Creating a Consumer Driven Energy Market

passivSYSTEMS

Introduction

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Introduction

UK based company in Newbury

Primary business capabilities

- Software development
- R&D
- Control hardware integration

Commercial Services

- Roof Top PV asset management
- Intelligent heating/cooling control services
- Smart asset control
- Energy aggregation services
- Data services
- O&M services

Our Achievements

- Established: September 2008
- HQ: Newbury, UK (circa 50 employees)
- Launched world's #1 smart thermostat

(CES 2010 – Top six hottest products)

- Released PassivEnergy platform in May 2010
- Which? Best smart thermostat award
- #1 residential Solar PV asset management company

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Introduction

Mission Statement

Our Mission is to create sustainable value through the use of smart technology within the residential energy supply market.

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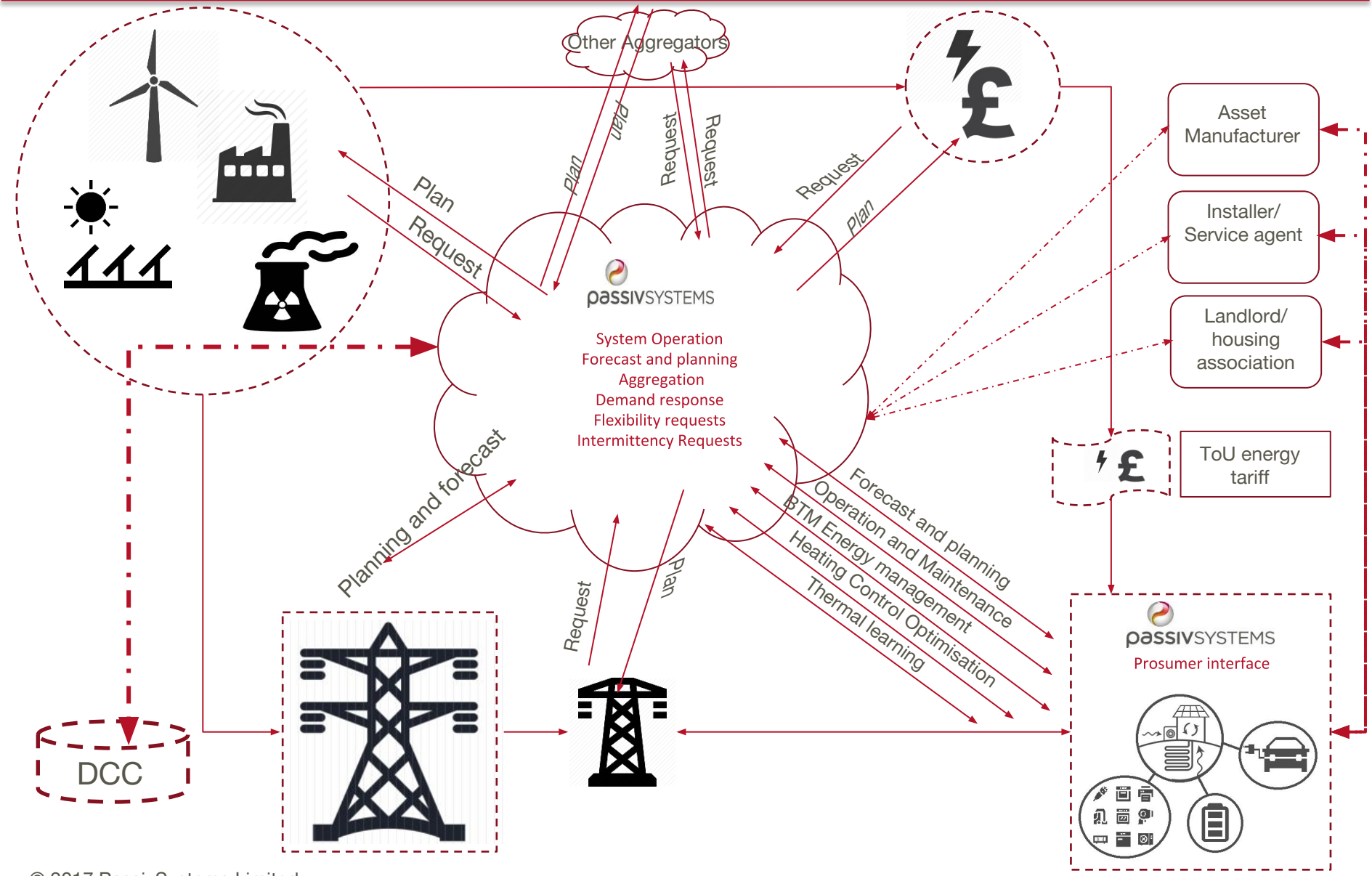
PassivSystems Prosumer Energy EcoSystem



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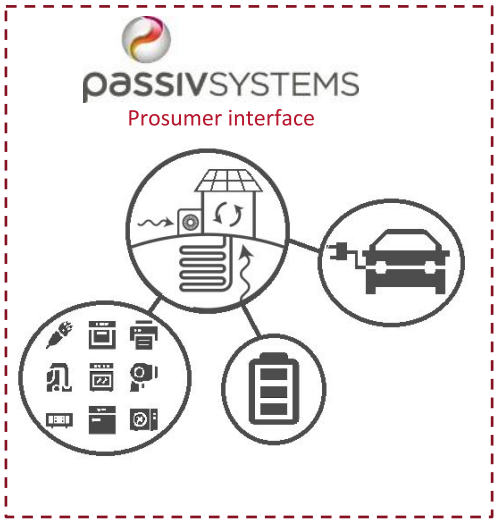
Energy Demand Management and Smart Control



All energy optimisation starts in the home. Smart heating control enables all of the appliances and assets to provide information on performance and energy usage as well as receive commands that affect their operation.

