Institution:
Cardiff University

Unit of Assessment:
16B

Title of case study:
Achieving Greener Building Services in Practice for Europe

1. Summary of the impact (indicative maximum 100 words)

The work described here has impacted on European policy and standards concerning energy efficiency in Building Services.

The impact arises from two Welsh School of Architecture led and European Commission funded projects, HARMONAC (focussed on inspection of air-conditioning systems) and iSERV (focussed on automatic system monitoring and feedback). These pan-European projects demonstrate achieved energy savings of up to 33% of total building electricity use in individual buildings, and potential savings up to €60Bn. These projects demonstrably impacted the recast European Energy Performance of Buildings Directive (EPBD) and the revision of EU Standards (European Committee for Standardisation (CEN)).

2. Underpinning research (indicative maximum 500 words)

The underpinning research described has occurred since 2000. The research produced the following insights specific to the impact claimed here:

Between 2000 and 2002, a research project funded by the Building Research Establishment (BRE), Toshiba Carrier and the National Grid Transco led by Professor Ian Knight of the Welsh School of Architecture (1987 to present) undertook detailed monitoring of air-conditioning (AC) system energy use in 32 UK Office Buildings. The published results from this empirical work provided a first insight into the ranges of energy consumption achieved by various types of AC systems in UK Offices. The work showed that, despite serving similar activities, the energy consumptions achieved in practice could be very different, and that some of this difference depended on the design of the cooling system [3.1].

A follow-on BRE funded project which analysed the breakdown of energy use between the various components of the AC systems, showing the role of all system components in overall AC system energy use, was undertaken between 2002 and 2004 (led by Ian Knight [3.2]). The above research projects led to an invitation to Ian Knight to participate as a Work Package Leader in the European project AUDITAC (Field benchmarking and market development for audit methods in air conditioning) proposed by École des Mines, Paris between Jan 2005 and Dec 2006. This project demonstrated that application of the European Committee for Standardisation (CEN) Standard for the mandatory Energy Performance of Buildings Directive (EPBD) Inspection of AC systems was difficult to achieve in practice with the number of accredited inspectors available in Europe, as well as not being cost effective in many instances [3.3].

Ian Knight proposed and ran a further European scale project (HARMONAC - Harmonizing Air Conditioning Inspection and Audit Procedures in the Tertiary Building Sector) to assess the impact of inspection of air conditioning systems on energy efficiency in practice, with a view to establishing savings achieved and identifying where procedural improvements might be found. HARMONAC ran from September 2007 to August 2010, and established that the range of energy conservation opportunities identified in individual AC systems by inspection was limited to 37% of the potential energy savings identified in those same systems by concurrent detailed energy measurements [p10 3.4]. This meant that the full range of potential energy savings was only accessible by detailed measurement. [3.4,3.5]

Following HARMONAC, Ian Knight is now running the pan-European iSERV project (Inspection of HVAC systems through continuous monitoring and benchmarking - 2011 – 2014).

iSERV applies the HARMONAC findings to 1000+ European HVAC systems across 20+ EU Member States, to establish HVAC component energy benchmarks for specific end use activities [3.6]. Preliminary findings indicate that the project objectives, to achieve the savings postulated in HARMONAC by providing feedback from HVAC data to the system owners, are being exceeded - with savings of up to 33% of total building electrical energy use being found.

3. References to the research (indicative maximum of six references)

3.1 **Knight IP** and **Dunn GN** - "Measured Energy Consumption and Carbon Emissions of Air-Conditioning in UK Office Buildings". Building Services Engineering Research & Technology Journal, p89-98, 26-2 CIBSE (2005) London. DOI: 10.1191/0143624405bt111oa

3.2 **Knight IP, Dunn GN** and Hitchin ER – "Measuring System Efficiencies of Liquid Chiller and Direct Expansion", ASHRAE Journal, 47(2) pages 26 – 32, February 2005. ISSN: 0001-2491. Available from HEI on request.

