

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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Delivering Innovation in Power Engineering

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.

Solution Overview	Representative Solution:					
overview						
	<u>Variant Solution:</u> Description:					
		EHV	HV	LV	Comments	
leadroom	Thermal Cable:			0%		_ •
Release (%)	Thermal Transformer:			0%		
	Voltage Head:			0%		
	Voltage Leg:			0%		1.
	Power Quality:			0%		1
	Fault Level:			0%		1
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 Ex	pectancy 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		0			
	Benefits Factor:		U			
Other Benefits	Impact on Fixed Losses (%):		%			
	Impact on Variable		%			1
	Losses (%): Impact on quality of Supply (%):	%				
Voor	solution is available:		2012			-
	(on soln) is available:		2012			-
ical uald	Source of Data:				I	1
Smart Solution		CONN		ΟΝΔΙ		1
Relevance	Focus:	2011				1
(WS3 Ph1)	Subset:					-

Table Error! No text of specified style in document..10verview of the Solution Template

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 433V¹ 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	Expected life of the solution in years
Solution	
Merit Order	
Disruption factor	Disruption represents the value attributed to the avoidance of disruption caused to the
(1-5)	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
	 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
	 A component or control type solution that could be readily redeployed, e.g. power donut
	 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	If a solution has benefits up or downstream to the voltage level it is applied at, then the
benefits factor	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	Estimated impact on fixed losses such as transformer iron loss, storage unit running
Losses (%)	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
LUSSES (76)	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 Refe	rence (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

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 £100			Capital cost of automation equipment and communications (assuming the primary infrastructure RMUs, etc) is already in place				
	Operational Expenditure:				Assumed per circuit cost of comms channels				
	NPV of Opex:				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 (£):	f	£21,421		Calculated from capex plus NPV of opex				
	Disuption Factor (1-5):		2		Minimal disrpution anticipated				
	Disruption Cost (£):	ł	£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				
	'ear solution is available:		2018		Estimate				
Year da	ata (on soln) is available:		2014						
	Source of Data:				and play, ENW C2C, SP Flexible Networks				
Smart Solution	Smart Solution Set:								
Relevance (WS3					enhancements to existing network architecture				
Ph1)	Subset:	Uption	s to c	rebiok	adaptive protection and control techniques				

Solution Overview	Representative Solution:	Temp	porary Meshing (soft open point)						
	Variant Solution:	HV - m	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							
		EHV	HV	LV	Comments				
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:				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				
	ear solution is available:		2016		Pending the outcome of the LCNF projects				
Year da	ata (on soln) is available:		2016						
					and play, ENW C2C, SP Flexible Networks				
Smart Solution	Smart Solution Set:								
Relevance (WS3					nhancements to existing network architecture				
Ph1)	Subset:	Options to deploy adaptive protection and control techniques							

Solution Overview	Representative Solution:	"Temporary meshing (sort open point) EHV - maximising latent capacity "Temporary meshing" refers to running the network solid, utilising latent capacity, and relying on						
	Variant Solution:							
	Description:							
		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 (£):	f	£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			
	'ear solution is available:		2014		Pending the outcome of the LCNF projects			
Year da	ata (on soln) is available:		2014		Development is incremental, and trials are underway			
					and play, ENW C2C, SP Flexible Networks			
Smart Solution	Smart Solution Set:							
Relevance (WS3					enhancements to existing network architecture			
Ph1)	Subset:	Option	is to de	eploy	adaptive protection and control techniques			

Solution Overview	Representative Solution:	Switched Capacitors							
	Variant Solution:	Switc	hed ca	pacito	ors @ LV				
	Description:		V 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	Thermal Cable:			0%	No improvement to thermal headroom				
Release (%)	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 Cost Curve Type			£142		Based on 20 year of annual operating expenditure @ 3.5% discount rate				
			2		Relatively established product, although not deployed in large quantities around the world				
Lif	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 o	data (on soln) is available:								
	Source of Data:	Wor	kstreai	m 2					
Smart Solution	Smart Solution Set:	Smar	t D-Ne	twork	s 1				
Relevance (WS	3 Focus:	Quali	Quality of supply; enhancements to existing network architecture						
Ph1)	Subset:	Wave	Waveform monitoring and waveform correction devices						

Solution	Representative	Swite	ched (Сарас	itors				
Overview	Solution:								
	Variant Solution:	Switc	hed ca	pacito	acitors @ 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	Thermal Cable:		0%		No improvement to thermal headroom				
Release (%)	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:	f	E300,00	0	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	£50			Assumed cost				
	Expenditure:								
	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				
Li	fe Expectancy of Solution:	30			Taken from WS2 model				
Merit Order	Totex (£):	f	£300,71	1	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	, Work	strea	n 2				
Smart Solution	n Smart Solution Set:	Smar	t D-Ne	twork	s 1				
Relevance (WS	53 Focus:	Quali	ty of s	upply;	enhancements to existing network architecture				
Ph1)	Subset:	Wave	eform i	nonit	oring and waveform correction devices				

Solution	Representative									
Overview	Solution:	ISwitched Capacitors								
	Variant Solution:									
					echanically switched devices as a low cost form of reactive power					
	Description:	comp	ensati	ion. Th	ney are used for voltage control and network stabilisation under heavy load					
		condi	conditions.							
		EHV	HV	LV	Comments					
Headroom	Thermal Cable:				No improvement to thermal headroom					
Release (%)		070			No improvement to thermal headroom					
11010030 (70)	Thermal Transformer:	0%								
	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 (£)					Estimated cost for the installation and commissioning of a EHV switched					
	Capital		E830,00	0	capacitor device.					
	Capital:		1830,00	0	It is noted that this cost does look high, and would value further analysis and					
					evidence from real trials and installations.					
	Operational		C1E0		Assumed cost					
	Expenditure:	£150								
-	NPV of Opex:	£6,768			Based on 20 year of annual operating expenditure @ 3.5% discount rate					
					Relatively established product, although not deployed in large quantities					
	Cost Curve Type:	2			around the world					
Life Expectancy of Solution:		30			Taken from WS2 model					
Merit Order	Totex (£):	£832,132		2	Calculated from capex plus NPV of opex					
			,		New land required to install, but not expected to be a significant disruption					
	Disuption Factor (1-5):	3			······································					
	Disruption Cost (£):		£10,000	0	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				Limited benefit					
	Benefits Factor:		1							
Other					Switched nature of the device, mean that they are not always in circuit. For					
Benefits	Impact on Fixed		5%		the purpose of the model an increase of 5% has been assumed					
	Losses (%):									
	Impact on Variable				Potential to reduce losses, through reduction of VAr flow - but not factored					
	Losses (%):		0%		into the default assumptions in the model.					
	Impact on quality of				No expected benefit					
	Supply (%):		0%							
1	Year solution is available:		2012		Solutions are in use today, although not extensive in GB					
	Year data (on soln) is available:		2012							
rearu	Source of Data:	Wor	estron	m 2	ļ					
Smart Solution	Smart Solution Set:									
Relevance (WS3		Quality of supply; enhancements to existing network architecture								
Ph1)	Waveform monitoring and waveform correction devices									

Solution Overview	Representative Solution:	RTTR	RTTR						
	Variant Solution:	RTTR	for LV	UG ca	ibles				
	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		LV	Comments				
Headroom					At present this is not a well-defined quantity, but it is envisaged that ratings				
Release (%)	Thermal Cable:			8%	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				
Cost (£)	Fault Level:			0%	No expected benefit Estimate based on the purchase and installation of monitoring devices at key				
	Capital:	£16,600			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				
Lifi	e 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	1	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	Benefits Factor: Impact on Fixed Losses		0%		No benefit expected				
2010113	(%): Impact on Variable Losses (%):		0%		Solution is expected to increase the variable losses (I ² R) 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				
			2013		Expect futher data from trials such as CLNR as the project completes (Dec				
					2013)				
Year d	lata (on soln) is available:		14/	ket	,				
	Source of Data:				m 2				
Year d Smart Solution Relevance (WS3	Source of Data: Smart Solution Set:	Smart	t D-Ne	twork	m 2				

Solution	Representative	RTTR									
Overview	Solution:			<u> </u>							
	Variant Solution:										
	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.								
		EHV	HV	LV	Comments						
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:	£0			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:				No ongoing opex cost assumed (NB. Costs of weather monitoring are factored into the associated Enabler)						
	NPV of Opex:				Based on 20 year of annual operating expenditure @ 3.5% discount rate						
	Cost Curve Type:				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 ² R) 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.						
Y	ear solution is available:		2015		Estimate - based on RTTR being an incremental development						
Year da	ata (on soln) is available:		2013		Expect futher data from trials such as CLNR as the project completes (Dec 2013)						
	Source of Data:										
Smart Solution	Smart Solution Set:										
Relevance (WS3					eliability, failure mode detection						
Ph1)	Subset:	Dynamic ratings for all plant types and multi element circuits									

Solution	Representative	0								
Overview	Solution:									
	Variant Solution:									
					rement and ambient forecasting data to predict the rating (and hence current					
	Description:	carryi	carrying capacity) of assets in a real-time mode.							
		This v	This variant considers RTTR for Secondary distribution transformers.							
		EHV	HV	LV	Comments					
Headroom	Thermal Cable:			0%	No expected benefit					
Release (%)	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					
Coot (C)	Fault Level:			0%	No expected benefit					
Cost (£)	Capital:				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 ² R) 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					
Y	(ear solution is available:		2015		Estimate - based on transformer RTTR being an incremental development					
Year da	ata (on soln) is available:		2013		Expect futher data from trials such as CLNR as the project completes (Dec 2013)					
	Source of Data:									
Smart Solution	Smart Solution Set:									
Relevance (WS3					eliability, failure mode detection					
Ph1)	Subset:	Uynar	nic rat	ings t	or all plant types and multi element circuits					

