

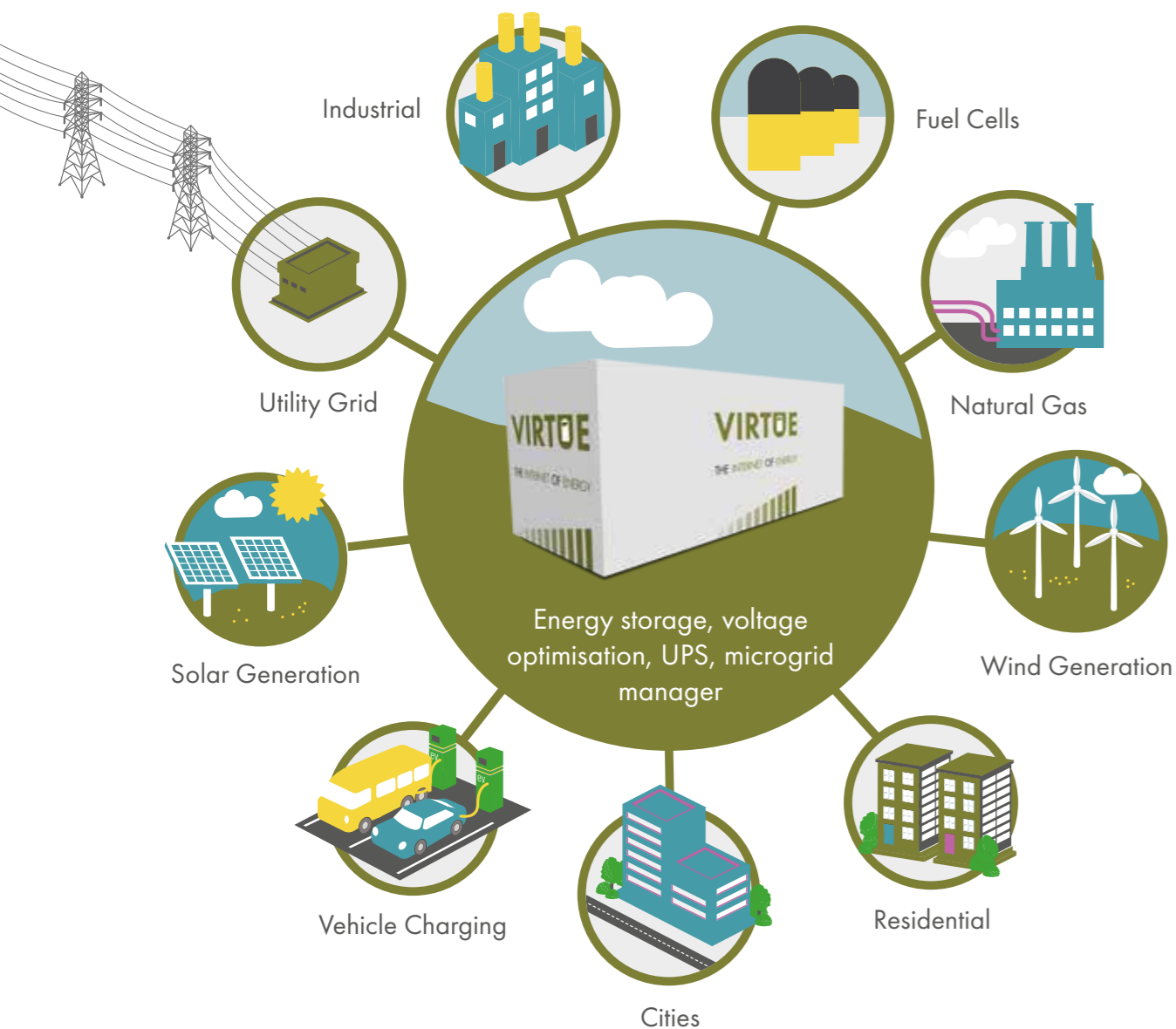
VIRTUE

THE INTERNET OF ENERGY

ENERGY STORAGE
SOLUTIONS



THE INTERNET OF ENERGY



Virtue is an integrated energy management and micro-grid solution with smart grid control.










It is forming an integral part in the future development of Smart Cities, enabling energy generated from sources such as wind and solar to be stored locally and ultimately more efficiently.

By allowing ultimate flexibility to business users and electricity grid operators, Virtue enables the evolution from the traditional model of electricity provision to a future smart system of integrated supply and consumption, resulting in lower energy costs, greater security of supply and the transition to a low carbon economy.

FUTURE GRID OUTLOOK

Driven by advances in technology and communications, the way we supply and consume electricity will look very different in the future.

The traditional model of large thermal power stations will be replaced by the Internet of Energy: a highly connected system of responsive power generation from both suppliers and consumers resulting in clean, secure and reliable electricity to power the homes, businesses and vehicles of tomorrow.

 <p>INDUSTRIAL</p> <p>Business users are able to make significant cost savings by utilising battery storage to power industrial sites during peak charging periods without having to alter production patterns. Sufficient battery storage will also negate the need for other forms of back up generation to provide on site UPS.</p>	 <p>FUEL CELLS</p> <p>Fuel cells generate electricity through harnessing the chemical reaction of positively charged hydrogen ions with oxygen. In order to sustain the chemical reaction fuel cells require a continuous source of fuel and oxygen. As fuel cells are powered by hydrogen and oxygen they generate electricity with very little pollution, as the by-product of combining these elements is water.</p>	 <p>NATURAL GAS</p> <p>In order to transition to a low carbon economy, natural gas is increasingly seen as the fuel of choice for large power stations as it emits less carbon and other pollutants than coal fired stations. Gas power stations are also able to adjust outputs more rapidly than other forms of thermal generation.</p>	 <p>WIND GENERATION</p> <p>The UK has the best natural wind resource in Europe to be exploited through onshore and offshore developments. Wind projects can be scaled from individual turbines providing power to industrial sites and communities to large multi turbine projects feeding directly to the National Grid.</p>	
 <p>RESIDENTIAL</p> <p>With the advent of domestic smart metering, residential consumers will increasingly be incentivised to shift their energy consumption to non peak hours through energy management and domestic battery storage.</p>	 <p>CITIES</p> <p>The Smart City idea conceptualises how cities of the future will incorporate technological developments into smart social infrastructure. Smart living allows greater connectivity and local energy management to create environmentally sustainable urban development.</p>	 <p>VEHICLE CHARGING</p> <p>As lithium ion costs decrease, electric cars will increasingly provide the transport of the future. Highly integrated and connected consumers will also be able to utilise the battery storage of their vehicles to provide backup energy to their homes.</p>	 <p>SOLAR GENERATION</p> <p>Solar PV is able to provide scalable clean energy from small scale household installations to grid scale projects. Allied with an effective storage medium, energy generated by solar PV throughout the day can be stored for discharge during the evening periods of peak demand.</p>	 <p>UTILITY GRID</p> <p>Battery storage will increasingly provide balancing services to local and national electricity networks, alleviating imbalances in supply and demand and allowing for greater penetration of intermittent renewable energy generation on to the grid.</p>

