

# ENERGY SYSTEMS TOOLKIT

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Electricity Markets Module



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Highlands and Islands Enterprise  
Iomairt na Gàidhealtachd 's nan Eilean

## BACKGROUND

The Energy Systems Toolkit (the 'Toolkit') is aimed at organisations, community groups or businesses, at different stages in the project development process, whether exploring ideas to develop into a project or additional options to include in a current project. The toolkit aims to provide further information to organisations on energy systems topics that will help to determine whether a project idea is viable or highlight alternative options that should be considered. The Toolkit also provides support through the development process to construction, highlighting any support available to them. This could include:

- Signposting businesses or communities to additional support (technical or financial) in developing their project, to potential project partners or to potential sources of funding;
- Provide detail on key considerations and barriers across different technology projects; or
- Highlight different technology projects and themes that have been developed successfully across Scotland.

For each of the topics, the guidance provided will be informative and will indicate the actions to be taken and the next steps the organisations should take to progress.

The Toolkit links to other relevant guidance documents, such as the [CARES Toolkit](#), which can be used in parallel.

## INTRODUCTION TO MARKETS

The electricity system is changing. Instead of a handful of utilities operating large power stations, small distributed generators are emerging across the country. These include community renewable energy projects (solar, wind and hydro), combined heat and power serving neighborhoods and back-up generators operated by businesses and the public sector.

The increasing amount of variable renewable power creates challenges for the stability and resilience of the UK's supply of electricity. New mechanisms are being used to balance the system and to allow more projects to connect to the grid (see the **Active Network Management** module for other technology solutions).

The markets for grid balancing services like back-up capacity and frequency response (also known as ancillary services), are growing quickly as new technology and new business models compete with the utilities. These markets create new opportunities for smaller energy projects to generate revenue in addition to the sale of electricity.

Thanks to aggregator companies, who manage lots of small generators as well as demand-side response capacity on behalf of their owners, the barriers to becoming active participants in the energy markets are falling.

This guide will introduce you to the ways your energy project could earn additional revenue, beyond just exporting electricity to the grid, and provides links to sources of more detailed information if you want to investigate further.

## POWER SUPPLY

Selling electricity and generation linked incentives is of course the most important revenue stream for community and other small energy projects. A brief summary of the different subsidy mechanisms and options for selling power is presented below. More detailed information is available in other modules of the Community and Renewable Energy Scheme toolkit on the Local Energy Scotland website<sup>1</sup>.

### Feed-in Tariff

The Feed-in Tariff (FIT) offers a premium payment per unit of electricity generated from renewable energy technologies. Solar PV, anaerobic digestion, wind, and hydropower up to 5MW capacity are eligible, as well as micro Combined Heat and Power systems less than 2kW capacity. It is the principal financial mechanism supporting smaller renewable energy generators.

Since the incentive was introduced in April 2010 it has led to tremendous growth in small and medium scale renewable energy installations and has led to more than 750,000 installations. While the majority are rooftop solar PV arrays, almost 7,000 wind turbines have been installed across the UK with support from the FIT according to government figures.

Local Energy Scotland have produced a guide to [Feed-in Tariffs](#)<sup>2</sup> which describes the tariffs<sup>3</sup>, bands rules and eligible technologies in more detail.

### Contracts for Difference

Contracts for Difference (CfD) support new investment in low-carbon electricity generation and provide long-term revenue stability for generators, allowing investment to come forward at a lower cost of capital and therefore at a lower cost to consumers overall. By providing a guaranteed minimum price for electricity, investors have greater certainty in their return on investment.

CfDs require generators to sell electricity into the market as usual, through a Power Purchase Agreement (PPA) with a supplier, but reduce exposure to variations in electricity prices by providing a variable top-up from the market price to a pre-agreed 'strike price'.

At times when the electricity market price exceeds the strike price, the generator is required to pay back the difference, protecting consumers from over-payment.

Local Energy Scotland have prepared a briefing paper on [Contracts for Difference](#) which described the market rules, the institutional framework and eligible technologies in more detail.