- Priority 1 Consumer Operation
- Priority 2 Energy Manager

Demand Energy Management via smart heating control allows the consumer to connect all of the assets and appliances to a system that can calculate and decide how the energy should be used and control or send control plans to the assets and appliances.
Energy management uses a number of software services using artificial intelligence to calculate the control strategies using comfort and cost as the measure for optimisation.
These services are:

- Thermal learning of the building
- Analysing weather and forecasting heat demand
- Analysing weather and forecasting solar generation (if applicable)
- Planning energy usage using historical data and day ahead market pricing
- Planning energy usage using data/plans from storage (if applicable)
- Planning energy usage from onsite generation (if applicable)
- Optimising heat generation against available energy
- Sending Energy Plan to Aggregator(s)
- Collecting meter readings
- Sending meter readings
- Status reporting
- Receive constraint instructions to minimise power demand or carbon emissions at the home level
- Capacity constraints in the national and local electricity network to allow heat loads to be shifted forwards or backwards or to another fuel source (Hybrid)

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Digital Energy Aggregation

Smart Heating Control enables the ability to aggregate all of the connected assets in a portfolio that can be managed as a single load within the energy market. The fluctuations with the energy network and at the consumer level, creates trading opportunities to:

- Transmission System Operators (TSO)
- Distribution System Operators (DSO)
- Energy Suppliers (BRP)
- Other Aggregators (AGR)

Aggregated Load Management allows the consumer to connect take part in the complex world of energy without being exposed to the risks and regulation of the energy industry. The transition to a low carbon system will require residential demand for electricity, fossil fuel and heat to be managed simultaneously, with generation, as the penetration of intermittent renewable energy sources and green gas is deployed on the infrastructure. Services operated at the aggregation level include:-

- System wide monitoring
- AMR
- Aggregated energy forecast and planning
- Demand response requests (Yellow, Orange regimes)
- Flexibility requests
- Intermittency requests
- Network constraint management
- Maximum demand control
- Validation services
- Connection compliance and notification
- Virtual NPAN

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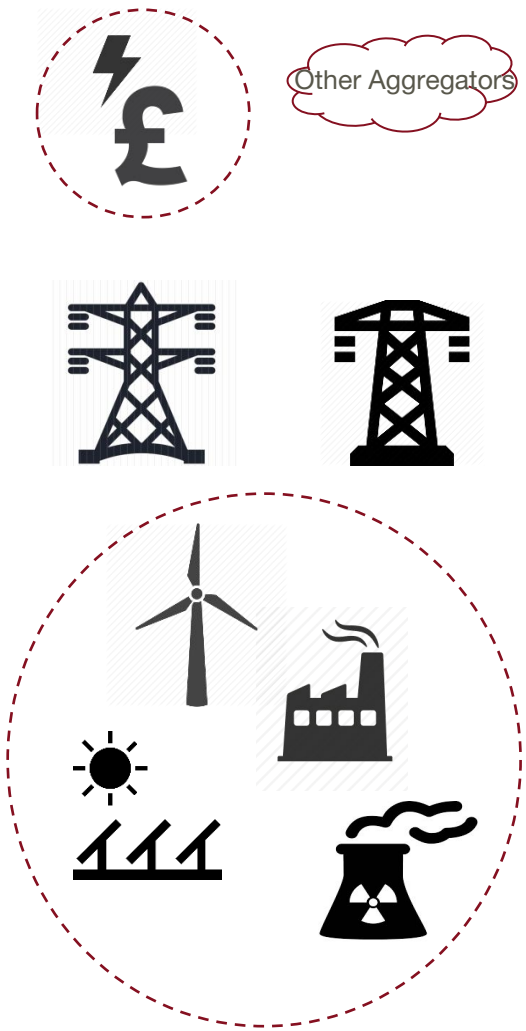
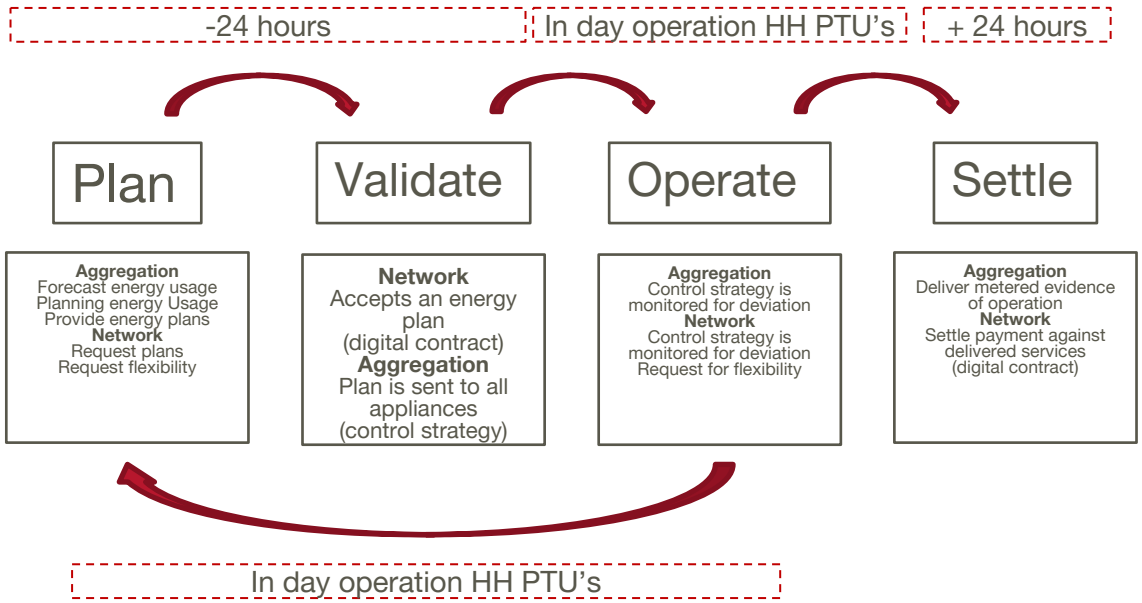
(Smart Grid) Digital Energy trading Principles



