The Voice of the Networks

Smart Grid Forum
WS3 Seminar

Completion of the Transform Model® and Least-Regrets Network Investments.
Introduction & Welcome

Hannah Nixon - Senior Partner, Distribution, Ofgem
## Agenda

<table>
<thead>
<tr>
<th>Topic</th>
<th>Speaker</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductions and Welcome</td>
<td>Hannah Nixon, Ofgem</td>
<td>1100</td>
</tr>
<tr>
<td>Development of Transform and WS3</td>
<td>Steve Johnson, Electricity North West</td>
<td>1110</td>
</tr>
<tr>
<td>Brief overview of Transform</td>
<td>Dave Roberts, EATL</td>
<td>1130</td>
</tr>
<tr>
<td>Findings from Transform</td>
<td>Dave Roberts, EATL</td>
<td>1200</td>
</tr>
<tr>
<td>Lunch</td>
<td></td>
<td>1245</td>
</tr>
<tr>
<td>DNO experience of using Transform</td>
<td>Roger Hey, WPD</td>
<td>1330</td>
</tr>
<tr>
<td>Inclusion of Emerging Technologies</td>
<td>John Parsons, BEAMA</td>
<td>1350</td>
</tr>
<tr>
<td>Governance of Transform and Emerging</td>
<td>Roger Hey, WPD</td>
<td>1405</td>
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<tr>
<td>Technologies</td>
<td></td>
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<tr>
<td>WS7 – an introduction</td>
<td>Gareth Evans, Ofgem</td>
<td>1425</td>
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<tr>
<td>IET Power Network Joint Vision work</td>
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<tr>
<td>Summary and Q&amp;A</td>
<td>Steve Johnson, Electricity North West</td>
<td>1455</td>
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</table>
The Development of Transform

Steve Johnson
Smart Grid Forum

• Set up by DECC and Ofgem in 2011

• Forum for initiating cross sector discussion and changes associated with the move to smart grids as a response to the 2030/2050 energy challenges

• A successful first two years; future of the Forum will be reviewed at its January 2013 meeting
Workstreams

• 1 – Assumptions and Scenarios – led by DECC
  – Suite of scenarios for heat pumps, electric vehicles, solar PV and wind generation delivered December 2011. Have had minor revisions since – but no significant changes

• 2 – Evaluation Framework – led by Ofgem
  – Economic model developed and published June 2012. Economic model also incorporated in WS3 model.

• 3 – Developing Networks for low carbon – led by DNOs
  – Phase 1 report published October 2012; Phase 2 – the Transform model and report published July 2013.

• 4 – Closing Doors
  – Watching brief on policy developments – particularly active in smart metering development
Workstreams - continued

• **5 – Ways of Working**
  – Concerned with overall dissemination and retention of smart grid knowledge

• **6 – Commercial and Regulatory**
  – WS6 very influential in the development of Ofgem’s RIIO ED1. Now turning its attention to the future rôle of the DNO and the legal, regulatory and commercial aspects of it.

• **7 – Technical Development of WS3**
  – Detailed technical modelling of the proposed smart grid. Ensuring that we build a distribution system for 2030 that works.
The Transform Model

- The key output from WS3

- Probably the most comprehensive economic model of the distribution system that has ever been built

- Used by Ofgem and the DNOs to inform and evaluate the RIIO ED1 price control review submissions

- Critical to helping understand the economic case for smart grids and what the likely benefits should be
Why consider modelling

Legal obligations to reduce carbon; which can be achieved via several different mechanisms

Each has specific implications on Distribution networks, these networks are long life; so need careful consideration to avoid wasted investment

Lots of new options to manage; how do you pick the right one, at the right time

And ultimately, how much will it all cost us
Where did it come from

Background Work

WS3 (Phase 1)

WS2

WS3 (Phase 2)

WS3 (Phase 3)

Today

Pre 2010

Sept 2011 – Feb 2012

Jan-Jul 2012

Oct 2012 – Mar 2013

Stand-alone spreadsheet models

Transform v1.0.0

Transform Model®

Transform v4.0.0
An uncertain world: Different mixes of large-scale generation will place different challenges on the conventional network design and operation

Installed capacity: medium decarbonisation scenario

Source: Redpoint analysis for the ENA, based on National Grid ‘Gone Green’ scenario

Installed capacity: low decarbonisation scenario

Source: Redpoint analysis for the ENA based on National Grid ‘Slow Progress’ scenario to 2030 and extrapolated to 2050
With disruptive technologies having scope to create significant challenge to LV networks

Residential HP : GB uptake scenarios
(number of units deployed - all sizes and types)

PV : GB uptake scenarios
(number of units deployed - all sizes and types)

EV : GB uptake scenarios by charging type
(number of units deployed - all sizes and types)

Source: SGF, WS1, DECC, Dec 2011

Heat Pumps
Photovoltaic
Electric Vehicles

Source: SGF, WS1, DECC, Dec 2011
PV uptake example

2002

PV = 0 MW

March 2013

PV = 1,600 MW

Source: FiTs Quarterly Update – Issue 12, 01/04/10-31/03/13, Ofgem E-Serve, June 2013
There are clear differences between the technologies adopted in different parts of the UK.

