UNRESTRICTED REPORT

Prepared for:

Energy Networks Association on behalf of

Smart Grids Forum – Work Stream 3

WS3 Phase 2 - SOLUTIONS ANNEX

A supporting document to "Assessing the Impact of Low Carbon Technologies on Great Britain's Power Distribution Networks"

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Smart Grids Forum –WS3

Assessing the Impact of Low Carbon Technologies on Great Britain's Power Distribution Networks

Project No: 82530

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Summary

This annex document has been produced to provide further information on the assumptions made behind the solutions that underpin the WS3 Phase 2 report.

It is to be treated as a starting set of assumptions that will be refined as trials are completed in Great Britain and beyond. Similarly, the list of solutions is not exhaustive and will continue to evolve as new solutions are developed and brought to the market.

1.1 Solution templates

An overview of the solution templates developed for this work is shown in the table below.

Table Error! No text of specified style in document.**.1Overview of the Solution Template**

Solution Overview	Representative Solution:				
	Variant Solution:				
	Description:				
		EHV	HV	LV	Comments
Headroom Release (%)	Thermal Cable:			0%	
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:		£0		
	Operational Expenditure:		£0		
	NPV of Opex:				Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		1		
	Life Expectancy of Solution:		40		
Merit Order	Totex (£):		£0		Calculated from capex plus NPV of opex
	Disuption Factor (1-5):		1		
	Disruption Cost (£):		£0		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):		1		
	Cross Network Benefits Factor:		0		
Other Benefits	Impact on Fixed Losses (%):		%		
	Impact on Variable Losses (%):		%		
	Impact on quality of Supply (%):		%		
	Year solution is available:		2012		
	Year data (on soln) is available:				
	Source of Data:				
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Further description is provided in Section 1.2.

1.2 Populating the templates

Each field requiring user entry/review is described as follows:

Headroom Release	
Thermal Conductor, %	Percentage of thermal constraint on a circuit (OHL or UG) released. A positive figure would represent an increase in the headroom on circuit capacity on the base-case (e.g. a dynamic line rating solution increasing a line rating from 100% to 130% would we entered as 30%)
Thermal Tx, %	Percentage of thermal constraint of transformer released. A positive figure would represent an increase on the current base-case (e.g. a dynamic transformer rating solution increasing an asset rating from 100% to 120% would be entered as 20%). Where: • LV = Distribution (HV/LV) Transformer • HV = Primary (EHV/HV) Transformer • EHV = Grid (/EHV) Transformer
Voltage Head, %	Percentage of voltage headroom released. Voltage headroom starting position is based on the difference between the (line) voltage at the transformer infeed and the upper statutory limit. • LV – starting position = 1.5% headroom (difference between 433V[1] and the upper statutory limit of 440V) • HV, e.g. 11kV – starting position = 6% headroom (as most Primary transformers have tap changers and can optimize voltages in line with Statutory limits) • EHV , e.g. 33kV or 132kV - starting position = 10% headroom (as most Grid transformers have tap changers and can optimize voltages in line with Statutory limits) An increase in headroom is therefore associated with a reduction in volts on the circuit or at the transformer infeed. A three-phase inline LV voltage regulator with an operating bandwidth of ±20V would be entered as giving 5% voltage headroom.
Voltage Leg, %	Percentage of voltage legroom released. Voltage legroom starting position is based on the difference between the (line) voltage at the end of a feeder and the lower statutory limit. • LV – starting position = 14.5% legroom (difference between the voltage at the busbars (433V) and the lower statutory limit of 376V) • HV, e.g. 11kV – starting position = 6% legroom (as most Primary transformers have tap changers and can optimize voltages in line with Statutory limits) • EHV , e.g. 33kV or 132kV - starting position = 10% legroom (as most Grid transformers have tap changers and can optimize voltages in line with Statutory limits) An increase in legroom is therefore associated with an increase in volts on the circuit or at the transformer infeed. A three-phase inline LV voltage regulator with an operating bandwidth of ±20V would be entered as giving 5% voltage legroom.
Power Quality, %	Percentage change of power quality. A positive figure would represent an increase in power quality headroom on the current base-case. Initial figures have been approximated, although this functionality is not enacted in the model.
Fault Level, %	Percentage of fault level released. As the fault levels differ by voltage level, fault level headroom is applied against the following bases: • LV – 25MVA: the design fault level for most LV distribution networks in GB • HV – 250MVA: the design fault level for most HV distribution networks in GB

[1] Many distribution transformers in GB are fixed tap from 11/0.433kV, with the network configured to maintain voltages within statutory limits under both no load (a high voltage issue for customers close to the transformer) and high load conditions (a low voltage issue for customers at the far end of the circuit).

	• EHV – 750MVA: the lower design fault level for EHV distribution networks in GB, noting that some networks now are designed to accommodate 1000MVA at 33kV. A positive figure would represent an increase in fault level headroom on the current base-case – e.g. the use of a Fault Current limiter at 11kV increasing the fault level capacity from 13.1kA (250MVA equivalent) to 16kA is captured as 20%.
Cost	
Capital (£)	The capital cost of procuring and installing the solution. This cost does not include the costs of associated enablers such as monitoring.
Operational Expenditure (£)	The annual estimated opex cost of the solution. This is based on either 20 years or the life expectancy of the solution (whichever is shortest). NB. This figure is then converted into an NPV equivalent, which is combined with the capital costs to form a cost of deployment.
Cost Curve Type	The cost curve applied to model the future change in cost of the solution based on time and volume. In summary these are: 1. Rising (120% of original cost after 30yrs) 2. Flat (100% original cost after 30yrs) 3. Shallow reduction (75% of original cost after 30yrs) 4. Medium reduction (50% of original cost after 30yrs) 5. High reduction (20% of original cost after 30yrs) See Appendix A for further details and supporting evidence on the cost curves.
Life Expectancy of Solution	Expected life of the solution in years
Merit Order	
Disruption factor (1-5)	Disruption represents the value attributed to the avoidance of disruption caused to the public by the installation and operation of a solution. 1. Very Low 2. Low 3. Moderate 4. High 5. Very High The Disruption Factor attributes are defined in more detail in Appendix A
Flexibility (1-5)	Low flexibility is represented by a 1, with 5 being high flexibility. Flexibility represents the ability to re-deploy a solution after the 5 year window considered by the WS3 model. 1. A permanent fixed asset, unable to be redeployed, e.g. underground cable 2. A fixed asset that can be redeployed, but with significant cost, e.g. transformer, HV storage unit, EHV D-FACTS device 3. A smaller fixed asset, that could be moved within the life of the asset, e.g. LV battery storage, HV in-line voltage regulator 4. A component or control type solution that could be readily redeployed, e.g. power donut 5. A portable device able to be redeployed with minimal time or operational expenditure, e.g. clippon CT or monitoring device in a DNOs substation
Cross network benefits factor	If a solution has benefits up or downstream to the voltage level it is applied at, then the value of those benefits is captured here. -2 20%-50% reduction in Headroom at higher/lower voltage levels -1 0%-20% reduction in Headroom at higher/lower voltage levels 0 No Benefit 1 0%-20% improvement in Headroom at higher/lower voltage levels 2 20%-50% improvement in Headroom at higher/lower voltage levels 3 >50% improvement in Headroom at higher/lower voltage levels NB. This parameter will affect what is and isn't deployed but we won't capture the value from the cross network benefits The Cross Network Benefits Factor attributes are defined in more detail in Appendix A.

Other Benefits	
Impact on Fixed Losses (%)	Estimated impact on fixed losses such as transformer iron loss, storage unit running losses in real terms as a percentage of that network loss
Impact on Variable Losses (%)	Estimated percentage impact on copper losses on a given network A negative figure would indicate an improvement (reduction) in losses; a positive figure would indicate an increase in losses. Many 'smart solutions' can have a detrimental impact on technical losses, for example the use of dynamic line rating (where the line rating is increased from 100% to 130%), could increase losses by as much as 69% (due to the squared relationship between current and copper losses) if running at full rating continuously
Impact on quality of supply (%)	Estimated percentage impact on CI/CMLs A positive figure would indicate an improvement in Supply Quality, a negative figure would indicate an reduction in Supply Quality (on the base case). For example, a solution
Year when solution becomes available	Some smart solutions are unavailable at present - this field allows for a year to be specified from when the solution can be deployed
Year when data on the solution is available	In order to validate the headroom release figures, some data from trial implementations may be required; this field allows a year when such (improved) data becomes available to be entered
Source of Data	Details on where the data is being provided from, e.g. a specific Tier 1 or Tier 2 Low Carbon Network Fund project
Smart Solution Reference (WS3 Ph1)	
Smart Solution Set	To which of the 12 solution sets taken from the WS3 Ph1 report doe this solution variant refer
Focus	The focus category as defined in the 12 smart solution sets
Subset	To which item in the list of the 12 smart solutions sets, does this solution variant refer

Smart Variant

Section	Field	EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Temporary Meshing (soft open point)**			
	Variant Solution:	LV - maximising latent capacity			
	Description:	"Temporary meshing" refers to running the network solid, utilising latent capacity, and relying on the use of automation to restore the network following a fault			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			50%	Doubling of network capacity possible - scaled back to 50% increase for this model
	Thermal Transformer:			5%	The use of temporary meshing is assumed to facilitate the transfer of load from one transformer to another, thereby providing some transformer headroom benefit.
	Voltage Head:			0%	No change to voltage headroom - likely to 'stiffen' the network which may result in high volts issues for networks with high amounts of generation.
	Voltage Leg:			2%	Likely to make the voltage on the network 'stiffer' so less voltage sag
	Power Quality:			10%	Small improvement in PQ headroom anticipated due to lower system source impedance
	Fault Level:			-33%	Reduction in fault level headroom, as more than one transformer feeding energy into a fault
Cost (£)	Capital:	£20,000			Capital cost of automation equipment and communications (assuming the primary infrastructure RMUs, etc) is already in place
	Operational Expenditure:	£100			Assumed per circuit cost of comms channels
	NPV of Opex:	£1,421			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			Flat profile assumed
	Life Expectancy of Solution:	25			Estimated life expectancy of secondary equipment (eg comms and automation)
Merit Order	Totex (£):	£21,421			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Minimal disrpution anticipated
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	4			Solution is flexible, and could be redeployed is necessary
	Cross Network Benefits Factor:	0			This solution may be able to provide voltage support to lower voltage networks, but this has not been factored into the default assumptions.
Other Benefits	Impact on Fixed Losses (%):	0%			Small reduction in losses considered as an assumption in the default of the model
	Impact on Variable Losses (%):	-5%			Small reduction in losses considered as an assumption in the default of the model
	Impact on quality of Supply (%):	30%			This solution should improve supply quality, owing to a reduction in source impedance
	Year solution is available:	2018			Estimate
	Year data (on soln) is available:	2014			
	Source of Data:	UKPN Flexible plug and play, ENW C2C, SP Flexible Networks			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 1			
	Focus:	Quality of supply; enhancements to existing network architecture			
	Subset:	Options to deploy adaptive protection and control techniques			

Smart Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Temporary Meshing (soft open point)**			
	Variant Solution:	HV - maximising latent capacity			
	Description:	"Temporary meshing" refers to running the network solid, utilising latent capacity, and relying on the use of automation to restore the network following a fault			
Headroom Release (%)	Thermal Cable:		50%		Doubling of network capacity possible - scaled back to 50% increase for this model
	Thermal Transformer:		8%		The use of temporary meshing is assumed to facilitate the transfer of load from one transformer to another, thereby providing some transformer headroom benefit.
	Voltage Head:		0%		No change to voltage headroom - likely to 'stiffen' the network which may result in high volts issues for networks with high amounts of generation.
	Voltage Leg:		2%		Likely to make the voltage on the network 'stiffer' so less voltage sag
	Power Quality:		10%		Small improvement in PQ headroom anticipated due to lower system source impedance
	Fault Level:		-33%		Reduction in fault level headroom, as more than one transformer feeding energy into a fault
Cost (£)	Capital:	£20,000			Capital cost of automation equipment and communications (assuming the primary infrastructure RMUs, etc) is already in place
	Operational Expenditure:	£500			Assumed per circuit cost of comms channels
	NPV of Opex:	£7,106			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Flat profile assumed
	Life Expectancy of Solution:	25			Estimated life expectancy of secondary equipment (eg comms and automation)
Merit Order	Totex (£):	£27,106			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Minimal disrpution anticipated
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	4			Solution is flexible, and could be redeployed is necessary
	Cross Network Benefits Factor:	0			This solution may be able to provide voltage support to lower voltage networks, but this has not been factored into the default assumptions.
Other Benefits	Impact on Fixed Losses (%):	-5%			Small reduction in losses considered as an assumption in the default of the model
	Impact on Variable Losses (%):	-5%			Small reduction in losses considered as an assumption in the default of the model
	Impact on quality of Supply (%):	30%			This solution should improve supply quality, owing to a reduction in source impedance
	Year solution is available:	2016			Pending the outcome of the LCNF projects
	Year data (on soln) is available:	2016			
	Source of Data:	UKPN Flexible plug and play, ENW C2C, SP Flexible Networks			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 1			
	Focus:	Quality of supply; enhancements to existing network architecture			
	Subset:	Options to deploy adaptive protection and control techniques			

Smart Variant

Solution Overview	Representative Solution:	**Temporary Meshing (soft open point)**			
	Variant Solution:	EHV - maximising latent capacity			
	Description:	“Temporary meshing” refers to running the network solid, utilising latent capacity, and relying on the use of automation to restore the network following a fault			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	50%			Doubling of network capacity possible - scaled back to 50% increase for this model
	Thermal Transformer:	10%			The use of temporary meshing is assumed to facilitate the transfer of load from one transformer to another, thereby providing some transformer headroom benefit.
	Voltage Head:	0%			No change to voltage headroom - likely to 'stiffen' the network which may result in high volts issues for networks with high amounts of generation.
	Voltage Leg:	1%			Likely to make the voltage on the network 'stiffer' so less voltage sag
	Power Quality:	10%			Small improvement in PQ headroom anticipated due to lower system source impedance
	Fault Level:	-33%			Reduction in fault level headroom, as more than one transformer feeding energy into a fault
Cost (£)	Capital:	£20,000			Capital cost of automation equipment and communications (assuming the primary infrastructure RMUs, etc) is already in place
	Operational Expenditure:	£500			Assumed per circuit cost of comms channels
	NPV of Opex:	£7,106			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Flat profile assumed
	Life Expectancy of Solution:	25			Estimated life expectancy of secondary equipment (eg comms and automation)
Merit Order	Totex (£):	£27,106			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	1			Minimal disrpution anticipated
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	4			Solution is flexible, and could be redeployed is necessary
	Cross Network Benefits Factor:	0			This solution may be able to provide voltage support to lower voltage networks, but this has not been factored into the default assumptions.
Other Benefits	Impact on Fixed Losses (%):	-5%			Small reduction in losses considered as an assumption in the default of the model
	Impact on Variable Losses (%):	-5%			Small reduction in losses considered as an assumption in the default of the model
	Impact on quality of Supply (%):	30%			This solution should improve supply quality, owing to a reduction in source impedance
	Year solution is available:	2014			Pending the outcome of the LCNF projects
	Year data (on soln) is available:	2014			Development is incremental, and trials are underway
	Source of Data:	UKPN Flexible plug and play, ENW C2C, SP Flexible Networks			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 1			
	Focus:	Quality of supply; enhancements to existing network architecture			
	Subset:	Options to deploy adaptive protection and control techniques			

Smart Variant

Solution Overview	Representative Solution:	**Switched Capacitors**			
	Variant Solution:	Switched capacitors @ LV			
	Description:	LV connected mechanically switched devices as a low cost form of reactive power compensation. They are used for voltage control and network stabilisation under heavy load conditions.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	No improvement to thermal headroom
	Thermal Transformer:			0%	No improvement to thermal headroom
	Voltage Head:			5%	Devices can improve voltage headroom - estimate
	Voltage Leg:			5%	Devices can improve voltage legroom - estimate
	Power Quality:			10%	Can be used as a filter for some system harmonics
	Fault Level:			0%	Switched capacitors have minimal effect on the short-circuit power
Cost (£)	Capital:	£50,000			Estimated cost for the installation and commissioning of a LV switched capacitor device. It is noted that this cost does look high, and would value further analysis and evidence from real trials and installations.
	Operational Expenditure:	£10			Assumed cost
	NPV of Opex:	£142			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Relatively established product, although not deployed in large quantities around the world
	Life Expectancy of Solution:	30			Assumed life expectancy of power electronics
Merit Order	Totex (£):	£50,142			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			New land required to install, but not expected to be a significant disruption
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			Asset could be moveable within its lifetime, but at a cost
	Cross Network Benefits Factor:	1			Limited benefit
Other Benefits	Impact on Fixed Losses (%):	5%			Switched nature of the device, mean that they are not always in circuit. For the purpose of the model an increase of 5% has been assumed
	Impact on Variable Losses (%):	0%			Potential to reduce losses, through reduction of VAr flow - but not factored into the default assumptions in the model.
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:	2012			Solutions are in use today, although not extensive in GB
	Year data (on soln) is available:				
	Source of Data:	Workstream 2			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 1			
	Focus:	Quality of supply; enhancements to existing network architecture			
	Subset:	Waveform monitoring and waveform correction devices			

Smart Variant

Solution Overview	Representative Solution:	**Switched Capacitors**			
	Variant Solution:	Switched capacitors @ HV			
	Description:	HV connected mechanically switched devices as a low cost form of reactive power compensation. They are used for voltage control and network stabilisation under heavy load conditions.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		0%		No improvement to thermal headroom
	Thermal Transformer:		0%		No improvement to thermal headroom
	Voltage Head:		6%		Devices can improve voltage headroom - estimate
	Voltage Leg:		6%		Devices can improve voltage legroom - estimate
	Power Quality:		10%		Can be used as a filter for some system harmonics
	Fault Level:		0%		Switched capacitors have minimal effect on the short-circuit power
Cost (£)	Capital:	£300,000			Estimated cost for the installation and commissioning of a HV switched capacitor device. It is noted that this cost does look high, and would value further analysis and evidence from real trials and installations.
	Operational Expenditure:	£50			Assumed cost
	NPV of Opex:	£711			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Relatively established product, although not deployed in large quantities around the world
	Life Expectancy of Solution:	30			Taken from WS2 model
Merit Order	Totex (£):	£300,711			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Lower distuption to that of EHV device
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			Asset could be moveable within its lifetime, but at a cost
	Cross Network Benefits Factor:	1			Limited benefit
Other Benefits	Impact on Fixed Losses (%):	5%			Switched nature of the device, mean that they are not always in circuit. For the purpose of the model an increase of 5% has been assumed
	Impact on Variable Losses (%):	0%			Potential to reduce losses, through reduction of VAr flow - but not factored into the default assumptions in the model.
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:	2012			Solutions are in use today, although not extensive in GB
	Year data (on soln) is available:				
	Source of Data:	CLNR, Workstream 2			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 1			
	Focus:	Quality of supply; enhancements to existing network architecture			
	Subset:	Waveform monitoring and waveform correction devices			

Smart Variant

Solution Overview	Representative Solution:	Switched Capacitors			
	Variant Solution:	Switched capacitors @ EHV			
	Description:	EHV connected mechanically switched devices as a low cost form of reactive power compensation. They are used for voltage control and network stabilisation under heavy load conditions.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	0%			No improvement to thermal headroom
	Thermal Transformer:	0%			No improvement to thermal headroom
	Voltage Head:	10%			Devices can improve voltage headroom - estimate
	Voltage Leg:	10%			Devices can improve voltage legroom - estimate
	Power Quality:	10%			Can be used as a filter for some system harmonics
	Fault Level:	0%			Switched capacitors have minimal effect on the short-circuit power
Cost (£)	Capital:	£830,000			Estimated cost for the installation and commissioning of a EHV switched capacitor device. It is noted that this cost does look high, and would value further analysis and evidence from real trials and installations.
	Operational Expenditure:	£150			Assumed cost
	NPV of Opex:	£6,768			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Relatively established product, although not deployed in large quantities around the world
	Life Expectancy of Solution:	30			Taken from WS2 model
Merit Order	Totex (£):	£832,132			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			New land required to install, but not expected to be a significant disruption
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			Asset could be moveable within its lifetime, but at a cost
	Cross Network Benefits Factor:	1			Limited benefit
Other Benefits	Impact on Fixed Losses (%):	5%			Switched nature of the device, mean that they are not always in circuit. For the purpose of the model an increase of 5% has been assumed
	Impact on Variable Losses (%):	0%			Potential to reduce losses, through reduction of VAr flow - but not factored into the default assumptions in the model.
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:	2012			Solutions are in use today, although not extensive in GB
	Year data (on soln) is available:				
	Source of Data:	Workstream 2			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 1			
	Focus:	Quality of supply; enhancements to existing network architecture			
	Subset:	Waveform monitoring and waveform correction devices			

Smart Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**RTTR**			
	Variant Solution:	RTTR for LV UG cables			
	Description:	The use of measurement and ambient forecasting data to predict the rating (and hence current carrying capacity) of assets in a real-time mode. This variant considers RTTR for LV underground cable circuits.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			8%	At present this is not a well-defined quantity, but it is envisaged that ratings could be enhanced by up to 10% dependent upon the difference between the actual load profile and the profile of Engineering Recommendation P17 – 'Load Curve G' (Loss Load Factor = 5.061). It should be noted that the rating enhancement for underground cables is likely to be considerably less than that available via applying dynamic ratings to overhead lines. This will again be dependent to a degree on the speed of any available demand or generation control on the network. We assume that the use of dynamic thermal rating has no impact on the degradation of the primary assets (the overhead lines, underground cables or transformers), i.e. no accelerated ageing.
	Thermal Transformer:			0%	No expected benefit
	Voltage Head:			0%	No expected benefit
	Voltage Leg:			0%	No expected benefit
	Power Quality:			0%	No expected benefit
	Fault Level:			0%	No expected benefit
Cost (£)	Capital:		£16,600		Estimate based on the purchase and installation of monitoring devices at key points along the underground cable. This cost is high on the assumption that as cables are a high value asset, that are permenantly damaged by thermal stressing, additional monitoring would be required along their length. Excavation to place monitoring devices next to, or on, the cable are also considered, further increasing the cost. Assuming the average LV circuit is 300m, with monitoring and communications at the start, middle and end of a circuit @ c£5k each. It is noted that this cost does appear high, and would value further evidence to support the true costs of real installations
	Operational Expenditure:		£0		No ongoing opex cost assumed (NB. Costs of weather monitoring are factored into the associated Enabler)
	NPV of Opex:		£0		Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		3		Assume a reduction in costs as solution volumes increase
	Life Expectancy of Solution:		15		At present, asset life is something of an unknown. The equipment is designed to act in a "fit and forget" manner without the requirement for ongoing maintenance. The life of the equipment for undergroud cable thermal ratings solutions (i.e. thermocouples, RTDs, etc.) is assumed to be 15 years;
Merit Order	Totex (£):		£16,600		Calculated from capex plus NPV of opex
	Disuption Factor (1-5):		2		Low disruption as the devices can be connected to the network with minimal of impact / outages
	Disruption Cost (£):		£2,500		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):		4		Devices could easily be moved from one circuit to another within their life expectancy
	Cross Network Benefits Factor:		0		No benefit expected
Other Benefits	Impact on Fixed Losses (%):		0%		No benefit expected
	Impact on Variable Losses (%):		0%		Solution is expected to increase the variable losses (I^2R) as more current is pushed down the circuit. The exact increase depends on the magnitude and duration of operating at these higher currents.
	Impact on quality of Supply (%):		1%		A marginal benefit to QoS as this solution may provide additional monitoring of the network, potentially assisting DNOs in identifying faults or fault locations.
	Year solution is available:		2015		Estimate
	Year data (on soln) is available:		2013		Expect futher data from trials such as CLNR as the project completes (Dec 2013)
	Source of Data:	CLNR, Workstream 2			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 3			
	Focus:	Plant & Systems reliability, failure mode detection			
	Subset:	Dynamic ratings for all plant types and multi element circuits			

Smart Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**RTTR**			
	Variant Solution:	RTTR for LV OH lines			
	Description:	The use of measurement and ambient forecasting data to predict the rating (and hence current carrying capacity) of assets in a real-time mode. This variant considers RTTR for LV overhead line circuits.			
Headroom Release (%)	Thermal Cable:			20%	The amount of thermal headroom that can be released depends on the topography of the network and the surrounding area. For example, lines across open fields can have their rating increased more than those running through wooded areas. The amount by which the rating is increased also depends on the speed of response of any associated demand or generation control. However, for a line across open ground an increase in rating of up to 30% can be expected - this has been fruther downplayed to 20% for LV circuits in the model. We assume that the use of dynamic thermal rating has no impact on the degradation of the primary assets (the overhead lines, underground cables or transformers), i.e. no accelerated ageing.
	Thermal Transformer:			0%	No benefit expected
	Voltage Head:			0%	No benefit expected
	Voltage Leg:			0%	No benefit expected
	Power Quality:			0%	No benefit expected
	Fault Level:			0%	No benefit expected
Cost (£)	Capital:	£4,980			Estimate based on the purchase and installation of monitoring devices (e.g. conductor mounted measurement devices) at key points along the overhead line circuit.
	Operational Expenditure:	£0			No ongoing opex cost assumed (NB. Costs of weather monitoring are factored into the associated Enabler)
	NPV of Opex:	£0			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			Assume a reduction in costs as solution volumes increase
	Life Expectancy of Solution:	15			At present, asset life is something of an unknown. The equipment is designed to act in a "fit and forget" manner without the requirement for ongoing maintenance. The life of the equipment for overhead line dynamic thermal ratings solutions (i.e. "power donuts", current transformers etc.) is assumed to be 15 years;
Merit Order	Totex (£):	£4,980			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Low disruption as the devices can be connected to the network with minimal of impact / outages
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	4			Devices could easily be moved from one circuit to another within their life expectancy
	Cross Network Benefits Factor:	0			No benefit expected
Other Benefits	Impact on Fixed Losses (%):	0%			No benefit expected
	Impact on Variable Losses (%):	0%			Solution is expected to increase the variable losses (I^2R) as more current is pushed down the circuit. The exact increase depends on the magnitude and duration of operating at these higher currents.
	Impact on quality of Supply (%):	1%			A marginal benefit to QoS as this solution may provide additional monitoring of the network, potentially assisting DNOs in identifying faults or fault locations.
	Year solution is available:	2015			Estimate - based on RTTR being an incremental development
	Year data (on soln) is available:	2013			Expect futher data from trials such as CLNR as the project completes (Dec 2013)
	Source of Data:	CLNR, Workstream 2			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 3			
	Focus:	Plant & Systems reliability, failure mode detection			
	Subset:	Dynamic ratings for all plant types and multi element circuits			

Smart Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**RTTR**			
	Variant Solution:	RTTR for HV/LV Tx			
	Description:	The use of measurement and ambient forecasting data to predict the rating (and hence current carrying capacity) of assets in a real-time mode. This variant considers RTTR for Secondary distribution transformers.			
Headroom Release (%)	Thermal Cable:			0%	No expected benefit
	Thermal Transformer:			10%	The amount of headroom released depends on the control strategy implemented and whether the purpose of the dynamic thermal rating is primarily to reduce ageing or increase ratings. Additional capacity of 10-20% is claimed by manufacturers but few applications have yet published data. Recent studies indicate that distribution transformers are possibly the most highly stressed part of the LV network. If the scheme is installed in tandem with some DSR, the headroom release will also depend on the speed of response of load or generation control, i.e. how quickly demand could be reduced if necessary will govern how far the asset can be stressed above its nominal rating. We assume that the use of dynamic thermal rating has no impact on the degradation of the primary assets (the overhead lines, underground cables or transformers), i.e. no accelerated ageing.
	Voltage Head:			0%	No expected benefit
	Voltage Leg:			0%	No expected benefit
	Power Quality:			0%	No expected benefit
	Fault Level:			0%	No expected benefit
Cost (£)	Capital:	£4,980			Estimate based on the purchase and installation of monitoring devices at a single Grid transformer.
	Operational Expenditure:	£0			No ongoing opex cost assumed (NB. Costs of weather monitoring are factored into the associated Enabler)
	NPV of Opex:	£0			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			Assume a reduction in costs as solution volumes increase
	Life Expectancy of Solution:	20			At present, asset life is something of an unknown. The equipment is designed to act in a "fit and forget" manner without the requirement for ongoing maintenance. The life of the equipment for transformer thermal ratings solutions is assumed to align with the transformer itself (c40yrs)
Merit Order	Totex (£):	£4,980			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Low disruption as the devices can be connected to the network with minimal of impact / outages
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	4			Devices could easily be moved from one circuit to another within their life expectancy
	Cross Network Benefits Factor:	0			No benefit expected
Other Benefits	Impact on Fixed Losses (%):	0%			No benefit expected
	Impact on Variable Losses (%):	10%			Solution is expected to increase the variable losses (I^2R) as more current is pushed down the circuit. The exact increase depends on the magnitude and duration of operating at these higher currents.
	Impact on quality of Supply (%):	1%			No benefit expected
	Year solution is available:	2015			Estimate - based on transformer RTTR being an incremental development
	Year data (on soln) is available:	2013			Expect futher data from trials such as CLNR as the project completes (Dec 2013)
	Source of Data:	CLNR, Workstream 2			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 3			
	Focus:	Plant & Systems reliability, failure mode detection			
	Subset:	Dynamic ratings for all plant types and multi element circuits			

Smart Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**RTTR**			
	Variant Solution:	RTTR for HV UG cables			
	Description:	The use of measurement and ambient forecasting data to predict the rating (and hence current carrying capacity) of assets in a real-time mode. This variant considers RTTR for HV underground cable circuits.			
Headroom Release (%)	Thermal Cable:		10%		At present this is not a well-defined quantity, but it is envisaged that ratings could be enhanced by up to 10% dependent upon the difference between the actual load profile and the profile of Engineering Recommendation P17 – 'Load Curve G' (Loss Load Factor = 5.061). It should be noted that the rating enhancement for underground cables is likely to be considerably less than that available via applying dynamic ratings to overhead lines. This will again be dependent to a degree on the speed of any available demand or generation control on the network. We assume that the use of dynamic thermal rating has no impact on the degradation of the primary assets (the overhead lines, underground cables or transformers), i.e. no accelerated ageing.
	Thermal Transformer:		0%		No expected benefit
	Voltage Head:		0%		No expected benefit
	Voltage Leg:		0%		No expected benefit
	Power Quality:		0%		No expected benefit
	Fault Level:		0%		No expected benefit
Cost (£)	Capital:		£24,900		Estimate based on the purchase and installation of monitoring devices at key points along the underground cable. This cost is high on the assumption that as cables are a high value asset, that are permenantly damaged by thermal stressing, additional monitoring would be required along their length. Excavation to place monitoring devices next to, or on, the cable are also considered, further increasing the cost. Assuming the average HV circuit is 5km, with monitoring and communications at every 1km of c£5k each. It is noted that this cost does appear high, and would value further evidence to support the true costs of real installations
	Operational Expenditure:		£0		No ongoing opex cost assumed (NB. Costs of weather monitoring are factored into the associated Enabler)
	NPV of Opex:		£0		Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		3		Assume a reduction in costs as solution volumes increase
	Life Expectancy of Solution:		15		At present, asset life is something of an unknown. The equipment is designed to act in a "fit and forget" manner without the requirement for ongoing maintenance. The life of the equipment for undergroud cable thermal ratings solutions (i.e. thermocouples, RTDs, etc.) is assumed to be 15 years;
Merit Order	Totex (£):		£24,900		Calculated from capex plus NPV of opex
	Disuption Factor (1-5):		2		Low disruption as the devices can be connected to the network with minimal of impact / outages
	Disruption Cost (£):		£2,500		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):		4		Devices could easily be moved from one circuit to another within their life expectancy
	Cross Network Benefits Factor:		0		No benefit expected
Other Benefits	Impact on Fixed Losses (%):		0%		No benefit expected
	Impact on Variable Losses (%):		10%		Solution is expected to increase the variable losses (I^2R) as more current is pushed down the circuit. The exact increase depends on the magnitude and duration of operating at these higher currents.
	Impact on quality of Supply (%):		0%		A marginal benefit to QoS as this solution may provide additional monitoring of the network, potentially assisting DNOs in identifying faults or fault locations.
	Year solution is available:		2015		Estimate
	Year data (on soln) is available:		2013		Expect futher data from trials such as CLNR as the project completes (Dec 2013)
	Source of Data:	CLNR, Workstream 2, SSE NINES			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 3			
	Focus:	Plant & Systems reliability, failure mode detection			
	Subset:	Dynamic ratings for all plant types and multi element circuits			

Smart Variant

Solution Overview	Representative Solution:	**RTTR**			
	Variant Solution:	RTTR for HV OH lines			
	Description:	The use of measurement and ambient forecasting data to predict the rating (and hence current carrying capacity) of assets in a real-time mode. This variant considers RTTR for HV overhead line circuits.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		30%		The amount of thermal headroom that can be released depends on the topography of the network and the surrounding area. For example, lines across open fields can have their rating increased more than those running through wooded areas. The amount by which the rating is increased also depends on the speed of response of any associated demand or generation control. However, for a line across open ground an increase in rating of up to 30% can be expected and this is what has been assumed in the model. We assume that the use of dynamic thermal rating has no impact on the degradation of the primary assets (the overhead lines, underground cables or transformers), i.e. no accelerated ageing.
	Thermal Transformer:		0%		No benefit expected
	Voltage Head:		0%		No benefit expected
	Voltage Leg:		0%		No benefit expected
	Power Quality:		0%		No benefit expected
	Fault Level:		0%		No benefit expected
Cost (£)	Capital:		£6,640		Estimate based on the purchase and installation of monitoring devices (e.g. conductor mounted measurement devices) at key points along the overhead line circuit.
	Operational Expenditure:		£0		No ongoing opex cost assumed (NB. Costs of weather monitoring are factored into the associated Enabler)
	NPV of Opex:		£0		Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		3		Assume a reduction in costs as solution volumes increase
	Life Expectancy of Solution:		15		At present, asset life is something of an unknown. The equipment is designed to act in a "fit and forget" manner without the requirement for ongoing maintenance. The life of the equipment for overhead line dynamic thermal ratings solutions (i.e. "power donuts", current transformers etc.) is assumed to be 15 years;
Merit Order	Totex (£):		£6,640		Calculated from capex plus NPV of opex
	Disuption Factor (1-5):		2		Low disruption as the devices can be connected to the network with minimal of impact / outages
	Disruption Cost (£):		£2,500		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):		4		Devices could easily be moved from one circuit to another within their life expectancy
	Cross Network Benefits Factor:		0		No benefit expected
Other Benefits	Impact on Fixed Losses (%):		0%		No benefit expected
	Impact on Variable Losses (%):		20%		Solution is expected to increase the variable losses (I^2R) as more current is pushed down the circuit. The exact increase depends on the magnitude and duration of operating at these higher currents.
	Impact on quality of Supply (%):		0%		A marginal benefit to QoS as this solution may provide additional monitoring of the network, potentially assisting DNOs in identifying faults or fault locations.
	Year solution is available:		2014		Estimate - based on RTTR being an incremental development
	Year data (on soln) is available:		2014		Expect futher data from trials such as CLNR as the project completes (Dec 2013)
	Source of Data:	CLNR, SSE T1 33kV, Workstream 2, SP Flexible Networks, SSE NINES, UKPN Flexible plug and play			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 3			
	Focus:	Plant & Systems reliability, failure mode detection			
	Subset:	Dynamic ratings for all plant types and multi element circuits			

