Smart Grids, Microgeneration & Storage: Commercialising the benefits

October 2013

An Ecuity report for the Micropower Council and Electricity Storage Network

Overview

Preface

The objective of reducing emissions whilst maintaining security of supply and improving affordability, presents unprecedented challenges for those tasked with delivering policy frameworks, investment and delivery capability in the United Kingdom.

In the past few years, a raft of policy developments including Electricity Market Reform and the widely criticised and currently stalled Smart Meter Roll-Out have been introduced to try and tackle our energy challenges. But are these missing a big opportunity to conserve generate and store energy within the UK's building stock generating considerable benefits and engaging consumers?

This paper was commissioned by the Micropower Council and Electricity Storage Network on a basic premise; that given the right policy framework and a fairer electricity market, building level microgeneration and storage technologies could have a huge role to play in meeting our energy challenges and empowering consumers

In research undertaken for this project, Ecuity considered the following areas:

- Drivers for smart grid developments and microgeneration technologies
- Growth of microgeneration and storage technologies and their potential role in demand side response for smart grids
- Role of time-of-use tariffs and National Grid's proposed Demand Side Balancing Reserve in commercialising demand side response
- Regulatory and commercial barriers to the uptake of microgeneration and participation in demand side response
- Policy proposals on commercial incentives and overcoming regulatory barriers

This work aspires to serve as a collaboration platform for all manufacturers, developers, energy suppliers, smart services providers and innovators who consider that microgeneration can support the transition to a smart, secure, low-carbon and affordable energy system.

Overview

Executive Summary

This report examines the role microgeneration technologies can play in developing smarter grids, tackling the barriers to integration and developing the commercial incentives for engaging in demand side response (DSR).

It puts forward policy recommendations aimed at improving consumer engagement, enhancing commercialisation potential and reflecting the value of more flexible low carbon and renewable technologies at the domestic level.

It is clear that there are a number of major opportunities ahead to enable microgeneration such as the roll out of smart meters and measures under Retail Market Reform. Greater take up of microgeneration would encourage consumer engagement with the energy market favouring bills reductions during times of rising prices.

Wider deployment of microgeneration, along with energy storage, has the potential to reduce costs involved in managing the network in light of growing demand unpredictability and variable renewable energy supply. **However, the development of appropriate policy and market mechanisms to reflect the value of microgeneration capacity and incentivise demand side response (DSR) is key.**

Developments such as the Capacity Market under the Electricity Market Reform (EMR) and National Grid's proposed Demand Side Balancing Reserve (DSBR) could create an additional income stream for intelligent homes that appropriately reflects system value.

The ability of microgeneration and storage enabled buildings to contribute to DSR is documented in this report with the use of aggregation tools being a key enabler so that multiple or even thousands of homes can provide energy when it is needed.

Heat pumps can provide electricity demand reduction, notable during winter time with the use of thermal storage. Micro Combined Heat and Power (Micro-CHP) can provide additional generation capacity at peak times and solar PV with storage can store electricity when generation is high but demand low, for use when system demand peaks, either to export or for self consumption.

Building a consistent and stable regulatory and policy framework to support the development of DSR markets will be critical to ensure optimum outcomes. Draft recommendations set out overleaf build on analysis developed for the purposes of this project, existing literature and considerable knowledge shared by industry participants.

Overview

Recommendations

A. Emergence of more flexible time-of-use tariffs

1. Retail Market Reform must not restrict Suppliers and Distribution Network Operators (DNOs) capacity to offer Time-of-Use (ToU) tariffs.
2. Half-hourly data from smart meters should be made available to Suppliers to support the development of ToU tariffs.
3. For Balancing & Settlement, a move to half-hourly settlement would support the introduction of ToU tariffs.
4. A restructuring of Distribution Use of System Charges (DUoS) for domestic customers would enable Suppliers to create more cost reflective ToU tariffs.

B. Development of market mechanisms to incentivise aggregators

1. National Grid's DSBR must include export from small scale and micro-generation and storage from 'beyond the meter'.
2. The DSBR project should be year-round rather than just for the winter months.
3. Microgeneration participation in the Capacity Market should not be excluded as a result of receiving fiscal support such as FITs.
4. Consistency in scheme design between the DSBR and Capacity Market is essential for investor confidence in developing the market space for DSR.

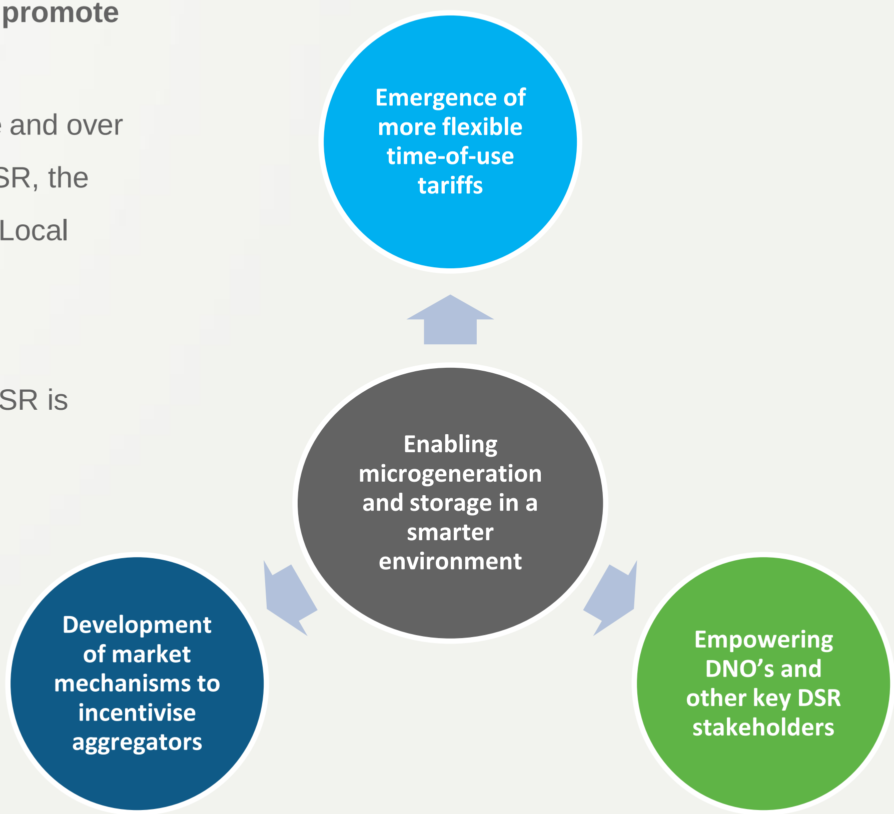
Overview

Recommendations

C. Empowering DNOs and other key stakeholders to promote DSR and storage

1. DNOs must be permitted to own and operate storage and over time, to take on a system operator role to facilitate DSR, the increased deployment of storage and the creation of Local Energy Markets.

2. Co-ordination between the various stakeholders of DSR is essential to avoid inefficient outcomes where network reinforcement is undertaken instead of DSR.



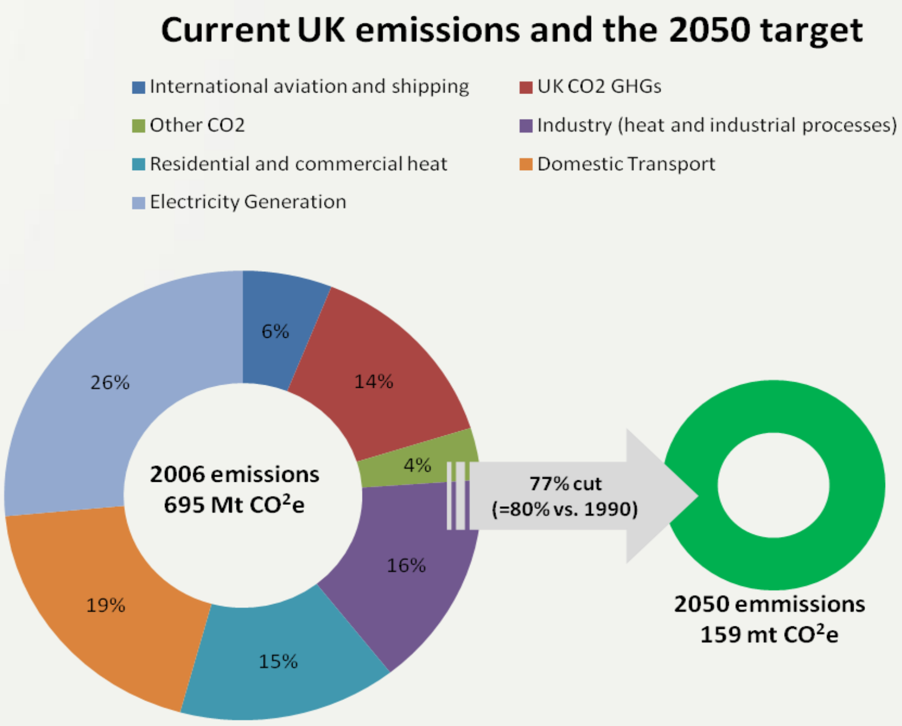
Distributed Generation and storage could provide a **key balancing service** for the electricity system

1

Smart Grid Drivers

Energy Policy Targets

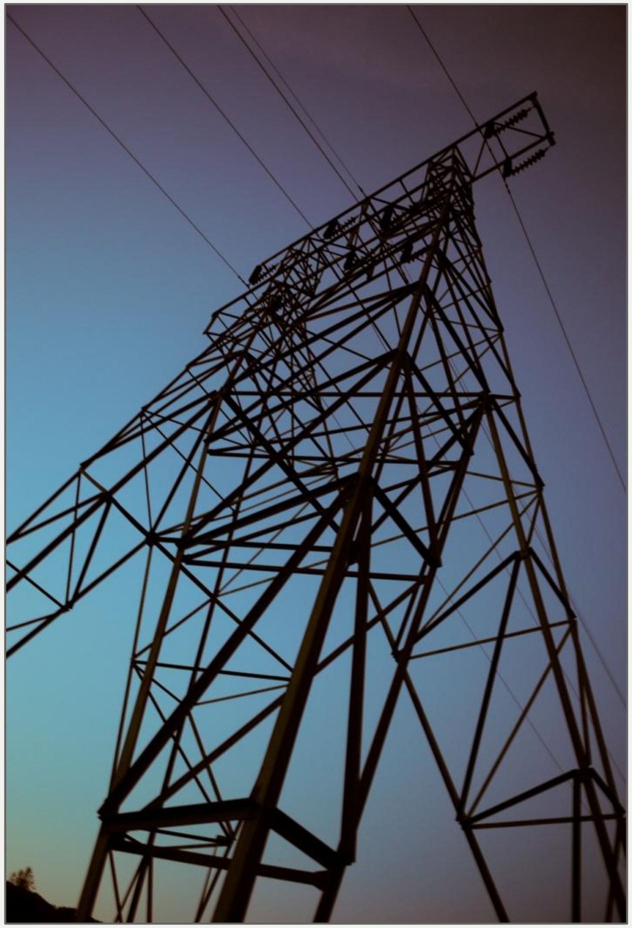
- UK's energy policy is supported by three key pillars: the need to maintain security of supply, reduce carbon emissions and to be both affordable and competitive to consumers and industry.
- To achieve a CO_2 reduction target of 34% by 2020 and 80% by 2050 on a 1990 baseline, the UK plans significant deployment of renewable technologies for heat and electricity generation. The UK has set a target to achieve 15% of its energy consumption from renewable sources by 2020.
- The National Grid in its UK Future Energy Scenarios Report published in July 2013 forecasts that electricity demand in the UK will remain relatively stable until 2030. However, over the next few years, 20% of existing power generation capacity (coal, oil, gas) is shutting down causing DECC's worst case capacity margins to go near -5% over the period 2022 to 2029.