Regional breakdown of installed capacity by technology (MW)

Regional breakdown of current wind projects

Regional breakdown of Total Installed Capacity by technology (MW)

Source: FiTs Quarterly Update – Issue 12, 01/04/10-31/03/13, Ofgem E-Serve, June 2013
PV installations have clustered in different parts of GB

Regional Breakdown of PV installations

Source: www.azure.eco.co.uk

<table>
<thead>
<tr>
<th>Percentage of network</th>
<th>Percentage of low-carbon technology installations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>9%</td>
</tr>
<tr>
<td>4%</td>
<td>17%</td>
</tr>
<tr>
<td>25%</td>
<td>48%</td>
</tr>
<tr>
<td>30%</td>
<td>22%</td>
</tr>
<tr>
<td>40%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Source: FiTs Quarterly Update – Issue 12, 01/04/10-31/03/13, Ofgem E-Serve, June 2013
The ‘new’ low carbon technologies produce very different demand profiles.
2. Today’s Networks
Not all networks are equal: The headroom of the networks differ throughout GB

Factors include:

Build specification

Customer type and customer density

Local geography
There is no such thing as an ‘average’ network

Some of the more common network types

EHV

HV

LV

urban
suburban
rural

CBD
Town centre
suburban
Terrace
Rural
There is no such thing as an ‘average’ customer.

**BUILDING TYPE**
- Size
- Heat loss
- Glazing

**ENVIRONMENT**
- Temperature
- Solar Flux

**APPLIANCES/EQUIPMENT**
- Power Rating
  - On/Standby
- Efficiency
- Programme/Cycle

**USERS**
- Number
- Activity Profile
- Energy Efficiency
- Attitude

Individual Consumption Profile
Point load demand profiles differ according to in-home technology, geography and time of year

- Seasonal variations
- Weekday Vs Weekend
- Appliance Type & Efficiency
- Temperature Sensitivity

Temperature Sensitivity

Standard Tariff Domestic  Domestic E7 Storage Heaters  Domestic Heat Pump
Hence, the mix of customers along a feeder has a significant impact on its overall demand profile.
3. Solutions
Fixing the problem: Selecting solutions with an increasing solution set

‘Business-As-Usual’ Investment

Conventional Solutions

“Lumpy” - high upfront costs, minimal running costs, long lives, produce step change in headroom

‘Smart’ Investment

Smart Solutions

Conventional Solutions

Solution Enablers

“Flexible” - lower upfront costs, some running costs, shorter lifetimes, smaller impact on headroom
Two methods to release headroom

Demand constant
Increase capacity
Increase headroom
e.g. RTTR

Reduce demand
Capacity constant
Increase headroom
e.g. DSR
Outlining the solution options, and making the link to LCN Fund projects

- Refined ‘conventional’ solution set
- Expanded ‘smart’ solution set
- Agreed a common language
- Populated an initial digest of solutions

<table>
<thead>
<tr>
<th>Solution Category</th>
<th>Count</th>
</tr>
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<tbody>
<tr>
<td>Representative</td>
<td>23</td>
</tr>
<tr>
<td>Variants</td>
<td>98</td>
</tr>
<tr>
<td>Enablers</td>
<td>35</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>156</strong></td>
</tr>
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</table>
4. Modelling the combinations
Four scenarios, aligned with the 4th Carbon Budget, are modelled:

**Scenario 1**
“High Abatement in Low Carbon Heat”

**Scenario 2**
“High Abatement in Transport”

**Scenario 3**
“High Electrification of Heat & Transport”

**Scenario 4**
“Carbon Credit Purchase”
Three distribution network investment strategies

<table>
<thead>
<tr>
<th>Description</th>
<th>Key attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conventional investment strategy</strong></td>
<td>● Roll out of conventional technologies only, when required</td>
</tr>
<tr>
<td><strong>Incremental smart grid investment strategy</strong></td>
<td>● Roll out of smart and conventional technologies, and associated control and communications architecture when required</td>
</tr>
<tr>
<td><strong>Top-down smart grid investment strategy</strong></td>
<td>● Upfront investment in control and communications architecture ● Investment in smart and conventional technologies when required</td>
</tr>
</tbody>
</table>

- Solutions tend to be more ‘lumpy’ (capital-intense and release more headroom)
- Longer asset lives
- Investments occur only when required
- Shorter asset lives
- High early investment
- Shorter asset lives

The strategies determine the set of technologies available for deployment in each scenario

Under each scenario, technologies from each strategy will be deployed to fully accommodate supply and demand
Solutions deployed on the basis of...