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<sup>1</sup> <http://www.localenergyscotland.org/funding-resources/resources-advice/cares-toolkit/>

<sup>2</sup> <http://www.localenergyscotland.org/funding-resources/resources-advice/cares-toolkit/project-development/feed-in-tariff/>

<sup>3</sup> <https://www.ofgem.gov.uk/environmental-programmes/fit/fit-tariff-rates>

## Renewable Heat Incentive

The Renewable Heat Incentive (RHI) is similar to the FIT and offers a premium payment per unit of heat generated in order to encourage greater uptake of renewable heating. A range of technologies including solid biomass, biogas, solar thermal and heat pumps are eligible. The non-domestic RHI was introduced in November 2011 for installations in commercial, industrial and agricultural sectors. The domestic RHI which supports renewable heating for households has been available since April 2014.

Local Energy Scotland have prepared a guide on the [Renewable Heat Incentive](#)

## Power Purchase Agreements

A Power Purchase Agreement (PPA) is a contract for the sale of electricity produced by a generator. They can be used to increase the value of the electricity generated. They are most suited to generators who export most of the electricity they produce to the grid, but PPA contracts are also used for the direct supply of electricity to a consumer.

The PPA contract will outline how much the generator is paid for exported power and the terms of the agreement. They can have fixed rates or they can be variable and track market prices. The Feed-in Tariff's export rate (a payment for each kWh exported to the grid) acts as a floor price for new FIT generators entering the supply market and so PPA prices should be higher than the current 4.91p/kWh (as of July 2016). The agreed PPA rate is usually above the FIT rate and lower than the retail electricity prices, providing an incentive to the purchaser.

A PPA is often agreed between the generator and a wholesale electricity supplier who has retail customers. However, PPAs can also be agreed between the generator and a single private purchaser, such as a large electricity consumer nearby.

A private wire connects the generator directly to the consumer. While generators can direct supply electricity via the distribution grid, through a process known as 'sleeving' or White Labelling, this is less common and there are very few case studies of where this will be relevant to community groups and smaller generators. Further information on these is available in the CARES [Commercial Business Model](#) module.

Private PPAs can help increase the value of the electricity generated, but cannot always be relied upon when financing a new energy project. Banks will be careful about lending to such projects because of the risk that the buyer's energy demand falls or they go out of business. Only the strongest corporate counterparties, with a strong credit rating, are likely to be considered acceptable.

## Innovative power supply options

There are a growing number of innovative power supply options becoming available to serve small generators. New businesses are finding new ways to help increase revenues and reduce the management burden.

For example, [e-Power Auctions](#) provide a simplified and more straightforward way for small generators to sell the power they generate, along with any associated renewable benefits, to the highest bidder. The auctions attract many buyer and sellers, offering competitive prices.

Piclo is one of the first online marketplace for renewable energy that is being trialed by Good Energy and Open Utility. The pilot service allows consumers and generators to buy and sell renewable energy locally, peer-to-peer via the platform. Piclo aims to reduce costs by matching supply with nearby demand, reducing grid charges and supporting the community. The [press release](#) includes more information.

### *Beinn Ghrideag, Isle of Lewis, Outer Hebrides*



*The community owned Beinn Ghrideag windfarm is one development that could participate in a Pico online auction.*

## **AGGREGATING SERVICES**

Aggregators command generation or demand reduction capacity by controlling large number of individual distributed loads and small generators on behalf of their owners. These are often large demand sites with loads that can be switched off for short periods or generators that aren't always fully utilised, such as combined heat and power plant or on-site standby diesel generators.

Aggregators act like virtual power plants. Many of the ancillary service markets described below (like the Short Term Operating Reserve (STOR) market and the frequency response markets) are aimed at medium or large, multi-MW generators. This excludes many smaller generators or demands from participating on their own. The aggregation of many smaller generators or demands allows them to operate in these markets and provide access to additional revenue streams. The market access they facilitate is an important part of the aggregator's commercial model. In exchange, the aggregator takes a share of the revenues.

There are a number of commercial aggregator organisations, some of which specialise in specific technologies or markets, such as aggregating loads for demand response or building a portfolio of generating capacity for STOR. Others operate across multiple markets.