Smart Variant

Solution Overview	Representative Solution:	**RTTR**			
	Variant Solution:	RTTR for EHV/HV Tx			
	Description:	The use of measurement and ambient forecasting data to predict the rating (and hence current carrying capacity) of assets in a real-time mode. This variant considers RTTR for Primary transformers.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	0%			No expected benefit
	Thermal Transformer:	10%			The amount of headroom released depends on the control strategy implemented and whether the purpose of the dynamic thermal rating is primarily to reduce ageing or increase ratings. Additional capacity of 10-20% is claimed by manufacturers but few applications have yet published data. Recent studies indicate that distribution transformers are possibly the most highly stressed part of the LV network. If the scheme is installed in tandem with some DSR, the headroom release will also depend on the speed of response of load or generation control, i.e. how quickly demand could be reduced if necessary will govern how far the asset can be stressed above its nominal rating. We assume that the use of dynamic thermal rating has no impact on the degradation of the primary assets (the overhead lines, underground cables or transformers), i.e. no accelerated ageing.
	Voltage Head:	0%			No expected benefit
	Voltage Leg:	0%			No expected benefit
	Power Quality:				No expected benefit
	Fault Level:				No expected benefit
Cost (£)	Capital:	£3,000			Estimate based on the purchase and installation of monitoring devices at a single Grid transformer. It is noted that this cost looks low, and would value more detailed assessment as trials take place.
	Operational Expenditure:	£0			No ongoing opex cost assumed (NB. Costs of weather monitoring are factored into the associated Enabler)
	NPV of Opex:	£0			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			Assume a reduction in costs as solution volumes increase
	Life Expectancy of Solution:	40			At present, asset life is something of an unknown. The equipment is designed to act in a "fit and forget" manner without the requirement for ongoing maintenance. The life of the equipment for transformer thermal ratings solutions is assumed to align with the transformer itself (c40yrs)
Merit Order	Totex (£):	£3,000			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Low disruption as the devices can be connected to the network with minimal of impact / outages
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	4			Devices could easily be moved from one circuit to another within their life expectancy
	Cross Network Benefits Factor:	0			No benefit expected
Other Benefits	Impact on Fixed Losses (%):	0%			No benefit expected
	Impact on Variable Losses (%):	20%			Solution is expected to increase the variable losses (I^2R) as more current is pushed down the circuit. The exact increase depends on the magnitude and duration of operating at these higher currents.
	Impact on quality of Supply (%):	0%			No benefit expected
	Year solution is available:	2015			Estimate - based on transformer RTTR being an incremental development
	Year data (on soln) is available:	2013			Expect futher data from trials such as CLNR as the project completes (Dec 2013)
	Source of Data:	CLNR, Workstream 2, SP Flexible Networks			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 3			
	Focus:	Plant & Systems reliability, failure mode detection			
	Subset:	Dynamic ratings for all plant types and multi element circuits			

Smart Variant

Section	Field	EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**RTTR**			
	Variant Solution:	RTTR for EHV UG cables			
	Description:	The use of measurement and ambient forecasting data to predict the rating (and hence current carrying capacity) of assets in a real-time mode. This variant considers RTTR for EHV underground cable circuits.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	10%			At present this is not a well-defined quantity, but it is envisaged that ratings could be enhanced by up to 10% dependent upon the difference between the actual load profile and the profile of Engineering Recommendation P17 – 'Load Curve G' (Loss Load Factor = 5.061). It should be noted that the rating enhancement for underground cables is likely to be considerably less than that available via applying dynamic ratings to overhead lines. This will again be dependent to a degree on the speed of any available demand or generation control on the network. We assume that the use of dynamic thermal rating has no impact on the degradation of the primary assets (the overhead lines, underground cables or transformers), i.e. no accelerated ageing.
	Thermal Transformer:	0%			No expected benefit
	Voltage Head:	0%			No expected benefit
	Voltage Leg:	0%			No expected benefit
	Power Quality:	0%			No expected benefit
	Fault Level:	0%			No expected benefit
Cost (£)	Capital:	£49,800			Estimate based on the purchase and installation of monitoring devices at key points along the underground cable. This cost is high on the assumption that as cables are a high value asset, that are permenantly damaged by thermal stressing, additional monitoring would be required along their length. Excavation to place monitoring devices next to, or on, the cable are also considered, further increasing the cost. Assuming the average EHV circuit is 4km, with monitoring and communications at every 0.5km of c£6k each. It is noted that this cost does appear high, and would value further evidence to support the true costs of real installations
	Operational Expenditure:	£0			No ongoing opex cost assumed (NB. Costs of weather monitoring are factored into the associated Enabler)
	NPV of Opex:	£0			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			Assume a reduction in costs as solution volumes increase
	Life Expectancy of Solution:	15			At present, asset life is something of an unknown. The equipment is designed to act in a "fit and forget" manner without the requirement for ongoing maintenance. The life of the equipment for undergroud cable thermal ratings solutions (i.e. thermocouples, RTDs, etc.) is assumed to be 15 years;
Merit Order	Totex (£):	£49,800			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Low disruption as the devices can be connected to the network with minimal of impact / outages
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	4			Devices could easily be moved from one circuit to another within their life expectancy
	Cross Network Benefits Factor:	0			No benefit expected
Other Benefits	Impact on Fixed Losses (%):	0%			No benefit expected
	Impact on Variable Losses (%):	10%			Solution is expected to increase the variable losses (I^2R) as more current is pushed down the circuit. The exact increase depends on the magnitude and duration of operating at these higher currents.
	Impact on quality of Supply (%):	1%			A marginal benefit to QoS as this solution may provide additional monitoring of the network, potentially assisting DNOs in identifying faults or fault locations.
	Year solution is available:	2015			Estimate - based on RTTR being an incremental development
	Year data (on soln) is available:	2013			Expect futher data from trials such as CLNR as the project completes (Dec 2013)
	Source of Data:	CLNR, Workstream 2			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 3			
	Focus:	Plant & Systems reliability, failure mode detection			
	Subset:	Dynamic ratings for all plant types and multi element circuits			

Smart Variant

Solution Overview	Representative Solution:	**RTTR**			
	Variant Solution:	RTTR for EHV OH lines			
	Description:	The use of measurement and ambient forecasting data to predict the rating (and hence current carrying capacity) of assets in a real-time mode. This variant considers RTTR for EHV overhead line circuits.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	30%			The amount of thermal headroom that can be released depends on the topography of the network and the surrounding area. For example, lines across open fields can have their rating increased more than those running through wooded areas. The amount by which the rating is increased also depends on the speed of response of any associated demand or generation control. However, for a line across open ground an increase in rating of up to 30% can be expected and this is what has been assumed in the model. We assume that the use of dynamic thermal rating has no impact on the degradation of the primary assets (the overhead lines, underground cables or transformers), i.e. no accelerated ageing.
	Thermal Transformer:	0%			No benefit expected
	Voltage Head:	0%			No benefit expected
	Voltage Leg:	0%			No benefit expected
	Power Quality:	0%			No benefit expected
	Fault Level:	0%			No benefit expected
Cost (£)	Capital:	£13,280			Estimate based on the purchase and installation of monitoring devices (e.g. conductor mounted measurement devices) at key points along the overhead line circuit.
	Operational Expenditure:	£0			No ongoing opex cost assumed (NB. Costs of weather monitoring are factored into the associated Enabler)
	NPV of Opex:	£0			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			Assume a reduction in costs as solution volumes increase
	Life Expectancy of Solution:	15			At present, asset life is something of an unknown. The equipment is designed to act in a "fit and forget" manner without the requirement for ongoing maintenance. The life of the equipment for overhead line dynamic thermal ratings solutions (i.e. "power donuts", current transformers etc.) is assumed to be 15 years;
Merit Order	Totex (£):	£13,280			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Low disruption as the devices can be connected to the network with minimal of impact / outages
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	4			Devices could easily be moved from one circuit to another within their life expectancy
	Cross Network Benefits Factor:	0			No benefit expected
Other Benefits	Impact on Fixed Losses (%):	0%			No benefit expected
	Impact on Variable Losses (%):	20%			Solution is expected to increase the variable losses (I^2R) as more current is pushed down the circuit. The exact increase depends on the magnitude and duration of operating at these higher currents.
	Impact on quality of Supply (%):	1%			A marginal benefit to QoS as this solution may provide additional monitoring of the network, potentially assisting DNOs in identifying faults or fault locations.
	Year solution is available:	2015			Estimate - based on RTTR being an incremental development
	Year data (on soln) is available:	2013			Expect futher data from trials such as CLNR as the project completes (Dec 2013)
	Source of Data:	CLNR, Workstream 2, WPD 132kV, SP Dynamic Rating			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 3			
	Focus:	Plant & Systems reliability, failure mode detection			
	Subset:	Dynamic ratings for all plant types and multi element circuits			

Smart Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Permanent Meshing of Networks**			
	Variant Solution:	Meshing LV Sub-Urban Networks			
	Description:	Converting the operation of the LV network from a radial feeder (with split points) to a solid mesh configuration.			
Headroom Release (%)	Thermal Cable:			50%	Increase due to balancing up of network with infeeds from two ends of a circuit
	Thermal Transformer:			5%	Uses latent capacity of transformers, from 50% utilisation for radial network to 66% utilisation for a three transformer meshed configuration. This has been scaled back for the LV suburban case to be 5%.
	Voltage Head:			0%	Meshed networks tend to solve low voltage problems, but can suffer from high volts: therefore no headroom benefits expected
	Voltage Leg:			2%	operating network as a mesh will reduce volt drops (as two in feeds [or more] on a given circuit)
	Power Quality:			20%	Lower circuit impedance, therefore a likely improvement in PQ headroom
	Fault Level:			-33%	A reduction in fault level capacity is expected with the meshing of circuits
Cost (£)	Capital:	£20,000			Likely to be a higher proportional cost than at EHV / HV due to the need for LV circuit breakers to be fitted to prevent backfeeding HV faults via the LV network (and resulting in damage to LV network).
	Operational Expenditure:	£100			Additional requirement for ongoing system studies to model the network (cost on a per feeder basis)
	NPV of Opex:	£1,421			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Costs are not expected to reduce over time
	Life Expectancy of Solution:	45			No different to a conventional network configuration; hence 45 years (in line with Ofgem's RAV treatment)
Merit Order	Totex (£):	£21,421			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			As per definition: "Network reconfiguration necessary in order to connect / commission solution."
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			The meshing could be 'undone' at a later date to make the network radial, but the assets could not be moved
	Cross Network Benefits Factor:	-1			Potential benefits at HV
Other Benefits	Impact on Fixed Losses (%):	0%			No impact on fixed losses
	Impact on Variable Losses (%):	-10%			Will increase copper losses, as more current will be pushed through existing circuits (worsening losses)
	Impact on quality of Supply (%):	30%			Expected to improve supply quality (ref LPN and SP-Manweb CI and CML figures)
	Year solution is available:	2012			Solution is available today (but not widely used)
	Year data (on soln) is available:				
	Source of Data:	UKPN AuRA-NMS & Interconnectable LV networks IFI project SP London Road 1			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 4			
	Focus:	Security of networks inc. physical threats, utilising new network architectures			
	Subset:	Use of meshed, rather than radial architectures			

Smart Variant

Solution Overview	Representative Solution:	**Permanent Meshing of Networks**			
	Variant Solution:	Meshing LV Urban Networks			
	Description:	Converting the operation of the LV network from a radial feeder (with split points) to a solid mesh configuration.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			50%	Increase due to balancing up of network with infeeds from two ends of a circuit
	Thermal Transformer:			10%	Uses latent capacity of transformers, from 50% utilisation for radial network to 66% utilisation for a three transformer meshed configuration. This has been scaled back for the LV urban case to 10%.
	Voltage Head:			0%	Meshed networks tend to solve low voltage problems, but can suffer from high volts: therefore no headroom benefits expected
	Voltage Leg:			2%	operating network as a mesh will reduce volt drops (as two in feeds [or more] on a given circuit)
	Power Quality:			20%	Lower circuit impedance, therefore a likely improvement in PQ headroom
	Fault Level:			-33%	A reduction in fault level capacity is expected with the meshing of circuits
Cost (£)	Capital:	£20,000			Likely to be a higher proportional cost than at EHV / HV due to the need for LV circuit breakers to be fitted to prevent backfeeding HV faults via the LV network (and resulting in damage to LV network).
	Operational Expenditure:	£100			Additional requirement for ongoing system studies to model the network (cost on a per feeder basis)
	NPV of Opex:	£1,421			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Costs are not expected to reduce over time
	Life Expectancy of Solution:	45			No different to a conventional network configuration; hence 45 years (in line with Ofgem's RAV treatment)
Merit Order	Totex (£):	£21,421			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			As per definition: "Network reconfiguration necessary in order to connect / commission solution."
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			The meshing could be 'undone' at a later date to make the network radial, but the assets could not be moved
	Cross Network Benefits Factor:	-1			Potential benefits at HV
Other Benefits	Impact on Fixed Losses (%):	0%			No impact on fixed losses
	Impact on Variable Losses (%):	-10%			Will increase copper losses, as more current will be pushed through existing circuits (worsening losses)
	Impact on quality of Supply (%):	30%			Expected to improve supply quality (ref LPN and SP-Manweb CI and CML figures)
	Year solution is available:	2012			Solution is available today (but not widely used)
	Year data (on soln) is available:				
	Source of Data:	UKPN AuRA-NMS & Interconnectable LV networks IFI project SP London Road 1			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 4			
	Focus:	Security of networks inc. physical threats, utilising new network architectures			
	Subset:	Use of meshed, rather than radial architectures			

Smart Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Permanent Meshing of Networks**			
	Variant Solution:	Meshing HV Networks			
	Description:	Converting the operation of the HV network from a radial ring (with split points) to a solid mesh configuration.			
Headroom Release (%)	Thermal Cable:		50%		Increase due to balancing up of network with infeeds from two ends of a circuit
	Thermal Transformer:		15%		Uses latent capacity of transformers, from 50% utilisation for radial network to 66% utilisation for a three transformer meshed configuration.
	Voltage Head:		0%		Meshed networks tend to solve low voltage problems, but can suffer from high volts: therefore no headroom benefits expected
	Voltage Leg:		2%		operating network as a mesh will reduce volt drops (as two in feeds [or more] on a given circuit)
	Power Quality:		20%		Lower circuit impedance, therefore a likely improvement in PQ headroom
	Fault Level:		-33%		A reduction in fault level capacity is expected with the meshing of circuits due to closing of split points and multiple transformers feeding into the fault. FL becomes a more complex problem and needs computational modelling rather than back-of-the-fag-packet calculations or rules of thumb.
Cost (£)	Capital:		£100,000		Higher cost than at EHV as this would require new current carrying infrastructure. This assumed cost is therefore be dominated by the installation of in circuit HV circuit breakers and LV circuit breakers (where necessary at infeeds), plus time to undertake system studies / protection assessment and then carry out reconfiguration (including protection changes)
	Operational Expenditure:		£100		Additional requirement for ongoing system studies to model the network (cost on a per feeder basis)
	NPV of Opex:		£1,421		Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		2		not expected to reduce in cost over time
	Life Expectancy of Solution:		45		No different to a conventional network configuration; hence 45 years (in line with Ofgem's RAV treatment)
Merit Order	Totex (£):		£101,421		Calculated from capex plus NPV of opex
	Disuption Factor (1-5):		3		As per definition: "Network reconfiguration necessary in order to connect / commission solution."
	Disruption Cost (£):		£10,000		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):		2		The meshing could be 'undone' at a later date to make the network radial, but the assets could not be moved
	Cross Network Benefits Factor:		-1		Operation of tighter voltages should result in voltage improvements at LV
Other Benefits	Impact on Fixed Losses (%):		0%		No expected change to fixed losses
	Impact on Variable Losses (%):		-10%		Will increase copper losses, as more current will be pushed through existing circuits (worsening losses)
	Impact on quality of Supply (%):		30%		Expected to improve supply quality (ref LPN and SP-Manweb CI and CML figures)
	Year solution is available:		2012		Solution is available today (but not widely used)
	Year data (on soln) is available:		2015		Few projects are looking into permenant meshing, but ENWL's C2C project should provide some insight. UKPN's LPN network and SP's Manweb network extensively run meshed networks.
	Source of Data:	ENW, Capacity 2 Customers (C2C), using GE PowerOn Fusion, NPG - KTP project, PhD interconnection business value case SP T1 Flexible Networks			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 4			
	Focus:	Security of networks inc. physical threats, utilising new network architectures			
	Subset:	Use of meshed, rather than radial architectures			

Smart Variant

Section	Field	EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Permanent Meshing of Networks**			
	Variant Solution:	Meshing EHV Networks			
	Description:	Converting the operation of the EHV network from a radial ring (with split points) to a solid mesh configuration.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	50%			Increase due to balancing up of network with infeeds from two ends of a circuit
	Thermal Transformer:	25%			Uses latent capacity of transformers, from 50% utilisation for radial network to 66% utilisation for a three transformer meshed configuration.
	Voltage Head:	0%			Meshed networks tend to solve low voltage problems, but can suffer from high volts: therefore no headroom benefits expected
	Voltage Leg:	1%			operating network as a mesh will reduce volt drops (as two in feeds [or more] on a given circuit)
	Power Quality:	30%			Lower circuit impedance, therefore a likely improvement in PQ headroom
	Fault Level:	-33%			A reduction in fault level capacity is expected with the meshing of circuits due to closing of split points and multiple transformers feeding into the fault. FL becomes a more complex problem and needs computational modelling rather than back-of-the-fag-packet calculations or rules of thumb.
Cost (£)	Capital:	£30,000			Assumed to be a relatively low cost at EHV - no specific new equipment (as HV network already has CBs to prevent backfeeding of faults). Included in this assumed cost is: time to undertake system studies / protection assessment and then carry out reconfiguration (including protection changes)
	Operational Expenditure:	£200			Additional requirement for ongoing system studies to model the network (cost on a per feeder basis)
	NPV of Opex:	£6,816			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			not expected to reduce in cost over time
	Life Expectancy of Solution:	45			No different to a conventional network configuration; hence 45 years (in line with Ofgem's RAV treatment)
Merit Order	Totex (£):	£32,842			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			As per definition: "Network reconfiguration necessary in order to connect / commission solution."
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			The meshing could be 'undone' at a later date to make the network radial, but the assets could not be moved
	Cross Network Benefits Factor:	-1			Operation of tighter voltages should result in voltage improvements at HV
Other Benefits	Impact on Fixed Losses (%):	-10%			An assumed increase in fixed losses as more transformers could be switched in at any given time to provide infeeds from both ends.
	Impact on Variable Losses (%):	-10%			Will increase copper losses, as more current will be pushed through existing circuits. Furthermore, VAr flow can be high on meshed networks if not appropriately managed
	Impact on quality of Supply (%):	30%			Expected to improve supply quality (ref LPN and SP-Manweb CI and CML figures)
	Year solution is available:	2012			Solution is available today (but not widely used)
	Year data (on soln) is available:	2014			Few projects are looking into permenant meshing, but ENWL's C2C project should provide some insight. UKPN's LPN network and SP's Manweb network extensively run meshed networks.
	Source of Data:	ENW, Capacity 2 Customers (C2C), using GE PowerOn Fusion, NPG - KTP project, PhD interconnection business value case SP T1 Flexible Networks			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 4			
	Focus:	Security of networks inc. physical threats, utilising new network architectures			
	Subset:	Use of meshed, rather than radial architectures			

Smart Variant

Solution Overview	Representative Solution:	**New Types Of Circuit Infrastructure**			
	Variant Solution:	Novel HV underground cable			
	Description:	The deployment of new, higher capacity, HV underground cables incorporating modern conductor types and designed in a way to minimise electrical resistance and reactance.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		150%		Assumed to give an increased benefit over conventional overhead line circuits.
	Thermal Transformer:		0%		No expected benefit
	Voltage Head:		0%		No expected benefit
	Voltage Leg:		3%		Small benefit to voltage legroom as a lower volt-drop down the circuit
	Power Quality:		0%		No expected benefit
	Fault Level:		0%		No expected benefit
Cost (£)	Capital:		£300,000		Assumed cost based on an average HV underground cable circuit length of 3km - assuming £100k/km
	Operational Expenditure:		£0		No anticipted cost
	NPV of Opex:		£0		Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		2		Costs assumed to be static over time - the effects of deploying larger volumes are cancelled out by rising price of aluminium / steel.
	Life Expectancy of Solution:		20		As per conventional overhead line infrastructure
Merit Order	Totex (£):		£300,000		Calculated from capex plus NPV of opex
	Disuption Factor (1-5):		4		Potentially large disruption to society whilst wayleaves/easements are agreed and new circuits are constructed.
	Disruption Cost (£):		£30,000		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):		1		Fixed asset. Once constructed cannot be moved.
	Cross Network Benefits Factor:		1		Potentially small improvement at apportioning load on Primary transformers.
Other Benefits	Impact on Fixed Losses (%):		0%		No expected benefit
	Impact on Variable Losses (%):		-20%		An expectation that the larger/different cable sizes and/or physical layout of cables will help to minimise resistance and reactance (respectively), which should help reduce losses.
	Impact on quality of Supply (%):		0%		No expected benefit
	Year solution is available:		2018		Estimate
	Year data (on soln) is available:		2015		Some small trials are happening, but no significant activity in GB
	Source of Data:	Initial estimates based on engineering judgement			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 3			
	Focus:	Plant & Systems reliability, failure mode detection			
	Subset:	Use of novel tower/insulation structures to enhance route capacity			

Smart Variant

Solution Overview	Representative Solution:	**New Types Of Circuit Infrastructure**			
	Variant Solution:	Novel EHV underground cable			
	Description:	The deployment of new, higher capacity, EHV underground cables incorporating modern conductor types and designed in a way to minimise electrical resistance and reactance.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	150%			Assumed to give an increased benefit over conventional overhead line circuits.
	Thermal Transformer:	0%			No expected benefit
	Voltage Head:	0%			No expected benefit
	Voltage Leg:	2%			Small benefit to voltage legroom as a lower volt-drop down the circuit
	Power Quality:	0%			No expected benefit
	Fault Level:	0%			No expected benefit
Cost (£)	Capital:	£900,000			Assumed cost based on an average EHV underground cable circuit length of 5km - assuming £180k/km
	Operational Expenditure:	£0			No anticipted cost
	NPV of Opex:	£0			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	1			Costs assumed to be static over time - the effects of deploying larger volumes are cancelled out by rising price of aluminium / steel.
	Life Expectancy of Solution:	20			As per conventional overhead line infrastructure
Merit Order	Totex (£):	£900,000			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	5			Potentially large disruption to society whilst wayleaves/easements are agreed and new circuits are constructed.
	Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			Fixed asset. Once constructed cannot be moved.
	Cross Network Benefits Factor:	1			Potentially small improvement at apportioning load on Primary transformers.
Other Benefits	Impact on Fixed Losses (%):	0%			No expected benefit
	Impact on Variable Losses (%):	-20%			An expectation that the larger/different cable sizes and/or physical layout of cables will help to minimise resistance and reactance (respectively), which should help reduce losses.
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:	2018			Estimate
	Year data (on soln) is available:	2015			Some small trials are happening, but no significant activity in GB
	Source of Data:	Initial estimates based on engineering judgement			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 3			
	Focus:	Plant & Systems reliability, failure mode detection			
	Subset:	Use of novel tower/insulation structures to enhance route capacity			

Smart Variant

Solution Overview	Representative Solution:	**New Types Of Circuit Infrastructure**			
	Variant Solution:	Novel HV tower and insulator structures			
	Description:	The deployment of new, higher capacity, HV overhead line infrastructure incorporating modern conductor types and designed in a way to minimise electrical resistance and reactance.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		150%		Assumed to give an increased benefit over conventional overhead line circuits.
	Thermal Transformer:		0%		No expected benefit
	Voltage Head:		0%		No expected benefit
	Voltage Leg:		3%		Small benefit to voltage legroom as a lower volt-drop down the circuit
	Power Quality:		0%		No expected benefit
	Fault Level:		0%		No expected benefit
Cost (£)	Capital:	£600,000			Assumed cost based on an average HV overhead line circuit length of 10km - assuming £60k/km
	Operational Expenditure:	£0			No anticipated cost
	NPV of Opex:	£0			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Costs assumed to be static over time - the effects of deploying larger volumes are cancelled out by rising price of aluminium / steel.
	Life Expectancy of Solution:	45			As per conventional overhead line infrastructure
Merit Order	Totex (£):	£600,000			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	4			Potentially large disruption to society whilst wayleaves are agreed and new circuits are constructed - not assumed to be as large as for EHV circuits
	Disruption Cost (£):	£30,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			Fixed asset. Once constructed cannot be moved.
	Cross Network Benefits Factor:	1			Potentially small improvement at apportioning load on upstream transformers.
Other Benefits	Impact on Fixed Losses (%):	0%			No expected benefit
	Impact on Variable Losses (%):	-20%			An expectation that the larger/different conductor sizes and/or physical layout of conductors will help to minimise resistance and reactance (respectively), which should help reduce losses.
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:	2018			Estimate
	Year data (on soln) is available:	2015			Some small trials are happening, but no significant activity in GB
	Source of Data:	Initial estimates based on engineering judgement			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 3			
	Focus:	Plant & Systems reliability, failure mode detection			
	Subset:	Use of novel tower/insulation structures to enhance route capacity			

Smart Variant

Solution Overview	Representative Solution:	**New Types Of Circuit Infrastructure**			
	Variant Solution:	Novel EHV tower and insulator structures			
	Description:	The deployment of new, higher capacity, EHV overhead line infrastructure incorporating modern conductor types and designed in a way to minimise electrical resistance and reactance.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	150%			Assumed to give an increased benefit over conventional overhead line circuits.
	Thermal Transformer:	0%			No expected benefit
	Voltage Head:	0%			No expected benefit
	Voltage Leg:	2%			Small benefit to voltage legroom as a lower volt-drop down the circuit
	Power Quality:	0%			No expected benefit
	Fault Level:	0%			No expected benefit
Cost (£)	Capital:	£900,000			Assumed cost based on an average EHV overhead line circuit length of 6km - assuming £150k/km
	Operational Expenditure:	£0			No anticipcted cost
	NPV of Opex:	£0			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Costs assumed to be static over time - the effects of deploying larger volumes are cancelled out by rising price of aluminium / steel.
	Life Expectancy of Solution:	45			As per conventional overhead line infrastructure
Merit Order	Totex (£):	£900,000			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	5			Potentially significant disruption to society whilst wayleaves are agreed and new circuits are constructed
	Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			Fixed asset. Once constructed cannot be moved.
	Cross Network Benefits Factor:	1			Potentially small improvement at HV.
Other Benefits	Impact on Fixed Losses (%):	0%			No expected benefit
	Impact on Variable Losses (%):	-20%			An expectation that the larger/different conductor sizes and/or physical layout of conductors will help to minimise resistance and reactance (respectively), which should help reduce losses.
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:	2018			Estimate
	Year data (on soln) is available:	2015			Some small trials are happening, but no significant activity in GB
	Source of Data:	Initial estimates based on engineering judgement			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 3			
	Focus:	Plant & Systems reliability, failure mode detection			
	Subset:	Use of novel tower/insulation structures to enhance route capacity			

Smart Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Local smart EV charging infrastructure**			
	Variant Solution:	Intelligent control devices			
	Description:	A novel monitoring and control solution to manage the supply of electricity to EVs connected to distribution networks, ensuring that the load of all EV chargers does not take the load above the rating of the LV circuit.			
Headroom Release (%)	Thermal Cable:			10%	Part of a DSR solution - assumed benefit
	Thermal Transformer:			5%	Part of a DSR solution - assumed benefit
	Voltage Head:			0%	No benefit for voltage headroom
	Voltage Leg:			5%	Scheduling of EV charging, could prevent excessive loading on networks, and consequental reduction in volts down a feeder
	Power Quality:			0%	Not antipated to improve power quality
	Fault Level:			0%	Not antipated to improve fault level
Cost (£)	Capital:	£15,000			Estimate, based on controlling up to 20 EVs on a feeder
	Operational Expenditure:	£250			Estimate for comms costs
	NPV of Opex:	£3,553			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	4			Potentially high volume product (dependent on the global appetite for EVs) that could see signfincant reductions in cost
	Life Expectancy of Solution:	25			Estimated life expectancy of secondary equipment (eg comms and automation)
Merit Order	Totex (£):	£18,553			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	1			Low disruption, as assumed to be located in a DNOs substation or embedded in a charging unit
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	4			Device could be moved if necessary
	Cross Network Benefits Factor:	2			No direct benefit to other networks, but an enabler for vehicle DSR / storage
Other Benefits	Impact on Fixed Losses (%):	0%			No expected benefit
	Impact on Variable Losses (%):	0%			No expected benefit
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:	2016			estimate
	Year data (on soln) is available:	2016			Pending network trials and operation with real EVs and real customers
	Source of Data:	EA Technology engineering judgement (based on known products)			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart EV Charging			
	Focus:	EV charging/discharging (V2G), Network management, Demand Response and other services			
	Subset:	Architecture - distributed processing - street, substation or community level, distributed charging			

Smart Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Generator Providing Network Support, e.g. PV Mode**			
	Variant Solution:	Generator support @ LV			
	Description:	Contracting with a larger LV 3-phase connected generator for them to operate their sets in PV (Real power and volts) mode rather than the conventional PQ (Real and Reactive power). The generator will draw VArs from the network at certain times, but ensure that the voltage on the network is not excessively raised at the point of connection.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	No expected benefit
	Thermal Transformer:			0%	No expected benefit
	Voltage Head:			4%	Generators operating in this manner should help provide voltage headroom. The full extent is clearly dependent on the size of the generation connection, but has been assumed to equal 4% as an average.
	Voltage Leg:			4%	As voltage headoom, generators operating in this manner should help provide voltage legroom. The full extent is clearly dependent on the size of the generation connection, but has been assumed to equal 4% as an average.
	Power Quality:				No expected benefit
	Fault Level:				No expected benefit
Cost (£)	Capital:	£2,000			Assumed cost of arranging the contract and any necessary control / monitoring infrastructure between the generator and the DNO.
	Operational Expenditure:	£1,000			Assumed cost to operate secure and high availability communications channels.
	NPV of Opex:	£14,212			Based on 5 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Assumed to be flat for the 5years of the operation of the contract
	Life Expectancy of Solution:	5			Commercial contract, treated in the same manner as DSR.
Merit Order	Totex (£):	£16,212			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	0			No disruption to the general public as this would be a contract agreed between generator and DNO.
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):				Whilst the concept of the contracts could be used in other areas, it would be tailored to a specific generator and network topology. It has therefore been assumed that this solution is not easily moved.
	Cross Network Benefits Factor:	0			No expected benefit
Other Benefits	Impact on Fixed Losses (%):	0%			No expected benefit
	Impact on Variable Losses (%):	0%			No expected benefit
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:	2012			The solution is used in a very small number of instances, but not yet widespread.
	Year data (on soln) is available:				
	Source of Data:				
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Intelligent voltage control			

Smart Variant

Solution Overview	Representative Solution:	**Generator Providing Network Support, e.g. PV Mode**			
	Variant Solution:	Generator support @ HV			
	Description:	Contracting with a HV connected generator for them to operate their sets in PV (Real power and volts) mode rather than the conventional PQ (Real and Reactive power). The generator will draw VArs from the network at certain times, but ensure that the voltage on the network is not excessively raised at the point of connection.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		0%		No expected benefit
	Thermal Transformer:		0%		No expected benefit
	Voltage Head:		4%		Generators operating in this manner should help provide voltage headroom. The full extent is clearly dependent on the size of the generation connection, but has been assumed to equal 2% as an average.
	Voltage Leg:		4%		As voltage headoom, generators operating in this manner should help provide voltage legroom. The full extent is clearly dependent on the size of the generation connection, but has been assumed to equal 2% as an average.
	Power Quality:				No expected benefit
	Fault Level:				No expected benefit
Cost (£)	Capital:		£10,000		Assumed cost of arranging the contract and any necessary control / monitoring infrastructure between the generator and the DNO.
	Operational Expenditure:		£5,000		Assumed cost to operate secure and high availability communications channels.
	NPV of Opex:		£71,062		Based on 5 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		2		Assumed to be flat for the 5years of the operation of the contract
	Life Expectancy of Solution:		5		Commercial contract, treated in the same manner as DSR.
Merit Order	Totex (£):		£81,062		Calculated from capex plus NPV of opex
	Disuption Factor (1-5):		0		No disruption to the general public as this would be a contract agreed between generator and DNO.
	Disruption Cost (£):		£0		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):				Whilst the concept of the contracts could be used in other areas, it would be tailored to a specific generator and network topology. It has therefore been assumed that this solution is not easily moved.
	Cross Network Benefits Factor:		0		No expected benefit
Other Benefits	Impact on Fixed Losses (%):		0%		No expected benefit
	Impact on Variable Losses (%):		0%		No expected benefit
	Impact on quality of Supply (%):		0%		No expected benefit
	Year solution is available:		2012		The solution is used in a very small number of instances, but not yet widespread.
	Year data (on soln) is available:				
	Source of Data:	WPD - FALCON T2 LCNF. 11kV Generator support			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Intelligent voltage control			

Smart Variant

Section	Field	EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Generator Providing Network Support, e.g. PV Mode**			
	Variant Solution:	Generator support @ EHV			
	Description:	Contracting with a EHV connected generator for them to operate their sets in PV (Real power and volts) mode rather than the conventional PQ (Real and Reactive power). The generator will draw VArs from the network at certain times, but ensure that the voltage on the network is not excessively raised at the point of connection.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	0%			No expected benefit
	Thermal Transformer:	0%			No expected benefit
	Voltage Head:	2%			Generators operating in this manner should help provide voltage headroom. The full extent is clearly dependent on the size of the generation connection, but has been assumed to equal 2% as an average.
	Voltage Leg:	2%			As voltage headoom, generators operating in this manner should help provide voltage legroom. The full extent is clearly dependent on the size of the generation connection, but has been assumed to equal 2% as an average.
	Power Quality:	0%			No expected benefit
	Fault Level:	0%			No expected benefit
Cost (£)	Capital:	£15,000			Assumed cost of arranging the contract and any necessary control / monitoring infrastructure between the generator and the DNO.
	Operational Expenditure:	£10,000			Assumed cost to operate secure and high availability communications channels.
	NPV of Opex:	£45,151			Based on 5 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Assumed to be flat for the 5years of the operation of the contract
	Life Expectancy of Solution:	5			Commercial contract, treated in the same manner as DSR.
Merit Order	Totex (£):	£60,151			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	1			No disruption to the general public as this would be a contract agreed between generator and DNO.
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			Whilst the concept of the contracts could be used in other areas, it would be tailored to a specific generator and network topology. It has therefore been assumed that this solution is not easily moved.
	Cross Network Benefits Factor:	0			No expected benefit
Other Benefits	Impact on Fixed Losses (%):	0%			No expected benefit
	Impact on Variable Losses (%):	0%			No expected benefit
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:	2012			The solution is used in a very small number of instances, but not yet widespread.
	Year data (on soln) is available:				
	Source of Data:	WPD - FALCON T2 LCNF			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Intelligent voltage control			

