The Smarter Network Storage Project

Dr. Panos Papadopoulos, June 2nd 2015
UK Power Networks – An Introduction

<table>
<thead>
<tr>
<th>Category</th>
<th>Total</th>
<th>% of Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>End Customers Millions</td>
<td>8.1</td>
<td>28%</td>
</tr>
<tr>
<td>Service Area km²</td>
<td>29,250</td>
<td>12%</td>
</tr>
<tr>
<td>Underground Network km</td>
<td>139,000</td>
<td>29%</td>
</tr>
<tr>
<td>Overhead Network km</td>
<td>46,500</td>
<td>15%</td>
</tr>
<tr>
<td>Energy Distributed TWh</td>
<td>84.8</td>
<td>28%</td>
</tr>
<tr>
<td>Peak Demand MW</td>
<td>16,229</td>
<td>N/A</td>
</tr>
<tr>
<td>New Connections</td>
<td>130,768</td>
<td>35%</td>
</tr>
</tbody>
</table>

One of the largest electricity distributors in the UK

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UK Power Networks’ Innovation Portfolio (large projects)
DOE Global Energy Storage Database

Global Project Installations Over Time

3.55 GW
599 Projects

Limited incentives for storage exist in UK and EU markets compared to other geographies…

- Californian mandate for 1.3GW of grid-connected storage by 2020
- Japanese subsidy programme for battery-based storage for residential and commercial, covering up to 2/3 of cost
- EU lags some other geographies for storage incentives, with just some isolated schemes:
  - E.g. Germany: Exemptions from grid tariffs for new storage; subsidies for residential-scale storage when paired with solar panels
  - E.g. Italy: Specific decree for TSO to install storage, resulting in targeted strategy for significant energy storage investment
### STORAGE OFFERS A WIDE RANGE OF APPLICATIONS* TO SUPPORT THE CARBON PLAN...

<table>
<thead>
<tr>
<th>Use-Case / Value stream of Services from Storage</th>
<th>TSO</th>
<th>DNO</th>
<th>Supplier</th>
<th>Generator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real-time management of power quality. Active and reactive power support</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short-term and seasonal support of intermittency challenges – Frequency Response, reserves/ancillary services markets. Smoothing renewable generation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak shifting of daily demand-spikes Deferring or avoiding reinforcement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy arbitrage and trading opportunities Reducing imbalance risk.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Value not maximised, leaving individual business cases less viable

…but simultaneous access to a number of markets is challenging under current UK market and regulatory frameworks.

- Existing UK trials have only explored technical viability and network impacts for a single industry ‘silo’
- Business models for leveraging full-system value remain un-tested

* US DOE lists 27 Use Cases
The Smarter Network Storage Project

- £13.2m LCN funding awarded in Nov 2012
- £4.0m investment by UK Power Networks

Location: Leighton Buzzard
Energy capacity: 10 MWh
Real power: 6 MW
SNS Key aims & learning outcomes

- Demonstrate multi-purpose application of storage – sharing learning on the realisable benefits
- Develop novel optimisation & control systems for storage
- Provide insight & assess viability of multiple business model variants
- Assess regulatory & legal barriers, develop recommendations & commercial arrangements for operation
- Deployment & operation of large-scale battery energy storage – adding to body of learning for DNOs
## Functions of SNS

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peak Shaving</strong></td>
<td>SNS uses its stored energy to meet peak demand which reduces the load on the network. This defers the need for network reinforcement to meet peak demand.</td>
</tr>
<tr>
<td><strong>Frequency Regulation</strong></td>
<td>SNS can regulate the grid frequency through power exchanges. This assists National Grid in stabilising the frequency of the wider electricity system.</td>
</tr>
<tr>
<td><strong>Reactive Power Support</strong></td>
<td>SNS has 7.5MVAR of reactive power capability. Reactive power can help improve power factor, reduce losses and support voltage levels on the local network.</td>
</tr>
<tr>
<td><strong>Reserve</strong></td>
<td>SNS provides reserve capacity and can be triggered remotely to export power. This assists National Grid in balancing electricity demand and supply.</td>
</tr>
<tr>
<td><strong>Tolling</strong></td>
<td>SNS can provide energy based on a given energy delivery profile. This can be used to manage imbalance risk and assist in hedging against peak electricity prices.</td>
</tr>
</tbody>
</table>
How does SNS Support the Network?

