Smart Networks
Innovation Assurance

Technical Assurance Review: Smart Networks Innovative Solutions

Prepared for UK Power Networks
By Chiltern Power Limited

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2. Overview

Objectives of this report

- UK Power Networks commissioned Chiltern Power Ltd to undertake an independent assurance review of the smart network Solutions currently under consideration in the company, both shorter term (for RIIO ED1) and longer term (for RIIO ED2); this report summarises the findings of that review, undertaken in early 2013.
- The purpose of the review has been to assess each of the proposed innovative solutions against the following categories: **FEASIBILITY** of practical deployment, **AVAILABILITY** and supply chain considerations, **SUITABILITY** to company's networks and its organisation, **COMPLETENESS** in regard to alternatives or variants, and at a general level the **CONSUMER ENGAGEMENT** requirements or impacts.
- The span of current solutions has been weighed against known innovative developments for power networks in the UK and internationally, drawing on a range of comparator sources, with view to identifying potential gaps, opportunities or risks for UK Power Networks. Some current projects (DPCR5) have also been included.

Methodology

- A template and scoring approach has been adopted that is intentionally high level in its perspective, being designed to capture a range of information and strategic judgements, while remaining readable and practical.

Headline Results

- Headline results are summarised on the following sheets

/ continued...

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"UK Power Networks has comprehensively analysed the potential technology solutions available and their commercial enablers, and has already put in hand a number of leading prototypes and early network deployments"

Overview

Current UKPN Solutions List

ED1 **1 - Demand Response (I&C Loads) via Aggregators**
ED1 **2 - Demand Response (I&C Generation) via Aggregators**
ED2 **3 - Demand Response (TOU tariffs) increment & decrement**
ED1 **4 - Real Time Thermal Ratings - overhead lines**
Late ED1 (or ED2) **5 - Real Time Thermal Ratings - transformers**
ED2 **6 - Real Time Thermal Ratings - cables**
ED1 **7 - Active Network Management (ANM)**
ED1 **8 - Fault Current Limiters**
ED1 **9 - Electricity Storage**
ED1 **10 - LV Automation & Network Meshing**
ED2 **11 - State Estimation - distribution networks**
ED1 **12. Centralised automation systems (in DMS core)**
ED2 **13 - Phasor Measurement Units & Phasor Data Concentrators**
ED1 **14 - Power Electronics for Volt/VAr management eg - STATCOM**
ED2 (or late ED1?) **15 - Active Network Management + Heat Integration**
ED1 **16 - Quad Boosters Q/Bs (33kV)**

Prioritisation Assessment from this review

	RIIO ED1: 2015 - 2023	RIIO ED2: 2023 - 2031
Currently Closer to Deployment Readiness	1, 7, 9, 2, 4, 8, 16, 10, 12	6, 11
Currently Remoter from Deployment Readiness	3, 14, 5, 15	13

Headline Results

- The listing above shows the smart network Solutions being brought forward by the company.
- The findings in regard to state of readiness and prioritisation are summarised in the adjacent matrix.
- This confirms, at a high level, a comprehensive range of projects, having a suitably diverse spread between ED1 and ED2, with states of readiness that are practical to address within the 8-year regulatory review periods.

"a comprehensive range of projects... with suitably diverse spread by year"

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Overview

Consolidation

Scores for Main Components	Solution - 1 DR - Load	Solution - 2 DR - Generation	Solution - 3 DR - TOU tariffs	Solution - 4 RTTR - Lines	Solution - 5 RTTR - Txfrs	Solution - 6 RTTR - Cables	Solution - 7 ANM	Solution - 8 FCL	Solution - 9 Storage	Solution - 10 LV automation	Solution - 11 State Estimation	Solution - 12 Centralised Automation	Solution - 13 PMUs and PDCs	Solution - 14 P/Electronics STATCOM	Solution - 15 Heat & ANM	Solution - 16 Quad Boosters
FEASIBILITY																
Highest score	5	5	4	5	4	4	5	4	4	4	4	5	5	4	3	5
Lowest score	3	3	2	4	2	1	3	3	2	2	1	2	1	3	1	3
AVAILABILITY																
Highest score	5	5	4	5	4	4	5	4	4	4	4	5	5	4	3	5
Lowest score	4	3	2	4	2	1	3	3	2	2	1	2	1	3	1	3
SUITABILITY																
Highest score	5	4	5	5	5	5	4	5	3	5	5	5	4	5	4	5
Lowest score	3	3	2	3	3	3	2	3	2	2	1	4	1	3	2	3
COMPLETENESS																
Highest score	4	4	4	5	4	4	4	4	4	3	4	4	4	4	4	5
Lowest score	2	2	2	5	3	3	1	2	2	2	3	1	1	3	4	5
CONSUMER ENGAGEMENT																
Score	3	4	1	3	4	5	3	4	2	4	4	5	5	5	2	5

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation
5 = Low risk, High confidence, entirely do-able

Headline Results

- The consolidated scorings from the templates are shown above, identifying lowest and highest scores by category.
- The legend shows the scoring conventions on a 1 to 5 scale, corresponding to Red /Amber/Green colour shading.
- It can be observed that there are many 'Greens' but some Solutions have aspects that are currently flagged 'Red'.
- 'Red' does not indicate project infeasibility, rather that deployment will require greater focus and risk management.

"power network innovation brings its challenges, as highlighted by the red flags"

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3. Scope & Methodology

Scope

- The smart network Solutions were drawn from a business opportunities analysis undertaken by UK Power Networks; this not surprisingly aligns with the company's IFI and Low Carbon Network Fund Tier 1 and Tier 2 projects.
- Some of the Solutions examined are at the stage of early deployment, others are still conceptual or at an exploratory stage. This is to be expected as successful innovation is commonly approached on a portfolio basis.
- In practice an innovative Solution comprises many elements that require interfacing operationally, technically, and commercially with existing network infrastructure and company business processes. To avoid this making an assessment such as this highly complex and the results hard to assimilate, a high-level approach has been adopted.
- The templates show the high-level approach adopting Categorisation by FEASIBILITY, AVAILABILITY, SUITABILITY, COMPLETENESS and CONSUMER ENGAGEMENT, with a number of sub-categories within each; furthermore the innovative Solution is considered by its MAIN COMPONENTS, SUB-COMPONENTS, and COMMUNICATIONS/ DATA.

Methodology

- The Template is further described in Appendix 1.
- The scoring of each Solution was undertaken through face to face interviews with those individuals identified.
- Additional insights were contributed by Chiltern Power Ltd and selected industry specialists.
- The contributors are listed in Appendix 2.
- An analysis of relationships between projects is provided in Appendix 3.

"... face to face interviews formed the basis of the review, drawing out not only technical details, but also insights into confidence, risk and deployment suitability...."

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4. Scores & Findings (1)

ED1/ED2 Solution:	**ED1**
Title:	**1 - Demand Response (I&C Loads) via Aggregators**
Lead engineer:	David Boyer

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation available
5 = Low risk, High confidence, entirely do-able
Enter 'x' if information is not applicable

Solution 1	**MAIN COMPONENTS**		**SUB COMPONENTS**		**COMMS & DATA**		**CONSUMER ENGAGEMENT**	
Reduction of consumer demand by prearranged contract and notification.	*Aggregator service*		*n/a*		*Link to Aggregator*			
	Deployment Confidence (1 Lo - 5 Hi)	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**
FEASIBILITY of practical deployment				*Main Component scores apply unless otherwise shown*		*Main Component scores apply unless otherwise shown*		*overall challenge summarised in one score*
The Technology Challenge	4	done now under TSO STOR services			5		3	Where part of a new connection scheme,
Used elsewhere in GB	5						x	the customer will need to understand and
The Installation Challenge	4	only at DNO end; cust is Aggregator resp'y					x	accept this methodology
Health, Safety & Sustainability	4	implications for higher asset utilisation					x	should assist speed of new connection
Maintainability	3	contract continuity; customer satisfaction					x	
Policies and standards required	3	P2/6 and licence impacts, esp if at scale					x	
AVAILABILITY supply chain considerations							**Opportunities & Observations**	
Confidence in vendor	5							
Confidence in installer	5						Not intended for domestic load at this stage	
Alternative vendors	4						This is specific/signalled/contractual DR, not by TOU tariff	
Dependence on partners	4	vendor high confid. but customers unknown					LCL project leads here	
Dependence on universities	x						Demand decrement, but consider for future demand increment	
							Commercial aggregators, at least for present implementation	
SUITABILITY to UKPN networks							Equipment installed with customers is owned by aggregator	
Availability of Modelling Tools	5						This Solution could be key if UKPN undertook a DSO role	
Specialist Application Guidance	3	to be developed, DR experience needed						
A range of application locations	4						Note ENW's CLASS project for DR by tap/voltage change -	
Impact on business architectures	4	more procedural than, say, ICT impact					possibly an extension to the developments here	
Avail of skills and resources	3	a new and sensitive work area					Note, CLASS is exploring interfaces to NG for Anc Services also	
							Need to understand interactions if TSO & DSO share DR services	
COMPLETENESS alternative or variant solutions								
Availability of alternatives	4	multiple aggregators, but their commercial			5		Move to domestic scale? consider with s/meters, &/or by TOU	
Substitutability of alternatives	2	arrangements may not be substitutable			5		The subject of Demand Response requires P2/6 and Ofgem	
		for a given network location					attention; whole-system optimisation rq'd here by TSO & DNOs	
Highest Scoring	5		Highest Scoring		Highest Scoring	5	Highest Scoring	3
Lowest Scoring	2		Lowest Scoring		Lowest Scoring	5	Lowest Scoring	3
Overall Highest Scoring	**5**							
Overall Lowest Scoring	**2**							

Assessment in Summary

- This Solution has only few scores that are in the lower range, indicating medium or high confidence overall in successful deployment
- Establishing effective working with Aggregators and integrating the associated operational interfaces is a matter requiring particular focus
- Note that while interfacing through an Aggregator as an intermediary offers a number of advantages, at least in the early years while experience is being gained, it is not straightforward to swop out an unsatisfactory aggregator as the new incoming intermediary may not have established I&C response contracts in the network area of interest

Business opportunities

- The assessment indicates that this Solution should provide an early opportunity to gain the business benefits of demand response
- Targeting I&C larger customers not only provides sensible 'scale' but has synergies with National Grid STOR ancillary services

Business risks

- Poor aggregator performance may not be readily substituted
- Whole-system benefit requires NG / DNO 'sharing' of DR services

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Scores & Findings (2)

ED1/ED2 Solution:	**ED1**
Title:	**2 - Demand Response (I&C Generation) via Aggregators**
Lead engineer:	David Boyer

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation available
5 = Low risk, High confidence, entirely do-able
Enter 'x' if information is not applicable