3.3 Adnot J, **Knight IP,** et al – "AUDITAC - Field benchmarking and Market development for Audit methods in Air Conditioning. Final Report to European Commission". January 2005 to December, 2006. Grant Agreement EIE/04/104/S07.38632. pp.104 February 2007. URL: http://eaci-projects.eu/iee/page/Page.jsp?op=project_detail&prid=1439

3.4 **Knight IP** 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 to European Commission." September 2007 to August 2010. Grant agreement no. EIE/07/132/SI2.466705. pp. 240 (Appendices pp. 2000+) December 2010. URL: http://orca.cf.ac.uk/7427/

3.5 **Knight I** and **Cambray JT** - "Air-conditioning inspections: time needed and potential energy savings", REHVA Journal (European Journal of Heating, Ventilating and Air Conditioning Technology), Volume 46, Issue 1, February 2009. Pp.20-26 www.rehvajournal.com ISSN: 1307-3729. URL: http://orca.cf.ac.uk/14287/1/Knight_RJ9_1-2009.pdf

3.6 **Knight IP** et al – "Benchmarking HVAC System Energy Use Using Sub-hourly Data", CLIMA 2013 Conference, pp 12, Prague, June 2013 published in proceedings. Available from HEI.

4. Details of the impact (indicative maximum 750 words)

Impact on EU policy, legislation and standards

HARMONAC was the major reference source used as evidence concerning the impact of the original Energy Performance of Buildings Directive (EPBD) 2002 on energy efficiency in HVAC systems in practice [5.1, 5.2]. The EPBD is the primary European Directive governing energy efficiency in buildings for EU Member States. From research undertaken during HARMONAC, and presented by Ian Knight on 3 separate occasions [5.3] to EU Member State legislators, the EPBD was accordingly amended during its recast in 2010 to allow automatic monitoring and feedback systems to be used to complement or replace inspection.

Gordon Sutherland, Senior Project Officer for the European Commission Executive Agency on Competitiveness and Innovation identified HARMONAC as 'instrumental in demonstrating the feasibility of monitoring air-conditioning systems'. [5.2] .

This influence on the legislative agenda continues with the iSERV project, presented to the Concerted Action 3 project in April 2011, December 2011 and October 2013 [5.4] as part of aiding EU Member States to transpose the recast EPBD. Data from real buildings (including major multi-nationals, see table 1) is informing energy savings achieved.

HARMONAC has also had a demonstrable impact on the current revisions to the European Committee for Standardisation (CEN) Standards in this area – EN 15239 and 15240 (on which the relevant British Standards are based):
"*… HARMONAC and iSERV and their impact on the further development of CEN Standards EN 15240 and 15239 … have created a solid basis for many developments that have been found necessary..."* – Jorma Railio (CEN member, and former CEN Convenor). [5.5].

Information for tenderers for rewriting the revised CEN standards in 2013 onwards refers explicitly to the HARMONAC work when considering the standards updates required for EN15239 and EN15240, which refer to the elements needed to be present in Inspecting Air Conditioning and Ventilation systems [5.6].

Practitioner impact: professional guidance to the building services industry and building designers

The UK Building Services Professional Body (CIBSE) and REHVA (the umbrella body for the European Building Services Professional Bodies) are full partners in iSERV, and are promoting the project to their 110,000 Building Services professional members. Their participation in iSERV follows presentations on HARMONAC to REHVA and the EU Professional Bodies [5.7]. These bodies, in turn, have disseminated the findings and associated tools and guidance to date from the iSERV project to their members in Journal Papers, Workshops and Articles [5.8, 5.9]. Both CIBSE and REHVA intend to publish professional guidance documents based on the project findings but these will not appear until after the project finishes in 2014.

The UK Education Funding Agency, which provides capital funding for schools in England (£2 billion in 2012-13), including building projects, now requires all new Schools built in England using their funding to use the iSERV spreadsheet as part of the design and operation of new buildings. [5.10]

Economic impact: reducing EU energy consumption

In 2007, the 27 EU Member States used around 2,800 TWh of electricity, of which Building HVAC systems consumed 11.1%. HARMONAC [3.2] concluded that 2% of the total electrical energy use could be saved across the EU Member States from energy efficiency improvements in HVAC systems. These savings would be worth around €6Bn/annum at current costs.

iSERV provides, and demonstrates, a process to allow these savings to be achieved in practice. Initial results concerning 3 buildings from HARMONAC show that these savings may have been underestimated by up to a factor of 10, although this will not be conclusively shown until all 1000+ iSERV systems buildings have been evaluated.