Solution Overview	Representative Solution:	RTTR							
	Variant Solution:	RTTR	for HV	/ UG c	ables				
	Description:		The use of measurement and ambient forecasting data to predict the rating (and hence carrying capacity) of assets in a real-time mode.						
		This v	ariant	consi	ders RTTR for HV 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% 0%		No expected benefit				
	Voltage Leg: Power Quality:		0%		No expected benefit No expected benefit				
	Fault Level:		0%		No expected benefit				
Cost (£)	Capital:	0% £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:		£U		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				
Life	<u>Cost Curve Type:</u> Expectancy of Solution:		3		Assume a reduction in costs as solution volumes increase 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 ² R) 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.				
Ye	ear solution is available:		2015		Estimate				
Year da	ta (on soln) is available:		2013	vetro-	Expect futher data from trials such as CLNR as the project completes (Dec 2013)				
mart Solution	Source of Data: Smart Solution Set:								
Relevance (WS3					eliability, failure mode detection				
Ph1)	Subset:				or all plant types and multi element circuits				

Solution	Representative								
Overview	Solution:	RTTR							
	Variant Solution:	RTTR f	or HV	OH li	nes				
		The use of measurement and ambient forecasting data to predict the rating (and hence current							
	Description:	carryin	arrying capacity) of assets in a real-time mode.						
	Description								
			_		ders RTTR for HV overhead line circuits.				
		EHV	HV	LV	Comments				
Headroom Release (%)					The amount of thermal headroom that can be released depends on the topography of the network and the surrounding area. For example, lines across				
Kelease (70)					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.				
	Thermal Cable:		30%		However, for a line across open ground an increase in rating of up to 30% can				
	merma cable.		50%		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.				
					transformers), i.e. no accelerated ageing.				
					No benefit expected				
	Thermal Transformer:		0%		P				
	Voltage Head:		0%		No benefit expected				
	Voltage Leg:		0%		No benefit expected				
	Power Quality:		0%		No benefit expected				
a (a)	Fault Level:		0%		No benefit expected				
Cost (£)	Carrital		E6,640		Estimate based on the purchase and installation of monitoring devices (e.g.				
	Capital:	1	10,040		conductor mounted measurement devices) at key points along the overhead line circuit.				
	Operational				No ongoing opex cost assumed (NB. Costs of weather monitoring are factored				
	Expenditure:		£0		into the associated Enabler)				
			60						
	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	e 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.				
			10						
					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 (£):	f	E6,640		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				
			2		of impact / outages				
	Disruption Cost (£):	f	E2,500		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)				
					Devices could easily be moved from one circuit to another within their life				
	Flexibility (1-5):		4		expectancy				
	Cross Network				No benefit expected				
	Benefits Factor:		0		P				
Other	Impact on Fixed		0%		No benefit expected				
Benefits	Losses (%):		070						
	Impact on Variable				Solution is expected to increase the variable losses (I ² R) as more current is				
	Losses (%):		20%		pushed down the circuit. The exact increase depends on the magnitude and				
					duration of operating at these higher currents.				
	Impact on quality of		0%		A marginal benefit to QoS as this solution may provide additional monitoring of the network, potentially assisting DNOs in identifying faults or fault				
	Supply (%):		070		locations.				
v	fear solution is available:		2014		Estimate - based on RTTR being an incremental development				
	ear solution is available.				Expect futher data from trials such as CLNR as the project completes (Dec				
Year d	ata (on soln) is available:		2014		2013)				
	Source of Data:				V, Workstream 2, SP Flexible Networks, SSE NINES, UKPN Flexible plug and play				
Smart Solution	Smart Solution Set:								
Relevance (WS3	B Focus:				eliability, failure mode detection				
Ph1)	Subset:	Dynam	nic rat	ings f	or all plant types and multi element circuits				

Solution	Representative	RTTR								
Overview	Solution:	RTTR for EHV/HV Tx								
			The use of measurement and ambient forecasting data to predict the rating (and hence current							
	Description:		carrying capacity) of assets in a real-time mode.							
				_	ders RTTR for Primary transformers.					
		EHV	HV	LV	Comments					
Headroom Release (%)	Thermal Cable:	0%			No expected benefit					
Release (%)	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	I	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					
L	ife 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					
					Low disruption as the devices can be connected to the network with minimal					
	Disuption Factor (1-5):		2		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	Impact on Fixed		001		No benefit expected					
Benefits	Losses (%):		0%							
	Impact on Variable Losses (%):		20%		Solution is expected to increase the variable losses (I ² R) 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)					
					m 2, SP Flexible Networks					
Smart Solutio										
Relevance (W					eliability, failure mode detection					
Ph1)	Subset:	ynan	nic ra	tings fo	or all plant types and multi element circuits					

Solution Overview	Representative Solution:								
		RTTR for EHV UG cables							
	Description:	carryi	ng cap	oacity)	rement and ambient forecasting data to predict the rating (and hence current of assets in a real-time mode.				
		_		_	ders 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:				No expected benefit				
	Power Quality: Fault Level:	0% 0%	_		No expected benefit No expected benefit				
	ost (£) 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				
Life	Cost Curve Type: e Expectancy of Solution:	3			Assume a reduction in costs as solution volumes increase 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				
benents	Impact on Variable	10%			Solution is expected to increase the variable losses (I ² R) as more current is pushed down the circuit. The exact increase depends on the magnitude and duration of operating at these higher currents. A marginal benefit to QoS as this solution may provide additional monitoring of				
	Losses (%):		1%		a consisting period to goo as this solution may provide dualitorial monitoring of				
	Losses (%): Impact on quality of Supply (%):		1%		the network, potentially assisting DNOs in identifying faults or fault locations.				
	Impact on quality of		1% 2015		the network, potentially assisting DNOs in identifying faults or fault locations.				
	Impact on quality of Supply (%):		2015						
	Impact on quality of Supply (%): Year solution is available: lata (on soln) is available:		2015 2013		the network, potentially assisting DNOs in identifying faults or fault locations. Estimate - based on RTTR being an incremental development Expect futher data from trials such as CLNR as the project completes (Dec 2013)				
Year d	Impact on quality of Supply (%): Year solution is available: Jata (on soln) is available: Source of Data:	CLNR	2015 2013 Wor	kstrea	the network, potentially assisting DNOs in identifying faults or fault locations. Estimate - based on RTTR being an incremental development Expect futher data from trials such as CLNR as the project completes (Dec 2013) m 2				
	Impact on quality of Supply (%): Year solution is available: lata (on soln) is available: Source of Data: Smart Solution Set:	CLNR, Smart	2015 2013 Wor	kstrea twork	the network, potentially assisting DNOs in identifying faults or fault locations. Estimate - based on RTTR being an incremental development Expect futher data from trials such as CLNR as the project completes (Dec 2013) m 2				

Solution	Representative	DTTD								
Overview	Solution:									
	Variant Solution:									
			The use of measurement and ambient forecasting data to predict the rating (and hence curre							
	Description:		ng cap	acity)	of assets in a real-time mode.					
		This v	This variant considers RTTR for EHV overhead line circuits.							
		EHV	HV	LV	Comments					
Headroom					The amount of thermal headroom that can be released depends on the					
Release (%)					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					
	Thermal Cable:	30%			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.					
					No benefit expected					
	Thermal Transformer:	0%								
	Voltage Head:	0%			No benefit expected					
	Voltage Leg:	0%			No benefit expected					
	Power Quality:	0%			No benefit expected					
Cost (£)	Fault Level:	0%			No benefit expected Estimate based on the purchase and installation of monitoring devices (e.g.					
	Capital:		£13,280)	conductor mounted measurement devices) at key points along the overhead					
					line circuit.					
	Operational		£0		No ongoing opex cost assumed (NB. Costs of weather monitoring are factored					
	Expenditure:		20		into the associated Enabler)					
	NPV of Opex:		£0		Decad on 20 year of annual anarching avaanditure @ 2 5% discount rate					
	Cost Curve Type:	3			Based on 20 year of annual operating expenditure @ 3.5% discount rate Assume a reduction in costs as solution volumes increase					
Lif	fe 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					
			2		Low disruption as the devices can be connected to the network with minimal					
	Disuption Factor (1-5):		2		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				No benefit expected					
	Benefits Factor:		0							
Other	Impact on Fixed		0%		No benefit expected					
Benefits	Losses (%):									
	Impact on Variable		20%		Solution is expected to increase the variable losses (I ² R) as more current is					
	Losses (%):		2070		pushed down the circuit. The exact increase depends on the magnitude and duration of operating at these higher currents.					
					A marginal benefit to QoS as this solution may provide additional monitoring					
	Impact on quality of		1%		of the network, potentially assisting DNOs in identifying faults or fault					
	Supply (%):				locations.					
	Year solution is available:		2015		Estimate - based on RTTR being an incremental development					
V	data (an cala) is susting t		2013		Expect futher data from trials such as CLNR as the project completes (Dec					
Year c	data (on soln) is available: Source of Data:		Wor	kstrop	2013) m 2, WPD 132kV, SP Dynamic Rating					
Smart Solution										
Relevance (WS					eliability, failure mode detection					
Ph1)	Subset:				or all plant types and multi element circuits					

Solution Overview	Representative Solution:	Perm	anen	t Meshi	ng of Networks				
	Variant Solution:	Meshi	Ieshing LV Sub-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:			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:	£100 £1,421			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:				Additional requirement for ongoing system studies to model the network (cost on a per feeder basis)				
	NPV of Opex:				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 (£):		£21,42	21	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 (£):		£2,50	0	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%	6	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)				
	ear solution is available:		201	2	Solution is available today (but not widely used)				
Year da	ta (on soln) is available:								
	Source of Data:				Interconnectable LV networks IFI project				
			ndon F						
Smart Solution	Smart Solution Set:								
Relevance (WS3					s inc. physical threats, utilising new network architectures				
Ph1)	Subset:	Use of	t mesh	ied, rath	er than radial architectures				