Solution 2	**MAIN COMPONENTS**		**SUB COMPONENTS**		**COMMS & DATA**		**CONSUMER ENGAGEMENT**	
Reduction of network net demand by prearranged contract and notification to run consumer generation.	*aggregator service*		*n/a*		*basic data exchange between DNO and aggregator as intermediary*			
	Deployment Confidence (1 Lo - 5 Hi)	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**
FEASIBILITY of practical deployment				*Main Component scores apply unless otherwise shown*		*Main Component scores apply unless otherwise shown*		*overall challenge summarised in one score*
The Technology Challenge	4		x		5	DNO interfaces required with aggregator	4	if the generation is a G59, there should already be a relationship with the customer
Used elsewhere in GB	5		x				x	
The Installation Challenge	4		x				x	
Health, Safety & Sustainability	3	fault level considerations & rotating plant	x				x	
Maintainability	3	more problematic in rural locations	x				x	
Policies and standards required	3	P2/6 considerations, esp if at scale	x				x	
AVAILABILITY supply chain considerations								**Opportunities & Observations**
Confidence in vendor	5							
Confidence in installer	5							Not intended for domestic DG at this stage
Alternative vendors	4							This is specific/signalled/contractual response, not by TOU tariff
Dependence on partners	4							The avail of standby gen in London/urban areas assists
Dependence on universities	x							Community heat and CHP in London should provide potential
								Commercial aggregators, at least for present implementation
SUITABILITY to UKPN networks								Equipment installed with customers is owned by aggregator
Availability of Modelling Tools	4							This Solution could be key if UKPN undertook a DSO role
Specialist Application Guidance	3	to be developed, DR experience needed						Need to understand interactions if TSO & DSO share services
A range of application locations	4							
Impact on business architectures	4							Note rotating plant involved, so additional HSS considerations
Avail of skills and resources	3							
								Diesel Rotating UPS devices (DRUPS) increase potential here
COMPLETENESS alternative or variant solutions								Move to domestic scale? consider with s/meters, &/or by TOU
Availability of alternatives	4	multiple aggregators, but their commercial			5			
Substitutability of alternatives	2	arrangements may not be substitutable			5			
		for a given network location						
Highest Scoring	5		Highest Scoring		Highest Scoring	5	Highest Scoring	4
Lowest Scoring	2		Lowest Scoring		Lowest Scoring	5	Lowest Scoring	4

Overall Highest Scoring	**5**
Overall Lowest Scoring	**2**

Assessment in Summary

- This aggregator-based service has good synergies with Solution 1 for demand response
- It has differing operational characteristics to demand response and more onerous HSS considerations, but these should not be particularly problematic
- The introduction by consumers of fast-UPS devices (DRUPS) brings further opportunities here

Business opportunities

- Similar to Solution 1, offering opportunities to relieve network constraints especially in urban areas where standby generation exists
- There is potential to extend this to Distributed Generation at community scale and, in due course, domestic scale

Business risks

- Special attention needed to rotating plant and raised fault in-feeds to the local network

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Scores & Findings (3)

ED1/ED2 Solution:	**ED2**
Title:	**3 - Demand Response (TOU tariffs) increment & decrement**
Lead engineer:	David Boyer

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation available
5 = Low risk, High confidence, entirely do-able
Enter 'x' if information is not applicable

Solution 3	**MAIN COMPONENTS**		**SUB COMPONENTS**		**COMMS & DATA**		**CONSUMER ENGAGEMENT**	
Variation of network demand by means of Time of Use (TOU) tariffs with consumers	*Supplier/Aggregator systems and commercial arrangements*		*n/a*		*High volume data communications and data management; engagement with DNO systems required*			
	Deployment Confidence (1 Lo - 5 Hi)	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**
FEASIBILITY of practical deployment				*Main Component scores apply unless otherwise shown*		*Main Component scores apply unless otherwise shown*		*overall challenge summarised in one score*
The Technology Challenge	4	linked to smart meter technical success					1	Requires consumer engagement
Used elsewhere in GB	3	not yet, except for trials					x	and behaviour change; adoption likely to
The Installation Challenge	2	requires multiple consumer interactions					x	be at risk to s/meter acceptability
Health, Safety & Sustainability	3	vulnerable customers, fuel poverty aspects					x	
Maintainability	3	commercial and behavioural, and support					x	
Policies and standards required	2	need to create from new					x	
AVAILABILITY supply chain considerations							**Opportunities & Observations**	
Confidence in vendor	4							
Confidence in installer	2	in the hands of third parties					Longer term opportunity, includes domestic consumers	
Alternative vendors	3	alternatives exist but not directly equivalent						
Dependence on partners	2	Supplier/aggregator ongoing dependency					Could be incremental and decremental DR	
Dependence on universities	x						Trial is in hand under UKPN's LCL project	
SUITABILITY to UKPN networks								
Availability of Modelling Tools	3	need to be developed, behavioural aspects					Implementation in conjunction with smart meters makes sense	
Specialist Application Guidance	2	to be developed, DR experience needed					In conjunction with Suppliers (and poss separate aggregators)	
A range of application locations	5						National roll-out of smart meters will influence the reaction	
Impact on business architectures	2	at high volumes, significant across DNO					of consumers, their appetite for DR and engagement with TOU	
Avail of skills and resources	3	new skills required					the consumer interfacing will be very different for a DNO	
							and beyond the experience of many staff	
COMPLETENESS alternative or variant solutions								
Availability of alternatives	4	multiple aggregators, but their commercial			3	big data vols, few alternatives	The more customers involved the 'statistically stronger' is the	
Substitutability of alternatives	2	arrangements may not be substitutable			4	std protocols would assist	expected service and the risks generally reduce	
		for a given network location					Uncertainty around Ofgem/DECC drive for simplified tariffs	
							Data management will be influenced by success of s/meter DCC	
Highest Scoring	5		Highest Scoring		Highest Scoring	4	Highest Scoring	1
Lowest Scoring	2		Lowest Scoring		Lowest Scoring	3	Lowest Scoring	1

Overall Highest Scoring	**5**
Overall Lowest Scoring	**1**

Assessment in Summary

- This Solution has high potential for delivering business benefits but the scores above reveal a number of Red flags and low (higher risk) scores
- Lessons from EDF's Tempo scheme in France may be helpful here
- Particular attention will be required to address the consumer interface, both for installation and on-going engagement, and to arrangements with the commercial intermediaries such as Suppliers and Aggregators
- An integrated approach is needed for all DR initiatives, especially at domestic level, with consideration of smart metering and its data capabilities

Business opportunities

- There is potential for helpful synergies with the GB national Smart Meter roll-out to build on good consumer engagement and to utilise smart meter data and other facilities
- This could offer both demand decrement and increment services

Business risks

- Poor delivery of the national Smart Meter roll-out could create additional barriers for engagement with consumers or disappoint in regard to data

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Scores & Findings (4)

ED1/ED2 Solution:	**ED1**
Title:	**4 - Real Time Thermal Ratings - overhead lines**
Lead engineer:	Ian Cooper

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation available
5 = Low risk, High confidence, entirely do-able
Enter 'x' if information is not applicable

Solution 4	**MAIN COMPONENTS**		**SUB COMPONENTS**		**COMMS & DATA**		**CONSUMER ENGAGEMENT**	
Sensing of operational line conditions in real time to determine maximum safe loading; note helpful synergy between high wind gen outputs and the cooling of associated lines	*temp monitoring or calculation model*		*ancillary equipment*		*from sensors and to control centre*			
	Deployment Confidence (1 Lo - 5 Hi)	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**
FEASIBILITY of practical deployment				*Main Component scores apply unless otherwise shown*		*Main Component scores apply unless otherwise shown*		*overall challenge summarised in one score*
The Technology Challenge	5						3	Where part of a new connection scheme,
Used elsewhere in GB	5	Note NPG's CLNR project					x	the customer will need to understand and
The Installation Challenge	4	will be site specific			3	depends on number/type of	x	accept this methodology
Health, Safety & Sustainability	5					sensors; data integration	x	curtailment forecasting tools needed
Maintainability	4	conductor sensors may be 'active' devices				needed across business	x	should assist speed of new connection
Policies and standards required	4	not aware of any international standards					x	
AVAILABILITY supply chain considerations								**Opportunities & Observations**
Confidence in vendor	5							
Confidence in installer	5							Use of fibre wrap as alternative sensoring; dual opportunity for end to end comms (eg protection)
Alternative vendors	4							
Dependence on partners	5	weather data from Met Service						Variant types of 'donut' available
Dependence on universities	x							Sag measuring method requires accurate line profile and min clearance positions known
SUITABILITY to UKPN networks								
Availability of Modelling Tools	4	forecasting tools will be needed						Note there is a time lag in the max sag occurring
Specialist Application Guidance	4							Modelling tools needed - forecasting of ratings and curtailment
A range of application locations	5							Could be useful technique in conjunction with line re-tensioning
Impact on business architectures	3							at selected spans
Avail of skills and resources	5							
								Impact on P2/6 needs to be addressed and formalised
COMPLETENESS alternative or variant solutions								
Availability of alternatives	5							This is more sophisticated than traditional seasonal ratings
Substitutability of alternatives	5							(potential for over-stressing is understood and addressed)
								hence consider visibility to Ofgem (very different to hsitorical
Highest Scoring	5		Highest Scoring		Highest Scoring	3	Highest Scoring	3
Lowest Scoring	3		Lowest Scoring		Lowest Scoring	3	Lowest Scoring	3
Overall Highest Scoring	**5**							
Overall Lowest Scoring	**3**							

Assessment in Summary

- This Solution has the potential to release greater capacity from existing overhead lines and, as the scores above show, there is a good degree of confidence across most aspects of deployment
- A relatively low score can be noted in regard to impact on Business Architectures, highlighting that if deployed at scale the data volumes are likely to require changes to traditional ICT systems and operational and planning practices in the company

Business opportunities

- This Solution, once proven, can be expected to have wide deployment potential and is relatively simple to install with limited outage requirements
- Helpful synergy between high wind gen output and assoc. line loadings

Business risks

- This moves business away from traditional deterministic operation and introduces an element of weather uncertainty and risk management

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Scores & Findings (5)

ED1/ED2 Solution:	**Late ED1 (or ED2)**
Title:	**5 - Real Time Thermal Ratings - transformers**
Lead engineer:	Bill d'Albertanson

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation available
5 = Low risk, High confidence, entirely do-able
Enter 'x' if information is not applicable

