VIRTUE

THE INTERNET OF ENERGY

Battery energy storage

“A missing piece of the energy jigsaw”

European Utility Week AWARDS 2015 OVERALL WINNER

Robert Hughes

3rd March 2017

HOW WE WORK WITH OUR CLIENTS

“Our philosophy is to deliver systems that are designed to meet the individual requirements of clients. We aim to play our part in helping the nation utilise its energy sources wisely to facilitate the internet of energy through our virtue system”

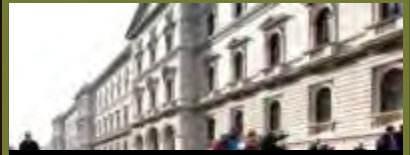
VIRTUE EV

TRUSTED BY LANDMARK SITES

Western Parliament - Australia

London City Hall - London

Emirates Towers - Dubai



Cabinet Office Buildings - London

Atlantis Palm Hotel - Dubai

Stock Exchange - London

Palace of Westminster - London

London City Hall - London

WHY THE NATIONAL GRID NEEDS ENERGY STORAGE

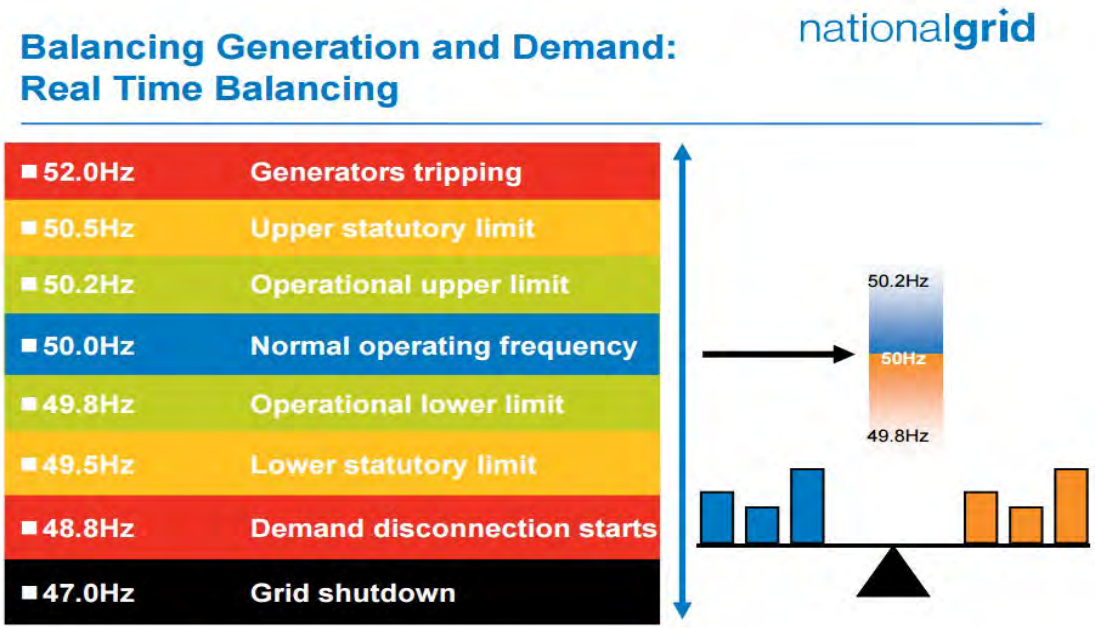
The National Grid must maintain frequency to 50.0Hz, therefore in order to provide a good service to the consumers it requires fast acting system to support the frequency.

The legal requirement of frequency which the National Grid must meet (illustrated by the graph on the right) is between 49.5Hz and 50.5Hz.

In addition to this the National Grid have set themselves an operational boundary of between 49.8Hz and 50.2Hz.

If the frequency drops, it means there is more demand than there is generation on the National Grid and when frequency rises, there is more generation than demand.

