Demand Response Services for the Water Industry

open energi

United Utilities provides over 1MW of flexible demand from their Davyhulme Waste Water Treatment Works in Manchester

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£1 billion
The value of the UK energy balancing market that you can share

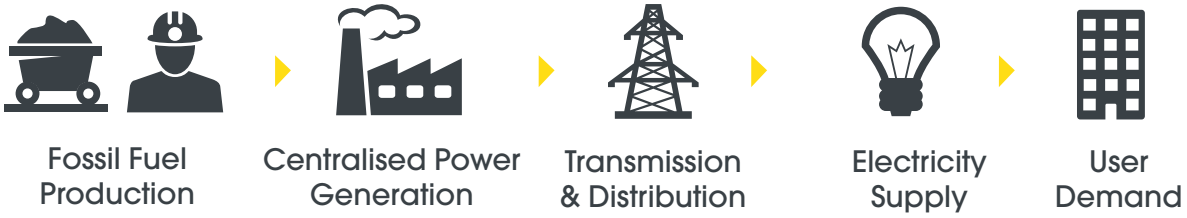
Pumps at Welsh Water are helping to balance the grid in real-time

Technology is changing the way we live. By 2020 it is estimated that there will be over 50 billion smart devices connected to the internet. Our ability to monitor and manage equipment in real-time from anywhere in the world is creating brand new markets with the potential to deliver productivity gains at a scale that hasn't been seen since the Industrial Revolution. This connectivity is paving the way for a new energy economy that is cleaner, cheaper, more secure and more efficient, and the water sector – which represents 2.5% of the UK's total electricity consumption - has a massive role to play in this transition.

Transformation of the energy system

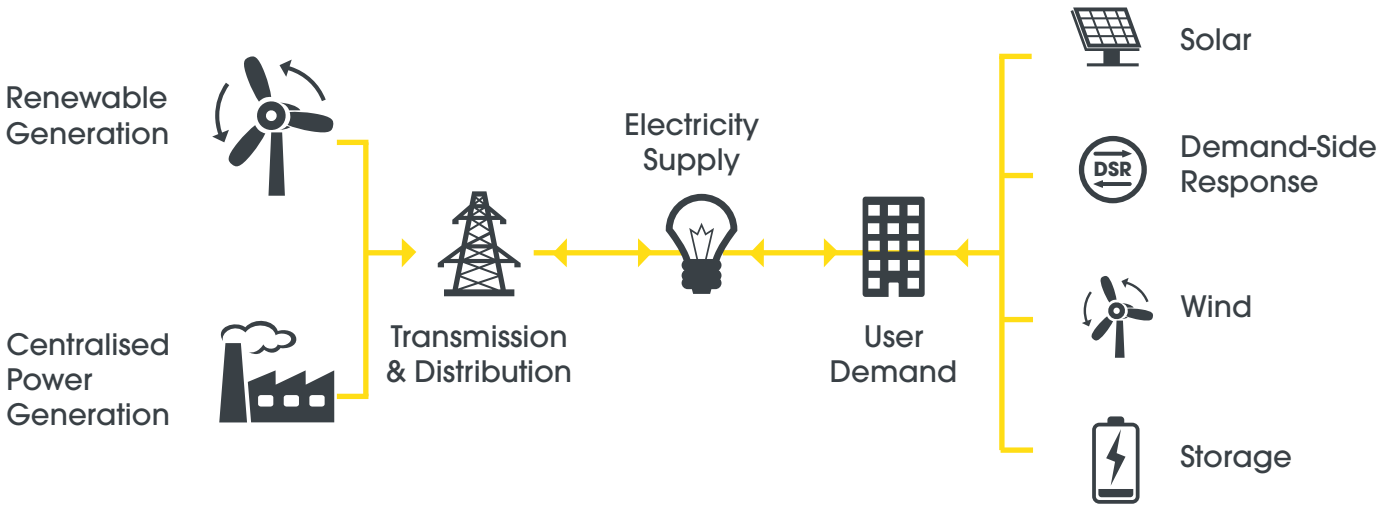
The Industrial Revolution created a thirst for energy that resulted in an inefficient value chain; centralised fossil fuelled power stations were built to meet occasional peaks in demand and this excess capacity was justified because energy was cheap and we had no way to control demand smartly.

But the energy industry has barely progressed since the first power station was built by Thomas Edison in the late 19th Century. With only a 6% increase in load factor in 130 years we have made only incremental improvements in actually using the infrastructure that generates our energy and the current supply-side model is hugely inefficient.