Solution 5	**MAIN COMPONENTS**		**SUB COMPONENTS**		**COMMS & DATA**		**CONSUMER ENGAGEMENT**	
Sensing of operational transformer conditions in real time to determine maximum safe loading	*modelling/processing software*		*sensors for the transformer and surrounding location*		*standard monitoring capabilities*			
	Deployment Confidence (1 Lo - 5 Hi)	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**
FEASIBILITY of practical deployment				*Main Component scores apply unless otherwise shown*		*Main Component scores apply unless otherwise shown*		*overall challenge summarised in one score*
The Technology Challenge	3	greater at complex (indoor) sites			5		4	
Used elsewhere in GB	2	not in general deployment for GB			5		x	
The Installation Challenge	4						x	
Health, Safety & Sustainability	3	care rqd for older plant, incthe tapchangers					x	
Maintainability	4	some time and effort will be needed					x	
Policies and standards required	4	P2/6 needs care, also LI output measures					x	
AVAILABILITY supply chain considerations								
Confidence in vendor	4	alternatives, in principle						
Confidence in installer	5							
Alternative vendors	5							
Dependence on partners	4	development of R/T algorithm needed						
Dependence on universities	3	could be helpful for the above						
SUITABILITY to UKPN networks								
Availability of Modelling Tools	4							
Specialist Application Guidance	4							
A range of application locations	5							
Impact on business architectures	3							
Avail of skills and resources	3							
COMPLETENESS alternative or variant solutions								
Availability of alternatives	4							
Substitutability of alternatives	3							
Highest Scoring	5				5		4	
Lowest Scoring	2				5		4	
Overall Highest Scoring	5							
Overall Lowest Scoring	2							

Opportunities & Observations

this could provide improved load shape analysis & plant analysis
real and reactive power loading to be considered
unusual locations of Txfrs (esp London sites) need care here

opportunities at Grid/Primary substations in all UKPN areas
currently only off-line analysis is undertaken

note thermal limiting case is usually for an N-1 event
risk calcs are sensitive to expopsure period (so NB load shapes)

Note NPG's CLNR project

Potential exists for more optimal solutions to network constraints by combining this solution with DR to optimise transformer thermal capacities

Assessment in Summary

- Unlike Solution 4 (overhead lines) this application of Real Time Thermal Ratings is not in general use and requires greater development; however it is familiar as on off-line technique and there is understanding of much of the underlying analysis needed
- Transformers are large and high cost items of plant, so a technique such as this which has potential to extend their capacity, is attractive in both cost/ benefit terms and in reduced disruption
- Helpful for locations where transformers are approaching firm capacity limits

Business opportunities

- This Solution, once standardised, has the potential to be valuable as a rapid-response to demand increases at a particular substation
- This could assist manage the timing of primary reinforcement decisions
- There is potential for more optimal solutions by combining with DR

Business risks

- Greater complexity for indoor transformer installations (typically in London) where the cooling arrangements are non-standard

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Scores & Findings (6)

ED1/ED2 Solution:	**ED2**
Title:	**6 - Real Time Thermal Ratings - cables**
Lead engineer:	Peter Lang/John Scott (plus views from National Grid)

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation available
5 = Low risk, High confidence, entirely do-able
Enter 'x' if information is not applicable

Solution 6	**MAIN COMPONENTS**		**SUB COMPONENTS**		**COMMS & DATA**		**CONSUMER ENGAGEMENT**	
Sensing of operational underground cable conditions in real time to determine maximum safe loading	*linear sensor device along route (eg a fibre optic) and R/T processing software*		*interface devices, repeaters, new user data interfaces and historical tracking etc*		*standard data links but historical tracking will require data storage*			
	Deployment Confidence (1 Lo - 5 Hi)	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**
FEASIBILITY of practical deployment				*Main Component scores apply unless otherwise shown*		*Main Component scores apply unless otherwise shown*		*overall challenge summarised in one score*
The Technology Challenge	3	only off-line tools do this at poresent			4	on route comms needed	5	Where part of a new connection scheme,
Used elsewhere in GB	1	not applied in GB for cables			4		x	the customer will need to understand and
The Installation Challenge	1	high if retrospective, OK if new route			3	depends on sensors used	x	accept this methodology
Health, Safety & Sustainability	4						x	curtailment forecasting tools needed
Maintainability	4	some unknowns here					x	
Policies and standards required	4	policy needed for interpretation of data					x	
AVAILABILITY supply chain considerations								**Opportunities & Observations**
Confidence in vendor	4							
Confidence in installer	5							
Alternative vendors	4							Note importance, esp for London, of cable tunnel thermal factors
Dependence on partners	4							
Dependence on universities	4	modelling may benefit from research						In longer term, superconducting cables may provide capacity enhancement when cable tunnel thermal limits are reached
SUITABILITY to UKPN networks								Tunnel cooling is also a potential option
Availability of Modelling Tools	3	forecasting tools do not exists						Possible option to install retrospectively sensing optic fibre for cables run in ducts and tunnels
Specialist Application Guidance	4	interpretation for practical application						
A range of application locations	5	heavily loaded cables/ congested tunnels						
Impact on business architectures	4							If changing climate affects cable thermal conditions, the case for this solution may be stronger
Avail of skills and resources	4	new considerations for all of asset life cycle						
COMPLETENESS alternative or variant solutions								Life-limiting factors of cables not well understood, especially for modern plastic (XLPE) designs
Availability of alternatives	4							
Substitutability of alternatives	3	some components harder to substitute						Note NPG's CLNR project
Highest Scoring	5		Highest Scoring		Highest Scoring	4	Highest Scoring	5
Lowest Scoring	1		Lowest Scoring		Lowest Scoring	3	Lowest Scoring	5
Overall Highest Scoring	**5**							
Overall Lowest Scoring	**1**							

Assessment in Summary

- This technique is not in routine use in GB, but has potential for maximising cable capacities and the optimal management of these expensive assets which have long repair times if damaged
- It is more straightforward to apply for new cable routes where fibre optic temperature sensing can be installed at the same time as the main cables
- Special care needed for cables in tunnels (but retro applic'n possible here)
- The life-limiting factors of cables are not well understood, especially for modern plastic insulated designs; scope here for industry joint research

Business opportunities

- Improvements to cable asset management and to cable capacity in real time have considerable business potential
- Changes to demand profiles (eg EV charging, Active Networks) may create additional value opportunities

Business risks

- Technical understanding of cable performance and failure mechanisms is incomplete - this needs to be addressed as an enabler

UK Power Networks

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Smart Networks Innovation Assurance

Scores & Findings (7)

ED1/ED2 Solution:	**ED1**
Title:	**7 - Active Network Management (ANM)**
Lead engineer:	Sotiris Georgiopoulos

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation available
5 = Low risk, High confidence, entirely do-able
Enter 'x' if information is not applicable

Solution 7	**MAIN COMPONENTS**		**SUB COMPONENTS**		**COMMS & DATA**		**CONSUMER ENGAGEMENT**	
Monitoring and controlling network elements in real time to make full use of available asset capacity; instructing generation +/- is one control option	*Semi-autonomous intelligent processing platform*		*Intelligent outstations, sensors and interface devices*		*ANM device interconnectivity and Control Centre interfaces*			
	Deployment Confidence (1 Lo - 5 Hi)	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**
FEASIBILITY of practical deployment				*Main Component scores apply unless otherwise shown*		*Main Component scores apply unless otherwise shown*		*overall challenge summarised in one score*
The Technology Challenge	3	expect move to '4' with FPP experience	5				3	Where part of a new connection scheme,
Used elsewhere in GB	4	Orkney shows encouraging experience	5		3		x	the customer will need to understand and
The Installation Challenge	5						x	accept this technique; curtailment modelling
Health, Safety & Sustainability	4	asset-stressing risks require care here					x	will be important and 'standardisation'
Maintainability	5	duplicated server for main system					x	evidence (ie not a guinea pig)
Policies and standards required	3	work to do; owner to be determined			4		x	
AVAILABILITY supply chain considerations								
Confidence in vendor	4	good track record to date						
Confidence in installer	5							
Alternative vendors	2	none currently, but s/ware industry standard			4			
Dependence on partners	4	vendor contract for modelling & support						
Dependence on universities	x							
SUITABILITY to UKPN networks								
Availability of Modelling Tools	2	UKPN do not have own curtailment model						
Specialist Application Guidance	3							
A range of application locations	4							
Impact on business architectures	2	high with volume; also security to address						
Avail of skills and resources	4							
COMPLETENESS alternative or variant solutions								
Availability of alternatives	1	no immediate substitution available for ANM			5			
Substitutability of alternatives	1	for the immediate future			5			

Opportunities & Observations

ANM has potential to be integrated with Real Time Thermal Ratings solutions, Quad Boosters, Storage, and Fault Level configuration control (inter-trips etc)

Opportunity to build ANM intelligence into substation RTUs

ANM can be viewed as an integration of 'smart solutions'

ANM adaptation to changes of network running arrangements requires special consideration in ANM schemes

Wider adoption and expansion of ANM requires consideration of company ICT philosophy and control system architectures

Good operational experience of ANM is evident on Orkney (SSE)

Impprtant to determine internal company 'ownership' of ANM

Who owns the IP if the vendor fails commercially?

Main Components	Sub Components	Comms & Data	Consumer Engagement
Highest Scoring 5	Highest Scoring 5	Highest Scoring 5	Highest Scoring 3
Lowest Scoring 1	Lowest Scoring 5	Lowest Scoring 3	Lowest Scoring 3

Overall Highest Scoring 5
Overall Lowest Scoring 1

Assessment in Summary

- This Solution is being pioneered by a single vendor, which brings some supply chain risks as shown above; however it has been successfully deployed by SSE and other DNOs are exploring adoption and development
- This is arguably one of the most creative of the portfolio of innovative Solutions as it operates at the core of network operation, it optimises network capacity in real time, and for the first time utilises a distributed/ federated ICT architecture for such controls
- ANM can be viewed as an integration of 'smart solutions' and beneficial further developments can be anticipated in the medium and long term

Business opportunities

- This solution is attractive as an option for enabling new connections on a constrained network; it utilises latent capacity in existing assets, interacts dynamically with the connectee, and avoids or defers primary reinforcement

Business risks

- Single vendor requires attention, but the evidence does not point to high risk; however, focus is needed to integrate this with company systems

UK Power Networks

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Smart Networks Innovation Assurance

Scores & Findings (8)

ED1/ED2 Solution:	**ED1**
Title:	**8 - Fault Current Limiters**
Lead engineer:	Ian Cooper

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation available
5 = Low risk, High confidence, entirely do-able
Enter 'x' if information is not applicable