Aggregators also strike bilateral agreements directly with National Grid to provide other services that are not publically auctioned. These are described below. These opportunities are only available through the aggregator which can make their commercial offers particularly valuable.

## Frequency Control by Demand Management (FCDM)

Frequency Control by Demand Management (FCDM) provides frequency response by automatically interrupting customer demand in response to frequency issues in around 2 seconds. Their demand is interrupted for up to 30 minutes which will, on average, happen 30 times per year. FCDM is therefore suited to demand sites which have a large demand for electricity, but is willing to shut down some functions at short notice. Annual returns are estimated to be between £30,000 and £40,000/MW.

## Demand turn-up service

Occasionally on windy days the amount of power supplied by wind turbines can exceed the demands from the grid. Rather than curtail generation, National Grid's demand turn-up service encourage businesses to increase their electricity consumption (provided it is used productively), or to reduce output from on-site embedded generators. This helps stabilise the grid and avoids the need for curtailment payments to the wind farm operators. Demand turn-up is typically activated overnight and on weekends.

Demand turn-up is a new innovative market which has been undergoing trials in 2016, with 309MW of demand capacity engaged. While the market is currently small compared to the wider ancillary services market, it is expected to grow at a rapid rate<sup>4</sup>.

A recent article describing the value of some aggregator services is provided in this [online article](#)

## Summary

Aggregating services	Technology and context	Overall suitability
<b>Frequency Control by Demand Management (FCDM)</b>	Large energy consuming sites that are willing to change their output or embedded generation when needed.	Accessible only via aggregators. Participants in the Highlands and Islands may be at a disadvantage.
<b>Demand turn-up service</b>	Large energy consuming sites that are able to productively increase their demand for electricity when needed.	Accessible only via aggregators. A new market which could become an important opportunity for energy consuming sites in the Highlands and Islands.

## Contacting an Aggregator

There are a number of aggregators in the market who can quickly be identified with a little research. Search online and you will find several options, including Open Energy, Limejump and Flextricity.

When engaging the aggregator, it is essential that you have the full details of the capacity and generation profile of your generator, of demand profile of your equipment. Response times are key for the aggregation services, so having these to hand will facilitate your discussions.

<sup>4</sup> <http://www.thinkinggrids.com/thinking-grids/ancillary-services-increasingly-important-marketplaces>

## PEAK POWER CAPACITY

Demand for electricity fluctuates throughout the day and with the seasons. We expect power to be available when we need it. Peaks in our total power demand occur each day as we get home from work, and are particularly acute during cold snaps.

While these extreme spikes in electricity demand are relatively infrequent, sufficient generating capacity needs to be in place to meet it. National Grid uses a combination of mechanisms to ensure that enough generating capacity will be available to meet peak demand. The Capacity Market and Short Term Operating Reserve (STOR) are two of the most important.

Triad management provides an opportunity for large energy consumers to reduce their energy costs and is also described in this section.

### The Capacity Market

The Capacity Market is a new mechanism for ensuring that there will be enough generating capacity available to meet the country's peak power demand. It was created through the government's Electricity Market Reform in 2014<sup>5</sup>. The first auctions have taken place and the Capacity Market is due to be fully operational by winter 2018. Capacity Agreements have been awarded for over 46GW as of December 2016<sup>6</sup>.

While larger power stations tend to dominate the Capacity Market, a range of smaller distributed generators can also participate, including hydropower and pumped hydro. Some aggregators have also won capacity for CHP/diesel generators and demand response. Batteries can also participate. Intermittent renewables like wind and solar provide unreliable capacity and cannot participate. Capacity Market income can be earned on top of other ancillary service payments but any project which has a contract for difference (CfD) agreement for selling power is excluded.

More information about participating in the Capacity Market can be found on [Ofgem's website](#)

The Capacity Market is large. While annual payments will be close to £1 billion, the value for smaller installations is relatively small. The clearing price for entering the Capacity Market through the primary auction was £19,400 per MW (2014/15 prices) for 1 year contracts. This is lower than for STOR which can mean it is a less attractive option, particularly for small distributed generators who would need to share revenue with an aggregator in order to gain access. A smaller annual capacity top-up auction to cover winter 2016/17 cleared at a higher price of £27,500 per MW.