The Aggregator (AGR) provides a detailed load profile to the network a day ahead. The various actors within the network are able to analyse the plan of energy use and issue a request to the AGR that will offer best value to the actor. The AGR will be able to process the request and return and offer to the actor.

The process for this request is built on 4 trading principles. This process is designed to allow the actors to iterate the process unit best value is achieved for that request. If a request is not achieved a yellow or orange regime maybe be operated.



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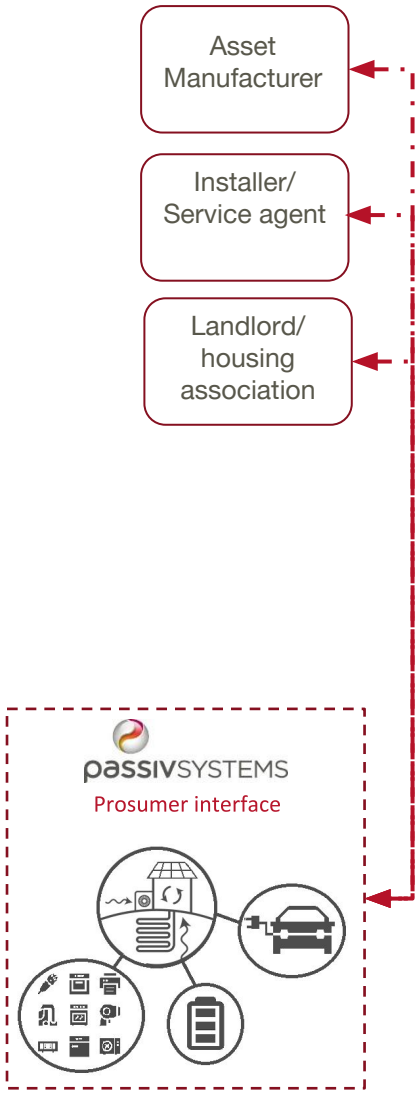
Source: Universal Smart Energy Framework

Digital Energy Operation and Maintenance



Service Suppliers and manufacturers who enable the connection of their product to aggregation services providers enhance the consumer experience by gaining user insights into the operation and durability of their products as well as new revenue opportunities not available to them before:

- Realtime operation and maintenance
- Brand loyalty sales opportunities with other connected products
- Data analysis of product performance
- Warranty cost management

Aggregation services allows for other services to be delivered into sectors like social landlords and local authority managed housing are responsible for ensuring:-

- Fuel poverty is managed
- Operation of systems are maintained
- Health and comfort is achieved
- Vulnerable residents are protected

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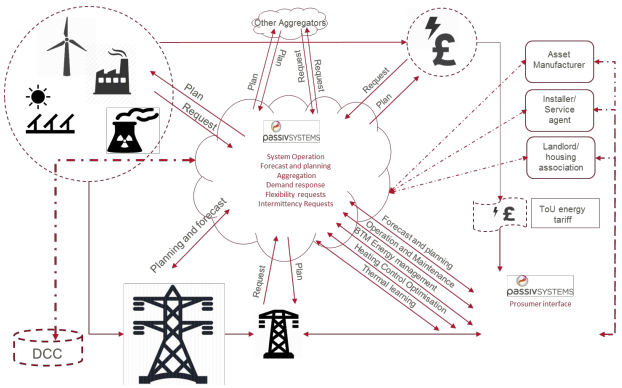
Digital Energy Communication



Digital energy communication requires continuous and secure connectivity to operate effectively and keep the energy network in balance. The current preferred methods are:-

- Broadband with guaranteed connection
- WAN (currently has limited capability)
- GSM (not suitable for demand response or control services)

AGR services requires the ability to communicate status changes and plan and re-forecast at least every 15 mins or at any point the system demand has changed which maybe on a minute by minute basis. This allows the aggregator to manage the portfolio and adjust where necessary to deliver its services. This may require an individual system currently participating in an event being removed or vice-versa.
Continuous communication ensures:-

- Consumer comfort is maintained
- Consumer confidence is maintained
- AGR services are delivered without penalty
- Network remains within balanced tolerances
- Network confidence to manage imbalance

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Moving forward to a Digital Energy Market

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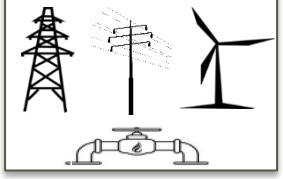
FREEDOM Project