Power Station

Transmission Network

Distribution Network

Leighton Buzzard 33/11kV Substation

Leighton Buzzard SNS

The electricity demand may exceed the capacity of one of the overhead lines during peak demand periods. By injecting the stored energy, SNS can help meet the electricity demand and reduce the load on the overhead lines. This avoids the need for traditional network reinforcement to meet peak demand.
The SNS smart optimisation and control system is a novel platform that schedules the energy storage to be utilised for a range of different applications, optimising value whilst ensuring network security is maintained.
## First Quarter Performance

<table>
<thead>
<tr>
<th>Application / Service</th>
<th>Availability / Requirements</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Shaving</td>
<td>24 days (72HH) with deviations over firm capacity experienced; Peak Power 3.2MVA; Peak Energy 5.41MVAh</td>
<td>Support provided. No N-1 outages requiring despatch.</td>
</tr>
<tr>
<td>TRIAD</td>
<td>TRIAD periods announced: 1) 4th Dec 14, 17:30 2) 19th Jan 15, 17:30 3) 2nd Feb 15, 18:00</td>
<td>1/3 TRIADS covered: 1) Idle for investigations 2) Idle for investigations 3) Peak export of 1600kWh</td>
</tr>
<tr>
<td>STOR</td>
<td>April Committed Season 1 for 2015: Weekday: 7:00 – 13.30; 19:00 – 22:00  Weekend: 10:00 – 13:30; 19:30 – 22:00</td>
<td>~100% 3MW Availability for 222.5 hours. 0 despatch calls</td>
</tr>
</tbody>
</table>
Other Learning Outputs

Consultation on possible future business models for grid-scale energy storage
July 2013

Design & planning considerations for grid-scale storage
October 2013

Design & Architecture of Optimisation & Forecasting platform
December 2013

GB Regulatory and Legal barriers for energy storage
June 2014

Commercial Arrangements for the shared use of storage flexibility
October 2014

Energy Storage as an Asset – Asset management, training and commissioning
May 2015

Recommendations for regulatory & legal amendments for storage
September 2015

Energy storage contribution to Security of Supply, and effect on standards
January 2016

Evaluation of value streams, business model viability
March 2016

More Information available at:
http://innovation.ukpowernetworks.co.uk/innovation
ED1 Challenges