HOW VIRTUE BENEFITS YOU

Virtue is an energy storage system which allows for greater control and flexibility of your electricity usage. The system is beneficial for the following reasons:



COST SAVINGS

- Minimise transmission costs (Triads)
- Minimise distribution costs (red DUoS)
- Maximum demand control
- Reduction of reactive power charges
- Average reduction of 24%* off your electricity bill (to increase to 40% by 2020)

*24% savings figures from Ofgem



POTENTIAL REVENUES

- National Grid incentives (FFR, EFR)
- Export at peak market prices
- Maximise renewable generation incomes
- Average revenues of £120,000 per MW



GENERAL BENEFITS

- Control of maximum demand
- Storing excess renewable energy
- Charging electric vehicles
- Full UPS capabilities

VIRTUE HAS FULL UPS CAPABILITIES FOR THE CONNECTED LOAD AND ELIMINATES THE NEED FOR ADDITIONAL BACK UP GENERATION



External view of the Virtue system



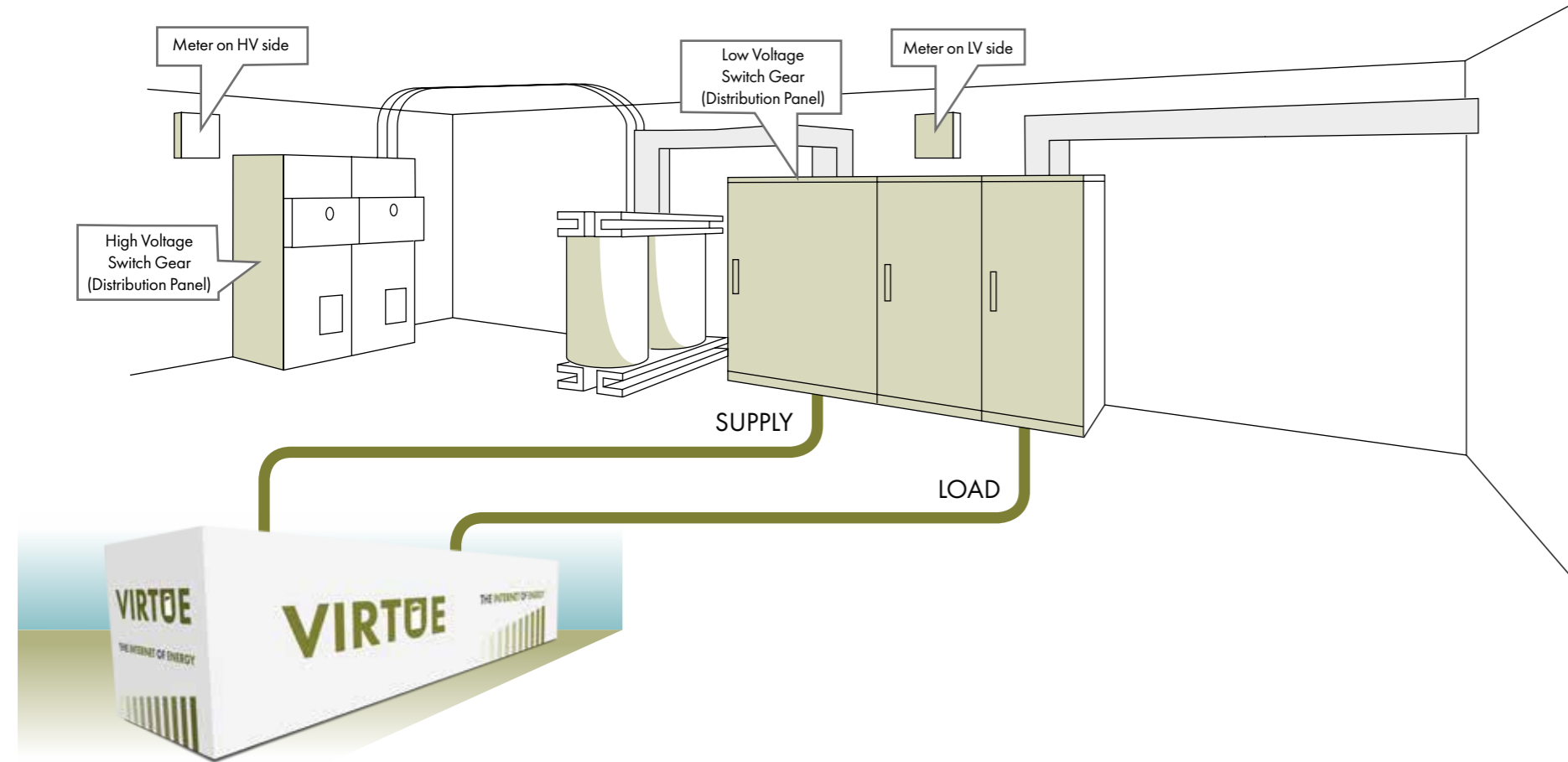
Internal casing



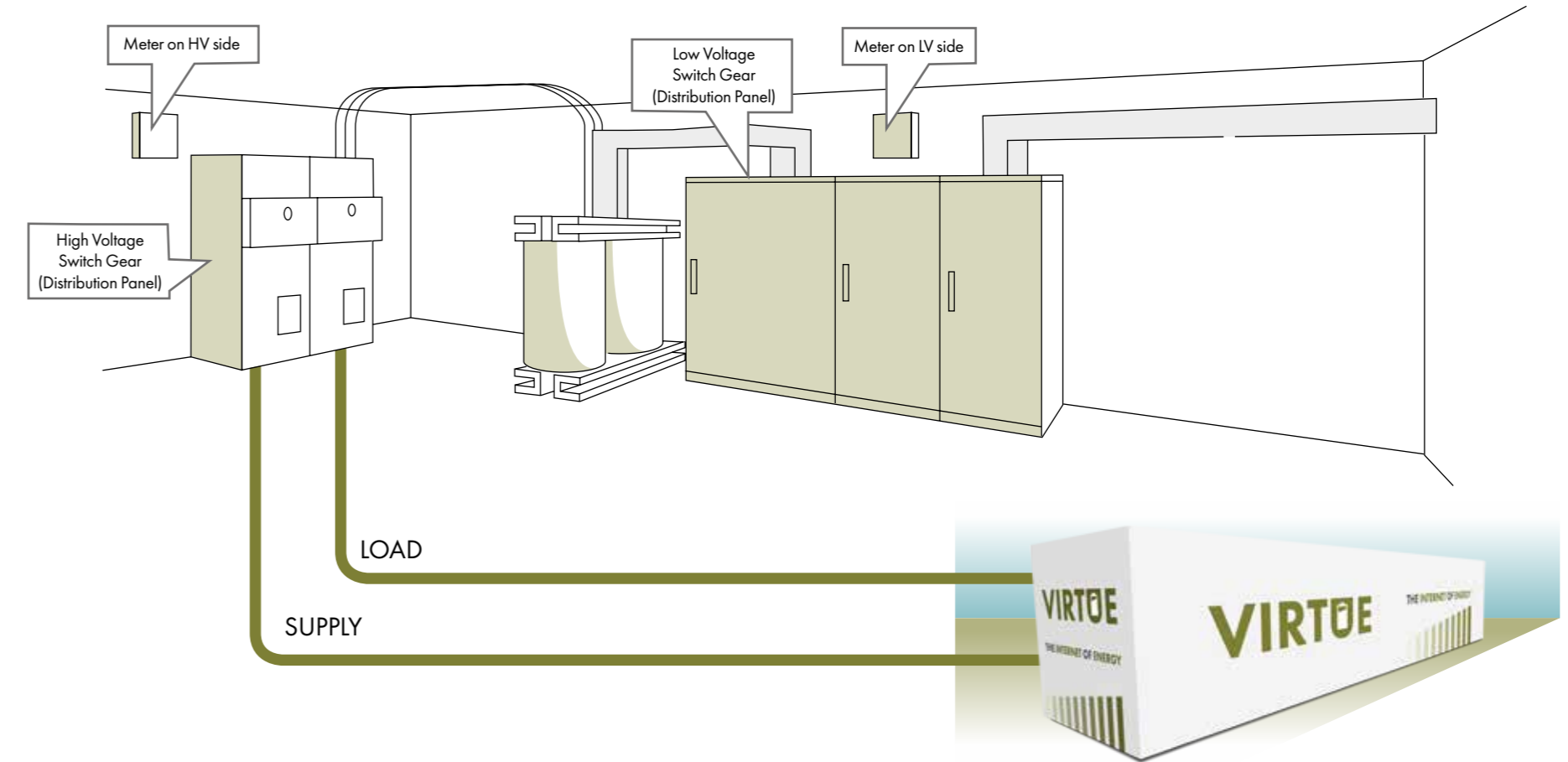
Battery cabinet

WHERE VIRTUE CONNECTS

Connecting Virtue on LV (Powerstar MAX optional)



Connecting Virtue on HV (Powerstar HV MAX optional)



VIRTUE SYSTEM TYPES



5ft CONTAINER

50kW output
Average 72kWh storage



10ft CONTAINER

100kW output
Average 220kWh storage



20ft CONTAINER

250kW output
Average 432kWh storage



40ft CONTAINER

1000kW output
Average 1000kWh storage

Systems can be connected in series to provide any output up to **10MVA** power output and **50MWh** storage



REDUCE

Reduce electricity consumption from the grid by using the UPS capabilities of Virtue during the peak/red DUoS and Triad tariffs