..headroom breaches:

- **High Thermal limits**: Thermal limits of plant and circuits
- **High Volts**: Upper Statutory limits
- **Low Volts**: Lower Statutory limits
- **High Fault Level**: Design fault level limits
- **Power quality issues**: The model could be expanded to include PQ against EU standards
Two Models: Two different purposes

Two models have been developed under this project, to reflect the different levels of granularity between GB and a DNO licence.

*Transform™* is the supported framework developed by EA Technology to quantify the results described in the WS3-Ph2 report. It is available from EA Technology on a commercial basis; all funding Network Operators, DECC and Ofgem have a licence to use the software for future analysis.
Summary of the Transform Model®

A representation of the entire GB electricity distribution network and describes the impact future scenarios may have on existing those networks

A parameter-based model, which allows the network to be constructed of common elements

Is based on real data from distribution networks, local authorities, central government and a range of other sources

Can assess and optimise investment over a range of conventional and ‘smart’ strategies, and involving a wide range of solutions
Further Questions
Dave A Roberts
Future Networks Director
EA Technology Europe

e. DaveA.Roberts@eatechnology.com
t. 0151 347 2318
Findings from WS3 Ph3 & updates to the Transform Model®

Smart Grid Forum WS3 – Phase 3
14th October 2013

www.eatechnology.com
WS3-Ph3: A consortium-led approach on behalf of the GB Smart Grid Forum (Work Stream 3)

Project Partners:
- element energy
- Chiltern Power
- EA technology
- smarter grid solutions

Working with:
- ena energy networks association
- WESTERN POWER DISTRIBUTION
  Serving the Midlands, South West and Wales
- national grid
- SP ENERGY NETWORKS
- Scottish and Southern Energy
  Power Distribution
- UK Power Networks
- NORTHERN POWERGRID
WS3 Phase 3 – Key Conclusions

1. The Transform Model® has been significantly enhanced;
2. A material cost-benefit continues to be indicated by adopting innovative ‘smart’ technologies;
3. The model is broadly insensitive to specific solutions;
4. It is not a detailed ‘solution picker’, rather it should be used to inform strategic investment decisions;
5. A ‘Selective’ Top Down strategy is shown to be beneficial; commencing in ED2;
6. Incorporating Tipping Points gives a further predicted investment benefit of around £1 billion in Totex to 2050;
7. The deployment of innovative solutions in ED1 is expected to create material challenges;
8. Likely solutions appearing in ED1, their deployment numbers, and their ramping periods are identified.
1. The Transform Model® has been significantly enhanced

Scenarios
- Alignment to 4CB
- Scenario Regionalisation

Solution refinement
- Capex and Opex
- Optimism Bias
- Cost Curves
- New enablers/solutions
- Enabler Mapping
- ‘Selective’ Top-Down

Further modelling refinement
- Tipping Points
- Business Implications/timescales

Plus full and thorough input, review and agreement from ALL DNO’s
2. A material cost-benefit continues to be indicated by adopting innovative ‘smart’ technologies.

Present Value (PV) of Totex to 2050

Sc 1 – High abatement in LC Heat
Sc 2 – High abatement in Transport
Sc 3 – High elect of Heat & Transport
Sc 4 – Credit Purchase

NB. Costs are those associated with managing LCT update on the distribution networks only.
2. A material cost-benefit continues to be indicated by adopting innovative ‘smart’ technologies

The spread of (network related) investment remains significant

Spread of GB network related investment (non-discounted cumulative total showing the two most extreme scenarios) to accommodate projections in Low Carbon Technologies connecting to the GB electricity distribution network

NB. Costs are those associated with managing LCT update on the distribution networks only
3. The model is broadly insensitive to specific solutions

Sample Output of top solutions selected (Scenario 3 – smart incremental)

<table>
<thead>
<tr>
<th>Solution/Enabler</th>
<th>Times Deployed</th>
<th>Lifetime (years)</th>
<th>Network Coverage to 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV Circuit Monitoring (along feeder)</td>
<td>541,282</td>
<td>20</td>
<td>30%</td>
</tr>
<tr>
<td>LV Ground mounted 11/LV Tx</td>
<td>253,174</td>
<td>40</td>
<td>26%</td>
</tr>
<tr>
<td>Communications to and from devices - LAST MILE ONLY</td>
<td>463,580</td>
<td>20</td>
<td>26%</td>
</tr>
<tr>
<td>HV/LV Tx Monitoring</td>
<td>419,110</td>
<td>20</td>
<td>24%</td>
</tr>
<tr>
<td>LV feeder monitoring at distribution substation</td>
<td>395,700</td>
<td>20</td>
<td>22%</td>
</tr>
<tr>
<td>Permanent Meshing of Networks - LV Urban</td>
<td>211,875</td>
<td>45</td>
<td>22%</td>
</tr>
<tr>
<td>Permanent Meshing of Networks - LV Sub-Urban</td>
<td>118,992</td>
<td>45</td>
<td>12%</td>
</tr>
<tr>
<td>RTTR for HV/LV transformers</td>
<td>211,798</td>
<td>15</td>
<td>9%</td>
</tr>
<tr>
<td>Generator Providing Network Support - LV</td>
<td>598,573</td>
<td>5</td>
<td>8%</td>
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<tr>
<td>DSR - DNO to residential</td>
<td>151,553</td>
<td>5</td>
<td>2%</td>
</tr>
</tbody>
</table>