Solution Overview	Representative Solution:	Perm	nanen	t Mesh	ing of Networks					
overview		Mesh	ingIV	Urban I	Networks					
		n: 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:	tional _{£100}		00	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:)	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 (£):		£21,42	21	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 (£):		£2,50	0	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%	5	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)					
Ye	ear solution is available:		2012	2	Solution is available today (but not widely used)					
Year da	ta (on soln) is available:									
	Source of Data:			-NMS & Road 1	Interconnectable LV networks IFI project					
Smart Solution	Smart Solution Set:	Smart	t D-Ne	tworks 4	1					
Relevance (WS3					s inc. physical threats, utilising new network architectures					
Ph1)	Subset:	Use o	f mesł	ned, rath	ner than radial architectures					

Solution Overview	Representative	Permanent Meshing of Networks							
	Solution: Variant Solution:	Mesh	ing HV I	Netwo	prks				
	Description:	Conve config	Converting the operation of the HV 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 Uses latent capacity of transformers, from 50% utilisation for radial network to				
	Thermal Transformer:		15%		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:	onal _{£100})	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:				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				
Life	Cost Curve Type: Expectancy of Solution:		2 45		not expected to reduce in cost over time 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)				
Y	ear solution is available:		2012		Solution is available today (but not widely used)				
Year da	ata (on soln) is available:	E NIVA/	2015	hy 2 Ci	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. ustomers (C2C), using GE PowerOn Fusion,				
		NPG - SP T1	KTP pro	oject, e Netv	PhD interconnection business value case vorks				
Smart Solution	Smart Solution Set:								
Relevance (WS3 Ph1)			· ·		ks inc. physical threats, utilising new network architectures ther than radial architectures				

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Solution Overview	Representative Solution:	Perma	ermanent Meshing of Networks						
	Variant Solution:	Meshii	ng EH\	/ Netv	vorks				
	Description:		Converting the operation of the EHV network from a radial ring (with split points) to 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				
Life	Cost Curve Type: Expectancy of Solution:	2 45			not expected to reduce in cost over time 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		1	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)				
Y	ear solution is available:		2012		Solution is available today (but not widely used)				
Year d	ata (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.				
		NPG - I SP T1 F	KTP pr Flexibl	oject, e Netv					
Smart Solution	Smart Solution Set:								
Relevance (WS3 Ph1)			Security of networks inc. physical threats, utilising new network architectures Jse of meshed, rather than radial architectures						

Solution Overview	Representative	New	Туре	s Of C	ircuit Infrastructure				
Overview	Solution:	Novo	Novel HV underground cable						
	Description:	The d	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:	f	300,00	0	Assumed cost based on an average HV underground cable circuit length of 3km - assuming £100k/km				
	Operational		£0		No anticipted cost				
	Expenditure:	20							
	NPV of Opex:	£O			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 (£):	f	300,00	0	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				
	ear solution is available:		2018		Estimate				
Year da	ata (on soln) is available:		2015		Some small trials are happening, but no significant activity in GB				
					ased on engineering judgement				
Smart Solution			t D-Ne						
Relevance (WS3			Plant & Systems reliability, failure mode detection						
Ph1)	Subset:	Use o	Use of novel tower/insulation structures to enhance route capacity						

Solution Overview	Representative Solution:	New T	ypes	Of Cir	cuit 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		£0		No anticipted cost				
	Expenditure:	20							
	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				
	'ear solution is available:		2018		Estimate				
Year da	ata (on soln) is available:		2015		Some small trials are happening, but no significant activity in GB				
	Source of Data:				sed on engineering judgement				
Smart Solution	Smart Solution Set:	Smart							
Relevance (WS3					liability, failure mode detection				
Ph1) Subset: Use of novel tower/insulation structures to enhance route capacity									

Solution Overview	Representative Solution:	New Types	Of Ci	rcuit 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:	£600,00	0	Assumed cost based on an average HV overhead line circuit length of 10km - assuming £60k/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	e Expectancy of Solution:	45		As per conventional overhead line infrastructure				
Merit Order	Totex (£):	£600,00	0	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 (£):	£30,00	D	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				
Y	Year solution is available:	2018		Estimate				
Year d	ata (on soln) is available:	2015		Some small trials are happening, but no significant activity in GB				
	Source of Data:	Initial estim	ates ba	ased on engineering judgement				
Smart Solution	Smart Solution Set:	Smart D-Net	works	3				
Relevance (WS3				eliability, failure mode detection				
Ph1)	Subset:	Use of novel tower/insulation structures to enhance route capacity						

Solution Overview	Representative Solution:	New T	ypes	Of Cir	cuit Infrastructure						
	Variant Solution:	Novel E	ovel 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		£0		No anticipted cost						
	Expenditure:										
	NPV of Opex:	£0			Based on 20 year of annual operating expenditure @ 3.5% discount rate						
					Costs assumed to be static over time - the effects of deploying larger volumes						
	Cost Curve Type:		2		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		1		Potentially small improvement at HV.						
	Benefits Factor:		1								
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 da	ata (on soln) is available:		2015		Some small trials are happening, but no significant activity in GB						
	Source of Data:	Initial e	estima	tes ba	sed on engineering judgement						
Smart Solution	Smart Solution Set:	Smart I	D-Net	works	3						
Relevance (WS3			· ·		liability, failure mode detection						
Ph1)	Subset:	Use of	Jse of novel tower/insulation structures to enhance route capacity								

Solution Overview	Representative Solution:	Local	smar	t EV o	charging infrastructure			
	Variant Solution:	Intelli	igent c	ontro	devices			
	Description:	distril	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.					
		EHV	HV	LV	Comments			
Headroom	Thermal Cable:			10%	Part of a DSR solution - assumed benefit			
Release (%)	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		£250		Estimate for comms costs			
	Expenditure:		1250					
	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	3	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 da	Year data (on soln) is available:		2016		Pending network trials and operation with real EVs and real customers			
	Source of Data:	EA Te	chnolo	ogy en	gineering judgement (based on known products)			
Smart Solution	Smart Solution Set:	Smar	t EV Cł	nargin	g			
Relevance (WS3	Focus:	EV ch	arging	/disch	arging (V2G), Network management, Demand Response and other services			
Ph1)	Subset:	Archi	tecture	e - dist	ributed processing - street, substation or community level, distributed charging			

Solution	Representative	Gene	erator	Prov	iding Network Support, e.g. PV Mode			
Overview	Solution:							
	Variant Solution:	Generator support @ LV						
	Description:	(Real The g	power enerat	and v or wil	a larger LV 3-phase connected generator for them to operate their sets in PV volts) mode rather than the conventional PQ (Real and Reactive power). I draw VArs from the network at certain times, but ensure that the voltage on t excessively raised at the point of connection.			
		EHV	HV	LV	Comments			
Headroom	Thermal Cable:			0%	No expected benefit			
Release (%)	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		£1,000		Assumed cost to operate secure and high availability communications			
-	Expenditure:	11,000			channels.			
	NPV of Opex:		£14,212	2	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	e Expectancy of Solution:		5		Commercial contract, treated in the same manner as DSR.			
Merit Order	Totex (£):		£16,212	2	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	Smart Solution Set:							
Relevance (WS3					nanagement of two way power flows			
Ph1)	Subset:	Intell	gent v	oltage	e control			

Solution Overview	Representative Solution:	Gene	nerator Providing Network Support, e.g. PV Mode						
	Variant Solution:	Generator support @ HV							
	Description:	volts) The ge	Contracting with a HV connected generator for them to operate their sets in PV (Real power a 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 of the network is not excessively raised at the point of connection.						
		EHV HV LV			Comments				
Headroom	Thermal Cable:		0%		No expected benefit				
Release (%)	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	65,000			Assumed cost to operate secure and high availability communications				
-	Expenditure:	£5,000			channels.				
	NPV of Opex:	f	£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 (£):	f	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 (%):			No expected benefit					
	'ear solution is available:	2012			The solution is used in a very small number of instances, but not yet widespread.				
Year da	ata (on soln) is available:			<u></u>					
					2 LCNF. 11kV Generator support				
Smart Solution	Smart Solution Set:								
Relevance (WS3					nanagement of two way power flows				
Ph1)	Subset:	Intelli	Intelligent voltage control						

Solution Overview	Representative Solution:	Generator Providing Network Support, e.g. PV Mode						
	Variant Solution:	Gene	rator s	uppor	t @ 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 of the network is not excessively raised at the point of connection.						
		EHV	HV	LV	Comments			
Headroom	Thermal Cable:	0%			No expected benefit			
Release (%)	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				Assumed cost to operate secure and high availability communications			
-	Expenditure:				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	e 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 (%):			No expected benefit				
	Year solution is available:		2012		The solution is used in a very small number of instances, but not yet widespread.			
Year d	ata (on soln) is available:							
	Source of Data:							
Smart Solution	Smart Solution Set:							
Relevance (WS3					nanagement of two way power flows			
Ph1)	Subset:	Intelligent voltage control						

Solution Overview	Representative Solution:	Genera	ator	Cons	traint Management, GSR (Generator Side Response)				
	Variant Solution:	LV GSR	(Gen	(Generator Side Response)					
	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	Thermal Cable:			0%	No anticipated benefit				
Release (%)	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:	£2	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 (£):	£2	27,106	ò	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 da	ta (on soln) is available:		2014						
					ntly in tests with ENW Tier 1,				
Smart Solution	Smart Solution Set:								
Relevance (WS3					nanagement of two way power flows				
Ph1)	Subset:	Intelligent voltage control							

Solution	Representative	Generator Constraint Management, GSR (Generator Side Response)						
Overview	Solution:			norat	ar Cida Daspansa)			
	Variant Solution:	HV GS	SR (Ge	nerat	or 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	Thermal Cable:		0%		No anticipated benefit			
Release (%)	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:	:	£28,42	5	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 (£):	f	E108,42	5	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 Variab Losses (9		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 da	ita (on soln) is available:		2014					
	Source of Data:	STAT	COM -	curre	ntly in tests with ENW Tier 1,			
Smart Solution	Smart Solution Set:	Smart	t D-Ne	twork	is 2			
Relevance (WS3	Focus:	DG co	nnect	ions, i	management of two way power flows			
Ph1)	Subset:	Intelli	gent v	oltage	e control			