Today, our energy system is undergoing a huge transformation. We are building a smarter grid, so that instead of adjusting supply to meet demand, we adjust demand to meet supply.

By harnessing flexibility in our demand for energy and increasing or decreasing consumption in line with available supply we are paving the way for a completely reimagined energy system that doesn't rely on polluting peaking power, that can better integrate renewable energy and most importantly, that gives consumers control over how, when and from where they consume their energy.



Building a new energy economy

This intelligent energy usage is called Demand Response and it is creating new more efficient patterns of demand which can be aggregated to create a virtual power station. Virtual power stations provide flexible capacity without the need to lay a single brick, offering the cleanest and most cost effective way to provide the power for our cities to operate, businesses to grow and citizens to lead healthy lives.

National Grid has recognised this, and in June 2015 established Power Responsive, a framework for turning debate into action with a practical platform to deliver Demand Response at scale by 2020.

Managing electricity supply and demand

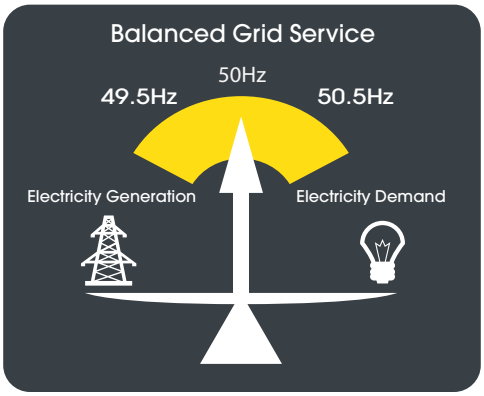
National Grid sits at the heart of the UK's energy system. As the UK's system operator, it is responsible for managing our electricity supply and demand and ensuring power supplies are maintained. Central to this is the need to balance electricity supply and demand on a second-by-second basis.

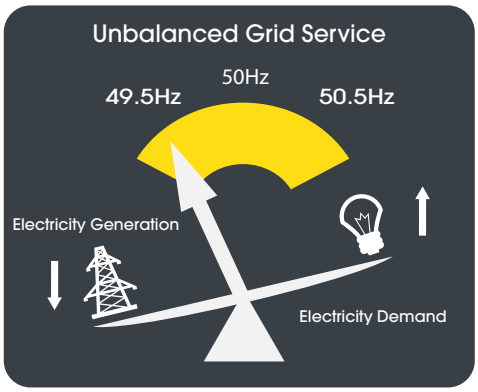
An indicator of this is the grid frequency which National Grid must maintain at 50 Hertz. Too much electricity causes the frequency to rise above 50 Hertz and could lead to equipment failures. Too little and the frequency drops below 50 Hertz, which could mean the lights go out. National Grid has a statutory mandate to keep power balanced between 49.50 - 50.50 Hz.

Traditionally it has relied on fossil fuelled peaking power stations increasing or decreasing their output to meet our ever changing demand. But as our energy mix changes and older "dirty" power stations are replaced by less flexible clean energy sources such as wind, solar and nuclear it is increasingly looking to businesses to provide alternative means of balancing the system.

This presents a new revenue opportunity for businesses. National Grid spends almost £1 billion a year on balancing electricity supply and demand and it wants to meet 30-50% of its balancing requirement from the demand-side by 2020. This equates to around £400 million annually. By 2030 National Grid wants the majority of its balancing needs to be met by flexible demand.

It's a fundamental part of National Grid's strategy to build a future low carbon grid. By sharing your flexible demand you can help to build a virtual power station, helping to transform our energy system and creating a circular economy where productivity and sustainability go hand in hand.





The Demand Response market is evolving rapidly with several new products being introduced in recent years, but the services can be categorised as follows:

Response services respond very rapidly (within seconds) and automatically to changes in grid frequency.

Dynamic Frequency Response

Dynamic frequency response is very fast acting (two seconds) and provides premium balancing both on and off to National Grid, 24/7, 365 days a year. The service has traditionally been bought from generators who are able 'track' the grid frequency by altering their output up or down to bring the system supply and demand back into balance. Open Energi is the first company in the UK to provide this service from the demand-side. Our Dynamic Demand technology provides a fully Dynamic frequency response service by adjusting the consumption of equipment – such as pumps, motors, fans and chillers - in line with grid frequency to mimic the output of a large power plant.

