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| <b>Institution:</b> Aston University                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                           |                                              |
| <b>Unit of Assessment:</b> 12 Engineering                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                           |                                              |
| <b>Title of case study:</b> Grid Edge – changing the way we use and store energy                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                           |                                              |
| <b>Period when the underpinning research was undertaken:</b> 2010 to present                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                           |                                              |
| <b>Details of staff conducting the underpinning research from the submitting unit:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                           |                                              |
| <b>Name(s):</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Role(s) (e.g. job title):</b>                          | <b>Period(s) employed by submitting HEI:</b> |
| Dr John Brammer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Lecturer in Chemical Engineering                          | 2002 to 2015                                 |
| Professor Prasanta Dey                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Professor of Operations Management, Aston Business School | 2004 to present                              |
| Professor Andreas Hornung                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Director of EBRI                                          | 2008 to 2013                                 |
| Dr Daniel Wright                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Researcher                                                | 2013 to 2017                                 |
| Dr James Scott                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Researcher                                                | 2013 to 2017                                 |
| Dr Yang Yang                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Research Fellow                                           | 2014 to 2019                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Lecturer                                                  | 2019 to present                              |
| <b>Period when the claimed impact occurred:</b> 2015 to December 2020                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                           |                                              |
| <b>Is this case study continued from a case study submitted in 2014?</b> No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                           |                                              |
| <b>1. Summary of the impact</b><br><p>The research has led to significant reductions in carbon emissions and energy costs via the Grid Edge spinout company. Grid Edge was established in 2016 to develop and commercialise cloud-based artificial intelligence software tools that were developed from Aston research. Using data analysis-driven notifications, the tools allow building operators to predict, optimise and control their buildings' energy profiles, reducing carbon emissions and costs and improving user comfort. The technology has been deployed successfully in ten sites by energy suppliers, housing developers and shopping centres – leading to average annual savings of 10-15% (and as much as 30%) in carbon emissions and costs. It also led to the creation of 15 full-time and three part-time jobs in Grid Edge.</p>                                                                                                            |                                                           |                                              |
| <b>2. Underpinning research</b><br><p>Grid Edge's tools and the machine learning control algorithms behind them were developed from a broad range of Aston research. The research focused on the integration of bioenergy and power storage technologies into grid connected and Localised Renewable Energy Systems (LRES). This research includes:</p> <ul style="list-style-type: none"> <li>• The processing of biomass and waste derived feedstocks for fuel production and heat and power generation <b>[R1,R2]</b>.</li> <li>• Development of business protocols for third party bi-flow, and low carbon, district heating network (DHN) connections <b>[R2,R4]</b>.</li> <li>• Advancement and demonstration of the potential of Vehicle to Grid (V2G) and battery storage infrastructure to support localised intelligent energy systems <b>[R6]</b>.</li> <li>• Exploitation of high value demand response balancing markets <b>[R3,R4,R5]</b>.</li> </ul> |                                                           |                                              |

- Development and demonstration of an intelligent control agent (ICA) that can process large amounts of current and predictive data to make autonomous, “intelligent” decisions around how optimally to operate a LRES [R3,R4,R5].
- Demonstration of the first commercial interoperation of small-scale bioenergy generation with a citywide heat network [R2,R4].
- Demonstration of the increasingly important role of LRES in supporting the traditional energy system through demand-side grid management [R3].
- Integration of the project innovations into an intelligent control agent that can continuously maximise system efficiency, service and profit [R3,R5].

Aston integrated these findings into a bioenergy demonstrator. This allowed the researchers to prove the feasibility of the technical and business aspects of the integrated control system and investigate the benefits of the interoperation of complimentary LRES technologies and the associated revenue streams.

The demonstrator incorporated multiple, integrated bioenergy technologies – pyrolysis, gasification and combustion – into a ~400kW dual-fuel, tri-generation system. This provides cooling, heat and power to a flexible, islanded micro-grid which supplies power to three mixed-use campus buildings. The dual-fuel system can operate using locally-sourced virgin and bio-waste solid material as well as liquid recycled oil-based biodiesel. The demonstrator provided a platform for a number of research studies on local energy usage and supply [R4,R5].

