

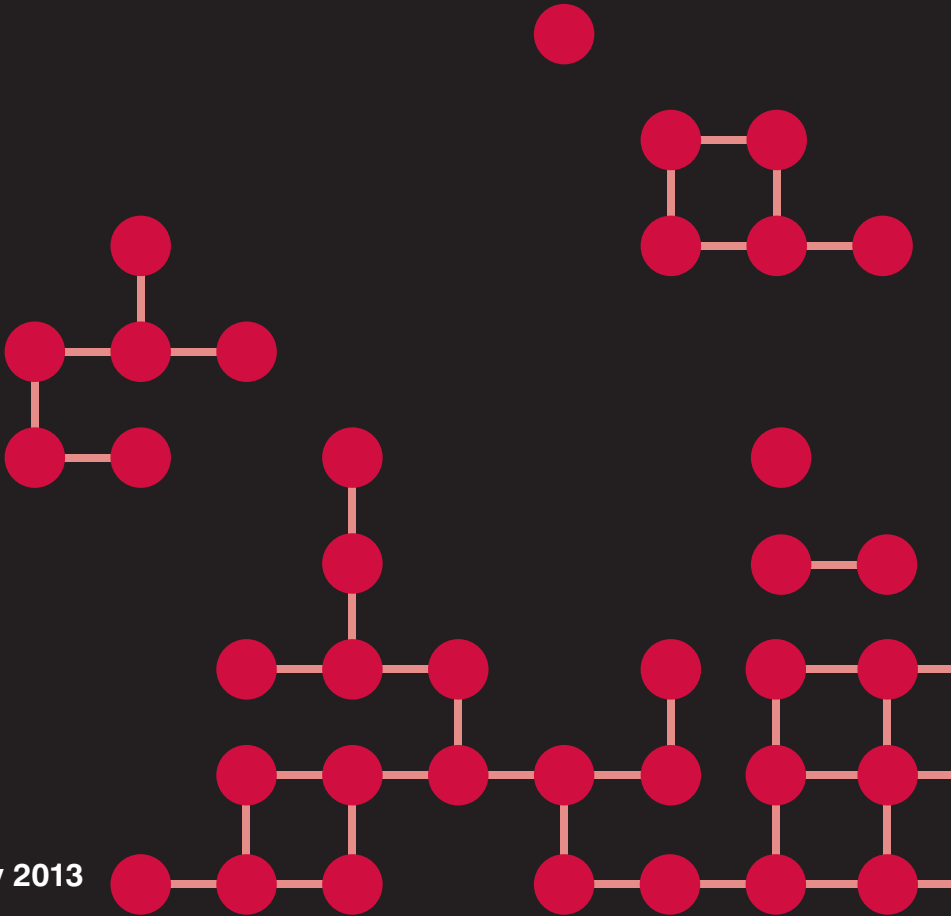
# Technology Strategy Board

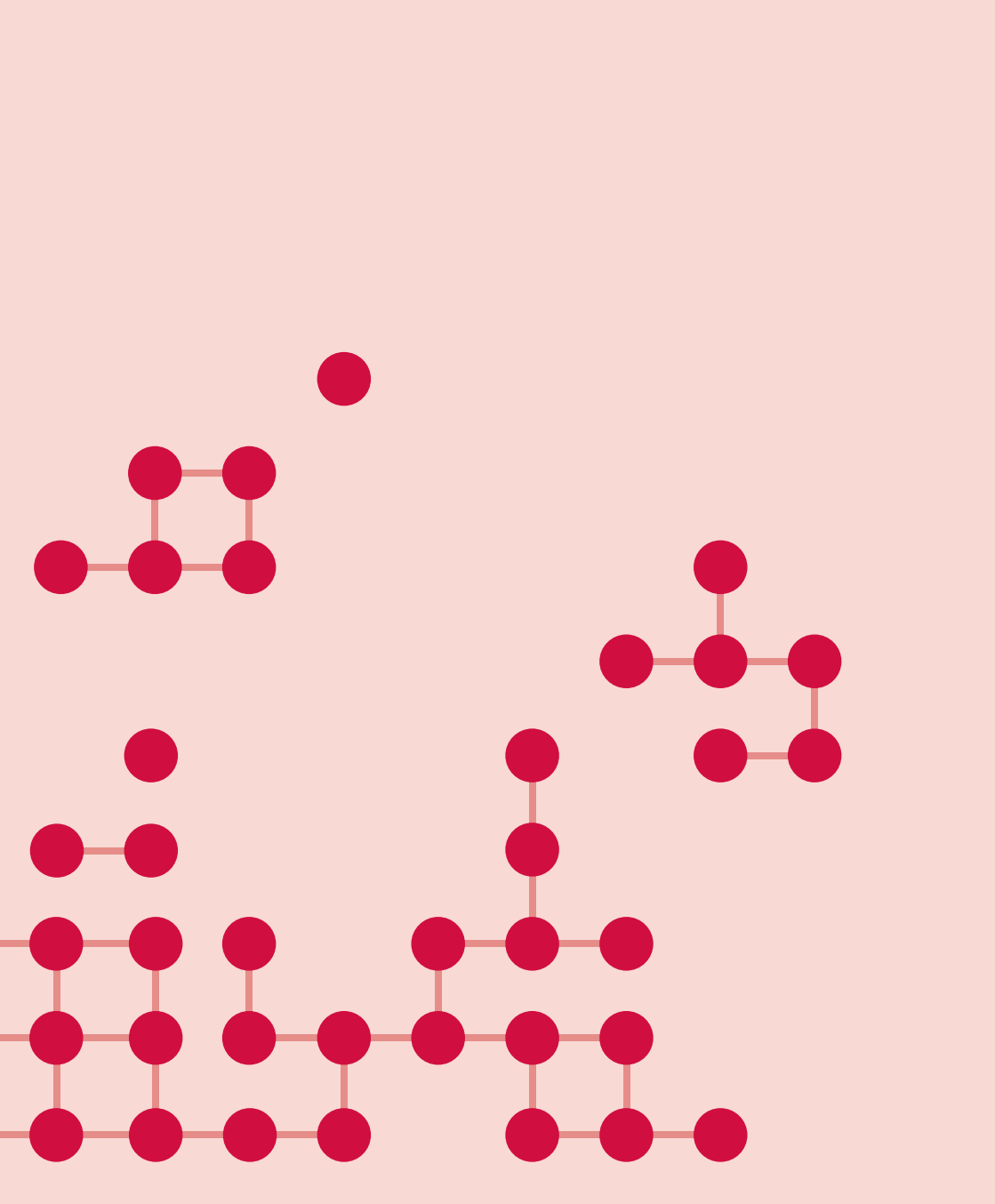
Driving Innovation

## Collaboration Nation

### Smart power distribution and demand

July 2013





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# Introduction

The development and use of new technologies drives economic growth, but early-stage innovation can be too high risk for many small and medium-sized businesses to undertake without support. Our feasibility study funding enables new ideas to be transformed into demonstrable technologies and techniques that can attract the partners, investors and future customers needed for successful and timely commercialisation. This directory showcases some of the feasibility studies we have funded in our energy supply programme.