Notes
1. The deployment of ‘DSR – DNO to residential’ is DNO-triggered DSR for local feeder management purposes. The numbers are based on the number of feeders to which this solution is applied, not the number of household; it does not include DSR that may be applied by suppliers for system balancing purposes.
2. The table above shows the top ten solutions by volume (not cost or benefit) – it naturally therefore draws out solutions applied to the LV network. The GB version of Transform™ has c1m LV feeders
4. It is not a detailed ‘solution picker’, rather it should be used to inform strategic investment decisions

PV of Totex with various solutions “switched off”

NB. Costs are those associated with managing LCT update on the distribution networks only
5. A ‘Selective’ Top Down strategy (Based on Comms and DSR Products) is shown to be beneficial;

PV of Totex comparing various smart strategies

Recap from slide 6

NB. Costs are those associated with managing LCT update on the distribution networks only
5. A ‘Selective’ Top Down strategy is shown to be beneficial; commencing in ED2

PV of Totex comparing different investment timelines for the Selective* Top-Down strategy

*Uses the ‘Only Comms and DSR Products’ as part of the Top-Down investment

NB. Costs are those associated with managing LCT update on the distribution networks only
6. Incorporating Tipping Points gives a further predicted investment benefit of around £1bn in Totex to 2050

Without action at the tipping points

With action at the tipping points

Difference between the two graphs

NB. Costs are those associated with managing LCT update on the distribution networks only
7. The deployment of innovative solutions in ED1 is expected to create material challenges

Upper threshold represents worst case (BAU investment strategy; high electrification of heat & transport)

Best investment case for same scenario
8. Likely solutions appearing in ED1, their deployment numbers, and their ramping periods are identified

Business impacts and timeframes assessed:

5: Very High - the solution will impact on processes and systems within the business, requiring substantial intervention, including management involvement

4: High - the solution will have impact that will require significant intervention, including management involvement

3: Medium - the solution will have impact that can be readily managed

2: Low - the process for introducing solution change at the tipping point will have some impact on the processes and systems within the business

1: Very Low - the process for introducing solution change at the tipping point will have limited impact on the processes and systems within the business

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<tr>
<td>Permanent Meshing - LV Urban</td>
<td></td>
<td>Trigger</td>
<td></td>
<td></td>
<td>Tip</td>
<td></td>
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<td>Permanent Meshing - LV Sub-Urban</td>
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<td>Trigger</td>
<td></td>
<td></td>
<td>Tip</td>
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<tr>
<td>RTTR for HV/LV transformers</td>
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<td>Trigger</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Trigger</td>
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<tr>
<td>Switched capacitors – LV</td>
<td>Trigger</td>
<td>Tip</td>
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<tr>
<td>Communications - LAST MILE ONLY</td>
<td>Trigger</td>
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<td></td>
<td>Tip</td>
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<tr>
<td>DSR - Products remotely control loads</td>
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<td></td>
<td></td>
<td>Trigger</td>
<td></td>
<td></td>
<td>Tip</td>
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</table>
8. Likely solutions appearing in ED1, their deployment numbers, and their ramping periods are identified