Static Frequency Response

A simpler version of frequency response where providers do not 'track' the frequency constantly but instead will provide all their response if the frequency ever deviates below a certain value (indicating there has been a large loss of generation). The service is provided by fitting a frequency relay switch which will either cut off demand or start up fast acting generators within seconds. The service tends to be required around 10 times per year and has traditionally been provided by large electricity consuming sites – such as cement kilns or aluminium smelting plants. It commands less of a premium in the market than Dynamic frequency response.

Reserve services respond to a signal from National Grid to help it manage the system over longer periods than response services (30 minutes – hours).

Short Term Operating Reserve (STOR)

STOR helps National Grid to manage a shortfall in supply by either providing additional electricity generation from spare plant capacity and back-up diesel generators or by reducing electricity demand. At least 90% of STOR provision comes from increasing generation whilst the remaining 10% comes from demand-side reductions. Whilst frequency response services provide an immediate response (0-30 minutes) STOR services can help National Grid to meet demand in the mid-term (20 minutes – 2 hours +) as larger, more efficient generators can be brought back online.

Demand Side Balancing Reserve (DSBR)

Demand Side Balancing Reserve is a service introduced in Winter 2014/15 to help National Grid manage with tight generation margins until the Capacity Market starts in 2018/19. It was designed to access a large volume of demand response very quickly and hence has low entry requirements, for example no additional metering or communication hardware is needed. Essentially National Grid will ask large energy consumers to not consume power over the evening peak. Participants must be able to respond within 4 hours of receiving a call and must be able to hold response for at least one hour.

Demand Turn Up

Demand Turn Up is a service to help National Grid manage periods of low demand on the system – typically during the summer months. This is a problem for National Grid as there needs to be a certain amount of large thermal generation online at any one time to ensure system stability (inertia, voltage control, frequency regulation etc.). Energy consumers can provide a valuable service by increasing their demand (or equally turning down on site generation) upon request. This presents an economic solution to alternative measures such as instructing wind farms to power down.

Peak price avoidance

Triad Avoidance

The Triads refer to the three half-hour settlement periods with highest system demand between November and February, separated by at least ten clear days. They traditionally occur on a weekday between 16:30 and 18:00 but can only be determined after the winter has finished. There is a strong incentive for consumers to shift demand away from these periods of high system demand as the Triad charges can be highly punitive and are rising year on year.

Red Zone Management

Distribution Network Operators use DUoS charges to cover the cost of converting and transporting power from the high voltage transmission lines through local distribution grids to domestic, commercial and industrial consumers. DUoS charges apply at all times but are far greater in magnitude during times of peak demand on the local network (Red Band). The Red Band window is defined but differs for each of the 14 distribution networks. Usually they occur around 4-7pm and only ever on weekdays.

Anticipated market developments

There are a number of trends which are impacting the demand for frequency response that suggest National Grid's requirement for demand-side services will increase over the coming years.

Historically, most real-time balancing has been provided by coal and gas fired power stations, some of which are closing and others of which have greatly reduced running hours. As National Grid loses this source of frequency response it needs to procure services from other sources.

Our changing energy mix also means there is less 'inertia' on the Grid. Traditional generation has large steam turbines which help to stabilise the Grid. If one power station trips it is a while before the kinetic energy in these turbines is used up. With wind and solar power there is not this same 'inertia', making frequency more difficult to manage as it can have large swings. The solution to this is to procure more (or faster) frequency response to manage the issue. National Grid's Enhanced Frequency Response market has been developed with this in mind – requiring full response within 1 second – and is expected to be a big draw for battery systems when it goes live in the next year or two.