The research demonstrated how complex energy systems could be intelligently optimised and controlled through innovative machine-learning methods, leading to the creation of Grid Edge in 2016. Grid Edge’s core AI technology enables building operators to integrate predictive machine-learning and data science analytics into an energy management strategy that is in harmony with any existing building management systems. It simplifies energy optimisation, harnessing the power of a building’s energy and environmental data to create dynamic forecasts for the management of carbon emissions, cost and comfort.

The company also worked with Aston to develop and demonstrate a new communication and control platform for Vehicle-to-Grid/Building (V2G/V2B). This is an off-vehicle system that controls how, when and at what rate electric vehicle batteries are charged and discharged, and is informed by local substation constraints and building energy requirements. The platform addresses the concerns of District Network Operators (DNOs), building managers and electric vehicle (EV) owners, leading to increased adoption of V2G and ultimately EVs. It also leads to reduced energy costs and helps enable the creation of low-carbon networks with a secure electricity supply [R6].

### 3. References to the research

- R1** Hossain, A.K., Serrano, C.J., Brammer, B., Omran, A., Ahmed, F., Smith, D.I., Davies, P.A. (2016) ‘Combustion of fuel blends containing digestate pyrolysis oil in a multi-cylinder compression ignition engine’, *Fuel*, Volume 171. <https://doi.org/10.1016/j.fuel.2015.12.012>
- R2** Yang, Y., Brammer, J.G., Wright, D.G., Scott, J.A., Serrano, C., Bridgwater, A.V. (2017) ‘Combined heat and power from the intermediate pyrolysis of biomass materials: performance, economics and environmental impact’, *Applied Energy* 191. <https://doi.org/10.1016/j.apenergy.2017.02.004>
- R3** Scott, J., Ho, W., Dey, P. (2012) ‘A review of multi-criteria decision-making methods for bioenergy systems’ *Energy* 42 (1). <https://doi.org/10.1016/j.energy.2012.03.074>
- R4** Wright, D., Dey, P. & Brammer, J. (2014) ‘A Barrier and Techno-economic Analysis of Small scale bCHP (Biomass Combined Heat and Power) Schemes in the UK Energy’, *Energy*, Volume 71. <https://doi.org/10.1016/j.energy.2014.04.079>
- R5** Wright, D. G., Dey, P. & Brammer, J. (2013) ‘A Fuzzy Levelised Energy Cost Method for Renewable Energy Technology Assessment’, *Energy Policy*, Volume 62. <https://doi.org/10.1016/j.enpol.2013.07.077>

**R6** Ivry, P., Scott, J., Yang, J., Lin, Z., Serrano, C. (2019) 'Paper no. 1170 - An evaluation of V2G for distribution network harmonic suppression'. Poster session at CIRED 2019.  
<http://dx.doi.org/10.34890/558>

#### 4. Details of the impact

Climate change is a global crisis, and businesses will need to reduce carbon emissions and use energy more efficiently to prevent the global temperature rise exceeding 1.5°C.

Grid Edge's tools enable customers to lower their buildings' carbon emissions and energy costs by 10-15% on average, with some registering reductions of over 30% **[S1]**. The technology has been deployed successfully in ten sites, demonstrating how a wide range of large energy consumers, such as airports, business districts and shopping centres, can benefit from the tools.

Developed from Aston's research, Grid Edge's predictive energy management tools use a broad range of data, including weather forecasts and expected occupancy, to enable customers to anticipate their buildings' energy demands. They can then adapt their energy use – by shifting load, leveraging periods of high renewable power generation, and effectively using their buildings' energy demand and generation flexibility like a giant battery – to reduce costs and carbon emissions, while optimising the comfort levels of those using the buildings.

The company was started by three Aston employees who initially worked for the company on a part-time basis. Growing interest in the technology and the company's expanding product portfolio has since driven the creation of 17 full-time and five part-time jobs **[S1]** to cover related data science and web development tasks.