Flexible Residential Energy Efficiency and Demand Optimisation and Management

Partners: Western Power Distribution; Wales & West Utilities; Imperial College London; City University London; DELTA Energy & Environment

Size: 2016-2018 £5.2m

Energy Company



- Modelling whole system benefits of hybridisation of domestic heating
- Exploring business model impacts for gas and electricity network operators
- Measuring actual performance of devices in 75 homes

Community

- USEF compliant aggregation model
- Aggregated portfolio optimisation against market price signals
- Frequency control, wholesale market, network constraint

Energy Services

- Advanced control algorithms developed for different heat pumps and boiler combinations
- Demand forecasting and load shifting
- Demand response services that monitor and maintain customer comfort levels

Consumer

- Cost optimised heat delivery
- New user interface design
- Advanced techniques to build consumer trust to support new service models
- Feedback on usage, cost and future budget

Key messages

- First major UK project bringing together gas and electricity network operators
- Will demonstrate the most advanced load control of hybrid heating systems (gas boiler + air source heat pump) in UK
- Modelling UK system value of hybrid heating flexibility
- Outputs will help to inform UK policy makers on roadmap for heat decarbonisation
- Installations in a range of public and private housing types in Bridgend, South Wales

PassivSystems' Role

- Project inception, design, and delivery responsibility
- Customer recruitment and community engagement
- Hybrid heating system procurement, installation and commissioning
- In home heating controls
- User interface design and implementation

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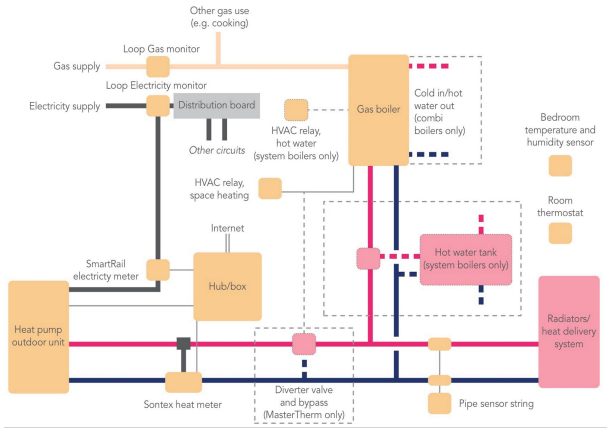
Evidence of the Potential Benefits: Freedom Project



Freedom Project: investigated the use of heating controls and predictive optimisation of running costs to deliver multi-vector solutions and low cost domestic heat decarbonisation. Also investigated potential benefits of hybrid heating systems for consumers, networks and energy system.

Results & Findings:

i. Hybrid heating systems can be low a cost pathway to fully decarbonise residential heat;

ii. Benefit estimates of up to £15.2b/year cost savings against full electrification;

iii. Systems worked in domestic properties, whether currently serviced by the gas grid, LPG or oil;

iv. Systems could optimise use of renewable power and green gas in existing utility infrastructure;

v. Flexibility controls support secure low carbon energy system;

vi. Warmth and comfort demands in all homes met over the winter without any changes to existing wet heating systems or thermal improvements to property;

vii. Heating controls used predictive optimisation of running costs for the aggregated load of homes in each half hour 24 hours ahead referencing weather forecast data, learned building thermal properties and individual home comfort schedules;

viii. Constraint instructions added to (i) minimise carbon emissions and/or (ii) limit power demand in each home or at portfolio level;

ix. When there is insufficient renewable electricity generation, when it is very cold and/or when there are capacity constraints in the national or local electricity network, the heat load can shift across to the gas network, and vice-versa, to provide uncompromised heat, flexibly using the vast energy storage within the gas system.

** Cross-sector collaboration between electricity and gas distribution networks Western Power Distribution and Wales & West Utilities and PassivSystems*