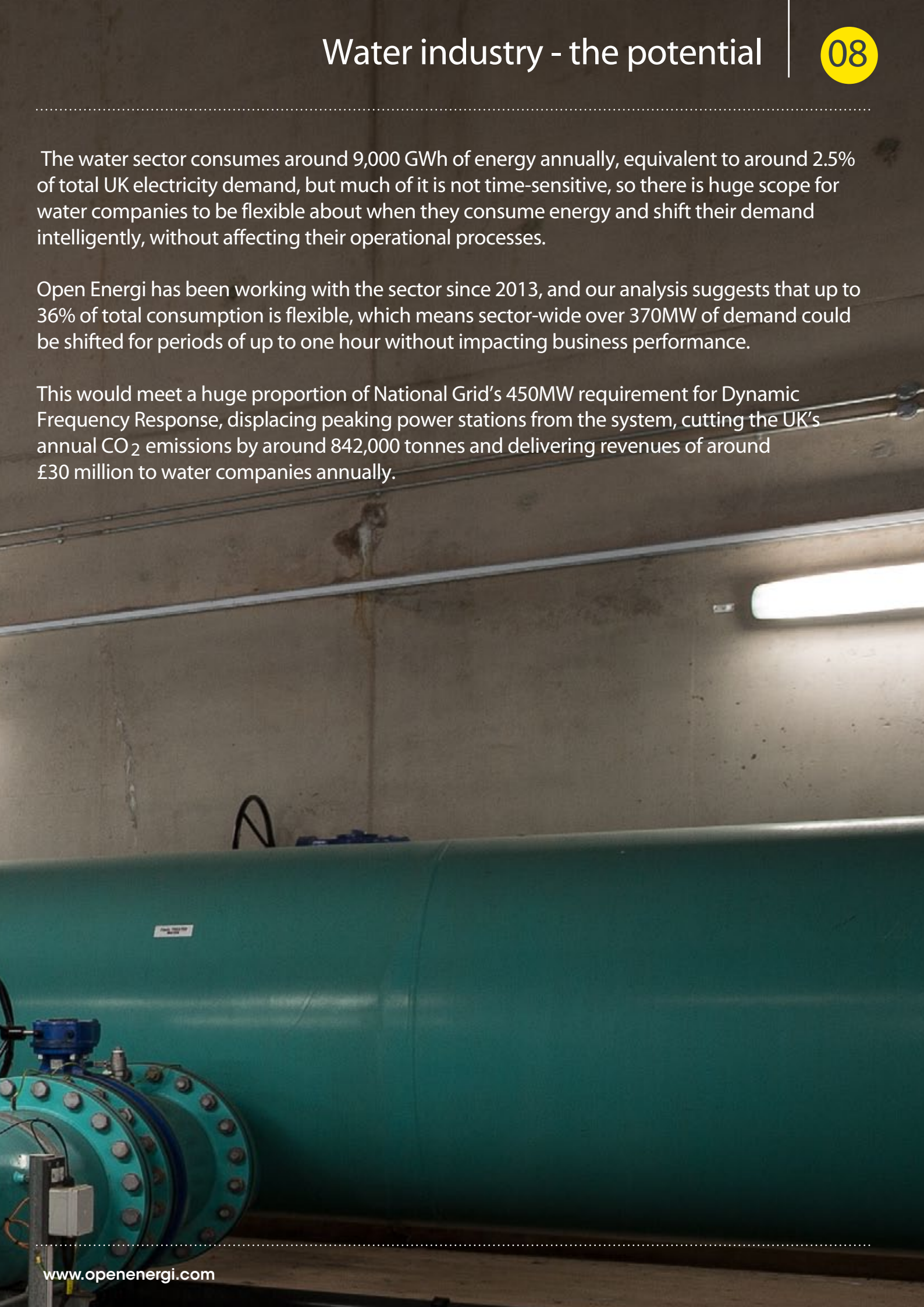
Another driver for increased demand is the size of plant. One of the reasons frequency response is procured is to provide backup if a large generator trips. The size of the service is therefore dictated in part by the 'largest loss' on the system. With larger nuclear plant more frequency response will need to be held in reserve.

To put real figures on this, National Grid predict (in their System Operability Framework) that the fast frequency response requirement will increase by 30 – 40% in the next 5 years and by 2030, the response requirement will be between 3 and 4 times today's level.

The water sector consumes around 9,000 GWh of energy annually, equivalent to around 2.5% of total UK electricity demand, but much of it is not time-sensitive, so there is huge scope for water companies to be flexible about when they consume energy and shift their demand intelligently, without affecting their operational processes.

Open Energi has been working with the sector since 2013, and our analysis suggests that up to 36% of total consumption is flexible, which means sector-wide over 370MW of demand could be shifted for periods of up to one hour without impacting business performance.

This would meet a huge proportion of National Grid's 450MW requirement for Dynamic Frequency Response, displacing peaking power stations from the system, cutting the UK's annual CO_2 emissions by around 842,000 tonnes and delivering revenues of around £30 million to water companies annually.



Open Energi's Dynamic Demand technology is harnessing flexibility in our demand for energy to create a virtual power station. It integrates with everyday equipment from fridges to furnaces and turns them into "smart devices" which can adjust their energy consumption in real-time without disrupting processes.

The technology provides a front-line Dynamic Frequency Response service which helps National Grid to balance electricity supply and demand in real-time, 24/7, 365 days a year. By aggregating the response from thousands of different devices up and down the country, Dynamic Demand is able to adjust demand to meet supply in real-time.