Solution Overview	Representative Solution:	Gene	erator	Cons	Generator Constraint Management, GSR (Generator Side Response)				
	Variant Solution:	EHV (GSR (G	enera	tor 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	Thermal Cable:	0%			No anticipated benefit				
Release (%)	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:	ł	£150,00	0	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 (th principle benefit to the generator would be a cheaper and/or quicker connection).				
	NPV of Opex:		£11,454	ł	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 (£):	ł	£221,06	2	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 (%): Impact on quality of Supply (%):			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.					
				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 da	ta (on soln) is available:		2014						
	Source of Data:	UKPN	l - Low	Carbo	on London; SSE - Orkney ANM RPZ scheme / NINES				
Smart Solution	Smart Solution Set:								
Relevance (WS3	Focus:	DG co	onnect	ions, r	nanagement of two way power flows				
Ph1)	Subset:	Intelli	igent v	oltage	e control				

Solution Overview	Representative Solution:	Fault Cur	Fault Current Limiters							
	Variant Solution:	HV Superc	onduct	ting 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	Thermal Cable:	0%		No expected benefit						
Release (%)	Thermal Transformer:	0%		No expected benefit						
	Voltage Head:	0%		No expected benefit						
	Voltage Leg:	0%		No expected benefit						
	Power Quality:	10%	5	No expected benefit						
	Fault Level:	50%	5	Potentially significant increases in FL headroom						
Cost (£)	Capital:	£500,0	000	Units are currently limited in volume, and are consequently high cost						
	Operational Expenditure:	£20	D	Additional maintenance in the initial stages of deployment						
	NPV of Opex:	£2,84	12	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						
Lif	e 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 (£):	£502,8	342	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 (£):	£10,0	00	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%	5	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 (%):			No expected benefit						
Year solution is available:		201	5	Some units are currently on-trial on networks, but have not yet been deployed 'in anger'						
Year o	data (on soln) is available:	201	5	information from existing projects						
	Source of Data:	Northern	Powerg	grid						
Smart Solution	Smart Solution Set:	Smart D-N	etworl	ks 2						
Relevance (WS			DG connections, management of two way power flows							
Ph1)		Fault limit								

Solution Overview	Representative Solution:	Fault Current Limiters						
	Variant Solution:	HV Non-su	IV Non-superconducting fault current limiters					
	Description:		The use of non-superconducting (eg. magnetic) materials, as a form of non-linear r clamp fault current levels at HV to within predefined limits.					
		EHV HV	LV	Comments				
Headroom	Thermal Cable:	0%		No expected benefit				
Release (%)	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:	£500,0	00	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:	£2,84	2	Based on 20 year of annual operating expenditure @ 3.5% discount rate				
	Cost Curve Type:			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				
Li	fe 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 (£):	£502,8	42	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 (£):	£10,00	00	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	5	Some units are currently on-trial on networks, but have not yet been deployed 'in anger'				
Year	data (on soln) is available:	2015	5	information from existing projects				
	Source of Data:	Northern F	owerg	rid				
Smart Solution	n Smart Solution Set:	Smart D-N	etwork	rs 2				
Relevance (WS Ph1)	53 Focus: Subset:	DG connec Fault limiti		management of two way power flows rices				
	0.0000							

Solution	Representative	Fault	Curr	nt Li	miters						
Overview	Solution:	Fault Current Limiters									
	Variant Solution:	HV re	HV reactors - mid circuit								
	Description:	The application of reactors part way down a HV circuit to limit fault current.									
		EHV	HV	LV	Comments						
Headroom	Thermal Cable:		0%		No expected benefit						
Release (%)	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		£100		estimate						
	Expenditure:										
	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	L	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						
Y	ear solution is available:		2012		Solutions are available today, although not typically used at LV						
Year da	ata (on soln) is available:				· - · ·						
	Source of Data:										
Smart Solution	Smart Solution Set:	Smart	: D-Ne	twork	s 2						
Relevance (WS3	Focus:	DG co	nnect	ions, r	management of two way power flows						
Ph1)	Subset:	Fault	limitir	g dev	ices						

Solution Overview	Representative Solution:	Fault	Curre	ent Li	miters				
		EHV S	uperc	onduc	ting fault current limiters				
	Description:	The u	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	Thermal Cable:	0%			No expected benefit				
Release (%)	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:	f	2750,00	0	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	e 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 (£):	f	752,84	2	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				
	ear solution is available:		2018		estimate				
Year d	ata (on soln) is available:		2018		information from existing projects				
	Source of Data:	UKPN	ETIp	roject	. SFCL on Bus section				
Smart Solution	Smart Solution Set:	Smart	t D-Ne	twork	s 2				
Relevance (WS3	Focus:	DG cc	nnect	ions, r	nanagement of two way power flows				
Ph1)	Subset:	Fault	limitin	g dev	ices				

Solution Overview	Representative Solution:	Fault Current Limiters							
	Variant Solution:	EHV N	Non-su	iperco	nducting 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.						
		EHV	HV	LV	Comments				
Headroom	Thermal Cable:	0%			No expected benefit				
Release (%)	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:	ł	£750,00	0	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	i	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)				
Li	fe 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 (£):	t	£752,84	2	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	D	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	I ETI p	roject	SFCL on Bus section				
Smart Solution	n Smart Solution Set:	Smar	t D-Ne	twork	is 2				
Relevance (WS	53 Focus:	DG co	onnect	ions, r	management of two way power flows				
Ph1)	Subset:	Fault	limitin	ng dev	ices				

Solution Overview	Representative Solution:	Enha	nced /	Autor	natic voltage Control (EAVC)			
overview		LV PoC voltage regulators						
	As the network starts to operate closer to these limits, DNOs may opt to introduce addition 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 EA system. This variant considers voltage regulation devices located at individual customers' premesis' businesses. These units maintain voltage to a single, or very small number of customers, an be suitable for both customers located near to a distribution substation (high volts) or thos located at the furthest point from the distribution substation (low volts)							
		EHV	ΗV	LV	Comments			
Headroom	Thermal Cable:			0%	No expected benefit			
Release (%)	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 I	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			
Ye	ear solution is available:		2012		Solutions are in use today, but not at scale			
	ta (on soln) is available:		2013		More learning to come from WPD and ENWL projects			
		Powe		ctor -	currently in tests with ENW Tier 1, WPD PhD@ Aston uni			
	Smart Solution Set:		•					
Smart Solution	Smart Sommon Ser							
Smart Solution Relevance (WS3					nanagement of two way power flows			

Solution Overview	Representative Solution:	Enhar	nced	Autor	natic voltage Control (EAVC)			
		LV circuit voltage regulators						
	As the autom transfo systen This va electro They r config	e netw natic v ormer n. ariant onic o may be uratio	ork st oltage s. Tog consie r mec e singl	arts to operate closer to these limits, DNOs may opt to introduce additional e control devices over and above those located at the grid and primary ether these new and existing voltage control devices will constitute an EAVC ders an in-line voltage regulator for LV circuits. These units may be power hanical in their nature, but all aim to optimise voltages on a given network. e, three or even two phase in their setup, depending on their size and				
		EHV	HV	LV	Comments			
Headroom Release (%)	Thermal Cable: Thermal Transformer:			0% 0%	No expected benefit 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:	f	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	e Expectancy of Solution:	20			Estimated life expectancy of this type of equipment			
Merit Order	Totex (£):	f	12,000	1	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			
	ear solution is available:		2012		Solutions are in use today, but not at scale			
Year d	ata (on soln) is available:		2013		More learning to come from WPD and ENWL projects			
	Source of Data:							
Smart Solution	Smart Solution Set:	Smart	D-Net	twork	s 2			
Relevance (WS	B Focus:	DG co	nnecti	ions, r	nanagement of two way power flows			
Ph1)	Subset:	Intellig	gent v	oltage	control			

Solution	Representative	IEnnanced Automatic Voltage Control (EAVC)							
Overview	Solution:								
	Variant Solution:								
					arts to operate closer to these limits, DNOs may opt to introduce additional				
				-	e control devices over and above those located at the grid and primary				
				rs. Tog	ether these new and existing voltage control devices will constitute an EAVC				
		syster	n.						
	Description:								
					ders 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.							
				-	le, three or even two phase in their setup, depending on their size and				
		ľ	guratio						
	7	EHV	HV	LV	Comments				
Headroom	Thermal Cable:		0%		No expected benefit				
Release (%)	Thermal Transformer:		0%		No expected benefit				
					Could be used to resolve high volts issues for a number of customers				
	Voltage Head:		6%						
	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)				
(,	· · · · · · · · · · · · · · · · · · ·				Assumed to be "fit and forget" maintenance-free devices - therefore no				
-	Operational	£0			ongoing operational expenditure assumed for this solution.				
	Expenditure:								
	NPV of Opex:	£0							
					Based on 20 year of annual operating expenditure @ 3.5% discount rate				
	Cost Curve Type:				LV application could see such a unit becoming relatively high volume, with				
					sharp roll-off rates				
	fe Expectancy of Solution:				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)				
					These products could be easily redeployed as other (more widespread)				
	Flexibility (1-5):		4		solutions are used				
	Cross Network				Potential to allow HV volts to operate outside of statutory limits (whilst				
	Benefits Factor:		1		ensuring LV customers receive volts within limits)				
Other	Impact on Fixed		201		Lossy devices, expected to give rise to a small increase in losses				
Benefits	Losses (%):		2%						
	Impact on Variable		0%		No change to variable losses anticipated with this solution				
	Losses (%):		0%						
	Impact on quality of		001		No expected benefit				
		0%							
	Year solution is available:		2012		Solutions are in use today, but not at scale				
	data (on soln) is available:		2013		More learning to come from WPD and ENWL projects				
	Source of Data:	Shunt	react	ors					
Smart Solution					s 2				
Relevance (WS					nanagement of two way power flows				
Ph1)				,	e control				