## Feasibility studies in smart power distribution and demand

Energy supply is one of the priority areas for the Technology Strategy Board. We aim to help UK business to address the 'trilemma' of energy security, affordability and sustainability, and to profit from the changes the world will have to make to its energy system.

This directory showcases projects that shared £2m awarded in 2012 for innovative feasibility studies into smart power distribution and demand. The awards were the first phase of a four-year programme that aims to encourage the development of new technologies that will help to integrate future demand and energy supply into a flexible, secure and resilient energy system.

There will be a complex mix of technologies generating, transmitting, distributing, and storing power by 2050, including nuclear power stations, offshore wind farms and solar panels. At the same time, demand for power will rise because of the electrification of heating systems and use of electric vehicles. The challenge for the power industry is to match demand with supply.

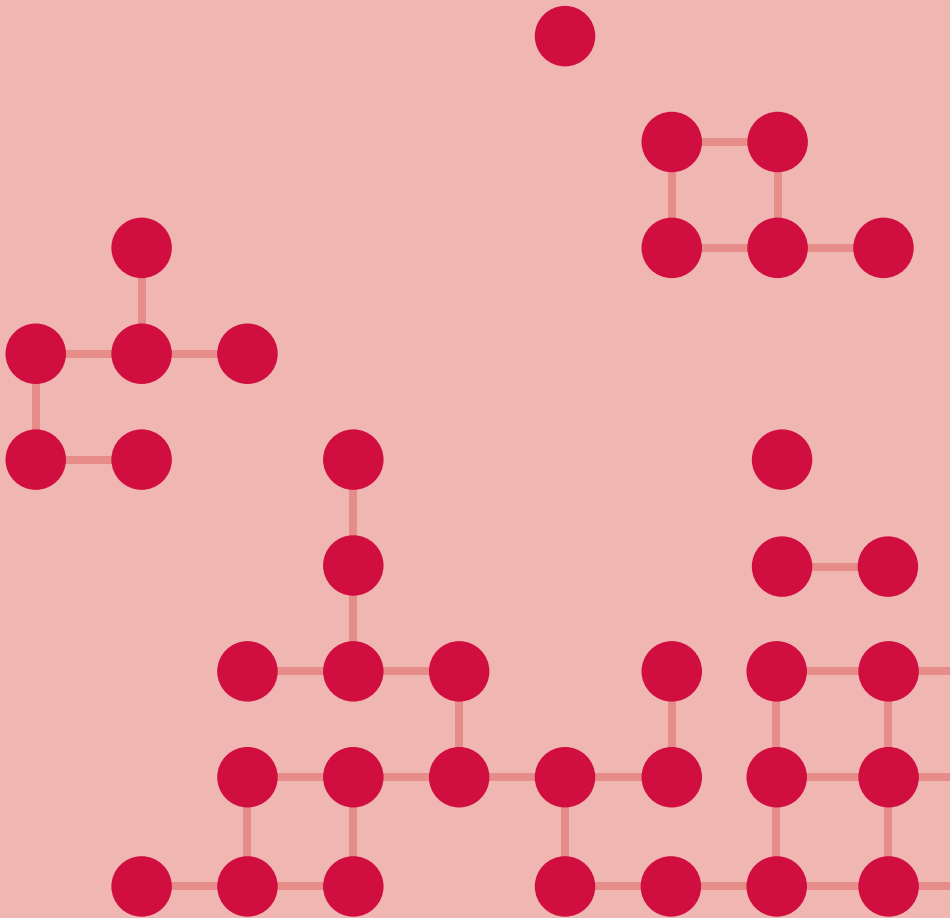
All the studies were led by small and medium-sized businesses, operating either alone or in collaboration with partners. Some projects were awarded up to £25k for studies lasting up to four months and others were awarded up to £100k for studies lasting between six and 12 months.

To find out more about our energy supply strategy, go to [www.innovateuk.org](http://www.innovateuk.org) and look under Our priorities. To meet people working in your area go to <http://connect.innovateuk.org/>



Collaboration Nation

# Smart power distribution and demand feasibility projects



# ADI Advanced Digital Institute

**Active virtual power plant with combined heat and power clusters (active CHP-VPP)**

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ADI create innovative solutions for improving people's everyday lives. We use electronics, communications and internet technologies to transform essential services such as healthcare, energy, housing and education.

## What was the business need that motivated the project?

There is a pressing operational need within the UK to improve the flexibility and resilience of the ageing electricity distribution network to efficiently address increasing demand while also meeting commitments to reduce carbon emissions by 20% by 2020, compared with 1990. Addressing this need alone is forecast to save the UK £8bn by 2020.

## What approach did you take to address the challenge?

We undertook a feasibility study into an 'active demand-response' supply control model at a low level in the network, where many small-scale combined heat and power (CHP) generating plants in the 10kW–1000kW range, and individual loads (such as building heating, ventilation and air-conditioning equipment) associated with these generation sets, are linked to distribution network operator network management signals in a system we are calling 'Active CHP-VPP'.

## What are the potential benefits?

The total world market for energy network systems is estimated to be £110bn globally by 2014. It is anticipated that by 2015 early-adopter distribution network operators globally will be commissioning active, distributed demand and supply management virtual power plant systems. The business drivers for distribution network operators are clear. The installed base of small combined heat and power plants is circa 50MW in London, 4GW in the UK, 100GW in Europe, and 320GW worldwide.

## What are the next steps?

The requirements for Active CHP-VPP can be used to shape offerings to the market place in terms of the combination of aggregation and constraint management and the required communications infrastructure. The consortium sees next steps as implementing the model on a live pilot follow-on project.



# AlertMe.com Ltd

## Plan capture of a domestic consumption dataset to inform smart demand

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AlertMe is a connected-home platform, established for seven years, with several very large global channel partners, including British Gas in the UK. AlertMe allows consumers to see and manage what is going on in their homes using their smart phone.

### What was the business need that motivated the project?

Today's electricity grid models capture only the macro level. Planning smart demand requires a detailed bottom-up model of individual household appliance consumption, which does not exist today. Government and the nascent smart-demand industry require a more detailed picture of the individual loads within UK households, and the extent to which they are dispatchable (can be adjusted according to demand) by time and demographic.

### What approach did you take to address the challenge?

Led by a consumer demand expert, this study worked out how to capture such a dataset, delivering a costed project proposal that has been tested against the requirements of many players in the smart-demand sector.

### What are the potential benefits?

When industry or government chooses to pursue certain smart-demand approaches, it needs data to back up that choice. This study shows how the vital data about household consumption (30% of all energy use) can be gathered in a way that is timely and continuous, and at much lower cost than previous studies.

### What are the next steps?

This thinking is being carried forward by several in the industry, for example by Cambridge Architectural Research, which gathers much of the data used by the Department for Energy and Climate Change to publish its annual energy consumption breakdown figures. Hopefully, as smart meters roll out, this work can be used to design real-time analysis.

# Amantys Ltd

## Predicting failure in adaptive networks

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Amantys specialises in the delivery of scalable, cost-effective solutions to meet the challenges of designing reliable and efficient power conversion in medium and high-voltage applications. The company was founded in 2010 to exploit intellectual property from the University of Cambridge.