- Earns revenue for providing High and Low response
- Paid for availability 24/7, 365 days a year
- Fastest responding dynamic demand-side service
- Governed by equipment control parameters
- Energy neutral
- Straightforward to install
- No process change required
- No impact on performance

Dynamic Demand: Applications within the water sector

Dynamic Demand has been integrated with a wide range of water industry assets. The applications are controlled whilst taking into account the process conditions at that time. Processes that Open Energi have integrated with Dynamic Demand to date include:

- Activated Sludge Plant (ASP) Blowers
- Surface Aeration
- Orbal Aeration
- Carrousel Aeration
- Aeration with RTC control
- Inlet Pumps
- Screw Pumps
- End of line fresh water pumping
- Odour control

Demand response at United Utilities

United Utilities was the first company in the North West and the first water firm in the country to sign-up for Dynamic Demand. The system acts like a "virtual power station", allowing National Grid to even out temporary peaks and troughs in demand instead of turning power stations up and down.

A smart box installed at United Utilities' sites allows its process equipment to "talk" to the grid. Motors and pumps can respond in seconds to variations in power frequency.

United Utilities has installed the technology on its wastewater treatment plants and water pumping stations. The results were so successful that it is now rolling out the programme across the whole North West region.

Over the next five years the company expects to have a total of 50MW of flexible capacity to offer up to National Grid – the equivalent of a conventional power station – reducing carbon emissions by 100,000 tonnes per year. The income this generates will be reinvested into site assets to reduce operating costs.

United Utilities

Fast facts

United Utilities help life flow smoothly for about 7 million people and 200,000 businesses in the North West by providing them with clean, fresh water every day.

United Utilities also take away and treat the North West's wastewater helping keep our rivers and beaches clean.

In partnership with Open Energi

"Water and wastewater treatment is a really energy intensive process – power is one of our biggest operating costs – so we're looking both inside and outside our business to see how we can work smarter. That means using less power and being willing to be flexible in the way we use that power."

Andy Pennick, Energy Manager at United Utilities

Water Supply and Networks

Process	Function	Components	Description	Energy Use	Availability
Resource	River Extraction	Pumps	Large volume transfer of river water to bank-side reservoirs or direct to treatment plant	High	Good
	Ground Water Extraction	Pumps	Pumps controlled by variable-frequency inverters	High	Good
Transmission	Pump into Supply from Balancing Tank	Pumps	Water pumped to potable storage tanks or directly into supply	High	Good

Waste Water Networks

Process	Function	Components	Description	Energy Use	Availability
Sewerage	Terminal Pumping Station	Pumps	Lift wastewater from trunk sewer into the waste water treatment process	High	High
Sewerage	Sewerage Pumping Station	Pumps	Typically 2 - pump on simple level controls	Medium	Good

Waste Water Treatment

Process	Function	Components	Description	Energy Use	Availability
Primary	Settling Tanks	Sludge Pumps	Settles out material and fine solids to form a primary sludge	Medium	Good
Secondary	Surface Aeration	Vertical Rotors	Mechanical rotor action transferring oxygen to settled sewage	High	Good
	Carousels	Horizontal Rotors	Combines activated sludge reactor and final settlement in one structure	High	Good
	Aeration	Air Blowers, Valves & Pipework	Fine bubble diffusion	High	Good
Secondary	Final Settlement Tank	Sludge Pumps	Remove surplus sludge from the process	Medium	Good
Tertiary	UV Sterilisation	High Power UV Light Sources	UV disinfects bacteriological agents in wastewater effluent	High	Good
Sludge Treatment	Thickening	Mechanical Belt Presses / De-watering	Separates water from sludge solids	Medium	Medium
Odour Control	Air Conditioning	Air Blowers	Large low pressure blowers and odour control	High	Good