Solution 8	**MAIN COMPONENTS**		**SUB COMPONENTS**		**COMMS & DATA**		**CONSUMER ENGAGEMENT**	
an in-line device that operates in the event of a system short-circuit, to limit the surge of fault current where it would otherwise exceed switchgear safe operating capability	*the resistor or reactor type main series element*		*DC power supplies and cooling*		*sensors and alarms similar to transformers*			
	Deployment Confidence (1 Lo - 5 Hi)	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**
FEASIBILITY of practical deployment				*Main Component scores apply unless otherwise shown*		*Main Component scores apply unless otherwise shown*		*overall challenge summarised in one score*
The Technology Challenge	3	limited international experience			4		4	Where part of a new connection scheme,
Used elsewhere in GB	3	yes but limited to date					x	the customer will need to understand and
The Installation Challenge	3	large devices, some sites impractical					x	accept this technique
Health, Safety & Sustainability	4	high magnetic fields to be considered		cooling systems likely to need			x	
Maintainability	4	similar to transformers but new aspects	3	specialist service support,			x	
Policies and standards required	4	IEEE has a working group		for early deployments			x	
AVAILABILITY supply chain considerations								**Opportunities & Observations**
Confidence in vendor	3	confidence in the vendors, but only two						These devices are attractive where DG adds to fault levels, or where closing split bus bars will optimise available capacity
Confidence in installer	5							Two main design types; two main vendors in the market at present; pros and cons to each type
Alternative vendors	2	limited at present						11kV devices being trialled in GB; opportunity to extend to 33kV and 132kV
Dependence on partners	2	vendors providing design and maintenance						
Dependence on universities	x							WPD's LCNF T2 Flexgrid project being monitored ref modelling and measurement of fault levels
SUITABILITY to UKPN networks								
Availability of Modelling Tools	3							Increased international demand would be expected to result in more vendors entering the market (will reduce the supply chain risks shown here) Note, relatively costly devices so cost trends important to track
Specialist Application Guidance	3	not written yet						
A range of application locations	3	reasonable, rising with higher voltage units						
Impact on business architectures	5							
Avail of skills and resources	4							
COMPLETENESS alternative or variant solutions								UKPN have a first device being manufactured by Wilson in Australia with design from a company in Israel
Availability of alternatives	2		4		4			
Substitutability of alternatives	2		4		5			
Highest Scoring	5		4		5		4	
Lowest Scoring	2		3		4		4	

Overall Highest Scoring 5
Overall Lowest Scoring 2

Assessment in Summary

- This is an emerging technology that has promising field trials taking place in UK. There are alternative designs and alternative vendors which adds complexity to the technical choice but reduces supply chain risks
- The equipment is large scale and currently relatively costly, but it is early days so volume sales would be expected to improve both aspects
- UKPN's first deployment (in hand) can be expected to provide valuable learning for installation, operation and maintenance; this should result in risk reductions and an improvement to the scores shown above

Business opportunities

- A promising innovation particularly where the connection of distributed generation results in fault levels unacceptable for substation switchgear
- Also opportunity to close split bus bars and optimise available capacity
- Most likely to be applicable in high demand density, urban locations

Business risks

- This technology operates under arduous network conditions (short-circuits) and thorough testing and monitoring is key to risk mitigation

UK Power Networks

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Smart Networks Innovation Assurance

Scores & Findings (9)

ED1/ED2 Solution:	**ED1**
Title:	**9 - Electricity Storage**
Lead engineer:	Peter Lang

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation available
5 = Low risk, High confidence, entirely do-able
Enter 'x' if information is not applicable

Solution 9	**MAIN COMPONENTS**		**SUB COMPONENTS**		**COMMS & DATA**		**CONSUMER ENGAGEMENT**	
Electricity storage at MW scale has potential to defer primary investment, control local volt/var conditions, assist variable renewable integration, and provide ancillary services to the TSO (and a future DSO)	*Storage device (eg battery), the dc/ac power conversion interface, and the optimisation control automation*		*fire protection, cooling, security etc*		*standard sunbstation supervision and control*			
	Deployment Confidence (1 Lo - 5 Hi)	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**
FEASIBILITY of practical deployment				*Main Component scores apply unless otherwise shown*		*Main Component scores apply unless otherwise shown*		*overall challenge summarised in one score*
The Technology Challenge	3	Elements 'proven', but not in this application	4		4	some bespoke aspects	2	careful attention where sited in residential
Used elsewhere in GB	3	Yes, but not commonplace	5		4		x	areas; lessons being learned from the
The Installation Challenge	3	location/space/neighbours challenges	5		5		x	early demonstration sites
Health, Safety & Sustainability	3	Hazops required; 'chemistry' is new to DNO	4		5		x	
Maintainability	4	relatively complex plant, much new to DNO	5		5		x	
Policies and standards required	2	None exists, policy to determine, P2/6 mods	3		4		x	
AVAILABILITY supply chain considerations							**Opportunities & Observations**	
Confidence in vendor	3	A number of vendors, but some are SMEs						
Confidence in installer	4	specialist work, especially for early applic's						
Alternative vendors	2	limited as components are highly integrated	4		5			
Dependence on partners	2	needed for analysis and design	5		5			
Dependence on universities	4	develop charge/discharge optimisation						
SUITABILITY to UKPN networks								
Availability of Modelling Tools	2	a 'time' dimension, so new tools needed	5					
Specialist Application Guidance	2	significant task here including training	3					
A range of application locations	3	limited by space; costs are currently high						
Impact on business architectures	2	trading mode' requires platform & interfaces	5					
Avail of skills and resources	3	Chemistry requires new skills; these will be						
		brought in but will need internalising						
COMPLETENESS alternative or variant solutions								
Availability of alternatives	4	in principle alternative types/providers exist	5		5			
Substitutability of alternatives	2	integrated systems prevent ready plug/play	4		5			
Highest Scoring	4		5		5		2	
Lowest Scoring	2		3		4		2	

Opportunities & Observations

The UKPN Hemsby battery project will assist inform and reduce uncertainties; also Leighton Buzzard project. Learning from SSE and WPD may be helpful; joint best practices possibly

The power electronic interface (dc/ac) is in effect a STATCOM (see Solution 14) which offers wider benefits

This assessment is to some extent generic as there are several technologies becoming available for bulk storage; early experience has been valuable in starting to understand the challenges and solutions for practical deployment

Overall Highest Scoring	**5**
Overall Lowest Scoring	**2**

Assessment in Summary

- Electricity storage at MW scale is becoming a practical reality and a number of alternative storage devices (eg batteries, compressed air, flywheels) are under development and trial application
- The mix of low scores shown above reflects the many uncertainties, but as with all new technologies these will only be resolved by practical deployment and first-hand operational and asset management experience
- The choice of technologies and suppliers helps mitigate supply chain risk for applications going forward (but less so within a single project)

Business opportunities

- Storage is attractive as a new opportunity for distribution networks
- It is operationally fast and flexible and under the full control of the DNO
- Storage can provide relief to network constraints and have commercial value for arbitrage and STOR services; it may be valuable to a DSO

Business risks

- The technologies are unfamiliar to DNOs and there is an important learning curve ahead; device 'chemistry' will require specialist support

UK Power Networks

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Smart Networks Innovation Assurance

Scores & Findings (10)

ED1/ED2 Solution: ED1

Title: 10 - LV Automation & Network Meshing

Lead engineer: Matthieu Michel

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation available
5 = Low risk, High confidence, entirely do-able
Enter 'x' if information is not applicable

Solution 10	MAIN COMPONENTS		SUB COMPONENTS		COMMS & DATA		CONSUMER ENGAGEMENT	
new devices & running arrangements at LV that provide automation, sensing and network observability; with benefits for network planning & operations, asset utilisation, quality of supply, and fault detection	*devices for LV frames and LV link boxes*		*n/a*		*Sensors, PLC comms, and data management*			
	Deployment Confidence (1 Lo - 5 Hi)	Evidence & Comment	Deployment Confidence (1 Lo - 5 Hi)	Evidence & Comment	Deployment Confidence (1 Lo - 5 Hi)	Evidence & Comment	Deployment Confidence (1 Lo - 5 Hi)	Evidence & Comment
FEASIBILITY of practical deployment				*Main Component scores apply unless otherwise shown*		*Main Component scores apply unless otherwise shown*		*overall challenge summarised in one score*
The Technology Challenge	3	early days; LCNF T1 trials will assist here			4	deployment locations unusual	4	potential for supply interruptions for
Used elsewhere in GB	2	not used elsewhere, other DNOs interested			4	for sensors and their comms	x	link box installations; needs good handling
The Installation Challenge	3	Link box replacement; consumer impact					x	maybe area opportunities with local councils
Health, Safety & Sustainability	2	thorough testing required; HSE interest					x	
Maintainability	3	3 currently but expected 5 with experience					x	
Policies and standards required	4	more development needed before roll out					x	
AVAILABILITY supply chain considerations								**Opportunities & Observations**
Confidence in vendor	4	TE and GE involved; Kelvatek trial also						New devices & network arrg'ts (eg meshing) are relevant here
Confidence in installer	5	strong UKPN role here						Work is in hand for automation at LV substations & link boxes
Alternative vendors	2	very limited for current projects			4			A range of benefits identified and wide potential application
Dependence on partners	4	dependence less with roll out experience						HSE issues being addressed for London meshed network
Dependence on universities	x							Link box replacement required where solution is applied
								The data visualisation project has helpful synergies here
SUITABILITY to UKPN networks								
Availability of Modelling Tools	2	planning tools require development						With roll out, expect 'big data' challenges; scope for distributed processing architecture here
Specialist Application Guidance	3	important, and policy issues still to resolve						Note space limits probably preclude use in LV feeder cabinets
A range of application locations	5	wide						A joint LCNF T1 project with WPD is addressing sensors
Impact on business architectures	3	a significant data impact on roll out						
Avail of skills and resources	3	field staff availability and training is key						Availability of much more LV information opens many new possibilities, but also creates challenges such as having to respond to issues that were previously 'uknown', or raising standards and expectations because the capability now exists
		visulaisation techniques will be valuable						
COMPLETENESS alternative or variant solutions								
Availability of alternatives	2							This could have a material impact on resources and ICT facilities; a clear business strategy will be important here
Substitutability of alternatives	2							De-meshing now req'd for some high density London networks
Highest Scoring	5							
Lowest Scoring	2							
Highest Scoring								
Lowest Scoring								
Highest Scoring					4			
Lowest Scoring					4			
Highest Scoring							4	
Lowest Scoring							4	
Overall Highest Scoring	5							
Overall Lowest Scoring	2							

Assessment in Summary

- There are a number of innovative devices being developed by UK Power Networks in conjunction with vendors; although at an early stage these have the potential to add significant benefit for LV network performance
- Automation at LV is a dramatic change for traditional networks that have been operated entirely passively; this is reflected in the relatively low scores shown above; new devices need consideration jointly with network meshing
- There are important policy issues to be resolved before scale roll-out can be successful (including data handling and assurance of operational safety)

Business opportunities

- These devices could ensure supply quality under normal operating conditions (network sensing) and be responsive to faults (automated local action for network 'self-healing' and improved fault detection)
- Consider in conjunction with LV meshing and de-meshing decisions

Business risks

- Limited vendor base; little operational experience in UK; rigorous testing required as installation will be in local s/s and pavement link boxes

UK Power Networks

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Smart Networks Innovation Assurance

