Institution: De Montfort University

Unit of Assessment: 13

Title of case study: Urban Analytics for energy management and user engagement in European public authorities and universities

Period when the underpinning research was undertaken: 2000–2019

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Prof. Paul Fleming	Director of Sustainable Development (now Emeritus Professor)	1995–2018
Dr Graeme Stuart	Senior Lecturer (IESD)	2004–present
Dr Leticia Ozawa-Meida	Senior Research Fellow (IESD)	2009–present
Mr David Everitt	Senior Research Fellow (IoCT)	2003–present

Period when the claimed impact occurred: 2014–2019

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact

Our research led to the uptake of modified energy management and sustainability communications behaviour in more than 40 organisations across the UK and Europe resulting in behaviour change at both the individual and organisational level. Through the delivery of our software and training, organisations have been able to more closely integrate utility metering data (electricity, heat, gas and water) into their operational practices. Individuals have been given access to high quality data in a form they can directly use to modify their behaviour. This has led to improved information and communication resulting in significant carbon emissions reductions of around 3,600t of CO_2 between 2014 and 2019 (6.6% average annual reduction from baseline emissions). DMU has created the spin-off company EcoVisum Ltd to deliver these services commercially.

2. Underpinning research

Our research in this area dates to the late 1990s (e.g. SHEEBA, EU FP4 JOE3987037,1999–2000) when a typical utility meter generated a maximum of 12 data points per year. From 2000, Automated Meter Reading (AMR) systems ('smart meters') were becoming increasingly common, typically producing 17,520 data values per year and calling for new approaches.

This change spawned the first phase of a programme of masters' and doctoral research producing a number of publications. We developed data-driven methodologies for energy managers that could be applied to rapidly identify waste and generate diagnostic reports in far more detail than had previously been possible [R1]. We also began developing tools for automating and simplifying the process from the perspective of the expert analyst.

In the EU project AIM4SMEs ('Automated and Intelligent Metering for SMEs', EU-IEE EISAV/EIE/07/136/2007, 2007–2009) our research focused on communication of newly abundant energy data to non-technical users (in this case SMEs). Energy efficiency advice and training was delivered by local authorities to support businesses to interpret the data and identify energy-saving opportunities. The project found that non-technical users had very different requirements from energy managers. As a result, the research expanded from modelling and analysis to include communication and visualisation.

In the early 2010s we began to explore a more integrated technical approach with standardised energy 'dashboards' fed by large databases of metering data. Automated analysis of near-real-time consumption data presented the opportunity to support users to learn through direct feedback how their behaviour can influence a building's energy performance. In a series of

smaller projects funded by the JISC Greening ICT Fund (Deliberative User Approach to the Living Lab, DUALL, in 2010; Greenview in 2012) and by ESPRC (GOODDEEDS Digital engaging & empowering employees for energy demand reduction, EP/K012312/1, 2013–2014), we designed and built several graphical user interfaces for non-technical users, including the DMU internal 'Go Green Week' app. Findings of these projects prompted research to investigate the most effective ways to communicate energy information to users and evaluate the ability of the designed visualisations to motivate or enable energy-saving behaviours [R2].

Subsequent projects focused on improving the integration of monitoring data into energy-management processes and energy-saving behaviours in universities and public authorities. These were explored from three perspectives: the bottom-up micro-level (individual and local), the top-down macro-level (organisation-wide and strategic) and the intermediate meso-level (community-focused and operational).

The SAVES project (Students Achieving Valuable Savings, EU-ICT IEE/13/719/SI2.675836, 2012–2014) and follow-up SAVES2 project (EU H2020 754203, 2017–2020) investigated ways of integrating automatically collected electricity data into the UK National Union of Students' (NUS) Student Switch Off (SSO) energy-saving competition. We created dashboard software that was used across 17 EU universities to enhance engagement and behaviour change activities in student accommodation blocks. The design was informed by focus groups with students across 5 countries [R3] using an agile, iterative development process to integrate findings continuously. Findings of the projects indicated that the dashboard and energy competitions were effective in engaging with students as well as in enabling, empowering and motivating them to save energy [R3].