Smart Grid Drivers

Impacts on the grid

- With the loss of 20% of generation capacity combined with targets of 15% of renewable energy by 2020, an overarching 80% CO_2 reduction by 2050, and anticipated electrification of heat and transport, both demand and supply of renewable and low carbon energy will be increasing rapidly.
- The structure of the UK's generation mix will therefore change from a large scale centralised fossil fuel based system, to that of a distributed renewables-based system.
- At the local level, with greater demand for electricity for transport and heating, coupled with high levels of microgeneration, these developments will heavily impact the electricity networks and system balancing.
- Demand side management will be necessary to manage congestion in electricity distribution at peak times – this will create opportunities for flexible and efficient distributed power generation.
- The smart grid is an effective tool to enable flexible generation. According to Smart Grid GB (Smart Grid: A Race worth winning, April 2012), full use of the smart grid could deliver cost savings of as much as £19 billion between 2012 and 2050 compared to traditional conventional network reinforcement.



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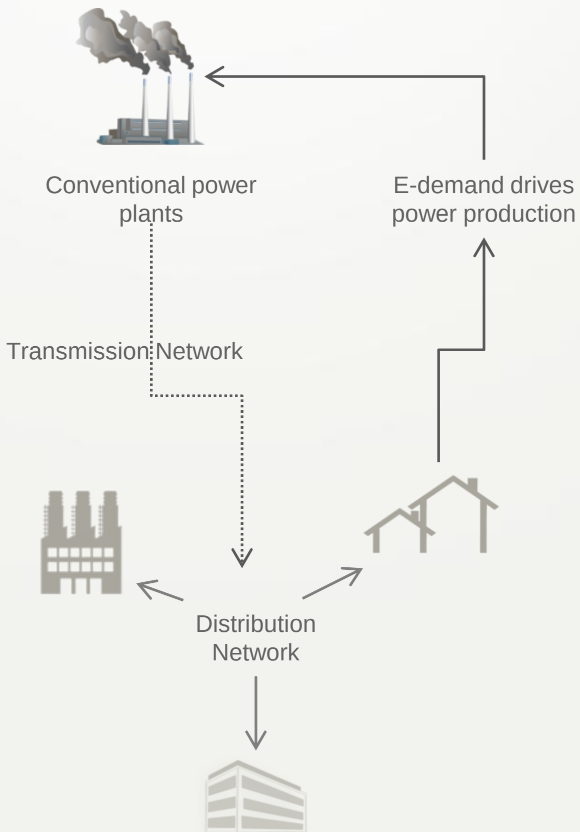
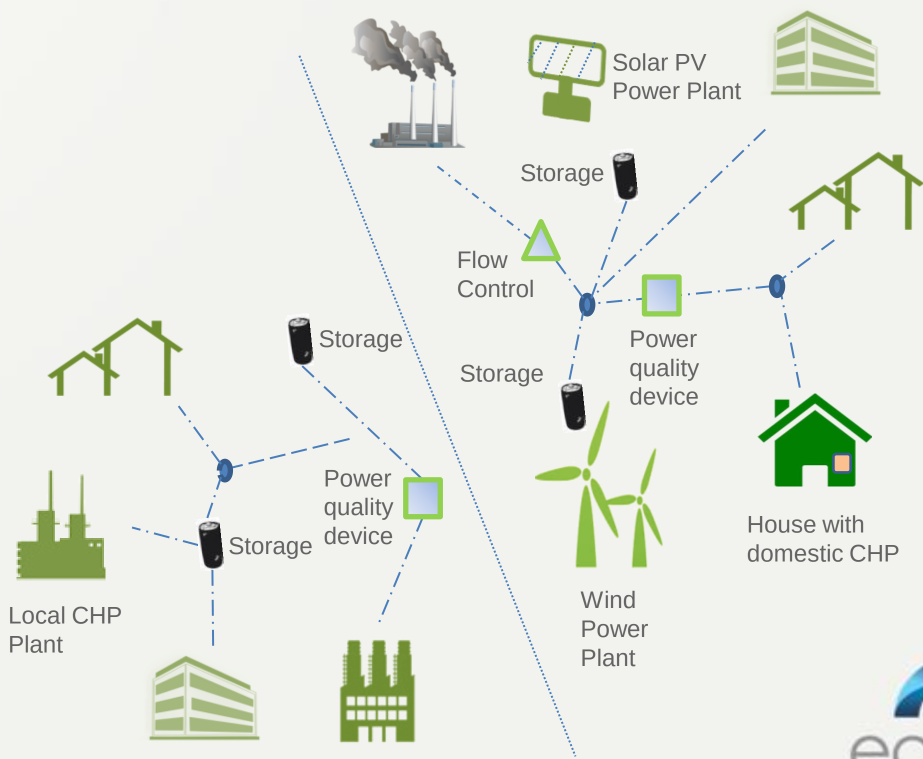
Smart Grid Drivers

Towards a more distributed energy system

Centralised Generation



De-Centralised Generation



2 Regulatory Environment

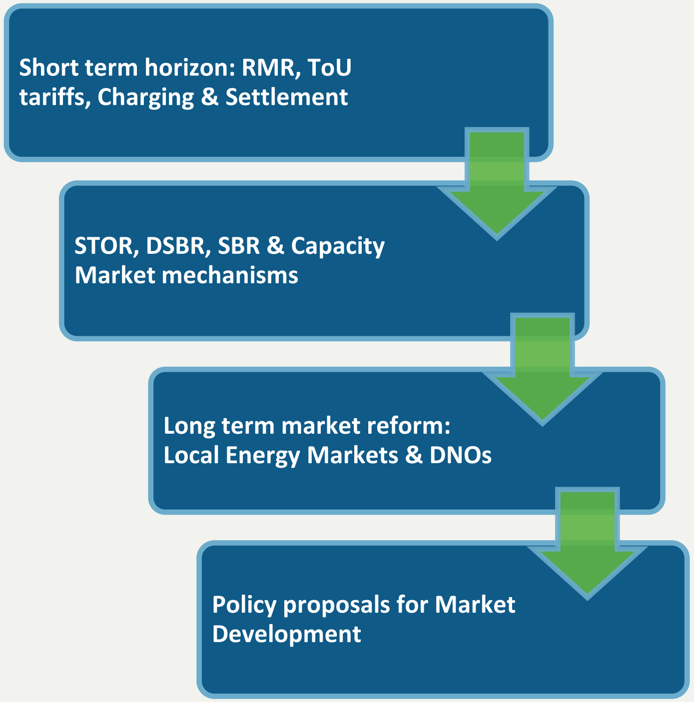
The current environment

- This section looks at the short, medium and longer term policy-driven market drivers to engaging demand side response from consumers in the domestic market and reflecting its proper value.

- For the short term, this will cover the area of Time of Use tariffs – both static and dynamic. These tariffs are the most immediate policy and commercial driver on the back of the smart meter roll out which will influence consumer behaviour in relation to DSR and microgeneration. Retail Market Reform, distribution charging, issues around settlement and half hourly meter reading will also be raised in this area.

- Over the medium term, the access to existing market mechanisms such as National Grid's STOR product will be examined, alongside the proposed DSBR, SBR and Government's Capacity Market Mechanism as detailed under its Electricity Market Reform schedule.

- Finally, the longer term market reform will be discussed looking at issues raised as part of the LCNF trials in the roles of DNOs and other potential new market participants on issues such as private wire networks and local energy markets. Consideration to the RIIO framework will be given alongside that of European legislation such as the Energy Efficiency Directive and the EU's Third Energy Package in respect of the unbundling requirements.



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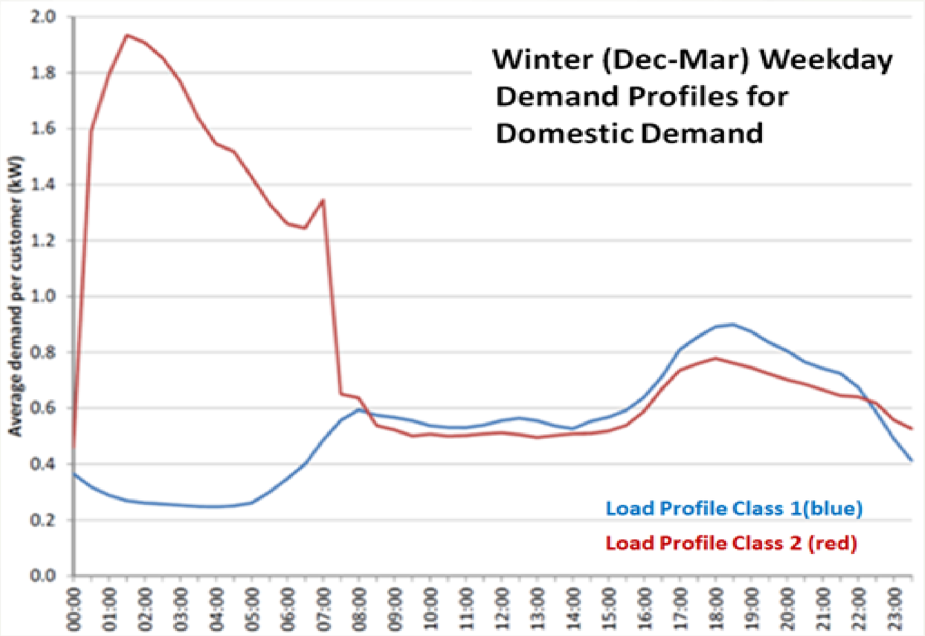
Regulatory Environment

Time of Use Tariffs



Profile data from Elexon: Load profile coefficients for 2011/12 by half-hour – plus – annualised energy consumption by Load Profile Class (and Grid Supply Point group) from September 2011

- Domestic consumers in the UK are already familiar with Time-of-Use Tariffs through the deployment of Economy-7 and Economy-10 meters. These are predominantly suited to properties which have electric heating, which can store heat overnight whilst charging to release heat the following day and evening.
- Looking at the profiles used for settlement on the electricity markets, the response of consumers to these tariffs can be seen when comparing Profiles 1 and 2 for domestic consumers.
- Consumers on Economy 7 and 10 tariffs, consume at much greater levels during the night than those on a uniform tariff, whilst consuming less during the rest of the day.