Scores & Findings (11)

ED1/ED2 Solution:	**ED2**
Title:	**11 - State Estimation - distribution networks**
Lead engineer:	Peter Lang

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation available
5 = Low risk, High confidence, entirely do-able
Enter 'x' if information is not applicable

Solution 11	**MAIN COMPONENTS**		**SUB COMPONENTS**		**COMMS & DATA**		**CONSUMER ENGAGEMENT**	
State Estimation is a software applicaton that operates in real time to validate data from network sensors (voltages and currents), eliminate bad data, and fill sensor gaps to achieve 'observable' networks	*processing software, typically run on a control centre DMS system, but could be run on distributed systems*		*associated applications that use the data*		*usually provided in close association with SCADA DMS facilities*			
	Deployment Confidence (1 Lo - 5 Hi)	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**
FEASIBILITY of practical deployment				*Main Component scores apply unless otherwise shown*		*Main Component scores apply unless otherwise shown*		*overall challenge summarised in one score*
The Technology Challenge	2	Greater uncertainty for LV networks	3		5		4	once operational experience has been
Used elsewhere in GB	1	not used by distribution, only transmission	4		5		x	gained, this technique should be a selling-
The Installation Challenge	3	integration needed; S/E vs Measured data	2	this has tentacles into ICT	4		x	point to any third parties impacted
Health, Safety & Sustainability	4	higher utilisation of assets, S/E accuracy					x	
Maintainability	4						x	
Policies and standards required	4						x	
AVAILABILITY supply chain considerations								**Opportunities & Observations**
Confidence in vendor	2	No vendor offers it currently						The RPZ 'GenAVC' project gave UKPN early experience
Confidence in installer	5							Could be implemented now at 132kV, where the data exists
Alternative vendors	3							however at lower voltages, esp LV, the different network
Dependence on partners	5							electrical characteristics (X/R) require changes to the proven
Dependence on universities	4	UKPN has sponsored some work here						methodologies widely used in transmission system EMSs
SUITABILITY to UKPN networks								LV automation and Smart Meters could provide more sensor
Availability of Modelling Tools	1	An integration challenge here						data and make State Estimation more feasible here
Specialist Application Guidance	4							Improved network observability may be helpful in the future
A range of application locations	5							with more volatile loads, say affecting voltages to consumers
Impact on business architectures	1	would require optimised use of two data						Fundamental question is if/when high observability is really
Avail of skills and resources	4	sources: measured and S/Estimated						of value, sufficient to make a business case. An option to keep
		Note GB TSO uses S/E as prime source						under review, perhaps small scale development to have the
COMPLETENESS alternative or variant solutions								techniques available would ensure a timely response cpability
Availability of alternatives	4	Various software development options exist						in the future. Note it could be an enabler for islanded networks.
Substitutability of alternatives	3	The s/ware needs careful integration						
Highest Scoring	5		4		5		4	
Lowest Scoring	1		2		4		4	

Overall Highest Scoring 5
Overall Lowest Scoring 1

Assessment in Summary

- This is a longer term option that can provide fully 'observable' network conditions (voltages, real and reactive power flows) under conditions of limited sensor deployment or sensor errors
- It is software coding that is currently widely used on transmission network internationally; however the software needs development to operate on distribution networks where the electrical characteristics are different
- This is an innovation that is sound to have in the company portfolio and would warrant being progressed to a stage of readiness, should high observability become advantageous; S/Meter data likely to impact here also

Business opportunities

- High network observability and confidence in sensor accuracy and error detection becomes important on 'active networks'; note that National Grid uses its State Estimated data to drive control centre applications
- Beneficial for advanced automation, and perhaps islanded operation

Business risks

- If a need case is identified, a State Estimator might be developed quickly but its impact on business systems may be slower to resolve

UK Power Networks

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Smart Networks Innovation Assurance

Scores & Findings (12)

ED1/ED2 Solution:	**ED1**
Title:	**12. Centralised automation systems (in DMS core)**
Lead engineer:	Bob Ferris - advice, not project lead

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation available
5 = Low risk, High confidence, entirely do-able
Enter 'x' if information is not applicable

Solution 12	**MAIN COMPONENTS**		**SUB COMPONENTS**		**COMMS & DATA**		**CONSUMER ENGAGEMENT**	
Automation of network fault response implemented in the core of the PowerOn Fusion (Enmac) DMS, not using the traditional scripts approach	*Software in the core DMS*		*n/a*		*standard DMS SCADA communications*			
	Deployment Confidence (1 Lo - 5 Hi)	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**
FEASIBILITY of practical deployment				*Main Component scores apply unless otherwise shown*		*Main Component scores apply unless otherwise shown*		*overall challenge summarised in one score*
The Technology Challenge	4	CN experience assists, but this is ambitious			4	comms critical, but standard	5	no impact on consumers for implementation
Used elsewhere in GB	2	no other applications of this approach			5		x	(automatic restoration needs risk managed
The Installation Challenge	3	commissioning & early use will need care			5		x	policy approach to ensure consumer safety -
Health, Safety & Sustainability	3	risk management required, safety aspects			5		x	eg broken conductor situations)
Maintainability	5						x	
Policies and standards required	5						x	
AVAILABILITY supply chain considerations								**Opportunities & Observations**
Confidence in vendor	4	GE is vendor, need to verify their delivery			5			UKPN is working with GE to implement network automation in the core of the PowerOn Fusion (Enmac) DMS system
Confidence in installer	5				5			
Alternative vendors	1	software is GE core so no alternatives			5			The former Central Networks (Bob Ferris) undertook something similar but in the periphery of Enmac as a prototype
Dependence on partners	x							
Dependence on universities	x							The key feature here is that it does not use the 'scripts' approach
SUITABILITY to UKPN networks								
Availability of Modelling Tools	5							Scripts are prone to aborting (comms failures, network changes etc) and are problematic for maintenance as networks change
Specialist Application Guidance	4							
A range of application locations	x							Note, only applicable to radial networks, not meshed Interaction with LV and other automation to be considered
Impact on business architectures	5							
Avail of skills and resources	4	Management of advanced automation rqd.						High dependence on communications; also attention needed to storm conditions and possible need to disable this functionality
COMPLETENESS alternative or variant solutions								
Availability of alternatives	1	as this is at the core of the DMS, there is no			5			Could be part of a hybrid/semi-distributed/federated architecture
Substitutability of alternatives	1	alternative or substitution option			5			
Highest Scoring	5		Highest Scoring		Highest Scoring	5	Highest Scoring	5
Lowest Scoring	1		Lowest Scoring		Lowest Scoring	4	Lowest Scoring	5

Overall Highest Scoring	**5**
Overall Lowest Scoring	**1**

Assessment in Summary

- This innovative development is in hand with GE for implementation in the core of the PowerOn (Enmac) DMS system at Fore Hamlet; it is understood to be a first and GE have not undertaken this automated network switching approach before
- The development is ambitious and will need thorough testing - while noting that software systems are inherently problematic to test rigorously; in view of the impact it could have on network security this will require careful risk management and consideration of operational policy (such as its use during storm conditions)

Business opportunities

- Enhanced automatic switching, in an ICT context that is informed by real time data is potentially powerful for improving Quality of Supply
- Integration with other automation Solutions (see ANM, Solution 7) requires care; but such a hybrid approach could bring added benefits

Business risks

- System testing will require a risk-managed approach as it cannot be exhaustive, ie considering all operational conditions and combinations

UK Power Networks

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Smart Networks Innovation Assurance

Scores & Findings (13)

ED1/ED2 Solution:	**ED2**
Title:	**13 - Phasor Measurement Units & Phasor Data Concentrators**
Lead engineer:	advice from John Scott

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation available
5 = Low risk, High confidence, entirely do-able
Enter 'x' if information is not applicable

Solution 13	**MAIN COMPONENTS**		**SUB COMPONENTS**		**COMMS & DATA**		**CONSUMER ENGAGEMENT**	
High precision sensors of voltages and currents across the network, sampled and compared at high rate in real time to monitor power system stability	*PMU sensor devices*		*PDC data concentrators, data visualisation techniques*		*Real Time data streaming, analysis, storage*			
	Deployment Confidence (1 Lo - 5 Hi)	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**
FEASIBILITY of practical deployment				*Main Component scores apply unless otherwise shown*		*Main Component scores apply unless otherwise shown*		*overall challenge summarised in one score*
The Technology Challenge	2	expect improvement with TSO experience					5	no direct consumer engagement
Used elsewhere in GB	1	no DNO experience in GB					x	
The Installation Challenge	5						x	
Health, Safety & Sustainability	3	care needed if used to drive system harder					x	
Maintainability	3	dispersed but high accuracy equipment					x	
Policies and standards required	1	need to develop but R&D required first					x	
AVAILABILITY supply chain considerations								
Confidence in vendor	4	probably provided by the big global players						
Confidence in installer	5	not anticipated to be complex						
Alternative vendors	4	standardisation would open the market						
Dependence on partners	4	in early years specialist support needed						
Dependence on universities	3	may be a source of R&D work						
SUITABILITY to UKPN networks								
Availability of Modelling Tools	1	not modellable by today's DNO tools						
Specialist Application Guidance	2	a new philosophy for control staff						
A range of application locations	4	depends on DG penetration, hot spots first						
Impact on business architectures	3	entirely new control room data source						
Avail of skills and resources	1	none in DNOs (and uncertain in TNOs)						
COMPLETENESS alternative or variant solutions								
Availability of alternatives	4	expect a number of vendors in market						
Substitutability of alternatives	3	depends on standardisation, open systems						
Highest Scoring	5							
Lowest Scoring	1							
Highest Scoring								
Lowest Scoring								
Highest Scoring								
Lowest Scoring								
Highest Scoring								
Lowest Scoring	5							
Overall Highest Scoring	5							
Overall Lowest Scoring	1							

Opportunities & Observations

In USA these are called Synchrophasor technologies
Currently being deployed on Transmission systems (inc NG).
Early days for data visualisation & interpretation

Likely to be of value for DNO networks as they become more "transmission like" with high DG penetrations & active devices

Development driver is USA and other transmission shutdowns
Addresses stability of operation, especially under disturbances

Integration needed with control room displays and automation to assist interpretation / action under adverse network conditions and control engineer high burden

Assessment in Summary

- This is a technology of potential value for the longer term at distribution level, but is under active development for transmission systems internationally
- A particular challenge is data interpretation for complex power system operating conditions; visualisation and decision support techniques are required, together with their integration into control room environments
- Likely to be of relevance where networks are 'active' with a high penetration of generation sources and system stability becomes a DNO/DSO concern

Business opportunities

- A tool for secure system operational management and intelligent support as networks become heavily loaded and highly 'active'

Business risks

- Plenty of data but insufficient information, resulting in sub-optimal real time decision making in the control room