Final Determination

<table>
<thead>
<tr>
<th>DNO</th>
<th>DPCRS totex**</th>
<th>Fast-track submitted totex</th>
<th>Slow-track final submitted totex</th>
<th>DPCRS final totex</th>
<th>Slow-track final totex</th>
<th>Ofgem’s view of slow-track fd allowance*</th>
<th>Difference between st submitted and fd allowance*</th>
<th>Difference between dd and fd allowances*</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENWL</td>
<td>1,949</td>
<td>1,900</td>
<td>1,876</td>
<td>1,794</td>
<td>1,808</td>
<td>1,85</td>
<td>-2.7%</td>
<td>1%</td>
</tr>
<tr>
<td>NPCN</td>
<td>1,307</td>
<td>1,365</td>
<td>1,368</td>
<td>1,243</td>
<td>1,230</td>
<td>1,25</td>
<td>-7.6%</td>
<td>1%</td>
</tr>
<tr>
<td>NPWWY</td>
<td>1,771</td>
<td>1,859</td>
<td>1,805</td>
<td>1,685</td>
<td>1,657</td>
<td>1,64</td>
<td>-6.1%</td>
<td>0%</td>
</tr>
<tr>
<td>LPN</td>
<td>1,762</td>
<td>1,968</td>
<td>1,970</td>
<td>1,749</td>
<td>1,704</td>
<td>1,71</td>
<td>-10.1%</td>
<td>1%</td>
</tr>
<tr>
<td>SPN</td>
<td>1,827</td>
<td>1,897</td>
<td>1,872</td>
<td>1,710</td>
<td>1,673</td>
<td>1,72</td>
<td>-8.0%</td>
<td>0%</td>
</tr>
<tr>
<td>EPN</td>
<td>2,753</td>
<td>2,861</td>
<td>2,775</td>
<td>2,537</td>
<td>2,457</td>
<td>2,56</td>
<td>-8.6%</td>
<td>0%</td>
</tr>
<tr>
<td>SPD</td>
<td>1,581</td>
<td>1,740</td>
<td>1,563</td>
<td>1,519</td>
<td>1,505</td>
<td>1,52</td>
<td>-2.8%</td>
<td>0%</td>
</tr>
<tr>
<td>SDNW</td>
<td>1,908</td>
<td>2,220</td>
<td>1,924</td>
<td>1,687</td>
<td>1,581</td>
<td>1,66</td>
<td>-13.4%</td>
<td>2.2%</td>
</tr>
<tr>
<td>SSEH</td>
<td>988</td>
<td>1,230</td>
<td>1,210</td>
<td>1,097</td>
<td>1,092</td>
<td>1,121</td>
<td>-7.4%</td>
<td>2.2%</td>
</tr>
<tr>
<td>SSEES</td>
<td>2,264</td>
<td>2,490</td>
<td>2,425</td>
<td>2,301</td>
<td>2,304</td>
<td>2,334</td>
<td>-3.7%</td>
<td>1.4%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>18,120</td>
<td>19,531</td>
<td>18,788</td>
<td>17,321</td>
<td>17,011</td>
<td>17,455</td>
<td>-7.1%</td>
<td>0.8%</td>
</tr>
</tbody>
</table>

Our final business plans include spending until 2023:
South-Eastern Power Networks, £1.71 billion
Eastern Power Networks £2.54 billion
London Power Networks £1.75 billion

**Important cuts!**

**Improved Efficiency**

**Increased Network Reliability**

**Identify Areas of Cost Reduction**
Network Innovation Allowance funding

**Strategy** Themes that aim to deliver tangible benefits fast

### Innovation Themes

- **Unit-cost challenge**
  - Cables, Transformers, Switchgear, etc

- **Impact on Planning and Operation, etc**
  - Electric Vehicles, Heat Pumps, etc

- **Asset Condition**

- **DG and Load**

- **Faulk and LV Network Design**

- **Volume challenge**
  - Overhead Lines, Transformers, Switchgear, etc

- **OHD Lines and Transformers Rating FCL SmartWire, etc**

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UKPN Innovation Strategy

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Challenges - Energy Storage from a DNO Perspective

• Energy pricing: visibility and forecasting
• Huge amounts of data from over 50,000 cells (higher number than our substations!), is data analytics/pattern recognition/predictive maintenance a way forward?

Challenges - General

• Probabilistic/Risk based planning with evolving P2/6 – Composition of load/generation profiles based on location (i.e. contribution to security of supply, ii. maximisation of capacity)
• Real-time forecasting, online state estimation/load flow
• Mechanisms for/Coordinated Voltage Control in LV/HV from DER with power electronics converters (“avoiding hunting” and interacting with existing systems-e.g. AVC)
• Optimisation of normally open points
• Smart metering data
Thank you

- For your attention
- to Nick Heyward, Ian Cooper, Jordi Ros, John Hayling, Paresh Mehta, Jose Barros and Sotiris Georgiopoulos for some of the material, the SNS project partners, and all the people that dedicated over 46,000 man-hours to build the ESS

http://www.ukpowernetworks.co.uk/innovation