The SMARTSPACES project (Saving Energy in Europe's Public Buildings Using ICT, EU-ICT 297273, 2012–2014) allowed us to build a prototype system for integrating the perspective of energy managers with responsibilities for large and diverse building portfolios into a user-friendly, non-technical interface [R4]. In the project we developed an evaluation framework that was used across 11 European public authorities. Formative evaluation informed the design of the system [R2]. The process and summative evaluation helped to identify improvements in the delivery of campaigns and communication factors that impacted on individual behaviour change [R5]. The follow-up EDI-Net project (The Energy Data Innovation Network; EU H2020 695916, 2016–2019) developed the SMARTSPACES concept further and deployed a scalable implementation of the data analytics and visualisation platform in over 1,000 buildings in three large EU public authorities [R6].

Our research led to the development of integrated systems including innovative data analytics and visualisations with intuitive and accessible user interfaces. These systems effectively transform raw data into accessible information that can be readily absorbed by users. This supports stakeholder participation in feedback loops in which users learn how their actions can influence their building's energy performance. Being accessible to all users, the system improves communication between stakeholders, fosters collaboration and collective action, encourages peer-to-peer learning and enables effective energy-saving behaviours [R3, R5, R6].

3. References to the research

The methodology papers [R2, R4] were presented in international peer-reviewed conferences targeting practitioners. Key papers reporting findings of the research [R1, R3, R5 and R6] were published in international research journals with high standards of peer review.

[R1] Stuart, G., Fleming, P., Ferreira, V. and Harris, P. (2007) 'Rapid analysis of time series data to identify changes in electricity consumption patterns in UK secondary schools', *Building and Environment*, 42(4): 1568–1580; DOI: https://doi.org/10.1016/j.buildenv.2006.01.004

[R2] Wilson, C. and Stuart, G. (2014) 'A persuasive case for ex ante evaluation of energy savings campaigns?', *2014 International Energy Program Evaluation Conference*, Berlin, Germany, pp 1–11 (peer reviewed). https://www.iepec.org/conf-docs/papers/2014/Caroline%20Wilson.pdf

[R3] Bull, R., Romanowicz, J., Jennings, N., Laskari, M., Stuart, G. and Everitt, D. (2018) 'Competing priorities: Lessons in engaging students to achieve energy savings in universities', *International Journal of Sustainability in Higher Education*, 19(7): 1220–1238; DOI: https://doi.org/10.1108/IJSHE-09-2017-0157

[R4] Stuart, G. and Fleming, P. (2014) 'Smart energy performance indicators for live historical and normative feedback systems', *Improving Energy Efficiency in Commercial Buildings: Proceedings of the International Conference IEECB'14*, Germany, pp 400–414 (peer-reviewed); https://ec.europa.eu/jrc/en/publication/books/proceedings-8th-international-conference-improving-energy-efficiency-commercial-buildings-ieecb-14

[R5] Ozawa-Meida, L., Wilson, C., Fleming, P., Stuart, G. and Holland, C. (2017) 'Institutional, social and individual behavioural effects of energy feedback in public buildings across eleven European cities', *Energy Policy*, 110: 222–233; DOI: https://doi.org/10.1016/j.enpol.2017.08.026

[R6] Stuart, G. and Ozawa-Meida, L. (2020) 'Supporting decentralised energy management through smart monitoring systems in public authorities', *Energies*, 13(20): art 5398; DOI: https://doi.org/10.3390/en13205398

4. Details of the impact

The primary routes to impact were the use of two distinct software systems developed by DMU in the SAVES/SAVES2 and EDI-Net projects. These systems were developed based on data analytics models and visualisation platforms, initially envisaged for energy managers, which subsequently evolved using user-friendly interfaces to facilitate communication and engagement with non-technical audiences.

The SAVES/SAVES2 and EDI-Net systems have been implemented in more than 40 organisations around Europe since 2012 and used in their associated engagement campaigns. The impact is both organisational/procedural and individual/behavioural at both the central and the local (i.e. building) level.