Smart Variant

Solution Overview	Representative Solution:	**Generator Constraint Management, GSR (Generator Side Response)**			
	Variant Solution:	LV GSR (Generator Side Response)			
	Description:	The use of commercial contracts, underpinned with automated signalling, between a DNO and generation customer(s) to ramp down export under certain network conditions. This variant considers larger generators (e.g. supermarkets, commercial buildings) connected to the LV network - it is not deemed to be a residential solution			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	No anticipated benefit
	Thermal Transformer:			0%	No anticipated benefit
	Voltage Head:			6%	By signalling to a generator at specific times of the day, it may be possible to reduce the voltage on the network (as generators tend to lift network volts as they export). For the LV network, this has assumed to be a headroom gain of 6%.
	Voltage Leg:			0%	No anticipated benefit
	Power Quality:			0%	No anticipated benefit
	Fault Level:			0%	No anticipated benefit
Cost (£)	Capital:	£20,000			Asssumed cost incorporating: specialist assessment work to tailor local network constraints to individual generators, establishment of the contracts between parties, installation and testing of equipment.
	Operational Expenditure:	£500			Assumed annual opex costs incorporating: high availability and secure communications, annual testing of system. NB. There is assumed to be no distruption payment made to generators associated with this solution (the principle benefit to the generator would be a cheaper and/or quicker connection).
	NPV of Opex:	£7,106			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Flat - as per DSR, this is linked to the short duration contract that would be put in place between DNO and generator.
	Life Expectancy of Solution:	5			As per DSR, these commercial contract solutions are considered to last 5 years in the model.
Merit Order	Totex (£):	£27,106			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	1			No disruption to customers at large - bilateral arrangement between DNO and generator
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			Assumed that the solution is unlikely to be moved in the 5years life of the commercial contract
	Cross Network Benefits Factor:	0			Not assumed to give a benefit to other network voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			No impact on fixed losses
	Impact on Variable Losses (%):	0%			Whilst there may be a marginal reduction in variable losses for the times when the constraint is enacted, it would be case specific. For modelling purpose, we assume no benefits.
	Impact on quality of Supply (%):	0%			This solution is not anticiapted to have an impact on QoS performance
	Year solution is available:	2012			This solution is available in 2012, albeit not used extensively.
	Year data (on soln) is available:	2014			
	Source of Data:	STATCOM - currently in tests with ENW Tier 1,			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Intelligent voltage control			

Smart Variant

Solution Overview	Representative Solution:	**Generator Constraint Management, GSR (Generator Side Response)**			
	Variant Solution:	HV GSR (Generator Side Response)			
	Description:	The use of commercial contracts, underpinned with automated signalling, between a DNO and generation customer(s) to ramp down export under certain network conditions. This variant is considers any generators connected to the HV network.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		0%		No anticipated benefit
	Thermal Transformer:		0%		No anticipated benefit
	Voltage Head:		4%		By signalling to a generator at specific times of the day, it may be possible to reduce the voltage on the network (as generators tend to lift network volts as they export). For the HV network, this has assumed to be a headroom gain of 4%.
	Voltage Leg:		0%		No anticipated benefit
	Power Quality:		0%		No anticipated benefit
	Fault Level:		0%		No anticipated benefit
Cost (£)	Capital:	£80,000			Asssumed cost incorporating: specialist assessment work to tailor local network constraints to individual generators, establishment of the contracts between parties, installation and testing of equipment.
	Operational Expenditure:	£2,000			Assumed annual opex costs incorporating: high availability and secure communications, annual testing of system. NB. There is assumed to be no distruption payment made to generators associated with this solution (the principle benefit to the generator would be a cheaper and/or quicker connection).
	NPV of Opex:	£28,425			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Flat - as per DSR, this is linked to the short duration contract that would be put in place between DNO and generator.
	Life Expectancy of Solution:	5			As per DSR, these commercial contract solutions are considered to last 5 years in the model.
Merit Order	Totex (£):	£108,425			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	1			No disruption to customers at large - bilateral arrangement between DNO and generator
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			Assumed that the solution is unlikely to be moved in the 5years life of the commercial contract
	Cross Network Benefits Factor:	0			Not assumed to give a benefit to other network voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			No impact on fixed losses
	Impact on Variable Losses (%):	0%			Whilst there may be a marginal reduction in variable losses for the times when the constraint is enacted, it would be case specific. For modelling purpose, we assume no benefits.
	Impact on quality of Supply (%):	0%			This solution is not anticiapted to have an impact on QoS performance
	Year solution is available:	2012			This solution is available in 2012, albeit not used extensively.
	Year data (on soln) is available:	2014			
	Source of Data:	STATCOM - currently in tests with ENW Tier 1,			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Intelligent voltage control			

Smart Variant

Solution Overview	Representative Solution:	**Generator Constraint Management, GSR (Generator Side Response)**			
	Variant Solution:	EHV GSR (Generator Side Response)			
	Description:	The use of commercial contracts, underpinned with automated signalling, between a DNO and generation customer(s) to ramp down export under certain network conditions. This variant considers larger generators connected to the EHV network.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	0%			No anticipated benefit
	Thermal Transformer:	0%			No anticipated benefit
	Voltage Head:	2%			By signalling to a generator at specific times of the day, it may be possible to reduce the voltage on the network (as generators tend to lift network volts as they export). For the EHV network, this has assumed to be a headroom gain of 2%.
	Voltage Leg:	0%			No anticipated benefit
	Power Quality:	0%			No anticipated benefit
	Fault Level:	0%			No anticipated benefit
Cost (£)	Capital:	£150,000			Asssumed cost incorporating: specialist assessment work to tailor local network constraints to individual generators, establishment of the contracts between parties, installation and testing of equipment.
	Operational Expenditure:	£5,000			Assumed annual opex costs incorporating: high availability and secure communications, annual testing of system. NB. There is assumed to be no distruption payment made to generators associated with this solution (the principle benefit to the generator would be a cheaper and/or quicker connection).
	NPV of Opex:	£11,454			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Flat - as per DSR, this is linked to the short duration contract that would be put in place between DNO and generator.
	Life Expectancy of Solution:	5			As per DSR, these commercial contract solutions are considered to last 5 years in the model.
Merit Order	Totex (£):	£221,062			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	1			No disruption to customers at large - bilateral arrangement between DNO and generator
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			Assumed that the solution is unlikely to be moved in the 5years life of the commercial contract
	Cross Network Benefits Factor:	0			Not assumed to give a benefit to other network voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			No impact on fixed losses
	Impact on Variable Losses (%):	0%			Whilst there may be a marginal reduction in variable losses for the times when the constraint is enacted, it would be case specific. For modelling purpose, we assume no benefits.
	Impact on quality of Supply (%):	0%			This solution is not anticiapted to have an impact on QoS performance
	Year solution is available:	2012			This solution is available in 2012, albeit not used extensively.
	Year data (on soln) is available:	2014			
	Source of Data:	UKPN - Low Carbon London; SSE - Orkney ANM RPZ scheme / NINES			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Intelligent voltage control			

Smart Variant

Solution Overview	Representative Solution:	**Fault Current Limiters**			
	Variant Solution:	HV Superconducting fault current limiters			
	Description:	The use of superconducting materials, as a form of non-linear resistor, to clamp fault current levels at HV to within predefined limits.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		0%		No expected benefit
	Thermal Transformer:		0%		No expected benefit
	Voltage Head:		0%		No expected benefit
	Voltage Leg:		0%		No expected benefit
	Power Quality:		10%		No expected benefit
	Fault Level:		50%		Potentially significant increases in FL headroom
Cost (£)	Capital:	£500,000			Units are currently limited in volume, and are consequently high cost
	Operational Expenditure:	£200			Additional maintenance in the initial stages of deployment
	NPV of Opex:	£2,842			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	4			Expect a reduction as units are produced in greater volumes, medium reduction as current costs are likely to be disproportionate to the end roll-out costs
	Life Expectancy of Solution:	25			Anticipate a shorter asset life as performing a safety critical role, and should not be allowed to fail due to end of life
Merit Order	Totex (£):	£502,842			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			Installation of equipment in a Network Operators' substation or on their circuits.
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			A fixed asset that can be redeployed, but with significant cost, e.g. transformer, HV storage unit, EHV D-FACTS device
	Cross Network Benefits Factor:	0			No expected benefit
Other Benefits	Impact on Fixed Losses (%):	10%			Fixed losses are likely to increase network losses due to additional load on the network (e.g.chiller units, etc)
	Impact on Variable Losses (%):	0%			The superconducting aspect of the device means that under normal load, there is no resistance; with resistance only being enacted under very high current densities.
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:	2015			Some units are currently on-trial on networks, but have not yet been deployed 'in anger'
	Year data (on soln) is available:	2015			information from existing projects
	Source of Data:	Northern Powergrid			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Fault limiting devices			

Smart Variant

Solution Overview	Representative Solution:	**Fault Current Limiters**			
	Variant Solution:	HV Non-superconducting fault current limiters			
	Description:	The use of non-superconducting (eg. magnetic) materials, as a form of non-linear resistor, to clamp fault current levels at HV to within predefined limits.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		0%		No expected benefit
	Thermal Transformer:		0%		No expected benefit
	Voltage Head:		0%		No expected benefit
	Voltage Leg:		0%		No expected benefit
	Power Quality:		0%		No expected benefit
	Fault Level:		40%		Potentially significant increases in FL headroom
Cost (£)	Capital:		£500,000		Units are currently limited in volume, and are consequently high cost
	Operational Expenditure:		£200		Additional maintenance in the initial stages of deployment
	NPV of Opex:		£2,842		Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		4		Expect a reduction as units are produced in greater volumes, medium reduction as current costs are likely to be disproportionate to the end roll-out costs
	Life Expectancy of Solution:		25		Anticipate a shorter asset life as performing a safety critical role, and should not be allowed to fail due to end of life
Merit Order	Totex (£):		£502,842		Calculated from capex plus NPV of opex
	Disuption Factor (1-5):		3		Installation of equipment in a Network Operators' substation or on their circuits.
	Disruption Cost (£):		£10,000		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):		2		A fixed asset that can be redeployed, but with significant cost, e.g. transformer, HV storage unit, EHV D-FACTS device
	Cross Network Benefits Factor:		0		No expected benefit
Other Benefits	Impact on Fixed Losses (%):		10%		
	Impact on Variable Losses (%):		0%		The superconducting aspect of the device means that under normal load, there is no resistance, under very high current densities, the deice Solution will increase network losses due to additional load on the network (e.g.chiller units, etc)
	Impact on quality of Supply (%):		0%		No expected benefit
	Year solution is available:		2015		Some units are currently on-trial on networks, but have not yet been deployed 'in anger'
	Year data (on soln) is available:		2015		information from existing projects
	Source of Data:	Northern Powergrid			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Fault limiting devices			

Smart Variant

Solution Overview	Representative Solution:	**Fault Current Limiters**			
	Variant Solution:	HV reactors - mid circuit			
	Description:	The application of reactors part way down a HV circuit to limit fault current.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		0%		No expected benefit
	Thermal Transformer:		0%		No expected benefit
	Voltage Head:		0%		No expected benefit
	Voltage Leg:		0%		No expected benefit
	Power Quality:		-10%		Reduction in Power Quality due to increased impedance.
	Fault Level:		20%		Significant increase in fault level
Cost (£)	Capital:	£50,000			estimate
	Operational Expenditure:	£100			estimate
	NPV of Opex:	£1,421			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Reactors at HV and EHV are relatively common devices, the combination of potentially larger volumes, but rising commodity prices (steel, copper), have been assumed to give a flat profile over time. For LV devices, they are not common, and would therefore be expected to reduce in cost.
	Life Expectancy of Solution:	45			Aligned to life expectancy of a transformer
Merit Order	Totex (£):	£51,421			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			Limited disruption during installation and commissioning
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			Devices could be moved during their lifetime, but not a trivial task
	Cross Network Benefits Factor:	0			No expected benefit
Other Benefits	Impact on Fixed Losses (%):	10%			A reactor is an impedance that is placed into a network, it is, by definition, a lossy device.
	Impact on Variable Losses (%):	0%			No impact on variable losses
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:	2012			Solutions are available today, although not typically used at LV
	Year data (on soln) is available:				
	Source of Data:				
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Fault limiting devices			

Smart Variant

Solution Overview	Representative Solution:	**Fault Current Limiters**			
	Variant Solution:	EHV Superconducting fault current limiters			
	Description:	The use of superconducting materials, as a form of non-linear resistor, to clamp fault current levels at EHV to within predefined limits.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	0%			No expected benefit
	Thermal Transformer:	0%			No expected benefit
	Voltage Head:	0%			No expected benefit
	Voltage Leg:	0%			No expected benefit
	Power Quality:	10%			Small improvement as this solution facilitates a lower impedance network configuration, i.e. temporary or permenant meshing
	Fault Level:	40%			Potentially significant increases in FL headroom
Cost (£)	Capital:	£750,000			Units are currently limited in volume, and are consequently high cost
	Operational Expenditure:	£200			Additional maintenance in the initial stages of deployment
	NPV of Opex:	£6,816			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			Expect a reduction as units are produced in greater volumes, but slow reduction (as not a high volume commodity at EHV)
	Life Expectancy of Solution:	25			Anticipate a shorter asset life as performing a safety critical role, and should not be allowed to fail due to end of life
Merit Order	Totex (£):	£752,842			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			Installation of equipment in a Network Operators' substation or on their circuits.
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			A fixed asset that can be redeployed, but with significant cost, e.g. transformer, HV storage unit, EHV D-FACTS device
	Cross Network Benefits Factor:	0			No expected benefit
Other Benefits	Impact on Fixed Losses (%):	10%			Fixed losses are likely to increase network losses due to additional load on the network (e.g.chiller units, etc)
	Impact on Variable Losses (%):	0%			The superconducting aspect of the device means that under normal load, there is no resistance; with resistance only being enacted under very high current densities.
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:	2018			estimate
	Year data (on soln) is available:	2018			information from existing projects
	Source of Data:	UKPN ETI project. SFCL on Bus section			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Fault limiting devices			

Smart Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Fault Current Limiters**			
	Variant Solution:	EHV Non-superconducting fault current limiters			
	Description:	The use of non-superconducting (eg magnetic) materials, as a form of non-linear resistor, to clamp fault current levels at EHV to within predefined limits.			
Headroom Release (%)	Thermal Cable:	0%			No expected benefit
	Thermal Transformer:	0%			No expected benefit
	Voltage Head:	0%			No expected benefit
	Voltage Leg:	0%			No expected benefit
	Power Quality:	0%			Small improvement as this solution facilitates a lower impedance network configuration, i.e. temporary or permenant meshing
	Fault Level:	50%			Potentially significant increases in FL headroom
Cost (£)	Capital:	£750,000			Units are currently limited in volume, and are consequently high cost
	Operational Expenditure:	£200			Additional maintenance in the initial stages of deployment
	NPV of Opex:	£6,816			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			Expect a reduction as units are produced in greater volumes, but slow reduction (as not a high volume commodity at EHV)
	Life Expectancy of Solution:	25			Anticipate a shorter asset life as performing a safety critical role, and should not be allowed to fail due to end of life
Merit Order	Totex (£):	£752,842			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			Installation of equipment in a Network Operators' substation or on their circuits.
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			A fixed asset that can be redeployed, but with significant cost, e.g. transformer, HV storage unit, EHV D-FACTS device
	Cross Network Benefits Factor:	0			No expected benefit
Other Benefits	Impact on Fixed Losses (%):	10%			
	Impact on Variable Losses (%):	0%			The superconducting aspect of the device means that under normal load, there is no resistance, under very high current densities, the deice Solution will increase network losses due to additional load on the network (e.g.chiller units, etc)
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:	2018			estimate
	Year data (on soln) is available:	2018			information from existing projects
	Source of Data:	UKPN ETI project. SFCL on Bus section			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Fault limiting devices			

Smart Variant

Solution Overview Representative Solution:	**Enhanced Automatic voltage Control (EAVC)**				
Variant Solution:	LV PoC voltage regulators				
Description:	As the network starts to operate closer to these limits, DNOs may opt to introduce additional automatic voltage control devices over and above those located at the grid and primary transformers. Together these new and existing voltage control devices will constitute an EAVC system. This variant considers voltage regulation devices located at individual customers' premesis' or businesses. These units maintain voltage to a single, or very small number of customers, and may be suitable for both customers located near to a distribution substation (high volts) or those located at the furthest point from the distribution substation (low volts)				
	EHV	**HV**	**LV**	**Comments**	
Headroom Release (%) Thermal Cable:			0%	No expected benefit	
Thermal Transformer:			0%	No expected benefit	
Voltage Head:			2%	Could be used to resolve high volts issues for a limited number of customers	
Voltage Leg:			2%	Could be used to resolve low volts issues for a limited number of customers	
Power Quality:			0%	No expected benefit	
Fault Level:			0%	No expected benefit	
Cost (£) Capital:	£2,000			Estimated cost for purchase and installation (per feeder)	
Operational Expenditure:	£50			Assumed to be "fit and forget" maintenance-free devices - therefore no ongoing operational expenditure assumed for this solution.	
NPV of Opex:	£711			Based on 20 year of annual operating expenditure @ 3.5% discount rate	
Cost Curve Type:	2			Potential to become a high volume commodity, hence a sharper roll-off	
Life Expectancy of Solution:	15			Estimated life expectancy of this type of consumer/network equipment	
Merit Order Totex (£):	£2,711			Calculated from capex plus NPV of opex	
Disuption Factor (1-5):	2			Limited distruption (likely to affect only 1-3 customers)	
Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)	
Flexibility (1-5):	4			These products could be easily redeployed as other (more widespread) solutions are used	
Cross Network Benefits Factor:	0			Potential to allow HV volts to operate outside of statutory limits (whilst ensuring LV customers receive volts within limits)	
Other Benefits Impact on Fixed Losses (%):	2%			Lossy devices, expected to give rise to a small increase in losses	
Impact on Variable Losses (%):	0%			No change to variable losses anticipated with this solution	
Impact on quality of Supply (%):	0%			No expected benefit	
Year solution is available:	2012			Solutions are in use today, but not at scale	
Year data (on soln) is available:	2013			More learning to come from WPD and ENWL projects	
Source of Data:	Powerperfector - currently in tests with ENW Tier 1, WPD PhD@ Aston uni				
Smart Solution Relevance (WS3 Ph1) Smart Solution Set:	Smart D-Networks 2				
Focus:	DG connections, management of two way power flows				
Subset:	Intelligent voltage control				

Smart Variant

Solution Overview	Representative Solution:	**Enhanced Automatic voltage Control (EAVC)**			
	Variant Solution:	LV circuit voltage regulators			
	Description:	As the network starts to operate closer to these limits, DNOs may opt to introduce additional automatic voltage control devices over and above those located at the grid and primary transformers. Together these new and existing voltage control devices will constitute an EAVC system. This variant considers an in-line voltage regulator for LV circuits. These units may be power electronic or mechanical in their nature, but all aim to optimise voltages on a given network. They may be single, three or even two phase in their setup, depending on their size and configuration.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	No expected benefit
	Thermal Transformer:			0%	No expected benefit
	Voltage Head:			10%	Could be used to resolve high volts issues for a number of customers
	Voltage Leg:			10%	Could be used to resolve low volts issues for a number of customers
	Power Quality:			0%	No expected benefit
	Fault Level:			0%	No expected benefit
Cost (£)	Capital:	£12,000			Estimated cost for purchase and installation (per feeder)
	Operational Expenditure:	£0			Assumed to be “fit and forget” maintenance-free devices - therefore no ongoing operational expenditure assumed for this solution.
	NPV of Opex:	£0			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			LV application could see such a unit becoming relatively high volume, with sharp roll-off rates
	Life Expectancy of Solution:	20			Estimated life expectancy of this type of equipment
Merit Order	Totex (£):	£12,000			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Likely to disrupt a number of customers down an LV feeder at time of installation/commissioning
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	4			These products could be easily redeployed as other (more widespread) solutions are used
	Cross Network Benefits Factor:	1			Potential to allow HV volts to operate outside of statutory limits (whilst ensuring LV customers receive volts within limits)
Other Benefits	Impact on Fixed Losses (%):	2%			Lossy devices, expected to give rise to a small increase in losses
	Impact on Variable Losses (%):	0%			No change to variable losses anticipated with this solution
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:	2012			Solutions are in use today, but not at scale
	Year data (on soln) is available:	2013			More learning to come from WPD and ENWL projects
	Source of Data:	Shunt reactors			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Intelligent voltage control			

Smart Variant

Solution Overview	Representative Solution:	**Enhanced Automatic voltage Control (EAVC)**			
	Variant Solution:	HV circuit voltage regulators			
	Description:	As the network starts to operate closer to these limits, DNOs may opt to introduce additional automatic voltage control devices over and above those located at the grid and primary transformers. Together these new and existing voltage control devices will constitute an EAVC system. This variant considers an in-line voltage regulator for HV circuits. These units may be power electronic or mechanical in their nature, but all aim to optimise voltages on a given network. They may be single, three or even two phase in their setup, depending on their size and configuration.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		0%		No expected benefit
	Thermal Transformer:		0%		No expected benefit
	Voltage Head:		6%		Could be used to resolve high volts issues for a number of customers
	Voltage Leg:		6%		Could be used to resolve low volts issues for a number of customers
	Power Quality:		0%		No expected benefit
	Fault Level:		0%		No expected benefit
Cost (£)	Capital:	£20,000			Estimated cost for purchase and installation (per feeder)
	Operational Expenditure:	£0			Assumed to be "fit and forget" maintenance-free devices - therefore no ongoing operational expenditure assumed for this solution.
	NPV of Opex:	£0			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			LV application could see such a unit becoming relatively high volume, with sharp roll-off rates
	Life Expectancy of Solution:	20			Estimated life expectancy of this type of equipment
Merit Order	Totex (£):	£20,000			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Likely to disrupt a number of customers down an LV feeder at time of installation/commissioning
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	4			These products could be easily redeployed as other (more widespread) solutions are used
	Cross Network Benefits Factor:	1			Potential to allow HV volts to operate outside of statutory limits (whilst ensuring LV customers receive volts within limits)
Other Benefits	Impact on Fixed Losses (%):	2%			Lossy devices, expected to give rise to a small increase in losses
	Impact on Variable Losses (%):	0%			No change to variable losses anticipated with this solution
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:	2012			Solutions are in use today, but not at scale
	Year data (on soln) is available:	2013			More learning to come from WPD and ENWL projects
	Source of Data:	Shunt reactors			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Intelligent voltage control			

Smart Variant

Solution Overview	Representative Solution:	**Enhanced Automatic voltage Control (EAVC)**			
	Variant Solution:	EHV circuit voltage regulators			
	Description:	As the network starts to operate closer to these limits, DNOs may opt to introduce additional automatic voltage control devices over and above those located at the grid and primary transformers. Together these new and existing voltage control devices will constitute an EAVC system. This variant consider an in-line voltage regulator for EHV circuits. These units may be power electronic or mechanical in their nature, but all aim to optimise voltages on a given network. At EHV they are likely to be three-phase ground mounted devices.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	0%			No expected benefit
	Thermal Transformer:	0%			No expected benefit
	Voltage Head:	6%			Could be used to resolve high volts issues for a number of customers
	Voltage Leg:	6%			Could be used to resolve low volts issues for a number of customers
	Power Quality:	0%			No expected benefit
	Fault Level:	0%			No expected benefit
Cost (£)	Capital:	£30,000			estimate
	Operational Expenditure:	£0			Assumed to be "fit and forget" maintenance-free devices - therefore no ongoing operational expenditure assumed for this solution.
	NPV of Opex:	£0			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			LV application could see such a unit becoming relatively high volume, with sharp roll-off rates
	Life Expectancy of Solution:	20			Estimated life expectancy of this type of equipment
Merit Order	Totex (£):	£30,000			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Likely to disrupt a number of customers down an LV feeder at time of installation/commissioning
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	4			These products could be easily redeployed as other (more widespread) solutions are used
	Cross Network Benefits Factor:	1			Potential to allow HV volts to operate outside of statutory limits (whilst ensuring LV customers receive volts within limits)
Other Benefits	Impact on Fixed Losses (%):	2%			Lossy devices, expected to give rise to a small increase in losses
	Impact on Variable Losses (%):	0%			No change to variable losses anticipated with this solution
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:	2012			Solutions are in use today, but not at scale
	Year data (on soln) is available:	2013			More learning to come from WPD and ENWL projects
	Source of Data:	Shunt reactors			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Intelligent voltage control			

Smart Variant

Solution Overview	Representative Solution:	**Enhanced Automatic voltage Control (EAVC)**			
	Variant Solution:	HV/LV Transformer Voltage Control			
	Description:	As the network starts to operate closer to these limits, DNOs may opt to introduce additional automatic voltage control devices over and above those located at the grid and primary transformers. Together these new and existing voltage control devices will constitute an EAVC system. This variant considers a tappable distribution transformer that can alter the LV busbar voltage to accommodate the different requirements of the LV feeders.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	No expected benefit
	Thermal Transformer:			0%	No expected benefit
	Voltage Head:			15%	Could be used to resolve high volts issues for a number of customers
	Voltage Leg:			15%	Could be used to resolve low volts issues for a number of customers
	Power Quality:			0%	No expected benefit
	Fault Level:			0%	No expected benefit
Cost (£)	Capital:	£25,000			estimate - used in the WS2 model
	Operational Expenditure:	£0			Assumed to be "fit and forget" maintenance-free devices - therefore no ongoing operational expenditure assumed for this solution.
	NPV of Opex:	£0			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Not expected to be a high volume commodity in the short term, but costs could easily drop as volumes increase
	Life Expectancy of Solution:	40			Estimated life expectancy of a distribution transformer
Merit Order	Totex (£):	£25,000			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			Likely to disrupt a number of customers down an LV feeder at time of installation/commissioning
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			Unlikely to be redeployed after initial installation
	Cross Network Benefits Factor:	1			Potential to allow HV volts to operate outside of statutory limits (whilst ensuring LV customers receive volts within limits)
Other Benefits	Impact on Fixed Losses (%):	2%			Lossy devices, expected to give rise to a small increase in losses
	Impact on Variable Losses (%):	0%			No change to variable losses anticipated with this solution
	Impact on quality of Supply (%):	0%			No expected benefit
	Year solution is available:				
	Year data (on soln) is available:				
	Source of Data:				
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Intelligent voltage control			

Smart Variant

Solution Overview	Representative Solution:	**Embedded DC Networks**			
	Variant Solution:	Embedded DC@LV			
	Description:	The application of point-to-point LV DC circuits to feed specific loads (used in a similar manner to transmission 'HVDC', but for distribution voltages). A retrofit solution to existing circuits.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			20%	Potentially significant increases in power flow as each conductor could carry equal to Vpeak (ac) = 1.41x ac rms values
	Thermal Transformer:			0%	Not expected to give gains to transformer rating (end power converters will become the limiting factor)
	Voltage Head:			10%	More controllable voltages with no reactive power voltage drops.
	Voltage Leg:			10%	More controllable voltages with no reactive power voltage drops.
	Power Quality:			50%	Use of DC is expected to improve the PQ resilience for devices connected to the DC networks
	Fault Level:			50%	Assumed to reduce the fault level, and therefore stress on switchgear.
Cost (£)	Capital:	£125,000			Estimate, assuming costs for two AC/DC converter stations at LV, plus minor works on the circuit. No significant change to the existing circuits have been assumed.
	Operational Expenditure:	£500			Estimate of the cost of operating and monitoring the converter stations on an annual basis. These costs have been assumed and would value further scrutiny.
	NPV of Opex:	£7,106			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Whilst volumes on LV networks (global) may be significant, there is no evidence to support this, therefore we have assumed a flat cost curve for this solution.
	Life Expectancy of Solution:	30			Expected to have a shorter asset life to HV and EHV deployments (assumed function of the manufacturing quality for a potentially more mass produced item)
Merit Order	Totex (£):	£132,106			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			New wayleaves would need to be attained, but expected to use existing circuit routes
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			Potential to redeploy the power electronics if it was found that load had changed in an area (although this would be unlikely)
	Cross Network Benefits Factor:	1			Has potential to give support to HV networks, and could reduce demands at certain SGT supply points.
Other Benefits	Impact on Fixed Losses (%):	20%			Whilst the use of dc has the potential to reduce network losses, this has to be traded off against the power loss of the converter station(s). It is assumed that at EHV the converters will be relatively efficient, but outweigh the variable losses seen by the network.
	Impact on Variable Losses (%):	-10%			Reduction in variable losses due to elimination of reactive power.
	Impact on quality of Supply (%):	0%			Not expected to change the QoS performance
	Year solution is available:				
	Year data (on soln) is available:				
	Source of Data:	No Supporting LCN funds as of 2012			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 4			
	Focus:	Security of networks inc. physical threats, utilising new network architectures			
	Subset:	DC networks (eg home / community) integrated with AC system			

Smart Variant

Solution Overview	Representative Solution:	**Embedded DC Networks**			
	Variant Solution:	Embedded DC@HV			
	Description:	The application of point-to-point HV DC circuits to feed specific loads (used in a similar manner to transmission 'HVDC', but for distribution voltages). A retrofit solution to existing circuits.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		30%		Potentially significant increases in power flow as each conductor could carry equal to Vpeak (ac) = 1.41x ac rms values
	Thermal Transformer:		0%		Not expected to give gains to transformer rating (end power converters will become the limiting factor)
	Voltage Head:		5%		More controllable voltages with no reactive power voltage drops.
	Voltage Leg:		5%		More controllable voltages with no reactive power voltage drops.
	Power Quality:		50%		Use of DC is expected to improve the PQ resilience for devices connected to the DC networks
	Fault Level:		50%		Assumed to reduce the fault level, and therefore stress on switchgear.
Cost (£)	Capital:	£250,000			Estimate, assuming costs for two AC/DC converter stations at HV, plus minor works on the circuit. No significant change to the existing circuits have been assumed.
	Operational Expenditure:	£5,000			Estimate of the cost of operating and monitoring the converter stations on an annual basis. These costs have been assumed and would value further scrutiny.
	NPV of Opex:	£71,062			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Assumed to have a flat cost curve on the basis of a limited deployment on HV distribution networks.
	Life Expectancy of Solution:	40			Expected to live as long as conventional assets (such as ac transformers or cables)
Merit Order	Totex (£):	£321,062			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			New wayleaves would need to be attained, but expected to use existing circuit routes
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			Potential to redeploy the power electronics if it was found that load had changed in an area (although this would be unlikely)
	Cross Network Benefits Factor:	1			Has potential to give support to HV networks, and could reduce demands at certain SGT supply points.
Other Benefits	Impact on Fixed Losses (%):	20%			Whilst the use of dc has the potential to reduce network losses, this has to be traded off against the power loss of the converter station(s). It is assumed that at EHV the converters will be relatively efficient, but outweigh the variable losses seen by the network.
	Impact on Variable Losses (%):	-10%			Reduction in variable losses due to elimination of reactive power.
	Impact on quality of Supply (%):	0%			Not expected to change the QoS performance
	Year solution is available:				
	Year data (on soln) is available:				
	Source of Data:	No Supporting LCN funds as of 2012			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 4			
	Focus:	Security of networks inc. physical threats, utilising new network architectures			
	Subset:	DC networks (eg home / community) integrated with AC system			

Smart Variant

Section	Field	EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Embedded DC Networks**			
	Variant Solution:	Embedded DC@EHV			
	Description:	The application of point-to-point EHV DC circuits to feed specific loads (used in a similar manner to transmission 'HVDC', but for distribution voltages). A retrofit solution to existing circuits.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	40%			Potentially significant increases in power flow as each conductor could carry equal to Vpeak (ac) = 1.41x ac rms values
	Thermal Transformer:	0%			Not expected to give gains to transformer rating (end power converters will become the limiting factor)
	Voltage Head:	2%			More controllable voltages with no reactive power voltage drops.
	Voltage Leg:	2%			More controllable voltages with no reactive power voltage drops.
	Power Quality:	50%			Use of DC is expected to improve the PQ resilience for devices connected to the DC networks
	Fault Level:	50%			Assumed to reduce the fault level, and therefore stress on switchgear.
Cost (£)	Capital:	£500,000			Estimate, assuming costs for two AC/DC converter stations at EHV, plus minor works on the circuit. No significant change to the existing circuits have been assumed.
	Operational Expenditure:	£10,000			Estimate of the cost of operating and monitoring the converter stations on an annual basis. These costs have been assumed and would value further scrutiny.
	NPV of Opex:	£16,285			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Assumed to have a flat cost curve on the basis of a limited deployment at distribution levels. NB. Could be a possibility for longer 132kV or 66kV circuits
	Life Expectancy of Solution:	40			Expected to live as long as conventional assets (such as ac transformers or cables)
Merit Order	Totex (£):	£642,124			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			New wayleaves would need to be attained, but expected to use existing circuit routes
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			Potential to redeploy the power electronics if it was found that load had changed in an area (although this would be unlikely)
	Cross Network Benefits Factor:	1			Has potential to give support to HV networks, and could reduce demands at certain SGT supply points.
Other Benefits	Impact on Fixed Losses (%):	20%			Whilst the use of dc has the potential to reduce network losses, this has to be traded off against the power loss of the converter station(s). It is assumed that at EHV the converters will be relatively efficient, but outweigh the variable losses seen by the network.
	Impact on Variable Losses (%):	-10%			Reduction in variable losses due to elimination of reactive power.
	Impact on quality of Supply (%):	0%			Not expected to change the QoS performance
	Year solution is available:				
	Year data (on soln) is available:				
	Source of Data:	No Supporting LCN funds as of 2012			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 4			
	Focus:	Security of networks inc. physical threats, utilising new network architectures			
	Subset:	DC networks (eg home / community) integrated with AC system			