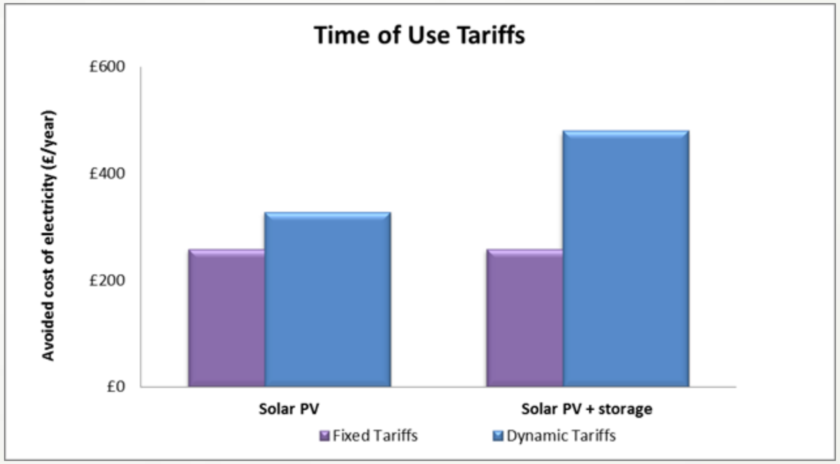
- ***Profile Class 1:*** *Domestic consumers who pay a uniform rate throughout the day*
- ***Profile Class 2:*** *Customers who have the potential for separately metered hours between midnight and 06:00 hours.*

- LCNF trials have also shown that consumers positively engage with ToU tariffs resulting in both bill savings and benefits for grid management. Initial results from the Customer-Led Network Revolution project led by Northern Power Grid have showed an average of 14% reduction in consumption during peak times, and that 71% of participants achieved a reduced bill by an average of 2.5%.

Time-of-Use tariffs could provide a fairer system of reward for distributed generation and behaviour change

Regulatory Environment

Time of Use Tariffs



- As shown for both PV and micro-CHP, the incentive to maximise self-consumption is already present through the avoidance of imports. This is amplified when taking into account rising electricity prices and the proposals to implement Time-of-Use tariffs, both static and dynamic.
- For heat pumps, Passiv Systems (PS), a home energy management approach has also demonstrated that with smart heat pump controls, variable electricity tariffs can be taken into account and benefits delivered to both the householder and to the grid. PS found that running a heat pump on an Economy 10 tariff with predictive control could lead to 40% cost savings for the householder with very little impact on comfort. Peak grid load was also reduced by 80% with much more electricity being consumed at cheap times, effectively storing energy in the fabric of the house ready for peak times.

Retail Market Reform

Ofgem will be implementing a series of measures to stimulate competition into the household energy market covering also the areas of pricing practices and tariff design.

The challenge for industry will be the impacts of limiting the number of tariffs together with potentially conflicting objectives under Government's smart meter roll-out.

Allowing consumers to opt out of smart meters will make it harder for benefits to be realised, since dealing with legacy systems will incur greater costs. Being able to opt out of sharing granular consumption data with suppliers will also reduce the ability of suppliers to offer ToU tariffs.

* Passivsystems 'Smart heat pumps: benefits and barriers' Report, July 2013

Regulatory Environment

Time of Use Tariffs

Settlement

Within the settlement process managed by Elexon under the 'Balancing & Settlements Code' (BSC), only a number of tariffs can be supported in the existing Non-Half Hourly (NHH) processes and systems (field lengths and interactions with other industry interfaces) and there may also be IT system and process implications for both suppliers and distribution businesses. For many and varied ToU tariffs, complex changes will be required.

For NHH, data from each tariff meter dynamically controlled by suppliers will be required. Some form of aggregation will be required prior to its use in the BSC central systems (i.e. to create HH profiles for these NHH customers). This will require new infrastructure or obligations on each supplier to provide such aggregated data, which may lead to increased costs to support such tariffs.

Half Hourly settlement provides fewer barriers to implementing dynamic ToU tariffs. This is because the HH meter data directly reflects the shape and volume of energy consumed by the customer.

Distribution Use of System (DUoS) Charging

Consumer electricity bills are made up of a number of areas including social and environmental costs, wholesale energy costs (nearly half of total costs) and that of both operating and delivery costs. Delivery costs, amounting to over 1/5th of energy bills, constitutes charges from both the transmission system and distribution networks.

Distribution Network Operators (DNO) bill suppliers for the costs of receiving electricity from the national grid, and feeding it into homes and businesses in the network. The majority of domestic consumption however is charged on the basis of a single time band. Consequently the charging is not reflective of the costs imposed on real time system management.

To make ToU tariffs as cost reflective as possible taking into account both energy supply and delivery costs, there is a proposal by the DNO, Electricity North West, for a new DUoS tariff for domestic customers to facilitate half hourly settlement if suppliers choose to pass through directly rather than smear across their customer base.

Regulatory Environment

National Grid & DSR

- The traded market in electricity closes one hour before delivery for every half hour of the day. In this last hour National Grid is responsible for taking balancing actions in the market to match the actual supply of energy to that in demand which may differ to that which was contracted between market participants.
- A number of tools are available of which STOR would be the most appropriate for microgeneration with longer lead in times. STOR covers both generation and demand sites.
- With the challenges in the electricity sector of declining capacity, increased demand and greater levels of renewable energy, National Grid STOR requirements will be increasing from 3.5GW in 2011 to 8GW by 2020.
- Over 4GW of new STOR capacity will be sought from new providers. It is here that third party aggregators will have a role to play by aggregating units that would not otherwise meet the 3 MW threshold for participation.
- However, at prices of between £30 and £40 /kW per annum, the availability payment is not sufficient to stimulate storage. Likewise, balancing services are not properly priced into the cash out / imbalance price which Elexon uses for settlement purposes.
- STOR contracts are also lengthy (160 pages), can be difficult to understand, and contract length in the balancing market means availability for the month ahead must be predicted. Microgeneration is therefore unsuitable for this measure.

National Grid Balancing Services – Imbalance Tools

- **Frequency Control Demand Management**: This has to be automatic, and available within 10-30 seconds, and sustained for up to 30 minutes.
- **Firm Frequency Response**
- **Fast Reserve**: To be available within 2 minutes, and sustained typically for 15 minutes.
- **Short Term Operating Reserve**: This has to be available with notice of between 20 minutes and 4 hours and sustained for up to 2 hours.

Regulatory Environment

National Grid & DSR

- Looking ahead, the new DSBR product which is planned for launch over winter 2014/15 will have a threshold for participation of 100kW. Our modelling suggests Microgeneration could proffer significant value to this scheme.
- The DSBR is designed to stimulate significant growth in the provision of DSR ahead of the Capacity Market mechanism, but given the capacity market will have a threshold of 2MW for participation, we anticipate that the DSBR mechanism may become an enduring arrangement.

Demand Side Balancing Reserve (DSBR)

To optimise scheme design, we propose the following:

- *DSBR participation criteria must include export from small scale and micro generation and storage from 'beyond the meter'*
- *The DSBR product should be year-round rather than just the winter months*
- *The most sensible option for National Grid is to procure the DSBR service from aggregators, suppliers, DNOs and larger users*
- *Simplicity, financial benefits and service standards must be at the centre of engaging consumers in the DSBR.*

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Regulatory Environment

EMR: Capacity Market

- With the challenges ahead for the electricity market, the Government is putting in place a series of new market measures under its Electricity Market Reform.
- A Capacity Market is a scheme where generators receive revenue streams, as incentives, for investing in generating capacity at times where there is stress on the grid. These generators, following a capacity auction, enter into capacity agreements. There are financial penalties if the capacity agreements are not met.

to the development of smart grids and that of DSR. DSR will be incorporated into the Capacity Market on a trial basis from winter 2016/17 in respect to providing both positive (additional generation) and negative (demand reduction) capacity to the UK market, with a 2MW threshold. This will help address the issues with variable generation and increased loads on the electricity networks:

EMR: Capacity Market

PARTICIPATION
Technology neutral, existing and new forms of capacity will be eligible to participate

DELIVERY PERIOD
Participants will be obliged to deliver energy in periods of stress, will be penalised if this is not met

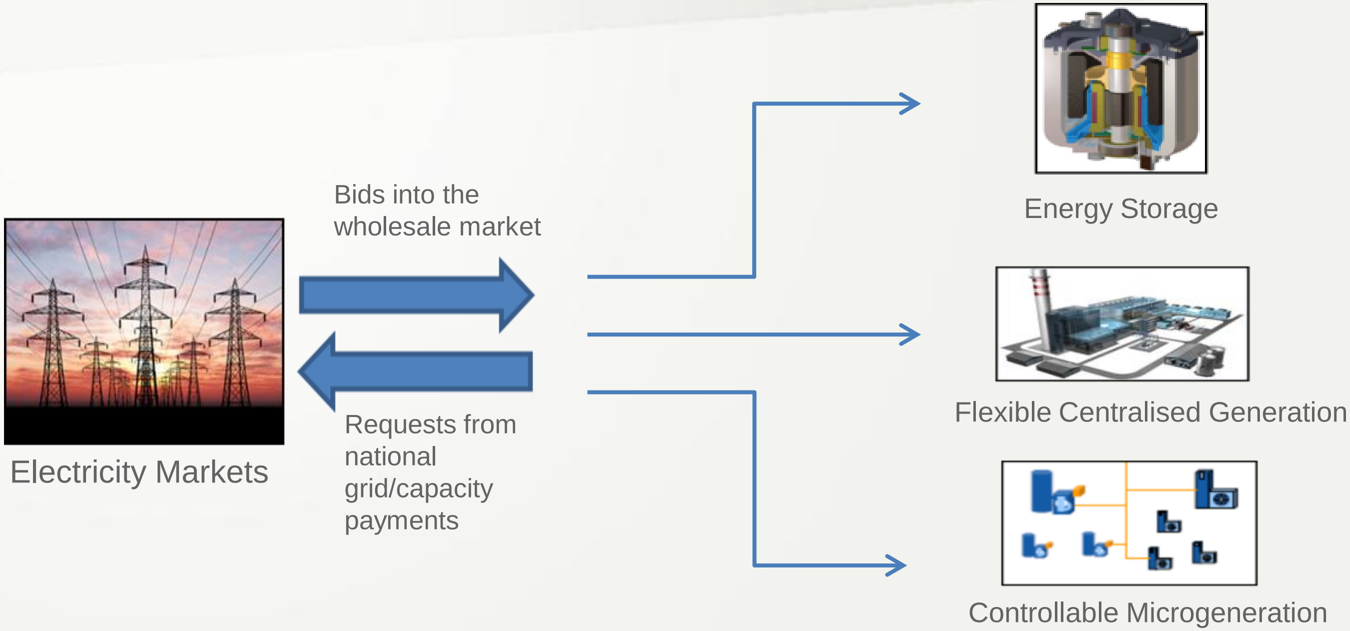
PAYMENTS
Successful bidders will be awarded 'capacity agreements', linked to the Value of Lost Load