Virtue can therefore help the National Grid maintain their operational limits by taking and storing energy when there is excess and supplying it back to the grid when required, during periods of high demand.



VIRTUE THE INTERNET OF ENERGY

Applications:

- Full site UPS
- Up to 25% energy savings Triad/DuoS
- Revenue from Grid programmes
- Peak shaving/reduce capacity charges
- Optional voltage optimisation
- Renewables integration

STORAGE TECHNOLOGIES

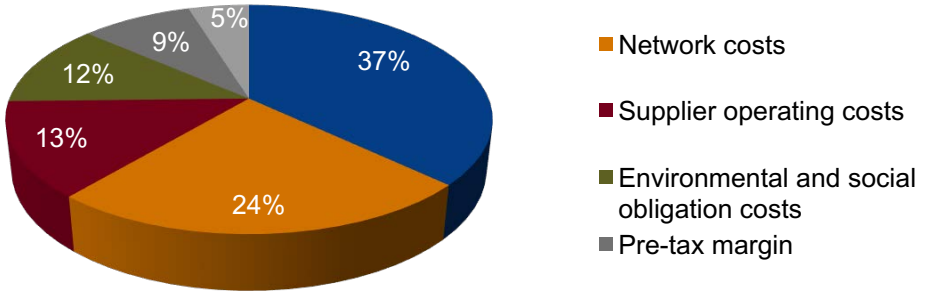
Question	Answer
What sizes available?	50Kw to 10MW
Pricing	Bespoke, catered to site
Response time	<15 milliseconds
Warranty cover	15 years. Faulty cells are tested and replaced, all Powerstar equipment fully covered as well. Manned response to a system issue within 8 working hours. Component issue replacement within 14 working days.
Cycles	6000 cycles @80% DOD @ 23+/- 5°C
Lifetime	25 years+
Capacity rating (depth of discharge)	100% charge up to 80% discharge. Reduced capacity over time compensated by greater discharge rate
Efficiency	96% charging efficiency (@1C) 97.2% discharging efficiency (@1C) @ linear load. Bi directional inverter@1000kW – 98.50%
Expected performance degradation	Efficiency will remain largely unchanged. Capacity as follows: @5 years – 96% @10 years – 91% @15 years – 82% @25 years – 69/70% @end of life – 60%
Noise	@ 1m 42 - 46 dBA
Lead time	3-4 months, depending on size of order
End of life	At end of ESCO, can be extended 5 years or unit will be retrieved if terminated. With purchase, will still be residual value/use of unit
O&M	O&M included with ESCO. Additional annual cost with purchase after 1st year. 1% of total (excluding installation) a year

NETWORK PASS-THROUGH COSTS

Some organisations obtain bills detailing full DUoS charges and some only show day and night rates, regardless of which you obtain charges are always made by the utility provider.

Installing a Virtue system will minimise the DUoS and Triad charges, which average 25% of your bill and enable participation in the National Grid incentives which could provide an income between £90,000 and £150,000 per MW of Virtue output (depending on your location).

Typical Electricity Bill Breakdown



Ofgem, 2015

The chart shows that currently 24% of an organisation's electricity bill are made up from these network charges.

This means that you could potentially influence this portion of your electricity bill and by implementing a Virtue system you could make 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 the percentage up to 40% of an electricity bill.

Example of DUoS charges varying throughout a day: (South West region)