Smart Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	Electrical Energy Storage			
	Variant Solution:	LV connected EES - small			
	Description:	Electrical Energy Storage (EES) technologies (smaller-sized LV connected batteries, e.g. serving 1 or 2 residential properties) deployed on a network to either deliver the peak demand, or absorb high levels of generation at key times of the day/year. The charge cycles of EES can be tuned to local network conditions, but is ultimately a function of the capacity (MW and MWh) of the units. Storage size for this variant is 50kW; 100kWh.			
Headroom Release (%)	Thermal Cable:			DM	Determined in the Model (DM): In a similar vein to Residential DSR, this EES solution is deployed in a comprehensive 'bottom-up' manner, taking into account the magnitude and duration of the peak, and the capacity (MW and MWh) available of the storage unit.
	Thermal Transformer:			DM	As Thermal Cable, this is calcuated within the model, and based on the aggregated ouput of the types of loads that can be moved.
	Voltage Head:			DM	EES would typically be used to flatten peaks created by generation (e.g. high volts resulting from PV in the middle of the day or onshore windfarms under windy conditions) or load (e.g. low volts resulting from EVs at the early evening peak).
	Voltage Leg:			DM	Based on the thermal profiles calculated within the model - flattening of peak demand will reduce volt drops along the circuit, thereby improving voltage legroom.
	Power Quality:			0%	No modelled benefit (it is noted that the converter on the battery unit may provide some power quality support, but as the model has not been setup to consider PQ issues, analysis has not been carried out on this aspect of EES)
	Fault Level:			-5%	EES can be made to 'look' like a generator to the network, feeding in fault current at the time of fault. As the storage unit sits behind power electronics, this effect is damped, but as this unit is medium sized it has been modelled as reducing FL headroom by 5%.
Cost (£)	Capital:	£250,000			Costs have been based on average prices seen in trials for the size of unit provided in 'Description' above and scaled accordingly. The costs include the procurement of storage units, power electronics, connection infrastructure, and installation & commissioning works.
	Operational Expenditure:	£100			Estimation of the annual cost of running communications to the devices. NB. The EES's energy costs have not been factored into this model, and are instead treated as a network loss.
	NPV of Opex:	£1,421			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	4			In 2012, EES units are not readily available off-the-shelf, with typical lead-times of 6-18 months. This is about equivalent to the amount of time that should be allocated for pre-installation project and site preparation, fire, operation and safety procedures. LV units could be deployed in large volumes, accelerating the cost curve roll off. However, it is noted that storage is a global market and is likely to be influenced by factors outside of the control or influence of GB.
	Life Expectancy of Solution:	20			EES asset life is electrochemically limited by the number of charge/discharge cycles that the technology can sustain without severe performance degradation. The chemicals used in flow-cell batteries are highly reactive; with every cycle the chemically active parts pollute to some degree, such that over the course of time, performance suffers. In this respect, flow cells offer the greatest potential for longevity as the active parts can be replaced or refreshed to renew performance. As life depends on cycles, limiting the number of cycles necessary to provide upgrade deferment by a form of intelligent control may be necessary. Considering daily cycles used for peak lopping over one-quarter of a year, the various technologies would have calendar lives (determined from cycle numbers per year) of up to 15 years for lead-acid and up to 30 years for sodium metal-halide. We have assumed a lifetime of 20 years within our modelling.
Merit Order	Totex (£):	£251,421			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Deployment requires suitable space to be available, which can be a premium, particularly in congested urban and suburban substations. Compared to reinforcement (e.g. the construction of new overhead lines or substations), planning processes should be reduced, although there may be additional complexities owing to the electrochemical nature of the units.
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	4			Most types of EES could be relocated or expanded in a modular manner as the need to peak lop changes over time. Given the interest in EES and the relatively limited supply capacity for utility-scale applications, availability will be subject to global markets.
	Cross Network Benefits Factor:	2			Solution is likely to provide a benefit to HV networks
Other Benefits	Impact on Fixed Losses (%):	15%			This solution is will increase fixed losses as the round-trip efficiency of a storage unit is less than 100% - this differs by manufacturer and storage type.
	Impact on Variable Losses (%):	-5%			As DSR, this solution has the ability to reduce the losses down a circuit by reducing the peak demand (less current, therefore less heating loss). As this is the smallest LV unit, it has less of an impact on LV losses.
	Impact on quality of Supply (%):	0%			This solution is not expected to give any benefit to QoS
	Year solution is available:	2015			Estimate - based on solutions being available for purchase (for trial)
	Year data (on soln) is available:				
	Source of Data:	NPG-CLNR, SSE NINES			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Utilise storage at domestic, substation and community level			

Smart Variant

Solution Overview	Representative Solution:	**Electrical Energy Storage**			
	Variant Solution:	LV connected EES - medium			
	Description:	Electrical Energy Storage (EES) technologies (medium-sized LV connected batteries, e.g. street level) deployed on a network to either deliver the peak demand, or absorb high levels of generation at key times of the day/year. The charge cycles of EES can be tuned to local network conditions, but is ultimately a function of the capacity (MW and MWh) of the units. Storage size for this variant is 75kW; 150kWh.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			DM	Determined in the Model (DM): In a similar vein to Residential DSR, this EES solution is deployed in a comprehensive 'bottom-up' manner, taking into account the magnitude and duration of the peak, and the capacity (MW and MWh) available of the storage unit.
	Thermal Transformer:			DM	As Thermal Cable, this is calcuated within the model, and based on the aggregated ouput of the types of loads that can be moved.
	Voltage Head:			DM	EES would typically be used to flatten peaks created by generation (e.g. high volts resulting from PV in the middle of the day or onshore windfarms under windy conditions) or load (e.g. low volts resulting from EVs at the early evening peak).
	Voltage Leg:			DM	Based on the thermal profiles calculated within the model - flattening of peak demand will reduce volt drops along the circuit, thereby improving voltage legroom.
	Power Quality:			0%	No modelled benefit (it is noted that the converter on the battery unit may provide some power quality support, but as the model has not been setup to consider PQ issues, analysis has not been carried out on this aspect of EES)
	Fault Level:			-8%	EES can be made to 'look' like a generator to the network, feeding in fault current at the time of fault. As the storage unit sits behind power electronics, this effect is damped, but as this unit is medium sized it has been modelled as reducing FL headroom by 8%.
Cost (£)	Capital:	£300,000			Costs have been based on average prices seen in trials for the size of unit provided in 'Description' above and scaled accordingly. The costs include the procurement of storage units, power electronics, connection infrastructure, and installation & commissioning works.
	Operational Expenditure:	£100			Estimation of the annual cost of running communications to the devices. NB. The EES's energy costs have not been factored into this model, and are instead treated as a network loss.
	NPV of Opex:	£1,421			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	4			In 2012, EES units are not readily available off-the-shelf, with typical lead-times of 6-18 months. This is about equivalent to the amount of time that should be allocated for pre-installation project and site preparation, fire, operation and safety procedures. LV units could be deployed in large volumes, accelerating the cost curve roll off. However, it is noted that storage is a global market and is likely to be influenced by factors outside of the control or influence of GB.
	Life Expectancy of Solution:	20			EES asset life is electrochemically limited by the number of charge/discharge cycles that the technology can sustain without severe performance degradation. The chemicals used in flow-cell batteries are highly reactive; with every cycle the chemically active parts pollute to some degree, such that over the course of time, performance suffers. In this respect, flow cells offer the greatest potential for longevity as the active parts can be replaced or refreshed to renew performance. As life depends on cycles, limiting the number of cycles necessary to provide upgrade deferment by a form of intelligent control may be necessary. Considering daily cycles used for peak lopping over one-quarter of a year, the various technologies would have calendar lives (determined from cycle numbers per year) of up to 15 years for lead-acid and up to 30 years for sodium metal-halide. We have assumed a lifetime of 20 years within our modelling.
Merit Order	Totex (£):	£301,421			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Deployment requires suitable space to be available, which can be a premium, particularly in congested urban and suburban substations. Compared to reinforcement (e.g. the construction of new overhead lines or substations), planning processes should be reduced, although there may be additional complexities owing to the electrochemical nature of the units.
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	3			Most types of EES could be relocated or expanded in a modular manner as the need to peak lop changes over time. Given the interest in EES and the relatively limited supply capacity for utility-scale applications, availability will be subject to global markets.
	Cross Network Benefits Factor:	2			Solution is likely to provide a benefit to HV networks
Other Benefits	Impact on Fixed Losses (%):	20%			This solution is will increase fixed losses as the round-trip efficiency of a storage unit is less than 100% - this differs by manufacturer and storage type.
	Impact on Variable Losses (%):	-10%			As DSR, this solution has the ability to reduce the losses down a circuit by reducing the peak demand (less current, therefore less heating loss).
	Impact on quality of Supply (%):	0%			This solution is not expected to give any benefit to QoS
	Year solution is available:	2015			Estimate - based on solutions being available for purchase (for trial)
	Year data (on soln) is available:				
	Source of Data:	NPG- CLNR, SSE NINES; SSE NTVV			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Utilise storage at domestic, substation and community level			

Smart Variant

Solution Overview	Representative Solution:	**Electrical Energy Storage**			
	Variant Solution:	LV connected EES - large			
	Description:	Electrical Energy Storage (EES) technologies (large LV connected batteries, e.g. at the distribution substation) deployed on a network to either deliver the peak demand, or absorb high levels of generation at key times of the day/year. The charge cycles of EES can be tuned to local network conditions, but is ultimately a function of the capacity (MW and MWh) of the units. Storage size for this variant is 100kW; 200kWh.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			DM	Determined in the Model (DM): In a similar vein to Residential DSR, this EES solution is deployed in a comprehensive 'bottom-up' manner, taking into account the magnitude and duration of the peak, and the capacity (MW and MWh) available of the storage unit.
	Thermal Transformer:			DM	As Thermal Cable, this is calcuated within the model, and based on the aggregated ouput of the types of loads that can be moved.
	Voltage Head:			DM	EES would typically be used to flatten peaks created by generation (e.g. high volts resulting from PV in the middle of the day or onshore windfarms under windy conditions) or load (e.g. low volts resulting from EVs at the early evening peak).
	Voltage Leg:			DM	Based on the thermal profiles calculated within the model - flattening of peak demand will reduce volt drops along the circuit, thereby improving voltage legroom.
	Power Quality:			0%	No modelled benefit (it is noted that the converter on the battery unit may provide some power quality support, but as the model has not been setup to consider PQ issues, analysis has not been carried out on this aspect of EES)
	Fault Level:			-10%	EES can be made to 'look' like a generator to the network, feeding in fault current at the time of fault. As the storage unit sits behind power electronics, this effect is damped, but as this unit is medium sized it has been modelled as reducing FL headroom by 10%.
Cost (£)	Capital:	£350,000			Costs have been based on average prices seen in trials for the size of unit provided in 'Description' above and scaled accordingly. The costs include the procurement of storage units, power electronics, connection infrastructure, and installation & commissioning works.
	Operational Expenditure:	£100			Estimation of the annual cost of running communications to the devices. NB. The EES's energy costs have not been factored into this model, and are instead treated as a network loss.
	NPV of Opex:	£1,421			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	4			In 2012, EES units are not readily available off-the-shelf, with typical lead-times of 6-18 months. This is about equivalent to the amount of time that should be allocated for pre-installation project and site preparation, fire, operation and safety procedures. LV units could be deployed in large volumes, accelerating the cost curve roll off. However, it is noted that storage is a global market and is likely to be influenced by factors outside of the control or influence of GB.
	Life Expectancy of Solution:	20			EES asset life is electrochemically limited by the number of charge/discharge cycles that the technology can sustain without severe performance degradation. The chemicals used in flow-cell batteries are highly reactive; with every cycle the chemically active parts pollute to some degree, such that over the course of time, performance suffers. In this respect, flow cells offer the greatest potential for longevity as the active parts can be replaced or refreshed to renew performance. As life depends on cycles, limiting the number of cycles necessary to provide upgrade deferment by a form of intelligent control may be necessary. Considering daily cycles used for peak lopping over one-quarter of a year, the various technologies would have calendar lives (determined from cycle numbers per year) of up to 15 years for lead-acid and up to 30 years for sodium metal-halide. We have assumed a lifetime of 20 years within our modelling.
Merit Order	Totex (£):	£351,421			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Deployment requires suitable space to be available, which can be a premium, particularly in congested urban and suburban substations. Compared to reinforcement (e.g. the construction of new overhead lines or substations), planning processes should be reduced, although there may be additional complexities owing to the electrochemical nature of the units.
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	3			Most types of EES could be relocated or expanded in a modular manner as the need to peak lop changes over time. Given the interest in EES and the relatively limited supply capacity for utility-scale applications, availability will be subject to global markets.
	Cross Network Benefits Factor:	2			Solution is likely to provide a benefit to HV networks
Other Benefits	Impact on Fixed Losses (%):	25%			This solution is will increase fixed losses as the round-trip efficiency of a storage unit is less than 100% - this differs by manufacturer and storage type.
	Impact on Variable Losses (%):	-15%			As DSR, this solution has the ability to reduce the losses down a circuit by reducing the peak demand (less current, therefore less heating loss). As this is the largest LV unit, it has the largest impact on LV losses.
	Impact on quality of Supply (%):	0%			This solution is not expected to give any benefit to QoS
	Year solution is available:	2015			Estimate - based on solutions being available for purchase (for trial)
	Year data (on soln) is available:				
	Source of Data:	NPG- CLNR, SSE NINES; SSE NTVV			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Utilise storage at domestic, substation and community level			

Smart Variant

Section	Field	EHV	HV	LV	Comments
Solution Overview	Representative Solution:	Electrical Energy Storage			
	Variant Solution:	HV connected EES - small			
	Description:	Electrical Energy Storage (EES) technologies (smaller-sized HV connected batteries) deployed on a network to either deliver the peak demand, or absorb high levels of generation at key times of the day/year. The charge cycles of EES can be tuned to local network conditions, but is ultimately a function of the capacity (MW and MWh) of the units. Storage size for this variant is 1.5MW; 3MWh.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		DM		Determined in the Model (DM): In a similar vein to Residential DSR, this EES solution is deployed in a comprehensive 'bottom-up' manner, taking into account the magnitude and duration of the peak, and the capacity (MW and MWh) available of the storage unit.
	Thermal Transformer:		DM		As Thermal Cable, this is calcuated within the model, and based on the aggregated ouput of the types of loads that can be moved.
	Voltage Head:		DM		EES would typically be used to flatten peaks created by generation (e.g. high volts resulting from PV in the middle of the day or onshore windfarms under windy conditions) or load (e.g. low volts resulting from EVs at the early evening peak).
	Voltage Leg:		DM		Based on the thermal profiles calculated within the model - flattening of peak demand will reduce volt drops along the circuit, thereby improving voltage legroom.
	Power Quality:		0%		No modelled benefit (it is noted that the converter on the battery unit may provide some power quality support, but as the model has not been setup to consider PQ issues, analysis has not been carried out on this aspect of EES)
	Fault Level:		-5%		EES can be made to 'look' like a generator to the network, feeding in fault current at the time of fault. As the storage unit sits behind power electronics, this effect is damped, but as this unit is medium sized it has been modelled as reducing FL headroom by 5%.
Cost (£)	Capital:		£3,400,000		Costs have been based on average prices seen in trials for the size of unit provided in 'Description' above and scaled accordingly. The costs include the procurement of storage units, power electronics, connection infrastructure, and installation & commissioning works.
	Operational Expenditure:		£250		Estimation of the annual cost of running communications to the devices. NB. The EES's energy costs have not been factored into this model, and are instead treated as a network loss.
	NPV of Opex:		£3,553		Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		3		In 2012, EES units are not readily available off-the-shelf, with typical lead-times of 6-18 months. This is about equivalent to the amount of time that should be allocated for pre-installation project and site preparation, fire, operation and safety procedures. HV units are unlikely to be deployed in large volumes, so whilst costs will reduce, it is not clear that they will reduce dramatically.
	Life Expectancy of Solution:		20		EES asset life is electrochemically limited by the number of charge/discharge cycles that the technology can sustain without severe performance degradation. The chemicals used in flow-cell batteries are highly reactive; with every cycle the chemically active parts pollute to some degree, such that over the course of time, performance suffers. In this respect, flow cells offer the greatest potential for longevity as the active parts can be replaced or refreshed to renew performance. As life depends on cycles, limiting the number of cycles necessary to provide upgrade deferment by a form of intelligent control may be necessary. Considering daily cycles used for peak lopping over one-quarter of a year, the various technologies would have calendar lives (determined from cycle numbers per year) of up to 15 years for lead-acid and up to 30 years for sodium metal-halide. We have assumed a lifetime of 20 years within our modelling.
Merit Order	Totex (£):		£3,403,553		Calculated from capex plus NPV of opex
	Disuption Factor (1-5):		3		Deployment requires suitable space to be available, which can be a premium, particularly in congested urban and suburban substations. Compared to reinforcement (e.g. the construction of new overhead lines or substations), planning processes should be reduced, although there may be additional complexities owing to the electrochemical nature of the units.
	Disruption Cost (£):		£10,000		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):		3		Most types of EES could be relocated or expanded in a modular manner as the need to peak lop changes over time. Given the interest in EES and the relatively limited supply capacity for utility-scale applications, availability will be subject to global markets.
	Cross Network Benefits Factor:		2		Solution will provide a benefit to LV and EHV networks
Other Benefits	Impact on Fixed Losses (%):		15%		This solution is will increase fixed losses as the round-trip efficiency of a storage unit is less than 100% - this differs by manufacturer and storage type.
	Impact on Variable Losses (%):		-5%		As DSR, this solution has the ability to reduce the losses down a circuit by reducing the peak demand (less current, therefore less heating loss). As this is the smallest HV unit, it has less of an impact on HV losses.
	Impact on quality of Supply (%):		0%		This solution is not expected to give any benefit to QoS
	Year solution is available:		2015		Estimate - based on solutions being available for purchase (for trial)
	Year data (on soln) is available:				
	Source of Data:	NPG- CLNR, SSE 1MW Shetland			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Utilise storage at domestic, substation and community level			

Smart Variant

Section	Item	EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Electrical Energy Storage**			
	Variant Solution:	HV connected EES - medium			
	Description:	Electrical Energy Storage (EES) technologies (medium-sized HV connected batteries) deployed on a network to either deliver the peak demand, or absorb high levels of generation at key times of the day/year. The charge cycles of EES can be tuned to local network conditions, but is ultimately a function of the capacity (MW and MWh) of the units. Storage size for this variant is 2.5MW; 5MWh.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		DM		Determined in the Model (DM): In a similar vein to Residential DSR, this EES solution is deployed in a comprehensive 'bottom-up' manner, taking into account the magnitude and duration of the peak, and the capacity (MW and MWh) available of the storage unit.
	Thermal Transformer:		DM		As Thermal Cable, this is calcuated within the model, and based on the aggregated ouput of the types of loads that can be moved.
	Voltage Head:		DM		EES would typically be used to flatten peaks created by generation (e.g. high volts resulting from PV in the middle of the day or onshore windfarms under windy conditions) or load (e.g. low volts resulting from EVs at the early evening peak).
	Voltage Leg:		DM		Based on the thermal profiles calculated within the model - flattening of peak demand will reduce volt drops along the circuit, thereby improving voltage legroom.
	Power Quality:		0%		No modelled benefit (it is noted that the converter on the battery unit may provide some power quality support, but as the model has not been setup to consider PQ issues, analysis has not been carried out on this aspect of EES)
	Fault Level:		-8%		EES can be made to 'look' like a generator to the network, feeding in fault current at the time of fault. As the storage unit sits behind power electronics, this effect is damped, but as this unit is medium sized it has been modelled as reducing FL headroom by 8%.
Cost (£)	Capital:		£3,800,000		Costs have been based on average prices seen in trials for the size of unit provided in 'Description' above and scaled accordingly. The costs include the procurement of storage units, power electronics, connection infrastructure, and installation & commissioning works.
	Operational Expenditure:		£250		Estimation of the annual cost of running communications to the devices. NB. The EES's energy costs have not been factored into this model, and are instead treated as a network loss.
	NPV of Opex:		£3,553		Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		3		In 2012, EES units are not readily available off-the-shelf, with typical lead-times of 6-18 months. This is about equivalent to the amount of time that should be allocated for pre-installation project and site preparation, fire, operation and safety procedures. HV units are unlikely to be deployed in large volumes, so whilst costs will reduce, it is not clear that they will reduce dramatically.
	Life Expectancy of Solution:		20		EES asset life is electrochemically limited by the number of charge/discharge cycles that the technology can sustain without severe performance degradation. The chemicals used in flow-cell batteries are highly reactive; with every cycle the chemically active parts pollute to some degree, such that over the course of time, performance suffers. In this respect, flow cells offer the greatest potential for longevity as the active parts can be replaced or refreshed to renew performance. As life depends on cycles, limiting the number of cycles necessary to provide upgrade deferment by a form of intelligent control may be necessary. Considering daily cycles used for peak lopping over one-quarter of a year, the various technologies would have calendar lives (determined from cycle numbers per year) of up to 15 years for lead-acid and up to 30 years for sodium metal-halide. We have assumed a lifetime of 20 years within our modelling.
Merit Order	Totex (£):		£3,803,553		Calculated from capex plus NPV of opex
	Disuption Factor (1-5):		3		Deployment requires suitable space to be available, which can be a premium, particularly in congested urban and suburban substations. Compared to reinforcement (e.g. the construction of new overhead lines or substations), planning processes should be reduced, although there may be additional complexities owing to the electrochemical nature of the units.
	Disruption Cost (£):		£10,000		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):		2		Most types of EES could be relocated or expanded in a modular manner as the need to peak lop changes over time. Given the interest in EES and the relatively limited supply capacity for utility-scale applications, availability will be subject to global markets.
	Cross Network Benefits Factor:		2		Solution will provide a benefit to LV and EHV networks
Other Benefits	Impact on Fixed Losses (%):		20%		This solution is will increase fixed losses as the round-trip efficiency of a storage unit is less than 100% - this differs by manufacturer and storage type.
	Impact on Variable Losses (%):		-10%		As DSR, this solution has the ability to reduce the losses down a circuit by reducing the peak demand (less current, therefore less heating loss).
	Impact on quality of Supply (%):		0%		This solution is not expected to give any benefit to QoS
	Year solution is available:		2015		Estimate - based on solutions being available for purchase (for trial)
	Year data (on soln) is available:				
	Source of Data:	NPG- CLNR, SSE 1MW Shetland			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Utilise storage at domestic, substation and community level			

Smart Variant

	EHV	HV	LV	Comments
Solution Overview — Representative Solution:	**Electrical Energy Storage**			
Variant Solution:	HV connected EES - large			
Description:	Electrical Energy Storage (EES) technologies (large HV connected batteries) deployed on a network to either deliver the peak demand, or absorb high levels of generation at key times of the day/year. The charge cycles of EES can be tuned to local network conditions, but is ultimately a function of the capacity (MW and MWh) of the units. Storage size for this variant is 3MW; 6MWh.			
Headroom Release (%) — Thermal Cable:		DM		Determined in the Model (DM): In a similar vein to Residential DSR, this EES solution is deployed in a comprehensive 'bottom-up' manner, taking into account the magnitude and duration of the peak, and the capacity (MW and MWh) available of the storage unit.
Thermal Transformer:		DM		As Thermal Cable, this is calcuated within the model, and based on the aggregated ouput of the types of loads that can be moved.
Voltage Head:		DM		EES would typically be used to flatten peaks created by generation (e.g. high volts resulting from PV in the middle of the day or onshore windfarms under windy conditions) or load (e.g. low volts resulting from EVs at the early evening peak).
Voltage Leg:		DM		Based on the thermal profiles calculated within the model - flattening of peak demand will reduce volt drops along the circuit, thereby improving voltage legroom.
Power Quality:		0%		No modelled benefit (it is noted that the converter on the battery unit may provide some power quality support, but as the model has not been setup to consider PQ issues, analysis has not been carried out on this aspect of EES)
Fault Level:		-10%		EES can be made to 'look' like a generator to the network, feeding in fault current at the time of fault. As the storage unit sits behind power electronics, this effect is damped, but as this unit is medium sized it has been modelled as reducing FL headroom by 10%.
Cost (£) — Capital:		£4,200,000		Costs have been based on average prices seen in trials for the size of unit provided in 'Description' above and scaled accordingly. The costs include the procurement of storage units, power electronics, connection infrastructure, and installation & commissioning works.
Operational Expenditure:		£250		Estimation of the annual cost of running communications to the devices. NB. The EES's energy costs have not been factored into this model, and are instead treated as a network loss.
NPV of Opex:		£3,553		Based on 20 year of annual operating expenditure @ 3.5% discount rate
Cost Curve Type:		3		In 2012, EES units are not readily available off-the-shelf, with typical lead-times of 6-18 months. This is about equivalent to the amount of time that should be allocated for pre-installation project and site preparation, fire, operation and safety procedures. HV units are unlikely to be deployed in large volumes, so whilst costs will reduce, it is not clear that they will reduce dramatically.
Life Expectancy of Solution:		20		EES asset life is electrochemically limited by the number of charge/discharge cycles that the technology can sustain without severe performance degradation. The chemicals used in flow-cell batteries are highly reactive; with every cycle the chemically active parts pollute to some degree, such that over the course of time, performance suffers. In this respect, flow cells offer the greatest potential for longevity as the active parts can be replaced or refreshed to renew performance. As life depends on cycles, limiting the number of cycles necessary to provide upgrade deferment by a form of intelligent control may be necessary. Considering daily cycles used for peak lopping over one-quarter of a year, the various technologies would have calendar lives (determined from cycle numbers per year) of up to 15 years for lead-acid and up to 30 years for sodium metal-halide. We have assumed a lifetime of 20 years within our modelling.
Merit Order — Totex (£):		£4,203,553		Calculated from capex plus NPV of opex
Disuption Factor (1-5):		3		Deployment requires suitable space to be available, which can be a premium, particularly in congested urban and suburban substations. Compared to reinforcement (e.g. the construction of new overhead lines or substations), planning processes should be reduced, although there may be additional complexities owing to the electrochemical nature of the units.
Disruption Cost (£):		£10,000		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
Flexibility (1-5):		2		Most types of EES could be relocated or expanded in a modular manner as the need to peak lop changes over time. Given the interest in EES and the relatively limited supply capacity for utility-scale applications, availability will be subject to global markets.
Cross Network Benefits Factor:		2		Solution will provide a benefit to LV and EHV networks
Other Benefits — Impact on Fixed Losses (%):		25%		This solution is will increase fixed losses as the round-trip efficiency of a storage unit is less than 100% - this differs by manufacturer and storage type.
Impact on Variable Losses (%):		-15%		As DSR, this solution has the ability to reduce the losses down a circuit by reducing the peak demand (less current, therefore less heating loss). As this is the largest HV unit, it has the largest impact on HV losses.
Impact on quality of Supply (%):		0%		This solution is not expected to give any benefit to QoS
Year solution is available:		2015		Estimate - based on solutions being available for purchase (for trial)
Year data (on soln) is available:				
Source of Data:	NPG- CLNR, SSE 1MW Shetland			
Smart Solution Relevance (WS3 Ph1) — Smart Solution Set:	Smart D-Networks 2			
Focus:	DG connections, management of two way power flows			
Subset:	Utilise storage at domestic, substation and community level			

Smart Variant

Solution Overview	Representative Solution:	**Electrical Energy Storage**			
	Variant Solution:	EHV connected EES - small			
	Description:	Electrical Energy Storage (EES) technologies (smaller-sized EHV connected batteries) deployed on a network to either deliver the peak demand, or absorb high levels of generation at key times of the day/year. The charge cycles of EES can be tuned to local network conditions, but is ultimately a function of the capacity (MW and MWh) of the units. Storage size for this variant is 7.5MW; 15MWh.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	DM			Determined in the Model (DM): In a similar vein to Residential DSR, this EES solution is deployed in a comprehensive 'bottom-up' manner, taking into account the magnitude and duration of the peak, and the capacity (MW and MWh) available of the storage unit.
	Thermal Transformer:	DM			As Thermal Cable, this is calcuated within the model, and based on the aggregated ouput of the types of loads that can be moved.
	Voltage Head:	DM			EES would typically be used to flatten peaks created by generation (e.g. high volts resulting from PV in the middle of the day or onshore windfarms under windy conditions) or load (e.g. low volts resulting from EVs at the early evening peak).
	Voltage Leg:	DM			Based on the thermal profiles calculated within the model - flattening of peak demand will reduce volt drops along the circuit, thereby improving voltage legroom.
	Power Quality:	0%			No modelled benefit (it is noted that the converter on the battery unit may provide some power quality support, but as the model has not been setup to consider PQ issues, analysis has not been carried out on this aspect of EES)
	Fault Level:	-5%			EES can be made to 'look' like a generator to the network, feeding in fault current at the time of fault. As the storage unit sits behind power electronics, this effect is damped, but as this unit is medium sized it has been modelled as reducing FL headroom by 5%.
Cost (£)	Capital:	£13,600,000			Costs have been based on average prices seen in trials for the size of unit provided in 'Description' above and scaled accordingly. The costs include the procurement of storage units, power electronics, connection infrastructure, and installation & commissioning works.
	Operational Expenditure:	£500			Estimation of the annual cost of running communications to the devices. NB. The EES's energy costs have not been factored into this model, and are instead treated as a network loss.
	NPV of Opex:	£7,106			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			In 2012, EES units are not readily available off-the-shelf, with typical lead-times of 6-18 months. This is about equivalent to the amount of time that should be allocated for pre-installation project and site preparation, fire, operation and safety procedures. EHV units are unlikely to be deployed in large volumes, so whilst costs will reduce, it is not clear that they will reduce dramatically.
	Life Expectancy of Solution:	20			EES asset life is electrochemically limited by the number of charge/discharge cycles that the technology can sustain without severe performance degradation. The chemicals used in flow-cell batteries are highly reactive; with every cycle the chemically active parts pollute to some degree, such that over the course of time, performance suffers. In this respect, flow cells offer the greatest potential for longevity as the active parts can be replaced or refreshed to renew performance. As life depends on cycles, limiting the number of cycles necessary to provide upgrade deferment by a form of intelligent control may be necessary. Considering daily cycles used for peak lopping over one-quarter of a year, the various technologies would have calendar lives (determined from cycle numbers per year) of up to 15 years for lead-acid and up to 30 years for sodium metal-halide. We have assumed a lifetime of 20 years within our modelling.
Merit Order	Totex (£):	£13,607,106			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			Deployment requires suitable space to be available, which can be a premium, particularly in congested urban and suburban substations. Compared to reinforcement (e.g. the construction of new overhead lines or substations), planning processes should be reduced, although there may be additional complexities owing to the electrochemical nature of the units.
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			Most types of EES could be relocated or expanded in a modular manner as the need to peak lop changes over time. Given the interest in EES and the relatively limited supply capacity for utility-scale applications, availability will be subject to global markets.
	Cross Network Benefits Factor:	2			Solution will provide a benefit to HV networks
Other Benefits	Impact on Fixed Losses (%):	15%			This solution is will increase fixed losses as the round-trip efficiency of a storage unit is less than 100% - this differs by manufacturer and storage type.
	Impact on Variable Losses (%):	-5%			As DSR, this solution has the ability to reduce the losses down a circuit by reducing the peak demand (less current, therefore less heating loss). As this is the smallest EHV unit, it has less of an impact on EHV losses.
	Impact on quality of Supply (%):	0%			This solution is not expected to give any benefit to QoS
	Year solution is available:	2015			Estimate - based on solutions being available for purchase (for trial)
	Year data (on soln) is available:				
	Source of Data:	NPG- CLNR; EA Technology project work on EES			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Utilise storage at domestic, substation and community level			

Smart Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Electrical Energy Storage**			
	Variant Solution:	EHV connected EES - medium			
	Description:	Electrical Energy Storage (EES) technologies (medium-sized EHV connected batteries) deployed on a network to either deliver the peak demand, or absorb high levels of generation at key times of the day/year. The charge cycles of EES can be tuned to local network conditions, but is ultimately a function of the capacity (MW and MWh) of the units. Storage size for this variant is 12.5MW; 25MWh.			
Headroom Release (%)	Thermal Cable:	DM			Determined in the Model (DM): In a similar vein to Residential DSR, this EES solution is deployed in a comprehensive 'bottom-up' manner, taking into account the magnitude and duration of the peak, and the capacity (MW and MWh) available of the storage unit.
	Thermal Transformer:	DM			As Thermal Cable, this is calcuated within the model, and based on the aggregated ouput of the types of loads that can be moved.
	Voltage Head:	DM			EES would typically be used to flatten peaks created by generation (e.g. high volts resulting from PV in the middle of the day or onshore windfarms under windy conditions) or load (e.g. low volts resulting from EVs at the early evening peak).
	Voltage Leg:	DM			Based on the thermal profiles calculated within the model - flattening of peak demand will reduce volt drops along the circuit, thereby improving voltage legroom.
	Power Quality:	0%			No modelled benefit (it is noted that the converter on the battery unit may provide some power quality support, but as the model has not been setup to consider PQ issues, analysis has not been carried out on this aspect of EES)
	Fault Level:	-8%			EES can be made to 'look' like a generator to the network, feeding in fault current at the time of fault. As the storage unit sits behind power electronics, this effect is damped, but as this unit is medium sized it has been modelled as reducing FL headroom by 8%.
Cost (£)	Capital:	£15,200,000			Costs have been based on average prices seen in trials for the size of unit provided in 'Description' above and scaled accordingly. The costs include the procurement of storage units, power electronics, connection infrastructure, and installation & commissioning works.
	Operational Expenditure:	£500			Estimation of the annual cost of running communications to the devices. NB. The EES's energy costs have not been factored into this model, and are instead treated as a network loss.
	NPV of Opex:	£7,106			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			In 2012, EES units are not readily available off-the-shelf, with typical lead-times of 6-18 months. This is about equivalent to the amount of time that should be allocated for pre-installation project and site preparation, fire, operation and safety procedures. EHV units are unlikely to be deployed in large volumes, so whilst costs will reduce, it is not clear that they will reduce dramatically.
	Life Expectancy of Solution:	20			EES asset life is electrochemically limited by the number of charge/discharge cycles that the technology can sustain without severe performance degradation. The chemicals used in flow-cell batteries are highly reactive; with every cycle the chemically active parts pollute to some degree, such that over the course of time, performance suffers. In this respect, flow cells offer the greatest potential for longevity as the active parts can be replaced or refreshed to renew performance. As life depends on cycles, limiting the number of cycles necessary to provide upgrade deferment by a form of intelligent control may be necessary. Considering daily cycles used for peak lopping over one-quarter of a year, the various technologies would have calendar lives (determined from cycle numbers per year) of up to 15 years for lead-acid and up to 30 years for sodium metal-halide. We have assumed a lifetime of 20 years within our modelling.
Merit Order	Totex (£):	£15,207,106			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			Deployment requires suitable space to be available, which can be a premium, particularly in congested urban and suburban substations. Compared to reinforcement (e.g. the construction of new overhead lines or substations), planning processes should be reduced, although there may be additional complexities owing to the electrochemical nature of the units.
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			Most types of EES could be relocated or expanded in a modular manner as the need to peak lop changes over time. Given the interest in EES and the relatively limited supply capacity for utility-scale applications, availability will be subject to global markets.
	Cross Network Benefits Factor:	2			Solution will provide a benefit to HV networks
Other Benefits	Impact on Fixed Losses (%):	20%			This solution is will increase fixed losses as the round-trip efficiency of a storage unit is less than 100% - this differs by manufacturer and storage type.
	Impact on Variable Losses (%):	-10%			As DSR, this solution has the ability to reduce the losses down a circuit by reducing the peak demand (less current, therefore less heating loss).
	Impact on quality of Supply (%):	0%			This solution is not expected to give any benefit to QoS
	Year solution is available:	2015			Estimate - based on solutions being available for purchase (for trial)
	Year data (on soln) is available:				
	Source of Data:	NPG- CLNR; EA Technology project work on EES			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Utilise storage at domestic, substation and community level			