### What was the business need that motivated the project?

The market for high-power electric systems is expanding rapidly due to the infrastructure build in developing countries and the desire to reduce CO2 emissions. The skills to design and build these systems are in very short supply. Amantys needed a way to accelerate the design process without taking the risk of building large high-voltage systems.

### What approach did you take to address the challenge?

High-power electronic systems used in applications such as transmission and distribution, medium-voltage motor drives, wind turbines and locomotives are by their very nature difficult to build, test and instrument. Amantys decided to invest in simulation as a way to evaluate, prototype and test systems before committing to hardware.

### What are the potential benefits?

The benefits are that the design process can be speeded up significantly, the risk in building the systems can be mitigated, and advanced ideas can be evaluated before committing to hardware. The project also helps to reduce the risks in designing power electronic systems for green applications. The project delivered an accurate simulation model for the main power electronic component (IGBT – insulated-gate bipolar transistor) and also a model for future silicon carbide devices.

### What are the next steps?

Amantys is using the simulation models to evaluate the performance of its advanced gate drivers when used with partners' IGBT modules. This allows Amantys to evaluate multiple alternatives before committing to hardware.

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The team comprises B9 Energy, SmartGridIreland and Fast Technologies. B9 Energy has 20 years' experience in the renewable sector. SmartGridIreland is a network of businesses wishing to develop smart-grid opportunities. Fast specialise in automation and controls for industry.

### **What was the business need that motivated the project?**

Energy storage systems deployed at the source of renewable generation are increasingly seen as an essential component of an intelligent grid network. This proposal explores cost-effective mechanisms for optimising the integration of renewables' generation through an energy storage interface to deliver a high-quality steady-flow, continuous output to the grid.

### **What approach did you take to address the challenge?**

The core concept is to export energy primarily through an intelligent storage system of optimised capacity and to provide a steady revenue stream. The model that we developed determines the best match of storage capacity and generator size to attain these revenues for a variety of scales and circumstances. This will ensure more power from these resources becomes dispatchable by smoothing the variability.

### **What are the potential benefits?**

Technology Strategy Board support has enabled us to conduct a feasibility study for the development of an integrated control and systems package that will facilitate intermittent renewable generators onto the distribution grid, control demand-side management units (load) and be capable of aggregating and delivering dispatchable high-quality power at source onto the grid, enabling site owners to maximise revenue streams, reduce energy costs and environmental impact and become more competitive.

### **What are the next steps?**

B9 Energy are in negotiations with a hardware manufacturer to produce the intelligent control system. We hope to test the system on a few demonstrator sites within the next few months before developing our product offering to the marketplace.

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The consortium is made up of leading players in building optimisation and human behaviour (Carnego), solar/LED and DC technology (Zeta) and an international sustainability consultancy with a track record of delivering sustainable communities.

### What was the business need that motivated the project?

Housing developments with large-scale solar deployment have a large peak output during the summer. This results in large additional costs to reinforce the local grid, which is acting as a direct disincentive to large-scale photovoltaic deployment. This conflict needs to be resolved through a combination of technical and social innovations that allow optimised energy use within a community without impacting the grid.

### What approach did you take to address the challenge?

We took a system-wide approach combining local storage, DC power, smart controls and behavioural feedback, combined with sophisticated modelling of energy flows. The system uses CAT-5 data cabling within homes, and is coupled with the ability to monitor and control energy flows, storage and appliances. The modelling has enabled us to optimise energy flows, demand shifting and energy storage both at a household and a neighbourhood level.

### What are the potential benefits?

Current developments are incurring additional grid reinforcement costs due to the high-peak photovoltaic export level. These can be mitigated. The approach enables the energy use within the development to be optimised. This brings technical benefits and enables households to get maximum financial value from photovoltaic (and other renewable) technology deployed. This will enable more photovoltaic to be successfully deployed and enable new community energy economic and social models.

### What are the next steps?

A prototype system has been successfully demonstrated. The next step will be to deploy pre-production systems within realistic home environments and then fully commercialise the technology. Additional funding is now being sought to complete these activities. Further work is also planned to drive forward innovative community energy models.

## Understanding consumer motivations for participating in a smart-power system

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The Centre for Sustainable Energy is an independent national charitable company that was initiated in 1979. Our mission is to share knowledge and practical experience to empower people to change the way they think and act about energy.

### What was the business need that motivated the project?

A smarter power system will rely partly on new behaviours from consumers that change the timing, nature and scale of their electricity demand. To date, little attention has been paid to the interests and motivations of consumers in playing the roles assumed of them in smarter-system modelling.

### What approach did you take to address the challenge?

We used the 'Five Ways to Wellbeing' (new economics foundation) as a foundation for developing three smart-meter services to engage consumers, based on control, community rewards and gamification (use of game thinking and game mechanics to engage users). These were designed with the help of a workshop involving technologists, designers and industry experts. These services were tested in consumer focus groups, where consumer discussions identified a number of key themes, such as choice, feedback and inconvenience, among others.

### What are the potential benefits?

This study has given us a greater understanding of consumer concerns and of what will realistically change their energy behaviour. This will allow for the development and effective use of smart-meter services for both the benefit of the grid and consumers. The effective and long-term use of smart meters will have financial and environmental benefits in terms of both reduced and shifted consumer energy demand.

### What are the next steps?

We are continuing the discussion with those that attended the initial workshop to make them aware of our findings and to see where they have taken the conversation. We are also producing a fuller report that will be aimed at energy companies, smart-meter developers and those doing similar research.

# Clean Energy Prospector

**Skyprospector: simulating 'microgeneration aware' dynamic demand technology**

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Clean Energy Prospector (CEPRO) was founded in 2009 with the goal to use technology to discover areas where financial and environmental benefits align. Our team has developed an affordable demand-side smart grid mesh radio technology.

## **What was the business need that motivated the project?**

'Microgeneration aware' smart-demand technology can manage when electricity is consumed to maximise use of on-site renewables. A mid-latitude UK domestic home with a 4kWp (peak power) solar array can save about £200 per year by actively managing electric heating of space and water.

## **What approach did you take to address the challenge?**

We developed Skyprospector, a tool that enables homes with microgeneration (initially solar photovoltaic with other technologies to follow) to run scenarios against their energy consumption dataset to precisely quantify the financial value and carbon impact of new demand-shifting technology they plan to install in their home. The tool focuses on space and water heating as these have most potential to be automatically demand shifted to achieve savings.

## **What are the potential benefits?**

By precisely quantifying potential savings in solar homes, Skyprospector will help drive sales of technology that provide homeowners with solar with the best return on investment. Industry beneficiaries will be companies in the supply chain for air source heat pumps and electric immersion heater controls. This includes manufacturers, distributors and installers.

## **What are the next steps?**

We will continue to run the current Skyprospector trial to gather a larger dataset; fund a larger trial of Skyprospector with a wider group of users in Bristol; and develop Skyprospector as a pre-sales tool for solar. We will develop the system further to support a wider range of gas meter types and to enable homes that do not yet have solar to participate.

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Clicks and Links Ltd provides IT solutions to the public and private sector. Partners in the consortium were design and engineering company Ove Arup and the University of Manchester.