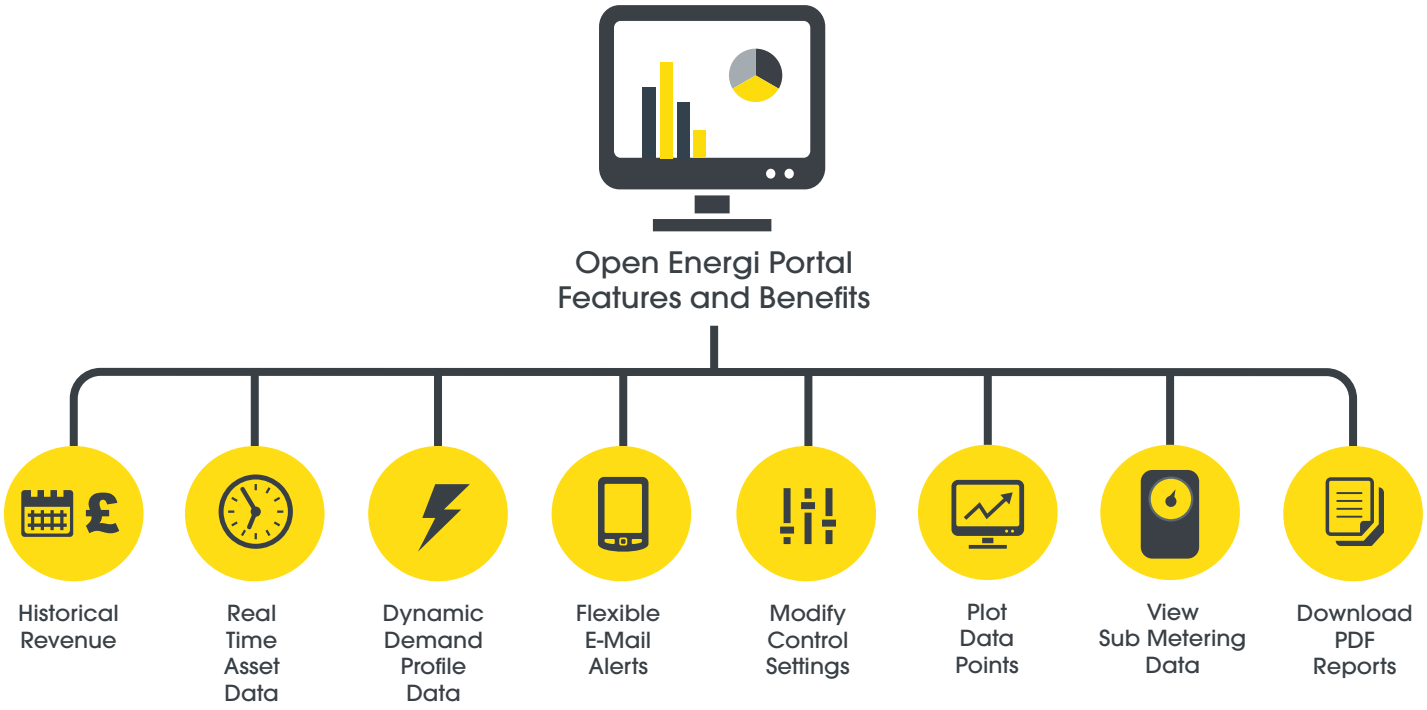
Tapping the power of data analytics

By leveraging the smart grid infrastructure installed as part of a Dynamic Demand implementation, Open Energi can capture detailed second-by-second data on the operation of Dynamic Demand loads. This can then be displayed through your web browser in an interactive, customised portal anywhere in the world.

Energy analytics from Open Energi represents an extremely powerful tool to drive outcomes and improve efficiencies. The water processing sector has the potential to better use this data that Open Energi captures every day.

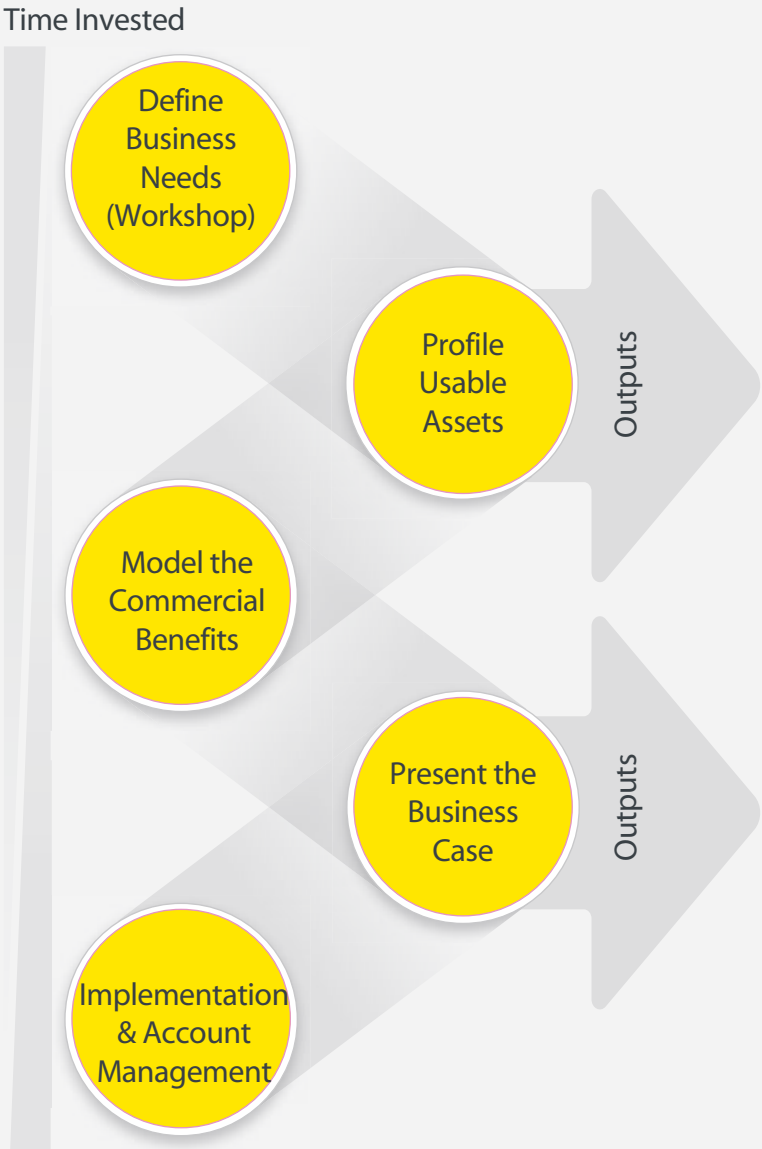
These business intelligence solutions not only help clients see what's happening throughout their systems, but can also predict what's going to happen. Having this power at your disposal allows engineering and energy managers to optimise assets and site usage resources, rethink programs and identify energy cost reductions more effectively.