PROCUREMENT
Government will run an auction in 2014 for delivery in 2018/19, subject to state aid clearance

Security of supply	The missing money problem	Minimise cost to taxpayers
• To reduce risk of power cuts due to inflexible and intermittent generation • To meet the increase in electricity demand from heat and transport sectors	• The Capacity Market will help the market reflect the real value of generating additional capacity at times of scarcity	• Avoiding the need for additional peaking plant will save money • Consumers may be able to obtain additional income streams on microgeneration

Regulatory Environment

EMR: Capacity Market



Policy design considerations:

- *Capacity market participation for microgeneration should not be excluded as a result of receiving fiscal support from a Government scheme such as FITs.*
- *There is no proposal for how the trial DSR project can be transitioned into the full Capacity Market.*
- *Consistency in scheme access and design with National Grids DSBR would help DSR development.*

Regulatory Environment

Value Chain Development

- As a result of the higher levels of renewables, distributed generation and demand for electricity, the distribution networks are already under significant strain. Since DNO investment costs are passed onto the consumer, Ofgem's new framework ensures that the £32 billion investment expected (double the rate over the last twenty years) will be undertaken as efficiently as possible.
- This new framework provides the setting for developing commercial opportunities for smarter grid solutions.
- A study in Austin, Texas, for the municipal utility showed there is significant value of micro-generation to the grid which is highly fragmented and not currently monetised.
- While the energy value of the solar power in this example was only around 7c/kWh (the value of the electricity it would displace), the available capacity, deferral of grid infrastructure upgrades and avoidance of delivery losses (e.g. transmission) added significantly to the value of PV to the utility.
- In the UK, following privatisation of the electricity industry, a range of stakeholders (both private and regulated) now share these benefits, so that income streams may be split, difficult to capture and potentially insufficient from dilution and costs involved.

RIIO Framework – ED1

The level of money that Distribution Network companies can make is governed by Ofgem price controls. For the period 2015 to 2013, the new RIIO (Revenue = Incentives + Innovation + Outputs) framework is in place which will be more performance based and is designed to encourage network companies to:

- *Put stakeholders at the heart of the decision making process*
- *Invest efficiently to ensure continued safe and reliable sources*
- *Innovate to reduce network costs for current and future consumers*
- *Play a full role in delivery of a low carbon economy*

Regulatory Environment

Value Chain Development

- In the case of storage, the benefits are shared by many of stakeholders: renewable developers, the TSOs and the distribution network operators. Suppliers would also gain value in helping balance their trading accounts for settlement purposes as would large customers as highlighted in the modelling results earlier in this report.
- But the roles and interactions between these stakeholders are complex and there is no clear route for funding storage: who should pay for, own and operate it?
- DNOs are considered the main beneficiary of storage for local network management– but whilst DNOs are allowed to own it, there are licensing and regulatory issues with operation. DNO's are restricted in buying and selling energy, however they may work with aggregators for services such as STOR. Alternatives could be renting storage from third parties, but this is complex and further erodes the value chain.

Policy Conclusion:

The fragmented industry structure suggests that either private companies need to be incentivised to invest in electricity storage or DNOs should be given the freedom to own and operate electricity storage by a revision to their licence conditions.

Real time pricing, both for energy and for system pricing operating costs would provide strong market signals to encourage the uptake of electricity storage and distributed generation and the incentive to participate in DSR.

Regulatory Environment

DSR & Local Energy Markets

- There are many stakeholders in the provision of DSR through the value chain and the interactions and impacts on parties.
- Without communication between parties, suppliers increasing / decreasing load will impact the distribution network potentially placing it under more strain – and likewise a DNO calling DSR, will likely negatively impact the trading accounts of suppliers.
- Consequently in the provision of DSR and that which can be provided from aggregating microgeneration, a new set of market arrangements is required which addresses all the roles and responsibilities particularly between DNOs, National Grid and suppliers. For example, if supplier balancing results in a shift away from peak hour, whilst this may benefit the Transmission System Operator, it could create a new peak at the local level with the DNO.
- Simplicity and transparency must be key to market design and also for engaging consumers in signing up to DSR programmes.

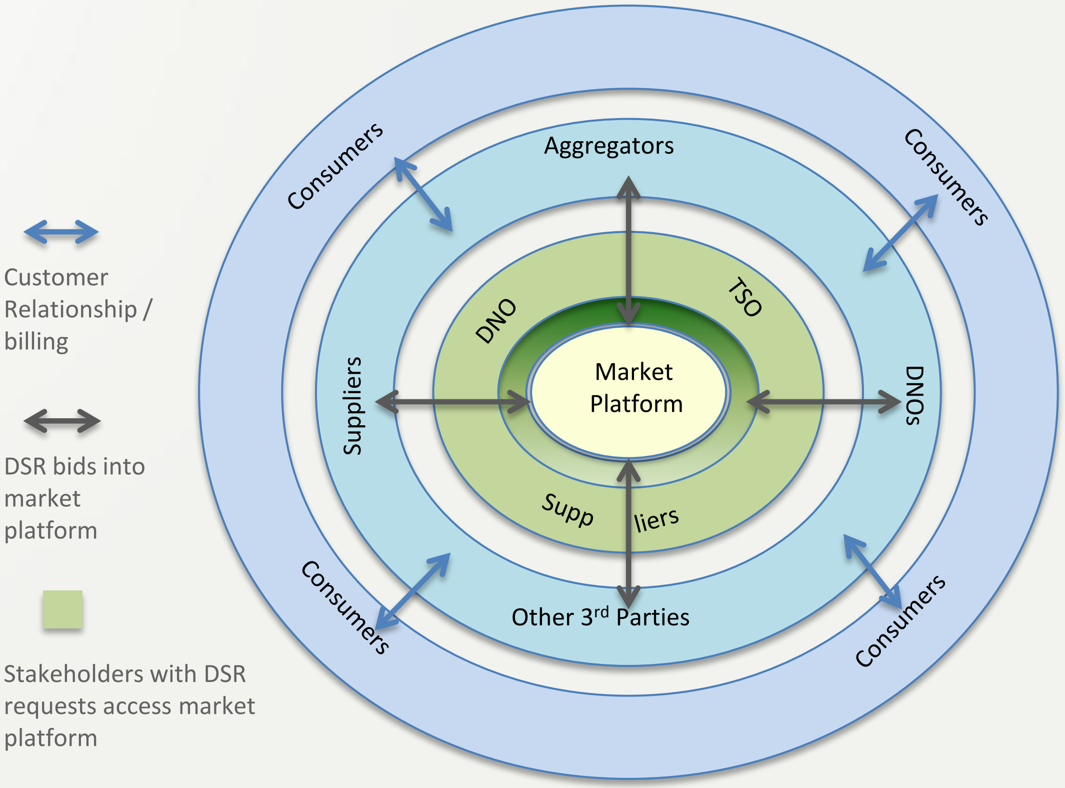
European Legislation

- *The Third Energy Package from the EU seeks to further liberalise and harmonise the European markets, to lower costs for consumers. However the 'unbundling requirements' aimed at reducing monopolies in the market, has had the effect that Network Operators are not allowed to own generation. The potential classification of storage as generation , therefore has consequences on DNO ownership and operation of storage.*
- *The EU Energy Efficiency Directive however has a more positive immediate bearing on DSR. Member States are being encouraged to make transmission and distribution tariffs more cost reflective to further DSR participation in balancing markets and ancillary services procurement. Likewise they must ensure that TSOs and DSOs, must treat DSR providers, including aggregators, in a non-discriminatory manner on the basis of their technical capabilities.*

Regulatory Environment

DSR & Local Energy Markets

- With the evolution of arrangements that will come as the necessity for balancing at the local level increases, DNOs are likely to transition to a Distribution System Operator role , as National Grid does for the transmission network.
- To this extent, the effective creation of Local Energy Markets (LEMs) may involve the emergence of new participants such as community organisations or even individuals.
- An investigation into the benefits of LEMs by the consultants, Swanbarton, suggests consumers' energy costs falling by 10% and local producers' revenues increasing by about 50% when storage participates in a local energy market.
- Under the forthcoming Network Innovation Competitions and RIIO ED1, trials looking at DNO to DSO development and LEMs need to take place.



Receipt for the real value of energy generated and stored could drastically reduce the need for government subsidies

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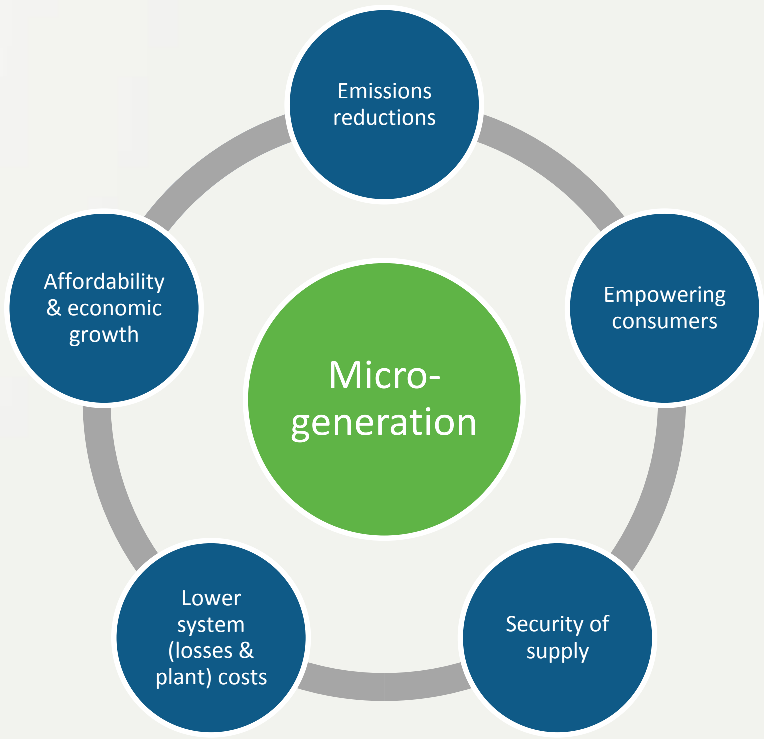
Microgeneration, Storage & DSR

Why Microgeneration?

- At a time when the domestic sector is already faced with higher energy bills and rising fuel poverty, the additional challenges ahead of declining capacity margins and higher energy costs are leading to unprecedented pressure on consumers.
- Yet in the drive to reduce the two thirds of UK CO_2 emissions the domestic sector produces, the electrification of heat and potentially transport could raise electricity consumption in the home. In 2012, the sector already accounted for 30% of overall UK electricity demand (DUKES 2013).
- But in looking at the role of consumers, going forward, microgeneration is set to play an ever increasing role both in creating new capacity and decarbonising the grid. At the same time, consumers will become more self-sufficient and less reliant on expensive grid imports.
- The analysis covers the growth potential of selected technologies and how they can be deployed most effectively in terms of grid requirements. At the consumer level the key areas are about maximising returns whilst minimising impacts on comfort levels.