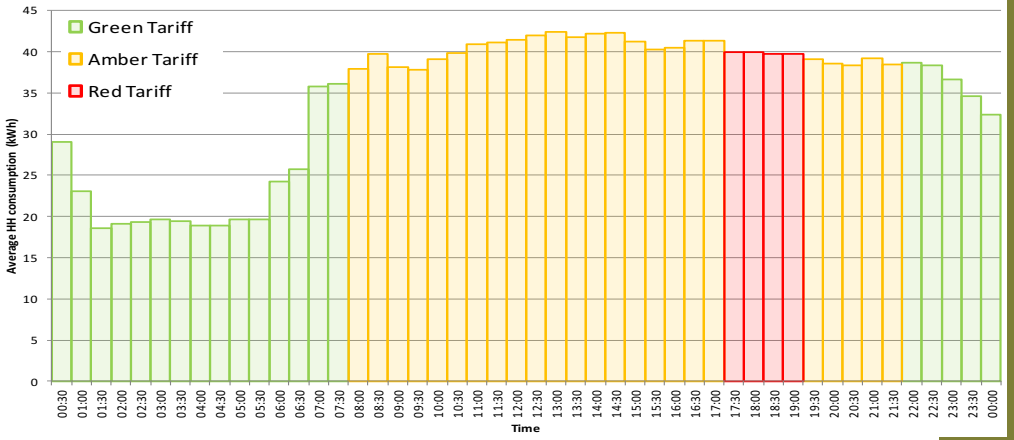
Green DUoS Tariff = 0.1p per kWh (21:30 – 07:30)	Amber DUoS Tariff) = 0.35p per kWh (07:30 - 17:00 & 19:00 – 21:30)	Red DUoS Tariff = 24.79p per kWh (17:00 – 19:00)

EFFECTS OF VIRTUE ON AN ELECTRICTY PROFILE

ELECTRICITY PROFILE BEFORE VIRTUE INSTALLATION

A typical load profile for a commercial store 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 incurring highest costs and inconsistent supply.

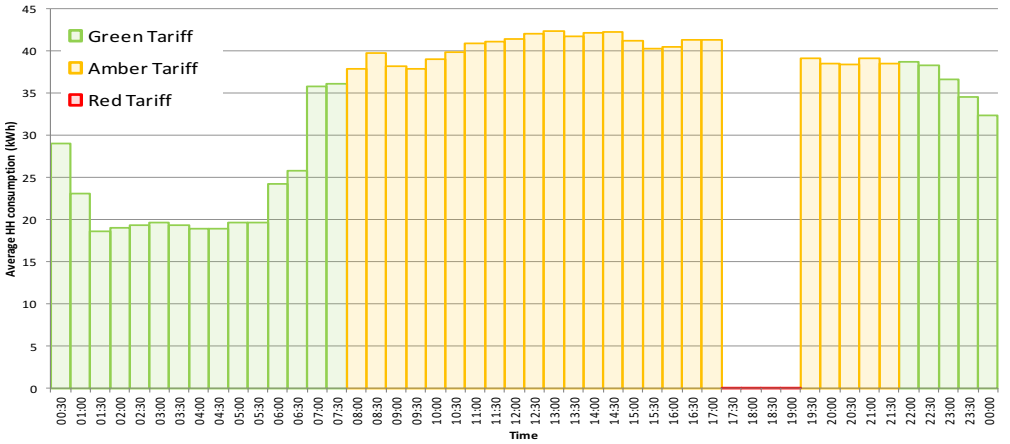
Fixed costs (DUoS & Triads) currently comprise 25% - 35% of the electricity bill and based on NG information these charges will increase to 40% - 50% by 2020.



ELECTRICITY PROFILE AFTER VIRTUE INSTALLATION

The same profile with Virtue. The high peak tariff period has been completely avoided by powering the site entirely from the Virtue storage medium. The rest of the load profile has remained unaltered, because the storage medium was charged using the induced negative power (back EMF), not power from the grid. Therefore not only is the consumer saving money, but they are also directly reducing kWh usage, both for themselves and the grid.

By removing your site from the red DUoS tariff periods the cost of electricity is reduced by an average of 25% (subject to location within UK).