Key benefits



Building the business case

Open Energi provides full project evaluation and technical support from needs analysis to implementation, providing pre-sales, systems architecture, and commercial resources to evaluate all customer applications. We work with your organisation to identify suitable customer assets and energy balancing applications. We then build a clear business case to demonstrate the return on investment and other benefits.



Working in conjunction with your energy and asset managers you can expect to list all suitable energy loads that can be Dynamic Demand "Smart Grid" enabled.

This provides your organisation with an indicative business case with minimum time invested.

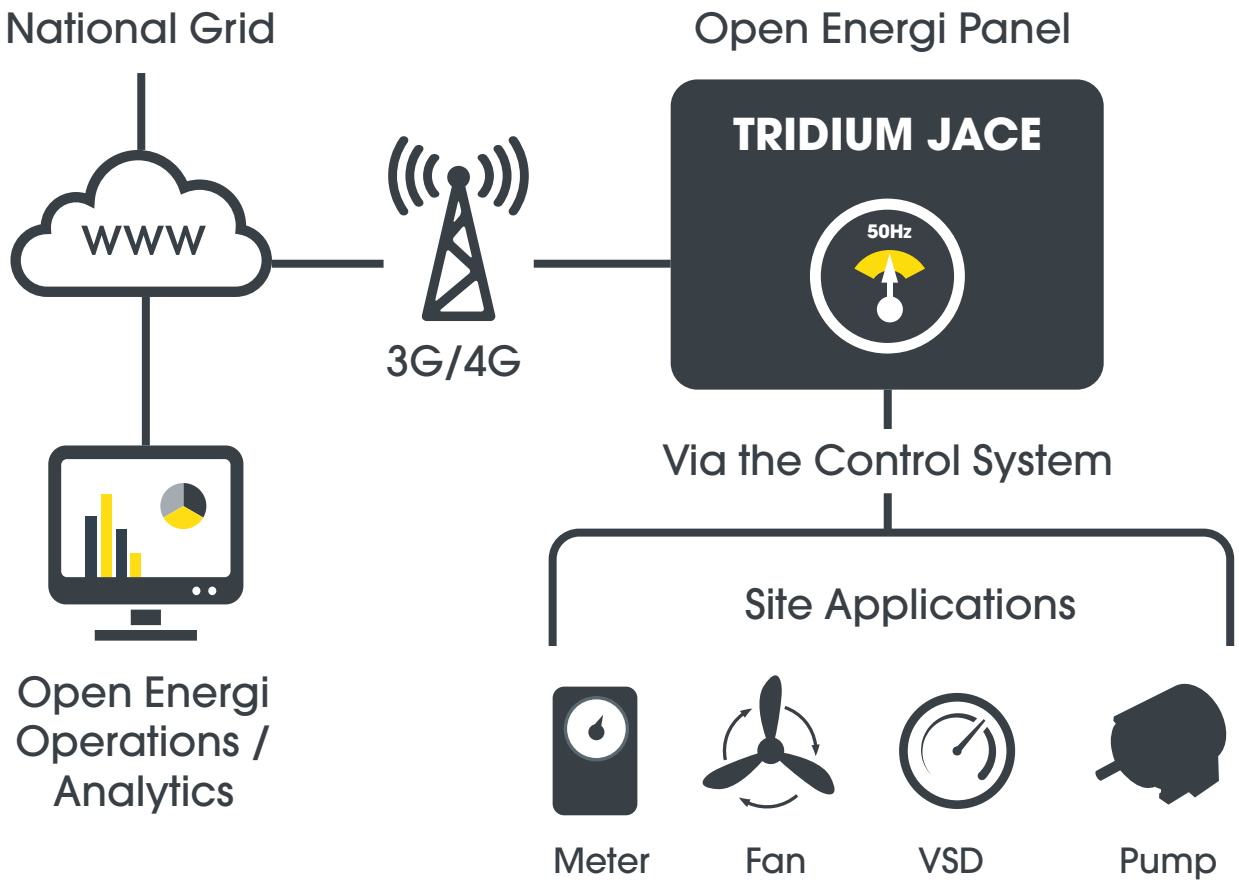
Provision of the business case that enables your organisation to agree adoption at Senior Executive Level;