STORE

Virtue allows sites to draw and store onsite renewable sources and energy at off-peak times when electricity is cheaper and when it would normally be wasted



SAVE

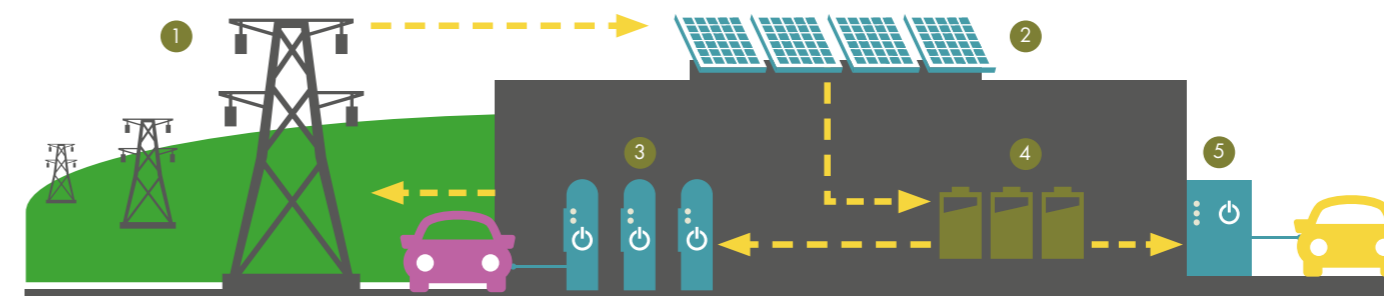
Switch to stored power at any time to maximise revenues, save energy and protect production costs



ELIMINATE

Eliminate operational risks through the full load UPS capabilities of the Virtue system

OTHER APPLICATIONS OF VIRTUE - SHARING THE STORAGE



- 1 Grid Supply
- 2 Solar Panels
- 3+5 Rapid EV Chargers
- 4 Energy Storage

As more companies are looking to invest in electric vehicles, the need for convenient and fast charging is becoming apparent. However, there are network barriers, currently limiting how many electrical vehicle (EV) chargers can be in an area. Large numbers of EVs connecting to the National Grid will have a significant impact upon the Distribution Network, causing major network overload unless appropriate management systems and network upgrading occurs. Not only is this issue applicable to the grid operators, but also business owners who have the issue of a limited supply and face potentially costly supply upgrades. Our Virtue EV rapid/fast charging system utilises battery storage to limit the amount of energy required from the network at any given time. The system doesn't just provide feasible rapid charging services, it also offers the following benefits:

Cost reduction - The system will store energy during night hours where there is usually excessive electricity generation (low cost) and use it during the day (high cost).