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Smart Networks Innovation Assurance

Scores & Findings (14)

ED1/ED2 Solution:	**ED1**
Title:	**14 - Power Electronics for Volt/VAr management eg - STATCOM**
Lead engineer:	Peter Lang

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation available
5 = Low risk, High confidence, entirely do-able
Enter 'x' if information is not applicable

Solution 14	**MAIN COMPONENTS**		**SUB COMPONENTS**		**COMMS & DATA**		**CONSUMER ENGAGEMENT**	
Power Electronic devices (SVC, STATCOM etc) are flexible and fast-acting reactive power controllers for addressing voltage conditions, flicker, power factor management, losses optimisation etc	*the Power Electronic device*		*cooling and other ancillary systems*		*standard substation supervision and control*			
	Deployment Confidence (1 Lo - 5 Hi)	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**
FEASIBILITY of practical deployment				*Main Component scores apply unless otherwise shown*		*Main Component scores apply unless otherwise shown*		*overall challenge summarised in one score*
The Technology Challenge	3	Technology 'proven' but not DNO applic'ns	4	Extensive systems but	4	extensions to standard	5	little contact anticipated with consumers
Used elsewhere in GB	4	Limited deployments (eg SSE Orkney)	5	standard kit	5	substation SCADA	x	
The Installation Challenge	3	Space, integration & auxiliaries to address	5		5		x	
Health, Safety & Sustainability	4	New but should be straightforward			5		x	
Maintainability	3	New so needing operational integration	5		5		x	
Policies and standards required	3	Need to be developed			4		x	
AVAILABILITY supply chain considerations							**Opportunities & Observations**	
Confidence in vendor	4	Choice of vendors, but bespoke deployment					Note the power electronic interface for energy storage systems is in effect a STATCOM and can be utilised for the functions described above at top left	
Confidence in installer	4							
Alternative vendors	4							
Dependence on partners	3	Design details and device management	4				Not a simple CBA case for some features (eg waveform)	
Dependence on universities	3	New tools needed for optimising locations	5					
SUITABILITY to UKPN networks							The flexibility of these devices for volt/var reactive management makes them attractive in principle as distribution networks become more active and heavily loaded; costs need monitoring	
Availability of Modelling Tools	3	Site selection and cost benefit case support						
Specialist Application Guidance	3	New devices require planning/ops guidance						
A range of application locations	4	Yes, but settings likely to need special care						
Impact on business architectures	5						These devices are well-proven at Transmission level and the down-scaling to Distribution also needs to include cost-optimisation and 'commoditisation'	
Avail of skills and resources	3	New to DNOs generally						
COMPLETENESS alternative or variant solutions							In the longer term their internal DC busbar could be considered for providing embedded dc circuits in local ac networks	
Availability of alternatives	4	alternative vendors but systems are	5		5		Note scope to gain benefit from the current lower statutory v-limit and so create more high volts headroom for DG connections	
Substitutability of alternatives	3	integrated so not Plug and Play	4		5			
	Highest Scoring 5 Lowest Scoring 3		Highest Scoring 5 Lowest Scoring 4		Highest Scoring 5 Lowest Scoring 4		Highest Scoring 5 Lowest Scoring 5	

Overall Highest Scoring 5
Overall Lowest Scoring 3

Assessment in Summary

- Power Electronics are well established on transmission networks (eg DC terminals, FACTS devices) and their application to distribution is reasonably straightforward at a technical level; as the scoring above indicates there are however a number of uncertainties and these require to be well-managed to deliver successful and cost-effective outcomes
- Power Electronics for interfaces to storage devices are likely to bring early operational experience to UK Power Networks and this should be helpful in raising the scores shown; asset management of this new class of device requires proactive attention

Business opportunities

- So-called 'Volt/Var' management is likely to provide low hanging fruit
- Power electronic devices are powerful for managing voltage, improving power factors & losses, and resolving waveform quality problems
- Further consideration of current statutory v-limits offers potential here

Business risks

- Down-scaling from Transmission to Distribution requires STATCOM costs to be addressed and this technology to be more commoditised

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Scores & Findings (15)

ED1/ED2 Solution:	**ED2 (or late ED1?)**
Title:	**15 - Active Network Management + Heat Integration**
Lead engineer:	Sotiris Georgiopoulos

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation available
5 = Low risk, High confidence, entirely do-able
Enter 'x' if information is not applicable

Solution 15	**MAIN COMPONENTS**		**SUB COMPONENTS**		**COMMS & DATA**		**CONSUMER ENGAGEMENT**	
Network solutions that integrate ANM with heat energy optimisation (eg hot water, space heating, community heating)	*ANM intelligence plus heat applications*		*sensors and outstation devices*		*data for automation and supervision*			
	Deployment Confidence (1 Lo - 5 Hi)	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**
FEASIBILITY of practical deployment				*Main Component scores apply unless otherwise shown*		*Main Component scores apply unless otherwise shown*		*overall challenge summarised in one score*
The Technology Challenge	2	not at present undertaken elsewhere in GB					2	close interaction with consumers
Used elsewhere in GB	1	SSE's NINES project is at an early stage					x	high volume if domestic applications
The Installation Challenge	2	close interaction with consumers					x	
Health, Safety & Sustainability	3	potentially new risks and issues to mitigate					x	
Maintainability	3	close interaction with consumers					x	
Policies and standards required	1	requires first-principles development					x	
AVAILABILITY supply chain considerations								
Confidence in vendor	2	not at present undertaken elsewhere in GB						
Confidence in installer	2	not at present undertaken elsewhere in GB						
Alternative vendors	2	not at present undertaken elsewhere in GB						
Dependence on partners	4							
Dependence on universities	x							
SUITABILITY to UKPN networks								
Availability of Modelling Tools	2	requires first-principles development						
Specialist Application Guidance	3	requires first-principles development						
A range of application locations	3	CHP exists and may expand under the RHI						
Impact on business architectures	4							
Avail of skills and resources	4							
COMPLETENESS alternative or variant solutions								
Availability of alternatives	4	less 'unique' than some innovations						
Substitutability of alternatives	4	standards might assist interchangeability						

Opportunities & Observations

ANM integration with heat might also be extended to gas

Monitor SSE's NINES project on Shetland

The commercial case and frameworks may be complex

A watching brief item for UKPN, but note it's an active area

DECC's Renewable Heat Incentive (RHI) may accelerate here

Community schemes may have potential to be easier to manage and DECC wider heat strategy may align here

DECC heat strategy should be monitored to spot opportunities

A number of cross-sector issues/opportunities likely to arise

Note low scores suggest long lead times for DNO responses

Highest Scoring	4	Highest Scoring	0	Highest Scoring		Highest Scoring	2
Lowest Scoring	1	Lowest Scoring		Lowest Scoring		Lowest Scoring	2

Overall Highest Scoring	**4**
Overall Lowest Scoring	**1**

Assessment in Summary

- The integration of Active Network Management (ANM) with heat at a local level (eg community or domestic) is attractive in principle as a form of energy storage and demand management - for example wind energy could be directed into hot water or space heaters to avoid network reinforcement
- It is helpful that SSE are trialling such arrangements in Shetland (NINES project); this is a small first step towards more integration across sectors and can be seen as a move towards' smart cities' of the future
- The challenges are not insurmountable, but the impact on business processes and policy is high in regard to the volume of issues to address

Business opportunities

- A first step towards more integrated energy management; this would complement 'demand management' as currently scoped
- In the longer term it could provide the company with experience that would underpin a smart cities or smart community strategy

Business risks

- Close consumer engagement; an entirely new activity for the company; needs first-principles thinking before development commences

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Scores & Findings (16)

ED1/ED2 Solution:	**ED1**
Title:	**16 - Quad Boosters Q/Bs (33kV)**
Lead engineer:	Sotiris Georgiopolous

1 = High Risk, Low confidence, significant unknowns
3 = Some unknowns or risks but wth mitigation available
5 = Low risk, High confidence, entirely do-able
Enter 'x' if information is not applicable

Solution 16	**MAIN COMPONENTS**		**SUB COMPONENTS**		**COMMS & DATA**		**CONSUMER ENGAGEMENT**	
a power system series device that enables power-sharing to be optimised between parallel circuits	*the transformer-like main equipment*		*controls and monitoring*		*similar to traditional power transformers*			
	Deployment Confidence (1 Lo - 5 Hi)	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**	**Deployment Confidence (1 Lo - 5 Hi)**	**Evidence & Comment**
FEASIBILITY of practical deployment				*Main Component scores apply unless otherwise shown*		*Main Component scores apply unless otherwise shown*		*overall challenge summarised in one score*
The Technology Challenge	4	protection design needs careful attention					5	should not be problematic to convince
Used elsewhere in GB	3	not at distribution voltages					x	customers, where they are involved
The Installation Challenge	5						x	
Health, Safety & Sustainability	4						x	
Maintainability	5						x	
Policies and standards required	4	largely addressed					x	
AVAILABILITY supply chain considerations								**Opportunities & Observations**
Confidence in vendor	5							UKPN are close to deploying a first Q/B at 33kV in Norfolk, design and manufacture from Wilson in Australia with control system by MR/Fundamentals in Germany/UK
Confidence in installer	5							
Alternative vendors	4							
Dependence on partners	5							
Dependence on universities	x							Traditionally Q/Bs have been deployed at Transmission voltages EU applications for managing cross-border flows
SUITABILITY to UKPN networks								
Availability of Modelling Tools	4							UKPN view this as Proof of Concept at present; however this may be attractive to address 33kV ring constraints (eg Norfolk)
Specialist Application Guidance	4							
A range of application locations	3	depends on parallel circuit opportunities						
Impact on business architectures	5							National Grid are accumulating operational experience but operate under manual control, with concerns for automation Note automation across mutiple devices requires consideration
Avail of skills and resources	5							
COMPLETENESS alternative or variant solutions								
Availability of alternatives	5							Application at voltages other than 33kV could be advantageous Greater system meshing in future may extend applications
Substitutability of alternatives	5							
Highest Scoring	5		Highest Scoring		Highest Scoring		Highest Scoring	5
Lowest Scoring	3		Lowest Scoring		Lowest Scoring		Lowest Scoring	5
Overall Highest Scoring	**5**							
Overall Lowest Scoring	**3**							

Assessment in Summary

- Quad Boosters are large items of power plant usually used at transmission level for channelling power to improve capacity sharing and maximise total power transfers; there is potential for use on distribution networks where such conditions arise, provided there is a satisfactory business case
- Application locations may be limited (determined by parallel line routings) but may increase where network meshing is used or will be further adopted
- The first deployment by UK Power Networks, now in hand, will be helpful for gaining whole life cycle experience of these devices

Business opportunities

- May be a good solution for enhancing network capacity for a connecting customer, avoiding the construction of a new circuit
- It may provide a constraint solution for 33kV i/conn networks such as in Norfolk which are problematic under outage conditions