<table>
<thead>
<tr>
<th>Smart Solution</th>
<th>Year First Deployed</th>
<th>Tipping Point Year</th>
<th>Ramping Period</th>
<th>Capex ED1 £M</th>
<th>Capex ED2 £M</th>
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<tr>
<td>Communications - LAST MILE ONLY</td>
<td>2013</td>
<td>2017</td>
<td>4</td>
<td>17</td>
<td>135</td>
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<tr>
<td>Switched capacitors - LV</td>
<td>2015</td>
<td>2017</td>
<td>2</td>
<td>34</td>
<td>0</td>
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<tr>
<td>LV Circuit Monitoring (along feeder)</td>
<td>2015</td>
<td>2025</td>
<td>10</td>
<td>8</td>
<td>82</td>
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<tr>
<td>Generator Network Support - LV</td>
<td>2017</td>
<td>2025</td>
<td>8</td>
<td>2</td>
<td>129</td>
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<td>HV/LV Tx Monitoring</td>
<td>2017</td>
<td>2027</td>
<td>10</td>
<td>1</td>
<td>32</td>
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<td>Permanent Meshing - LV Urban</td>
<td>2018</td>
<td>2018</td>
<td>0</td>
<td>38</td>
<td>99</td>
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<td>RTTR for HV Overhead Lines</td>
<td>2019</td>
<td>2025</td>
<td>6</td>
<td>3.4</td>
<td>61</td>
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<td>EHV Circuit Monitoring</td>
<td>2019</td>
<td>2026</td>
<td>7</td>
<td>1.6</td>
<td>27.5</td>
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<tr>
<td>Permanent Meshing - LV Sub-Urban</td>
<td>2020</td>
<td>2020</td>
<td>0</td>
<td>69</td>
<td>750</td>
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<td>RTTR for HV/LV transformers</td>
<td>2022</td>
<td>2024</td>
<td>2</td>
<td>2.5</td>
<td>87</td>
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<tr>
<td>DSR - Products remotely control loads</td>
<td>2022</td>
<td>2022</td>
<td>0</td>
<td>33</td>
<td>202</td>
</tr>
<tr>
<td>DSR - DNO to residential</td>
<td>2022</td>
<td>2030</td>
<td>8</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Generator Network Support - HV</td>
<td>2022</td>
<td>2029</td>
<td>7</td>
<td>1.4</td>
<td>29</td>
</tr>
<tr>
<td>Temporary Meshing - HV</td>
<td>2022</td>
<td>2025</td>
<td>3</td>
<td>4</td>
<td>42</td>
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<tr>
<td>Advanced control systems - HV</td>
<td>2022</td>
<td>2025</td>
<td>3</td>
<td>1</td>
<td>12.5</td>
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<td>RMUs Fitted with Actuators</td>
<td>2022</td>
<td>2025</td>
<td>3</td>
<td>2</td>
<td>21</td>
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<td>Dynamic Network Protection 11kV</td>
<td>2022</td>
<td>2024</td>
<td>2</td>
<td>3</td>
<td>31</td>
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<tr>
<td>RTTR for EHV/HV transformers</td>
<td>2027</td>
<td>2029</td>
<td>2</td>
<td>0</td>
<td>61</td>
</tr>
<tr>
<td>RTTR for HV Underground Cables</td>
<td>2029</td>
<td>2029</td>
<td>0</td>
<td>0</td>
<td>14</td>
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</tbody>
</table>
8. Likely solutions appearing in ED1, their deployment numbers, and their ramping periods are identified

- **RIIO-ED1**
  - First deployment of solution or enabler: Fewer new solutions but a ramp up in deployment – capital implications
  - Total number of deployments*: 16,000 - 42,000
  - Trigger points reached
  - Tipping points reached
  - Relatively small number of trigger and tipping points reached, but done for the first time – resourcing impact

- **RIIO-ED2**
  - First deployment of solution or enabler: Fewer new solutions but a ramp up in deployment – capital implications
  - Total number of deployments*: 350,000 - 900,000
  - Trigger points reached
  - Tipping points reached
  - Large number of solutions hitting trigger and tipping points – resourcing impact

*Deployment numbers based on GB figures for the ‘Selective Top Down’ investment strategy and the two extreme scenarios (Credit Purchase and High Electrification of Heat & Transport)
WS3 Ph3 Recommendations

**Strong cost benefit** in adopting a smart investment strategy of the order of 25-30% to 2050;

Conclusions **not sensitive to any one individual smart solution**;

Tipping Point analysis provides early warning to DNOs for preparation for specific smart solutions;

Investment benefits can be obtained through implementing a “Selective” Top Down strategy where only the enablers required for the top-ranked solutions are deployed.

Model outputs will continue to improve as more information is known.
Model refinements: Ofgem Cost Benefit Analysis alignment

- Refinements to the economic model
- Ensures consistency with current Ofgem methodologies
- Agreed between DNOs and Ofgem June 2013
- Implemented July-August 2013

<table>
<thead>
<tr>
<th>Summary of updates to CBA* guidance Parameter</th>
<th>Impact on outputs (financial, solutions selected etc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBA period extended to 45 years</td>
<td>Increased expenditure (due to longer time to accumulate spend)</td>
</tr>
<tr>
<td>Price base moved forward to 2012/13</td>
<td>3.6% increase in expenditure</td>
</tr>
<tr>
<td>Base year moved to 2015</td>
<td>3.6% increase in expenditure</td>
</tr>
<tr>
<td>Depreciation calculation start 1 year after invest</td>
<td>Slight reduction in annualised cost</td>
</tr>
<tr>
<td>Conversion of capital costs to annual costs recovered through customers bills</td>
<td>Nil to existing outputs</td>
</tr>
<tr>
<td>Capitalisation assumptions</td>
<td>Negligible</td>
</tr>
<tr>
<td>Financial benefits in year 1 (no benefits in year 0)</td>
<td>Very Low</td>
</tr>
<tr>
<td>Discount rate 3.5% falls to 3% in year 30</td>
<td>Low</td>
</tr>
<tr>
<td>Overall Impact</td>
<td>awaiting feedback</td>
</tr>
</tbody>
</table>

CBA – Cost Benefit Analysis
Updated results following the completion of the Ofgem CBA work

Present Value (PV) of Totex to 2050

- Sc 1 – High abatement in LC Heat
- Sc 2 – High abatement in Transport
- Sc 3 – High elect of Heat & Transport
- Sc 4 – Credit Purchase

NB. Costs are those associated with managing LCT update on the distribution networks only
Updated results following the completion of the Ofgem CBA work