Smart grid integration - The system behaves like a virtual power station, and is constantly in communication with the grid, allowing participation in schemes such as FFR (Firm Frequency Response) & EFR (Enhanced Frequency Response).

UPS functionality - Critical loads downstream of the supply provided for the charger will have full UPS protection for typically 30 minutes.

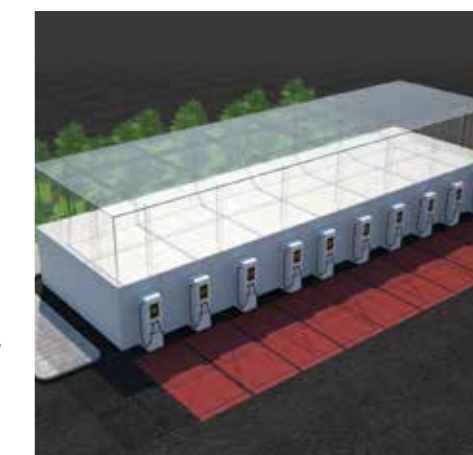
CO₂ reduction - By diverting the use of energy from day time to night time, where generation is higher than demand, there is a substantial CO₂ saving. DECC has agreed that for each kWh diverted from day usage to night usage, there is 0.49636kg CO₂ saved.

Renewable connectivity - Renewable energy can be connected directly (direct DC) to charge the storage medium for future DSR or charging.



Virtue EV Rapid Charger 1

The "Bus Stop" design shown is a combined DC rapid charger and energy storage system. This particular Virtue EV provides off grid rapid charging (50kW CHAdeMO), allowing a site with limited grid import capacity, to rapid charge vehicles without upgrading infrastructure. The system can also be charged directly through renewable generation, so that the charging of vehicles can be done independently from the grid.



Virtue EV Rapid Charger 2

The Virtue EV design utilises 1MWhs of battery storage with 500kW output to provide 10 rapid chargers or 20 fast chargers (22kW) with stored energy, allowing cars to be entirely charged off-grid at a minimum of twice a day. The facility has the ability to draw from onsite renewable energy to charge the batteries throughout the day and utilises this energy to provide power to the car chargers. The unit also performs Demand Side Response (DSR) and supports 500kW of associated load in the event of an outage.

WHY VIRTUE IS NEEDED

A secure and reliable electricity supply is required and Virtue delivers fundamental improvements in the way electricity is generated, delivered and consumed.

It is also able to make the most of renewable energy sources through improving reliability of renewable generation and maximising the benefits of wind and solar generation, in turn reducing the reliance on fossil fuels.

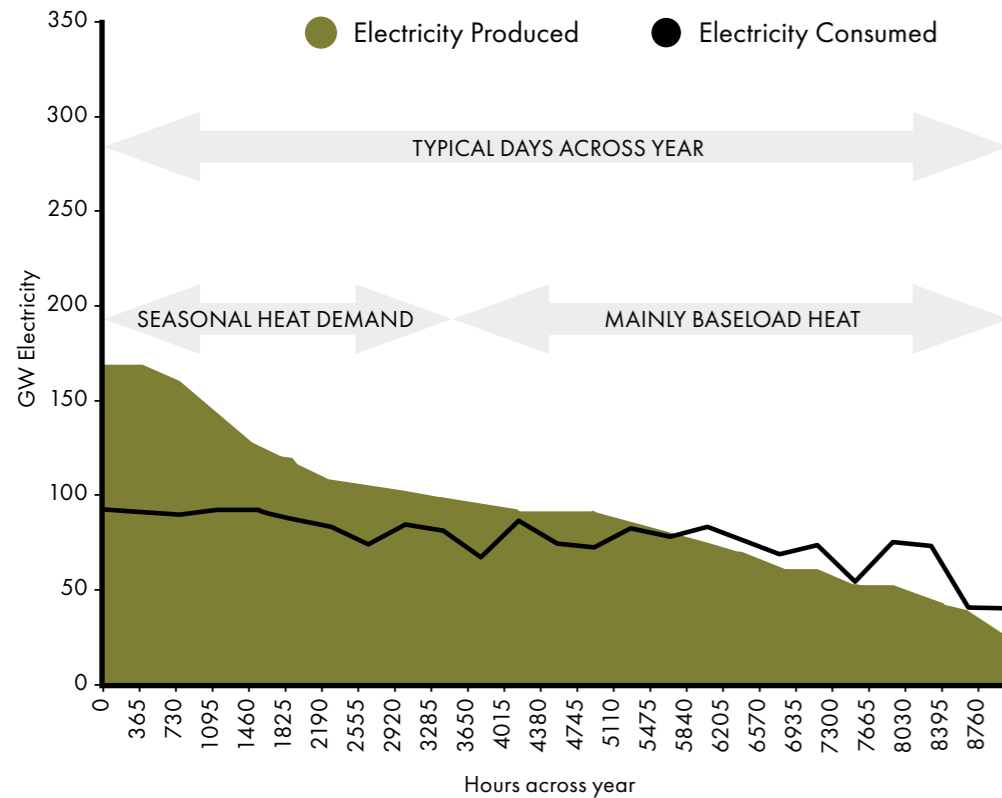
Through balancing power demand Virtue is also crucially able to make the electricity power network more resilient, efficient and cleaner reducing significant wastage in energy and resource.