VIRTUE – TRIAD COSTS

Zone	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	34.63	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	45.5	51.73	56.33	70.21
7	**Midlands**	45.74	48.26	54.9	59.81	73.9
8	**East Midlands**	44.72	47.01	53.94	58.54	72.66
9	**South Wales**	42.31	45.44	52.55	58.06	72.1
10	**Southern**	50.08	52.83	60.14	64.84	78.61
11	**South East**	49.2	51.83	58.58	62.85	76.7
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

Information accurate as of May 2016, data provided from National Grid

VIRTUE PROPOSAL EXAMPLE

Customer Specification

Company type:

UK MANUFACTURER (NORTH WALES)

Site Specification:

2,000 kVA Output Power

1,476 kWh Capacity

Purchasing Virtue

Price: £1,703,599

Payback Period: 5 years, 6 months

Return on Investment: 18.4%

Annual Savings:

	2017	2018	2019	2020
Fixed revenues DUoS Savings	£26,454	£13,873	£14,705	£15,587
Fixed revenues Triad Savings	£41,708	£47,419	£54,636	£64,359
Fixed revenues CM Savings	£14,796	£14,796	£14,796	£14,796
Non-Fixed Revenues FFR	£228,333	£228,333	£228,333	£228,333
TOTAL ANNUAL SAVINGS	**£311,291**	**£304,421**	**£312,470**	**£323,075**

- DUoS savings for 2018 onwards are based on predictions supplied by the Distribution Connection and Use of System Agreement (DCUSA)
- Triad savings up to 2020 are based on rates published by the National Grid's Tariff Information Paper February 2016
- FFR and EFR are 4 year contracts with the incentives set by the National Grid

UTILISING THE STORAGE – VIRTUE EV

Avoid Costly Upgrades

CO_2 Reduction

Renewable Connectivity

Cost Reduction

Smart Grid Integration
– Potential Income

UPS Functionality

THIS IS A REVOLUTION

- 60,000 Electric Vehicles (EV) registered between 2011 – 2016
- More than half of all new car registrations could be electric by 2027, registering around 1.3m a year”
- Government forecast for all new cars and vans to be electric by 2040

Source: Go Ultra Low (SMMT)

VIRTUE EV

BUT WE HAVE TO CHARGE THEM...

The UK network of EV charging points has also increased, and as of Q3, 2016 there are:

- 4,200 charging locations
- 6,500 charging devices
- 11,650 charging connectors

The proportion of charger types has also changed dramatically with an increase in high power (rapid) units being installed across the UK.

THE CONSTRAINTS ON EV ROLL OUT

- Grid capability
- Cost of upgrade
- Consumer anxiety – range & charging time
- Number of charging points

STORAGE IS KEY TO THE SOLUTION

In order to cope with the increase in demand for electric vehicles, the grid can do one of three things:

1. Introduce more capacity to the grid through generation and expand the networks capacity

2. Introduce more flexible generation in order to deal with spikes seen from chargers

3. Introduce local storage to greatly reduce the demand spike by using storage to deal with the ramp up of power

Option 3 is the most cost effective for the network as options 1 & 2 both require the local, and eventually, the national network to be upgraded in order to handle the capacity increase / capacity potential.