Solution Overview	Representative Solution:	Enha	nced	Autor	natic voltage Control (EAVC)				
	Variant Solution:	EHV c	circuit	voltag	e 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 L		LV	Comments				
Headroom	Thermal Cable:	0%			No expected benefit				
Release (%)	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	e 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				
١	ear solution is available:		2012		Solutions are in use today, but not at scale				
Year d	ata (on soln) is available:		2013		More learning to come from WPD and ENWL projects				
	Source of Data:	Shunt	t react	ors					
Smart Solution	Smart Solution Set:	Smart	t D-Ne	twork	s 2				
Relevance (WS3	B Focus:	DG co	onnect	ions, r	nanagement of two way power flows				
Ph1)	Subset:	Intelli	igent v	oltage	e control				

Solution Overview	Representative Solution:	IENNANCED AUTOMATIC VOITAGE CONTROL (EAVC)							
		HV/L\	/ Tran	sform	er 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							
		This variant considers a tappable distribution transformer that can alter the LV busbar vo accommodate the different requirements of the LV feeders.							
		EHV	HV	LV	Comments				
Headroom	Thermal Cable:			0%	No expected benefit				
Release (%)	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:				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 40			Not expected to be a high volume commodity in the short term, but costs could easily drop as volumes increase				
Life	Expectancy of Solution:				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		1		Potential to allow HV volts to operate outside of statutory limits (whilst				
	Benefits Factor:		T		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				
١	fear solution is available:								
Year d	ata (on soln) is available:								
	Source of Data:								
Smart Solution	Smart Solution Set:	Smar	t D-Ne	twork	s 2				
Relevance (WS3	B Focus:	DG cc	nnect	ions, r	nanagement of two way power flows				
Ph1)	Subset:	Intelli	gent v	oltage	e control				

Solution Overview	Representative	Embedded DC Networks								
Overview	Solution: Variant Solution:	Embe	dded	ഥറ്രം	N.					
	Description:	Embedded DC@LV 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:	f	£125,00	0	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:				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 (£):	f	E 132,1 0	6	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	0	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					
Ye	ear solution is available:									
	ta (on soln) is available:									
		No Su	pport	ing LC	N funds as of 2012					
Smart Solution	Smart Solution Set:									
Relevance (WS3					rks inc. physical threats, utilising new network architectures					
Ph1)	Subset:	DC ne	etwork	s (eg l	nome / community) integrated with AC system					

Solution Overview	Representative Solution:	Embe	edded	DC	letworks					
	Variant Solution:	Embe	dded I	DC@F	IV					
	Description:		The application of point-to-point HV DC circuits to feed specific loads (used in a similar manner 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:	f	250,00	0	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		2	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	e Expectancy of Solution:		40		Expected to live as long as conventional assets (such as ac transformers or cables)					
Merit Order	Totex (£):	f	321,06	2	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					
Y	Year solution is available:									
Year d	ata (on soln) is available:									
					N funds as of 2012					
Smart Solution	Smart Solution Set:	Smart	D-Ne	twork	s 4					
Relevance (WS			· ·		rks inc. physical threats, utilising new network architectures					
Ph1)	Subset:	DC ne	etwork	s (eg	home / community) integrated with AC system					

Solution	Representative	I Empedded DC Networks						
Overview	Solution:		<u></u>					
	Variant Solution:	Embe	dded [DC@E	HV			
	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 Not expected to give gains to transformer rating (end power converters will			
	Thermal Transformer:	0%			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:	f	500,00	D	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 (£):	f	642,12	4	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			
Ye	ear solution is available:							
	ta (on soln) is available:							
		No Su	ipporti	ng LC	N funds as of 2012			
Smart Solution	Smart Solution Set:							
Relevance (WS3	Focus:	Secur	ity of r	netwo	rks inc. physical threats, utilising new network architectures			
Ph1)	Subset:	DC ne	twork	s (eg l	nome / community) integrated with AC system			

Solution Overview	Representative	Lectrical Energy Storage							
overview	Solution: Variant Solution:	LV connected EES - small							
	Description:	Electri proper of the	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 apacity (MW and MWh) of the units.						
				_	nis variant is 50kW; 100kWh.				
Headroom		EHV	HV	LV	Comments Determined in the Model (DM): In a similar vein to Residential DSR, this EES solution is deployed in				
Release (%)	Thermal Cable:			DM	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. EES would typically be used to flatten peaks created by generation (e.g. high volts resulting from PV				
	Voltage Head:			DM	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. No modelled benefit (it is noted that the converter on the battery unit may provide some power				
	Power Quality:			0%	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:	£2	250,00	0	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		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:				or initialitie of GB.				
		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 (£):	£2	251,42	1	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 (£):	f	E2,500		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.				
benents	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				
	ear solution is available:		2015		Estimate - based on solutions being available for purchase (for trial)				
Year da	ata (on soln) is available: Source of Data:	NPG-C	LNR.	SSE NI	l INES				
Smart Solution	Smart Solution Set:								
Relevance (WS3					nanagement of two way power flows				
Ph1)	Subset:	Utilise	stora	ge at	domestic, substation and community level				

Overview	Representative	Electrical Energy Storage							
C VCI VIEW	Solution: Variant Solution:	LV cor	nnecte	ed EES	s - medium				
	Description:	Electrical Energy Storage (EES) technologies (medium-sized LV connected batteries, e.g. street level) deployed on 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 an 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		£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: f1,421 Cost Curve Type: 4		4 L n o 20 p q n		Based on 20 year of annual operating expenditure @ 3.5% discount rate In 2012, EES units are not readily available off-the-shelf, with typical lead-times of 6-18 months. Thi 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:					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 (£):	£	301,42	1	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	2			Solution is likely to provide a benefit to HV networks				
	Benefits Factor:								
Other Benefits	Benefits Factor: 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 Fixed Losses (%): Impact on Variable		20% -10%		100% - this differs by manufacturer and storage type. As DSR, this solution has the ability to reduce the losses down a circuit by reducing the peak demand				
	Impact on Fixed Losses (%): Impact on Variable Losses (%): Impact on quality of				100% - this differs by manufacturer and storage type.				
Benefits	Impact on Fixed Losses (%): Impact on Variable Losses (%):		-10%		100% - this differs by manufacturer and storage type. 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).				
Benefits Y	Impact on Fixed Losses (%): Impact on Variable Losses (%): Impact on quality of Supply (%): ear solution is available: ata (on soln) is available:		-10% 0% 2015	SSE N	100% - this differs by manufacturer and storage type. 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). This solution is not expected to give any benefit to QoS				
Benefits Y	Impact on Fixed Losses (%): Impact on Variable Losses (%): Impact on quality of Supply (%): ear solution is available: ata (on soln) is available: Source of Data: Smart Solution Set:	NPG- I Smart	-10% 0% 2015 CLNR,	twork	100% - this differs by manufacturer and storage type. 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). This solution is not expected to give any benefit to QoS Estimate - based on solutions being available for purchase (for trial) UNES; SSE NTVV				

Solution Overview	Representative	Electi	Electrical Energy Storage						
	Solution: Variant Solution:	LV cor	nnecte	ed EES	- large				
	Description:	Electrical Energy Storage (EES) technologies (large LV connected batteries, e.g. at the distribution substati on a network to either deliver the peak demand, or absorb high levels of generation at key times of the d charge cycles of EES can be tuned to local network conditions, but is ultimately a function of the capacity 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. EES would typically be used to flatten peaks created by generation (e.g. high volts resulting from PV				
	Voltage Head:			DM	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 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 influences of 6.2				
Life	Expectancy of Solution:				or influence of GB.				
		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 (£):	£	351,42	1	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				
	ear solution is available: ata (on soln) is available:		2015		Estimate - based on solutions being available for purchase (for trial)				
real ua	Source of Data:	NPG-	CLNR.	SSE N	INES; SSE NTVV				
Smart Solution	Smart Solution Set:								
Relevance (WS3					nanagement of two way power flows				
Ph1)	Subset:	Utilise	e stora	ge at	domestic, substation and community level				

Solution Overview	Representative Solution:	Electrical Energy Storage								
	Variant Solution:	HV connected EES - small								
	Description:	deliver can be	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. EES would typically be used to flatten peaks created by generation (e.g. high volts resulting from PV					
	Voltage Head:		DM		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)					
(c-+) (f)	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 (£)	t (£) Capital: £3,400,000		00	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:	f	3,553		Based on 20 year of annual operating expenditure @ 3.5% discount rate					
	Cost Curve Type: 3 Life Expectancy of Solution:		3 <u>-</u>		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.					
			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,	,403,55	3	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 (f):	£	10,000		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report) Most types of EES could be relocated or expanded in a modular manner as the need to peak lop					
	Flexibility (1-5): Cross Network		3		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. Solution will provide a benefit to LV and EHV networks					
	Benefits Factor:		2		Solution will provide a deficite to Ev and ETTV HELWOIKS					
Other	Impact on Fixed		15%		This solution is will increase fixed losses as the round-trip efficiency of a storage unit is less than					
Benefits	Losses (%): Impact on Variable Losses (%):		-5%		100% - this differs by manufacturer and storage type. 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 d	ata (on soln) is available: Source of Data:			SSE 1	MW Shetland					
Smart Solution										
Relevance (WS					nanagement of two way power flows					
Ph1)					domestic, substation and community level					

Solution Overview	Representative Solution:	Flectrical 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:	£3,8	£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:	ł	£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 20			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:				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	3	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 (£):	£1	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		2		Solution will provide a benefit to LV and EHV networks					
Other Benefits	Benefits Factor: 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		-10%		As DSR, this solution has the ability to reduce the losses down a circuit by reducing the peak demand (loss current, therefore loss beating loss)					
	Losses (%): Impact on quality of Supply (%):		0%		(less current, therefore less heating loss). This solution is not expected to give any benefit to QoS					
	ear solution is available:	2	2015		Estimate - based on solutions being available for purchase (for trial)					
Year d	ata (on soln) is available: Source of Data:	NPG- C		SSF 1	MW Shetland					
Smart Solution	Smart Solution Set:									
Relevance (WS		DG con	inectio	ons, r	nanagement of two way power flows					
Ph1)	Subset:	Utilise	storag	ge at	domestic, substation and community level					