### What was the business need that motivated the project?

The need was for an operational toolkit for a proposed urban energy enterprise that would manage local energy generation, storage and trading. The study included investigation of the technical, legal, commercial, regulatory, operational and institutional considerations and potential barriers to the creation of such a model using Greater Manchester as a reference.

### What approach did you take to address the challenge?

The two key challenges for U-VEX included accessibility of data and the complex structure of the energy market, particularly for electricity in the UK. Whilst the first can be overcome with some degree of persistence and involvement of key players, the second is more structural and, at present, limits the potential in the UK for new entrants to the energy market at the urban level unless they have significant resources.

### What are the potential benefits?

The U-VEX toolkit potentially allows an urban energy enterprise to plan and manage local energy generation, storage and trading. Such enterprises could be public or private bodies, or public/private partnerships. The concept could be applied to support the development of local/urban energy policy.

### What are the next steps?

The consortium has already successfully applied for European Commission funding to support the development of the U-VEX toolkit and its implementation in Turin/Manchester. We will continue to explore public and private funding options. Equally important is the development of an appropriate business model for charging for use of the toolkit.

# Digital & Future Technologies Ltd

**PRIMPS – portable remote intelligent monitored power system**

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Digital & Future Technologies develops wireless control systems for the temporary site and event industry. We specialise in providing remote monitoring or data transfer for clients.

## **What was the business need that motivated the project?**

The project was undertaken to provide IP-based (using a web interface) control of remote gas-powered generators for the entertainment, event and construction industry. There was a need for dry fuel generators that could monitor themselves and send back information regarding their operation and fuel status providing a unique remote controllable power system.

## **What approach did you take to address the challenge?**

PRIMPS1, a prototype, was demonstrated and confirmed there was a significant interest within the industry for remote control of power and, more importantly, the ability to understand how much power was being used and where without having to send a human to read a meter. It was discovered that there are a minefield of regulations regarding gas-powered generators but that a part of the system has great potential.

## **What are the potential benefits?**

The part of the PRIMPS system that we decided to manufacture focused on the remote modulation of the power being consumed over powerline ethernet systems. We have developed a system for the temporary events market that allows them to monitor their power usage from anywhere downstream of the power supply. We have also teamed up with another company to integrate full ethernet powerline capabilities into the product.

## **What are the next steps?**

We are currently working on the marketing of the products and the range will be made available in quarter three of 2013. The range will be launched at PLASA trade show in October. We are also working on distribution abroad and moving into the construction industry with the product.



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dseConsulting Ltd uses the latest simulation techniques to build analytical models that allow our customers to test their business models and business decisions. The consortium also included Critical Software Technologies, the University of Greenwich and Cardiff University.

### What was the business need that motivated the project?

This project looked at the emerging business of energy resource aggregation (where groups of consumers join to purchase energy). In future power systems, it is expected that energy resources such as electric vehicles and micro-generators will be controlled in an aggregated fashion, bringing benefits for the aggregators as well as the users/owners. This project addressed the infrastructure that will enable the aggregation of energy resources to be realised.

### What approach did you take to address the challenge?

In order for aggregated control to be realised, the project participants proposed multi-agent systems as the control method. This project gave an initial indication on whether the concept of agent-based controllers is viable for commercial purposes. The technical requirements of the control equipment and the costs and benefits of the approach were analysed. This research has flagged up some of the complexities of the business model associated with this approach.

### What are the potential benefits?

The proposed approach provides the user with autonomy over the use of their equipment, while enabling its control for the greater benefit of the power system and all its stakeholders. It can help in reducing the need for costly additional generation plants or network upgrades, increasing the carbon efficiency of power generation and facilitating the integration and uptake of electric vehicles and micro-generators.

### What are the next steps?

The partners intend to take this research forward and work further towards the exploitation of this technology. The next step will be an initial experimental validation of the controllers. The preferred pathway to market was identified as through integration with existing products offered by Critical Software Technologies.

# Exergy Devices Ltd

**Embedded generator analytics for distribution network operators**

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We are a small R&D business started in 2006 that develops intellectual property relating to energy management and control, with a particular focus on 'smart home' and 'smart grid' projects

### **What was the business need that motivated the project?**

Micro electricity generators such as photovoltaic panels are now common. This creates a problem for distribution network operators because consumer demand for electricity cannot be measured at the transformer when demand is partly met by these embedded generators. They therefore need a new method to measure and predict the underlying consumer demand for electricity on any network segment.

### **What approach did you take to address the challenge?**

We applied signal processing and correlation techniques to measurements of current flow at transformers taken at intervals of between 10 minutes and half an hour. We were able to detect the 'signature' of wind and photovoltaic generators and estimate their capacity. From this, we are able to calculate and predict actual consumer demand using neural network methods. This capability is novel.

### **What are the potential benefits?**

It restores to distribution network operators the level of understanding on the performance and loading of their networks that they had before feed-in tariffs and large-scale micro generation. It is a key 'smart grid' component that, along with other methods for managing electricity demand, has the potential to save £10bn. The Technology Strategy Board project has allowed us to realise a prototype system that can be demonstrated to potential customers.

### **What are the next steps?**

We are in conversation with several potential customers interested in taking this technology forward to a field trial that will prove the use cases and business benefits, and demonstrate integration with operational IT systems.

## Fault current limiter for smart-power grids

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FaultCurrent Ltd produce fault current limiter products that will enable the connection of distributed generation and provide protection of the power distribution network.

### What was the business need that motivated the project?

Fault current levels are rising in all distribution networks due partly to demand and partly to local generation connection. In order to avoid massive network upgrade costs, fault current limiters will be vital to prevent grid damage and to facilitate the safe connection between renewable energy generators and the power grid, particularly within the emerging smart grid.

### What approach did you take to address the challenge?

The technology behind the new fault current limiter has been achieved through a combination of magnetic engineering insights, including using low-cost ferrite magnets to saturate an iron inductor. A combination of 3D finite-element modelling and laboratory-scale prototypes provided the proof of principle to then scale up the concept to a 20MVA power level to address distribution network operator and distributed generation customer applications.

### What are the potential benefits?

This technology results in a low-operational-cost, 'fit and forget', completely passive, autonomous system that requires no external power, back-up or control, and recovers automatically when the fault is cleared.

### What are the next steps?

A new company called FaultCurrent Ltd has been established and has gained sufficient investment funds to now develop the real full-scale 11KV 20MVA product. A type-approved product will be made available to distribution network operators and distributed power generator installations.

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Grid Scientific Ltd is focused on defining, designing and delivering solutions for electricity network operators that facilitate integration of existing and planned systems to improve operations or support introduction of new services.

### **What was the business need that motivated the project?**

The complexity of networks and services will increase sharply as the move towards the 'smart grid' gains momentum. The ability to respond rapidly and flexibly and to assimilate and manage new technologies effectively will be difficult without a significant change in the use of ICT, the integration of disparate systems and the automation of processes.

