VIRTUE
ENERGY STORAGE SOLUTIONS

Your Flexible Power Future
Your Flexible Power Future

Project Objectives (what are your objectives)

1. Provide Backup Power Resilience to partial load (500kW)?
2. Add 1000KVA solar PV to new Building and a new Wind Turbine?
3. Reduce the imported grid energy to a minimum of x% total electrical consumption?
4. Utilise Virtue BESS to monitor/optimise all generation sources and control the exported energy (if required)?
5. Shed Controllable Loads (if required)?
6. Reduce the energy consumption through Powerstar Voltage Regulation?
7. Update your existing HV infrastructure?
8. Add EV Chargers and manage their loads
Our Patented HV MAX or On-line SO-LO Distribution Transformers
REMOTE MONITORING CAPABILITIES

Powerstar SO-LO remote monitoring allows for greater visibility and understanding of how the equipment is operating by providing comprehensive data on:

- Online oil analysis
- Volts on each phase
- Phase to phase metrics
- Amps on each phase
- Real power measured in kW per phase
- Power factor
- Temperature of core transformer
- Harmonic distortion
- Total system kVA
- Total system kWh
- GPS location
REMOTE MONITORING: OVERVIEW

The platform’s homepage provides an overview of the transformer’s performance.
REMOTE MONITORING: OIL ANALYSIS

Further details about the system’s oil condition can be found on the OIL FCS page.
POWERSTAR SO-LO (SMART DISTRIBUTION TRANSFORMER)

- Quite certain savings
- Savings can be easily verified
- Verification process: laboratory testing of existing transformer after decommissioning
- Dependent on current transformer efficiencies and loading characteristics

**SUMMARY OF RETURNS:**

<table>
<thead>
<tr>
<th>Average Payback (yrs)</th>
<th>Period of Benefit</th>
<th>Life Expectancy Of Technology</th>
</tr>
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<tbody>
<tr>
<td>5 - 7</td>
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</tbody>
</table>

- Average ROI
  - Up to 15%

- CERTAIN REVENUES/SAVINGS
- QUITE CERTAIN REVENUES/SAVINGS
- LESS CERTAIN REVENUES/SAVINGS
Our Patented VO-VR Technologies
PATENTED POWERSTAR DESIGN

**Most VO systems**

500kVA

Traditional systems transform the entire power output from one voltage to another, and although they reduce voltage they also increase current.

**The patented Powerstar system**

500kVA

Due to the patented design of Powerstar, and the third control winding, Powerstar creates negative power (back EMF) whereby any excess voltage is chopped and sent in the direction of the supply. This ensures only around a tenth of power is transformed, resulting in reduced voltage AND current.
NEGATIVE POWER (BACK EMF) DEMONSTRATION

The snapshot below shows the negative current (Back EMF) – i.e. 180° out of phase from the primary current – when Powerstar is activated.

Click here to view the full negative power (Back EMF) demonstration video.
A report entitled ‘Simulation Study for a Transformer Based Voltage Regulator’ concluded:

1) The mathematical and simulation model presented in the report explains how the voltage regulator works.

2) The theoretic analysis and simulation results prove that the voltage regulator can lead to energy saving.

3) The overall power consumption is reduced because the negative power is induced and feedbacks to the power source. Virtually, this power can be considered as power “generated” from the load side.

4) The induced current or power can be measured using a separated power supply by using an ordinary transformer (not an autotransformer).

FULL REPORT AVAILABLE ON REQUEST
The most recent independent test on a Powerstar system was carried out by AEP at the infamous Dolan Research Centre in Ohio, USA. A Powerstar was tested under laboratory conditions in order to verify the effect the system had on both electricity consumption and efficiencies on compressors and pumps.

Therefore confirming that using Powerstar to run the equipment tested at its design characteristics not only reduced its energy consumption but also improved the efficiency of the equipment.
Easy to Verify – On-Line fully automated verification

LOW VOLTAGE METER

<table>
<thead>
<tr>
<th></th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>36.0 A</td>
<td>32.0 A</td>
<td>28.0 A</td>
</tr>
<tr>
<td>Voltage</td>
<td>224.0 V</td>
<td>224.0 V</td>
<td>224.0 V</td>
</tr>
<tr>
<td>Voltage THD</td>
<td>1.69 %</td>
<td>2.00 %</td>
<td>3.40 %</td>
</tr>
<tr>
<td>Current THD</td>
<td>7.20 %</td>
<td>7.82 %</td>
<td>9.30 %</td>
</tr>
<tr>
<td>Frequency</td>
<td>50.00 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>214.60 kW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Factor</td>
<td>0.987</td>
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<td></td>
</tr>
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</table>
POWERSTAR MAX / HV MAX (HV/LV VOLTAGE OPTIMISATION)

- Certain savings
  - Savings can be easily verified
  - Verification process: periodically turning the optimiser on and off
  - Verification can be achieved remotely, if required

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<tbody>
<tr>
<td>2 - 5</td>
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</tbody>
</table>

- **Average ROI**
  - Up to 30%

- **CERTAIN REVENUES/SAVINGS**
- **QUITE CERTAIN REVENUES/SAVINGS**
- **LESS CERTAIN REVENUES/SAVINGS**
Our Patented Virtue
VIRTUE energy storage solutions are 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 utilised more efficiently. Additionally, due to its full UPS capabilities it offers site wide backup to critical systems.
ISSUES WITH THE CURRENT ENERGY LANDSCAPE

- Supply issues have become increasingly common as the UK electricity network struggles to keep up with increased demand.