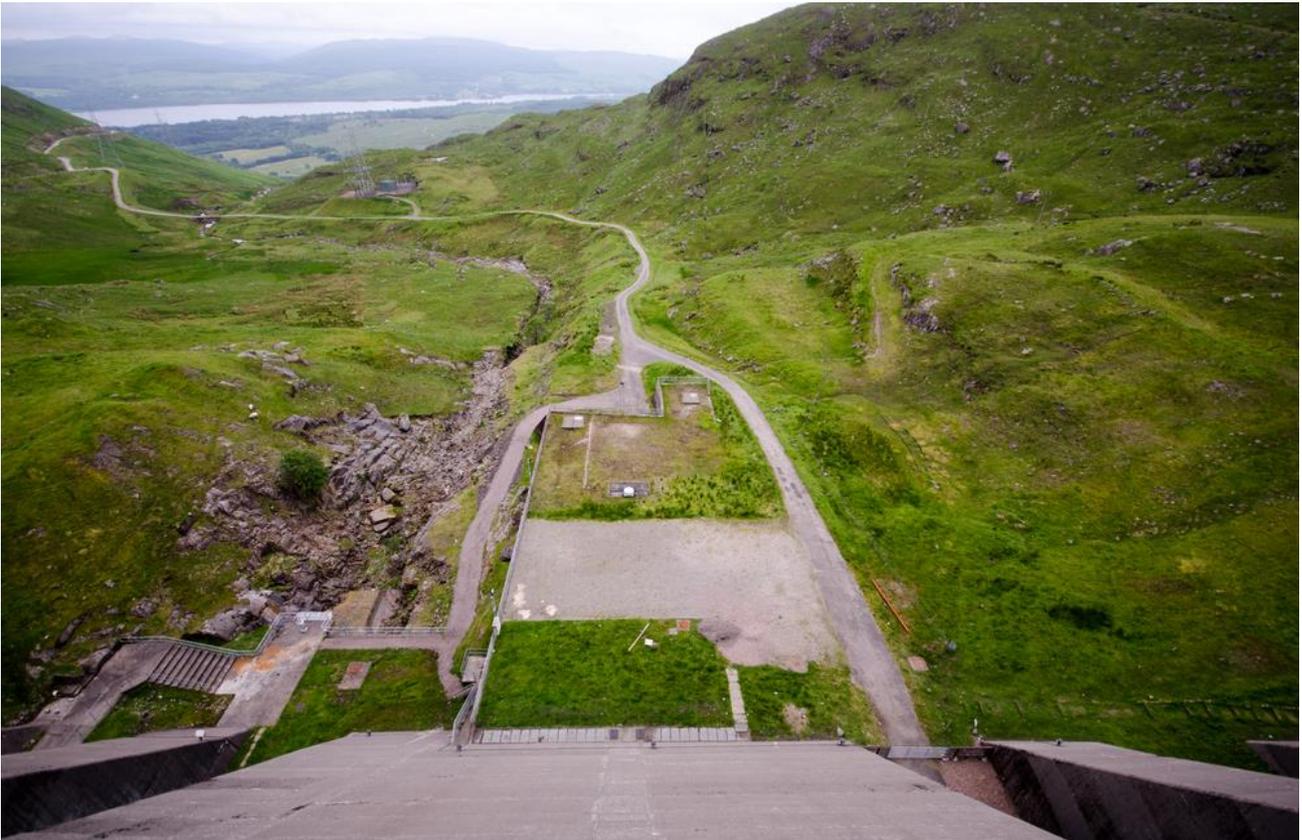
For the majority of communities and other small energy generators, the Capacity Market can only be accessed via aggregators. While the Capacity Market does not allocate capacity according to location, higher transmission charges in Scotland mean that generating stations in Scotland can be less competitive than other parts of the UK. There are some participants in Scotland, including Scottish Power's pumped storage plant at Cruachan (428MW) and 68MW of hydropower capacity<sup>7</sup>.

