- The reduction of risk to all actors trying to achieve energy savings in specific building design and operation situations
- Allowing end users to participate in their energy use reduction by providing them with a route to do so
- Establishing better market conditions for energy efficient products for manufacturers
- Establishing a clearer basis for an Energy Services market, thus allowing the establishment of better trust between the parties involved
- Establishing a clear link between design intent and achieved results, thereby allowing robust energy efficiency solutions to become established. This is essential to understanding what is possible for low or zero energy buildings to achieve when servicing real end use activities
- Dividing ownership of the energy consumption between landlords and tenants, allowing clear responsibility for achieving energy savings in specific areas.

The potential energy savings at stake are substantial, and appear to be achievable for very attractive rates of return in many cases. It is hoped that the iSERVcmb project will prove persuasive enough to trigger the widespread deployment of Monitoring and Feedback systems throughout the EU MS. ■

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References

1 Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC Text with EEA relevance. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32012L0027:EN:NOT. Accessed 09/12/2013

2 Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0091:EN:NOT. Accessed 20/11/2013

3 Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast). http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32010L0031:EN:NOT. Accessed 20/11/2013

4 Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (Text with EEA relevance). http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32009L0125:EN:NOT. Accessed 09/12/2013

5 Knight I et al – "HARMONAC - Harmonizing Air Conditioning Inspection and Audit Procedures in the Tertiary Building Sector. Energy Consumption in European Air Conditioning Systems and the Air Conditioning System Inspection Process – FINAL REPORT", Intelligent Energy Europe Project Number: EISAV/EIE/07/132/2007. European Commission, October 2010. ISBN: 978-1-899895-50-2. www.harmonac.info and http://www.eaci-projects.eu/iee/page/Page.jsp?op=project_detail&prid=1605 Accessed 20/11/2013

6 Buildings Performance Institute Europe (BPIE) - Europe's buildings under the microscope: A country-by-country review of the energy performance of buildings, October 2011. ISBN: 9789491143014

Publication newsflash

IEA Heat Pump Centre Focuses on HP Efficiency in Real Conditions

In technical product development in any field, one needs to track performance of the product, to check if a specific modification resulted in an improvement or not. Also, the end user wants his purchased and installed product to perform as specified (at least), and needs methods to check this. Further, other actors along the developing, marketing and dissemination chain need to be aware of the end-user's reaction and needs – and preferably be able to anticipate them. All this calls for performance monitoring and evaluation.

The topic of the recent issue of the IEA Heat Pump Centre Newsletter is Heat pump performance monitoring and evaluation. A summary of the long-term heat pump field monitoring is provided, as well as evaluations of a part-load performance of an air conditioner, and of a foundation heat exchanger. Also, a method for on-line monitoring and evaluation of heat pump performance is described. In addition, you will find a Strategic Outlook from the US.

The IEA HPC Newsletter is a newsletter/journal from the IEA Heat Pump Centre (HPC) with four issues per year. The HPC is an international information service for heat pumping technologies, applications and markets. Visit the website at www.heatpumpcentre.org

The IEA Heat Pump Centre Newsletter can be downloaded (free for readers in HPP member countries) from www.heatpumpcentre.org/en/newsletter/Sidor/default.aspx

The Heat Pump Centre (HPC) is the central information activity of the IEA Heat Pump Programme (HPP). HPP operates under the International Energy Agency (IEA) and was founded in 1978. The current member countries are Austria, Canada, Denmark, Finland, France, Italy, Germany, Japan, the Netherlands, Norway, South Korea, Sweden, Switzerland, United Kingdom and the United States.

The IEA Heat Pump Programme is a non-profit organisation under which participants in different countries cooperate in projects in the field of heat pumps and related heat pumping technologies such as air conditioning, refrigeration and working fluids (refrigerants). Under the management of an Executive Committee representing the member countries, the Programme carries out a strategy to accelerate the use of heat pumps in all applications where they can reduce energy consumption for the benefit of the environment.