- Many sites are experiencing problems such as brownouts, blackouts, voltage spikes and dips causing significant damage to electrical equipment and sensitive business operations.

- A 2017 report found that energy related failures can total as much as 17% of annual revenues.*

- There were 1743 blackouts in 2017, a 77% increase from the 986 blackouts or brownouts in 2016 which was a 46% increase from 2015^.

- The South East of England was the region with the highest number of blackouts, with an average cost of €66,170 (£55,000) per hour.

Sources:
* Centrica, 2017
^ChannelBiz, Electrical Times, 2016
### Parameter Status

<table>
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<tr>
<th>Parameter</th>
<th>Status</th>
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<tbody>
<tr>
<td>State of Charge</td>
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<tr>
<td>State of Health</td>
<td>97.0 %</td>
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<tr>
<td>System Current DC</td>
<td>84.0 A</td>
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<tr>
<td>System Voltage DC</td>
<td>730.6 V</td>
</tr>
<tr>
<td>Racks Online</td>
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</tr>
<tr>
<td>Total Rack Number</td>
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</tr>
<tr>
<td>Max Cell Temperature</td>
<td>27.89 C</td>
</tr>
<tr>
<td>Min Cell Temperature</td>
<td>21.73 C</td>
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<tr>
<td>Max Cell Voltage</td>
<td>3.718 V</td>
</tr>
<tr>
<td>Min Cell Voltage</td>
<td>3.689 V</td>
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### BMS

<table>
<thead>
<tr>
<th>Rack</th>
<th>Status</th>
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<tr>
<td>1</td>
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</tr>
<tr>
<td>2</td>
<td>ONLINE</td>
</tr>
<tr>
<td>3</td>
<td>ONLINE</td>
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<td>ONLINE</td>
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<td>5</td>
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<td>6</td>
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<td>7</td>
<td>ONLINE</td>
</tr>
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<td>ONLINE</td>
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POWERSTAR VIRTUE (BATTERY ENERGY STORAGE)

- National Grid balancing contracts (tender based contracts)
- DUoS and Triads (on peak, off-peak and demand charges)
- Optimisation of renewable generation (PPA or simple energy differential)
- Optimisation of other assets (i.e. Cogen, CHP, Biomass, generators)
- Uninterruptible Power Supply (UPS) element

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<tr>
<td></td>
<td></td>
<td>Up to 13%</td>
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<tr>
<td>5 - 8</td>
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- UP TO CERTAIN REVENUES/SAVINGS
- QUITE CERTAIN REVENUES/SAVINGS
- LESS CERTAIN REVENUES/SAVINGS

### REVENUE AND SAVINGS BREAKDOWN:

- Solar PV
- FFR
- Offset Import
- BM
- DUoS
- CM Levy
- Triads
- UPS

- LESS CERTAIN REVENUES/SAVINGS
- QUITE CERTAIN REVENUES/SAVINGS
- CERTAIN REVENUES/SAVINGS
Controllable Loads
Switching controllable loads based on sensors

Small or Large Loads can be connected to the EMS and depending on sensing, these loads can be automatically switched ON/OFF thus ensuring minimum load on Grid imported energy and added savings.

Based on project objectives, the automation of such loads could be an important factor.
EV Charging – Must be Green

No need to Overload the Grid
Control the amount of current flowing based on parameters (renewable available, time of parking, etc)
The VIRTUE EV prototype, based at our head office in Sheffield, has a 50kW rapid DC and 11kW fast AC charger which can be connected to a 16A grid supply and still deliver 106A DC rapid charge to EV cars. It contains 80kWh of NMC batteries, a 50KW bi-directional grid based Inverter with full UPS capabilities and a 6kW PV canopy providing some of the storage for the NMC batteries.

As with all Powerstar solutions, VIRTUE EV is a bespoke product and therefore can be tailored to suit a clients needs.