### **What approach did you take to address the challenge?**

The coherence engine is an intelligent model-based integration framework that facilitates interworking and data sharing between multiple systems. These systems may be used to manage networks, to enable introduction of new services or to support process automation. The framework provides a level of abstraction from individual applications and supports and embodies relevant core standards. It applies learning gained from the telecommunications sector's experience of addressing similar technical and operational challenges.

### **What are the potential benefits?**

The coherence engine is seen as an important enabling system to facilitate evolution in the electricity sector and ensure that operational environments and processes are better equipped to keep pace with infrastructure and technology developments. It will help mitigate risk, lower costs and accelerate the roadmap for change. In addition, early effort in this emerging solution offers an opportunity for the UK to lead in a growing global market.

### **What are the next steps?**

The next steps are to develop a prototype of the coherence engine to validate the approach, functional requirements and technologies; to demonstrate core capabilities; and to assess detailed integration, modelling and scalability requirements. Further development phases would be undertaken to deliver and introduce an industrial-strength, commercially viable product.

# High Voltage Partial Discharge Ltd

An integrated smart grid monitoring and protection platform  
for electricity distribution medium-voltage networks

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HVPD are experts in on-line partial discharge (OLPD) insulation condition monitoring technology for medium and high-voltage cables and plant. Our OLPD condition monitoring technologies are used to support condition-based management schemes applied to complete medium-voltage and high-voltage power networks.

### What was the business need that motivated the project?

A system was needed that identifies changes in the operation of electricity distribution networks related to increasing renewable energy generation and power electronic loads. Our monitoring system provides operators with detailed information on these largely unknown effects. By providing more efficient protection, control, supply quality and insulation condition measurements, our device will help to optimise distribution networks.

### What approach did you take to address the challenge?

We have integrated existing sensor technologies to deliver and demonstrate a 'smart grid triple sensor'. This required new hardware and software to be developed and integrated into a new platform using a new combined (triple) PD/PQ/EF (partial discharge/power quality/electric field) sensor. Monitoring of a commercial distribution network was carried out. A market consultation and analysis was undertaken.

### What are the potential benefits?

A prototype integrated sensor smart grid monitoring platform has been demonstrated. Products based on this prototype will be first-to-market devices. Our market analysis has specified opportunities and target customers. Subsequent work on development prototyping, industrialisation and system installation will create at least seven new positions at HVPD. Sales of the first system are expected early 2015. Smart grid inspired devices will increase distribution network operating efficiency.

### What are the next steps?

The smart grid prototype is being exploited in the development testing and new product development of an integrated high-voltage network monitoring system for offshore renewable networks in a project co-funded by the Department for Energy and Climate Change. Results are also feeding into a regional growth fund product development project to develop a 'holistic' high-voltage plant condition monitoring system.

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The hydrogen gas inject project consortium includes ITM Power, SSE, National Grid, Skotia Gas Networks, SHFCA, Shell and Kiwa. Between us we have all the experience required to investigate the technical and commercial viability of hydrogen gas injection into the grid.

### What was the business need that motivated the project?

The UK quotient of renewables' generation will increase by a factor of five over the next decade, increasing the unpredictability of supply, presenting significant technical and financial challenges, and threatening the viability of larger scale roll-out and attainment of national targets. Taking excess renewable energy, converting it to hydrogen and injecting this into the grid represents a potentially valuable opportunity.

### What approach did you take to address the challenge?

The consortium took a three-tier approach. First, we did preliminary research, acquiring geographic data of wind farms, gas terminals, compressor and venting stations, storage facilities, gas flow and power demands. Second, we created models and simulations, defining all key parameters for a generation model; calculating aggregate surplus capacity based on historic data; and simulating hydrogen production at a single wind farm. Third, we shared the information between project and partner managements.

### What are the potential benefits?

Current installed wind capacity is roughly 5.5GW and is forecast to increase to 26.9GW by 2020. Our feasibility study will enable us to embark on a development program to use electrolysis for demand-levelling and injection of hydrogen into the natural gas network. It will result in a reduction of constraint payments and the conversion of an otherwise wasted source of power into a convenient store of energy.

### What are the next steps?

We would look to develop a small (300kW) prototype electrolyser for a field trial to interact with variable and intermittent supply conditions. The project would take about two years, after which full-scale commercialisation (at least 3MW) is envisaged by 2018.

# KiWi Power Ltd

Open source micro metering and control  
for peer-to-peer micro grid

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KiWi Power was founded in 2009 as a smart-grid company that specialises in managing electricity demand between large industrial and commercial consumers and grid-system operators.

### What was the business need that motivated the project?

Our vision was development of an ultra-low-cost, robust platform for the deployment of demand response to meet balancing requirements and financial incentives to shift load. This is necessary because, while demand response exists for major energy users, there has been little attempt to build demand response for small and medium-sized enterprises (SMEs).

### What approach did you take to address the challenge?

This project involved specifying and designing a new type of metering and control solution based on standard web technologies and building on open-source designs for hardware and software. It involved building and testing multiple prototypes to develop the level of functionality and robustness required for business customers.

### What are the potential benefits?

The platform opens up hundreds of megawatts to demand response by lowering the cost of installation and operation and making it economically viable. This represents a little penetrated market of several millions of pounds a year. By using existing demand-side assets, we can lower our dependence on expensive and polluting peaking power stations for reserve services and help renewable technologies participate in the generation mix.

### What are the next steps?

We plan to run a series of trials with the technology on our customer sites where there is untapped opportunity. This will be followed by a wider roll-out to SMEs, which will also gain from free metering and energy management software.

## Assessing the benefits of demand-side response participation in a capacity market

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KiWi Power provides demand-side management and demand-response services to industrial and commercial customers. We specialise in smart grid, demand response, renewable energy technologies, standing reserve, energy efficiency and optimisation, and smart-metering technology.

### What was the business need that motivated the project?

Demand response is widely regarded as a crucial component of future electricity systems. Demand response has the potential to reduce peak demand by reducing loads on request and thereby avoiding the use of some of the most-costly-to-run and polluting generators on the system and improving security of supply.

### What approach did you take to address the challenge?

This project gave UK academics unprecedented access to empirical data of demand-response trials in the non-domestic sector. Half hourly load profiles could be analysed and compared for different sites and sectors. In close collaboration with experts from the demand aggregator, it was possible to develop recommendations to policy makers, which could see the resource more than double in some sectors.

### What are the potential benefits?

Based on the analysis of primary data and estimations developed with expert insights, we have been able to identify regulatory barriers, which, if removed, could lead to additional peak load capacity of up to 1GW in one of the reviewed sectors alone. UK-wide, the savings on capital spent are expected to exceed £1bn.

### What are the next steps?

Demand response has the potential to reduce electricity demand on the grid at critical periods. However, the scale and the mechanisms to deliver this potential are poorly understood. The analysis of demand response is data intensive and requires careful baseline methodologies. Only a small share of the data has been reviewed.



## Augmented reality game to modify consumer energy consumption and aggregate consumer behaviour data

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Legendary Games is a cutting-edge HTML5 games developer newly formed to tackle the recent rise in online and smart-device applications and working in tandem with academics from Staffordshire University to reduce energy consumption using online games.