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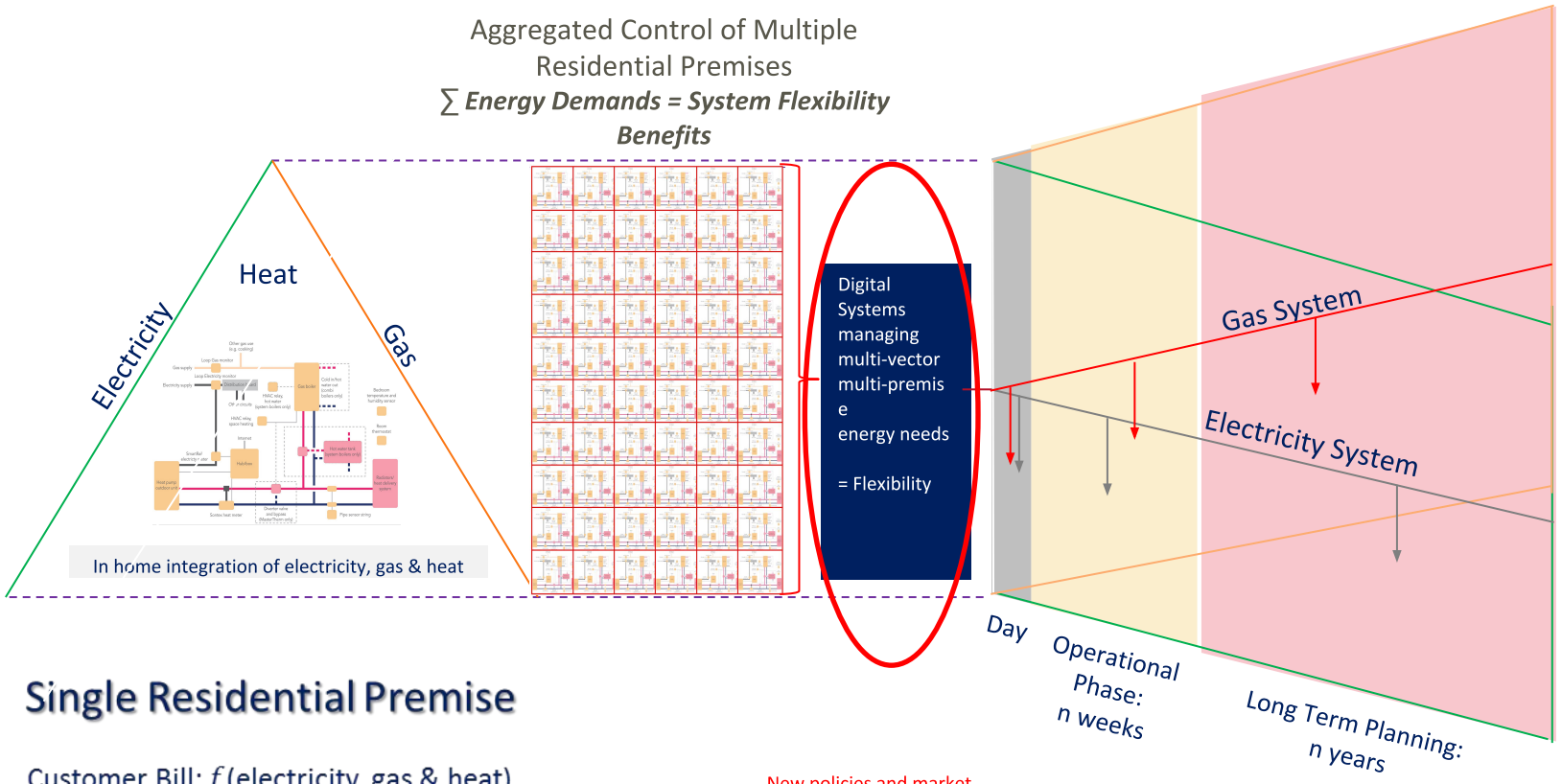
Evidence of the Potential Benefits: Freedom Project

Demand Aggregation & Digitalization

Aggregated Control of Multiple Residential Premises

∑ ***Energy Demands = System Flexibility Benefits***



Single Residential Premise

Customer Bill: f(electricity, gas & heat)

New policies and market mechanisms required to incentivize the development of such systems and support their implementation.

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Evidence of the Potential Benefits: Freedom Project

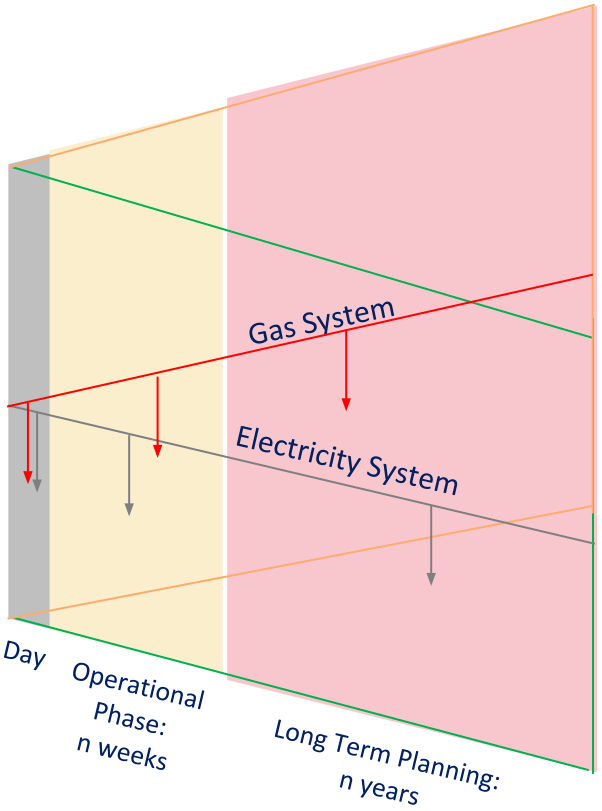
Benefits of Residential Energy Demand Aggregation

Aggregated Control of Multiple Residential Premises
∑ ***Energy Demands = System Flexibility Benefits***

On the Day: - Frequency & Demand response to counteract Supply variability (due to resource intermittency);
- Substitute Electricity & Gas based on relative prices to minimise Customer (and System) costs;
- Reduce and/or shift Demand at times of 'system peak' to reduce system stress and safeguard security of supply;
- Manage Demand (+ -) to utilise 'low marginal cost generation' and minimise uneconomic stop start of conventional generation (including nuclear).

Operational: - Optimise Electricity & Gas demand based on forecast availability of renewable resources (e.g. short and medium term weather forecasts);
- Optimise Electricity & Gas demand in light of gas availability;
- Optimise Electricity & Gas demand in light of 'carbon constraints' & 'relative prices'
- Manage Energy demand to minimise Customer (and System) costs.