Smart Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Electrical Energy Storage**			
	Variant Solution:	EHV connected EES - large			
	Description:	Electrical Energy Storage (EES) technologies (large EHV connected batteries) deployed on a network to either deliver the peak demand, or absorb high levels of generation at key times of the day/year. The charge cycles of EES can be tuned to local network conditions, but is ultimately a function of the capacity (MW and MWh) of the units. Storage size for this variant is 15MW; 30MWh.			
Headroom Release (%)	Thermal Cable:	DM			Determined in the Model (DM): In a similar vein to Residential DSR, this EES solution is deployed in a comprehensive 'bottom-up' manner, taking into account the magnitude and duration of the peak, and the capacity (MW and MWh) available of the storage unit.
	Thermal Transformer:	DM			As Thermal Cable, this is calcuated within the model, and based on the aggregated ouput of the types of loads that can be moved.
	Voltage Head:	DM			EES would typically be used to flatten peaks created by generation (e.g. high volts resulting from PV in the middle of the day or onshore windfarms under windy conditions) or load (e.g. low volts resulting from EVs at the early evening peak).
	Voltage Leg:	DM			Based on the thermal profiles calculated within the model - flattening of peak demand will reduce volt drops along the circuit, thereby improving voltage legroom.
	Power Quality:	0%			No modelled benefit (it is noted that the converter on the battery unit may provide some power quality support, but as the model has not been setup to consider PQ issues, analysis has not been carried out on this aspect of EES)
	Fault Level:	-10%			EES can be made to 'look' like a generator to the network, feeding in fault current at the time of fault. As the storage unit sits behind power electronics, this effect is damped, but as this unit is large it has been modelled as reducing FL headroom by 10%.
Cost (£)	Capital:	£16,800,000			Costs have been based on average prices seen in trials for the size of unit provided in 'Description' above and scaled accordingly. The costs include the procurement of storage units, power electronics, connection infrastructure, and installation & commissioning works.
	Operational Expenditure:	£500			Estimation of the annual cost of running communications to the devices. NB. The EES's energy costs have not been factored into this model, and are instead treated as a network loss.
	NPV of Opex:	£7,106			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			In 2012, EES units are not readily available off-the-shelf, with typical lead-times of 6-18 months. This is about equivalent to the amount of time that should be allocated for pre-installation project and site preparation, fire, operation and safety procedures. EHV units are unlikely to be deployed in large volumes, so whilst costs will reduce, it is not clear that they will reduce dramatically.
	Life Expectancy of Solution:	20			EES asset life is electrochemically limited by the number of charge/discharge cycles that the technology can sustain without severe performance degradation. The chemicals used in flow-cell batteries are highly reactive; with every cycle the chemically active parts pollute to some degree, such that over the course of time, performance suffers. In this respect, flow cells offer the greatest potential for longevity as the active parts can be replaced or refreshed to renew performance. As life depends on cycles, limiting the number of cycles necessary to provide upgrade deferment by a form of intelligent control may be necessary. Considering daily cycles used for peak lopping over one-quarter of a year, the various technologies would have calendar lives (determined from cycle numbers per year) of up to 15 years for lead-acid and up to 30 years for sodium metal-halide. We have assumed a lifetime of 20 years within our modelling.
Merit Order	Totex (£):	£16,807,106			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			Deployment requires suitable space to be available, which can be a premium, particularly in congested urban and suburban substations. Compared to reinforcement (e.g. the construction of new overhead lines or substations), planning processes should be reduced, although there may be additional complexities owing to the electrochemical nature of the units.
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			Most types of EES could be relocated or expanded in a modular manner as the need to peak lop changes over time. Given the interest in EES and the relatively limited supply capacity for utility-scale applications, availability will be subject to global markets.
	Cross Network Benefits Factor:	2			Solution will provide a benefit to HV networks
Other Benefits	Impact on Fixed Losses (%):	25%			This solution is will increase fixed losses as the round-trip efficiency of a storage unit is less than 100% - this differs by manufacturer and storage type.
	Impact on Variable Losses (%):	-15%			As DSR, this solution has the ability to reduce the losses down a circuit by reducing the peak demand (less current, therefore less heating loss). As this is the largest EHV unit, it has the greatest impact on EHV losses.
	Impact on quality of Supply (%):	0%			This solution is not expected to give any benefit to QoS
	Year solution is available:	2015			Estimate - based on solutions being available for purchase (for trial)
	Year data (on soln) is available:				
	Source of Data:	NPG- CLNR; EA Technology project work on EES			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	Utilise storage at domestic, substation and community level			

Smart Variant

Solution Overview	Representative Solution:	**Electrical Energy Storage**			
	Variant Solution:	EES - HV Central Business District (commercial building level)			
	Description:	The DNO's use of storage located in a large HV connected commercial building (e.g. large office block, bank, etc) via a commercial contract with a building owner. NB. The primary use of the storage for the building owner may be for UPS (Uniterruptable Power Supply) reasons. Storage size for this variant is 500kW; 1,000kWh.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		10%		EES in this form could be used like DSR to reduce the peak demand on the network. The amount of demand to be shifted, is a function of the size of the storage unit, and assumed to be 10% in this instance.
	Thermal Transformer:		5%		If EES is only applied on one HV feeder, the benefit to the Primary transformer would be reduced. 5% has been taken as the starting assumption in the model.
	Voltage Head:		0%		Not expected to give any benefit to the voltage headroom.
	Voltage Leg:		2%		As DSR, a small secondary benefit would be realised to low volts situations, as shifting the peak to a different time of day would give rise to lower volt drops on the network.
	Power Quality:		0%		This form of EES is not expected to give rise to any PQ benefits
	Fault Level:		-5%		EES can be made to 'look' like a generator to the network, feeding in fault current at the time of fault. As the storage unit sits behind power electronics, this effect is somewhat damped - hence a reduction in 5% in FL headroom.
Cost (£)	Capital:	£10,000			Up front costs to establish communications and control infrastructure from the DNO to the commercial building(s), and to set up the initial EES contracts.
	Operational Expenditure:	£250,000			Payments to customer on an annual basis. NB. This is an initial estimate, and would be subject to further scrutiny and analysis.
	NPV of Opex:	£1,128,763			Based on 5 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Flat cost, linked to the duration of the commercial contract and the relatively short life expectancy.
	Life Expectancy of Solution:	5			All DSR contracts are deemed to be in place for a maximum of 5 years.
Merit Order	Totex (£):	£1,138,763			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			Would disrupt those customers with the DSR contract (of which there may be many depending on the feeder type, location and load density), but unlikely to affect anyone else.
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	3			Solution could be redeployed, but the capital costs would have to be repeated.
	Cross Network Benefits Factor:	2			Likely to provide a benefit to the HV network.
Other Benefits	Impact on Fixed Losses (%):	25%			This solution is will increase fixed losses as the round-trip efficiency of a storage unit is less than 100% - this differs by manufacturer and storage type. An efficiency of 75% has been applied in this model.
	Impact on Variable Losses (%):	-10%			As DSR, this solution has the ability to reduce the losses down a circuit by reducing the peak demand (less current, therefore less heating loss)
	Impact on quality of Supply (%):	0%			This solution is not expected to give any benefit to QoS
	Year solution is available:	2016			Estimate
	Year data (on soln) is available:				
	Source of Data:				
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart buildings and connected communities			
	Focus:	SME, C & I buildings and all aspects of new Built Environments			
	Subset:	Buildings provide energy storage (heat/elec) services			

Smart Variant

Solution Overview	Representative Solution:	**DSR**			
	Variant Solution:	DNO to commercial DSR (direct with HV customers)			
	Description:	Demand Side Response contract between a DNO and a single or small number of HV connected customers to resolve HV network constraints.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			5%	DSR reduces the peak demand on the network. Initial work carried out by DNOs and supported by work of a number of industry bodies (IEA, etc) have identified that c10% of conventional demand can be shifted, depending on the type of loads in use. Under the direct contract (led by the DNO) approach, it is assumed that a maximum of 5% is realised.
	Thermal Transformer:			3%	If DSR is only applied on one EHV feeder, the benefit to the Grid transformer would be reduced. 3% has been taken as the starting assumption in the model.
	Voltage Head:			0%	Not expected to give any benefit to the voltage headroom.
	Voltage Leg:			1%	A small secondary benefit would be realised to low volts situations, as shifting the peak to a different time of day would give rise to lower volt drops on the network.
	Power Quality:			0%	DSR is not expected to give rise to any PQ benefits
	Fault Level:			0%	DSR is not expected to give rise to any fault level benefits
Cost (£)	Capital:		£5,000		Up front costs to establish communications and control infrastructure from the DNO to the commercial building(s), and to set up the initial DSR contracts.
	Operational Expenditure:		£20,000		Payments to customer on an annual basis (based on payments made under equalised incentive for 1x DNO)
	NPV of Opex:		£90,301		Based on 5 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		2		Flat cost, linked to the duration of the commercial contract and the relatively short life expectancy.
	Life Expectancy of Solution:		5		All DSR contracts are deemed to be in place for a maximum of 5 years.
Merit Order	Totex (£):		£95,301		Calculated from capex plus NPV of opex
	Disuption Factor (1-5):		4		Would disrupt those customers with the DSR contract (of which there may be many depending on the feeder type, location and load density), but unlikely to affect anyone else.
	Disruption Cost (£):		£30,000		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):		3		Solution could be redeployed, but the capital costs would have to be repeated.
	Cross Network Benefits Factor:		3		Likely to provide a benefit to the HV network.
Other Benefits	Impact on Fixed Losses (%):		0%		This solution is not expected to give any benefit to fixed losses.
	Impact on Variable Losses (%):		-20%		Solution has the ability to reduce the losses down a circuit by reducing the peak demand (less current, therefore less heating loss)
	Impact on quality of Supply (%):		0%		This solution is not expected to give any benefit to QoS
	Year solution is available:		2012		Limited deployment with 1x in place for one DNO in 2012
	Year data (on soln) is available:		2014		Expect further information to be available following the successful outcome of LCN Fund projects
	Source of Data:	UKPN - Flextricity, WPD FALCON, plus information based on real deployments at HV by 1x DNO			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	DR Services aggregated for LV & HV network management			

Smart Variant

Solution Overview	Representative Solution:	**DSR**			
	Variant Solution:	DNO to commercial DSR (direct with EHV customers)			
	Description:	Demand Side Response contract between a DNO and a single or small number of EHV connected customers to resolve EHV network constraints.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			5%	DSR reduces the peak demand on the network. Initial work carried out by DNOs and supported by work of a number of industry bodies (IEA, etc) have identified that c10% of conventional demand can be shifted, depending on the type of loads in use. Under the direct contract (led by the DNO) approach, it is assumed that a maximum of 5% is realised.
	Thermal Transformer:			3%	If DSR is only applied on one EHV feeder, the benefit to the Grid transformer would be reduced. 3% has been taken as the starting assumption in the model.
	Voltage Head:			0%	Not expected to give any benefit to the voltage headroom.
	Voltage Leg:			1%	A small secondary benefit would be realised to low volts situations, as shifting the peak to a different time of day would give rise to lower volt drops on the network.
	Power Quality:			0%	DSR is not expected to give rise to any PQ benefits
	Fault Level:			0%	DSR is not expected to give rise to any fault level benefits
Cost (£)	Capital:	£5,000			Up front costs to establish communications and control infrastructure from the DNO to the commercial building(s), and to set up the initial DSR contracts.
	Operational Expenditure:	£35,000			Payments to customer on an annual basis. NB. This is an initial estimate, and would be subject to further scrutiny and analysis.
	NPV of Opex:	£158,027			Based on 5 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Flat cost, linked to the duration of the commercial contract and the relatively short life expectancy.
	Life Expectancy of Solution:	5			All DSR contracts are deemed to be in place for a maximum of 5 years.
Merit Order	Totex (£):	£163,027			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Would disrupt those customers with the DSR contract (of which there may be many depending on the feeder type, location and load density), but unlikely to affect anyone else.
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	3			Solution could be redeployed, but the capital costs would have to be repeated.
	Cross Network Benefits Factor:	2			Likely to provide a benefit to the HV network.
Other Benefits	Impact on Fixed Losses (%):	0%			This solution is not expected to give any benefit to fixed losses.
	Impact on Variable Losses (%):	-20%			Solution has the ability to reduce the losses down a circuit by reducing the peak demand (less current, therefore less heating loss)
	Impact on quality of Supply (%):	0%			This solution is not expected to give any benefit to QoS
	Year solution is available:	2012			Limited deployment with 1x in place for one DNO in 2012 (albeit at HV)
	Year data (on soln) is available:	2015			Expect further information to be available following the successful outcome of LCN Fund projects
	Source of Data:	UKPN - Flextricity, WPD FALCON, plus information based on real deployments at EHV by 1x DNO			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	DR Services aggregated for LV & HV network management			

Smart Variant

Solution Overview	Representative Solution:	**DSR**			
	Variant Solution:	DNO to aggregetor led commercial DSR (HV customer)			
	Description:	Demand Side Response contract between a DNO and an Aggregator (who in turn contracts with a number of HV connected customers) to resolve HV network constraints.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	10%			DSR reduces the peak demand on the network. Initial work carried out by the host DNO identified that 10% of conventional demand can be shifted, depending on the type of loads in use. In this particular instance, the host DNO restricts use to c5%, but we have modelled the ability to use the full 10%.
	Thermal Transformer:	5%			If DSR is only applied on one HV feeder, the benefit to the Primary transformer would be significantly reduced. 5% has been taken as the starting assumption in the model.
	Voltage Head:	0%			Not expected to give any benefit to the voltage headroom.
	Voltage Leg:	2%			A small secondary benefit would be realised to low volts situations, as shifting the peak to a different time of day would give rise to lower volt drops on the network. As the EHV network experiences limited volt-drop, this has been assumed to give a 2% improvement.
	Power Quality:	0%			DSR is not expected to give rise to any PQ benefits
	Fault Level:	0%			DSR is not expected to give rise to any fault level benefits
Cost (£)	Capital:	£5,000			Assumed costs (based on the EHV Aggregator figures). Up-front costs to establish communications & control infrastructure and contracts between the DNO and the aggregator.
	Operational Expenditure:	£20,000			£20k has been based on a reservation fee (with the Aggregator) of c£1.5k pcm (for an agreed number of MW), plus £2k payments to customer on an annual basis. NB. This is an initial estimate, and would be subject to further scrutiny and analysis.
	NPV of Opex:	£90,301			Based on 5 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Flat cost, linked to the duration of the commercial contract and the relatively short life expectancy.
	Life Expectancy of Solution:	5			All DSR contracts are deemed to be in place for a maximum of 5 years.
Merit Order	Totex (£):	£95,301			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			Would disrupt those customers with the DSR contract (of which there may be several depending on the feeder type, location and load density), but unlikely to affect anyone else.
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	3			Solution could be redeployed, but the capital costs would have to be repeated.
	Cross Network Benefits Factor:	2			Likely to provide a benefit to the HV network - additional capacity.
Other Benefits	Impact on Fixed Losses (%):	0%			This solution is not expected to give any benefit to fixed losses.
	Impact on Variable Losses (%):	-20%			Solution has the ability to reduce the losses down a circuit by reducing the peak demand (less current, therefore less heating loss)
	Impact on quality of Supply (%):	0%			This solution is not expected to give any benefit to QoS
	Year solution is available:	2012			Commercial contract in place today under the Equalised Incentive of DPCR5.
	Year data (on soln) is available:	2012			Solution in place
	Source of Data:	Based on 1x DNO's EHV solution (DNO not named for reasons of commercial confidentiality)			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	DR Services aggregated for LV & HV network management			

Smart Variant

Solution Overview	Representative Solution:	**DSR**			
	Variant Solution:	DNO to aggregetor led commercial DSR (EHV customer)			
	Description:	Demand Side Response contract between a DNO and an Aggregator (who in turn contracts with a number of larger EHV connected customers) to resolve EHV network constraints.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	10%			DSR reduces the peak demand on the network. Initial work carried out by the host DNO identified that 10% of conventional demand can be shifted, depending on the type of loads in use. In this particular instance, the host DNO restricts use to c5%, but we have modelled the ability to use the full 10%.
	Thermal Transformer:	5%			If DSR is only applied on one EHV feeder, the benefit to the Grid transformer would be significantly reduced. 5% has been taken as the starting assumption in the model.
	Voltage Head:	0%			Not expected to give any benefit to the voltage headroom.
	Voltage Leg:	2%			A small secondary benefit would be realised to low volts situations, as shifting the peak to a different time of day would give rise to lower volt drops on the network. As the EHV network experiences limited volt-drop, this has been assumed to give a 2% improvement.
	Power Quality:	0%			DSR is not expected to give rise to any PQ benefits
	Fault Level:	0%			DSR is not expected to give rise to any fault level benefits
Cost (£)	Capital:	£20,000			Up front costs to establish communications & control infrastructure and contracts between the DNO and the aggregator.
	Operational Expenditure:	£200,000			£200k has been based on a reservation fee (with the Aggregator) of c£16k pcm (for an agreed number of MW), plus £8k payments to customer on an annual basis. NB. This is an initial estimate, and would be subject to further scrutiny and analysis.
	NPV of Opex:	£903,010			Based on 5 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Flat cost, linked to the duration of the commercial contract and the relatively short life expectancy.
	Life Expectancy of Solution:	5			All DSR contracts are deemed to be in place for a maximum of 5 years.
Merit Order	Totex (£):	£923,010			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			Would disrupt those customers with the DSR contract (of which there may be several depending on the feeder type, location and load density), but unlikely to affect anyone else.
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	3			Solution could be redeployed, but the capital costs would have to be repeated.
	Cross Network Benefits Factor:	2			Likely to provide a benefit to the HV network - additional capacity.
Other Benefits	Impact on Fixed Losses (%):	0%			This solution is not expected to give any benefit to fixed losses.
	Impact on Variable Losses (%):	-20%			Solution has the ability to reduce the losses down a circuit by reducing the peak demand (less current, therefore less heating loss)
	Impact on quality of Supply (%):	0%			This solution is not expected to give any benefit to QoS
	Year solution is available:	2012			Commercial contract in place today under the Equalised Incentive of DPCR5.
	Year data (on soln) is available:	2012			Solution in place
	Source of Data:	1x DNO (not named for reasons of commercial confidentiality)			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	DR Services aggregated for LV & HV network management			

Smart Variant

Section	Item	EHV	HV	LV	Comments
Solution Overview	Representative Solution:	DSR			
	Variant Solution:	DNO led residential DSR			
	Description:	DNO triggered Demand Side Response with residential customers. It is 'DNO triggered' as opposed to national-led as it is initiated through breach of local network limits such as circuit or transformer loading, voltage limits, rather than used to manage national generation / supply positions.			
		EHV	HV	LV	Comments
Headroom Release (%)	Thermal Cable:			DM	Determined within the Model (DM): This is a more complex form of DSR is calculated on each of the daily profiles in the model and assumes a bottom-up analysis of loads in the home, only adjusting loads that are enabled (storage heating, EVs, etc) and in timeframes permitted. The amount of DSR'able load therefore changes with the scenarios, depending on the input assumptions around the volumes of EVs (for example) and of the public acceptance to DSR.
	Thermal Transformer:			DM	As Thermal Cable, this is calcuated within the model, and based on the aggregated ouput of the types of loads that can be moved.
	Voltage Head:			DM	Based on the thermal profiles - it is noted that the voltage headroom benefits are limited for this solution.
	Voltage Leg:			DM	Based on the thermal profiles calculated within the model - flattening of peak demand will reduce volt drops along the circuit, thereby improving voltage legroom.
	Power Quality:			0%	No expected benefit
	Fault Level:			0%	No expected benefit
Cost (£)	Capital:	£1,000			Up front costs to the DNO on a per LV feeder basis to enable this solution and/or establish any contracts with customers (e.g. assumed to be via suppliers in order to achieve economies of scale).
	Operational Expenditure:	£100			This is annual operating expenditure required for communications to LV connected customers (assumed to be £100p.a. per LV feeder).
	NPV of Opex:	£452			Based on 5 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Flat cost, linked to the duration of the commercial contract and the relatively short life expectancy.
	Life Expectancy of Solution:	5			All DSR contracts are deemed to be in place for a maximum of 5 years.
Merit Order	Totex (£):	£1,452			Calculated from capex plus NPV of opex. In addition for this more complex modelling of DSR, an inconvenience charge is calculated and included within the model. In the GB model this cost is purely the cost of compensating the customer for the inconvenience of moving their load. In the regional model it includes an allowance for compensating the supplier for adjusting their generation mix (in the GB model the precise affect of this is calculated by the model developed by Frontier Economics, which can not be replicated in the GB model).
	Disuption Factor (1-5):	5			In order to achieve significant benefits to the DNO (10%+) a number of customers would effectively need to be disrupted, hence the high figure here.
	Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	4			Solution could be redeployed, but not trivial to recruit additional customers, nor to change their behaviour.
	Cross Network Benefits Factor:	2			Likely to provide a strong benefit to the HV network.
Other Benefits	Impact on Fixed Losses (%):	0%			This solution is not expected to give any benefit to fixed losses.
	Impact on Variable Losses (%):	-20%			Solution has the ability to reduce the losses down a circuit by reducing the peak demand (less current, therefore less heating loss)
	Impact on quality of Supply (%):	0%			This solution is not expected to give any benefit to QoS
	Year solution is available:				
	Year data (on soln) is available:				
	Source of Data:	SSE - NINES; NPG - CLNR			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 2			
	Focus:	DG connections, management of two way power flows			
	Subset:	DR Services aggregated for LV & HV network management			

Smart Variant

Solution Overview	Representative Solution:	**DSR**			
	Variant Solution:	DNO to Central business District DSR			
	Description:	Demand Side Response contracts in place between a DNO and LV connected buildings, such as offices, located in a city centre or CBD.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			10%	DSR reduces the peak demand on the network. Initial work carried out by DNOs and supported by work of a number of industry bodies (IEA, etc) have identified that c10% of conventional demand can be shifted, depending on the type of loads in use. As this solution focuses on LV commercial customers (e.g. offices with air conditioning load), 10% is believed to be a reasonable starting assumption.
	Thermal Transformer:			5%	If DSR is only applied on one LV feeder, the benefit to the HV/LV transformer would be significantly reduced. 5% has been taken as the starting assumption in the model.
	Voltage Head:			0%	Not expected to give any benefit to the voltage headroom.
	Voltage Leg:			3%	A small secondary benefit would be realised to low volts situations, as shifting the peak to a different time of day would give rise to lower volt drops on the network.
	Power Quality:			0%	DSR is not expected to give rise to any PQ benefits
	Fault Level:			0%	DSR is not expected to give rise to any fault level benefits
Cost (£)	Capital:	£10,000			Up front costs to establish communications and control infrastructure from the DNO to the commercial building(s), and to set up the initial DSR contracts.
	Operational Expenditure:	£500			Payments to customer on an annual basis. NB. This is an initial estimate, and would be subject to further scrutiny and analysis.
	NPV of Opex:	£2,258			Based on 5 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Flat cost, linked to the duration of the commercial contract and the relatively short life expectancy.
	Life Expectancy of Solution:	5			All DSR contracts are deemed to be in place for a maximum of 5 years.
Merit Order	Totex (£):	£12,258			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			Would disrupt those customers with the DSR contract (of which there may be many depending on the feeder type, location and load density), but unlikely to affect anyone else.
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	3			Solution could be redeployed, but the capital costs would have to be repeated.
	Cross Network Benefits Factor:	2			Likely to provide a benefit to the HV network.
Other Benefits	Impact on Fixed Losses (%):	0%			This solution is not expected to give any benefit to fixed losses.
	Impact on Variable Losses (%):	-20%			Solution has the ability to reduce the losses down a circuit by reducing the peak demand (less current, therefore less heating loss)
	Impact on quality of Supply (%):	0%			This solution is not expected to give any benefit to QoS
	Year solution is available:	2016			Assumed incremental development, but no known live projects at time of writing
	Year data (on soln) is available:	2015			estimate
	Source of Data:	UKPN: Low Carbon London			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart buildings and connected communities			
	Focus:	SME, C & I buildings and all aspects of new Built Environments			
	Subset:	Buildings provide DR services and DG services			

Smart Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Distribution Flexible AC Transmission Systems (D-FACTS)**			
	Variant Solution:	D-FACTS@ LV			
	Description:	Series or shunt connected static power electronics as a means to enhance controllability and increase power transfer capability of the LV network			
Headroom Release (%)	Thermal Cable:			8%	D-FACTS have the ability to change power flow on a given circuit, which will yield benefits in terms of circuit headroom. Exact parameters will depend on the size of device, the connection location and the load on the network. D-FACTS are considered to give less benefit than STATCOM devices, hence 8% has been used in the model.
	Thermal Transformer:			4%	A D-FACTS device applied to a single LV circuit will have a small, but measureable, benefit to the transformer loading - captured here as 4% benefit.
	Voltage Head:			8%	D-FACTS technologies are able to supress volts on a given network. Exact parameters will depend on the size of the device, D-FACTS are considered to give less benefit than STATCOM devices, hence 8% has been used in the model.
	Voltage Leg:			8%	D-FACTS technologies are able to lift volts on a given network. Exact parameters will depend on the size of the device, D-FACTS are considered to give less benefit than STATCOM devices, hence 8% has been used in the model.
	Power Quality:			20%	D-FACTS devices are deemed able to rapidly inject VArs to correct for power quality issues. As they are fast switching devices, a benefit of 20% has been assumed in the model (for all voltages). Exact parameters will depend on the size of the units.
	Fault Level:			5%	D-FACTS are considered to have a limited ability to change network fault levels
Cost (£)	Capital:	£35,000			Estimate
	Operational Expenditure:	£100			Estimate (annual cost) - principally communications / monitoring costs
	NPV of Opex:	£1,421			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			Not based on consumer electronics, and applications at EHV are likely to remain niche and limited, hence a slow roll-off
	Life Expectancy of Solution:	40			Assumed to have a similar asset life to modern switchgear / transformers
Merit Order	Totex (£):	£36,421			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			New land necessary to locate device, likely short duration outage requirements to connect
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			Not expected to be a moveable device (but more flexible than an underground cable)
	Cross Network Benefits Factor:	1			Some potential to give benefits to HV networks
Other Benefits	Impact on Fixed Losses (%):	10%			Assumed to increase fixed losses, as the devices are not lossless, and energy is required to operate the units.
	Impact on Variable Losses (%):	-20%			Potentially significant improvement on network losses by minimising VAr flow down a circuit.
	Impact on quality of Supply (%):	0%			This solution is not anticipated to improve QoS
	Year solution is available:	2016			Assumed incremental development, but no known live projects at time of writing
	Year data (on soln) is available:	2015			estimate
	Source of Data:				
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 3			
	Focus:	Plant & Systems reliability, failure mode detection			
	Subset:	Loss optimisation techniques - utilise new devices such as D-FACTS			

Smart Variant

Solution Overview Representative Solution:	**Distribution Flexible AC Transmission Systems (D-FACTS)**				
Variant Solution:	D-FACTS@ HV				
Description:	Series or shunt connected static power electronics as a means to enhance controllability and increase power transfer capability of the HV network				
	EHV	**HV**	**LV**	**Comments**	
Headroom Release (%) Thermal Cable:		8%		D-FACTS have the ability to change power flow on a given circuit, which will yield benefits in terms of circuit headroom. Exact parameters will depend on the size of device, the connection location and the load on the network. D-FACTS are considered to give less benefit than STATCOM devices, hence 8% has been used in the model.	
Thermal Transformer:		4%		A D-FACTS device applied to a single HV circuit will have a small, but measureable, benefit to the transformer loading - captured here as 4% benefit.	
Voltage Head:		8%		D-FACTS technologies are able to supress volts on a given network. Exact parameters will depend on the size of the device, D-FACTS are considered to give less benefit than STATCOM devices, hence 8% has been used in the model.	
Voltage Leg:		8%		D-FACTS technologies are able to lift volts on a given network. Exact parameters will depend on the size of the device, D-FACTS are considered to give less benefit than STATCOM devices, hence 8% has been used in the model.	
Power Quality:		20%		D-FACTS devices are deemed able to rapidly inject VArs to correct for power quality issues. As they are fast switching devices, a benefit of 20% has been assumed in the model (for all voltages). Exact parameters will depend on the size of the units.	
Fault Level:		5%		D-FACTS are considered to have a limited ability to change network fault levels	
Cost (£) Capital:	£100,000			Estimate	
Operational Expenditure:	£200			Estimate (annual cost) - principally communications / monitoring costs	
NPV of Opex:	£2,842			Based on 20 year of annual operating expenditure @ 3.5% discount rate	
Cost Curve Type:	3			Not based on consumer electronics, and applications at EHV are likely to remain niche and limited, hence a slow roll-off	
Life Expectancy of Solution:	40			Assumed to have a similar asset life to modern switchgear / transformers	
Merit Order Totex (£):	£102,842			Calculated from capex plus NPV of opex	
Disuption Factor (1-5):	3			New land necessary to locate device, likely short duration outage requirements to connect	
Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)	
Flexibility (1-5):	2			Not expected to be a moveable device (but more flexible than an underground cable)	
Cross Network Benefits Factor:	1			Some potential to give benefits to HV networks	
Other Benefits Impact on Fixed Losses (%):	10%			Assumed to increase fixed losses, as the devices are not lossless, and energy is required to operate the units.	
Impact on Variable Losses (%):	-20%			Potentially significant improvement on network losses by minimising VAr flow down a circuit.	
Impact on quality of Supply (%):	0%			This solution is not anticipated to improve QoS	
Year solution is available:	2012			Solutions are available today, albeit they are not widely used in GB	
Year data (on soln) is available:					
Source of Data:	UKPN Flexible plug and play				
Smart Solution Relevance (WS3 Ph1) Smart Solution Set:	Smart D-Networks 3				
Focus:	Plant & Systems reliability, failure mode detection				
Subset:	Loss optimisation techniques - utilise new devices such as D-FACTS				

Smart Variant

Section	Field	EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Distribution Flexible AC Transmission Systems (D-FACTS)**			
	Variant Solution:	D-FACTS@ EHV			
	Description:	Series or shunt connected static power electronics as a means to enhance controllability and increase power transfer capability of the EHV network			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	8%			D-FACTS have the ability to change power flow on a given circuit, which will yield benefits in terms of circuit headroom. Exact parameters will depend on the size of device, the connection location and the load on the network. D-FACTS are considered to give less benefit than STATCOM devices, hence 8% has been used in the model.
	Thermal Transformer:	4%			A D-FACTS device applied to a single EHV circuit will have a small, but measureable, benefit to the transformer loading - captured here as 4% benefit.
	Voltage Head:	8%			D-FACTS technologies are able to supress volts on a given network. Exact parameters will depend on the size of the device, D-FACTS are considered to give less benefit than STATCOM devices, hence 8% has been used in the model.
	Voltage Leg:	8%			D-FACTS technologies are able to lift volts on a given network. Exact parameters will depend on the size of the device, D-FACTS are considered to give less benefit than STATCOM devices, hence 8% has been used in the model.
	Power Quality:	20%			D-FACTS devices are deemed able to rapidly inject VArs to correct for power quality issues. As they are fast switching devices, a benefit of 20% has been assumed in the model (for all voltages). Exact parameters will depend on the size of the units.
	Fault Level:	5%			D-FACTS are considered to have a limited ability to change network fault levels
Cost (£)	Capital:	£200,000			Estimate
	Operational Expenditure:	£200			Estimate (annual cost) - principally communications / monitoring costs
	NPV of Opex:	£6,816			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			Not based on consumer electronics, and applications at EHV are likely to remain niche and limited, hence a slow roll-off
	Life Expectancy of Solution:	40			Assumed to have a similar asset life to modern switchgear / transformers
Merit Order	Totex (£):	£202,842			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			New land necessary to locate device, likely short duration outage requirements to connect
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			Not expected to be a moveable device (but more flexible than an underground cable)
	Cross Network Benefits Factor:	1			Some potential to give benefits to HV networks
Other Benefits	Impact on Fixed Losses (%):	10%			Assumed to increase fixed losses, as the devices are not lossless, and energy is required to operate the units.
	Impact on Variable Losses (%):	-20%			Potentially significant improvement on network losses by minimising VAr flow down a circuit.
	Impact on quality of Supply (%):	0%			This solution is not anticipated to improve QoS
	Year solution is available:	2016			Assumed incremental development, but no known live projects at time of writing
	Year data (on soln) is available:	2015			estimate
	Source of Data:				
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 3			
	Focus:	Plant & Systems reliability, failure mode detection			
	Subset:	Loss optimisation techniques - utilise new devices such as D-FACTS			

Smart Variant

Solution Overview	Representative Solution:	**Distribution Flexible AC Transmission Systems (D-FACTS)**			
	Variant Solution:	LV connected STATCOM			
	Description:	STATCOMs (Static Synchronous Compensators) are power electronics device, capable of injecting VArs to a network for voltage support or power flow management of LV networks			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			10%	STATCOMS have the ability to change power flow on a given circuit, which will yield benefits in terms of circuit headroom. Exact parameters will depend on the size of device, the connection location and the load on the network - 10% has been used as a conservative assumption in the model.
	Thermal Transformer:			5%	A STATCOM applied to a single LV circuit will have a small, but measureable, benefit to the transformer loading - captured here as 5% benefit.
	Voltage Head:			15%	STATCOM technologies are able to supress volts on a given network. Exact parameters will depend on the size of the device, but have been assumed to be 15% for LV circuits.
	Voltage Leg:			15%	STATCOM technologies are able to lift volts on a given network. Exact parameters will depend on the size of the device, but have been assumed to be 15% for LV circuits.
	Power Quality:			20%	STATCOM devices are deemed able to rapidly inject VArs to correct for power quality issues. As they are fast switching devices, a benefit of 20% has been assumed in the model (for all voltages). Exact parameters will depend on the size of the units.
	Fault Level:			5%	STATCOMS are considered to have a limited ability to change network fault levels
Cost (£)	Capital:	£30,000			Estimate
	Operational Expenditure:	£100			Estimate (annual cost) - principally communications / monitoring costs
	NPV of Opex:	£1,421			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			Not based on consumer electronics, and applications at LV are likely to remain niche and limited, hence a slow roll-off
	Life Expectancy of Solution:	40			Assumed to have a similar asset life to modern switchgear / transformers
Merit Order	Totex (£):	£31,421			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			New land necessary to locate device, likely short duration outage requirements to connect
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			Not expected to be a moveable device (but more flexible than an underground cable)
	Cross Network Benefits Factor:	1			Some potential to give benefits to HV networks
Other Benefits	Impact on Fixed Losses (%):	10%			Assumed to increase fixed losses, as the devices are not lossless, and energy is required to operate the units.
	Impact on Variable Losses (%):	-25%			Potentially significant improvement on network losses by minimising VAr flow down a circuit.
	Impact on quality of Supply (%):	0%			This solution is not anticipated to improve QoS
	Year solution is available:	2016			Assumed incremental development, but no known live projects at time of writing
	Year data (on soln) is available:	2015			estimate
	Source of Data:	ENW IFI T1 LV Voltage Regulation,			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 1			
	Focus:	Quality of supply; enhancements to existing network architecture			
	Subset:	Waveform monitoring and waveform correction devices			

Smart Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Distribution Flexible AC Transmission Systems (D-FACTS)**			
	Variant Solution:	HV connected STATCOM			
	Description:	STATCOMs (Static Synchronous Compensators) are power electronics device, capable of injecting VArs to a network for voltage support or power flow management of HV networks			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		10%		STATCOMS have the ability to change power flow on a given circuit, which will yield benefits in terms of circuit headroom. Exact parameters will depend on the size of device, the connection location and the load on the network - 10% has been used as a conservative assumption in the model.
	Thermal Transformer:		5%		A STATCOM applied to a single HV circuit will have a small, but measureable, benefit to the transformer loading - captured here as 5% benefit.
	Voltage Head:		12%		STATCOM technologies are able to supress volts on a given network. Exact parameters will depend on the size of the device, but have been assumed to be 12% for HV circuits.
	Voltage Leg:		12%		STATCOM technologies are able to lift volts on a given network. Exact parameters will depend on the size of the device, but have been assumed to be 12% for LV circuits.
	Power Quality:		20%		STATCOM devices are deemed able to rapidly inject VArs to correct for power quality issues. As they are fast switching devices, a benefit of 20% has been assumed in the model (for all voltages). Exact parameters will depend on the size of the units.
	Fault Level:		5%		STATCOMS are considered to have a limited ability to change network fault levels
Cost (£)	Capital:		£150,000		Estimate
	Operational Expenditure:		£200		Estimate (annual cost) - principally communications / monitoring costs
	NPV of Opex:		£2,842		Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		3		Not based on consumer electronics, and applications at HV are likely to remain niche and limited, hence a slow roll-off
	Life Expectancy of Solution:		40		Assumed to have a similar asset life to modern switchgear / transformers
Merit Order	Totex (£):		£152,842		Calculated from capex plus NPV of opex
	Disuption Factor (1-5):		3		New land necessary to locate device, likely short duration outage requirements to connect
	Disruption Cost (£):		£10,000		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):		2		Not expected to be a moveable device (but more flexible than an underground cable)
	Cross Network Benefits Factor:		2		Some potential to give benefits to EHV networks
Other Benefits	Impact on Fixed Losses (%):		10%		Assumed to increase fixed losses, as the devices are not lossless, and energy is required to operate the units.
	Impact on Variable Losses (%):		-25%		Potentially significant improvement on network losses by minimising VAr flow down a circuit.
	Impact on quality of Supply (%):		0%		This solution is not anticipated to improve QoS
	Year solution is available:		2012		Solutions are available today, albeit they are not widely used in GB
	Year data (on soln) is available:		2014		WPD T1 project Nr Falmouth
	Source of Data:	WPD IFI T1 nr Falmouth?			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 1			
	Focus:	Quality of supply; enhancements to existing network architecture			
	Subset:	Waveform monitoring and waveform correction devices			