HELPING TO MATCH DEMAND

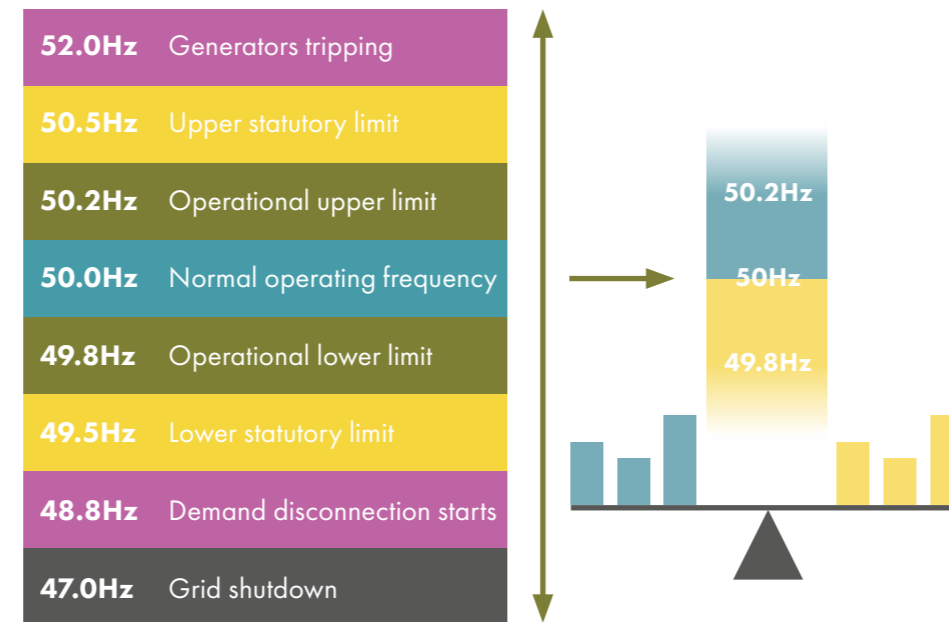
The graph below shows that for more than 125 days a year, up to 50% more electricity is generated than is required, resulting in a significant waste of energy and resources.

In order to achieve our statutory CO₂ reduction of 80% by 2050 this wasted energy must be harnessed, and Virtue can help to achieve this. In addition to ensure there is a closer generation and demand match at micro grid level the National Grid provides incentives for organisations to support it.

National Grid Graphs 2015



Balancing Generation and Demand: Real Time Balancing



Based on information from National Grid

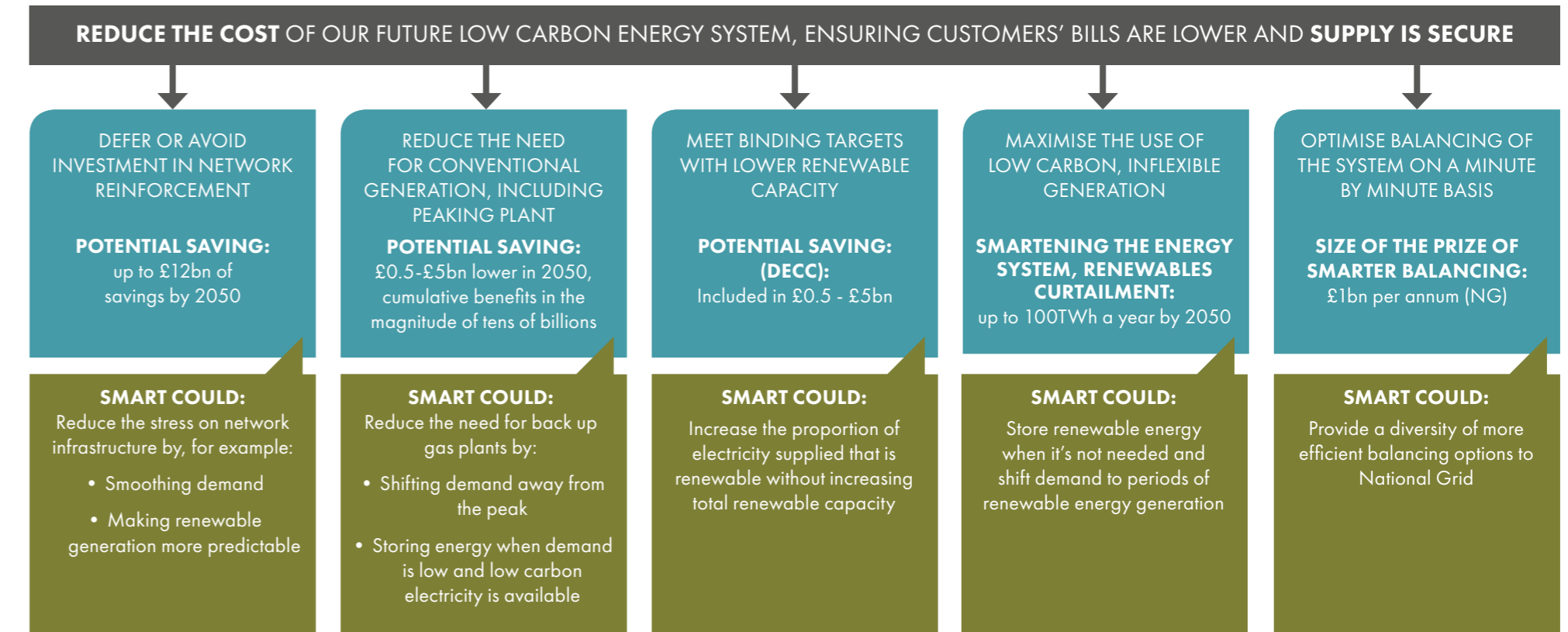
The Department of Energy & Climate Change (DECC) recently issued a report 'Towards a Smart Energy System' summarising how a smart energy system, based around new forms of flexibility, could help the UK deliver objectives more effectively.

The report outlines how incorporating a smart, flexible energy system driven by energy storage, Demand Side Response (DSR), smart networks and interconnection will contribute towards a number of benefits including increasing renewables as a

proportion of the energy mix, avoiding investment in network reinforcement, reducing the need for a significant increase in reserve generation capacity and lessening the requirement for back up thermal generation.

The chart below is a representation from a chart used in the DECC report which highlights how a smart energy system can help.