Heat storage and electrically driven heating has a huge potential as a cost effective tool for balancing the electricity system

Current Market

Heat Pumps

Potential Market Size

Growth projections

In 2011, there were c. 10,000 ASHP installations – by 2015, 275,200 ASHP and 1,400 GSHP are expected. By 2020 the number should reach 600,000 heat pump units and 2.6 million by 2025 according to the 4th Carbon Budget.

Customer Engagement

Smart meter roll out from 2015 will give consumers greater information about their energy usage.

Consumers could be incentivised by lower electricity tariffs at off peak times, but the process needs significant automation and level of comfort must be maintained. Space for hot water storage will also be required.

Technology Description

Domestic Air Source Heat Pumps encompass an electric driven reverse refrigerant cycle taking heat from the ambient air for space and water heating.

Domestic Ground Source Heat Pumps take heat from the ground – heat is captured via an evaporator in ground loop or bore hole.

DSR Potential

Heat pumps are interruptible for short periods with no discernible impact on comfort levels within home.

Built-in or retrofit control and communication capability to enable remote dispatch.

Addition of heat storage to increase flexibility in the timing of heat pump operations.

Technology Challenges

For ASHPs: improvements to cost, performance and operating noise. Efficiency also drops with ambient temperature.

For GSHPs: units more suitable for low flow temperatures, so low retrofit potential. Not suitable for some locations. Borehole technology increases the range of potential properties but is expensive.

Current Market

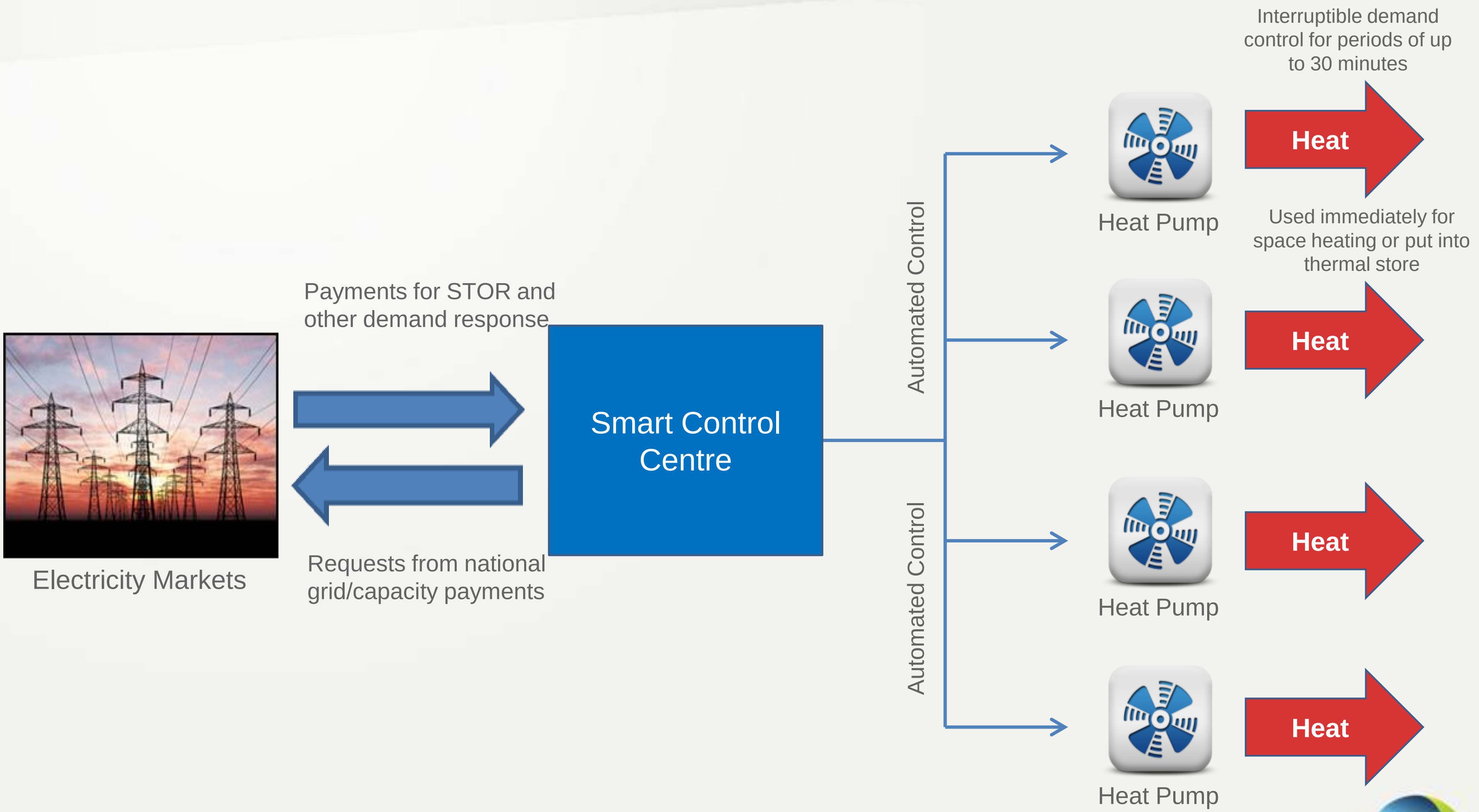
Policy Environment – Heat Pumps

Policy Factors influencing roll out	Details
Match to energy policy	ASHPs are highly energy efficient and use a renewable source to produce 2 to 3 units of heat for one unit of electricity. GSHPs are the most efficient heat pump technology and therefore optimal source of energy if costs can be reduced.
Green Deal (GD) / ECO	Eligible for GD financing and ECO under 'Affordable Warmth'.
Building Regulations	Would benefit from a requirement for higher efficiency heating system.
RHI / FITs	RHI eligibility: tariffs of 8.8 p/kWh for GSHP and 7.3 p/kWh for ASHP sufficient in most cases to achieve 7.5% rate of return – payable only on the renewable component of heat generated.

Policy Factors influencing roll out	Details
EDR	Some concerns over impact on electricity requirements. Carbon saving impacted by power sector decarbonisation.
DSR Arrangements	Heat pumps are interruptible for short periods of time, though may need to have thermal storage to maintain comfort. Aggregated, 1,000 3kw heat pumps could provide 3MW of interruptible short term reserve (see next page for schematic). Trials for smarter operation of heat pumps have yet to take place, but may do so under National Grid's DSBR programme or the Capacity Market under EMR.

Current Market

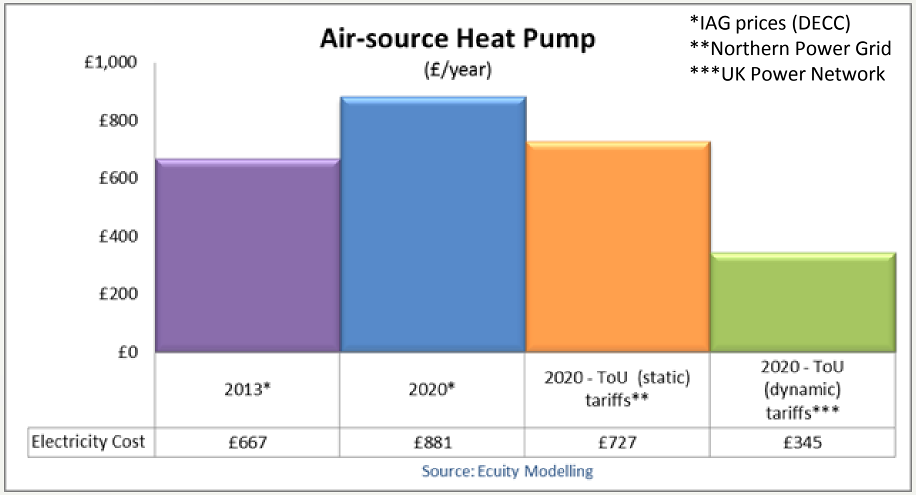
The potential of heat pump aggregators



Microgeneration Technologies

Economics of Heat Pumps in the Smart Grid

- Given that heat pumps will 'top up' with electricity particularly during the winter months, rising electricity prices may then lead to higher energy bills.
- However with the introduction of Time-of-Use tariffs, this may encourage smarter uses of ASHPs with smart heat pump controls utilising thermal storage with immersion heaters to run the heat pumps at least cost.
- Our modelling shows that at current prices, the annual electricity bill of a 7.5kW heat pump would be nearly £700. With the introduction of dynamic ToU tariffs, by 2020 this could fall to £345.
- Alternatively, if several ASHPs are aggregated together, a 100kW DSR service could be provided by varying the level of electricity consumption (for DSBR assumptions see next page).
- Under National Grid's proposed DSBR service, the modelling results displayed below, show the value that could be obtained per installation under 4 scenarios (figures in £/year per unit).
- If generation capacity can be incorporated into the scheme, this could mean values of over £2,000 per unit per year if DSR is called on a high utilisation fee.



ASHP	Scenario 1	Scenario 1*	Scenario 2	Scenario 2*
Set up payment	£15	£15	£15	£15
Utilisation Fee - Low	£72		£27	
Utilisation Fee - High		£2,160		£810
Total	£87	£2,175	£42	£825

***Scenario 1**: DR called on 48 days of the year, 1 hour per day*
***Scenario 2**: DR called on 12 days of the year, 1.5 hours per day*

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Demand side balancing reserve

DSBR	Product 1
PARTICIPATION	Consumers (or "behind-the-meter" or embedded generation) able to deliver demand reduction at sites which are half-hourly metered in central settlement.
DELIVERY PERIOD	Peak-times on non-holiday weekdays (Nov-Feb, 4pm to 8pm)[2]
PAYMENTS	Set-up payments (£5/kW - £10/kW) + utilisation payments equal to the Value of Lost Load (£500/mWh – £15,000/mWh).
PROCUREMENT	Tenders will be held in 2013/14 for delivery in Winter 2014/15 and Winter 2015/16. A further tender would be held, if required, for additional DSBR in Winter 2015/16.

Combined Heat and Power systems provide essential heating services and power on demand for on-site use, storage or export

Current Market

micro-CHP

Potential Market Size

In July 2013, MCS had 590 mCHP installations registered.

mCHP deployment is expected to increase significantly over the coming years with the introduction of new products. Around 8 million homes in UK could be suitable for mCHP (Carbon Trust).

Customer Engagement

Smart meter roll out from 2015 will give consumers greater information about their energy usage.

Consumers could be incentivised to generate more electricity by higher electricity tariffs at peak times, but process needs significant automation and heat storage to enable flexibility.

Technology Description

Stirling Engine / Organic Rankine Cycle: Heat led condensing boiler for space heating and hot water, with secondary electricity generation (heat 6:1).

Fuel Cell: Electricity generation through the chemical oxidisation of gaseous fuel (such as hydrogen or methane) with secondary heat for hot water (0.33 heat: 1 electricity).

DSR Potential

Heat led mCHP tends to generate more power at times of peak demand (e.g. evenings and winter), therefore naturally reduces the need to operate and maintain peaking plants.