<sup>5</sup> <https://www.gov.uk/government/news/decc-sets-out-its-capacity-market-parameters-for-201920-auction>

<sup>6</sup> [Information on subsequent auctions will be published here: https://www.emrdeliverybody.com/cm/home.aspx](https://www.emrdeliverybody.com/cm/home.aspx)

<sup>7</sup> [http://www.scottishpower.com/news/pages/scottishpower\\_secures\\_capacity\\_market\\_agreements.asp](http://www.scottishpower.com/news/pages/scottishpower_secures_capacity_market_agreements.asp)

### Cruachan Dam, a pumped storage hydroelectric power station in the Scottish West Highlands.



### STOR

Short Term Operating Reserve (STOR) provides National Grid with reserve power to meet unanticipated demands for peak power capacity, for instance when a large power station goes offline or demand increases rapidly.

When additional capacity is needed, National Grid instructs participants to deliver the agreed extra output. They are rewarded with availability and usage fees determined at auction. STOR is usually provided by small and medium sized distributed generators. They must be dispatchable so much of STOR is provided by diesel generators, combined heat and power (CHP) and demand side response.

There are a number of technical requirements that must be met in order to directly participate in STOR. The pre-qualification criteria include:

- Rated generation (or demand-reducing) capacity of at least 3MW
- Must be able to sustain delivery for at least 2 hours
- Normally able to respond within 20 minutes

The clearing price of STOR auctions has been relatively stable over the past few years, in the £20,000 - £30,000<sup>8</sup> per MW per year range, although this depends on a number of factors. This is higher than for the capacity market.

Generators below 3MW cannot enter the STOR market directly. However, an increasing number of service providers aggregate the output of many small plant owners and bid these into the STOR

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<sup>8</sup> Michael Curtis of the University of Reading has produced estimates of the revenue available from different ancillary service markets. These estimates have been used throughout and should not be used to inform investment decisions: <http://www.irgc.org/wp-content/uploads/2015/09/Curtis-Demand-Response-2015.pdf>

market on their behalf. This is creating opportunities for standby generators to increase their running hours.

Peak power capacity is most effective when located near to the demand. As a result, STOR providers from Scotland are not favored. There were no Scottish providers of STOR in 2013/14 and only about 1% of total capacity in 2014/15. The Scottish STOR providers were not utilised during either year meaning they didn't earn any usage fees.

As a result, STOR is not considered an important source of income for projects in Highlands and Islands at this time.

### Combined heat and power gas boiler



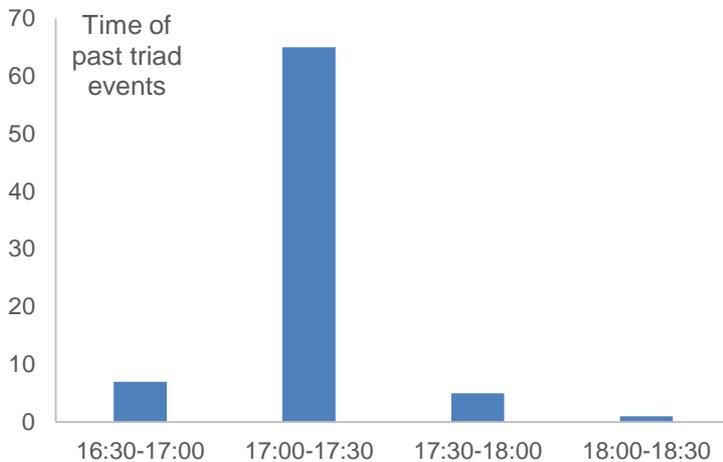
### Triad management

Triads are the three half-hours of peak electricity demand between the beginning of November and the end of February each year. Triad events usually occur when cold weather increases electricity demand and the UK wide power system is under maximum stress.

An electricity consumer's demand during the triad periods is used as a way of measuring the pressure they put on the electricity system and is used to calculate how much they are charged for using the network. Triad charges are included in the bills of large electricity consuming sites with half hourly meters.