Grid Edge attracted initial equity investment of £360,000. In 2019, it raised £2.5 million at a BP Ventures-led Series A, pre-money valuation funding round, reaching a post-money valuation of £9.7 million **[S1]**. To date, the company has generated in excess of £200,000 in customer revenue **[S1]**, received a £500,000 loan from a Big Six energy company and has been granted around £1.3 million in R&D funding from various BEIS competitions **[S1]**. Family office investment house Goldacre joined BP as a co-investor in the 2019 funding round, to enhance its smart real estate and future cities technology portfolio. This investment will enable Grid Edge to expand in the UK market, utilising existing partnerships in the real estate sector, and explore further opportunities in Europe **[S3]**.

Grid Edge has secured commercial contracts with several high-profile customers, including Birmingham Airport, the Bullring (Birmingham) and Intu Trafford Centre (Manchester) shopping centres, housing developers BMO and Barkley Group, and Kent County Council. The technology has been deployed in nine sites, with Hammerson Group (Bullring & Grand Central) moving to a Software as a Service (SaaS) contract for multiple sites **[S1]**.

In an initial six-week trial at the Bullring shopping centre in Birmingham, the technology led to a 140,000kWh reduction in the site's energy consumption and a more than £23,000 saving in energy costs, leading to an anticipated annual carbon and energy cost saving of 10-15%. The Bullring still uses the technology **[S2, S3]**.

Other customers have benefitted from similar savings. Total savings depend on the weather, customers' energy profiles, building use and multiple other factors considered by the system's prediction algorithms, as well as the decisions made by building managers based on the information provided by Grid Edge's tools. But measurements show that energy cost savings and carbon emissions reductions are at least 10-15%, with the potential to reach 30% or more for some.

Working with Kent County Council's Energy and Estates team they integrated solar power generation data with the trial building energy profile and created a digital twin and predictive model. The system discovered the HVAC system was running sub-optimally and there was inefficient out-of-hours consumption. A new HVAC strategy was deployed along with targeted energy strategies and energy demand management at peak solar levels, which all resulted in approximately 60% energy savings and an annualised cost saving of c.£30k. **[S5]**

BP states that Grid Edge's tools are a key development for a low carbon future. Nacho Gimenez, Managing Director for BP Ventures **[S4]**, said: "Digital technologies are a critical component to

drive the transition to a low-carbon future. Using data, we can unlock the flexibility in-built in existing energy systems. This is the most efficient way to reduce the carbon intensity and power consumption required to keep buildings comfortable. Grid Edge's machine learning and data-driven approach is what really sets them apart."

Grid Edge is now further developing technologies through BEIS and client-funded research projects. These include optimising algorithms to integrate Vehicle-to-Grid electric vehicle charging technologies and help balance loads, as well as creating tools to decarbonise low-grade heat networks and manage loads according to energy prices.

Grid Edge has won multiple awards [A1-A10 in S6] including: 2019 KPMG Best British Tech Start Up (Midlands Winner, UK Finalist) [A9]; 2019 RAC Cooling Industry Awards (Best Innovation) [A8]; 2016: Silicon Canal Tech Awards (Best Start Up) [A3]. This demonstrates the value to the end user communities of this technology.

## 5. Sources to corroborate the impact

**S1** Testimonial statement from Grid Edge

**S2** Hammerson 2018 Annual Report, p.36

**S3** Graham Lanktree, Hammerson gains an energy saving edge, May 2019, 49-50, Property Week, <https://tinyurl.com/yxtgc8le>

**S4** BP expands its digital energy portfolio by investing in energy management platform, Grid Edge BP.com Press Release, Oct 2019, <https://tinyurl.com/y593c7ze>

**S5** UKGBC (Green Buildings Council) Innovation Insights: Reducing Operations Carbon, p. 18 <https://www.ukgbc.org/wp-content/uploads/2021/01/UKGBC-Innovation-Insights-Reducing-operational-carbon.pdf>

**S6** Summary of Grid Edge related awards [A1-A10]