Benefits of a smart energy system



The chart is a representation of the 'benefits of more flexible solution in a smart energy system' chart from the DECC report 'Towards a Smart Energy System'



DUoS – TARIFFS – PEAK TARIFF

ZONE NAME	DUoS p/kWh LV - HH 2015	DUoS p/kWh LV - HH 2016	DUoS p/kWh LV - HH 2017
1. Northern Scotland	05.09	05.54	07.12
2. Southern Scotland	11.31	11.86	11.67
3. Northern	08.46	10.77	10.49
4. North West	09.08	11.33	09.66
5. Yorkshire	07.77	08.66	08.87
6. N Wales & Mersey	14.73	14.53	14.63
7. Midlands	10.10	11.23	11.09
8. East Midlands	09.98	11.30	11.37
9. South Wales	12.05	12.61	13.33
10. Southern	08.88	11.70	09.02
11. South East	10.38	11.62	11.19
12. Eastern	09.93	10.98	10.91
13. South West	20.51	24.79	25.24
14. London	03.44	04.25	04.37

www.energynetworks.org

TRIAD COSTS

ZONE NAME	16/17(£/kW)	17/18(£/kW)	18/19(£/kW)	19/20(£/kW)	20/21(£/kW)
1. Northern Scotland	40.97	29.73	35.59	35.84	51.32
2. Southern Scotland	40.24	30.45	34.64	36.55	49.53
3. Northern	42.93	38.16	44.38	47.98	60.86
4. North West	42.83	43.59	49.66	54.12	67.87
5. Yorkshire	42.49	44.13	50.88	55.42	69.28
6. N Wales & Mersey	42.68	45.50	51.73	56.33	70.21
7. Midlands	45.74	48.26	54.90	59.81	73.90
8. East Midlands	44.72	47.01	53.94	58.54	72.66
9. South Wales	42.31	45.44	52.55	58.06	72.10
10. Southern	50.08	52.83	60.14	64.84	78.61
11. South East	49.20	51.83	58.58	62.85	76.70
12. Eastern	46.54	49.02	56.09	60.42	74.54
13. South West	48.58	51.43	58.77	66.05	79.66
14. London	51.87	54.37	61.23	65.78	79.94

www.nationalgrid.com

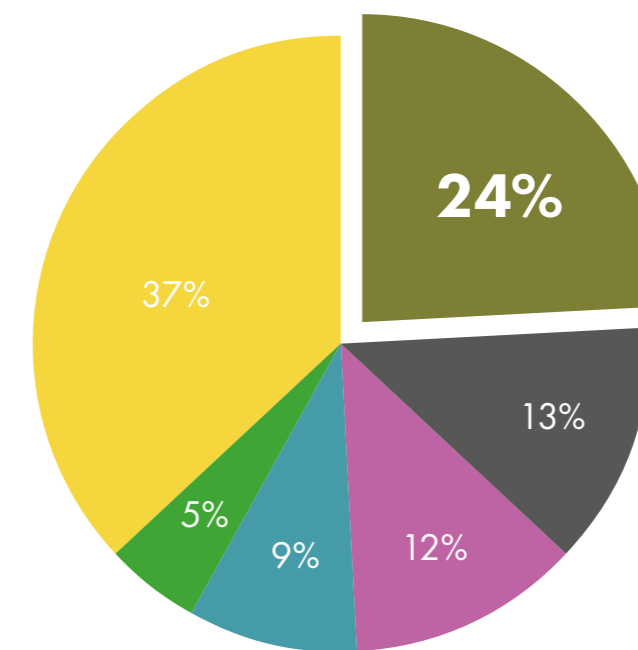
NETWORK PASS-THROUGH COSTS

Suppliers pay network costs to other companies who operate and maintain the electricity network, as well as other costs to support government backed renewable energy schemes.

Most organisations will have these costs itemised on their supplier electricity bill and will vary dependent on your geographic location.

Some organisations obtain bills detailing full DUoS charges, whereas other bills may only show day and night rates. Regardless of the type of bill that is obtained charges are always made by the utility provider.

Installing Virtue will minimise the DUoS and Triad charges, which on average represent 24% of total electricity bills and enable participation in National Grid incentive schemes which provide an income between £90,000 and £150,000 per MW of Virtue.



Typical electricity bill breakdown

The chart shows that typically 24% of an organisation's electricity bill is made up from network charges. This portion of the electricity bill can be influenced by installing a Virtue system which could produce a 24% saving – depending on your geographically determined Triad and DUoS charges. It is predicted that over the coming years the price of electric will increase to a rate that pushes network charges to represent 40% of an electricity bill.

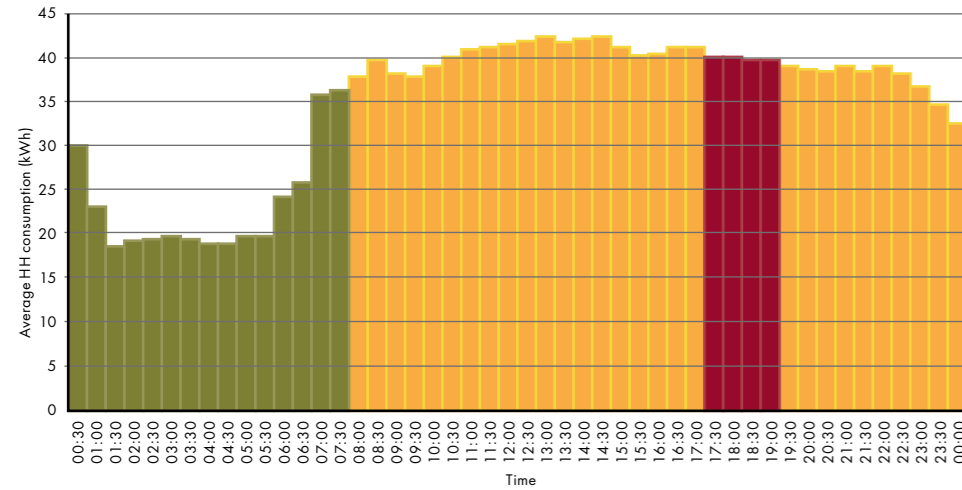
- Wholesales costs
- Network costs**
- Supplier operating costs
- Environmental and social obligation costs
- Pre-tax margin

EXAMPLE OF DUoS CHARGES VARYING THROUGH THE DAY (SOUTH WEST UK)