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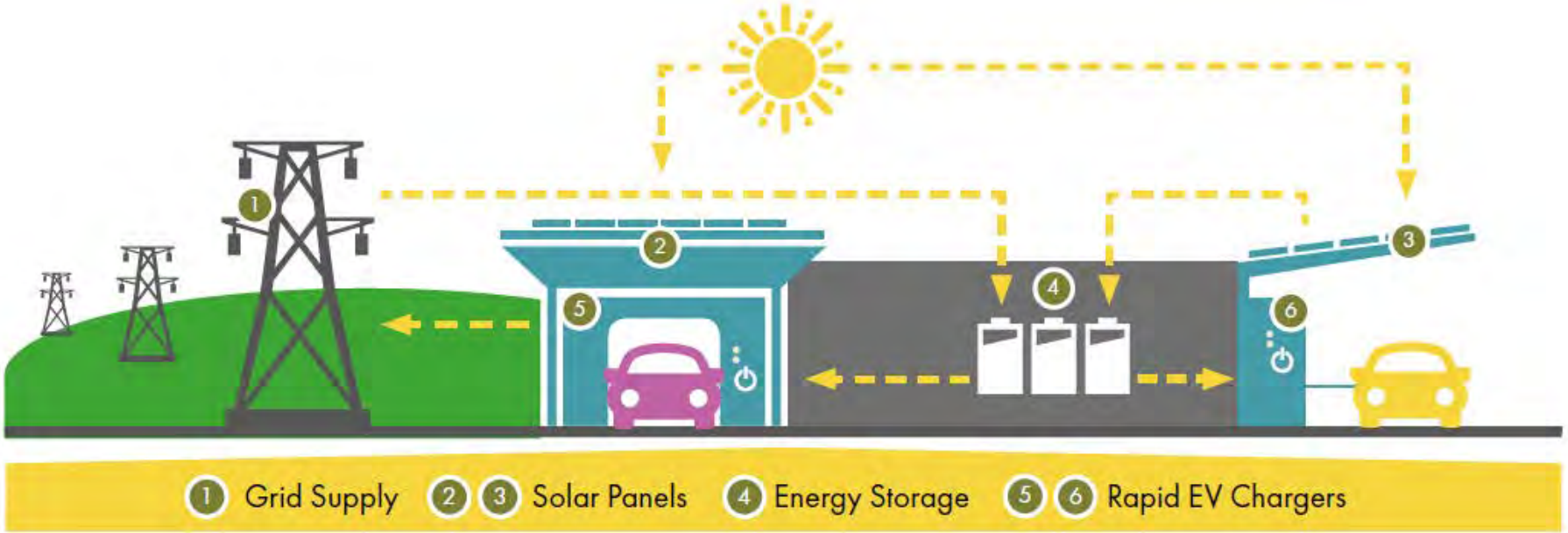
AND WHAT ABOUT THE PEOPLE?

- Ease of charging
- Fit consumer lifestyle
- Smart technology

HOW DOES IT WORK?



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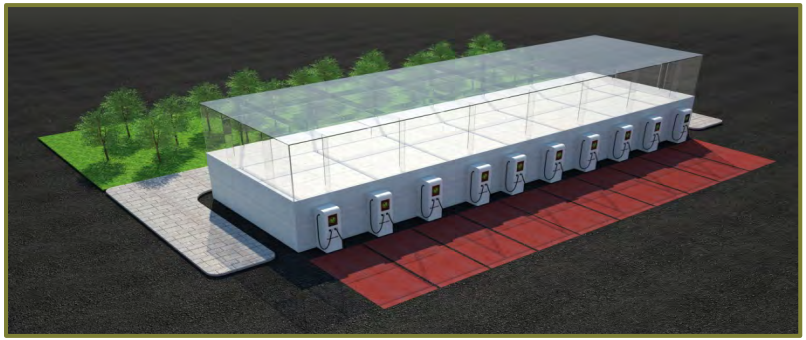
VIRTUE EV FLEXIBLE ALTERNATIVES

VIRTUE EV RAPID CHARGER 1

The ‘bus stop’ design is a combined DC rapid/fast EV charger and energy storage system with integrated 6kW solar or 12kW (PV) canopies.

VIRTUE EV RAPID CHARGER 2



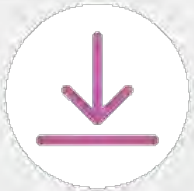
The Virtue EV design utilises 1MWhs of battery storage with 500kW output to provide 10 rapid chargers or 20 fast chargers (22kW) with stored energy.

STANDING OUT FROM THE CROWD

Avoid Costly Upgrades

Cost Reduction

Renewable Connectivity



CO_2 Reduction

Smart Grid Integration
– Potential Income

UPS Functionality

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DRIVING INNOVATIONS IN ENERGY STORAGE

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