The spread of (network related) investment remains significant

Spread of GB network related investment (non-discounted cumulative total) showing the two most extreme scenarios to accommodate projections in Low Carbon Technologies connecting to the GB electricity distribution network

NB. Costs are those associated with managing LCT update on the distribution networks only
Further Questions
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EA Technology Europe

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LUNCH
Roger Hey
Western Power Distribution
Using Transform

- GB and Licence models – key differences
- Configuration of Licence model with DNO data
- Initial testing and improvements
- Overall assessment of Transform
- Limitations of Transform
- Model sensitivities
- Informing RIIO ED1 Business Plans
- Conclusions
Transform is available in two variants

A GB model
- Uses DECC scenarios only
- Limited configuration
- Basic consideration of generation, transmission and supply

A licence area model requiring user customisation
- Allows development of DNO specific analysis based on “best view’’ LCT scenarios
- Highly configurable to allow best representation of DNO networks (by licence or more granular if needed – eg. a city)

Both variants are a long-term strategic tool
- looking at the bigger picture – out to 2050.
- therefore not so well suited to shorter-term analysis - i.e. near term <8 year period) although it can do it.
Installation and configuration

- Transform is a tool for expert users
  - Complex Excel interface
  - Few notes or user guidance
  - Limited input validation

- Licence area models need to be configured to provide an approximation of a DNO network:
  - Network Details,
  - Network Topologies
  - Starting Capacities

- Many DNOs requested additional support from EATL to assist with configuration
Initial testing and improvements

- Accelerated development timescales involved DNO users identifying bugs and change requirements
  - Eg, validation errors; double counting of results; Inconsistent results
  - Favoured DSR heavily – led to a review of DSR cost assumptions
  - Required wide scale deployment of many enablers – led to a review of solution/enabler mapping
- Consequently frequent software releases created an additional variable for DNOs to consider when analysing results
- A complex model requiring expert users:
  - Requires detailed “drill down” to see where solutions are deployed
  - Difficult to see year on year expenditure by solution, requiring back calculations
- Transform has proven itself as a highly configurable tool
Overall Assessment of Transform

- The model will forecast plausible expenditure plans based on Low Carbon Technology uptake scenarios.
- The model results change in a predictable manner with adjustments to inputs (e.g., turning off solutions).
- Feeder types across all DNO networks can be represented adequately by a small number of generic networks (with only a few exceptions).
- Methodology used robust enough to allow further development.
  - Eg. to handle new generic feeder types, for example feeders which in the future may be classified as “LCT loaded” or those which already have smart solutions deployed.
Limitations of Transform

- Transform is a parametric model with simplified analysis of thermal and voltage constraints
  - Ignores power quality; simplistic approach to network balance; simplistic fault level assessment
- Not all network voltages are well represented by the model.
  - Eg. 20kV; island networks; clustering of embedded DG at HV/EHV; major urban centres
- Assumptions need to be understood before drawing conclusions
  - Eg. New networks assumed to be “fit and forget” (ie: LCT ready)
- Some workarounds needed for results to be plausible
  - Eg. Year 0 investment cost treatment
- Engineering judgment needed for result interpretation
  - Eg. Meshing of tapered networks
Model sensitivities

- Transform is highly sensitive to small changes in some variables
  - Some obvious – like solution costs
  - Some not – eg. apportionment of HV feeders to EHV; apportionment of LV rural feeder types, apportionment of LCT uptake to LV feeder types

- The model outputs are only as good as its solution and enabler inputs.
  - Costs
  - Effectiveness
  - Time to deployment
  - Solutions not yet invented!

- Network starting capacities required adjustment to get plausible results
Informing ED1

• Transform was used by all DNOs to inform ED1 plans
• But no direct read across from Transform to DNO business plans
  • Complementary external studies
  • Additional in house modelling
  • Stakeholder engagement
• Ofgem also has a Transform Licence allowing the sharing of some network parameters and results
• Workarounds were needed to allow any comparison of ED1 numbers and Transform outputs (change in approach since WS3 subsequently incorporated into the software)
Conclusions

• Assisted in production of RIIO ED1 plans through the creation of an envelope for future investments, using industry “best view” of smart solutions and enabler.

• The development of Transform was a research and development activity (low “TRL”).

• It will be further evolved (e.g., tuned from feedback from LCNF and Supply Chain).

• However, it is the most comprehensive investment model for distribution networks ever developed.

• Workstream 7 will provide a sense check of results.