EFFECTS OF VIRTUE ON ELECTRICITY PROFILE

Electricity profile before Virtue installation

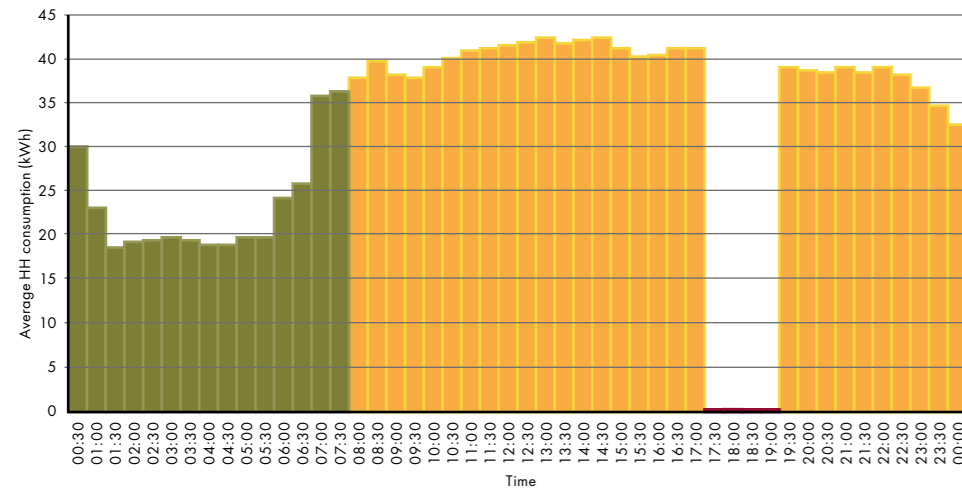


The chart shows a typical load profile for a commercial site with no on-site renewables.

The green line indicates low tariff periods, the yellow line indicates medial tariff periods, and the red region indicates the high peak tariff periods. It is this dark shaded column that illustrates the region that the facility needs to avoid, in order to prevent incurring highest costs and inconsistent supply.

Fixed costs (DUoS & Triads) currently comprise 24% of the electricity bill based on Ofgem information and these charges will increase to 40% by 2020 based on NG information.

Electricity profile after Virtue installation



The chart shows the same profile with Virtue installed. The high peak tariff period has been completely avoided by powering the site entirely from the Virtue storage medium. The storage medium was charged overnight at the much cheaper green band rates and discharged during red band rates.

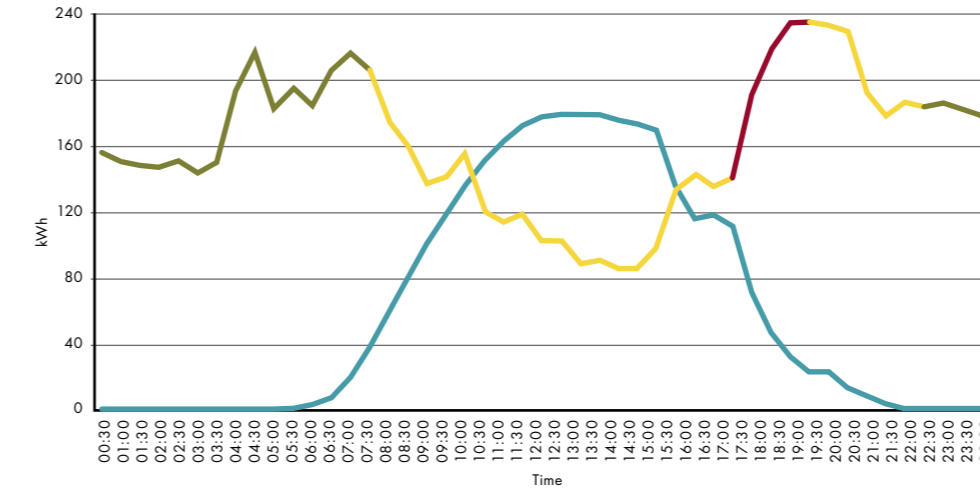
By removing your site from the red DUoS tariff periods the cost of electricity is reduced by an average of 24% (subject to location within UK).

Store Load ■ ■ ■

EFFECTS OF VIRTUE ON A SITE WITH SOLAR

Load profiles with solar panels on a sunny day

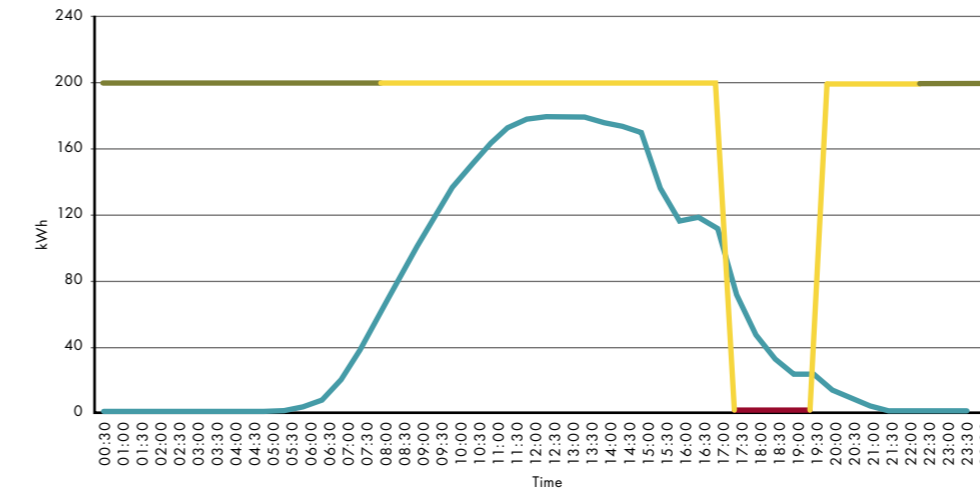
Before Virtue installation



The chart shows a typical load profile (green-yellow-red) of a site fitted with 200kW of solar panels on a particularly sunny summer's day.

The direct effect of solar on the load profile is quite substantial, reducing the site's overall consumption of electricity by 32.6%. However, the majority of this load reduction occurs during non-peak hours, with solar only reducing the load requirement of the store during peak tariff times by 18%.

After Virtue installation



The chart shows Virtue utilising solar power in such a way as to prevent the store ever demanding more than 200kWh per hour of energy from the grid, as well as removing the site completely from grid power during peak tariff.

Therefore the Virtue system operates to control maximum demand from the grid, eliminating the need to expand capacity and reducing availability charges.