The triad charge is formed of a flat national rate and a zonal charge, both set per kW of peak demand during the triads. The zonal tariff varies across the UK and reflects grid costs and usage. The zonal charges are highest in Southern England and lower in the Highlands and Islands, but still provides a strong incentive for large energy consumers to reduce demand, to run any onsite generators or use energy storage to shift demand away from triads.

In past years all Triad periods fell between 16:30 and 18:30, with most at 17:00 to 17:30, shown below. So a site using diesel generation to manage Triads would run for 2 hours or so on the winter week days during the winter months when Triads occur.



Cutting demand, or increasing onsite generation during a triad can reduce charges substantially. standby generators which are underutilised are an attractive way of reducing demand during Triad periods, as well as energy efficiency measures which can deliver savings at peak times.

Aggregators will often take advantage of triad management as part of their service. Triad warning services are also available, which send you an alert when a triad event is likely, allowing you to reduce consumption at specific time.

## Summary

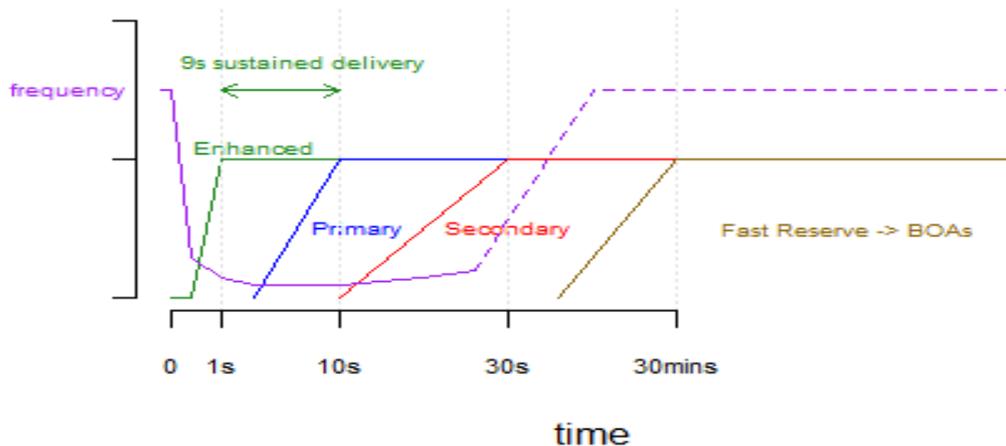
Peak power capacity	Technology and context	Overall suitability
<b>The Capacity Market</b>	Dispatchable capacity that can increase output when needed, including diesel, gas CHP and biomass generators.	Likely to be less profitable than STOR.
<b>STOR</b>	Demand-side management can also participate.	Potentially suitable but participants in the Highlands and Islands may be at a disadvantage.
<b>Triad management</b>	Dispatchable capacity installed in large energy consuming sites. Increased energy efficiency can also be used for triad management.	A valuable opportunity for all large energy consuming sites.

## FREQUENCY RESPONSE

Frequency response services help maintain grid stability by holding the system frequency within a narrow band either side of 50Hz. Frequency is continuously balanced second-by-second with changes to the amount of generation in the system. This tends to be provided by large gas power stations. But when the frequency moves sharply, for example in response to an unforeseen plant shutdown, other mechanisms are triggered. Spare generating capacity is brought online with those able to respond quickly called on first, while larger, but slower to react, generators are ramped up to balance the system.

Frequency response is provided through a number of markets, depending on the speed at which the frequency response is activated. Primary frequency response are expected to activate within 1-10 seconds and secondary response in 10-30 seconds, at which point the overall supply and demand should be brought back into balance. National Grid have also identified a need for frequency services with a more rapid response and have created the new Enhanced Frequency Response (EFR) market which is designed to activate in 1 second (or less).

Frequency response markets work together to respond to a drop in system frequency.