• Some Low Carbon Network Fund projects are developing detailed planning systems (NPADDS; SIM).
Inclusion of Emerging Technologies
John Parsons, Deputy Director
BEAMA Power Sector
19th Oct 2013
BEAMA Response to TRANSFORM

• **Strategic viewpoint of manufacturers**
  • Manufacturers share an interest in the reinforcement of the grid being affordable and acceptable to the public and other stakeholders
  • Manufacturers want smart grid analysis tools to be accurate so that their products can compete fairly
Where we are now

- **Industry sees risks and issues**
  - Difficult to reveal cost data
    - Products and systems not well defined
    - Giving away competitive position and setting market expectations on price
    - Not always easy to access necessary expertise
  - Results not always as expected
  - Potential for a lot of work for uncertain benefit
  - Uncertainty over long term value of Transform

- **BEAMA role**
  - Has been working to assist industry input to TRANSFORM
  - Acting to facilitate discussion between stakeholders and build confidence in TRANSFORM
Future Work

• **Continue to Clarify the purpose and role of TRANSFORM**
  • Not a purchasing or design tool
  • Intended to set strategic direction

• **Work with stakeholders to develop ongoing support process for TRANSFORM**
  • How to integrate new products and:
    – Align products at different development levels
    – Avoid TRANSFORM becoming a barrier to new products

• **Work with stakeholders to support TRANSFORM:**
  • Update solutions and input data
  • Validate model against trial output data
  • Interpret model outputs
Governance of Transform

Roger Hey
Western Power Distribution
Governance - WS3 model and datasets

The models outputs are only as good as the models inputs

Where refinements in the input datasets are likely to come from:

- National scenario dataset(s)
  - WS1 (DECC)
  - DNOs
  - Other datasets (FiT, RHI, DfT, etc)

- Feeder loads
  - DNOs (specific analysis / LCN Fund projects)

- Point loads
  - OEMs
  - Specific analysis (e.g. HP, EV operating regime)
  - DNOs (LCN Fund projects)

- GB regionalisation
  - WS1 (DECC)
  - DNOs
  - Other datasets (FiT, RHI, DfT, etc)

- Smart Solutions
  - DNOs (LCN Fund projects)
  - OEMs

- Smart Enablers
  - OEMs
  - Other (Smart Metering / DCC contract / LCN Fund projects)
## What’s covered by Governance

<table>
<thead>
<tr>
<th>What</th>
<th>The Model</th>
<th>GB dataset</th>
<th>GB DNO licence specific datasets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transform™ (the modelling platform used for WS3-Ph2)</td>
<td>All ‘vanilla’ datasets contained in the model specific for the GB</td>
<td>The DNO tailored datasets (e.g. network data, company specific adjustments, etc)</td>
</tr>
<tr>
<td>Who</td>
<td>EA Technology</td>
<td>SGF (WS3 to lead)</td>
<td>Individual DNO licence holders</td>
</tr>
<tr>
<td>Responsible for..</td>
<td>Maintenance and mechanics of the modelling platform and software coding. Version control of model(s)</td>
<td>Agreement of the input datasets, through a formal process</td>
<td>Tweaking the DNO models to suit individual licence requirements</td>
</tr>
<tr>
<td>Duration</td>
<td>In perpetuity</td>
<td>For as long as required</td>
<td>For as long as required</td>
</tr>
</tbody>
</table>

### Version: Trunk. Minor. Dataset

- **Major coding change**
- **Minor coding change**
- **Change to the model data**

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- Governance
- Warranty
- Business Case
Governance – Progress to Date

Website live Nov 2012 - http://www.eatransform.com/
Observations from Period 1

• All DNO’s using the model as part of RIIO-ED1 planning
  • A lot more individual users..
  • ..and a large number of specific direct queries
• A number of changes from the SGS and GS work
• DECC revised their datasets for DG and EVs (WS1)
• A separate meeting held with BEAMA
  • Contributions expected in the next Governance review period
• The overlap of the current Governance period with ED1 planning timescales may have resulted in only the most immediate changes being requested.
Observations from Period 2

- Several areas where the model has already been updated - Rigorous version control in place
- Three areas outstanding from Ph1 (cost benefit analysis underway)
- Suggestion received through the website to look at the load profiles in the model for commercial and domestic loads
- Currently under review by WS3 members
Review process

Who: WS3 panel
Why: A broad range of stakeholders
How long: Fortnight (with a conference call at the end)
An iterative process with evidence from innovation trials will improve the evidence base – version control in place

- A total of 45 separate variables in the model
- As more information comes to light, the model output will be improved
- For example:
  - LV network parameters
  - LCT profiles, e.g. electric vehicle charging profiles
  - Solution costs & benefits
2030 Electricity Distribution

- By 2030 - fundamental changes in the way we operate the electricity supply chain
- We are moving from a system where a relatively small number of active devices are able to securely control the system to one where potentially millions of active devices will have to work together and still deliver a secure, stable system. There is no precedent for this anywhere in the world
- This is a ‘whole system’ challenge
- However, it is proposed that there is a specific challenge to better understand the role that distribution systems will play
- This will require modelling in detail (i.e. actual power flows in a nodal system model) the performance of typical LV, HV and EHV networks using DECC’s 2030 scenarios to establish with more confidence that network development options used in the WS3 model will deliver the outcomes we expect.
### The situation today

<table>
<thead>
<tr>
<th>Large Generators</th>
<th>Transmission</th>
<th>Distribution</th>
<th>Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 2000 BMUs</td>
<td>Smart transmission network</td>
<td>Essentially passive network</td>
<td>Essentially uncontrolled demand</td>
</tr>
<tr>
<td>&lt;25% of BMUs take well over 50% of balancing volume</td>
<td>Growing penetration of DG</td>
<td></td>
<td>Minimal generation or customer engagement</td>
</tr>
<tr>
<td>Most BMUs controllable</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Active network**
- **Passive network**
- **Uncontrolled**
### The situation in 2030?