Long Term Planning:
- Once digital management systems are 'proven' evaluations of resources (capacity) required to meet forecast gas and electricity demand will evaluate demands as 'dynamic' not static and therefore reduce the capacity required to satisfy stipulated planning and security of supply standards.



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Evidence of the Potential Benefits: Freedom Project

Consumer Benefits

- Consumers should no longer be simply 'residual recipients' of de-carbonisation costs but incentivised to participate in and directly benefit from 'a multi vector (fossil fuel, electricity and heat) energy market;
- Digitalisation can facilitate the aggregation of residential energy demands and allow household gas and electricity and heat demands to be managed simultaneously. This would be a significant innovation as 'residential energy demand' would no longer be simply a 'passive' driver of energy system costs but a dynamic 'demand side' resource; and
- Digital systems managing 'aggregated' residential energy demands would have numerous benefits, including the ability to manage demand to:
  - react to changing gas and electricity prices in ways and timescales individual consumers could not;
  - respond to changing system conditions in ways and timescales individual customers could not;
  - counteract intermittent renewable supply in ways and timescales individual customers could not;
  - anticipate changing weather conditions such that, for example, in advance of a forecast cold spell homes could be pre-heated in off-peak periods to reduce customer bills and reduce gas and/or electricity system demands in peak periods;
  - determine whether to use gas or electricity to generate heat given relative gas and electricity prices and carbon constraints; and
  - contribute to gas and electricity system flexibility and thereby reduce investment required to satisfy stipulated security of supply standards.
- But if customers participate and contribute to the provision of a 'dynamic demand side resource' capable of generating 'supply side' benefits they should receive an appropriate share of any resulting benefits.

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Smart Communities Project

Air Source Heat Pump load management

Partners: HITACHI Inspire the Next

2014-2017

Size: £20m

Energy Company

VPP

- Rich API interface from VPP to HEMS
- Forecasting of demand by home based using learned building thermodynamics, weather and occupancy
- Load constraint and demand turn down

Community

- Active community portfolio management based on home temperature performance against SLAs
- Consumer opt out of DSR events

Energy Services

- Advanced control algorithms developed for ASHPs
- Demand forecasting and load shifting
- Heat metering and monitoring
- Real-time user guidance on demand response actions

Consumer

- Smart phone and internet connected heating controls
- Simple occupancy based control of heat pump

Key messages

- NEDO funded demonstration of the feasibility of aggregation systems for the residential heat market
- Allowed Virtual Power Plant to manage heat pump demand through APIs
- Provided advanced forecasting and control of heat demand
- Field trial evidenced ability to shift ASHP heat demand without impacting on thermal comfort

PassivSystems' Role

- Home Energy Management System (HEMS) design, development and testing
- Advanced heat load forecasting
- Advanced demand management
- In-home heating controls and hardware integration
- Home simulation models to test broad range of DSR events
- Installer support tool development
- Installer training

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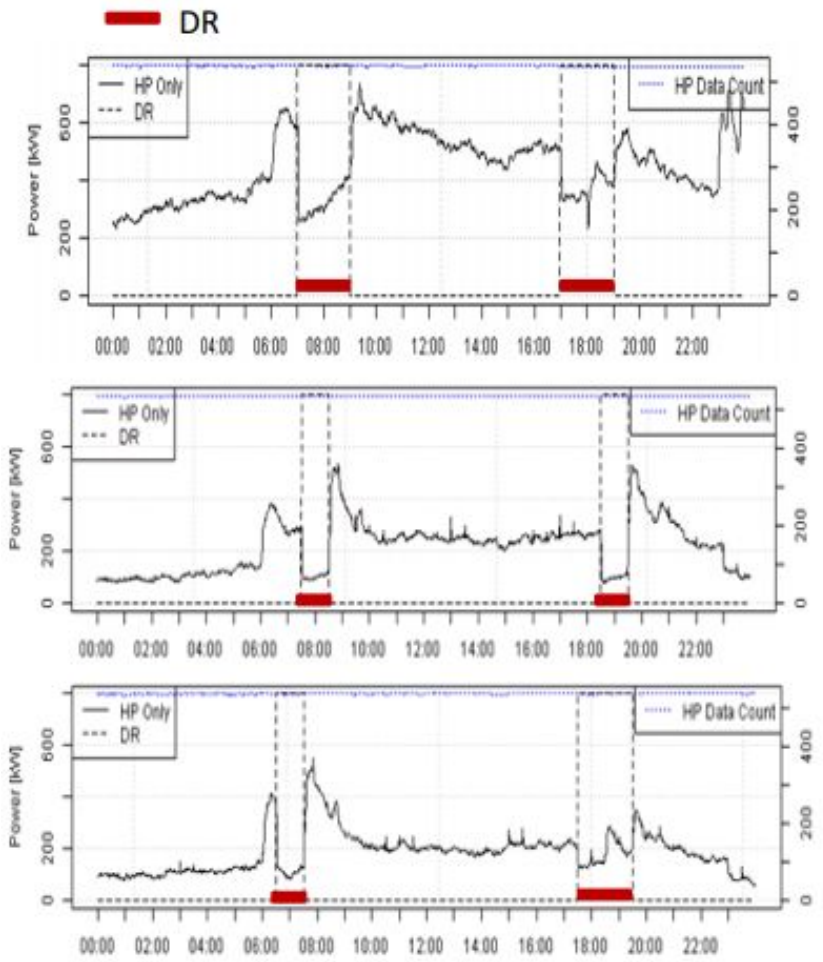
Evidence of the Potential Benefits: Smart Communities Project