The beneficiaries of HARMONAC and iSERV range from Building End Users (via reduced operating costs and improved internal conditions), Building Services Designers, Operators and Maintainers (better understanding of the operation and maintenance of AC systems in buildings), through to Professional Bodies and EU Member State Legislators.

Table1 lists the range of Multinational companies participating in iSERV as both data providers and receivers. This shows breadth of impact being achieved across Europe.

Tesco	British Telecom	WALDNER	Rhoss	Lennox
FNAC	First Facility	Siemens	ArCotel	McDonalds
Baxter	Schneider Electric	SKANSKA	Socomec	Vodafone
Allianz	Johnson Controls	Media markt	Eversheds	Metro AG
Cofely	LG Electronics	Marriott	DAIKIN	Honeywell
Spar	Best Western	NH Hoteles	Unicredit	Carrier
H&M	Falkensteiner	Ibis Hotels	France Air	Eurobank
ALDI	Relais & Chateaux	Mercure	MITIE	Toshiba
IKEA	Grupo Inditex (ZARA, MANGO etc)	Swegon	Santander	Trane

5. Sources to corroborate the impact (indicative maximum of 10 references)

1. The final report from the European Commission's Intelligent Energy Europe Concerted Action II Project, 2010, details the impact of HARMONAC on the recast EPBD legislative process (pages I-7 and pages II-55 onwards) : http://www.epbd-ca.org/Medias/Downloads/CA_Book_Implementing_the_EPBD_Featuring_Country_Reports_2010.pdf

2. Ongoing impact on policy and implementation is demonstrated in Gordon Sutherland's and Bruce Young's articles in this issue. REHVA Journal, Volume 49, Issue 3, March 2012. http://www.rehva.eu/index.php?id=140

3. Confirmation of impact of the EU legislators transposing the EPBD into national legislation in CONFIDENTIAL MINUTES/PRESENTATIONS/AGENDAS at Lyons IEE Concerted Action II Meeting (2008), Prague IEE Concerted Action II Meeting (2008), and Amsterdam IEE Concerted Action II Meeting (2010). Four PDFs provided.

4. Confirmation of presentation to the EU legislators transposing the recast EPBD into national legislation from CONFIDENTIAL MINUTES of Vienna IEE Concerted Action III Meeting(2011).

5. Email exchange with Jorma Railio (CEN member, and former CEN Convenor))on 26th January 2012. It corroborates the claimed impact of HARMONAC on the rewriting of the CEN Standards in this area which is currently underway and due for completion in 2014.

6. CEN Document CEN/TC 156 N1101 (dated14/2/2013). ADDITIONAL INFORMATION FOR REQUEST FOR TENDER EPBD (M/480) PHASE 2. Corroborates claim of impact on CEN Standards EN15239 and EN15240 on page 4.

7. Invited presentation and workshop on the IEE HARMONAC Project final findings. CLIMA 2010 and REHVA Congress May 2010, Amsterdam. This source corroborates claims of impact on the Profession. This workshop led REHVA deciding to participate in iSERV.

8. REHVA iSERV Vol 49, Issue 1, Jan 2012 p 6 – 11, p 53. Example of REHVA iSERVE publication which corroborates impact on the profession and wider Industry, as REHVA is the umbrella body for all the EU Member States Building Services professionals: http://www.rehva.eu/index.php?id=150&L=0%2527

9. Smith, Alex – "Early Warning System", (January 2013), *CIBSE Journal,* pp59-62. Confirmation that the professional body CIBSE is citing ISERV findings: http://www.cibsejournal.com/archive/PDFs/CIBSE-Journal-2013-01.pdf

10. The use of iSERV is specified in the UK Education Funding Agency's Specification for Future Schools (2012) pp 28, 39, 41, 42, 44 - 47, 53 .http://media.education.gov.uk/assets/files/pdf/p/psbp%20sos%20june%202013.pdf

All testimony, documents and web pages available on request from the HEI.