Micro-CHP is also flexible and a natural fit with key renewable solutions (see graph in next page (see schematic in next page).

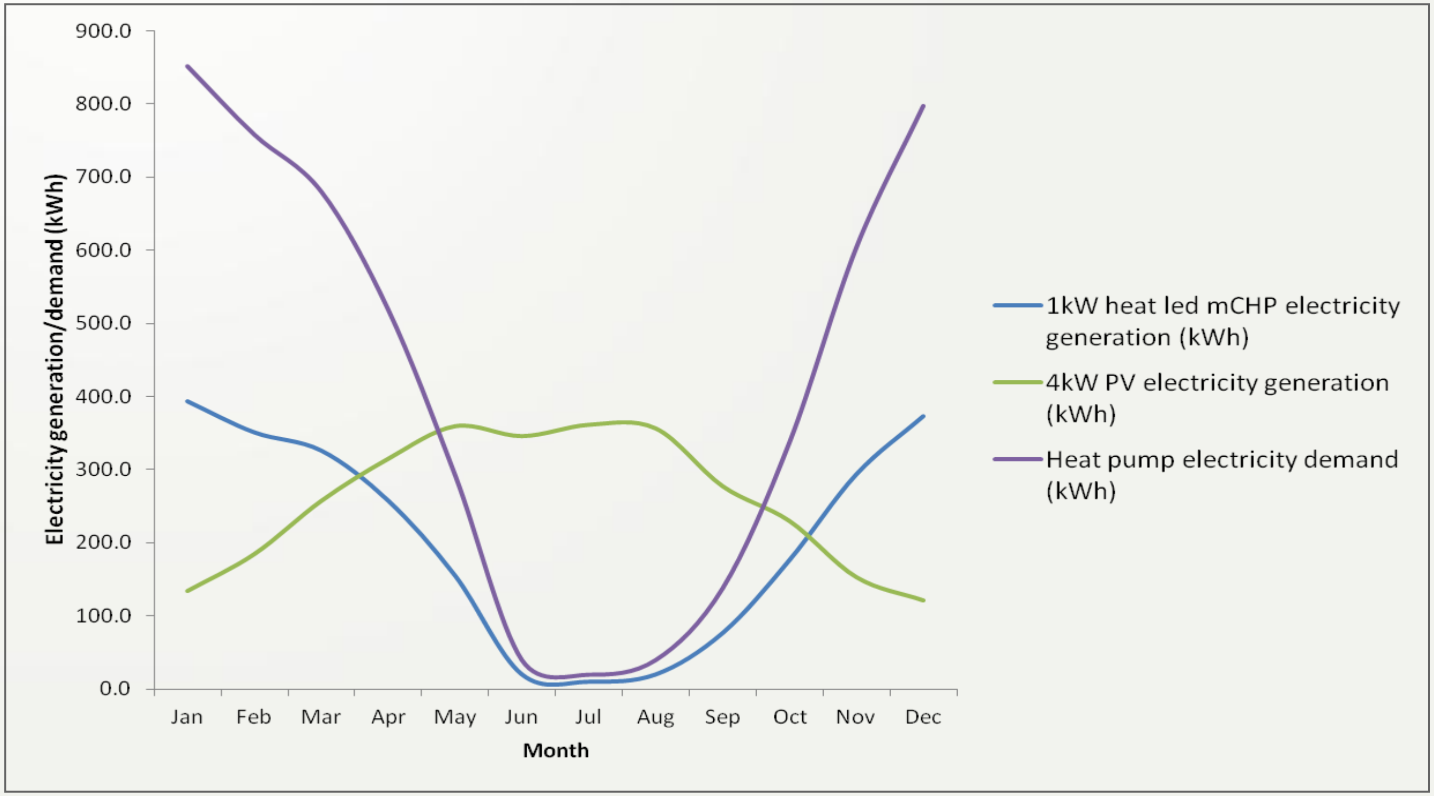
Technology Challenges

Stirling Engine: Needs change to EU ENTSO-E electrical installation standards. Improve performance and reduce costs to be competitive with gas condensing boiler.

Fuel Cell: high capital costs, although cost reduction potential of technology proven in Japanese market.

Current Market

Electricity generation from mCHP and fit with key distributed renewable technologies



Current Market

Policy Environment – mCHP

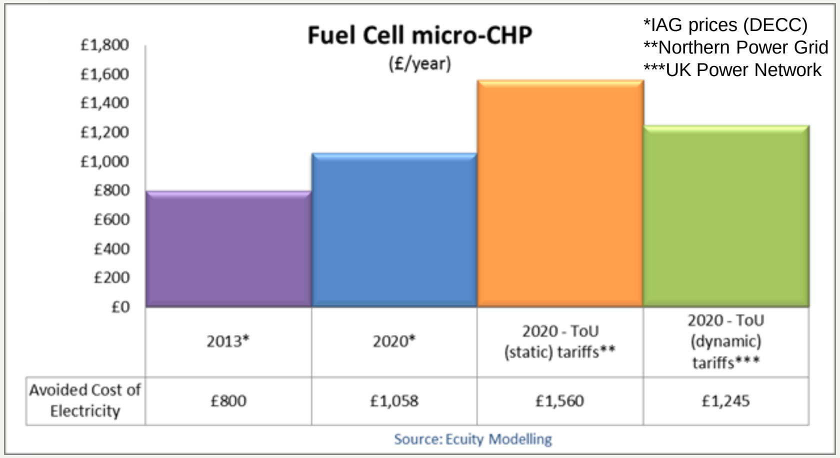
Policy Factors influencing roll out	Details
Match to energy policy	Localised flexible electricity generation that can support management of electricity distribution congestion in decarbonised future, reduce energy bills and CO2 emissions. Operation in a modular fashion in a shared environment (social housing, community heating schemes etc.). Coupling with heat pumps, either at individual property level or at scale. Stirling Engine mCHP is marketed as the next generation of efficient boiler and is regarded by Government as 'an effective transition technology until the electricity grid decarbonises'.
Green Deal (GD) / ECO	Eligible for GD financing and ECO under 'Affordable Warmth'.
Building Regulations	Would benefit from a requirement for higher efficiency heating system.
FITs / Export Tariffs	Maximum of 30,000 mCHP installations up to 2kW eligible for FiT of 12.9 p/kWh to then be reviewed. Export tariffs of 4.6 p/kWh are not considered reflective of the electricity exported. Consumers also receive the benefit of any avoided purchase of centralised energy power, currently around 15p/kWh.

Policy Factors influencing roll out	Details
EDR	Through onsite generation, reduction in transmission and distribution losses, which on a national basis constitute around 7% electricity generated.
DSR Arrangements	Trials at the micro / domestic level have yet to take place, but may do so under National Grid's DSBR programme or the Capacity Market under EMR – if allowed to do so. At the medium and larger scale, CHP is already participating in STOR through larger scale aggregators.

Microgeneration Technologies

Economics of Micro-CHP in the Smart Grid

- Micro-CHP generates mostly during peak demand periods, and therefore has the potential to act as a grid support mechanism to cope with capacity constraints and short-term spikes in demand.
- Comparing the value of exporting electricity to that of self consumption (and avoiding electricity imports), export tariffs for mCHP are just 4.6p/kWh compared to the cost of importing, at a wholesale price of 15.2p/kWh.
- With a differential of 10.6 p/kWh, this shows that increasing the levels of self consumption, by putting excess generation into storage, provides much additional value to that of exporting excess generation.
- This differential will increase with the incorporation of static and dynamic tariffs. For a typical Fuel Cell CHP, this differential could double by 2020 from £800 to nearly £1,600 per annum.
- Alternatively, if a number of mCHPs are aggregated together, the combined capacity could form an effective virtual power plant for additional generation capacity at times of system stress. For this to occur, additional generation capacity must be properly rewarded.
- Under National Grid's proposed DSBR service, the modelling results displayed , show the value that could be obtained per installation under 4 scenarios (figures in £/year per unit).
- If generation capacity can be incorporated into the scheme, this could mean values of up to £1,445 per unit per year if DSR is called on a high utilisation fee.



mCHP	Scenario 1	Scenario 1*	Scenario 2	Scenario 2*
Set up payment	£10	£5	£10	£5
Utilisation Fee - Low	£15		£48	
Utilisation Fee - High		£450		£1,440
Total	£25	£455	£58	£ 1,445

Scenario 1*: DR called on 15 days of the year, 2 hours per day*
Scenario 2*: DR called on 48 days of the year, 2 hours per day*

A typical Solar PV system could save **over a tonne of carbon emissions over annum**

Current Market

Solar PV

Potential Market Size

Growth projections

Until 2010, there was a run-rate of 2MW pa, but during 2011, this went over 750MW. In April 2013, UK broke the 2.5GW barrier mark, and by end 2016, 9.4GW is expected. The upper growth target is around 20GW by 2020. Government is targeting 4 million homes to have solar by 2020 – this could mean 13.2GW if average capacity is 3.3kW.

Customer Engagement

Solar PV has the highest level of awareness amongst consumers for renewable microgeneration technologies and the FIT support scheme has encouraged extensive growth. PV tariffs are now lower however continued growth is expected, supported by the introduction of domestic storage to PV.

Technology Description

Most photovoltaic systems are made up of panels that fit on top of an existing roof – they can still generate some electricity even on cloudy days. Solar tiles can also be used in place of ordinary roof tiles, though cost nearly twice as much.

DSR Potential

In some areas, level of PV installations is already causing problems for network management and investment, limiting further roll-out in some cases.

PV + storage offers opportunities both technically and commercially to manage the network constraints and participate in balancing mechanism, for commercial benefit amongst a number of stakeholders.

Technology Challenges

Is the market (manufacturing, supply, quality control etc) geared up to deliver the rapid expansion in growth that is expected?

Built-in or retrofit control and communication capability to enable remote dispatch of storage would be required.

Current Market

Policy Environment – Solar PV

Policy Factors influencing roll out	Details
Match to energy policy	PV has high commercial awareness, and with market potential, DECC has set a nominal target figure of 20GW by 2020 according to its 2012 impact assessment. PVs have fallen substantially in cost and represent a huge potential for consumers to generate onsite – particularly important given the increases in demand expected e.g. through electric vehicle deployment.
RHI / FITs	FIT eligibility: tariffs range from 12.89p/kWh for <2kW to 15.44p/kW for plants <4kw or at the medium rate of 13.9p/kW – various other medium and higher rates for plants – rates for different size categories. Tariff levels will be reviewed as costs fall. Consumers are increasingly interested in maximising self consumption due to rising electricity prices increasing-the cost of 'importing' into the site.

Policy Factors influencing roll out	Details
Green Deal (GD) / ECO	Eligible for GD financing and ECO under 'Affordable Warmth'.
Building Regulations	Would benefit from a requirement for higher efficiency heating system.
DSR Arrangements	On their own not likely to be able to contribute to DSR – however together with storage there is potential. Trials taking place under LCNF e.g. Sola Bristol with regards to DNO utilisation to manage constraints, but beyond that there are no BAU commercial contracts either with DNOs or National Grid. In future, should the mechanisms permit, they may be able to participate under National Grid's DSBR programme or the Capacity Market under Electricity Market Reform.