### Firm Frequency Response

Firm frequency response (FFR) indicates that a generator has a 'firm' agreement with National Grid to help when a frequency imbalance occurs. FFR is comprised of two markets, primary and secondary which are based on the response time and duration. FFR is provided by large power stations as well as smaller distributed generators that can be despatched on demand, but also potentially energy storage.

The table below includes the key requirements of the primary and secondary FFR markets.

	Primary	Secondary
<b>Response time</b>	2 to 10 seconds	Up to 30 seconds
<b>Maximum duration</b>	1 to 2 minutes	30 minutes
<b>Minimum capacity</b>	10MW	10MW
<b>Capacity procured annually</b>	200-700MW	700-1400MW
<b>Annual returns</b>	£15-20k /MW	£30-40k /MW

FFR can be provided dynamically, with output rising and falling automatically in line with the system frequency, or when a static trigger is activated and generation is quickly increased to the agreed level. Demand is greatest for static secondary response services and, because of the higher expected annual returns, is the more important market for community groups and small scale generators.

FFR operates in windows, within which you must be available to provide frequency response if called upon. As a result, electricity generation would be restricted during these periods, potentially offsetting any additional value from FFR. As a result it is most suited to standby generators who are not generally in use.

Because the minimum size for participation is 10MW, it is likely that this market will be accessed through aggregators. They would help you to install metering equipment that is capable of second by second measurement, which lets National Grid track performance.

### Enhanced Frequency Response

The Enhanced Frequency Response (EFR) market has been specifically designed to support the deployment of rapid response energy storage technologies. Lithium ion batteries, larger versions of the ones in mobile phones, are one of the few technologies which can meet the requirement for fast and sustained response.

This is a new market and the results of the first auction were published in August 2016. In total 200MW of capacity was procured, most of which was large multi-MW batteries to be installed alongside existing generators and renewable energy installations. There was a lot of interest in the auction and is considered a strong indicator of the future potential of energy storage.

Frequency response is not location specific, however, as with other ancillary services National Grid appear to have a preference for capacity nearer to the large demand centres in the south of the UK. National Grid has stated their intention to hold regular auctions 'over the next 10 to 20 years' but this is not confirmed.

EFR is viewed as an important revenue stream for battery developers because this new market has been designed specifically for energy storage and is kick-starting the industry in the UK. If you have, or are considering, large scale battery storage linked to your generator, this may be something you want to consider.

### Summary

Frequency response	Technology and context	Overall suitability
<b>Firm Frequency Response</b>	Dispatchable capacity that can increase output when needed, including diesel generators and gas CHP. Demand-side management can also participate.	Potentially suitable when accessed via aggregators
<b>Enhanced Frequency Response</b>	Large dedicated lithium ion energy storage systems, potentially installed as part of a larger energy project.	A new market which is at its early stages. Bidders in the Highlands and Islands may be at a disadvantage.

## ANCILLARY SERVICE MARKETS SUMMARY

The table below provides a brief summary of the ancillary service markets, the technology or context which the market is most relevant to and its overall suitability to smaller energy projects in the Highlands and Islands.

Peak power capacity	Technology and context	Overall suitability
<b>The Capacity Market</b>	Dispatchable capacity that can increase output when needed, including diesel, gas CHP and biomass generators. Demand-side management can also participate.	Likely to be less profitable than STOR.
<b>STOR</b>		Technically suitable but participants in the Highlands and Islands may be at a disadvantage.
<b>Triad management</b>	Dispatchable capacity installed in large energy consuming sites. Increased energy efficiency can also be used for triad management.	A valuable opportunity for all large energy consuming sites.
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<b>Aggregator services</b>		
<b>Frequency Control by Demand Management (FCDM)</b>	Large energy consuming sites that are willing to change their output or embedded generation when needed.	Accessible only via aggregators. Participants in the Highlands and Islands may be at a disadvantage.
<b>Demand turn-up service</b>	Large energy consuming sites that are able to productively increase their demand for electricity when needed.	Accessible only via aggregators. A new market which could become an important opportunity for energy consuming sites in the Highlands and Islands.

Commissioned by Highlands and Islands Enterprise.

Produced by Ricardo Energy & Environment

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This document was last updated January 2017