Everything from the charger head (i.e. CHAdeMO/type 1/type2), the integrated solar canopy (i.e. 6/12kW) and the capacity to charge (i.e. 50/100/150kW) can be adapted and scaled as required, making VIRTUE EV a futureproof investment.
VIRTUE EV: A MULTITUDE OF POSSIBILITIES

Real life application of a custom made single VIRTUE EV unit shown on site at a clients premises in London
Guernsey EV Project:

Green Spaces indicate Rapid chargers with a maximum of only $\frac{1}{2}$h parking.
Grey Spaces indicate Fast chargers with a maximum of only 1h parking.
POWERSTAR VIRTUE EV (BATTERY BUFFERED EV CHARGING)

- Benefits from Powerstar VIRTUE
- Revenue from vehicle charging (dependent on how many cars and times of charging)

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<th>Average Payback (yrs)</th>
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<th>Average ROI</th>
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<tbody>
<tr>
<td>6 - 8</td>
<td></td>
<td>Up to 13%</td>
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Life Expectancy Of Technology

- CERTAIN REVENUES/SAVINGS
- QUITE CERTAIN REVENUES/SAVINGS
- LESS CERTAIN REVENUES/SAVINGS
EXAMPLES OF GENERATION OPTIMISATION
THE CASE FOR A COMPLETE SOLUTION

EXAMPLE CASE:

- 2x Powerstar Voltage Optimisation
- 1x Powerstar Distribution Transformer
- 2x Wind Turbines
- 1x Powerstar VIRTUE
- 1x Fast/Rapid Electric Vehicle Charging Station

SUMMARY OF RETURNS:

- Average Payback (yrs): 4 - 6
- Period of Benefit: 0 to 25
- Life Expectancy Of Technology: 4 - 6

Average ROI: Up to 16%

REVENUE AND SAVINGS BREAKDOWN:

- FFR
- Offset Import
- BM
- DUoS
- Triads
- CM Levy
- Voltage Optimisation
- UPS
- Solar PV

CERTAIN REVENUES/SAVINGS

QUITE CERTAIN REVENUES/SAVINGS

LESS CERTAIN REVENUES/SAVINGS
Power Resilience
Supporting sites through grid interruptions

Load is supported by Virtue

Grid Supply Interrupted

Load is supported by Virtue

Grid Supply Interrupted
ENERGY RESILIENCE: METALLICS MANUFACTURER

VIRTUE solution with integrated voltage regulation for the main purpose of maximising enhancing resilience through full UPS capabilities.

RESULTS:
- 7% Voltage optimisation savings
- Graphs show an instance UPS supporting load

CLIENT: Stoba – Metallics Manufacturer
LOCATION: Sussex, UK
TECHNOLOGY: BESS with UPS
MAXIMISING RENEWABLES: HOLIDAY ACCOMMODATION

VIRTUE solution with integrated voltage regulation for the main purpose of maximising on-site renewables generation.

RESULTS:
- A Yearly 57.3% energy reduction
- Only 2% import from the grid in June 2018
Adding the Virtue system allows the full optimisation of the existing CHP generating an additional value of £103,000 per year.
OPTIMISING EXISTING OR NEW PV SYSTEMS

The graph shows VIRTUE utilising solar power in such a way as to prevent the store ever demanding more than 100kWh per half hour of energy from the grid, as well as removing the site completely from grid power during peak tariff. Therefore the VIRTUE operates to control maximum demand from the grid and optimises the PV generation.
VIRTUE: PHOTOS OF SOME EXISTING SYSTEMS

Due to the bespoke nature of the solution, VIRTUE can be customer built to fit your footprint and can be fit externally or internally.

A 1.25MW containerised solution (HESTON – May 2017)

Built into an existing room – 100KW (Utility Alliance – Newcastle – March 2015)
VIRTUE: PHOTOS OF SOME EXISTING SYSTEMS

A 250MW containerised solution (ASDA – Newquay)- June 2015

1.15MW containerised solution – Internal View (ASDA – Swindon Haden – Jan 2018)
VIRTUE: PHOTOS OF SOME EXISTING SYSTEMS

A 1.5MW containerised solution
(BEMIS Flexible Packaging – Dec 2017)

A 500KW containerised solution
(Osprey – Oct 2017)
VIRTUE: PHOTOS OF SOME EXISTING SYSTEMS

A 200KW – Built into a room
(South Staff Council– August 2017)
Supporting Town Hall and Data Centre

A 50KW – Built into a room
(Retailer – March 2016)
VIRTUE: PHOTOS OF SOME EXISTING SYSTEMS

A 1MW – Stoba Internationale (Component Manufacturer)

A 350KW – Council (Data Centre and Administration Building)
Left unbranded at the customers request)
VIRTUE: INSTALLATION TIMELAPSE VIDEO

https://www.youtube.com/watch?v=4Iyi4b0l_Co&feature=youtu.be
DEPLOYMENT OF POWERSTAR VIRTUE (UK)

Powerstar has deployed its VIRTUE energy storage solutions into a variety of sectors across the United Kingdom including:

- Retail
- Manufacturing
- Leisure
- Distribution/Logistics

Due to its bespoke nature, it can provide a multitude of benefits including enhanced supply resilience, maximisation of existing generation assets, cost savings and carbon emission reductions.

Powerstar has in excess of 75% of BESS in the UK for Behind the Meter Clients.
PLEASE LET US KNOW HOW WE CAN HELP YOU FURTHER

www.powerstar.com