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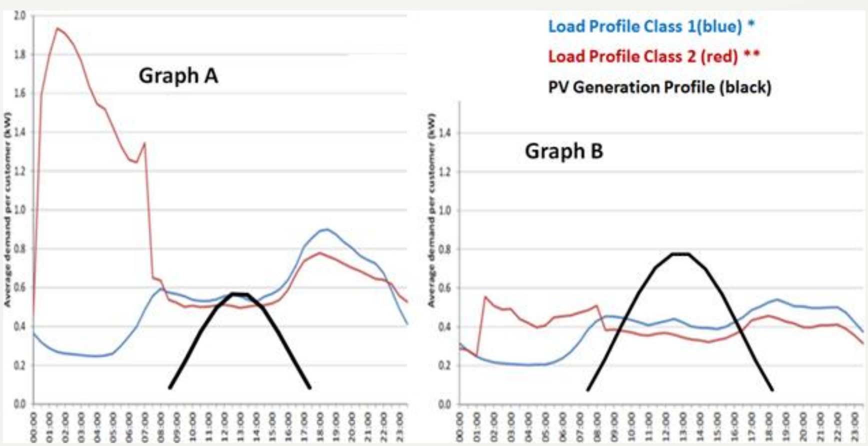
Microgeneration Technologies

Economics of Solar PV in the Smart Grid

- Solar PV in the UK notably took off with the introduction of the Feed in Tariff scheme in 2010, starting from approximately 30,000 units at c. 300MW at the end of March 2010 to surpassing the 2.5GW milestone in April 2013.
- The financial benefits of PV consist of generation income at 14.9p/kWh (the FIT tariff), export income at 4.6p/kWh and the avoided cost of electricity at 15.2p/kWh.
- However, when comparing domestic profiles (1 and 2) to the typical generation profile – there is a mismatch between time of generation and consumption where PV generation peaks and demand is at its lowest. During low demand, excess electricity is exported back to the grid at 4.6p/kWh, when overall system demand is also below peak (and wholesale prices also lower). During peak times, consumers then have to import at around 15.2p/kWh.
- This naturally leads to the incentive for consumers to maximise self consumption of the electricity they generate, reflective of Profile Class 2 consumers who already maximise consumption at night time on the low economy 7 tariffs.
- PV with storage enables full self consumption by allowing consumers to use electricity generated during the day at peak times i.e. when the grid is under stress (4pm to 8pm).



Profile data from Elexon: Load profile coefficients for 2011/12 by half-hour – plus – annualised energy consumption by Load Profile Class (and Grid Supply Point group) from September 2011

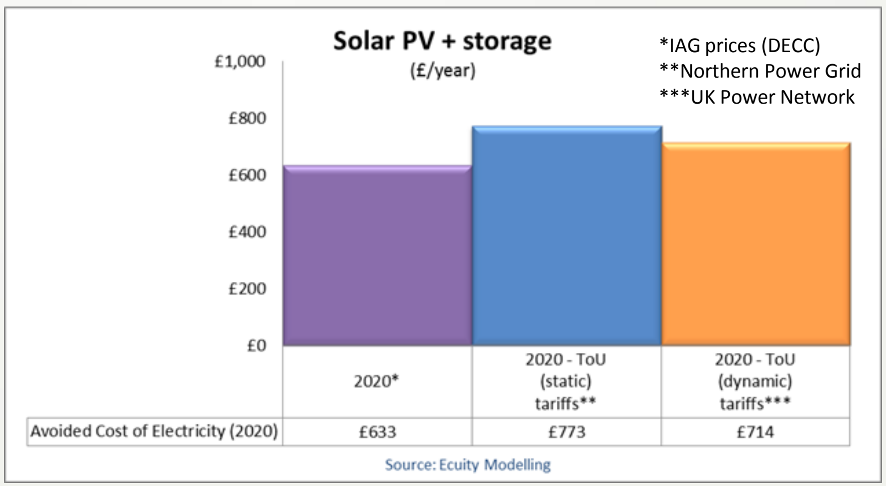
Graph A: Winter weekday with average February generation
Graph B: Summer weekend with average August generation

*** Profile Class 1:** Domestic consumers who pay a uniform rate throughout the day
**** Profile Class 2:** Customers who have the potential for separately metered hours between midnight and 06:00 hours.

Microgeneration Technologies

Commercials – Solar PV

- The driver to self consume is amplified when taking into account rising electricity prices, decreasing feed in tariffs and the expected reduction in storage costs.*
- Time of use (ToU) tariffs designed to reflect the real cost of electricity at different time intervals can also increase the value of on-site generation – i.e. higher energy savings for the consumer.



*"For battery-based residential PV energy storage systems, IHS predicts an average cost reduction of around 45% during the next five years, largely due to decreases in battery prices."

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Cost-effective storage technologies can multiply the value of microgen, adding predictability and providing a boost to the electricity system at peak times

Current Market

Electricity Storage

Potential Market Size

Growth projections

Assessments of system-wide value of electricity storage indicate that it would be worth £10 billion per annum in system savings by 2020* for the UK.

With increasing levels of wind generation the requirement will become greater – up to 305GW globally with 30% wind power capacity

Customer Engagement

Consumers with micro-generation could be incentivised by having a genuine time dependent feed-in-tariff or by dynamic electricity tariffs.

Community Energy Schemes and Local Electricity Markets may also engage consumers.

Technology Description

There are many different electricity storage technologies at a range of sizes to suit a broad range of applications from the domestic to the grid scale.

Electricity storage offers flexibility, allowing for the integration of greater amounts of renewable generation, without the need for high carbon peaking plant.

Response Potential

Electricity storage can time shift energy and provide power response. It can offer multiple reliable ancillary services, such as STOR and FFR to NGET or provide constraint management services to a DNO.

Technology Challenges

Technology is mature and successfully demonstrated, but in the UK lack of system experience limits deployment.

High investment cost, but low long-term running costs.

Regulatory barriers

*"For battery-based residential PV energy storage systems, IHS predicts an average cost reduction of around 45% during the next five years, largely due to decreases in battery prices."

Current Market

Policy Environment – Storage

Policy Factors influencing roll out	Details
No Strategy	Electricity storage offers system flexibility at a time when there is an increasing amount of variable generation and decreasing amounts of thermal generation. It is recognised that electricity storage will be needed in the future, but there is no strategy to ensure that storage is on the system to meet that need.
Limited Support	There is a DECC innovation program to support the development and deployment of electricity storage. There is also support for academic and industrial research into novel forms of storage. Storage only deployed as part of Ofgem Low Carbon Network Fund projects. No incentives (as offered in Germany and USA).

Policy Factors influencing roll out	Details
EMR	Capacity Market may offer opportunities to a limited number of storage providers, but will not result in the installation of significant amounts of storage.
Income Streams	For storage to be economically viable it needs more than one income stream: but this is not always possible, or if it is it incurs additional transaction costs that reduce the benefit.
Regulatory Barriers	There is no licence category for storage. It is generally treated as generation and this limits ownership and operation options.

Microgeneration Technologies

Commercials – Storage

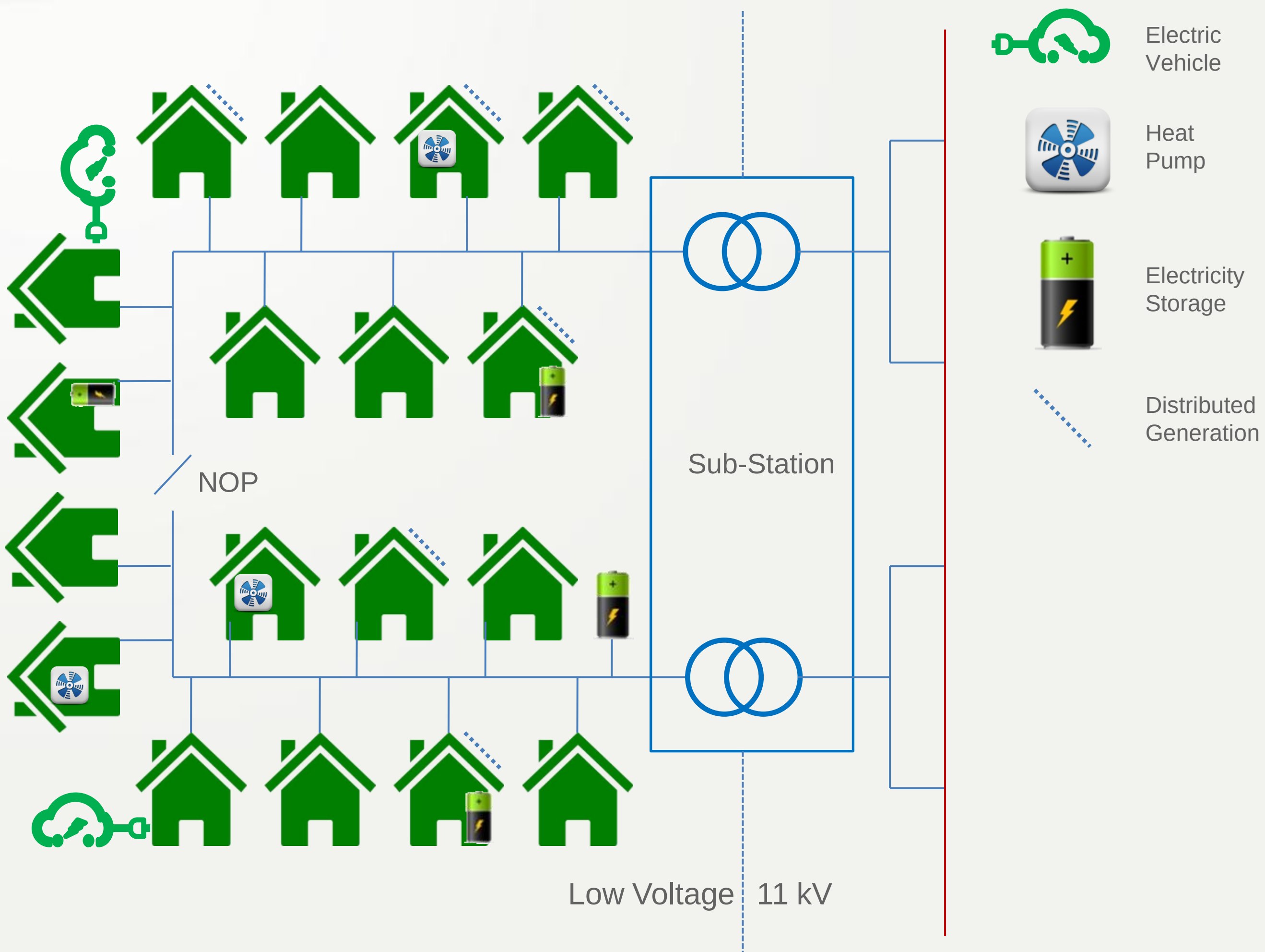
- Local Electricity Markets would allow local people to trade their electricity locally (see graph on next page). A Technology Strategy Board funded feasibility study performed by Swanbarton Limited and IPL demonstrated that Local Electricity Markets would provide financial benefits to consumers and producers, while better managing electricity on the distribution network so facilitating greater uptake of distributed generation. These benefits increased substantially if electricity storage was included.
- The GB system is designed around central large-scale generation meeting dispersed inflexible demand – top down. Microgeneration is increasingly commonplace, providing small-scale distributed generation – bottom up. Local markets and Community Energy Schemes (where local trading of electricity is permitted) would promote a lower carbon and more efficient electricity network.
- While peer-to-peer electricity trading is not yet permitted under GB regulations, an aggregated approach would work now, empowering and powering local people.