(1) DMU DISTINCT SOFTWARE SYSTEMS AND THEIR USERS

The dashboard software developed by DMU imported and managed electricity data from accommodation blocks in 17 universities across 5 countries in Europe (UK, Lithuania, Cyprus, Greece, Sweden) used by 50,314 students in 2014/15 and 2015/16 in the SAVES project [C1, p 6]. In the SAVES2 project, the dashboard was adapted to work more closely with the Student Switch Off campaign with an average of 43,600 students in 13 more universities across 7 countries (UK, Bulgaria, Cyprus, Greece, Ireland, Lithuania, Romania) [C2, p 4; C6, p 4] in 2017/18 and 2018/19, winning a digital innovation award [C3].

The EDI-Net system focuses on energy management in public buildings. This system was developed by DMU and the consortium partner CIMNE. It was deployed in 1,329 buildings in local/regional governments in three countries (Leicester City Council in the UK; Stadt Nuremberg in Germany; Generalitat of Catalonia in Spain), reaching around 540,000 users, including energy/facility/building managers, staff, teachers, pupils, students, patients and visitors during the project (2017–2019) [C4, pp 45–46]. The usefulness of the system for energy management and engagement activities have attracted further organisations around Europe to adopt the system, including Nottinghamshire Healthcare Trust, Blaby District Council and Charnwood Borough Council in the UK as well as Landeshauptstadt Kiel, Niederhöchstadt and Stadt Eschborn in Germany.

(2) ENERGY/WATER SAVINGS AND BEHAVIOURAL CHANGE

Our research has identified that communicating building energy performance to non-technical users is a significant contributor to support behaviour change and improve energy management. For non-technical users, the freely available web-based dashboards and league tables are easily accessed by teachers in schools or by students in their dormitories keeping energy savings at the forefront of everybody's minds and facilitating discussion about the performance of their buildings.

Dashboards have been used to support energy savings competitions, such as the annual SSO [C1, C10] and the EDI-Net schools' competition in Leicester, as well as in the energy management training of schools' staff for the Eco-Schools Green Flag applications [C5, C9].

> 'DMU's primary role in the SAVES project was to design and develop an online energy dashboard based on engagement with university partners and student focus groups. The dashboard provided students with on-demand feedback on performance at each hall by using data from smart meters to automatically update published savings calculations on a daily basis' [C10, p 1].

These activities contribute to increasing awareness and knowledge of energy efficiency across different communities [C8, C9, C10].

> 'The dashboard allows participating universities to present key data from their Student Switch Off energy-saving competitions in a way which is accessible and understandable for participating students' [C10, p 1].

> 'Through the tools and training, we have been able to support school leaders and student teams in schools to quickly review data without having to massively interrogate the data or the need to have a deeper understanding of energy systems' [C9, p 1].

These competitions and regular energy feedback have prompted simple actions to save energy and to support positive behaviour change. In the SAVES project, a 7% average reduction of electricity use compared to the baseline year was recorded across participating dormitories in 2014–2016 [C1, p 35] and a 6% average reduction in SAVES2 in 2017–2019 [C6, p 6; C2, p 7], with total accumulative savings of 7.8 GWh of electricity and 3,610t CO_2 [C1, p 35; C2, p 7; C6, p 6].

For technical users in public buildings, the EDI-Net dashboards' energy performance league tables and detailed diagnostic reports provide useful information to energy/building managers for the timely detection and correction of energy/water wastage documented in case studies during the project lifetime [C7, pp 56–83]. In 2018, wastage of 12,800 m^3 of water (accounting for over £44,000 of water costs) was avoided in cultural and school buildings in Nuremberg through the identification of water leakages from the visualisations in the EDI-Net dashboard. Following the notification from central energy managers, local managers took quick action to solve the malfunctions of water systems or replace defective valves [C8, pp 4–5]. Another benefit of EDI-Net has been that the centralised energy management is being gradually transferred to the local buildings through the monitoring of consumption patterns in the dashboard. As a result, wastage avoidance actions occur more promptly and effectively in a more decentralised energy-management approach [C8, C9].