- Income generation
- Potential energy reductions
- Upgraded hardware & energy

What equipment do you install on site?

The following technical diagram details typical hardware and communications equipment that is installed on site. Open Energi engineers work with customers to conduct a thorough site survey.

- Fully qualified engineering services
- Wired and wireless site installation solutions



Open Energi's Dynamic Demand solution is a software controlled algorithm which operates on a rules based platform, it does not switch assets outside of existing operational requirements.

Who are Open Energi?
Open Energi works with energy users to unlock new revenues through a smart approach to managing their energy loads. Our complete range of energy demand management solutions provide the most efficient and profitable returns on the market.

What is energy demand management?
Energy demand management is the process of adjusting your electricity use in response to changes in the supply of electricity. This helps to ensure that the demand for electricity equals the supply of electricity and the grid is balanced – vital to maintaining power supplies.

Why is balancing the grid important?
Electricity cannot be stored economically, so at any point in time, the supply and demand for electricity must be equal. National Grid must constantly monitor and adjust the supply of electricity to maintain this balance. Currently this is mainly achieved by operating power stations at spare capacity and adjusting the supply of electricity to meet demand. This approach is inefficient, costly and polluting.

What solutions do you offer?
Open Energi offers a complete range of energy demand management solutions, including Dynamic Demand. This patented technology is unique to Open Energi and provides National Grid with the fastest available response to grid imbalances. As a result, it also offers energy users the highest revenue generating potential.

How much can I earn?
National Grid rewards companies that are able to alter their energy demand in order to provide the balance between supply and demand that is essential to keep electricity flowing. Open Energi provides the National Grid with a grid balancing service, and shares the revenues from this with our customers. The amount of revenue generated varies according to the solution provided. We will work with you to identify suitable equipment and commercialise your energy loads in the most efficient and profitable way.

What is Dynamic Demand?
Dynamic Demand is an energy demand management solution unique to Open Energi that reacts instantaneously to second-by-second changes in the balance between supply and demand on the grid. It makes subtle adjustments to the demand for electricity by automatically altering the timing of an appliance's electrical consumption. When a significant number of units are fitted with the technology, an automatic electricity "balancing service" is created, reducing demand when there is a supply shortage and vice versa.

Dynamic Demand is ideal for use with stored energy devices such as refrigerators, heating and ventilation systems, air conditioning units, water heaters and industrial processes. The consumption of electricity of these types of appliances is not time critical, because although they need energy, as long as they operate between expected limits, such as temperature, it does not matter precisely when that energy is used. Because Dynamic Demand provides National Grid with the fastest available response to grid imbalances, it also offers energy users the highest revenue generating potential.

Will we have to change how or when we use our equipment?
No, Dynamic Demand is a completely autonomous solution that requires no behavioural change from the user and has no impact on equipment performance.

How does it benefit the environment?
In the UK, energy demand management has the ability to reduce CO_2 emissions by almost 2 million tonnes a year, by displacing the partly-loaded, coal-fired power stations currently used to help balance the grid. It also facilitates the deployment of more intermittent renewable generation such as wind and solar power, by helping National Grid to manage the peaks and troughs in supply inherent in renewables.

How much will it cost?
The cost of implementing energy demand management varies depending on the solution. We offer a range of installation and software options to provide energy users with a share of the revenue received from National Grid.

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