Participant	Current	With LEM		With Storage*	
Consumer Spend	£146 K	£139 K	-5%	£132 K	-10%
Producer Revenue	£42 K	£49 K	+17%	£58 K	+58%
Aggregator Revenue	N/A	£2.4 K		£5.7 K	
Incumbent Supplier	£105 K	£88 K	-16%	£68 K	-35%

Economics: per Low voltage Feeder per year
*Storage: 250 kW, 2 hour duration (£500 K)

Microgeneration Technologies

Commercials – Storage



Courtesy of Swanbarton

4 Conclusion

An increasing role for microgeneration

- Over the coming decade the combination of decreased generation capacity from coal and oil, higher levels of demand and increased levels of variable generation from renewables mean that balancing supply and demand on the grid will become ever more challenging.
- Furthermore, local distribution networks are already experiencing congestion with the growth of distributed generation (DG): some areas are already building restrictions into connection agreements for new sites.
- To address the challenges of higher demand, connection of DG and managing the peaks and troughs of renewable generation, demand side management (both reducing and increasing demand) will be an essential tool for both the transmission and distribution networks.
- Microgeneration is also set to play an ever increasing role in creating new capacity and decarbonising the grid – and at the same time, provide a valuable tool to consumers for reducing their energy bills when compared to importing from the grid.
- Microgeneration technologies, in particular heat pumps, PV, mCHP and storage could also have a significant role in supporting network management through DSR provision and reducing the levels of network.

Microgeneration Technologies

- *Heat Pumps: 600,000 heat pumps are expected by 2020 and with the use of storage and smart heat pump controls, the electrical demand over winter time could be managed to provide DSR capacity in terms of load reduction.*
- *Micro-CHP can provide additional generation capacity where there is storage for heat. Likewise its typical generation profile is also a natural fit with both heat pumps and solar PV production.*
- *The benefits to consumers of combining PV with storage are the most clear with PV generation peaking around midday with system peak starting late afternoon. With storage, consumers can also participate in providing both negative and positive demand response capacity.*

Recommendations

Need to unlock the commercial value

- For all these technologies, a trade-off between the value of storing onsite for later self consumption or providing additional capacity into a mechanism such as National Grids DSBR (provided a change is made to the DSBR mechanism to allow export of electricity from 'beyond the meter' from both mCHP and storage) will then need to be made.
- For storage alone, significant regulatory and commercial barriers need to be overcome to realise the commercial value that storage inherently has and could obtain for network management.
- Once the DSBR and Capacity Market are up-and running, there will be additional commercial value to access. At the moment however, DNOs are not allowed to own / operate generation assets or commercial platforms in regards to balancing their networks, and likewise are unable to offer service into National Grid's balancing mechanism.

The role of aggregators will be key

- The role of aggregators will be key to engaging microgeneration and storage in mechanisms such as the DSBR with minimal levels set on capacity required. Likewise for consumers, the interface with DSR must be as unobtrusive and as simple as possible – if not invisible.
- Consideration of DSR and of ToU tariffs must be put at the fore in the decision making around Retail Market Reform and the future of settlement processes so as not to restrict the introduction of these innovations by limiting the number of tariffs suppliers can offer.
- For smart metering, 'smart meters' as currently specified will not be fit for purpose in measuring energy flows in houses, so thought must be given to streamline the installation of meters in homes to improve cost efficiency and minimise disturbance to the consumer. Additionally, the granularity of data to be given to suppliers will only be on a daily basis for billing purposes, rather than at the half hourly unless consumers openly agree to permit this.

Recommendations

Market arrangements need to maximise DSR potential

- In the longer term, as the demand for participation in DSR increases, so the market arrangements will need to evolve to maximise DSR potential.
- Arrangements for the central coordination between various actors is key because:

  - Supplier actions (e.g. load or tariff switching) have system implications for Distribution Businesses, and

  - Distribution business actions have commercial implications for suppliers (e.g. Settlement imbalance).
- Uncertainty in the arrangements for DSR would lead to inefficient outcomes, e.g. A network reinforcement when DSR would be a more cost effective solution. Likewise, there may be increased costs driven by 'uncertainty' of system usage and power flows with an impact on security of supply.
- A single set of market arrangements however would facilitate an efficient use of DSR where all interests can be considered, aligned and a common approach applied across the country.

Policy design should enable microgeneration

- Consistency between Governments proposed Capacity Market and National Grid's DSBR mechanism would also facilitate DSR development by increasing standardisation, lowering administration costs for participants, thereby boosting investor confidence. In both of these schemes, microgeneration must be included – regardless of whether it is behind or beyond the meter and whether it receives / has received financial support such as from the FIT scheme.

ANNEX

Annex A

Glossary

ASHP	Air Source Heat Pump
Balancing Mechanism	A period of time which allows National Grid to call upon additional generation / consumption or reduce generation/ consumption in order to balance the system minute by minute, from one hour before each trading period
BAU	Business As Usual
BSC	Balancing & Settlements Code: The legal document that sets out the rules for the operation and governance of the Balancing Mechanism and Imbalance Settlement
Capacity Market	Measures as part of EMR package which aims at ensuring Security of Supply in regards to times of peak demand from 2017/18 onwards
CfD	Contracts for Difference – measure as part of EMR package which replaces the Renewables Obligation and offers investors (including nuclear) greater certainty in returns on investment
DG	Distributed Generation (power generation connected at the distribution network level as opposed to the transmission system)
DECC	Department of Energy & Climate Change
DNO	Distribution Network Operator
DSBR	Demand Side Balancing Reserve – an additional 'tool' proposed by National Grid to help balance the electricity network in regards to reducing demand between now and the introduction of the Capacity Market
DSM	Demand side management – see definition for DSR
DSO	Distribution System Operator – a notional concept that DNO's could evolve to become system operators and have similar functions for balancing the distribution networks as, National Grid, the TSO, has for the transmission system
DSR	Demand Side Response refers to changes consumers make to their energy use in response to some form of signal such as price
DUKES	Digest of UK Energy Statistics – published annually by DECC
DUOS	Distribution Use of System Charges – levied on consumers on the distribution network for the cost of distributing electricity to them
ECO	Energy Company Obligation
EDR	Electricity Demand Reduction
EMR	Electricity Market Reform – a series of measures proposed by DECC to transform the UK electricity market
ENTSO-E	European Network of Transmission Operators – Electricity
FFR	Fast Frequency Response – one of National Grid's tools for balancing the electricity transmission system
FIT	Feed in Tariffs – financial incentive provided to microgeneration
GD	Green Deal

Annex A

Glossary

GSHP	Ground Source Heat Pump
GSP	Grid Supply Point: means a Systems Connection Point at which the Transmission System is connected to a Distribution System
HH	Consumption data that is available from a meter on a half hourly basis for the purposes of settlement.
IT	Information Technology
LCNF	Low Carbon Network Fund – Funding mechanism set up by Ofgem to support smart grid innovation on distribution networks
LEM	Local Energy Market
mCHP	Micro Combined Heat and Power
MCS	Microgeneration Certification Scheme
NGET	National Grid Electricity Transmission
NHH	Non-half-hourly – which refers to meter equipment or data that is for a time period other than half hourly, normally monthly or longer
Profile Class	A classification of profiles which represents an exclusive category of customers whose consumption can be reasonably approximated to a common profile for settlement purposes
PV	Photovoltaic
RHI	Renewable Heat Incentive

RIIO	Revenue= Incentive + Innovation + Outputs: new Ofgem framework for stimulating innovation in the distribution networks
RMR	Retail Market Review by Ofgem composing of a number of measures to make a 'simpler, clearer and fairer energy market'
SBR	System Balancing Reserve – an additional 'tool' proposed by National Grid to help balance the electricity network in regards to supplying additional generation capacity into the system, prior to introduction of the Capacity Market
STOR	Short Term Operating Reserve – one of National Grid's tools for balancing the electricity transmission system
ToU Tariffs	Time-of-Use tariffs are where customers pay different prices at different times of the day. Peak prices are higher and off-peak are lower than the standard rate. They can be predefined i.e. static or can change 'dynamically' according to real time system requirements
TSO	Transmission System Operator – The role National Grid takes in managing the transmission network
VoLL	Value of Lost Load – is the estimated amount that customers receiving electricity with firm contracts would be willing to pay to avoid a disruption in their electricity service

Annex B

TOU Data Sheet

Micro-CHP	
Reference installation size (kW)	1 kWe
Load Factor %	60%
Typical Annual Yield (kWh per annum)	5,256 kWh
Project Lifetime (Tech Life) in Years	20 yrs

ASHP	
Reference installation size (kW)	7.5 kW
Load Factor %	20%
Electricity Requirement (kWh per annum)	4,380 kWh
Project Lifetime (Tech Life) in Years	20 yrs

Solar PV	
Reference installation size (kW)	4 kWe
Load Factor %	8.5%
Typical Annual Yield (kWh per annum)	3,400 kWh
Project Lifetime (Tech Life) in Years	35 yrs

Electricity Storage	
Stored Electricity	50%
Efficiency	85%
Project Lifetime (Tech Life) in Years	5-8 yrs

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Annex B

DSBR Data Sheet – mCHP & ASHP

Micro-CHP	
Reference installation size (kW)	1 kWe
Load Factor %	60%
Typical Annual Yield (kWh per annum)	5,256 kWh
Project Lifetime (Tech Life) in Years	20 yrs

ASHP	
Reference installation size (kW)	7.5 kW
Load Factor %	20%
Electricity Requirement (kWh per annum)	4,380 kWh
Project Lifetime (Tech Life) in Years	20 yrs

DSBR	Product 1
PARTICIPATION	Consumers (or "behind-the-meter" or embedded generation)able to deliver demand reduction at sites which are half-hourly metered in central settlement. The threshold for participation will be 100 kW.
DELIVERY PERIOD	Peak-times on non-holiday weekdays (Nov-Feb, 4pm to 8pm)[2]
PAYMENTS	Set-up payments (£5/kW - £10/kW) + utilisation payments equal to the VoLL (£500/mWh – £15,000/mWh)
PROCUREMENT	tenders will be held in 2013/14 for delivery in Winter 2014/15 and Winter 2015/16. A further tender would be held, if required, for additional DSBR in Winter 2015/16.