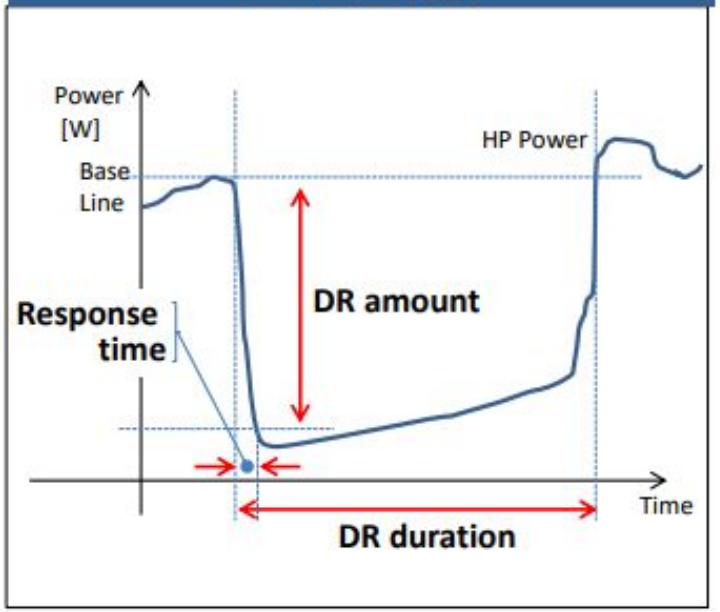
Examples of DR Profile (Aggregated)



DR Trials

Num. of target housing	4 – 550 housing
Period	18 month (Oct. 2015 –Mar.2017)
Total DR trial times	~ 360

DR Parameters



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Smart Energy Islands Project

Air Source Heat Pump load management

Partners: European Union, European Regional Development Fund; HITACHI Inspire the Next; moixa; Council of the Isles of Scilly

Size: 2017-2019, £10.8m

Energy Company

- API interface from VPP to Aggregator
- Aggregated forecasting of demand
- Price driven DSR model
- Advanced risk analysis of DSR contracts

Community

- USEF compliant aggregation model
- Aggregated portfolio optimisation against VPP price signals
- Co-ordination of multiple in-home demand aggregators

Energy Services

- Optimisation of Solar PV, ASHP, battery and immersion loads
- Orchestrated demand management
- Metering and monitoring

Consumer

- Smart phone and internet connected HEMS controls
- Real-time user guidance on demand response actions

Key messages

- Smart grid solution for Isles of Scilly to support greater levels of renewable generation
- Solution designed against USEF market model
- Advanced forecasting of heat demand
- Field trial evidenced ability to shift ASHP heat demand without impacting on thermal comfort

PassivSystems' Role

- Aggregation platform design, development and testing
- Home Energy Management System (HEMS) design, development and testing
- Advanced whole home load forecasting
- Advanced heat demand management
- In-home heating controls and hardware integration
- Home simulation and aggregation models to test broad range of DSR events
- Installer support tool development

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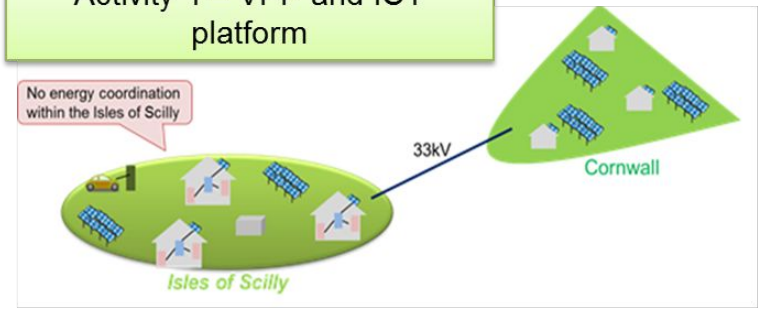
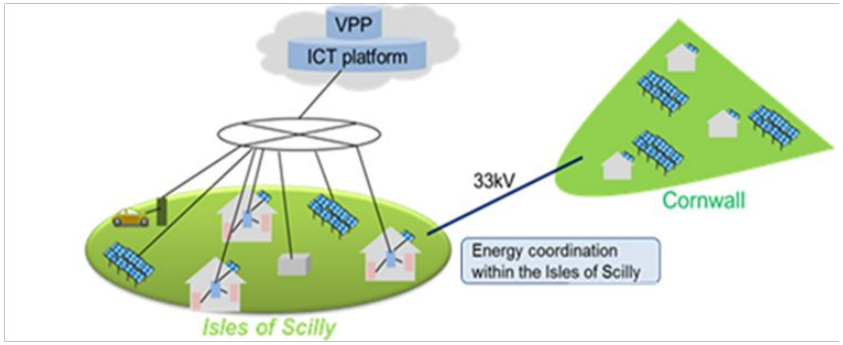
Project status: Installation phase

Core Technical Activities

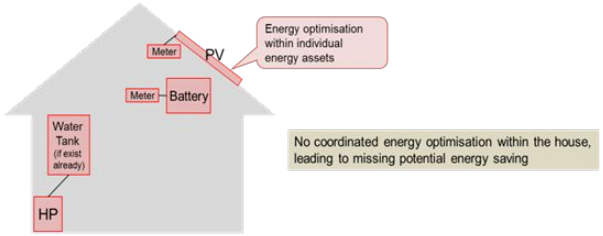
European Union
European Regional Development Fund