Solution Overview	Representative Solution:	Electrical Energy Storage									
	Variant Solution:	HV cor	nnecte	d EES	5 - large						
	Description:	peak d to loca	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.								
		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:	£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:				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 Cost Curve Type: 3 Life Expectancy of Solution: 20		lı is 3 s		Based on 20 year of annual operating expenditure @ 3.5% discount rate 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.						
Lin			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,	,203,55	3	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) Most types of EES could be relocated or expanded in a modular manner as the need to peak lop						
	Flexibility (1-5):		2		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: lata (on soln) is available:		2015		Estimate - based on solutions being available for purchase (for trial)						
Smort Colutio	Source of Data:										
Smart Solution	Smart Solution Set:		v-ivet	work	52						
Relevance (WS	3 Focus:	DG cor	nnecti	ons r	nanagement of two way power flows						

Solution Overview	Representative Solution:	Electrical Energy Storage							
	Variant Solution:	EHV c	onnected I	ES - small					
	Description:	Electrical Energy Storage (EES) technologies (smaller-sized EHV connected batteries) deployed on a network to e deliver the peak demand, or absorb high levels of generation at key times of the day/year. The charge cycles of can be tuned to local network conditions, but is ultimately a function of the capacity (MW and MWh) of the unit Storage size for this variant is 7.5MW; 15MWh.							
		EHV	HV LV						
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. EES would typically be used to flatten peaks created by generation (e.g. high volts resulting from PV					
	Voltage Head:	DM		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 (£)	t (£) Capital: £13,600,000		3,600,000	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 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:	pe: 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.					
L	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 (£):	£1	3,607,106	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:	L	2	Solution will provide a benefit to HV networks					
Other	Impact on Fixed		15%	This solution is will increase fixed losses as the round-trip efficiency of a storage unit is less than					
Benefits	Losses (%): Impact on Variable Losses (%):		-5%	100% - this differs by manufacturer and storage type. 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)					
				echnology project work on EES					
Smart Solution									
Relevance (WS Ph1)				management of two way power flows					
PN1)	Subset:	Utilise	e storage a	t domestic, substation and community level					

Solution Overview	Representative Solution:	Elect	rical Ener	gy 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.								
		EHV	HV L\	/ 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 (£)	i ost (£) Capital:		5,200,000	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	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 (£):	£1	5,207,106	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 (£):	1	£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		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		-10%	As DSR, this solution has the ability to reduce the losses down a circuit by reducing the peak demand (loss surrout therefore loss botting loss)						
	Losses (%): Impact on quality of Supply (%):		0%	(less current, therefore less heating loss). This solution is not expected to give any benefit to QoS						
١	Year solution is available:		2015	Estimate - based on solutions being available for purchase (for trial)						
Year d	lata (on soln) is available:		0 N							
Smart Solution	Source of Data: Smart Solution Set:			Technology project work on EES						
Relevance (WS				, management of two way power flows						
Ph1)	Subset:			at domestic, substation and community level						

Solution Overview	Representative Solution:	Electrical Energy Storage							
	Variant Solution:	EHV c	onnected El	S - large					
	Description:	Electrical Energy Storage (EES) technologies (large EHV connected batteries) deployed on a network to either the peak demand, or absorb high levels of generation at key times of the day/year. The charge cycles of EES 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.							
		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. EES would typically be used to flatten peaks created by generation (e.g. high volts resulting from PV					
	Voltage Head:	DM		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. No modelled benefit (it is noted that the converter on the battery unit may provide some power					
	Power Quality:	0%		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:	£1	6,800,000	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.					
		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 (£):	£1	6,807,106	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 (f):	ł	10,000	Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report) Most types of EES could be relocated or expanded in a modular manner as the need to peak lop					
	Flexibility (1-5):		2	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.					
011	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: data (on soln) is available:		2015	Estimate - based on solutions being available for purchase (for trial)					
				chnology project work on EES					
Smart Solution			D-Network						
Relevance (WS Ph1)	3 Focus: Subset:			nanagement of two way power flows domestic, substation and community level					

Solution Overview	Representative Solution:	Electrical Energy Storage							
	Variant Solution:	EES -	ES - HV Central Business District (commercial building level)						
Description		The D comn NB. T	NO's i nercial he prii	use of I contr mary (storage located in a large HV connected commercial building (e.g. large office block, bank, etc) via a ract with a building owner. Jse of the storage for the building owner may be for UPS (Uniterruptable Power Supply) reasons. nis 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 £1,128,763		10	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:			63	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 (£):	£	1,138,7	63	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	0	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				
١	Year solution is available:		2016		Estimate				
Year d	ata (on soln) is available:								
	Source of Data:								
Smart Solution	Smart Solution Set:	Smar	t build	ings a	nd connected communities				
Relevance (WS					gs and all aspects of new Built Environments				
Ph1)	Subset:	Buildings provide energy storage (heat/elec) services							

Solution Overview	Representative Solution:	DSR	R							
	Variant Solution:									
	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 (£):		£95,303	1	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	D	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					
Y	'ear solution is available:		2012		Limited deployment with 1x in place for one DNO in 2012					
Year d	ata (on soln) is available:		2014		Expect further information to be available following the successful outcome of LCN Fund projects					
	Source of Data:	UKPN	- Flex	tricity	WPD FALCON, plus information based on real deployments at HV by 1x DNO					
Smart Solution	Smart Solution Set:	Smar	t D-Ne	twork	s 2					
Relevance (WS3					nanagement of two way power flows					
Ph1)					gated for LV & HV network management					

Solution Overview	Representative Solution:	DNO to commercial DSR (direct with EHV customers)								
overview	Variant Solution:									
	Description:									
		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	£35,000			Payments to customer on an annual basis. NB. This is an initial estimate, and					
	Expenditure:	200,000			would be subject to further scrutiny and analysis.					
	NPV of Opex:	1	£158,02	7	Based on 5 year of annual operating expenditure @ 3.5% discount rate Flat cost, linked to the duration of the commercial contract and the relatively					
	Cost Curve Type:				short life expectancy.					
Life	Expectancy of Solution:				All DSR contracts are deemed to be in place for a maximum of 5 years.					
Merit Order	Totex (£):	ł	E163,02	7	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.					
Schents	Impact on Variable				Solution has the ability to reduce the losses down a circuit by reducing the					
	Losses (%):		-20%		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					
Y	fear solution is available:		2012		Limited deployment with 1x in place for one DNO in 2012 (albeit at HV)					
Year d	ata (on soln) is available: Source of Data:	UKPN	2015 I - Flex		Expect further information to be available following the successful outcome of LCN Fund projects , WPD FALCON, plus information based on real deployments at EHV by 1x DNO					
Smart Solution	Smart Solution Set:	Smar	t D-Ne	twork	s 2					
Relevance (WS3					nanagement of two way power flows					
Ph1)					gated for LV & HV network management					

Solution Overview	Representative Solution:	IDSK									
	Variant Solution:	DNO	to agg	regeto	or led commercial DSR (HV customer)						
	Description:	Demand Side Response contract between a DNO and an Aggregator (who in turn contracts with 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	L	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						
	fear solution is available:		2012		Commercial contract in place today under the Equalised Incentive of DPCR5.						
Year d	ata (on soln) is available: Source of Data:	Basec	2012 d on 1x	DNO	Solution in place 's EHV solution (DNO not named for reasons of commercial confidentiality)						
Smart Solution	Smart Solution Set:	Smar	t D-Ne	twork	s 2						
Relevance (WS					nanagement of two way power flows						
Ph1)					gated for LV & HV network management						

Solution Overview	Representative Solution:	DSR							
overnen		DNO	to agg	reget	or led commercial DSR (EHV customer)				
	Description:	Demand Side Response contract between a DNO and an Aggregator (who in turn contracts with 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				
	Operational Expenditure:	1 £200.000		00	contracts between the DNO and the aggregator. £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 (£):	ł	£923,01	.0	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	0	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		-20%		Solution has the ability to reduce the losses down a circuit by reducing the				
	Losses (%):				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				
Ye	ear solution is available:		2012		Commercial contract in place today under the Equalised Incentive of DPCR5.				
Year da	ta (on soln) is available:		2012		Solution in place				
					ed for reasons of commercial confidentiality)				
Smart Solution	Smart Solution Set:								
Relevance (WS3					nanagement of two way power flows				
Ph1)	Subset:	DK SE	ervices	aggre	gated for LV & HV network management				

Solution	Representative	DSR								
Overview	Solution:									
	Variant Solution:									
	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		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					
Cost (£)	Fault Level: Capital:		£1,000	0%	No expected benefit 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	£100			This is annual operating expenditure required for communications to LV					
	Expenditure:				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 Flat cost, linked to the duration of the commercial contract and the relatively					
Life	Cost Curve Type: Expectancy of Solution:	2			short life expectancy.					
		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 (£):	£	100,00	0	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 da	ta (on soln) is available: Source of Data:	55F - N		NPG	- CI NR					
Smart Solution	Smart Solution Set:									
Relevance (WS3 Ph1)	Focus:	DG co	nnect	ions, r	nanagement of two way power flows gated for LV & HV network management					

Solution Overview	Representative Solution:	DSR										
	Variant Solution:	DNO 1	to Cen	tral b	usiness 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	3	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		-20%		Solution has the ability to reduce the losses down a circuit by reducing the							
	Losses (%):				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							
	ear solution is available:		2016		Assumed incremental development, but no known live projects at time of writing							
Year da	ta (on soln) is available:		2015		estimate							
	Source of Data:											
Smart Solution					nd connected communities							
Relevance (WS3					gs and all aspects of new Built Environments							
Ph1)	Subset:	Buildi	ngs pr	ovide	DR services and DG services							