Business risks

- Limited experience at distribution voltages in UK

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Sources and Insights

- The following sources were used as cross-references to assist checking the completeness of the UK Power Networks innovation portfolio:

  - **EU Smartgrids Technology Platform Strategic Research Agenda 2012**

    www.smartgrids.eu/documents/sra2035.pdf

  - **RPI-X@20: Technological change in electricity and gas networks - KEMA survey.**
    www.ofgem.gov.uk/Networks/rpix20/ConsultReports/Documents1/KEMA%20Technology%20changes%20Final%20Report.pdf

  - **GB Smart Grid Forum, Workstream 3 report**

    www.ofgem.gov.uk/Pages/MoreInformation.aspx?docid=18&refer=Networks/SGF/Publications

  - **Asia Pacific Economic Co-operation, Smart Grid Initiative ASGI**

    www.egnret.ewg.apec.org/meetings/egnret36/E3-APEC%20Smart%20Grid%20Initiative%20(ASGI).pdf

  - **South Korea Jeju Island smart grids test bed**

    http://smartgrid.jeju.go.kr/eng/contents/index.php?mid=0202

  - **Grid Scientific Ltd - Coherence Engine for power control architectures**

    https://connect.innovateuk.org/web/eric.brown.1/documents?p_p_id=20&p_p_lifecycle=0&p_p_state=normal&p_p_mode=view&p_p_col_id=column-1&p_p_col_count=1&ns_20_struts_action=%2Fdocument_library%2Fview&ns_20_folderId=10983374

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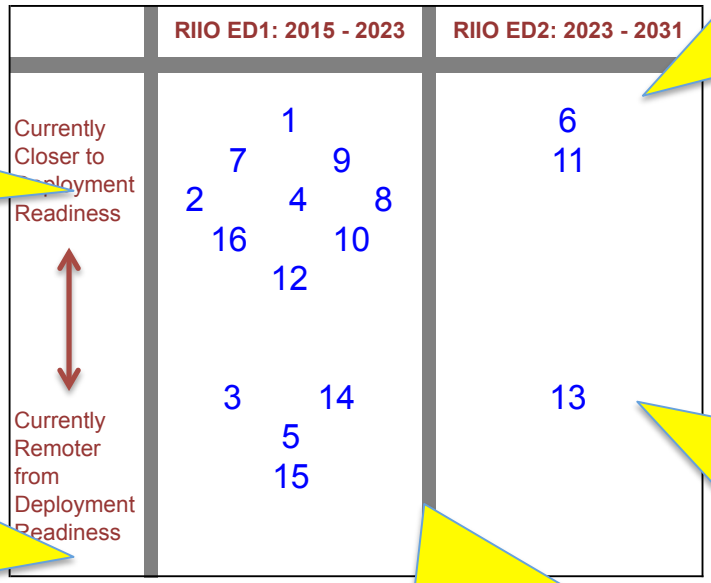
"... innovation on power networks is gathering pace in Britain and internationally.... the company has an excellent grasp on current and emerging opportunities .... "

Smart Networks Innovation Assurance

Potential Opportunities

Prioritisation Assessment from this review



No additions to the short term list of active projects

***Consider**:*
Automated network reconfiguration, for meshed networks

Solid State tap-changers at LV

Development of DSO tools especially for Solar/Wind forecasting

Protection for low fault level networks - perhaps adaptive state control

***Consider**:*
Insulated cross-arms

Switched capacitors + STATCOM for reactive management

Smart EV charging eg for car parks

Integration of ANM with Building Management Systems BMS

***Enablers**:*
Standardisation and international alignment

Smart Meter data integration

Testing & Certification including use of independent laboratories and network 'test bed' facilities

***Consider**:*
Resilience techniques for climate change extremes including intentional islanding

Embedded DC circuits associated with sources in STATCOMs

Power Electronic devices condition monitoring

Solid state transformers

Smart Cities - holistic integration across utilities

Commentary

- The numbers above refer to the Solutions List in Section 2, Overview
- New partners may be beneficial eg from the automotive sector for smart EV charging
- The business case to advance the priorities above, or to add new Solutions, is likely to be driven by the out-turn of the planning scenarios such as the actual pace of EV, PV, HP and DG deployments and of their clustering

"... a small number of further innovative Solutions has been identified for the company to consider including in its portfolio..... these are beyond the short term"

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6. Concluding Remarks

In Conclusion:

FEASIBILITY
None of the innovative Solutions reviewed is infeasible; however, this report highlights where delivery focus is needed.

AVAILABILITY
The supply chain for some Solutions has risks (eg single vendors), but these are considered to be manageable.

SUITABILITY
All the Solutions are apposite for the company's networks, both addressing constraints and creating opportunities.

COMPLETENESS
Section 5 highlights a number of additional Solutions for consideration by the company; these are all for the medium and longer term and no 'gaps' have been identified in the shorter term plans.

CONSUMER ENGAGEMENT
No show-stoppers have been identified but note the wide range of scorings on Sheet 5, including some 'Red' flags.

COMPANY READINESS
There is a valuable pool of engineering competence in the company and the individuals interviewed demonstrated competence and commitment; skills and resourcing will however need careful attention by senior management, especially when the more ambitious projects come forward for assessment and deployment and the highlighted 'Red' flag items are addressed. To do otherwise will add to risk and jeopardise the release of business benefits.

Partnering with selected vendors and academics is likely to be effective and warrants a strategic approach with long term goals aligned with the company's Innovation Strategy. Successful partnering takes time and senior engagement.

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"..the GB power network is set for fundamental change, at a scale not seen for forty years.... UK Power Networks has an impressive portfolio of innovative projects that can be expected to bring benefits for consumers and wider society...."

/continued...

Concluding Remarks

Practical pointers from discussions

Tipping points
For deployment and scale roll-out, it is important to anticipate the 'Tipping Points' at which cumulative numbers or costs of a particular Solution warrant its standardisation; only with this step can cost-effectiveness be optimised for procurement, spares, training, and the implementation of new business architectures for ICT and cross-business integration. The Smart Grid Forum 'Transform' model and the company's Smart Network Plan review process will assist.

Ownership
Innovative Solutions may not align with traditional departmental boundaries; unambiguous accountability should be assigned to each new Solution, noting they depart from the traditional 'fit and forget' passive philosophy. The corollary is the Solutions will require continuing attention, especially in their early life, and this will need to be resourced.

Health Indices, Condition Monitoring and Asset Renewal
Innovative Solutions require new thinking for asset management and regulatory reporting, including condition assessment and asset replacement policies.

Communications integrity
Communications arrangements suited to early deployment may be inappropriate at scale; for example mobile phone networks may be quick and convenient but may be unwise for scale roll-out where communications failure is operationally critical. These communications are rarely secure against local power interruptions and are prone to disruption if the public demand peak access.

Cyber Security
All the innovative solutions make increased use of real time data and communications. Business Architecture considerations should include defences against malicious attack. This is best incorporated from the start of a design.

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"…. it's the detail that makes the difference…. successful field deployment of innovation always requires local Champions..."

Concluding Remarks

Relationships between Solutions

Appendix 3 shows an analysis of key relationships between Solutions

For IT and Big Data
Two groups of Solutions with commonalities are identified and these will each be likely to benefit from an integrated approach to IT/Communications/Data management.

These groups are Solutions 4, 5, 6 and 11, 13, 15.

For Business Processes
Two groups of Solutions are identified for high impact on company business processes; the first group is likely to be more demanding to address as it is also associated with greater data volumes.

These groups are 3, 11, 15 and 7, 9, 10.

For Skills and Resources
Two groups of Solutions are identified for high or medium skills impact; the first group is likely to be more demanding to address as it also has high business process impact, so is likely to involve a more diverse cross-section of company staff.

These groups are 3, 7, 9, 10, 11, 15 and 1, 2, 5, 12, 13, 14.

"…. the Company's portfolio does not comprise discrete Solutions…. there will be business advantage in addressing integrated solutions in the groupings identified..."

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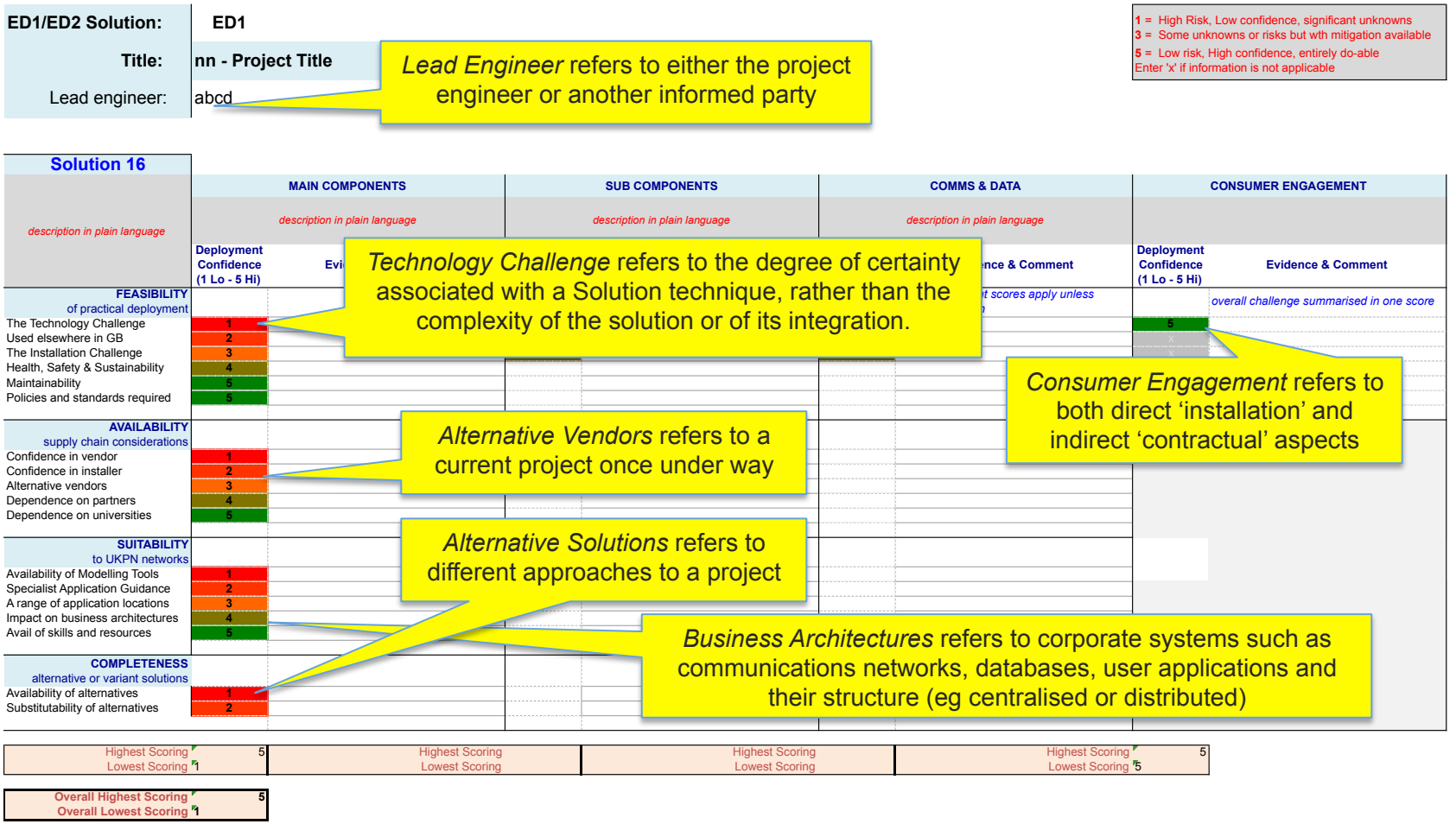
Appendix 1: Assessment Template



The Assessment Template

- The Template is largely self-explanatory; however the highlighted items above may assist interpretation
- The scoring of the elements was undertaken in conjunction with the Lead Engineers identified and combines and element of strategic judgement, particularly for the more futuristic items
- Some interpretation is required where a 'Solution' may in fact have different forms of implementation (for example different types of energy storage device or network sensor), and for differing application locations that may create special considerations such as in dense urban networks, or close to consumers.