### What was the business need that motivated the project?

Energy suppliers are looking for ways to reduce consumer energy consumption to meet the Energy Efficiency Commitment (EEC) obligation and to incentivise interaction with smart meters. The results from the project indicate that a games application could help meet these requirements.

### What approach did you take to address the challenge?

At a technical level the consortium worked with and analysed data provided by British Gas, integrated with a clamp solution provided by AlertMe.com and carried out qualitative surveys of a device user's behaviour. The university researched and wrote papers on the use of rewards' mechanisms and designed a template application interface.

### What are the potential benefits?

We have produced a route plan and feature list of how a successful application that would reduce consumption by up to 10% could be built. This has obvious commercial and environmental opportunities, with consumers and energy suppliers benefitting from any future application using these results.

### What are the next steps?

We are looking for funding partners to help fund the creation of the final application.

## Modelling & testing through novel retrofit controls, impact of smart appliances & user behaviour on grid balancing

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Moixa Technology aims to change the way we produce and use electricity. Moixa Design rethinks market axioms and develops distinctive intellectual property and new product categories that are more usable, portable and sustainable.

### What was the business need that motivated the project?

The project examined the potential of smart appliances and smart control for time-shifting of high-load domestic appliances in balancing the grid. The project aimed to gather real-world data, to overcome surprisingly poor market evidence, and to show what inventory of power load or shift could actually be made accessible for demand-side participation, virtual power plant and other models.

### What approach did you take to address the challenge?

The team focused on and tested novel designs and demand-side participation processes that engage with consumers, to validate what types of energy intervention may be possible, and therefore explore rate-of-adoption and consumer-behaviour issues and opportunities. The aim was to potentially accelerate this through novel retrofit and demand-side engagement solutions as a corollary to the study.

### What are the potential benefits?

We sought to establish the degree to which smart appliances could be significant in creating shiftable power loads for use in grid programs, such as STOR (Short Term Operating Reserve), or new tariff models – and improve on the potential of smart appliances (such as washing/wet appliances) to be a significant resource for future demand-side participation programmes and grid balancing.

### What are the next steps?

The potential is to both design retrofittable widgets that could be deployed on a subset of the 50 million-plus UK wet-good appliances, in advance of natural replacement cycles, to create significant inventory for demand-side participation programmes, and to better understand what types of end user intervention are possible.

# Moixa Technology Ltd

**Grid-shift and peak reduction through distributed storage, smart DC and virtual power plant models**

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Moixa Technology aims to change the way we produce and use electricity.

### What was the business need that motivated the project?

There was a need to demonstrate validity of a distributed storage model combining DC lighting and power provision; to measure the asset of battery storage to utilities, government and distribution network operators; to refine core 'smart' battery management systems; to test system components; to assess potential for aggregated storage systems; and to create key partners to allow exploitation of distributed storage across the UK.

### What approach did you take to address the challenge?

The project would not have been successful without the many complementary skill sets brought together through the consortium. The goal was to demonstrate the benefits of distributed battery storage. Through the close collaboration of UK industry and academia, the team was able to comprehensively show how battery storage will improve services and reduce the living cost for millions of people, at the same time demonstrating the advantages to the whole UK grid.

### What are the potential benefits?

The project has helped push the case for distributed storage and demand-side participation. The work done has directly fuelled the commercialisation of Moixa's system (Maslow), resolving many of the barriers to market-wide penetration. Rigorous analysis of competing battery technologies was undertaken, allowing Moixa to remain at the leading edge of battery technology. This enables the continuous improvement needed to maximise the huge potential of smart distributed battery storage.

### What are the next steps?

The clear case made through the project for wide deployment of distributed battery storage has led directly to a Department of Energy and Climate Change contract to design a full grid linked system. Moixa aims to deliver 1MWh of storage to the national grid by 2014.

## The importance of growing DC (direct current) load to grid balancing and demand-side participation applications

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The project is led by Moixa Technology, a pioneer of distributed storage and local DC power networks. The project is supported by AMEE, an expert in energy data extraction and software integration.

### What was the business need that motivated the project?

Moixa believes the potential for DC (direct current) load monitoring and shifting via smart control, demand-side participation and storage is highly significant and may in fact become a dominant mechanism in helping to balance the grid by 2020.

### What approach did you take to address the challenge?

This project has explored the potential impact of growing DC demand on the future grid, which will be an increasing proportion of domestic daily and peak load. It has helped to demonstrate the potential importance of this for the smart grid and opportunities to significantly help balance the grid at low cost through novel technological innovations and convergences.

### What are the potential benefits?

The work has helped to demonstrate that there is a case for more research and trials demonstrating the impact that DC load can have on future grid and demand-side participation opportunities. This is being used as a driver in the development of our Maslow system (see [www.moixatechnology.com](http://www.moixatechnology.com) for details).

### What are the next steps?

We now need to establish a rigorous case for adjusting smart grid planning. Given the speed at which DC products are adopted/replaced, this is essential. Standards for power data must be built into next-generation consumer ICT – for example a USB power delivery standard.

# Open Energi

**Developing Dynamic Demand™ smart grid in refrigeration using creative industries & a controls manufacturer**

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Open Energi works with energy users to unlock new revenues through a smart approach to managing their energy loads.

### **What was the business need that motivated the project?**

The need for fast-acting electricity reserve services is growing rapidly as electrical demands increase and electricity supply becomes more scarce and intermittent. Open Energi Dynamic Demand technology transforms certain types of electrical loads into revenue-generating grid-balancing loads without affecting their primary function. One such asset is commercial refrigeration, which represents about 5% of total UK electricity consumption.

### **What approach did you take to address the challenge?**

Making small alterations to the electrical consumption of commercial refrigeration to balance the National Grid in times of both electrical shortages and surges has many technical challenges. The most significant challenge is aligning the requirements of National Grid balancing services, in terms of the speediness and duration of response, against the requirements of the fridge pack, which has to ensure the safety of perishable goods as efficiently as possible.

### **What are the potential benefits?**

If Open Energi Dynamic Demand is deployed in the commercial refrigeration assets of the five largest retailers in the UK, it has the potential to harness about 100MW of balancing energy, about 7% of the UK requirement. This in turn would generate revenues of up to £10m a year, and carbon savings of up to 200,000 tonnes a year, by displacing traditional balancing services.

### **What are the next steps?**

Following a successful Technology Strategy Board project and live field test in 10 supermarkets, the technical and commercial feasibility of the technology has been proven. What is now important is to refine the value proposition to make it attractive enough to load hosts to participate so that the benefits can be realised.

## Residential householders trading demand reductions in an online 'generation game'

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We are two small engineering consultancies specialising in the design, testing, monitoring and failure investigation of power systems. During our eight years, we have built a diverse and vibrant team of talented engineers and launched other innovative energy-tech businesses.

### What was the business need that motivated the project?

The UK grid is under increasing stress. Instant load switching is an increasingly valuable asset to the network operator due to growing national demand and the growing integration of renewable capacity. Where industrial loads are commonly used for grid-balancing, domestic loads have seldom been employed to address regular imbalances due to the high cost of retrofit and difficulty of engaging householders.