<table>
<thead>
<tr>
<th>Large Generators</th>
<th>Transmission</th>
<th>Distribution</th>
<th>Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of BMUs?</td>
<td>Smart network</td>
<td>Active/Smart network</td>
<td>Controlled</td>
</tr>
<tr>
<td>Very significant intermittent generation</td>
<td>Greater international interconnection</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Significant offshore connections</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### The Challenge

What will this network look like and how will it transition from today's network?

- Millions of controllable loads
- Millions of small generators
- Increased demand

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The situation in 2030? (WHOLE SYSTEM ISSUE)
WS7 – Digging Deeper

- WS7 is a natural progression of the work completed by WS2 and WS3
- WS2 offered a high level view of the relative costs of ‘smart’ and ‘BAU’ network development options
- WS3 dramatically increased the granularity of the WS2 work – but did not consider the operational viability of the solutions proposed
- WS7 ‘digs deeper’ to explore network operational issues using nodal models
The WS7 study is intended to carry out the technical analysis necessary to confirm how the network described by the Transform outputs will be realised. This will both confirm its technical viability and provide an understanding of its characteristics, for example to identify what control co-ordination may be required to ensure reliable and robust whole-system operation. Most importantly, it will highlight any new roles and responsibilities that a DNO will be required to accept from a largely technical perspective.
Phase 1 nearing completion
Participants

• Led by the WS3 ‘team’
• Academia (EPSRC’s HubNet team) actively involved
• Strong linkages with the IET’s Power Networks Joint Vision initiative
• Ofgem and DECC members of the steering group
• Intention to engage third party resources for Phase 2
Timetable

• Study approved by the SGF in April 2013
• Phase 1 to be completed for next SGF meeting on 22 October
• With SGF support, Phase 2 will commence and is expected to be completed by April 2014
• The focus on dissemination will continue
Thank you for your attention

Questions?
Ofgem is the Office of Gas and Electricity Markets.

Our priority is to protect and to make a positive difference for all energy consumers. We work to promote value for money, security of supply and sustainability for present and future generations. We do this through the supervision and development of markets, regulation and the delivery of government schemes.

We work effectively with, but independently of, government, the energy industry and other stakeholders. We do so within a legal framework determined by the UK government and the European Union.
Power Networks Joint Vision
An IET Expert Group

Smart Grid Forum WS3 Dissemination
Event 14th October 2013
Power Networks Joint Vision

PNJV’s Context

- Transformational change is ahead
- It spans Transmission, Distribution, Consumers, and wider society
- Cost-effective, timely solutions are needed
- Sharing professional knowledge & insights makes good sense
Power Networks Joint Vision

The Change Drivers

- New Demand Types
- New System Architectures
- New interactions
- New Generation Sources

IET The Institution of Engineering and Technology
Power Networks Joint Vision

PNJV’s Goals

• The challenges are seen to warrant more attention than occasional conferences and publications and in particular they require a holistic approach.

• There is a real opportunity to deliver step-changes in capability that will benefit consumers and society at large.

• PNJV’s job is not to ‘have all the answers’ but to identify potential hazards to those answers being developed through the normal processes of power industry business.

• The group first met in November 2012, see http://www.theiet.org/policy/media/press-releases/20130522.cfm for the launch press release.

• The IET is providing impartial facilitation and staff support.
Emerging Findings

- Fundamental changes to Britain’s power grid are already starting to take place and are expected to accelerate.
- Changes in Voltage behaviours and in Frequency characteristics are already observable – and causes/effects span company boundaries.
- The changes are potentially disruptive to the secure and cost-effective operation of the power grid and need to be addressed by a ‘whole-systems’ approach.
- It is timely to remember that GB is a power island.
- It will come as a shock to many that in spite of being established for 80 years the national electricity network faces material new challenges.
- The scale and complexity of the challenges ahead is new.
Power Networks Joint Vision

An example of changing complexities
Power Networks Joint Vision

Next Steps

PNJV is preparing a report and an overview policy statement

The date for release is targeted before the end of the year

It will contain The IET’s conclusions and recommendations

It will not claim to present the formal view of the companies of PNJV members

Smart Grid Forum WS7 is pursuing technical validation for the 2030 system
Power Networks Joint Vision

Thank you
Questions welcomed

john.scott@chilternpower.com
Smart Grid Forum WS3 Seminar

Completion of the Transform Model® and Least-Regrets Network Investments

Summary & QA

Steve Johnson