Store Load ■ ■ ■ Solar ■

VIRTUE - GRID INCENTIVES

National Grid contracts reserves of demand (it pays end-users for the option of temporarily reducing their demand) and supply. These reserves can be called upon to compensate for unpredicted changes in supply and demand of electricity, so they are keeping the system in balance. The reserves differ in their required response time:



EXPORT

On average in 2016 exporting at peak tariff provides an additional income of 8.6p per kWh exported.



FIRM FREQUENCY RESPONSE (FFR) - VIRTUE

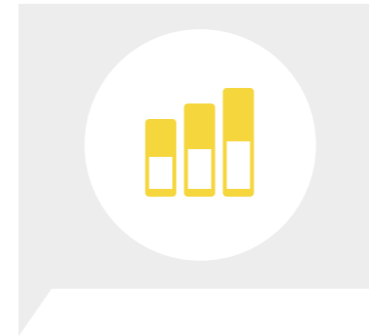
Is the firm provision of Dynamic or Non-Dynamic response to changes in frequency.

National Grid procures the services through a competitive tender process, where tenders can be for low frequency events, high frequency events or both.



ENHANCED FREQUENCY RESPONSE (EFR) - VIRTUE

Is defined by National Grid Electricity Transmission as being generation that achieves 100% active power output at 1 second (or less) of registering a frequency deviation. This is in contrast with existing frequency response services of Primary and High, which have timescales of 10 seconds, and Secondary which has timescales of 30 seconds. With a Virtual Power Plant (VPP) the benefits are enhanced.



DEMAND TURN UP

Demand Turn Up is a service procured by National Grid to encourage energy users to increase demand when there is an imbalance on the electricity system.

By being paid to charge a battery storage system during times of excess energy (typically overnight and during weekend afternoons), consumers are able to maximise revenue opportunities and further aid the integration of renewable energy sources onto the electricity system. This service is set to become increasingly important as demand falls and generation from wind and solar increases.

COMPANY BACKGROUND

Virtue is an energy storage system capable of delivering significant financial savings and greater control of electricity usage anywhere in the world.

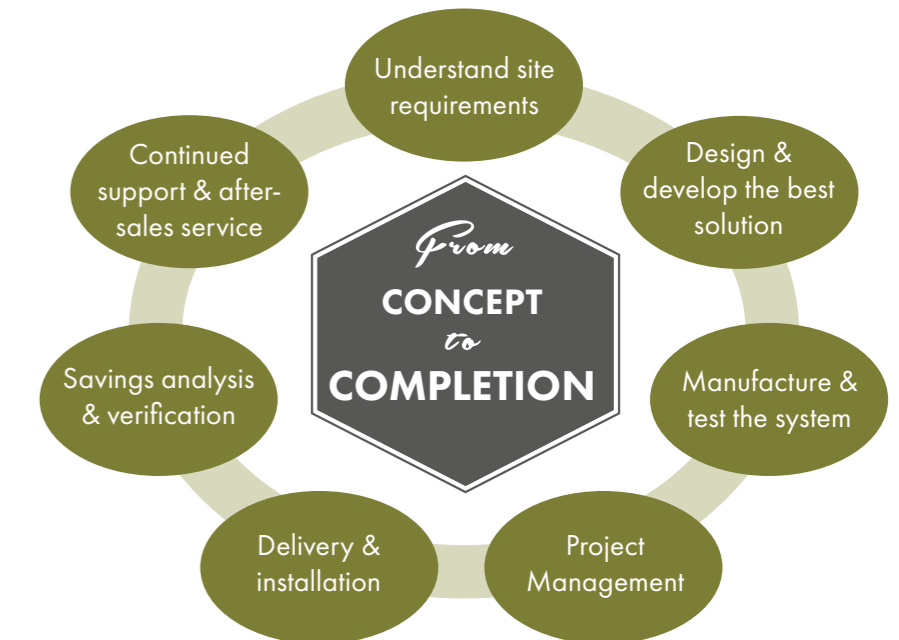
Designed and manufactured by renowned energy management innovation specialists Powerstar, Virtue is backed by an experienced, engineering focused team who have more than 200 years combined experience in the design and project management of energy systems.

Virtue is designed and manufactured to the highest recognised international standards, providing assurance that the solutions represent the most efficient and highest quality systems on the market.

In addition, with full R&D, design, engineering, manufacturing and assembly facilities in-house they can offer clients a crucial differential of flexibility as solutions can be adapted to tackle whatever challenges clients face.

OUR APPROACH

We deliver a full concept to completion service, utilising the vast experience of the Virtue team to understand the unique requirements of our clients and ensuring all projects are implemented within required parameters, without any negative impact on business operations and delivering tangible results.



FUNDING VIRTUE THROUGH ESCO

The ESCO Model

The ESCO (Energy Savings Company) funding model allows organisations to claim all the benefits associated with improved energy efficiency and energy storage without any capital outlay.

Through the ESCO model all up-front investment for a Virtue project is fully provided, with the investment recouped over an agreed payback period, through the savings generated.

ALL THE BENEFITS OF ENERGY STORAGE WITH NONE OF THE COST

STAGE 1 Analysis



An analysis of the current business operations, energy usage and examination of site and facility.

STAGE 2 Viability



Feasibility calculations are carried out on the projects including costs, savings and payback periods.

STAGE 3 Finance



A clear and concise finance package is created with all details agreed upon.

STAGE 4 Implementation



The project is then undertaken with the installation carried out as agreed.

STAGE 5 Verification



Ongoing savings verification reporting service is provided to monitor performance.

ESCO MODEL PURCHASING EXAMPLE

Virtue installed at **NO** cost to the customer

Annual fixed revenues received by customer*	£468,752
Annual rent for 10 years (80% of fixed revenues)	£375,001
Annual savings retained by customers (20% of fixed revenues)*	£93,750
Total saving at the end of 10 years rental	£937,503

* Figures are recalculated annually (1st April) as they are dependent on annual consumption, recorded Triad demand and the DUoS rates

* Figures based on 5MW output with 8.2MWh storage

Please note: Purchasing through ESCO is subject to eligibility



Warranties apply to systems installed within the UK and are subject to storage technology used. Exact warranties for each system will be clearly communicated as part of the proposal

VIRTUE

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