### What approach did you take to address the challenge?

Our technology and platform brings smart grid to the householder as a game by providing a low-cost, self-install route through which they can 'offer' control of their appliances to the grid in return for large cash (and other) rewards. We designed and implemented a versatile control system for 40 arbitrary appliances across 20 homes, also capable of collecting and storing high-resolution energy data to allow in-depth load pattern and engagement analysis.

### What are the potential benefits?

Primary benefits are increased demand-side control to the system operator to the financial benefit of domestic energy customers. We estimate 5GW of suitable domestic loads exist in the UK today, worth over £100m a year to consumers. Environmental benefits include displacing carbon-intensive peak-power plants and delaying intrusive infrastructure improvements. We would also greatly increase the market for UK manufacturers of smart-tech equipment we have identified, with associated job creation.

### What are the next steps?

With over 20 million UK homes suitable for low-cost participation today, we are keenly seeking partners, investors or housing groups to see our successful concept in a wider trial or even facilitate a commercial roll-out. Investment is primarily required for scaling-up technical systems and marketing efforts.

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PassivSystems is a leading provider of connected home services and home energy management systems. The company was established in 2008 and now has 81 employees, with more than half the staff engaged in R&D or (mainly software) product development.

### What was the business need that motivated the project?

The market for heat pumps is expected to grow because of government incentives such as the Renewable Heat Incentive, so we want the PassivSystems home energy management product line to support heat pumps. There are currently no energy-saving, user-friendly, smart-grid-ready heat pump controls on the market, and this project was aimed at enabling us to develop and validate our approach for such a product.

### What approach did you take to address the challenge?

A simulation model produced by the University of Strathclyde was used to test novel control approaches from PassivSystems and BRE that address the challenge of smarter heat pump control and the potential for demand shifting and for hybrid systems such as a heat pump plus storage heaters. We have been able to prove the efficacy of our approach and quantify the benefits of such systems.

### What are the potential benefits?

Electrifying heat supply through the use of heat pump technology is a key element in the move away from fossil fuels, but effective dynamic control remains a barrier to wider heat pump deployment. This project was an essential step towards developing smarter heat pump controls that save energy and contribute to a more resilient grid through demand-side management, while delivering comfort and value for money to the consumer.

### What are the next steps?

The next step is to develop a physical interface to a real heat pump and a proof-of-concept demonstration of the benefits in the field. PassivSystems will then be able to go to market and begin constructing an installed base of homes to provide an aggregated demand response service.

## Smart dynamic load profiles for distribution networks

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PPA Energy is a UK techno-economic renewable energy and management consultancy with expertise in advising government and regulatory bodies and private developers on energy planning and management.

### What was the business need that motivated the project?

This was primarily a research study to investigate potential solutions for arising problems on distribution networks by using novel techniques.

### What approach did you take to address the challenge?

We used real-life practical data in order to assess the performance of a variety of proposed techniques and establish a preliminary insight into the technical feasibility of and benefits provided by this novel approach

### What are the potential benefits?

The potential benefits include: ability to classify load profiles by shape, estimating load types; prediction of future load growths; alerts to potentially hazardous scenarios (regional swells of demand forecasted with new technologies); provision of fast computation and data reduction techniques required for real-life use.

### What are the next steps?

The project aims to optimise existing network infrastructure and provide techniques to better manage regional clusters of growing load centres that are becoming dispersed and mobile, and provide informative analysis in planning new infrastructure.



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Sasie Ltd is one of the UK's leading accredited installers of renewable energy systems. Sasie specialises in the integration of multiple renewable technologies into single systems using fully programmable internet-connected controls.

**What was the business need that motivated the project?**

SmartNet aims to develop and pilot an integrated domestic energy system and internal environmental control platform. Based upon networked diagnostic hardware and software, real-time analysis of energy equipment performance and internal building environment will facilitate optimised active equipment control according to specific household requirements.

**What approach did you take to address the challenge?**

The main technical challenges found are: finding billing energy meters that are easy to install, compatible with the controller and, most important, reasonably priced; finding robust, accurate and affordable wireless sensors and SIM cards; opening communication protocols between the controller and the data server at Loughborough University – the data sent by the controller can be analysed in real time, however, the optimised control algorithms cannot be uploaded in the controller in real time.

**What are the potential benefits?**

Through the installation of SmartNet into a domestic setting, modelling undertaken at Loughborough University predicts at least a 15% increase in system efficiency, equating to a cost reduction of £150-£200 for an average dwelling per year. Development of SmartNet to large-scale production will provide a multitude of opportunities, benefiting the local economy through the creation of jobs, and providing apprenticeship prospects for a variety of skill sets.

**What are the next steps?**

We would like all the technology to be made in the UK and are currently exploring the possibilities of creating our own controller. If successful, manufacturing of the entire SmartNet system will be undertaken using British technology, extending the economic benefit to wider UK developers.

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A collaboration between two companies, Sentec and Selex ES, the GridKey system brings together a patented innovative current sensor developed by Sentec with Selex ES's custom-developed electronics metrology and communications unit.

### What was the business need that motivated the project?

The need was to deliver slimline current sensors suitable for retrofitting on all feeder cables in sub-stations, which would then be tested using our GridKey facilities. The resulting sensor will fit all sub-stations as a result of a slimline profile, while uniquely retaining accuracy and durability. The solution can be retrofitted with minimal expense and disruption to the network operator.

### What approach did you take to address the challenge?

The project assessed the feasibility of an innovative method to sense current flow in a conductor. The challenge was to construct a prototype to demonstrate that: the measurement accuracy required is achievable; the durability of the sensor will mean that the accuracy will be achievable for the lifetime of an installation; and the sensor size will enable it to be fitted to all sub-stations.

### What are the potential benefits?

The slimline sensor will allow the retrofitting of the low-voltage sub-station network with a system to measure and communicate current flow. Utilities can use it to: reduce feeder cable losses; identify sub-stations not operating at maximum efficiency; estimate the probability of equipment failure; plan greater capacity using existing investment; and identify where investment is needed.

### What are the next steps?

We will continue to conduct field evaluation trials, select manufacturing partners to achieve cost reduction of parts and assembly, and prepare product submission for safety approvals and environmental tests. On completion of the project, a commercialised system will be delivered, sold through the existing GridKey collaboration.

## Local energy markets modelling and analysis (LEMMA): market and information systems' structures

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Swanbarton is a specialist consultant in electrical energy storage and markets. It is an SME established for 10 years and based in Wiltshire. IPL is a developer of business critical software and systems. It was established 30 years ago and is based in Bath and has 200 employees.

### What was the business need that motivated the project?

The challenge is to integrate increasing amounts of distributed renewable generation and at the same time mitigate the problems of voltage rise and network control on local distribution feeders. Alongside that we need to offer distributed generation producers commercially attractive prices without unsustainable subsidies.

### What approach did you take to address the challenge?

We assessed the feasibility of local energy markets, where energy is traded between neighbouring consumers and generators at prices agreed between them, by devising a range of models for local energy trading. We analysed and simulated the necessary ICT infrastructure and built discrete-event simulations and a steady-state economic model. We had discussions with the Department for Energy and Climate Change, OFGEM and distribution network operators to assess the regulatory framework.