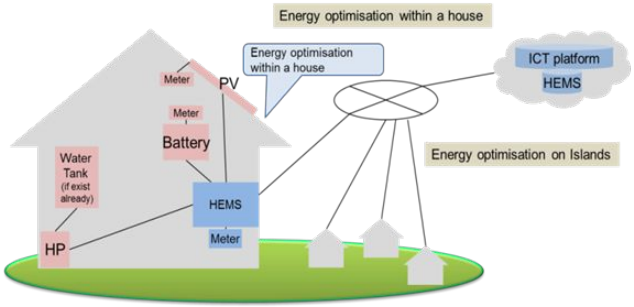
Activity 1 – VPP and ICT platform



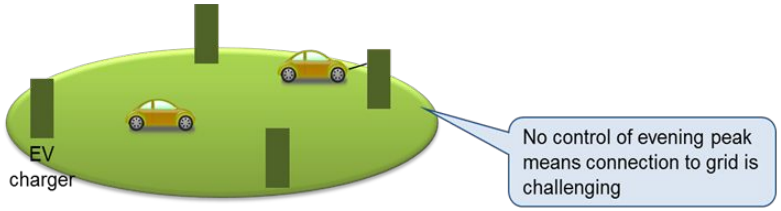


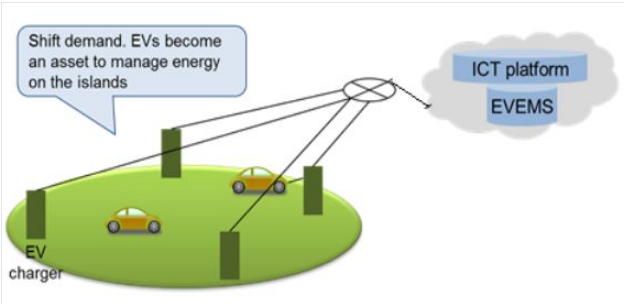
Activity 3 – HEMS & BEMS





Activity 4 – EVEMS





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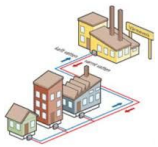
NOTICE Project

Network Optimisation Through Intelligent Control Execution

Partners: Department of Energy & Climate Change; WSP | Parsons Brinckerhoff; e.on UK

Size: 2014-2017, £690k

Energy Company



- Modelling whole system benefits of domestic heat demand load flattening
- Measuring actual performance of controls in 30 homes
- Sigfox automated meter reading service

Community

- Load shifting using different mathematical models for aggregated control
- Impact of different community load management parameters on customer comfort

Energy Services

- Advanced control algorithms developed for Heat Interface Units
- Demand forecasting and load shifting
- Delta t optimisation using dynamic valve control to modulate flow temperatures

Consumer

- Surveys of usability of existing and new heating controls
- Heat usage feedback and peer comparison

Key messages

- First UK project to demonstrate active load control at the end points of a district heating network
- Demonstrated opex savings of 40% for heat network operator
- High levels of customer satisfaction with heating controls
- UK's first deployment of Sigfox IOT comms for heat meter AMR

PassivSystems' Role

- Project inception, design, and delivery responsibility
- Customer recruitment and community engagement
- In home heating controls
- Sigfox AMR service creation, implementation and operation
- Installer support tool development

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Seamless Demand Response Pilot Project

Ground Source Heat Pump Control and Optimisation in Social Housing

Partners: Department of Energy & Climate Change; UCL Energy Institute; yarlington building communities; Westward Housing Group

Size: 2013-2015, £1.2m

Energy Company

- System value derived from TOU tariffs
- Modelling consumer cost savings with Economy 7 and Economy 10 tariffs
- Measuring actual performance of controls in 100 homes with ASHP or GSHP

Community

- Aggregated portfolio view and home control panel for social landlords
- Avoided home visits by remote analysis and settings configuration

Energy Services

- Advanced control algorithms developed for ASHP and GSHP
- Load shifting based on TOU tariffs

Consumer

- Surveys of usability of existing and new heating controls
- GUI design collaboration with RSL
- In-home tablet based controls

Key messages

- First UK demonstration of heat pump load shifting using building mass as a thermal store
- Installed in social housing, typically rural, elderly, vulnerable tenants
- New user interface developed to aid tenant operation of the system
- Heating system efficiency improved by 10% through smart heat pump operation
- Demonstrated ability to derive further savings from load shifting with TOU tariffs

PassivSystems' Role

- Project inception, design, and delivery responsibility
- Customer recruitment and community engagement
- In home heating controls
- Metering and monitoring
- Advanced control algorithm development using thermal mass of the building as a heat store

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An invitation by me

Energy Market Actors: I invite all energy actors to acknowledge that the residential sector can contribute to national energy policy objectives with support and incentives for the digitalisation and aggregation of residential energy demands.

I also invite the opportunity to create/develop trials or schemes with significant scale to demonstrate and confirm the multiple benefits of digitally managed ‘aggregated’ residential energy demand.

Product Manufacturers: I invite you to embrace the sharing of information and control of your products with others for the benefit of the consumer. Provide them with the ability to create value within a digital energy market. Seek to collaborate with energy actors and including aggregators.

Service providers: I invite you to explore the opportunity to enhance your capability you currently have by working with us and others to deliver greater consumer service and experiences.

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Many thanks for your time.

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