> 'Here is where the EDI-Net dashboard leverages the available technical possibilities and enables the energy management department to improve the knowledge and the people's motivation to support the city's sustainability goals' [C8, p 2].

Decision-makers in the city of Nuremberg also recognise the value of using the dashboard to change how they communicate and engage with non-technical users, particularly to make energy visible [C7, p 40].

(3) LEGACY

A key requirement of SAVES was the legacy of the dashboard. In agreement with NUS-UK [C10], DMU created a spin-off company to continue maintaining the dashboard service to universities. To that end, EcoVisum Ltd (www.ecovisum.com) was formed in April 2016 (Company number 10100103) [C11] by the DMU academic partners in the SAVES project. NUS-UK continues to promote the energy dashboard as an additional service to their SSO competition. EcoVisum has been operating the dashboard commercially since 2017.

Following the end of the EDI-Net project, EcoVisum is taking on the legacy of the EDI-Net dashboard and supporting the sustainable energy policies in Nuremberg [C8], Leicester City Council [C9] and other local authorities.

'The usefulness and potential of the dashboard on delivering sustainable energy policy is also relevant […] engagement with users is increasingly becoming more important. Therefore, the City of Nuremberg is continuing using the EDI-Net dashboard to further develop strategies to engage with the public' [C8, pp 5–6].

EcoVisum are a full partner in the SAVES2 consortium with a budget of over £70,000 (£1,349,000 total project budget) [C11] and continue to operate the SAVES and EDI-Net dashboards commercially with clients in the UK and Germany. At the time of writing, the EDI-Net dashboard is being developed further and EcoVisum are training graduate interns.

5. Sources to corroborate the impact

[C1] *Students Achieving Valuable Energy Savings, Project Report 2014–17*, SAVES, pp 6, 14–16, 33–35; https://saves.nus.org.uk/resources/final-report-saves-1

[C2] *D1.2 Common Performance Indicators update #2 (2018–19)*, SAVES2, p 7; https://saves.nus.org.uk/resources/our-impact-2018-19

[C3] SAVES2 (2019) *SAVES2 Energy Dashboard Wins 'Best In Class' Digital Innovation Award*, 14 November 2019; https://saves.nus.org.uk/articles/saves2-energy-dashboard-wins-best-in-class-digital-innovation-award

[C4] *EDI-Net Final technical report (August 2019)*, EDI-Net, pp 37–38, 45–46.

[C5] Leicester City Council (2018) *Eco-Schools Leicester News September 2018*, Leicester, UK, pp 10, 16; https://schools.leicester.gov.uk/media/4717/september-2018.pdf and Leicester City Council (2019) *Eco-Schools Leicester News January 2019*, Leicester, UK, p 42; https://schools.leicester.gov.uk/media/5644/january-2019.pdf

[C6] *D1.1 Common Performance Indicators update #1*, SAVES2, p 6; https://saves.nus.org.uk/resources/our-impact-2017-18

[C7] *EDI-Net Deliverable 7.4 Final report (evaluation)*, EDI-Net, pp 40, 56–83; https://www.edi-net.eu/fileadmin/Inhalte/Dokumente/Deliverables/D7_4_Final_evaluation_report.pdf

[C8] Testimonial from the Head of Department for Cross-Sectional Tasks (previously Head of the Municipal Energy Management), Stadt Nürnberg, highlighting EDI-Net Impact

[C9] Testimonial from the Environmental Education Coordinator, Leicester City Council, highlighting the impact of EDI-Net, Environmental Education Service

[C10] Testimonial from the Director of Engagement for SOS-UK, and International Programme Manager for NUS-UK

[C11] Companies house (2020) EcoVisum Ltd: https://find-and-update.company-information.service.gov.uk/company/10100103/filing-history ; and CORDIS (2020). Students Achieving Valuable Energy Savings 2, Fact sheet; https://cordis.europa.eu/project/id/754203