Smart Variant

Solution Overview	Representative Solution:	**Distribution Flexible AC Transmission Systems (D-FACTS)**			
	Variant Solution:	EHV connected STATCOM			
	Description:	STATCOMs (Static Synchronous Compensators) are power electronics device, capable of injecting VArs to a network for voltage support or power flow management of EHV networks			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	10%			STATCOMS have the ability to change power flow on a given circuit, which will yield benefits in terms of circuit headroom. Exact parameters will depend on the size of device, the connection location and the load on the network - 10% has been used as a conservative assumption in the model.
	Thermal Transformer:	5%			A STATCOM applied to a single EHV circuit will have a small, but measureable, benefit to the transformer loading - captured here as 5% benefit.
	Voltage Head:	10%			STATCOM technologies are able to supress volts on a given network. Exact parameters will depend on the size of the device, but have been assumed to be 10% in this instance.
	Voltage Leg:	10%			STATCOM technologies are able to lift volts on a given network. Exact parameters will depend on the size of the device, but have been assumed to be 10% in this instance.
	Power Quality:	20%			STATCOM devices are deemed able to rapidly inject VArs to correct for power quality issues. As they are fast switching devices, a benefit of 20% has been assumed in the model (for all voltages). Exact parameters will depend on the size of the units.
	Fault Level:	5%			STATCOMS are considered to have a limited ability to change network fault levels
Cost (£)	Capital:	£250,000			Estimate
	Operational Expenditure:	£200			Estimate (annual cost) - principally communications / monitoring costs
	NPV of Opex:	£6,816			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			Not based on consumer electronics, and applications at EHV are likely to remain niche and limited, hence a slow roll-off
	Life Expectancy of Solution:	40			Assumed to have a similar asset life to modern switchgear / transformers
Merit Order	Totex (£):	£252,842			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	3			New land necessary to locate device, likely short duration outage requirements to connect
	Disruption Cost (£):	£10,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			Not expected to be a moveable device (but more flexible than an underground cable)
	Cross Network Benefits Factor:	1			Some potential to give benefits to HV networks
Other Benefits	Impact on Fixed Losses (%):	10%			Assumed to increase fixed losses, as the devices are not lossless, and energy is required to operate the units.
	Impact on Variable Losses (%):	-25%			Potentially significant improvement on network losses by minimising VAr flow down a circuit.
	Impact on quality of Supply (%):	0%			This solution is not anticipated to improve QoS
	Year solution is available:	2016			Assumed incremental development, but no known live projects at time of writing
	Year data (on soln) is available:	2015			estimate
	Source of Data:				
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 1			
	Focus:	Quality of supply; enhancements to existing network architecture			
	Subset:	Waveform monitoring and waveform correction devices			

Smart Variant

Section	Field	EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Active Network Management - Dynamic Network Reconfiguration**			
	Variant Solution:	LV			
	Description:	The pro-active movement of LV network split (or open) points to align with the null loading points within the network in real time.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			10%	The amount of headroom that can be released from this solution varies considerably from one implementation to another, as it is heavily dependent on the amount of load present on adjoining portions of the network. In some rare cases, it may be possible to effectively double the capacity and release up to 100% headroom, however there will be many instances when only a marginal amount of headroom is available. For the purposes of the model, an average headroom release figure of 10% has been assumed at LV (aligned to assumptions in the WS2 report).
	Thermal Transformer:			5%	This solution is expected to give rise to lower transformer headroom benefits, as it would depend on the number of EHV feeders out of a Grid substation that have ANM-DNR applied.
	Voltage Head:			3%	A 3% improvement to headroom has been assumed. NB. This is different to the WS2 figures due to a change in modelling approach.
	Voltage Leg:			5%	A 5% improvement to legroom has been assumed. NB. This is different to the WS2 figures due to a change in modelling approach.
	Power Quality:			5%	Marginal improvement in PQ through alignment of load/network impedance
	Fault Level:			0%	Solution not anticipated to affect network fault level
Cost (£)	Capital:	£15,000			Estimated cost based on engineering judgement - equal to 75% (initially) of that at HV
	Operational Expenditure:	£100			Estimate (annual cost). Principally this is associated with the cost of communications channels (availability and data).
	NPV of Opex:	£1,421			Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Faster roll off than EHV and HV as solution is not yet deployed at scale
	Life Expectancy of Solution:	20			Lifetime is likely to be governed by the monitoring equipment that needs to be installed, in the first instance. However, the importance of load growth on adjacent feeders should not be discounted. This model does not deal with regional issues, and hence a lifetime of 20 years has been assumed.
Merit Order	Totex (£):	£16,421			Calculated from capex plus NPV of opex
	Disuption Factor (1-5):	2			Installation to existing assets, limited customer impact
	Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	3			Automation equipment can be moved to other locations, but non trivial
	Cross Network Benefits Factor:	1			Some load management for HV networks
Other Benefits	Impact on Fixed Losses (%):	0%			No improvement / reduction on fixed losses expected
	Impact on Variable Losses (%):	-5%			Marginal improvement in losses through alignment of load/network impedance
	Impact on quality of Supply (%):	0%			No improvement / reduction in supply quality expected
	Year solution is available:	2016			Assumed incremental development, but no known live projects at time of writing
	Year data (on soln) is available:	2015			estimate
	Source of Data:	SGF - Workstream 2 model and report			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 1			
	Focus:	Quality of supply; enhancements to existing network architecture			
	Subset:	Intelligent Switching			

Smart Variant

Section	Field	EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**Active Network Management - Dynamic Network Reconfiguration**			
	Variant Solution:	HV			
	Description:	The pro-active movement of HV network split (or open) points to align with the null loading points within the network in real time.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		30%		The amount of headroom that can be released from this solution varies considerably from one implementation to another, as it is heavily dependent on the amount of load present on adjoining portions of the network. In some rare cases, it may be possible to effectively double the capacity and release up to 100% headroom, however there will be many instances when only a marginal amount of headroom is available. For the purposes of the model, an average headroom release figure of 30% has been assumed at HV (aligned to assumptions in the WS2 report).
	Thermal Transformer:		10%		This solution is expected to give rise to lower transformer headroom benefits, as it would depend on the number of HV feeders out of a Primary substation that have ANM-DNR applied.
	Voltage Head:		3%		A 3% improvement to headroom has been assumed. NB. This is different to the WS2 figures due to a change in modelling approach.
	Voltage Leg:		3%		A 3% improvement to legroom has been assumed. NB. This is different to the WS2 figures due to a change in modelling approach.
	Power Quality:		5%		Marginal improvement in PQ through alignment of load/network impedance
	Fault Level:		0%		Solution not anticipated to affect network fault level
Cost (£)	Capital:		£50,000		Estimated cost, noting that this is a higher capex than at EHV owing to more complex circuits (network branching and potential infeeds).
	Operational Expenditure:		£250		Estimate (annual cost). Principally this is associated with the cost of communications channels (availability and data).
	NPV of Opex:		£3,553		Based on 20 year of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		2		Not expecting a fast roll off of costs as technology is relatively mature
	Life Expectancy of Solution:		20		Lifetime is likely to be governed by the monitoring equipment that needs to be installed, in the first instance. However, the importance of load growth on adjacent feeders should not be discounted. This model does not deal with regional issues, and hence a lifetime of 20 years has been assumed.
Merit Order	Totex (£):		£53,553		Calculated from capex plus NPV of opex
	Disuption Factor (1-5):		2		Installation to existing assets, limited customer impact
	Disruption Cost (£):		£2,500		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):		3		Automation equipment can be moved to other locations, but non trivial
	Cross Network Benefits Factor:		1		Some load management benefits for EHV networks
Other Benefits	Impact on Fixed Losses (%):		0%		No improvement / reduction on fixed losses expected
	Impact on Variable Losses (%):		-5%		Marginal improvement in losses through alignment of load/network impedance
	Impact on quality of Supply (%):		0%		No improvement / reduction in supply quality expected
	Year solution is available:		2012		
	Year data (on soln) is available:		2014		
	Source of Data:	UKPN - AuRA - NMS (IFI); SP - Flexible Networks for a Low Carbon Future (LCNF)			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	Smart D-Networks 1			
	Focus:	Quality of supply; enhancements to existing network architecture			
	Subset:	Intelligent Switching			

Smart Variant

Solution Overview Representative Solution:	**Active Network Management - Dynamic Network Reconfiguration**				
Variant Solution:	EHV				
Description:	The pro-active movement of EHV network split (or open) points to align with the null loading points within the network in real-time.				
	EHV	**HV**	**LV**	**Comments**	
Headroom Release (%) Thermal Cable:	30%			The amount of headroom that can be released from this solution varies considerably from one implementation to another, as it is heavily dependent on the amount of load present on adjoining portions of the network. In some rare cases, it may be possible to effectively double the capacity and release up to 100% headroom, however there will be many instances when only a marginal amount of headroom is available. For the purposes of the model, an average headroom release figure of 30% has been assumed at EHV (aligned to assumptions in the WS2 report).	
Thermal Transformer:	10%			This solution is expected to give rise to lower transformer headroom benefits, as it would depend on the number of EHV feeders out of a Grid substation that have ANM-DNR applied.	
Voltage Head:	2%			A 2% improvement to headroom has been assumed. NB. This is different to the WS2 figures due to a change in modelling approach.	
Voltage Leg:	2%			A 2% improvement to legroom has been assumed. NB. This is different to the WS2 figures due to a change in modelling approach.	
Power Quality:	5%			Marginal improvement in PQ through alignment of load/network impedance	
Fault Level:	0%			Solution not anticipated to affect network fault level	
Cost (£) Capital:	£40,000			Estimated cost based on best engineering judgement.	
Operational Expenditure:	£500			Estimate (annual cost). Principally this is associated with the cost of communications channels (availability and data).	
NPV of Opex:	£7,106			Based on 20 year of annual operating expenditure @ 3.5% discount rate	
Cost Curve Type:	2			Flat - Not expecting a roll off of costs as technology is relatively mature	
Life Expectancy of Solution:	20			Lifetime is likely to be governed by the monitoring equipment that needs to be installed, in the first instance. However, the importance of load growth on adjacent feeders should not be discounted. This model does not deal with regional issues, and hence a lifetime of 20 years has been assumed.	
Merit Order Totex (£):	£47,106			Calculated from capex plus NPV of opex	
Disuption Factor (1-5):	2			Installation to existing assets, limited customer impact	
Disruption Cost (£):	£2,500			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)	
Flexibility (1-5):	3			Automation equipment can be moved to other locations, but non trivial	
Cross Network Benefits Factor:	1			Potential support on HV networks	
Other Benefits Impact on Fixed Losses (%):	0%			No improvement / reduction on fixed losses expected	
Impact on Variable Losses (%):	-5%			Marginal improvement in losses through alignment of load/network impedance	
Impact on quality of Supply (%):	0%			No improvement / reduction in supply quality expected	
Year solution is available:	2012			Solutions are available today, albeit they are not widely used in GB	
Year data (on soln) is available:	2014			SP - Flexible Networks for a Low Carbon Future	
Source of Data:	SGF - Workstream 2 model and report				
Smart Solution Relevance (WS3 Ph1) Smart Solution Set:	Smart D-Networks 1				
Focus:	Quality of supply; enhancements to existing network architecture				
Subset:	Intelligent Switching				

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Phase imbalance -HV circuit			
	Description:	Device to monitor the load on three phases of an HV circuit and hence determine the level of imbalance that exists between phases			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		0%		Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:		0%		
	Voltage Head:		0%		
	Voltage Leg:		0%		
	Power Quality:		0%		
	Fault Level:		0%		
Cost (£)	Capital:	£1,000			Cost is as per the LV phase imbalance monitoring equipment, but clearly equipment needs to be designed to a higher rating if connecting at HV, hence the increased costs as against those for LV
	Operational Expenditure:	£10			Small opex associated with obtaining the data from the device, but no maintenance should be necessary over its 20 year life
	NPV of Opex:	£142			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	4			Addressing phase imbalance can offer a cost-effective way to release headroom, meaning that a large number of these devices could be deployed, hence reducing costs over time
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£1,142			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Quality of supply enhancements to existing network architecture			
	Subset:	Phase imbalance sensors/correction (improve losses and capacity)			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Phase imbalance - LV connect customer, 3 phase			
	Description:	Device installed at the interface to a customer with a three phase supply to montor the load on ecah phase and hence determine the level of phase imbalance present			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:	£20			This is s a simple, low cost, 3 phase load monitoring device
	Operational Expenditure:	£0			Opex costs are very low as ther eis not a requirement to regularly update the load information, given that it is unlikely that the balance across the three phases will change unless the customer makes some significant change to their connected equipment
	NPV of Opex:	£3			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	4			Addressing phase imbalance can offer a cost-effective way to release headroom, meaning that a large number of these devices could be deployed, hence reducing costs over time
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£23			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Quality of supply enhancements to existing network architecture			
	Subset:	Phase imbalance sensors/correction (improve losses and capacity)			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Phase imbalance -smart meter phase identification			
	Description:	Device installed at the interface to a domestic customer with a single phase supply to establish the phase to which that customer is connected			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:	£10			This is a very simple device that will be very low cost
	Operational Expenditure:	£0			There are no significant opex costs as (unlike some monitoring) it is not necessary to obtain data updates frequently (the phase of connection will not change unless some conscious work is carried out to bring about a change)
	NPV of Opex:	£1			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	4			Addressing phase imbalance can offer a cost-effective way to release headroom, meaning that a large number of these devices could be deployed, hence reducing costs over time
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£11			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Quality of supply enhancements to existing network architecture			
	Subset:	Phase imbalance sensors/correction (improve losses and capacity)			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Phase imbalance - LV circuit			
	Description:	Device to monitor the load on all three phases of an LV circuit and hence determine the level of imbalance that exists between phases			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:	£500			Load monitoring equipment installed along a feeder is more expensive than that contained within the distribution substation. Moreover, the costs are much higher than those associated with a three phase monitoring device installed at a customer's premises owing to the more strenuous specification required
	Operational Expenditure:	£5			Small opex associated with obtaining the data from the device, but no maintenance should be necessary over its 20 year life
	NPV of Opex:	£71			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	4			Addressing phase imbalance can offer a cost-effective way to release headroom, meaning that a large number of these devices could be deployed, hence reducing costs over time
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£571			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Quality of supply enhancements to existing network architecture			
	Subset:	Phase imbalance sensors/correction (improve losses and capacity)			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Phase imbalance - LV dist s/s			
	Description:	Device to monitor the load on all three phases on the LV side of a transformer at a distribution substation and hence determine the level of imbalance that exists between phases			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:	£250			Load monitoring equipment contained within the distribution substation is less expensive than equipment needing to be installed out on the network, but a three phase monitoring device here needs a higher specification than one to be installed at a customer's premises, hence is of higher cost
	Operational Expenditure:	£3			Very little opex is associated with this enabler; there will be a samll charge associated with extracting the data from the monitoring equipment
	NPV of Opex:	£36			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	4			Addressing phase imbalance can offer a cost-effective way to release headroom, meaning that a large number of these devices could be deployed, hence reducing costs over time
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£286			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Quality of supply enhancements to existing network architecture			
	Subset:	Phase imbalance sensors/correction (improve losses and capacity)			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Smart Metering infrastructure -DNO to DCC 2 way control			
	Description:	Equipment to enable 2 way communication between the DNO and DCC to obtain data and enact DSR			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:	£10,000			Fairly extensive communication and IT equipment would be required to enable this two way communication and control; estimated at £10k
	Operational Expenditure:	£100			Opex in terms of costs of maintaining communications links
	NPV of Opex:	£1,421			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			The costs associated with data from the DCC are very much an unknown quantity at present and the assumption has been taken that they remain constant over time
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£11,421			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	DG connections management of 2 way power flows			
	Subset:	DR services aggregated for LV and HV network management			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Smart Metering infrastructure -DNO to DCC 2 way A+D			
	Description:	Equipment to enable 2 way communication between the DNO and DCC to obtain data and allow DSR to be enacted			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:	£5,000			This is similar to the 2 way communication and control, but does not include the ability to directly enact DSR, hence less complex equipment is reuqired; estimated at £5k.
	Operational Expenditure:	£50			Less complex equipment, with less critical communications channels reuslts in a lower opex cost
	NPV of Opex:	£711			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			The costs associated with data from the DCC are very much an unknown quantity at present and the assumption has been taken that they remain constant over time
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£5,711			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	DG connections management of 2 way power flows			
	Subset:	DR services aggregated for LV and HV network management			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Smart Metering infrastructure - DCC to DNO 1 way			
	Description:	Equipment to enable 1 way communication between the DNO and DCC to obtain smart meter data			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:	£1,000			This is much simpler than the 2 way communication and control, requiring only the flow of dta from the DCC to the DNO; hence the cost is significantly less.
	Operational Expenditure:	£10			Relatively simple communications channels, hence a low annual opex cost to maintain these links
	NPV of Opex:	£142			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			The costs associated with data from the DCC are very much an unknown quantity at present and the assumption has been taken that they remain constant over time
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£1,142			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	DG connections management of 2 way power flows			
	Subset:	DR services aggregated for LV and HV network management			

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Monitoring waveform quality (LV Feeder)			
	Description:	Device to monitor the waveform along an LV feeder and hence enable LV power quality solutions			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:	£3,000			Installation of devices and necessary local communications to monitor the waveform along an LV feeder (much more complex logistically than monitoring in a substation) and report back to a central hub
	Operational Expenditure:	£30			Opex associated with relaying the data
	NPV of Opex:	£426			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			It is envisaged that these devices may be deployed in some numbers (although not as widespread as phase imbalance monitoring, for example); hence a slight reduction in cost over time is anticipated
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£3,426			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Quality of supply enhancements to existing network architecture			
	Subset:	Waveform monitoring and waveform correction devices			

Smart Enabler

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Monitoring waveform quality (HV feeder)			
	Description:	Device to monitor the waveform along an HV feeder and hence enable LV power quality solutions			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		0%		Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:		0%		
	Voltage Head:		0%		
	Voltage Leg:		0%		
	Power Quality:		0%		
	Fault Level:		0%		
Cost (£)	Capital:		£5,000		Installation of devices and necessary local communications to monitor the waveform along an HV feeder presents a similar cost to that for LV, but the equipment needs to be of a higher specification and there are increased logistical issues with installing at HV rather thna LV hence the increased cost from £3k to £5k
	Operational Expenditure:		£50		Opex associated with relaying the data
	NPV of Opex:		£711		Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		3		It is envisaged that these devices may be deployed in some numbers (although not as widespread as phase imbalance monitoring, for example); hence a slight reduction in cost over time is anticipated
	Life Expectancy of Solution:		20		All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):		£5,711		Calculated from above
	Disuption Factor (1-5):		0		The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):		£0		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):		0		It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:		0		Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):		0%		Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):		0%		Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):		0%		Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:		2012		
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Quality of supply enhancements to existing network architecture			
	Subset:	Waveform monitoring and waveform correction devices			

Smart Enabler

Section	Field	Value
Solution Overview	Representative Solution:	**ENABLER**
	Variant Solution:	Monitoring waveform quality (HV/LV Tx)
	Description:	Device to monitor the waveform at a distribution substation and hence enable LV power quality solutions

Section	Field	EHV	HV	LV	Comments
Headroom Release (%)	Thermal Cable:	%	0%	0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:	%	0%	0%	
	Voltage Head:	%	0%	0%	
	Voltage Leg:	%	0%	0%	
	Power Quality:		0%		
	Fault Level:		0%		

Section	Field	Value	Comments
Cost (£)	Capital:	£10,000	Installation of devices at the substation together with equipment to backhaul the data as necessary
	Operational Expenditure:	£100	Opex associated with relaying the data
	NPV of Opex:	£1,421	Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3	It is envisaged that these devices may be deployed in some numbers (although not as widespread as phase imbalance monitoring, for example); hence a slight reduction in cost over time is anticipated
	Life Expectancy of Solution:	20	All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£11,421	Calculated from above
	Disuption Factor (1-5):	0	The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0	Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0	It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0	Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%	Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%	Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%	Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012	
	Year data (on soln) is available:		
	Source of Data:	Initial estimates	
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER	
	Focus:	Quality of supply enhancements to existing network architecture	
	Subset:	Waveform monitoring and waveform correction devices	

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Monitoring waveform quality (EHV/HV Tx)			
	Description:	Device to monitor the waveform at a primary substation and hence enable LV power quality solutions			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	0%			Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:	0%			
	Voltage Head:	0%			
	Voltage Leg:	0%			
	Power Quality:	0%			
	Fault Level:	0%			
Cost (£)	Capital:	£15,000			Installation of devices at the substation together with equipment to backhaul the data as necessary; not that eqiupment at a primary substation will be of higher specification than that at the distribution substation hence the cost differential
	Operational Expenditure:	£150			Opex associated with relaying the data
	NPV of Opex:	£2,132			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			It is envisaged that these devices may be deployed in some numbers (although not as widespread as phase imbalance monitoring, for example); hence a slight reduction in cost over time is anticipated
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£17,132			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Quality of supply enhancements to existing network architecture			
	Subset:	Waveform monitoring and waveform correction devices			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Weather monitoring			
	Description:	Weather monitoring stations with localised communications for use in RTTR solutions at all voltages			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	0%	0%	0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:	0%	0%	0%	
	Voltage Head:	0%	0%	0%	
	Voltage Leg:	0%	0%	0%	
	Power Quality:	0%	0%	0%	
	Fault Level:	0%	0%	0%	
Cost (£)	Capital:	£5,000			Installation of a weather station and associated local communications to send the data to a processing hub such that decisions regarding the use of RTTR solutions can be taken
	Operational Expenditure:	£50			Opex associated with data transfer
	NPV of Opex:	£711			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			Weather monitoring could well be required in a large number of locations such that the benefits of RTTR at different voltages be relaised; hence the costs are anticipated to reduce slightly over time
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£5,711			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Plant and systems reliability, failure mode detection			
	Subset:	Dynamic ratings for all plant types and multi-element circuits			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Dynamic Network Protection, 11kV			
	Description:	Network protection to support solutions such as temporary meshing			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		0%		Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:		0%		
	Voltage Head:		0%		
	Voltage Leg:		0%		
	Power Quality:		0%		
	Fault Level:		0%		
Cost (£)	Capital:	£7,500			New relays with associated local communications that can respond to varying network configurations (and hence varying currents) will be considerably more expensive than existing 11kV protection
	Operational Expenditure:	£75			There will be some opex associated with ensuring the relays are set appropriately for the varying conditions they will observe over their twenty year life
	NPV of Opex:	£1,066			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			If temporary meshing solutions are adopted, then there could well be widescal roll-out of dynamic HV protection, meaning that costs are likely to reduce over the modelled period
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£8,566			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Quality of supply enhancements to existing network architecture; Security of networks inc physical threats, utilising new network architectures			
	Subset:	Options to deploy adaptive protection and control techniques; Use of meshed rather than radial			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Communications to DSR aggregator			
	Description:	Communications equipment to allow a DNO to interact with an aggregator to call upon certain DSR solutions			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:	£10,000			Settting up the necessary equipment and systems to allow aggregator led DSR to be used will involve communications equipment and commercial arrangements
	Operational Expenditure:	£100			Ongoing opex associated with the communications links and maintaining a contract with the aggregator
	NPV of Opex:	£1,421			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			Initially costs will be fairly high in setting up communciations with aggregators, but as such agreements become more widespread it is envisaged these costs will fall
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£11,421			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	DG connections management of 2 way power flows			
	Subset:	DR services aggregated for LV and HV network management			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	RMUs Fitted with Actuators			
	Description:	11kV RMUs that are equipped with actuators allowing automatic operation in response to network triggers to facilitate Active Network Management solutions			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		0%		Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:		0%		
	Voltage Head:		0%		
	Voltage Leg:		0%		
	Power Quality:		0%		
	Fault Level:		0%		
Cost (£)	Capital:	£15,000			This cost is based on that of an 11kV RMU with an uplift for the additional actuator that would be required to facilitate the remote/automated operation of the device
	Operational Expenditure:	£150			There is some opex associated with maintaining the equipment over its life (particularly if it is called upon to operate many times)
	NPV of Opex:	£2,132			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			Economies of scale are likely for this enabler as DNOs could have standard arranegements with suppliers (built on existing arrangements for RMUs)
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£17,132			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Quality of supply enhancements to existing network architecture			
	Subset:	Intelligent switching			

Smart Enabler

Solution Overview	Representative Solution:	ENABLER			
	Variant Solution:	LV feeder monitoring at distribution substation w/ state estimation			
	Description:	Device to monitor the load and voltage observed for each feeder at a distribution substation, making use of state estimation			
		EHV	HV	LV	Comments
Headroom Release (%)	Thermal Cable:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:	£500			Installation of devices at a distribution substation to record voltage and load on each feeder (in this case making use of state estimation) is anticipated to be £500
	Operational Expenditure:	£5			Small opex associated with any local communications
	NPV of Opex:	£71			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	4			It is likely that LV feeder monitoring will be highly deployed (as large amounts of LCTs will be connected at LV) hence the costs are expected to fall significantly over time
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£571			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	DG connections management of 2 way power flows			
	Subset:	Sensors and state estimation for observability of flows/voltages			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	LV feeder monitoring at distribution substation			
	Description:	Device to monitor the load and voltage observed for each feeder at a distribution substation			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:	£500			Installation of devices at a distribution substation to record voltage and load on each feeder is anticipated to be £500
	Operational Expenditure:	£5			Small opex associated with any local communications
	NPV of Opex:	£71			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	4			It is likely that LV feeder monitoring will be highly deployed (as large amounts of LCTs will be connected at LV) hence the costs are expected to fall significantly over time
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£571			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Quality of supply enhancements to existing network architecture; DG connections, management of 2 way power flows			
	Subset:	Waveform monitoring and waveform correction devices; Intelligent voltage control; Sensors and state estimation for observability of flows/voltages			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	LV Circuit monitoring (along feeder) w/ state estimation			
	Description:	Device to monitor the voltage (and load) along LV circuits, making use of state estimation, to inform solutions such as EAVC by allowing revised set points to be calculated based on observed voltages			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:	£500			Installation of devices along an LV feeder making use of state estimation is anticipated to be in the region of £500
	Operational Expenditure:	£5			Small opex associated with any local communications
	NPV of Opex:	£71			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	4			It is likely that LV feeder monitoring will be highly deployed (as large amounts of LCTs will be connected at LV) hence the costs are expected to fall significantly over time
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£571			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	DG connections, management of 2 way power flows			
	Subset:	Intelligent voltage control; Sensors and state estimation for observability of flows/voltages			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	LV Circuit Monitoring (along feeder)			
	Description:	Device to monitor the voltage (and load) along LV circuits to inform solutions such as EAVC by allowing revised set points to be calculated based on observed voltages			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:	£1,000			Installation of devices along an LV feeder is expected to be higher cost than at the distribution substation as a result of the logistical issues asscoiated with connecting along a feeder
	Operational Expenditure:	£10			Small opex associated with any local communications
	NPV of Opex:	£142			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	4			It is likely that LV feeder monitoring will be highly deployed (as large amounts of LCTs will be connected at LV) hence the costs are expected to fall significantly over time
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£1,142			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Quality of supply enhancements to existing network architecture; DG connections, management of 2 way power flows			
	Subset:	Waveform monitoring and waveform correction devices; Intelligent voltage control; Sensors and state estimation for observability of flows/voltages			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Link boxes fitted with remote control			
	Description:	Devices equipped to link boxes to enable them to be operated remotely to facilitate solutions such as Active Network Management			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:	£5,000			Installing communications and actuators to allow link boxes to be remotely operated is estinmated to be at a cost of £5k
	Operational Expenditure:	£50			There will be some opex associated with maintaining the actuators in the link box, but this is thought to be very low, together with any necessary communications opex
	NPV of Opex:	£711			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			The level of uptake of this enabler is linked to the amount of active network management or meshing that takes place and hence it is expected that there will be a slight reduction in costs over time
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£5,711			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Quality of supply enhancements to existing network architecture			
	Subset:	Intelligent switching			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	HV/LV Tx Monitoring			
	Description:	Device to monitor the load and voltage observed at a distribution transformer to facilitate solutions such as EAVC at various voltage levels			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	0%	0%	0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:	0%	0%	0%	
	Voltage Head:	0%	0%	0%	
	Voltage Leg:	0%	0%	0%	
	Power Quality:	0%	0%	0%	
	Fault Level:	0%	0%	0%	
Cost (£)	Capital:	£1,000			Installation of devices at a distribution substation to record voltage and load at the distribution transformer represents a slightly higher cost than installing on a feedre at the substation as the equipment will need to be of a higher specification
	Operational Expenditure:	£10			Small opex associated with any local communications
	NPV of Opex:	£142			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			The level of monitoring that will be installed at substations is likely to be less than the amount of monitoring equipment installed along feeders, hence the cost is anticipated to reduce by a smaller amount, applied here as cost curve 3
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£1,142			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	DG connections, management of 2 way power flows			
	Subset:	Intelligent voltage control; Sensors and state estimation for observability of flows/voltages			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	HV Circuit Monitoring (along feeder) w/ State Estimation			
	Description:	Device to monitor the voltage (and load) along HV circuits, making use of state estimation, to inform solutions such as EAVC by allowing revised set points to be calculated based on observed voltages			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		0%		Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:		0%		
	Voltage Head:		0%		
	Voltage Leg:		0%		
	Power Quality:		0%		
	Fault Level:		0%		
Cost (£)	Capital:		£2,500		This cost is similar to that of installing monitoring along an HV feeder, but as it makes use of state estimation, some savings are possible, hence the slightly lower cost
	Operational Expenditure:		£25		Small opex associated with any local communications
	NPV of Opex:		£355		Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		3		The level of monitoring that will be installed at HV is likely to be less than the amount of monitoring equipment installed at LV (owing to a smaller number of circuits), hence the cost is anticipated to reduce by a smaller amount, applied here as cost curve 3
	Life Expectancy of Solution:		20		All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):		£2,855		Calculated from above
	Disuption Factor (1-5):		0		The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):		£0		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):		0		It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:		0		Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):		0%		Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):		0%		Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):		0%		Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:		2012		
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	DG connections, management of 2 way power flows			
	Subset:	Intelligent voltage control; Sensors and state estimation for observability of flows/voltages			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	HV Circuit Monitoring (along feeder)			
	Description:	Device to monitor the voltage (and load) along HV circuits to inform solutions such as EAVC by allowing revised set points to be calculated based on observed voltages			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		0%		Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:		0%		
	Voltage Head:		0%		
	Voltage Leg:		0%		
	Power Quality:		0%		
	Fault Level:		0%		
Cost (£)	Capital:		£3,000		Installation of devices along an HV feeder is expected to be higher cost than at the substation as a result of the logistical issues asscoiated with connecting along a feeder. Furthernore, the cost along an HV feeder is significantly higher than along an LV feeder owing to the need for equipment to be higher rated and the more complex logistics in installation
	Operational Expenditure:		£30		Small opex associated with any local communications
	NPV of Opex:		£426		Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		3		The level of monitoring that will be installed at HV is likely to be less than the amount of monitoring equipment installed at LV (owing to a smaller number of circuits), hence the cost is anticipated to reduce by a smaller amount, applied here as cost curve 3
	Life Expectancy of Solution:		20		All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):		£3,426		Calculated from above
	Disuption Factor (1-5):		0		The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):		£0		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):		0		It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:		0		Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):		0%		Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):		0%		Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):		0%		Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:		2012		
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Quality of supply enhancements to existing network architecture; DG connections, management of 2 way power flows			
	Subset:	Waveform monitoring and waveform correction devices; Intelligent voltage control; Sensors and state estimation for observability of flows/voltages			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	EHV Circuit Monitoring			
	Description:	Device to monitor the voltage (and load) along EHV circuits to inform solutions such as EAVC by allowing revised set points to be calculated based on observed voltages			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	0%			Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:	0%			
	Voltage Head:	0%			
	Voltage Leg:	0%			
	Power Quality:	0%			
	Fault Level:	0%			
Cost (£)	Capital:	£5,000			Installation of devices along an EHV feeder is simialr to that along an HV feeder, but at higher owing to the need for equipment to be higher rated and the more complex logistics in installation
	Operational Expenditure:	£50			Small opex associated with any local communications
	NPV of Opex:	£711			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	3			The level of monitoring that will be installed at EHV is likely to be less than the amount of monitoring equipment installed at LV (owing to a smaller number of circuits), hence the cost is anticipated to reduce by a smaller amount, applied here as cost curve 3
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£5,711			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Quality of supply enhancements to existing network architecture; DG connections, management of 2 way power flows			
	Subset:	Waveform monitoring and waveform correction devices; Intelligent voltage control; Sensors and state estimation for observability of flows/voltages			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	DSR - Products to remotely control EV charging			
	Description:	Equipement necessary at the substation and charging point to remotely control EV charging and hence enable management of thermal and voltage issues on the LV network			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:	£1,500			Cost of installing equipment at local distribution substation (including communications equipemt) along with equipment at the consumer end of the feeder to allow the charging point to interface with the smart charging solution
	Operational Expenditure:	£15			There is a small opex cost associated with the communications involved in this arrangement
	NPV of Opex:	£213			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			These solutions are based heavily on communications technology and this is anticipated to remain relatively constant in terms of cost across the modelled period
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£1,713			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	EV charging/discharging (V2G), Network Management, Demand Response and other services			
	Subset:	Open systems with standardised communication protocols and standardised functionality for EVs/charging points; Architecture - distributed processing - street, substation or community level, distributed charging management with aggregated reporting and supervision for reliability			

Smart Enabler

Section	Field	EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	DSR - Products to remotely control loads at consumer premises			
	Description:	Devices to enable the interaction with customer loads such as smart appliances to facilitate DSR solutions			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:			0%	
	Voltage Head:			0%	
	Voltage Leg:			0%	
	Power Quality:			0%	
	Fault Level:			0%	
Cost (£)	Capital:		£500		Cost of installing equipment at local distribution substation (including communications equipment) along with equipment at the consumer end of the feeder to allow the smart appliances, say, to interface with the equipment to enact the DSR solution
	Operational Expenditure:		£5		There is a small opex cost associated with the communications involved in this arrangement
	NPV of Opex:		£71		Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:		2		These solutions are based heavily on communications technology and this is anticipated to remain relatively constant in terms of cost across the modelled period
	Life Expectancy of Solution:		20		All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):		£571		Calculated from above
	Disuption Factor (1-5):		0		The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):		£0		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):		0		It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:		0		Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):		0%		Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):		0%		Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):		0%		Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:		2012		
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	DG connections management of 2 way power flows			
	Subset:	DR services aggregated for LV and HV network management			