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Appendix 2: Acknowledgements

Chiltern Power Ltd is pleased to acknowledge the contributions of the following people, who were open and constructive in every case. It was, incidentally, reassuring to have contact with such a cadre of engineering competence within UK Power Networks.

UK Power Networks
David Boyer
Ian Cooper
Bill d'Abertanson
Bob Ferris
Sotiris Georgiopoulos
Peter Lang
Dr Cristiano Marantes
Matthieu Michel
Dave Openshaw
Martin Wilcox

National Grid Plc
Ian Welch

Smarter Grid Solutions
Dr Bob Currie

Amantys Power Electronics Switching
Bryn Parry

Grid Scientific power control architecture
Eric Brown

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"...UK Power Networks provided access to an impressive group of engineers, many at a relatively early stage in their careers, who exhibited competence, enthusiasm and commitment for the innovative Solutions under review.... "

Appendix 3: Relationships

	Scoring for Business Archi-tecture	Scoring for Comms and Data	Scoring for Skills & Resources	*Impact for Skills and Resources*	*Impact for Business Processes*	*Impact for IT systems & Big Data*	
1 - Demand Response (I&C Loads) via Aggregators	4	5	3	Medium	Medium	Low	assume an Aggregator is utilised
2 - Demand Response (I&C Generation) via Aggregators	4	5	3	Medium	Medium	Low	assume an Aggregator is utilised
3 - Demand Response (TOU tariffs) increment & decrement	2	4	3	High	High	High	Data volumes high, even with intermediary services
4 - Real Time Thermal Ratings - overhead lines	3	5	5	Low	Medium	Medium	Smart Metering data will be relevant here Reasonably high data volumes, planning/ops/field impact
5 - Real Time Thermal Ratings - transformers	3	5	3	Medium	Medium	Medium	Moderately high data volumes, planning/ops/field impact
6 - Real Time Thermal Ratings - cables	4	4	4	Low	Medium	Low	Longer term Limited deployment volumes, but planning/ops/field impact
7 - Active Network Management (ANM)	2	3	4	Medium	High	Low	Longer term Business impact is wide but data volumes not exceptional
8 - Fault Current Limiters	5	4	4	Low	Low	Low	semi-autonomous systems; use of exception reporting Limited deployment volumes
9 - Electricity Storage	2	4	3	Medium	High	Medium	Business impact wide (eg trading) but data volumes modest
10 - LV Automation & Network Meshing	3	4	3	Medium	High	Medium	High volumes and wide impact across the business
11 - State Estimation - distribution networks	1	5	4	Medium	High	High	Potentially a large new data source; requires integration
12. Centralised automation systems (in DMS core)	5	4	4	Medium	Low	Medium	Longer term and currently not well defined Impact largely within the PowerOn DMS environment
13 - Phasor Measurement Units & Phasor Data Concentrators	3	2	1	Medium	Low	Medium	Potential for large data, but impact limited to control
14 - Power Electronics for Volt/VAr management eg - STATCOM	5	4	3	Medium	Low	Low	Longer term and currently not well defined
15 - Active Network Management + Heat Integration	4	2	4	Medium	High	High	Business impact is wide but data volumes not exceptional
16 - Quad Boosters Q/Bs (33kV)	5	4	5	Low	Low	Low	But longer term and corrently not well defined

The above analysis compares the Solutions to draw out relationships between considerations of

IT & data,
Business Processes, and
Skills & Resources.

The following three slides duplicate the above but add commentary >

/continued...

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Relationships - IT

	Scoring for Business Archi-tecture	Scoring for Comms and Data	Scoring for Skills & Resources	*Impact for Skills and Resources*	*Impact for Business Processes*	*Impact for IT systems & Big Data*	
1 - Demand Response (I&C Loads) via Aggregators	4	5	3	Medium	Medium	Low	assume an Aggregator is utilised
2 - Demand Response (I&C Generation) via Aggregators	4	5	3	Medium	Medium	Low	assu
3 - Demand Response (TOU tariffs) increment & decrement	2	4	3	High	High	High	Data
4 - Real Time Thermal Ratings - overhead lines	3	5	5	Low	Medium	Medium	Reas
5 - Real Time Thermal Ratings - transformers	3	5	3	Medium	Medium	Medium	Mode
6 - Real Time Thermal Ratings - cables	4	4	4	Low	Medium	Low	Limit
7 - Active Network Management (ANM)	2	3	4	Medium	High	Low	Longe Busir
8 - Fault Current Limiters	5	4	4	Low	Low	Low	semi- Limit
9 - Electricity Storage	2	4	3	Medium	High	Medium	Busir
10 - LV Automation	3	4	3	Medium	High	Medium	High
11 - State Estimation - distribution networks	1	5	4	Medium	High	High	Poter
12. Centralised automation systems (in DMS core)	5	4	4	Medium	Low	Medium	Longe Impa
13 - Phasor Measurement Units & Phasor Data Concentrators	3	2	1	Medium	Low	Medium	Poter
14 - Power Electronics for Volt/VAr management eg - STATCOM	5	4	3	Medium	Low	Low	Longe
15 - Active Network Management + Heat Integration	4	2	4	Medium	High	High	Busir
16 - Quad Boosters Q/Bs (33kV)	5	4	5	Low	Low	Low	But longer term and corrently not well defined

IT & Big Data

4, 5, and 6 have commonalities for IT and data

11, 13, and 15 have commonalities for IT and data

Note that two groups of commonalities can be identified and these will each be likely to benefit from an integrated approach to IT/Communications/Data management.

/continued...

Relationships - Processes

	Scoring for Business Archi-tecture	Scoring for Comms and Data	Scoring for Skills & Resources	*Impact for Skills and Resources*	*Impact for Business Processes*	*Impact for IT systems & Big Data*
1 - Demand Response (I&C Loads) via Aggregators	4	5	3	Medium	Medium	Low
2 - Demand Response (I&C Generation) via Aggregators	4	5	3	Medium	Medium	Low
3 - Demand Response (TOU tariffs) increment & decrement	2	4	3	High	High	High
4 - Real Time Thermal Ratings - overhead lines	3	5	5	Low	Medium	Medium
5 - Real Time Thermal Ratings - transformers	3	5	3	Medium	Medium	Medium
6 - Real Time Thermal Ratings - cables	4	4	4	Low	Medium	Low
7 - Active Network Management (ANM)	2	3	4	Medium	High	Low
8 - Fault Current Limiters	5	4	4	Low	Low	Low
9 - Electricity Storage	2	4	3	Medium	High	Medium
10 - LV Automation	3	4	3	Medium	High	Medium
11 - State Estimation - distribution networks	1	5	4	Medium	High	High
12. Centralised automation systems (in DMS core)	5	4	4	Medium	Low	Medium
13 - Phasor Measurement Units & Phasor Data Concentrators	3	2	1	Medium	Low	Medium
14 - Power Electronics for Volt/VAr management eg - STATCOM	5	4	3	Medium	Low	Low
15 - Active Network Management + Heat Integration	4	2	4	Medium	High	High
16 - Quad Boosters Q/Bs (33kV)	5	4	5	Low	Low	Low

Business Processes

High impact identified, and high data volumes (3, 11, 15)

High impact identified but medium/low data volumes (7, 9, 10)

Note that two groups have been identified for high impact on company business processes; the first group is likely to be more demanding to address as it is also associated with greater data volumes.

/continued...

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Relationships - Skills

	Scoring for Business Archi-tecture	Scoring for Comms and Data	Scoring for Skills & Resources	*Impact for Skills and Resources*	*Impact for Business Processes*	*Impact for IT systems & Big Data*
1 - Demand Response (I&C Loads) via Aggregators	4	5	3	Medium	Medium	Low
2 - Demand Response (I&C Generation) via Aggregators	4	5	3	Medium	Medium	Low
3 - Demand Response (TOU tariffs) increment & decrement	2	4	3	High	High	High
4 - Real Time Thermal Ratings - overhead lines	3	5	5	Low	Medium	Medium
5 - Real Time Thermal Ratings - transformers	3	5	3	Medium	Medium	Medium
6 - Real Time Thermal Ratings - cables	4	4	4	Low	Medium	Medium
7 - Active Network Management (ANM)	2	3	4	Medium	High	Low
8 - Fault Current Limiters	5	4	4	Low	Low	Low
9 - Electricity Storage	2	4	3	Medium	High	Medium
10 - LV Automation	3	4	3	Medium	High	Medium
11 - State Estimation - distribution networks	1	5	4	Medium	High	High
12. Centralised automation systems (in DMS core)	5	4	4	Medium	Low	Medium
13 - Phasor Measurement Units & Phasor Data Concentrators	3	2	1	Medium	Low	Medium
14 - Power Electronics for Volt/VAr management eg - STATCOM	5	4	3	Medium	Low	Low
15 - Active Network Management + Heat Integration	4	2	4	Medium	High	High
16 - Quad Boosters Q/Bs (33kV)	5	4	5	Low	Low	Low

Skills & Resources

High or medium skills impact identified, and associated high business process impact, indicating a wide group (3, 7, 9, 10, 11, and 15)

High or medium skills impact identified but medium/low business process impact, indicating a more targeted group (1, 2, 5, 12, 13, and 14)

Note that two groups have been identified for high or medium skills impact; the first group is likely to be more demanding to address as it also has high business process impact, so is likely to involve a more diverse cross-section of company staff.

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