### What are the potential benefits?

Local energy market participants benefit from lower electricity purchase prices and higher selling prices for locally sourced electricity. These benefits are enhanced if local energy storage is also incorporated. Using local energy may reduce loading on the local feeder, reducing the need for network upgrades, while increasing the penetration of distributed generation. The local energy market may provide feedback on network operation, giving distribution network operators new management options via economic intervention.

### What are the next steps?

We are developing our proprietary trading agent and a full desktop trading validation study. We expect to work with the distribution network operators to develop the concept further and carry out a live trial. We are seeking partners with expertise in resilient software, power capable hardware and access to funding.

## Load shifting community scale renewable heating

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thEnergy has joined with leading industrial cooling manufacturers, Klima-Therm, and the engineering department at Imperial College, to assess the feasibility of combining large-scale thermal storage, solar thermal, and heat pump technologies to create a 'virtual power plant'.

### What was the business need that motivated the project?

UK thermal load is being increasingly electrified (with heat pumps incentivised as renewable energy) at the same time as power generating capacity is being significantly reduced. This project offers the potential to provide renewably generated heat and hot water to homes when required, whilst allowing for grid balancing and efficient demand-side management, at utility scale.

### What approach did you take to address the challenge?

Building on a previously successful proof-of-market study, this project now comprehensively addresses issues such as the regulatory framework, demand and supply economics for the provision of 'comfort' rather than simply power consumption, and technological investigation of related technologies (particularly thermal energy storage). Combining these factors into a 100-home concept design, heat pumps in association with thermal storage will, for the first time, effectively decouple demand from supply.

### What are the potential benefits?

Once commercialised, the load-shifting approach will minimise the requirement for additional peaking plant capacity, and thus the requirement for potentially billions in capital expenditure. By offering an effective energy storage mechanism, decoupling demand and supply at grid scale, it will also ensure maximum use of renewable energy. This will reduce demand for imported electricity, and imported fuel for generation, helping to secure the future of the UK's electricity supply.

### What are the next steps?

The immediate output of this project includes design proposals for a 100+ home grid-connected renewable heating scheme, including architectural and engineering details. Development of this proof-of-concept demonstrator is sought via appropriate construction partners and a variety of funding sources, such as infrastructure investment funds or RIIO (Revenue set to deliver strong Incentives, Innovation and Outputs) incentives.

Explore how the 'gamification' of energy consumption could be used to drive consumers to use less energy

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Nalin Sharma, of Video Mind Games, a consultancy specialising in innovation across games technology and business models, collaborated with Pilgrim Beart, of AlertMe.com, a leading technology innovator in cloud-based smart-home services.

## What was the business need that motivated the project?

It is difficult to get consumers to change their behaviour towards energy consumption, and thereby use less energy. Typically, the medium to communicate and invite such changes is pure information through leaflets, web sites and videos, which have limited success in engaging customers.

## What approach did you take to address the challenge?

The business proposition is to raise consumer awareness of electricity consumption through an attractive, engaging and simple computer game that has a high replay value. This could be used by utilities and bodies such as the Energy Saving Trust to attract entertain and inform consumers. This study has produced a game called Smart Energy Tower Defense, which visualises electricity consumption in the form of electric bots marching towards electrical appliances.

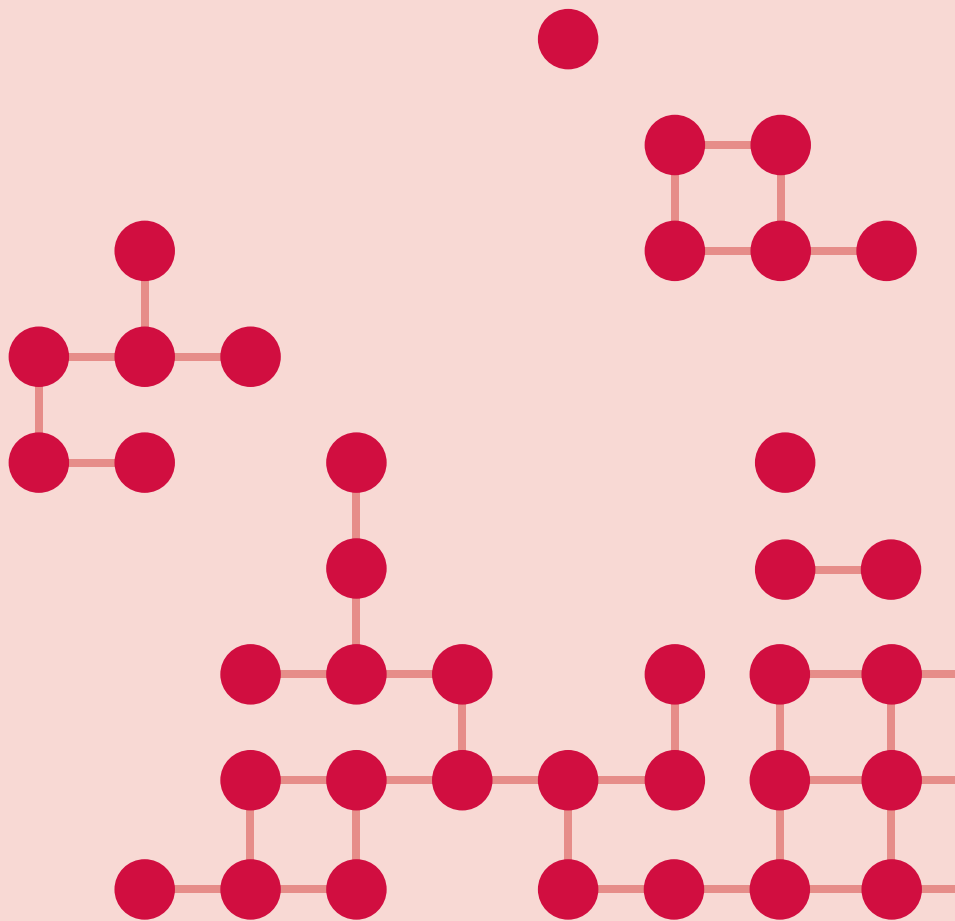
## What are the potential benefits?

The main benefit will be to educate and inform people in a fun and engaging way that energy consumption has a real cost, but that, more importantly, people can do something about it. It is important to demonstrate that video games can get messages across in interesting ways that stick better in consumers' minds. If this works, then there could be significant opportunities for applying these lessons in other areas.

## What are the next steps?

We plan to polish up the game so it can be published in alpha form; prepare a soft launch with a video and press release; gain feedback from initial consumers; write up a case study/presentation; and approach companies to discuss some of the commercial propositions.





The Technology Strategy Board is the UK's innovation agency. Its goal is to accelerate economic growth by stimulating and supporting business-led innovation. Sponsored by the Department for Business, Innovation and Skills (BIS), the Technology Strategy Board brings together business, research and the public sector, supporting and accelerating the development of innovative products and services to meet market needs, tackle major societal challenges and help build the future economy. For more information please visit [www.innovateuk.org](http://www.innovateuk.org).

**Disclaimer**

The entries in this directory were provided by the individual companies. The Technology Strategy Board cannot guarantee the accuracy or completeness of any of the information about the winning projects.

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