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Design tools			
	Description:	New design tools and software with enhanced capabilites; e.g. the inclusion of EES			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	0%	0%	0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:	0%	0%	0%	
	Voltage Head:	0%	0%	0%	
	Voltage Leg:	0%	0%	0%	
	Power Quality:	0%	0%	0%	
	Fault Level:	0%	0%	0%	
Cost (£)	Capital:	£10,000			Cost based on purchasing a licence for industry specific software tools to ensure modelling of new solutions is avaialble
	Operational Expenditure:	£100			Some ongoing support and maintenance costs tht would be charged by the software developer
	NPV of Opex:	£1,421			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			There will not be any economies of scale associated with the purchase of design tools, hence the cost will remain constant
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£11,421			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Security of networks inc physical threats, utilising new network architectures			
	Subset:	Forecasting and modelling tools for DNOs to manage new demands			

Smart Enabler

Solution Overview Representative Solution:	**ENABLER**				
Variant Solution:	Communications to and from devices				
Description:	Communications which support remote devices such as RTTR				
	EHV	**HV**	**LV**	**Comments**	
Headroom Release (%) Thermal Cable:	0%	0%	0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.	
Thermal Transformer:	0%	0%	0%		
Voltage Head:	0%	0%	0%		
Voltage Leg:	0%	0%	0%		
Power Quality:	0%	0%	0%		
Fault Level:	0%	0%	0%		
Cost (£) Capital:	£1,000			There is a need for communications over considerable distances for some solutions, such as RTTR where the circuit being monitored may be a remote overhead line and the central hub determining the rating to be applied could be many miles away	
Operational Expenditure:	£10			There is an opex cost in maintaining the communications links	
NPV of Opex:	£142			Based on 20 years of annual operating expenditure @ 3.5% discount rate	
Cost Curve Type:	3			It is anticipated that these simple communications devices will reduce in cost as they are widely deployed; hence the application of cost curve 3	
Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced	
Merit Order Totex (£):	£1,142			Calculated from above	
Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders	
Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)	
Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed	
Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels	
Other Benefits Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network	
Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network	
Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect	
Year solution becomes available:	2012				
Year data (on soln) is available:					
Source of Data:	Initial estimates				
Smart Solution Relevance (WS3 Ph1) Smart Solution Set:	ENABLER				
Focus:	DG connections management of 2 way power flows				
Subset:	Utilise storage at domestic, substation and community level; DR services aggregated for LV and HV network management				

Smart Enabler

Solution Overview	Representative Solution:	**ENABLER**			
	Variant Solution:	Advanced control systems			
	Description:	System to intelligently control remote equipment and hence facilitate solutions such as Active Network Management			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	0%	0%	0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.
	Thermal Transformer:	0%	0%	0%	
	Voltage Head:	0%	0%	0%	
	Voltage Leg:	0%	0%	0%	
	Power Quality:	0%	0%	0%	
	Fault Level:	0%	0%	0%	
Cost (£)	Capital:	£15,000			Intelligent control systems will need to be implemented to oversee active network management solutions (dynamic reconfiguration, temporary meshing etc) which may involve complex control algorithms, housed in a location some distance from the network in question. A cost of £15k is estimated to set up such a control system with adequate communcations.
	Operational Expenditure:	£150			There are some costs associated with maintaining the control system in the event of network changes and also the communications links
	NPV of Opex:	£2,132			Based on 20 years of annual operating expenditure @ 3.5% discount rate
	Cost Curve Type:	2			Control systems are not expected to reduce in cost over the modelled period
	Life Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will need to be replaced
Merit Order	Totex (£):	£17,132			Calculated from above
	Disuption Factor (1-5):	0			The installation of enablers is a very low disruption activity and does not adversely affect the public or other stakeholders
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	0			It is envisaged that the enablers are fixed once installed
	Cross Network Benefits Factor:	0			Enablers do not directly result in additional benefits to other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Enablers do not affect the fixed losses within the network
	Impact on Variable Losses (%):	0%			Enablers do not affect the variable losses within the network
	Impact on quality of Supply (%):	0%			Enablers facilitate solutions which may improve the quality of supply, but they do not, in themselves, have an effect
	Year solution becomes available:	2012			
	Year data (on soln) is available:				
	Source of Data:	Initial estimates			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	ENABLER			
	Focus:	Quality of supply enhancements to existing network architecture; DG connections management of 2 way power flows			
	Subset:	Intelligent switching; Options to deploy adaptive protection and control techniques; Utilise storage at domestic, substation and community level			

Conventional Variant

Solution Overview	Representative Solution:	**EHV overhead network**			
	Variant Solution:	Major works			
	Description:	This major works at EHV is primarily composed of significant amounts of overhead line construction to create new EHV circuits (because the model does not consider grid transformers directly). This allows for headroom on existing EHV circuits to increase as load is transferred to the new feeders.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	500%			The very extensive EHV reinforcement by way of several new circuits means that the feeders should have their load significantly reduced, shown here as a 500% increase in headroom
	Thermal Transformer:	500%			While the model does not consider grid transformers directly, this is include for completeness to ensure consistency with lower voltages and also ensure that in the event of load increasing to an unmanageable level, this solution will provide a suitable level of headroom release to allow the model to continue to function appropriately without throwing an error
	Voltage Head:	1%			A marginal benefit may be seen for voltage headroom as the load and generation is split across several circuits
	Voltage Leg:	8%			A fairly significant voltage legroom benefit will arise as the load is distributed across numerous circuits. This benefit is not as great as would be observed at lower voltages
	Power Quality:	0%			There will be no effect on power quality
	Fault Level:	-20%			The creation of new circuits and hence addition of multiple infeeds will reduce the source impedance and therefore increase the fault level by a greater degree than that observed for minor works. This has been captured here as a 20% reduction in fault level headroom
Cost (£)	Capital:	£3,000,000			The cost is composed of significant overhead line construction (8km of EHV and 8km of HV) together with appropriate pole mounted switchgear to connect these new assets into the existing infrastructure.
	Operational Expenditure:	£0			It is assumed that no opex costs are associated with the solution
	NPV of Opex:				
	Cost Curve Type:	1			The cost of the solution will increase over time as metal prices increase
	Life Expectancy of Solution:	40			The lifetime of the assets will be a minimum of 40 years and hence the solution will not expire during the modelled period
Merit Order	Totex (£):	£3,000,000			Calculated from above
	Disuption Factor (1-5):	5			There will be very high disruption to the public in construction of 16km of new overhead line at a range of locations across a geographic area.
	Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			This solution cannot realistically be re-used at another location once installed
	Cross Network Benefits Factor:	0			The benefits will be exclusively to the EHV network as the solution is not intended to specifically reduce the loading on associated HV circuits, for example
Other Benefits	Impact on Fixed Losses (%):	0%			Negligible impact on fixed losses
	Impact on Variable Losses (%):	-2%			A slight reduction in variable losses is envisaged as the numerous new assets installed will all be loaded to low levels thereby incurring low losses
	Impact on quality of Supply (%):	40%			There will be a significant improvement in quality of supply as fewer customers will be supplied via one circuit or one transformer, hence fewer CIs will arise as a result of an outage. This improvement has been deemed to be of the order of 40%.
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Section	Field	EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**EHV overhead network**			
	Variant Solution:	Minor works			
	Description:	This solution involves fairly extensive restructuring of the EHV overhead network to spread the load more evenly wihtin a small geographic area via the use of additional circuits			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	100%			The extensive reinforcement of the EHV network means that the existing feeders should have their load halved
	Thermal Transformer:	100%			The model does not specifcially concern itself with grid transformers, but this figure is included for completeness to replicate the additional headroom gain from lower voltage minor works
	Voltage Head:	1%			A marginal benefit may be seen for voltage headroom as the load and generation is split across two circuits
	Voltage Leg:	3%			Some voltage legroom benefit will arise as the load is distributed across two transformers and more circuits
	Power Quality:	0%			There will be no effect on power quality
	Fault Level:	-15%			The addition of new infeeds to the network will reduce the source impedance and hence increase the fault level by a greater degree than merely if the transformer were replaced. This has been captured here as a 15% reduction in fault level headroom
Cost (£)	Capital:	£1,000,000			The cost is composed of fairly extensive overhead works (3km of EHV overhead line and 3km of new HV overhead line) and associated pole mounted plant etc to extend the existing network
	Operational Expenditure:	£0			It is assumed that no opex costs are associated with the solution
	NPV of Opex:				
	Cost Curve Type:	1			The cost of the solution will increase over time as metal prices increase
	Life Expectancy of Solution:	40			The lifetime of the assets will be a minimum of 40 years and hence the solution will not expire during the modelled period
Merit Order	Totex (£):	£1,000,000			Calculated from above
	Disuption Factor (1-5):	5			There will be very high disruption to the public in the construction of 6km of new overhead lines
	Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			This solution cannot realistically be re-used at another location once installed
	Cross Network Benefits Factor:	0			The benefits will be exclusively to the EHV network as it is not envisaged that the application of this solution will reduce the load on feeders or transformers at lower voltages
Other Benefits	Impact on Fixed Losses (%):	0%			Negligible impact on fixed losses
	Impact on Variable Losses (%):	0%			Negligible impact on variable losses as there will be more equipment installed via which losses may arise, but the assets will be loaded to lower levels thereby reducing the level of losses within them
	Impact on quality of Supply (%):	30%			There will be a significant improvement in quality of supply as fewer customers will be supplied via a single circuit, hence fewer CIs will arise as a result of an outage. This improvement has been deemed to be of the order of 30%.
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Solution Overview Representative Solution:	**EHV overhead network**				
Variant Solution:	New Split feeder				
Description:	Install a new EHV feeder from a primary substation, part way along the already split EHV feeder. The new feeder needs to be connected into the existing network such that one third of the total load on the original feeder and the split feeder is now transferred to the new split feeder. A diagram showing this is included in 13.2 of the WS3 Report.				
	EHV	**HV**	**LV**	**Comments**	
Headroom Release (%) Thermal Cable:	80%			By picking up a large amount of load from the already split feeder, the thermal headroom is significantly increased	
Thermal Transformer:	0%			This solution solves a circuit problem but has no effect on the substation load	
Voltage Head:	1%			Marginal benefit through splitting the load (and any generation present) across two feeders	
Voltage Leg:	3%			Potentially there could be some benefit here as the circuit is reduced in length, making voltage drop less of an issue	
Power Quality:	0%			No impact on power quality	
Fault Level:	0%			No impact on fault level	
Cost (£) Capital:	£660,000			Cost based on an assumed average length for EHV overhead circuit; meaning that the solution requires approximately 5km of EHV conductor, a new EHV circuit breaker and some additional work to connect the new circuit into the, already split, existing network	
Operational Expenditure:	£0			No opex costs incurred once the overhead line is installed	
NPV of Opex:					
Cost Curve Type:	1			Increase over time as metal prices increase	
Life Expectancy of Solution:	40			The solution remains valid for the entire modelled period	
Merit Order Totex (£):	£660,000			Calculated from above	
Disuption Factor (1-5):	5			Erecting some 5km of overhead line causes significant disruption to the general public in the area	
Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)	
Flexibility (1-5):	1			No flexibility as the amount of work required to re-use an installed overhead line outweighs any benefits this might realise	
Cross Network Benefits Factor:	0			This solution resolves a problem on a specific EHV feeder, but has no benefit to other voltages as the load experienced there will remain constant	
Other Benefits Impact on Fixed Losses (%):	0%			No impact on fixed losses anticipated	
Impact on Variable Losses (%):	-2%			The load carried by the circuit will reduce, therefore reducing the variable losses (which are proportional to the square of the current)	
Impact on quality of Supply (%):	20%			Having fewer customers connected to one circuit effectively halves the number of CIs that would be incurred in the event of an outage	
Year solution becomes available:	2012				
Year data (on soln) is available:	2012				
Source of Data:	DPCR5 unit costs and discussion with Network Operators				
Smart Solution Relevance (WS3 Ph1) Smart Solution Set:	CONVENTIONAL				
Focus:					
Subset:					

Conventional Variant

Solution Overview Representative Solution:	**EHV overhead network**				
Variant Solution:	Split feeder				
Description:	Install a new EHV overhead feeder out of a BSP to the midpoint of an existing feeder. Break the existing feeder and pick up the 50% of the load from that feeder onto the new feeder.				
	EHV	**HV**	**LV**	**Comments**	
Headroom Release (%) Thermal Cable:	100%			By picking up 50% of the load from the existing feeder, the thermal headroom is doubled	
Thermal Transformer:	0%			This solution solves a circuit problem but has no effect on the substation load	
Voltage Head:	1%			Marginal benefit through splitting the load (and any generation present) across two feeders	
Voltage Leg:	6%			Potentially there could be significant benefit here as the circuit is reduced to 50% of its original length, making voltage drop less of an issue	
Power Quality:	0%			No impact on power quality	
Fault Level:	0%			No impact on fault level	
Cost (£) Capital:	£600,000			Cost based on an assumed average length for EHV overhead circuit; meaning that the solution requires approximately 5km of EHV conductor, a new EHV circuit breaker and some work to connect the new circuit into the existing network	
Operational Expenditure:	£0			No opex costs incurred once the overhead line is installed	
NPV of Opex:					
Cost Curve Type:	1			Increase over time as metal prices increase	
Life Expectancy of Solution:	40			The solution remains valid for the entire modelled period	
Merit Order Totex (£):	£600,000			Calculated from above	
Disuption Factor (1-5):	5			Erecting some 5km of overhead line causes significant disruption to the general public in the area	
Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)	
Flexibility (1-5):	1			No flexibility as the amount of work required to re-use an installed overhead line outweighs any benefits this might realise	
Cross Network Benefits Factor:	0			This solution resolves a problem on a specific EHV feeder, but has no benefit to other voltages as the load experienced there will remain constant	
Other Benefits Impact on Fixed Losses (%):	0%			No impact on fixed losses anticipated	
Impact on Variable Losses (%):	-2%			The load carried by the circuit will reduce, therefore reducing the variable losses (which are proportional to the square of the current)	
Impact on quality of Supply (%):	20%			Having fewer customers connected to one circuit effectively halves the number of CIs that would be incurred in the event of an outage	
Year solution becomes available:	2012				
Year data (on soln) is available:	2012				
Source of Data:	DPCR5 unit costs and discussion with Network Operators				
Smart Solution Relevance (WS3 Ph1) Smart Solution Set:	CONVENTIONAL				
Focus:					
Subset:					

Conventional Variant

Solution Overview	Representative Solution:	**EHV underground network**			
	Variant Solution:	Major works			
	Description:	The major works at EHV is primarily composed of significant amounts of cable laying to create new EHV circuits (because the model does not consider grid transformers directly). This allows for headroom on existing EHV circuits to increase as load is transferred to the new feeders.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	500%			The very extensive EHV reinforcement by way of several new circuits means that the feeders should have their load significantly reduced, shown here as a 500% increase in headroom
	Thermal Transformer:	500%			While the model does not consider grid transformers directly, this is include for completeness to ensure consistency with lower voltages and also ensure that in the event of load increasing to an unmanageable level, this solution will provide a suitable level of headroom release to allow the model to continue to function appropriately without throwing an error
	Voltage Head:	1%			A marginal benefit may be seen for voltage headroom as the load and generation is split across several transformers
	Voltage Leg:	8%			A fairly significant voltage legroom benefit will arise as the load is distributed across numerous circuits. This benefit is not as great as would be observed at lower voltages
	Power Quality:	0%			There will be no effect on power quality
	Fault Level:	-20%			The creation of new circuits and hence addition of multiple infeeds will reduce the source impedance and therefore increase the fault level by a greater degree than that observed for minor works. This has been captured here as a 20% reduction in fault level headroom
Cost (£)	Capital:	£5,000,000			The cost is composed of significant cable laying activity (8km of EHV and 8km of HV) together with appropriate switchgear and cable jointing to connect these new assets into the existing infrastructure.
	Operational Expenditure:	£0			It is assumed that no opex costs are associated with the solution
	NPV of Opex:				
	Cost Curve Type:	1			The cost of the solution will increase over time as metal prices increase
	Life Expectancy of Solution:	40			The lifetime of the assets will be a minimum of 40 years and hence the solution will not expire during the modelled period
Merit Order	Totex (£):	£5,000,000			Calculated from above
	Disuption Factor (1-5):	5			There will be very high disruption to the public in the laying of HV and EHV cable at a range of locations across a geographic area.
	Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			This solution cannot realistically be re-used at another location once installed
	Cross Network Benefits Factor:	0			The benefits will be exclusively to the EHV network as the solution is not intended to specifically reduce the loading on associated HV circuits, for example
Other Benefits	Impact on Fixed Losses (%):	0%			Negligible impact on fixed losses
	Impact on Variable Losses (%):	-2%			A slight reduction in variable losses is envisaged as the numerous new assets installed will all be loaded to low levels thereby incurring low losses
	Impact on quality of Supply (%):	40%			There will be a significant improvement in quality of supply as fewer customers will be supplied via one circuit or one transformer, hence fewer CIs will arise as a result of an outage. This improvement has been deemed to be of the order of 40%.
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Solution Overview	Representative Solution:	**EHV underground network**			
	Variant Solution:	Minor works			
	Description:	This solution involves fairly extensive restructuring of the EHV network to spread the load more evenly wihtin a small geographic area via the use of additional circuits			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	100%			The extensive reinforcement of the EHV network means that the existing feeders should have their load halved
	Thermal Transformer:	100%			The model does not specfcially concern itself with grid transformers, but this figure is included for completeness to replicate the additional headroom gain from lower voltage minor works
	Voltage Head:	1%			A marginal benefit may be seen for voltage headroom as the load and generation is split across two circuits
	Voltage Leg:	3%			Some voltage legroom benefit will arise as the load is distributed across two transformers and more circuits
	Power Quality:	0%			There will be no effect on power quality
	Fault Level:	-15%			The addition of new infeeds to the network will reduce the source impedance and hence increase the fault level by a greater degree than merely if the transformer were replaced. This has been captured here as a 15% reduction in fault level headroom
Cost (£)	Capital:	£1,200,000			The cost is composed of fairly extensive cabling works (3km of EHV cable and 3km of new HV cable) and associated jointing work etc to extend the existing network
	Operational Expenditure:	£0			It is assumed that no opex costs are associated with the solution
	NPV of Opex:				
	Cost Curve Type:	1			The cost of the solution will increase over time as metal prices increase
	Life Expectancy of Solution:	40			The lifetime of the assets will be a minimum of 40 years and hence the solution will not expire during the modelled period
Merit Order	Totex (£):	£1,200,000			Calculated from above
	Disuption Factor (1-5):	5			There will be very high disruption to the public in the extensive laying of EHV and HV cable
	Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			This solution cannot realistically be re-used at another location once installed
	Cross Network Benefits Factor:	0			The benefits will be exclusively to the EHV network as it is not intended that this solution will release headroom on existing HV feeders, for example
Other Benefits	Impact on Fixed Losses (%):	0%			Negligible impact on fixed losses
	Impact on Variable Losses (%):	0%			Negligible impact on variable losses as there will be more equipment installed via which losses may arise, but the assets will be loaded to lower levels thereby reducing the level of losses within them
	Impact on quality of Supply (%):	30%			There will be a significant improvement in quality of supply as fewer customers will be supplied via a single circuit, hence fewer CIs will arise as a result of an outage. This improvement has been deemed to be of the order of 30%.
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Solution Overview	Representative Solution:	**EHV underground network**			
	Variant Solution:	New Split feeder			
	Description:	Lay a new EHV feeder from a primary substation, part way along the already split EHV feeder. Perform some cross jointing such that one third of the total load on the original feeder and the split feeder is now transferred to the new split feeder. A diagram showing this is included in 13.2 of the WS3 Report.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	80%			By picking up 50% of the load from the existing feeder, the thermal headroom is doubled
	Thermal Transformer:	0%			This solution solves a circuit problem but has no effect on the substation load
	Voltage Head:	1%			Marginal benefit through splitting the load (and any generation present) across two feeders
	Voltage Leg:	3%			Potentially there could be reasonable benefit here as the circuit is reduced to 66% of its original length, making voltage drop less of an issue
	Power Quality:	0%			No impact on power quality
	Fault Level:	0%			No impact on fault level
Cost (£)	Capital:	£684,860			Cost based on an assumed average length of 4km for EHV underground circuit; therefore 2km of EHV cable required, together with a new EHV circuit breaker plus some additional cross-jointing to allow for the fact that this is the second splitting of the feeder
	Operational Expenditure:	£0			No opex costs incurred once the cable is installed
	NPV of Opex:				
	Cost Curve Type:	1			Increase over time as metal prices increase
	Life Expectancy of Solution:	40			The solution remains valid for the entire modelled period
Merit Order	Totex (£):	£684,860			Calculated from above
	Disuption Factor (1-5):	5			Excavating and laying 2km of cable causes significant disruption to the general public in the area
	Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			No flexibility as the amount of work required to move an installed cable outweighs any benefits this might realise
	Cross Network Benefits Factor:	0			This solution resolves a problem on a specific EHV feeder, but has no benefit to lower voltages as the load experienced there will remain constant
Other Benefits	Impact on Fixed Losses (%):	0%			No impact on fixed losses anticipated
	Impact on Variable Losses (%):	-2%			The load carried by the cable will reduce, therefore reducing the variable losses (which are proportional to the square of the current)
	Impact on quality of Supply (%):	20%			Having fewer customers connected to one circuit reduces the number of CIs that would be incurred in the event of an outage
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Conventional Variant

Solution Overview	Representative Solution:	**EHV underground network**			
	Variant Solution:	Split feeder			
	Description:	Lay a new EHV underground feeder out of a BSP to the midpoint of an existing feeder. Break the existing feeder and pick up the 50% of the load from that feeder onto the new feeder.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:	100%			By picking up 50% of the load from the existing feeder, the thermal headroom is doubled
	Thermal Transformer:	0%			This solution solves a circuit problem but has no effect on the substation load
	Voltage Head:	1%			Marginal benefit through splitting the load (and any generation present) across two feeders
	Voltage Leg:	6%			Potentially there could be significant benefit here as the circuit is reduced to 50% of its original length, making voltage drop less of an issue
	Power Quality:	0%			No impact on power quality
	Fault Level:	0%			No impact on fault level
Cost (£)	Capital:	£622,600			Cost based on an assumed average length of 4km for EHV underground circuit; therefore 2km of EHV cable required, plus some jointing and a new EHV circuit breaker
	Operational Expenditure:	£0			No opex costs incurred once the cable is installed
	NPV of Opex:				
	Cost Curve Type:	1			Increase over time as metal prices increase
	Life Expectancy of Solution:	40			The solution remains valid for the entire modelled period
Merit Order	Totex (£):	£622,600			Calculated from above
	Disuption Factor (1-5):	5			Excavating and laying 2km of cable causes significant disruption to the general public in the area
	Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			No flexibility as the amount of work requried to move an installed cable outweighs any benefots this might realise
	Cross Network Benefits Factor:	0			This solution resolves a problem on a specific EHV feeder, but has no benefit to lower voltages as the load experienced there will remain constant
Other Benefits	Impact on Fixed Losses (%):	0%			No impact on fixed losses anticipated
	Impact on Variable Losses (%):	-2%			The load carried by the cable will reduce, therefore reducing the variable losses (which are proportional to the square of the current)
	Impact on quality of Supply (%):	20%			Having fewer customers connected to one circuit effectively halves the number of CIs that would be incurred in the event of an outage
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Solution Overview Representative Solution:	**HV overhead network**				
Variant Solution:	Major works				
Description:	The major works option here is composed of the construction of several new substations (with associated new overhead lines) in an area that has seen significant load growth and requires wholesale investment. An example of how this might be represented can be seen in section 13.2 of the WS3 report.				
	EHV	**HV**	**LV**	**Comments**	
Headroom Release (%) Thermal Cable:		500%		The new transformers and associated circuits mean that the feeders should have their load significantly reduced, shown here as a 500% increase in headroom	
Thermal Transformer:		500%		The new transformer means that the existing transformer will have its load significantly reduced, shown here as a 500% increase in headroom	
Voltage Head:		1%		A marginal benefit may be seen for voltage headroom as the load and generation is split across several transformers	
Voltage Leg:		15%		Significant voltage legroom benefit will arise as the load is distributed across numerous transformers and circuits	
Power Quality:		0%		There will be no effect on power quality	
Fault Level:		-20%		The addition of mulitple transformers will reduce the source impedance and hence increase the fault level by a greater degree than that observed for minor works. This has been captured here as a 20% reduction in fault level headroom	
Cost (£) Capital:	£900,000			The cost is composed of two new ground mounted primary transformers, 2km of EHV overhead line to supply the new transformers and associated jointing to connect these to the network; 4km of new HV overhead line to supply multiple circuits that will connect to the existing HV infrastructure.	
Operational Expenditure:	£0			It is assumed that no opex costs are associated with the solution	
NPV of Opex:					
Cost Curve Type:	1			The cost of the solution will increase over time as metal prices increase	
Life Expectancy of Solution:	40			The lifetime of the assets will be a minimum of 40 years and hence the solution will not expire during the modelled period	
Merit Order Totex (£):	£900,000			Calculated from above	
Disuption Factor (1-5):	5			There will be high disruption to the public in the construction of HV and EHV overhead lines and the installation of new primary transformers at new substation sites.	
Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)	
Flexibility (1-5):	1			This solution cannot realistically be re-used at another location once installed	
Cross Network Benefits Factor:	0			The benefits will be exclusively to the LV network as it is envisaged that the new transformers will be connected to the same HV circuit as the existing transformer	
Other Benefits Impact on Fixed Losses (%):	0%			Negligible impact on fixed losses	
Impact on Variable Losses (%):	-2%			A slight reduction in variable losses is envisaged as the numerous new assets installed will all be loaded to low levels thereby incurring low losses	
Impact on quality of Supply (%):	40%			There will be a significant improvement in quality of supply as fewer customers will be supplied via one circuit or one transformer, hence fewer CIs will arise as a result of an outage. This improvement has been deemed to be of the order of 40%.	
Year solution becomes available:	2012				
Year data (on soln) is available:	2012				
Source of Data:	DPCR5 unit costs and discussion with Network Operators				
Smart Solution Relevance (WS3 Ph1) Smart Solution Set:	CONVENTIONAL				
Focus:					
Subset:					

Conventional Variant

Solution Overview	Representative Solution:	**HV overhead network**			
	Variant Solution:	Minor works			
	Description:	This solution takes the form of an additional primary transformer at, or near to, the location of the original transformer. A small amount of EHV overhead line is allowed for, while the solution also incorporates the construction of several HV overhead circuits to connect to the existing HV infrastructure. A diagram showing the solution can be found in section 13.2 of the WS3 report.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		100%		The new transformer and associated circuits mean that the feeders should have their load halved
	Thermal Transformer:		100%		The new transformer means that the existing transformer will have its load halved (i.e. its headroom doubled)
	Voltage Head:		1%		A marginal benefit may be seen for voltage headroom as the load and generation is aplit across two transformers
	Voltage Leg:		6%		Some voltage legroom benefit will arise as the load is distributed across two transformers and more circuits
	Power Quality:		0%		There will be no effect on power quality
	Fault Level:		-15%		The addition of a second transformer will reduce the source impedance and hence increase the fault level by a greater degree than merely if the transformer were replaced. This has been captured here as a 15% reduction in fault level headroom
Cost (£)	Capital:	£500,000			The cost is composed of a new primary transformer, 500m of EHV conductor to supply the new transformer and associated jointing to connect this to the network; 1km of new HV overhead line to stitch the new transformer into the existing HV infrastrructure.
	Operational Expenditure:	£0			It is assumed that no opex costs are associated with the solution
	NPV of Opex:				
	Cost Curve Type:	1			The cost of the solution will increase over time as metal prices increase
	Life Expectancy of Solution:	40			The lifetime of the assets will be a minimum of 40 years and hence the solution will not expire during the modelled period
Merit Order	Totex (£):	£500,000			Calculated from above
	Disuption Factor (1-5):	5			There will be very high disruption to the public in the construction of new EHV and HV overhead lines and the installation of a new primary transformer either at a new substation site, or adjacent to an existing transformer
	Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			This solution cannot relaistically be re-used at another location once installed
	Cross Network Benefits Factor:	0			The benefits will be exclusively to the HV network as it is envisaged that the new transformer will be connected to the same EHV circuit as the existing transformer
Other Benefits	Impact on Fixed Losses (%):	0%			Negligible impact on fixed losses
	Impact on Variable Losses (%):	0%			Negligible impact on variable losses as there will be more equipment installed via which losses may arise, but the assets will be loaded to lower levels thereby reducing the level of losses within them
	Impact on quality of Supply (%):	30%			There will be a significant improvement in quality of supply as fewer customers will be supplied via one circuit or one transformer, hence fewer CIs will arise as a result of an outage. This improvement has been deemed to be of the order of 30%.
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Solution Overview	Representative Solution:	**HV overhead network**			
	Variant Solution:	Small 33/11 Tx			
	Description:	Replacement of a small primary transformer (such as a 10/14MVA Tx) with a larger primary transformer (such as a 12/24MVA Tx). Note that this replacement results in a smaller Tx than that for a comparable underground network.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		0%		This solution resolves an issue regarding the transformer (substation) load and has no effect on individual HV feeders
	Thermal Transformer:		80%		Replacing the transformer with a larger unit will release significant headroom for the substation in question
	Voltage Head:		1%		A marginal benefit may be observed in terms of voltage headroom
	Voltage Leg:		6%		Some benefit for voltage legroom will arise
	Power Quality:		0%		No impact on power quality
	Fault Level:		-10%		The larger Tx will have a lower impedance and will result in an increase in fault level, captured here as a 10% reduction in headroom
Cost (£)	Capital:	£97,500			This cost is based on the cost of a new primary transformer, split across the average number of HV feeders supplied by that transformer
	Operational Expenditure:	£0			It is assumed that there is no opex associated with the new transformer
	NPV of Opex:				
	Cost Curve Type:	1			Costs are assumed to increase with metal prices
	Life Expectancy of Solution:	40			The transformer has a life of 40 years, meaning it will not require replacement during the modelled period
Merit Order	Totex (£):	£97,500			Calculated from above
	Disuption Factor (1-5):	4			The disruption is fairly high, owing to the potential civil works involved etc, but it is likely that the new transformer will fit in the same location as the old transformer
	Disruption Cost (£):	£30,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			There is a limited amount of flexibility with this solution in that the transformer could be re-used in another location if necessary; however there are some costs associated with removal and transportation of the transformer hence the low factor
	Cross Network Benefits Factor:	0			This provides a solution to a specific problem and does not directly alleviate load on other circuits or at other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Negligible impact on fixed losses
	Impact on Variable Losses (%):	1%			A slight increase may be seen in variable losses through the larger transformer
	Impact on quality of Supply (%):	0%			There will be no impact on quality of supply measures
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Solution Overview Representative Solution:	**HV overhead network**				
Variant Solution:	New Split feeder				
Description:	Install a new HV feeder from a primary substation, part way along the already split HV feeder. The new feeder needs to be connected into the existing network such that one third of the total load on the original feeder and the split feeder is now transferred to the new split feeder. A diagram showing this is included in 13.2 of the WS3 Report.				
	EHV	**HV**	**LV**	**Comments**	
Headroom Release (%) Thermal Cable:		80%		By picking up a large amount of load from the already split feeder, the thermal headroom is significantly increased	
Thermal Transformer:		0%		This solution solves a circuit problem but has no effect on the substation load	
Voltage Head:		1%		Marginal benefit through splitting the load (and any generation present) across two feeders	
Voltage Leg:		6%		Potentially there could be significant benefit here as the circuit length is reduced, making voltage drop less of an issue	
Power Quality:		0%		No impact on power quality	
Fault Level:		0%		No impact on fault level	
Cost (£) Capital:	£346,500			Cost based on an assumed average length for HV overhead circuit; meaning that the solution requires approximately 7km of HV conductor, a new HV circuit breaker and some additional work to connect the new circuit into the, already split, existing network	
Operational Expenditure:	£0			No opex costs incurred once the overhead line is installed	
NPV of Opex:					
Cost Curve Type:	1			Increase over time as metal prices increase	
Life Expectancy of Solution:	40			The solution remains valid for the entire modelled period	
Merit Order Totex (£):	£346,500			Calculated from above	
Disuption Factor (1-5):	4			Erecting some 7km of overhead line causes significant disruption to the general public in the area	
Disruption Cost (£):	£30,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)	
Flexibility (1-5):	1			No flexibility as the amount of work requried to move an installed cable outweighs any benefots this might realise	
Cross Network Benefits Factor:	0			This solution resolves a problem on a specific HV feeder, but has no benefit to other voltages as the load experienced there will remain constant	
Other Benefits Impact on Fixed Losses (%):	0%			No impact on fixed losses anticipated	
Impact on Variable Losses (%):	-2%			The load carried by the circuit will reduce, therefore reducing the variable losses (which are proportional to the square of the current)	
Impact on quality of Supply (%):	20%			Having fewer customers connected to one circuit effectively halves the number of CIs that would be incurred in the event of an outage	
Year solution becomes available:	2012				
Year data (on soln) is available:	2012				
Source of Data:	DPCR5 unit costs and discussion with Network Operators				
Smart Solution Relevance (WS3 Ph1) Smart Solution Set:	CONVENTIONAL				
Focus:					
Subset:					

Solution Overview	Representative Solution:	**HV overhead network**			
	Variant Solution:	Split feeder			
	Description:	Install a new HV overhead feeder out of a primary substation to the midpoint of an existing feeder. Break the existing feeder and pick up the 50% of the load from that feeder onto the new feeder.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		100%		By picking up 50% of the load from the existing feeder, the thermal headroom is doubled
	Thermal Transformer:		0%		This solution solves a circuit problem but has no effect on the substation load
	Voltage Head:		1%		Marginal benefit through splitting the load (and any generation present) across two feeders
	Voltage Leg:		12%		Potentially there could be significant benefit here as the circuit is reduced to 50% of its original length, making voltage drop less of an issue
	Power Quality:		0%		No impact on power quality
	Fault Level:		0%		No impact on fault level
Cost (£)	Capital:	£315,000			Cost based on an assumed average length for HV overhead circuit; meaning that the solution requires approximately 7km of HV conductor, a new HV circuit breaker and some work to connect the new circuit into the existing network
	Operational Expenditure:	£0			No opex costs incurred once the overhead line is installed
	NPV of Opex:				
	Cost Curve Type:	1			Increase over time as metal prices increase
	Life Expectancy of Solution:	40			The solution remains valid for the entire modelled period
Merit Order	Totex (£):	£315,000			Calculated from above
	Disuption Factor (1-5):	4			Erecting some 7km of overhead line causes significant disruption to the general public in the area
	Disruption Cost (£):	£30,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			No flexibility as the amount of work requried to move an installed cable outweighs any benefots this might realise
	Cross Network Benefits Factor:	0			This solution resolves a problem on a specific HV feeder, but has no benefit to other voltages as the load experienced there will remain constant
Other Benefits	Impact on Fixed Losses (%):	0%			No impact on fixed losses anticipated
	Impact on Variable Losses (%):	-2%			The load carried by the circuit will reduce, therefore reducing the variable losses (which are proportional to the square of the current)
	Impact on quality of Supply (%):	20%			Having fewer customers connected to one circuit effectively halves the number of CIs that would be incurred in the event of an outage
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Conventional Variant