Solution Overview	Representative Solution:	Distribution Flexible AC Transmission Systems (D-FACIS)								
	Variant Solution:	D-FA	CTS@ I	LV						
	Description:		Series or shunt connected static power electronics as a means to enhance controllability ar increase power transfer capability of the LV 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 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%		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	L	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					
Y	ear solution is available:		2016		Assumed incremental development, but no known live projects at time of writing					
Year data (on soln) is available:			2015		estimate					
.cur uu	Source of Data:		0							
					•					
Smart Solution	Smart Solution Set:	Smar	t D-Ne	twork	S 3					
Smart Solution Relevance (WS3	Smart Solution Set: Focus:				s 3 eliability, failure mode detection					

Solution Overview	Representative Solution:	Distribution Flexible AC Transmission Systems (D-FAC15)								
	Variant Solution:									
	Description:		Series or shunt connected static power electronics as a means to enhance controllability and increase power transfer capability of the HV network							
		EHV H	V LV	Comments						
Headroom Release (%)	Thermal Cable:	89	6	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:	49	6	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:	89	6	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:	89	6	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%	6	D-FACTS are considered to have a limited ability to change network fault levels						
Cost (£)	Capital:	£100,000		Estimate						
	Operational Expenditure:	£20	00	Estimate (annual cost) - principally communications / monitoring costs						
	NPV of Opex:	£2,8	42	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 (£):	£10,0	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 Repofits	Impact on Fixed	10	%	Assumed to increase fixed losses, as the devices are not lossless, and energy is						
Benefits	Losses (%): Impact on Variable Losses (%):	-20	%	required to operate the units. Potentially significant improvement on network losses by minimising VAr flow down a circuit.						
	Impact on quality of Supply (%):	0%	6	This solution is not anticipated to improve QoS						
Ye	ear solution is available:	201	12	Solutions are available today, albeit they are not widely used in GB						
	ta (on soln) is available:									
	Source of Data:	UKPN Fle	xible pl	ug and play						
Smart Solution	Smart Solution Set:									
Relevance (WS3				reliability, failure mode detection						
Ph1)	Subset:	Loss optir	nisatio	n techniques - utilise new devices such as D-FACTS						

Solution Overview	Representative Solution:	Distribution Flexible AC Transmission Systems (D-FACTS)								
	Variant Solution:	D-FA	CTS@ I	ΗV						
	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.					
(c)	Fault Level:	5%			D-FACTS are considered to have a limited ability to change network fault levels					
Cost (£)	Capital:	ł	£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 (£):	ł	E 202,8 4	2	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	Impact on Fixed		10%		Assumed to increase fixed losses, as the devices are not lossless, and energy is					
Benefits	Losses (%):				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					
Ye	ear solution is available:		2016		Assumed incremental development, but no known live projects at time of writing					
	ta (on soln) is available:		2015		estimate					
	Source of Data:									
Smart Solution	Smart Solution Set:	Smar	t D-Ne	twork	is 3					
Relevance (WS3	Focus:				eliability, failure mode detection					
					techniques - utilise new devices such as D-FACTS					

Solution Overview	Representative Solution:	Distr	Distribution Flexible AC Transmission Systems (D-FACTS)						
	Variant Solution:	LV co	nnecte	ed STA	тсом				
	Description:	STATCOMs (Static Synchronous Compensators) are power electronics device, capable of injecti 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:		£30,00	C	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				
Li	ife Expectancy of Solution:		40		Assumed to have a similar asset life to modern switchgear / transformers				
Merit Order	Totex (£):		£31,42	1	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	D	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		1		Some potential to give benefits to HV networks				
	Benefits Factor:								
Other	Impact on Fixed		10%		Assumed to increase fixed losses, as the devices are not lossless, and energy is				
Benefits	Losses (%):				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 Vo	Itage Regulation,				
Smart Solution									
Relevance (WS					enhancements to existing network architecture				
Ph1)	Subset:	Wave	veform monitoring and waveform correction devices						

Solution Overview	Representative Solution:	Distribution Flexible AC Transmission Systems (D-FACTS)									
	Variant Solution:	HV co	nnect	ed ST/	ATCOM						
	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	ΗV	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:	f	150,00	0	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 (£):	f	152,84	2	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 (£):	ł	E10,000)	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 Bonofits	Impact on Fixed		10%		Assumed to increase fixed losses, as the devices are not lossless, and energy is required to operate the units.						
Benefits	Losses (%): Impact on Variable		-25%		Potentially significant improvement on network losses by minimising VAr flow						
	Losses (%): Impact on quality of				down a circuit. This solution is not anticipated to improve QoS						
	Supply (%):		0%								
Y	ear solution is available:		2012		Solutions are available today, albeit they are not widely used in GB						
Year da	ata (on soln) is available:		2014		WPD T1 project Nr Falmouth						
	Source of Data:	WPD	IFI T1	nr Fal	mouth?						
Smart Solution	Smart Solution Set:										
Relevance (WS3			· .		enhancements to existing network architecture						
Ph1)	Subset:	Wave	form r	nonit	oring and waveform correction devices						

Solution Overview	Representative Solution:	Distri	Distribution Flexible AC Transmission Systems (D-FACTS)					
	Variant Solution:	EHV c	onnec	ted S	TATCOM			
	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:	f	250,00	0	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	e Expectancy of Solution:		40		Assumed to have a similar asset life to modern switchgear / transformers			
Merit Order	Totex (£):	f	252,84	2	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			
	ata (on soln) is available:		2015		estimate			
	Source of Data:				•			
Smart Solution	Smart Solution Set:	Smart	<u>D-Ne</u>	twork	is 1			
Relevance (WS	B Focus:	Qualit	ty of s	upply;	enhancements to existing network architecture			
	Waveform monitoring and waveform correction devices							

Solution Overview	Representative Solution:	Active	e Net	work	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	ΗV	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. Marginal improvement in PQ through alignment of load/network impedance						
	Power Quality:			5%							
0	Fault Level:			0%	Solution not anticipated to affect network fault level						
Cost (£)	Capital:	f	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: Cost Curve Type:	:	£1,421		Based on 20 year of annual operating expenditure @ 3.5% discount rate 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 (£):	f	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						
	fear solution is available:		2016		Assumed incremental development, but no known live projects at time of writing						
Year d	ata (on soln) is available:		2015		estimate						
Concert C. J. et					2 model and report						
Smart Solution Relevance (WS3	Smart Solution Set:				s 1 enhancements to existing network architecture						
Ph1)	Subset:										
	Subset:	meme	50113	WILLI	"5						

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Solution Overview	Representative Solution:	Active Network Management - Dynamic Network Recomputation								
Overview	Variant Solution:	HV								
	Variant Solution:	ΠV								
	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	ΗV	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 (£):	i	£53,553	1	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 da	ta (on soln) is available:		2014							
					AS (IFI); SP - Flexible Networks for a Low Carbon Future (LCNF)					
Smart Solution	Smart Solution Set:									
Relevance (WS3 Ph1)	Focus: Subset:		·		enhancements to existing network architecture ing					

Smart Variant

Solution Overview	Representative Solution:	Activ	ctive Network Management - Dynamic Network Reconfiguration							
		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	5	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					
	ear solution is available:		2012		Solutions are available today, albeit they are not widely used in GB					
Year da	ta (on soln) is available:	0.0-	2014		SP - Flexible Networks for a Low Carbon Future					
					2 model and report					
Smart Solution	Smart Solution Set:									
Relevance (WS3 Ph1)	Focus: Subset:				enhancements to existing network architecture ing					

Solution	Representative	ENAB	LER						
Overview	Solution:								
	Variant Solution:								
	Description:				the load on three phases of an HV circuit and hence determine the level of the set ween phases				
		IIIDala	ince th	atexis	ts between phases				
		EHV	HV	LV	Comments				
Headroom Release (%)	Thermal Cable:		0%		-				
	Thermal Transformer:		0%		Enablers are installed to facilitate solutions, which in turn release headroom.				
	Voltage Head:		0%		Enablers themselves release no headroom.				
	Voltage Leg:		0%						
	Power Quality:		0%						
	Fault Level:		0%						
Cost (£)	Capital:	£1,0			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	£10			Small opex associated with obtaining the data from the device, but no				
	Expenditure				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-	0			The installation of enablers is a very low disruption activity and does not				
	5):				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		0		Enablers do not directly result in additional benefits to other voltage levels				
	Benefits Factor:		0						
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				Enablers facilitate solutions which may improve the quality of supply, but they				
	Supply (%):		0%		do not, in themselves, have an effect				
Year solu	tion becomes available:		2012						
	ta (on soln) is available:								
	Source of Data:	Initial	estima	tes	•				
Smart Solution	Smart Solution Set:	ENABL	.ER						
Relevance (WS3				pply ei	nhancements to existing network architecture				
Ph1)					ensors/correction (improve losses and capacity)				

Solution	Representative	IENABLEK							
Overview	Solution:								
	Variant Solution:	Phase	e imba	lance	- LV connect customer, 3 phase				
	Description:	Devic	e insta	lled a	t the interface to a customer with a three phase supply to montor the load on				
		ecah	phase	and h	ence determine the level of phase imbalance present				
		EHV	HV	LV	Comments				
Headroom	Thermal Cable:			0%					
Release (%)	Thermal Transformer:			0%	Enablers are installed to facilitate solutions, which in turn release headroom.				
	Voltage Head:			0%	Enablers are installed to facilitate solutions, which in turn release nead oom.				
	Voltage Leg:			0%					
	Power Quality:			0%					
	Fault Level:			0%					
Cost (£)	Capital:		£20		This is s a simple, low cost, 3 phase load monitoring device				
					Opex costs are very low as ther eis not a requirement to regularly update the				
	Operational		£0		load information, given that it is unlikely that the balance across the three				
	Expenditure:		10		phases will change unless the customer makes some significant change to				
					their connected equipment				
	NPV of Opex:		£3						
	NEV OI OPEX.		15		Based on 20 years of annual operating expenditure @ 3.5% discount rate				
					Addressing phase imbalance can offer a cost-effective way to release				
	Cost Curve Type:		4		headroom, meaning that a large number of these devices could be deployed,				
					hence reducing costs over time				
Life I	Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will				
			20		need to be replaced				
Merit Order	Totex (£):		£23		Calculated from above				
	Disuption Factor (1-		0		The installation of enablers is a very low disruption activity and does not				
	5):		0		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		0		Enablers do not directly result in additional benefits to other voltage levels				
	Benefits Factor:		0						
Other	Impact on Fixed		0%		Enablers do not affect the fixed losses within the network				
Benefits	Losses (%):		υ%						
	Impact on Variable		0%		Enablers do not affect the variable losses within the network				
	Losses (%):		0%						
	Impact on quality of		0%		Enablers facilitate solutions which may improve the quality of supply, but they				
	Supply (%):		0%		do not, in themselves, have an effect				
Year solut	ion becomes available:		2012						
Year dat	a (on soln) is available:								
	Source of Data:	Initial	estim	ates					
Smart Solution	Smart Solution Set:	ENAB	LER						
Relevance (WS3	Focus:	Quali	ty of si	upply	enhancements to existing network architecture				
Ph1)			· ·		sensors/correction (improve losses and capacity)				