Solution Overview Representative Solution:	**HV underground network**				
Variant Solution:	Major works				
Description:	The major works option here is composed of the construction of several new substations (with associated cabling) in an area that has seen significant load growth and requires wholesale investment. An example of how this might be represented can be seen in section 13.2 of the WS3 report.				
	EHV	**HV**	**LV**	**Comments**	
Headroom Release (%) Thermal Cable:		500%		The new transformers and associated circuits mean that the feeders should have their load significantly reduced, shown here as a 500% increase in headroom	
Thermal Transformer:		500%		The new transformer means that the existing transformer will have its load significantly reduced, shown here as a 500% increase in headroom	
Voltage Head:		1%		A marginal benefit may be seen for voltage headroom as the load and generation is split across several transformers	
Voltage Leg:		15%		Significant voltage legroom benefit will arise as the load is distributed across numerous transformers and circuits	
Power Quality:		0%		There will be no effect on power quality	
Fault Level:		-20%		The addition of mulitple transformers will reduce the source impedance and hence increase the fault level by a greater degree than that observed for minor works. This has been captured here as a 20% reduction in fault level headroom	
Cost (£) Capital:	£1,500,000			The cost is composed of two new ground mounted primary transformers, 2km of EHV cable to supply the new transformers and associated jointing to connect these to the network; 4km of new HV cable to supply multiple circuits that will connect to the existing HV infrastructure.	
Operational Expenditure:	£0			It is assumed that no opex costs are associated with the solution	
NPV of Opex:					
Cost Curve Type:	1			The cost of the solution will increase over time as metal prices increase	
Life Expectancy of Solution:	40			The lifetime of the assets will be a minimum of 40 years and hence the solution will not expire during the modelled period	
Merit Order Totex (£):	£1,500,000			Calculated from above	
Disuption Factor (1-5):	5			There will be high disruption to the public in the laying of HV and EHV cable and the installation of new primary transformers at new substation sites.	
Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)	
Flexibility (1-5):	1			This solution cannot realistically be re-used at another location once installed	
Cross Network Benefits Factor:	0			The benefits will be exclusively to the HV network as it is envisaged that the new transformers will be connected to the same EHV circuit as the existing transformer	
Other Benefits Impact on Fixed Losses (%):	0%			Negligible impact on fixed losses	
Impact on Variable Losses (%):	-2%			A slight reduction in variable losses is envisaged as the numerous new assets installed will all be loaded to low levels thereby incurring low losses	
Impact on quality of Supply (%):	40%			There will be a significant improvement in quality of supply as fewer customers will be supplied via one circuit or one transformer, hence fewer CIs will arise as a result of an outage. This improvement has been deemed to be of the order of 40%.	
Year solution becomes available:	2012				
Year data (on soln) is available:	2012				
Source of Data:	DPCR5 unit costs and discussion with Network Operators				
Smart Solution Relevance (WS3 Ph1) Smart Solution Set:	CONVENTIONAL				
Focus:					
Subset:					

Conventional Variant

Solution Overview	Representative Solution:	**HV underground network**			
	Variant Solution:	Minor works			
	Description:	This solution takes the form of an additional primary transformer at, or near to, the location of the original transformer. A small amount of EHV cabling is allowed for, while the solution also incorporates the construction of several HV circuits to connect to the existing HV infrastructure. A diagram showing the solution can be found in section 13.2 of the WS3 report.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		100%		The new transformer and associated circuits mean that the feeders should have their load halved
	Thermal Transformer:		100%		The new transformer means that the existing transformer will have its load halved (i.e. its headroom doubled)
	Voltage Head:		1%		A marginal benefit may be seen for voltage headroom as the load and generation is aplit across two transformers
	Voltage Leg:		6%		Some voltage legroom benefit will arise as the load is distributed across two transformers and more circuits
	Power Quality:		0%		There will be no effect on power quality
	Fault Level:		-15%		The addition of a second transformer will reduce the source impedance and hence increase the fault level by a greater degree than merely if the transformer were replaced. This has been captured here as a 15% reduction in fault level headroom
Cost (£)	Capital:	£450,000			The cost is composed of a new primary transformer, 500m of EHV cable to supply the new transformer and associated jointing to connect this to the network; 1km of new HV cable to stitch the new transformer into the existing HV infrastrructure.
	Operational Expenditure:	£0			It is assumed that no opex costs are associated with the solution
	NPV of Opex:				
	Cost Curve Type:	1			The cost of the solution will increase over time as metal prices increase
	Life Expectancy of Solution:	40			The lifetime of the assets will be a minimum of 40 years and hence the solution will not expire during the modelled period
Merit Order	Totex (£):	£450,000			Calculated from above
	Disuption Factor (1-5):	5			There will be very high disruption to the public in the laying of EHV and HV cable and the installation of a new ground mounted transformer either at a new substation site, or adjacent to an existing transformer
	Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			This solution cannot relaistically be re-used at another location once installed
	Cross Network Benefits Factor:	0			The benefits will be exclusively to the HV network as it is envisaged that the new transformer will be connected to the same EHV circuit as the existing transformer
Other Benefits	Impact on Fixed Losses (%):	0%			Negligible impact on fixed losses
	Impact on Variable Losses (%):	0%			Negligible impact on variable losses as there will be more equipment installed via which losses may arise, but the assets will be loaded to lower levels thereby reducing the level of losses within them
	Impact on quality of Supply (%):	30%			There will be a significant improvement in quality of supply as fewer customers will be supplied via one circuit or one transformer, hence fewer CIs will arise as a result of an outage. This improvement has been deemed to be of the order of 30%.
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Solution Overview Representative Solution:	**HV underground network**				
Variant Solution:	Large 33/11 Tx				
Description:	Replacement of a ground mounted primary transformer (such as a 12/24MVA Tx) with a higher rated transformer in the same location (such as a 19/38MVA Tx). Note that these transformers are larger than those observed for a comparable overead network.				
	EHV	**HV**	**LV**	**Comments**	
Headroom Release (%) Thermal Cable:		0%		This solution resolves an issue regarding the transformer (substation) load and has no effect on individual HV feeders	
Thermal Transformer:		80%		Replacing the transformer with a larger unit will release significant headroom for the substation in question	
Voltage Head:		1%		A marginal benefit may be observed in terms of voltage headroom	
Voltage Leg:		6%		Some benefit for voltage legroom will arise	
Power Quality:		0%		No impact on power quality	
Fault Level:		-10%		The larger Tx will have a lower impedance and will result in an increase in fault level, captured here as a 10% reduction in headroom	
Cost (£) Capital:	£86,667			This cost is based on the cost of a new primary transformer, split across the average number of HV feeders supplied by that transformer	
Operational Expenditure:	£0			It is assumed that there is no opex associated with the new transformer	
NPV of Opex:					
Cost Curve Type:	1			Costs are assumed to increase with metal prices	
Life Expectancy of Solution:	40			The transformer has a life of 40 years, meaning it will not require replacement during the modelled period	
Merit Order Totex (£):	£86,667			Calculated from above	
Disuption Factor (1-5):	5			The disruption is high, owing to the potential civil works involved etc as the new, larger transformer may require additional space to be accommodated	
Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)	
Flexibility (1-5):	2			There is a limited amount of flexibility with this solution in that the transformer could be re-used in another location if necessary; however there are some costs associated with removal and transportation of the transformer hence the low factor	
Cross Network Benefits Factor:	0			This provides a solution to a specific problem and does not directly alleviate load on other circuits or at other voltage levels	
Other Benefits Impact on Fixed Losses (%):	0%			Negligible impact on fixed losses	
Impact on Variable Losses (%):	1%			A slight increase may be seen in variable losses through the larger transformer	
Impact on quality of Supply (%):	0%			There will be no impact on quality of supply measures	
Year solution becomes available:	2012				
Year data (on soln) is available:	2012				
Source of Data:	DPCR5 unit costs and discussion with Network Operators				
Smart Solution Relevance (WS3 Ph1) Smart Solution Set:	CONVENTIONAL				
Focus:					
Subset:					

Solution Overview	Representative Solution:	**HV underground network**			
	Variant Solution:	New Split feeder			
	Description:	Lay a new HV feeder from a primary substation, part way along the already split HV feeder. Perform some cross jointing such that one third of the total load on the original feeder and the split feeder is now transferred to the new split feeder. A diagram showing this is included in 13.2 of the WS3 Report.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:		80%		By picking up 50% of the load from the existing feeder, the thermal headroom is doubled
	Thermal Transformer:		0%		This solution solves a circuit problem but has no effect on the substation load
	Voltage Head:		1%		Marginal benefit through splitting the load (and any generation present) across two feeders
	Voltage Leg:		6%		Potentially there could be reasonable benefit here as the circuit is reduced to 66% of its original length, making voltage drop less of an issue
	Power Quality:		0%		No impact on power quality
	Fault Level:		0%		No impact on fault level
Cost (£)	Capital:	£239,360			Cost based on an assumed average length of 4km for HV underground circuit; therefore 2km of HV cable required, together with a new HV circuit breaker plus some additional cross-jointing to allow for the fact that this is the second splitting of the feeder
	Operational Expenditure:	£0			No opex costs incurred once the cable is installed
	NPV of Opex:				
	Cost Curve Type:	1			Increase over time as metal prices increase
	Life Expectancy of Solution:	40			The solution remains valid for the entire modelled period
Merit Order	Totex (£):	£239,360			Calculated from above
	Disuption Factor (1-5):	5			Excavating and laying 2km of cable causes fairly significant disruption to the general public in the area
	Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			No flexibility as the amount of work required to move an installed cable outweighs any benefits this might realise
	Cross Network Benefits Factor:	0			This solution resolves a problem on a specific HV feeder, but has no benefit to other voltages as the load experienced there will remain constant
Other Benefits	Impact on Fixed Losses (%):	0%			No impact on fixed losses anticipated
	Impact on Variable Losses (%):	-2%			The load carried by the cable will reduce, therefore reducing the variable losses (which are proportional to the square of the current)
	Impact on quality of Supply (%):	20%			Having fewer customers connected to one circuit reduces the number of CIs that would be incurred in the event of an outage
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Conventional Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**HV underground network**			
	Variant Solution:	Split feeder			
	Description:	Lay a new HV underground feeder out of a primary substation to the midpoint of an existing feeder. Break the existing feeder and pick up the 50% of the load from that feeder onto the new feeder.			
Headroom Release (%)	Thermal Cable:		100%		By picking up 50% of the load from the existing feeder, the thermal headroom is doubled
	Thermal Transformer:		0%		This solution solves a circuit problem but has no effect on the substation load
	Voltage Head:		1%		Marginal benefit through splitting the load (and any generation present) across two feeders
	Voltage Leg:		12%		Potentially there could be significant benefit here as the circuit is reduced to 50% of its original length, making voltage drop less of an issue
	Power Quality:		0%		No impact on power quality
	Fault Level:		0%		No impact on fault level
Cost (£)	Capital:	£217,600			Cost based on an assumed average length of 4km for HV underground circuit; therefore 2km of HV cable required, plus some jointing and a new HV circuit breaker
	Operational Expenditure:	£0			No opex costs incurred once the cable is installed
	NPV of Opex:				
	Cost Curve Type:	1			Increase over time as metal prices increase
	Life Expectancy of Solution:	40			The solution remains valid for the entire modelled period
Merit Order	Totex (£):	£217,600			Calculated from above
	Disuption Factor (1-5):	5			Excavating and laying 2km of cable causes significant disruption to the general public in the area
	Disruption Cost (£):	£100,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			No flexibility as the amount of work requried to move an installed cable outweighs any benefots this might realise
	Cross Network Benefits Factor:	0			This solution resolves a problem on a specific HV feeder, but has no benefit to other voltages as the load experienced there will remain constant
Other Benefits	Impact on Fixed Losses (%):	0%			No impact on fixed losses anticipated
	Impact on Variable Losses (%):	-2%			The load carried by the cable will reduce, therefore reducing the variable losses (which are proportional to the square of the current)
	Impact on quality of Supply (%):	20%			Having fewer customers connected to one circuit effectively halves the number of CIs that would be incurred in the event of an outage
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Solution Overview	Representative Solution:	**LV overhead network**			
	Variant Solution:	Major works			
	Description:	The major works option here is composed of the construction of several new pole mounted substations (with associated conductoring) in an area that has seen significant load growth and requires wholesale investment. An example of how this might be represented can be seen in section 13.2 of the WS3 report.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			500%	The new transformers and associated circuits mean that the feeders should have their load significantly reduced, shown here as a 500% increase in headroom
	Thermal Transformer:			500%	The new transformer means that the existing transformer will have its load significantly reduced, shown here as a 500% increase in headroom
	Voltage Head:			1%	A marginal benefit may be seen for voltage headroom as the load and generation is split across several transformers
	Voltage Leg:			15%	Significant voltage legroom benefit will arise as the load is distributed across numerous transformers and circuits
	Power Quality:			0%	There will be no effect on power quality
	Fault Level:			-20%	The addition of mulitple transformers will reduce the source impedance and hence increase the fault level by a greater degree than that observed for minor works. This has been captured here as a 20% reduction in fault level headroom
Cost (£)	Capital:	£125,000			The cost is composed of two new pole mounted distribution transformers, 1km of HV cable to supply the new transformers and associated jointing to connect these to the network; 1.8km of new LV conductor to supply six new circuits at an average length of 300m each.
	Operational Expenditure:	£0			It is assumed that no opex costs are associated with the solution
	NPV of Opex:				
	Cost Curve Type:	1			The cost of the solution will increase over time as metal prices increase
	Life Expectancy of Solution:	40			The lifetime of the assets will be a minimum of 40 years and hence the solution will not expire during the modelled period
Merit Order	Totex (£):	£125,000			Calculated from above
	Disuption Factor (1-5):	4			There will be high disruption to the public in the laying of HV and LV cable and the installation of new ground mounted transformers at new substation sites.
	Disruption Cost (£):	£30,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			This solution cannot realistically be re-used at another location once installed
	Cross Network Benefits Factor:	0			The benefits will be exclusively to the LV network as it is envisaged that the new transformers will be connected to the same HV circuit as the existing transformer
Other Benefits	Impact on Fixed Losses (%):	0%			Negligible impact on fixed losses
	Impact on Variable Losses (%):	-2%			A slight reduction in variable losses is envisaged as the numerous new assets installed will all be loaded to low levels thereby incurring low losses
	Impact on quality of Supply (%):	40%			There will be a significant improvement in quality of supply as fewer customers will be supplied via one circuit or one transformer, hence fewer CIs will arise as a result of an outage. This improvement has been deemed to be of the order of 40%.
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Solution Overview	Representative Solution:	**LV overhead network**			
	Variant Solution:	Minor works			
	Description:	This solution incorportaes the installation of a new pole mounted transformer, close to an exiting HV line and heavily loaded pole mounted transformer. The solution involves HV and LV lines as well as the new transformer. A representative diagram can be found in section 13.2 of the WS3 report.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			100%	The new transformer and associated circuits mean that the feeders should have their load halved
	Thermal Transformer:			100%	The new transformer means that the existing transformer will have its load halved (i.e. its headroom doubled)
	Voltage Head:			1%	A marginal benefit may be seen for voltage headroom as the load and generation is aplit across two transformers
	Voltage Leg:			6%	Some voltage legroom benefit will arise as the load is distributed across two transformers and more circuits
	Power Quality:			0%	There will be no effect on power quality
	Fault Level:			-15%	The addition of a second transformer will reduce the source impedance and hence increase the fault level by a greater degree than merely if the transformer were replaced. This has been captured here as a 15% reduction in fault level headroom
Cost (£)	Capital:	£20,000			The cost is compoased of a new pole mounted distribution transformer, 100m of HV conductor to supply the new transformer and associated jointing to connect this to the network; 800m of new LV conductor to supply two new circuits at an average length of 400m each.
	Operational Expenditure:	£0			It is assumed that no opex costs are associated with the solution
	NPV of Opex:				
	Cost Curve Type:	1			The cost of the solution will increase over time as metal prices increase
	Life Expectancy of Solution:	40			The lifetime of the assets will be a minimum of 40 years and hence the solution will not expire during the modelled period
Merit Order	Totex (£):	£20,000			Calculated from above
	Disuption Factor (1-5):	4			There will be high disruption to the public in the erection of new poles and the construction of new HV and LV circuits together with the installation of a new pole mounted transformer
	Disruption Cost (£):	£30,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			This solution cannot relaistically be re-used at another location once installed
	Cross Network Benefits Factor:	0			The benefits will be exclusively to the LV network as it is envisaged that the new transformer will be connected to the same HV circuit as the existing transformer
Other Benefits	Impact on Fixed Losses (%):	0%			Negligible impact on fixed losses
	Impact on Variable Losses (%):	0%			Negligible impact on variable losses as there will be more equipment installed via which losses may arise, but the assets will be loaded to lower levels thereby reducing the level of losses within them
	Impact on quality of Supply (%):	30%			There will be a significant improvement in quality of supply as fewer customers will be supplied via one circuit or one transformer, hence fewer CIs will arise as a result of an outage. This improvement has been deemed to be of the order of 30%.
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Solution Overview Representative Solution:	**LV overhead network**				
Variant Solution:	Pole mounted 11/LV Tx				
Description:	Replacement of a pole mounted distribution transformer with a larger pole mounted transformer				
	EHV	**HV**	**LV**	**Comments**	
Headroom Release (%) Thermal Cable:			0%	This solution resolves an issue regarding the transformer (substation) load and has no effect on individual LV feeders	
Thermal Transformer:			80%	Replacing the transformer with a larger unit will release significant headroom for the substation in question	
Voltage Head:			1%	A marginal benefit may be observed in terms of voltage headroom	
Voltage Leg:			6%	Some benefit for voltage legroom will arise	
Power Quality:			0%	No impact on power quality	
Fault Level:			-10%	The larger Tx will have a lower impedance and will result in an increase in fault level, captured here as a 10% reduction in headroom	
Cost (£) Capital:	£1,450			This cost is based on the cost of a new distribution transformer, split across the average number of LV feeders supplied by that transformer (2)	
Operational Expenditure:	£0			It is assumed that there is no opex associated with the new transformer	
NPV of Opex:					
Cost Curve Type:	1			Costs are assumed to increase with metal prices	
Life Expectancy of Solution:	40			The transformer has a life of 40 years, meaning it will not require replacement during the modelled period	
Merit Order Totex (£):	£1,450			Calculated from above	
Disuption Factor (1-5):	4			The disruption is fairly high, owing to the potential civil works involved In erecting a suitable pole etc	
Disruption Cost (£):	£30,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)	
Flexibility (1-5):	2			There is a limited amount of flexibility with this solution in that the transformer could be re-used in another location if necessary; however there are some costs associated with removal and transportation of the transformer hence the low factor	
Cross Network Benefits Factor:	0			This provides a solution to a specific problem and does not directly alleviate load on other circuits or at other voltage levels	
Other Benefits Impact on Fixed Losses (%):	0%			Negligible impact on fixed losses	
Impact on Variable Losses (%):	1%			A slight increase may be seen in variable losses through the larger transformer	
Impact on quality of Supply (%):	0%			There will be no impact on quality of supply measures	
Year solution becomes available:	2012				
Year data (on soln) is available:	2012				
Source of Data:	DPCR5 unit costs and discussion with Network Operators				
Smart Solution Relevance (WS3 Ph1) Smart Solution Set:	CONVENTIONAL				
Focus:					
Subset:					

Conventional Variant

Solution Overview	Representative Solution:	**LV overhead network**			
	Variant Solution:	New Split feeder			
	Description:	Install a new LV feeder from a distribution substation, part way along the already split LV feeder. The new feeder needs to be connected into the existing network such that one third of the total load on the original feeder and the split feeder is now transferred to the new split feeder. A diagram showing this is included in 13.2 of the WS3 Report.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			80%	By picking up a large amount of load from the already split feeder, the thermal headroom is significantly increased
	Thermal Transformer:			0%	This solution solves a circuit problem but has no effect on the substation load
	Voltage Head:			1%	Marginal benefit through splitting the load (and any generation present) across two feeders
	Voltage Leg:			6%	Potentially there could be significant benefit here as the circuit length is reduced, making voltage drop less of an issue
	Power Quality:			0%	No impact on power quality
	Fault Level:			0%	No impact on fault level
Cost (£)	Capital:	£11,000			Cost based on an assumed average length of 500m for LV overhead circuit; therefore 250m of LV conductor required plus some additional cost for connecting the new split feeder into the existing network
	Operational Expenditure:	£0			No opex costs incurred once the conductor is installed
	NPV of Opex:				
	Cost Curve Type:	1			Increase over time as metal prices increase
	Life Expectancy of Solution:	40			The solution remains valid for the entire modelled period
Merit Order	Totex (£):	£11,000			Calculated from above
	Disuption Factor (1-5):	4			Erecting 250m of new overhead circuit causes fairly high disruption to the general public in the area
	Disruption Cost (£):	£30,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			No flexibility as, once installed, the circuti would not be re-used elsewhere
	Cross Network Benefits Factor:	0			This solution resolves a problem on a specific LV feeder, but has no benefit to higher voltages as the load experienced there will remain constant
Other Benefits	Impact on Fixed Losses (%):	0%			No impact on fixed losses anticipated
	Impact on Variable Losses (%):	-2%			The load carried by the circuit will reduce, therefore reducing the variable losses (which are proportional to the square of the current)
	Impact on quality of Supply (%):	20%			Having fewer customers connected to one circuit effectively halves the number of CIs that would be incurred in the event of an outage
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Solution Overview Representative Solution:	**LV overhead network**				
Variant Solution:	Split feeder				
Description:	Install a new LV overhead feeder out of a distribution substation to the midpoint of an existing feeder. Break the existing feeder and pick up the 50% of the load from that feeder onto the new feeder.				
	EHV	**HV**	**LV**	**Comments**	
Headroom Release (%) Thermal Cable:			100%	By picking up 50% of the load from the existing feeder, the thermal headroom is doubled	
Thermal Transformer:			0%	This solution solves a circuit problem but has no effect on the substation load	
Voltage Head:			1%	Marginal benefit through splitting the load (and any generation present) across two feeders	
Voltage Leg:			12%	Potentially there could be significant benefit here as the circuit is reduced to 50% of its original length, making voltage drop less of an issue	
Power Quality:			0%	No impact on power quality	
Fault Level:			0%	No impact on fault level	
Cost (£) Capital:	£10,000			Cost based on an assumed average length of 500m for LV overhead circuit; threfore 250m of LV conductor required	
Operational Expenditure:	£0			No opex costs incurred once the conductor is installed	
NPV of Opex:					
Cost Curve Type:	1			Increase over time as metal prices increase	
Life Expectancy of Solution:	40			The solution remains valid for the entire modelled period	
Merit Order Totex (£):	£10,000			Calculated from above	
Disuption Factor (1-5):	4			Erecting 250m of new overhead circuit causes fairly high disruption to the general public in the area	
Disruption Cost (£):	£30,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)	
Flexibility (1-5):	1			No flexibility as, once installed, the circuti would not be re-used elsewhere	
Cross Network Benefits Factor:	0			This solution resolves a problem on a specific LV feeder, but has no benefit to higher voltages as the load experienced there will remain constant	
Other Benefits Impact on Fixed Losses (%):	0%			No impact on fixed losses anticipated	
Impact on Variable Losses (%):	-2%			The load carried by the circuit will reduce, therefore reducing the variable losses (which are proportional to the square of the current)	
Impact on quality of Supply (%):	20%			Having fewer customers connected to one circuit effectively halves the number of CIs that would be incurred in the event of an outage	
Year solution becomes available:	2012				
Year data (on soln) is available:	2012				
Source of Data:	DPCR5 unit costs and discussion with Network Operators				
Smart Solution Relevance (WS3 Ph1) Smart Solution Set:	CONVENTIONAL				
Focus:					
Subset:					

Conventional Variant

		EHV	HV	LV	Comments
Solution Overview	Representative Solution:	**LV Underground network**			
	Variant Solution:	Major works			
	Description:	The major works option here is composed of the construction of several new substations (with associated cabling) in an area that has seen significant load growth and requires wholesale investment. An example of how this might be represented can be seen in section 13.2 of the WS3 report.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			500%	The new transformers and associated circuits mean that the feeders should have their load significantly reduced, shown here as a 500% increase in headroom
	Thermal Transformer:			500%	The new transformer means that the existing transformer will have its load significantly reduced, shown here as a 500% increase in headroom
	Voltage Head:			1%	A marginal benefit may be seen for voltage headroom as the load and generation is split across several transformers
	Voltage Leg:			15%	Significant voltage legroom benefit will arise as the load is distributed across numerous transformers and circuits
	Power Quality:			0%	There will be no effect on power quality
	Fault Level:			-20%	The addition of mulitple transformers will reduce the source impedance and hence increase the fault level by a greater degree than that observed for minor works. This has been captured here as a 20% reduction in fault level headroom
Cost (£)	Capital:	£250,000			The cost is composed of two new ground mounted distribution transformers, 400m of HV cable to supply the new transformers and associated jointing to connect these to the network; 1.8km of new LV cable to supply six new circuits at an average length of 300m each.
	Operational Expenditure:	£0			It is assumed that no opex costs are associated with the solution
	NPV of Opex:				
	Cost Curve Type:	1			The cost of the solution will increase over time as metal prices increase
	Life Expectancy of Solution:	40			The lifetime of the assets will be a minimum of 40 years and hence the solution will not expire during the modelled period
Merit Order	Totex (£):	£250,000			Calculated from above
	Disuption Factor (1-5):	4			There will be high disruption to the public in the laying of HV and LV cable and the installation of new ground mounted transformers at new substation sites.
	Disruption Cost (£):	£30,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			This solution cannot realistically be re-used at another location once installed
	Cross Network Benefits Factor:	0			The benefits will be exclusively to the LV network as it is envisaged that the new transformers will be connected to the same HV circuit as the existing transformer
Other Benefits	Impact on Fixed Losses (%):	0%			Negligible impact on fixed losses
	Impact on Variable Losses (%):	-2%			A slight reduction in variable losses is envisaged as the numerous new assets installed will all be loaded to low levels thereby incurring low losses
	Impact on quality of Supply (%):	40%			There will be a significant improvement in quality of supply as fewer customers will be supplied via one circuit or one transformer, hence fewer CIs will arise as a result of an outage. This improvement has been deemed to be of the order of 40%.
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Solution Overview	Representative Solution:	**LV Underground network**			
	Variant Solution:	Minor works			
	Description:	This solution takes the form of a second distribution transformer at, or near to, the location of the original transformer. A small amount of HV cabling is allowed for, while the solution also incorporates the construction of several LV circuits. A diagram showing the solution can be found in section 13.2 of the WS3 report.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			100%	The new transformer and associated circuits mean that the feeders should have their load halved
	Thermal Transformer:			100%	The new transformer means that the existing transformer will have its load halved (i.e. its headroom doubled)
	Voltage Head:			1%	A marginal benefit may be seen for voltage headroom as the load and generation is aplit across two transformers
	Voltage Leg:			6%	Some voltage legroom benefit will arise as the load is distributed across two transformers and more circuits
	Power Quality:			0%	There will be no effect on power quality
	Fault Level:			-15%	The addition of a second transformer will reduce the source impedance and hence increase the fault level by a greater degree than merely if the transformer were replaced. This has been captured here as a 15% reduction in fault level headroom
Cost (£)	Capital:	£80,000			The cost is compoased of a new ground mounted distribution transformer, 100m of HV cable to supply the new transformer and associated jointing to connect this to the network; 600m of new LV cable to supply two new circuits at an average length of 300m each.
	Operational Expenditure:	£0			It is assumed that no opex costs are associated with the solution
	NPV of Opex:				
	Cost Curve Type:	1			The cost of the solution will increase over time as metal prices increase
	Life Expectancy of Solution:	40			The lifetime of the assets will be a minimum of 40 years and hence the solution will not expire during the modelled period
Merit Order	Totex (£):	£80,000			Calculated from above
	Disuption Factor (1-5):	4			There will be high disruption to the public in the laying of HV and LV cable and the installation of a new ground mounted transformer either at a new substation site, or adjacent to an existing transformer
	Disruption Cost (£):	£30,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			This solution cannot relaistically be re-used at another location once installed
	Cross Network Benefits Factor:	0			The benefits will be exclusively to the LV network as it is envisaged that the new transformer will be connected to the same HV circuit as the existing transformer
Other Benefits	Impact on Fixed Losses (%):	0%			Negligible impact on fixed losses
	Impact on Variable Losses (%):	0%			Negligible impact on variable losses as there will be more equipment installed via which losses may arise, but the assets will be loaded to lower levels thereby reducing the level of losses within them
	Impact on quality of Supply (%):	30%			There will be a significant improvement in quality of supply as fewer customers will be supplied via one circuit or one transformer, hence fewer CIs will arise as a result of an outage. This improvement has been deemed to be of the order of 30%.
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Solution Overview	Representative Solution:	**LV Underground network**			
	Variant Solution:	Ground mounted 11/LV Tx			
	Description:	Replacement of an existing distribution transformer with a larger unit			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			0%	This solution resolves an issue regarding the transformer (substation) load and has no effect on individual LV feeders
	Thermal Transformer:			80%	Replacing the transformer with a larger unit will release significant headroom for the substation in question
	Voltage Head:			1%	A marginal benefit may be observed in terms of voltage headroom
	Voltage Leg:			6%	Some benefit for voltage legroom will arise
	Power Quality:			0%	No impact on power quality
	Fault Level:			-10%	The larger Tx will have a lower impedance and will result in an increase in fault level, captured here as a 10% reduction in headroom
Cost (£)	Capital:	£3,432			This cost is based on the cost of a new distribution transformer, split across the average number of LV feeders supplied by that transformer (4)
	Operational Expenditure:	£0			It is assumed that there is no opex associated with the new transformer
	NPV of Opex:				
	Cost Curve Type:	1			Costs are assumed to increase with metal prices
	Life Expectancy of Solution:	40			The transformer has a life of 40 years, meaning it will not require replacement during the modelled period
Merit Order	Totex (£):	£3,432			Calculated from above
	Disuption Factor (1-5):	4			The disruption is fairly high, owing to the potential civil works involved etc
	Disruption Cost (£):	£30,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	2			There is a limited amount of flexibility with this solution in that the transformer could be re-used in another location if necessary; however there are some costs associated with removal and transportation of the transformer hence the low factor
	Cross Network Benefits Factor:	0			This provides a solution to a specific problem and does not directly alleviate load on other circuits or at other voltage levels
Other Benefits	Impact on Fixed Losses (%):	0%			Negligible impact on fixed losses
	Impact on Variable Losses (%):	1%			A slight increase may be seen in variable losses through the larger transformer
	Impact on quality of Supply (%):	0%			There will be no impact on quality of supply measures
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Solution Overview	Representative Solution:	**LV Underground network**			
	Variant Solution:	New Split feeder			
	Description:	Lay a new LV feeder from a distribution substation, part way along the already split LV feeder. Perform some cross jointing such that one third of the total load on the original feeder and the split feeder is now transferred to the new split feeder. A diagram showing this is included in 13.2 of the WS3 Report.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			80%	By picking up a large amount of load from the already split feeder, the thermal headroom is significantly increased
	Thermal Transformer:			0%	This solution solves a circuit problem but has no effect on the substation load
	Voltage Head:			1%	Marginal benefit through splitting the load (and any generation present) across two feeders
	Voltage Leg:			6%	Potentially there could be reasonable benefit here as the circuit is reduced to 66% of its original length, making voltage drop less of an issue
	Power Quality:			0%	No impact on power quality
	Fault Level:			0%	No impact on fault level
Cost (£)	Capital:	£33,000			Cost based on an assumed average length of 300m for LV underground circuit; therefore 150m of LV cable required, plus some additional cross-jointing to allow for the fact that this is the second splitting of the feeder
	Operational Expenditure:	£0			No opex costs incurred once the cable is installed
	NPV of Opex:				
	Cost Curve Type:	1			Increase over time as metal prices increase
	Life Expectancy of Solution:	40			The solution remains valid for the entire modelled period
Merit Order	Totex (£):	£33,000			Calculated from above
	Disuption Factor (1-5):	4			Excavating and laying 150m of cable causes fairly high disruption to the general public in the area
	Disruption Cost (£):	£30,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			No flexibility as the amount of work requried to move an installed cable outweighs any benefits this might realise
	Cross Network Benefits Factor:	0			This solution resolves a problem on a specific LV feeder, but has no benefit to higher voltages as the load experienced there will remain constant
Other Benefits	Impact on Fixed Losses (%):	0%			No impact on fixed losses anticipated
	Impact on Variable Losses (%):	-2%			The load carried by the cable will reduce, therefore reducing the variable losses (which are proportional to the square of the current)
	Impact on quality of Supply (%):	20%			Having fewer customers connected to one circuit reduces the number of CIs that would be incurred in the event of an outage
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
	Subset:				

Conventional Variant

Solution Overview	Representative Solution:	**LV Underground network**			
	Variant Solution:	Split feeder			
	Description:	Lay a new LV underground feeder out of a distribution substation to the midpoint of an existing feeder. Break the existing feeder and pick up the 50% of the load from that feeder onto the new feeder.			
		EHV	**HV**	**LV**	**Comments**
Headroom Release (%)	Thermal Cable:			100%	By picking up 50% of the load from the existing feeder, the thermal headroom is doubled
	Thermal Transformer:			0%	This solution solves a circuit problem but has no effect on the substation load
	Voltage Head:			1%	Marginal benefit through splitting the load (and any generation present) across two feeders
	Voltage Leg:			12%	Potentially there could be significant benefit here as the circuit is reduced to 50% of its original length, making voltage drop less of an issue
	Power Quality:			0%	No impact on power quality
	Fault Level:			0%	No impact on fault level
Cost (£)	Capital:	£30,000			Cost based on an assumed average length of 300m for LV underground circuit; threfore 150m of LV cable required, plus some jointing
	Operational Expenditure:	£0			No opex costs incurred once the cable is installed
	NPV of Opex:				
	Cost Curve Type:	1			Increase over time as metal prices increase
	Life Expectancy of Solution:	40			The solution remains valid for the entire modelled period
Merit Order	Totex (£):	£30,000			Calculated from above
	Disuption Factor (1-5):	4			Excavating and laying 150m of cable causes fairly high disruption to the general public in the area
	Disruption Cost (£):	£30,000			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):	1			No flexibility as the amount of work requried to move an installed cable outweighs any benefots this might realise
	Cross Network Benefits Factor:	0			This solution resolves a problem on a specific LV feeder, but has no benefit to higher voltages as the load experienced there will remain constant
Other Benefits	Impact on Fixed Losses (%):	0%			No impact on fixed losses anticipated
	Impact on Variable Losses (%):	-2%			The load carried by the cable will reduce, therefore reducing the variable losses (which are proportional to the square of the current)
	Impact on quality of Supply (%):	20%			Having fewer customers connected to one circuit effectively halves the number of CIs that would be incurred in the event of an outage
	Year solution becomes available:	2012			
	Year data (on soln) is available:	2012			
	Source of Data:	DPCR5 unit costs and discussion with Network Operators			
Smart Solution Relevance (WS3 Ph1)	Smart Solution Set:	CONVENTIONAL			
	Focus:				
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