Solution	Representative	tative ENABLER						
Overview	Solution:							
	Variant Solution:	Phase	e imba	lance	-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	Thermal Cable:			0%				
telease (%)	Thermal Transformer:			0%	Enablers are installed to facilitate solutions, which in turn release headroom.			
	Voltage Head:			0%	Enablers themselves release no headroom.			
_	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 solut	tion becomes available:		2012					
Year da	ta (on soln) is available:							
	Source of Data:	Initial	estim	ates				
Smart Solution	Smart Solution Set:	ENAB	LER					
Relevance (WS3			· ·		enhancements to existing network architecture			
Ph1)	Subset:	Phase	e imba	lance	sensors/correction (improve losses and capacity)			

Solution	Representative	ENABLER						
Overview	Solution:							
	Variant Solution:							
	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	Thermal Cable:		0%					
Release (%)	Thermal Transformer:		0%	Fachlars are installed to facilitate colutions, which is turn release because				
	Voltage Head:		0%	Enablers are installed to facilitate solutions, which in turn release headroom.				
	Voltage Leg:		0%	Enablers themselves release no headroom.				
	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			Small opex associated with obtaining the data from the device, but no				
	Expenditure:	£5		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 solu	tion becomes available:	2012	2					
Year da	ta (on soln) is available:							
	Source of Data:	Initial estin	nates					
Smart Solution	Smart Solution Set:	ENABLER						
Relevance (WS3	B Focus:	Quality of s	supply	enhancements to existing network architecture				
Ph1)	Subset:	Phase imba	alance	sensors/correction (improve losses and capacity)				

Solution	Representative	ENABLER							
Overview	Solution:								
			hase imbalance - LV dist s/s						
	Description:								
		substation and hence determine the level of imbalance that exists between phases							
		EHV HV	LV	Comments					
Headroom	Thermal Cable:		0%						
Release (%)	Thermal Transformer:		0%						
	Voltage Head:		0%	Enablers are installed to facilitate solutions, which in turn release headroom.					
	Voltage Leg:		0%	Enablers themselves release no headroom.					
	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 E	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	5	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 solut	ion becomes available:	201	2						
Year dat	a (on soln) is available:								
	Source of Data:	Initial estir	nates						
Smart Solution	Smart Solution Set:	ENABLER							
Relevance (WS3	Focus:	Quality of	supply	enhancements to existing network architecture					
Ph1)	Subset:			sensors/correction (improve losses and capacity)					

Solution	Representative										
Overview	Solution:										
	Variant Solution:	Smar	t Mete	ering inf	rastructure -DNO to DCC 2 way control						
				-	le 2 way communication between the DNO and DCC to obtain data and enact						
		DSR									
		EHV	HV	LV	Comments						
Headroom	Thermal Cable:			0%							
Release (%)	Thermal Transformer:			0%							
	Voltage Head:			0%	Enablers are installed to facilitate solutions, which in turn release headroom.						
	Voltage Leg:			0%	Enablers themselves release no headroom.						
	Power Quality:			0%							
	Fault Level:			0%							
Cost (£)					Fairly extensive communication and IT equipment would be required to enable						
			£10,00	00	this two way communication and control; estimated at £10k						
	Capital:										
	Operational		£100		Opex in terms of costs of maintaining communications links						
	Expenditure:	1100									
	NPV of Opex:		£1,42	1							
				-	Based on 20 years of annual operating expenditure @ 3.5% discount rate						
					The costs associated with data from the DCC are very much an unknown						
	Cost Curve Type:		2		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						
			20		need to be replaced						
Merit Order	Totex (£):		£11,42	21	Calculated from above						
	Disuption Factor (1-		0		The installation of enablers is a very low disruption activity and does not						
	5):				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		0		Enablers do not directly result in additional benefits to other voltage levels						
	Benefits Factor:										
Other	Impact on Fixed		0%		Enablers do not affect the fixed losses within the network						
Benefits	Losses (%):										
	Impact on Variable		0%		Enablers do not affect the variable losses within the network						
	Losses (%):										
	Impact on quality of		0%		Enablers facilitate solutions which may improve the quality of supply, but they						
	Supply (%):				do not, in themselves, have an effect						
	tion becomes available:		2012	2							
Year da	ta (on soln) is available:	<u> </u>									
	Source of Data:			ates							
Smart Solution	Smart Solution Set:	-									
Relevance (WS3					nagement of 2 way power flows						
Ph1)	Subset:	DR se	rvices	aggrega	ated for LV and HV network management						

Solution	Representative							
Overview	Solution:	IENADLER						
	Variant Solution:	Smar	t Mete	ring ir	nfrastructure -DNO to DCC 2 way A+D			
	Description:		Equipment to enable 2 way communication between the DNO and DCC to obtain da DSR to be enacted					
		EHV	HV	LV	Comments			
Headroom	Thermal Cable:			0%				
Release (%)	Thermal Transformer:			0%	Enablers are installed to facilitate solutions, which in turn release headroom.			
	Voltage Head:			0%	Enablers are installed to facilitate solutions, which in turn release nead oom.			
	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			
	ition becomes available:		2012					
Year da	ata (on soln) is available:							
	Source of Data:	Initia	estim	ates				
Smart Solution	Smart Solution Set:							
Relevance (WS					nanagement of 2 way power flows			
Ph1)	Subset:	DR se	rvices	aggre	gated for LV and HV network management			

Solution	Representative	ENAE	BLER							
Overview	Solution:									
					frastructure - DCC to DNO 1 way					
	Description:		ment	to ena	ble 1 way communication between the DNO and DCC to obtain smart meter					
		data								
		EHV	HV	LV	Comments					
Headroom	Thermal Cable:			0%						
Release (%)	Thermal Transformer:			0%						
	Voltage Head:			0%	Enablers are installed to facilitate solutions, which in turn release headroom.					
	Voltage Leg:			0%	Enablers themselves release no headroom.					
	Power Quality:			0%						
	Fault Level:			0%						
Cost (£)					This is much simpler than the 2 way communication and control, requiring					
	Capital:		£1,000		only the flow of dta from the DCC to the DNO; hence the cost is significantly less.					
	Operational		C10		Relatively simple communications channels, hence a low annual opex cost to					
	Expenditure:	£10			maintain these links					
	NDV of Oreau		£142							
	NPV of Opex:		1142		Based on 20 years of annual operating expenditure @ 3.5% discount rate					
					The costs associated with data from the DCC are very much an unknown					
	Cost Curve Type:		2		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					
			20		need to be replaced					
Merit Order	Totex (£):		£1,142		Calculated from above					
	Disuption Factor (1-		0		The installation of enablers is a very low disruption activity and does not					
	5):		0		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		0		Enablers do not directly result in additional benefits to other voltage levels					
	Benefits Factor:		0							
Other	Impact on Fixed		0%		Enablers do not affect the fixed losses within the network					
Benefits	Losses (%):		070							
	Impact on Variable		0%		Enablers do not affect the variable losses within the network					
	Losses (%):		0/0							
	Impact on quality of		0%		Enablers facilitate solutions which may improve the quality of supply, but they					
	Supply (%):		0,0		do not, in themselves, have an effect					
Year solut	tion becomes available:		2012							
Year dat	ta (on soln) is available:									
	Source of Data:	Initia	estim	ates						
Smart Solution	Smart Solution Set:	ENAB	LER							
Relevance (WS3	Focus:	DG co	onnect	ions n	nanagement of 2 way power flows					
Ph1)	Subset:	DR se	rvices	aggre	gated for LV and HV network management					

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Solution	Representative		FD					
Overview	Solution:	ENABL	ENABLER Monitoring waveform quality (LV Feeder)					
		Monito						
	Description:	Device to monitor the waveform along an LV feeder and hence enable LV power quality solutions						
		EHV	HV	LV	Comments			
Headroom	Thermal Cable:			0%	connicito			
Release (%)	Thermal Transformer:			0%				
	Voltage Head:			0%	Enablers are installed to facilitate solutions, which in turn release headroom.			
	Voltage Leg:			0%	Enablers themselves release no headroom.			
	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 E	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 solut	ion becomes available:	2	2012					
Year dat	a (on soln) is available:							
	Source of Data:	Initial e	estima	ates				
Smart Solution	Smart Solution Set:	ř						
Relevance (WS3				upply	enhancements to existing network architecture			
Ph1)	Subset:				pring and waveform correction devices			

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Solution	Representative	ENABLER							
Overview	Solution:								
			form quality (HV feeder)						
	Description:	Device to monitor the waveform along an HV feeder and hence enable LV power quality solutions							
		30/01/01/3							
		EHV HV		Comments					
Headroom	Thermal Cable:	0%							
Release (%)	Thermal Transformer:	0%		1					
	Voltage Head:	0%		Enablers are installed to facilitate solutions, which in turn release headroom					
	Voltage Leg:	0%		Enablers themselves release no headroom.					
	Power Quality:	0%							
	Fault Level:	0%							
Cost (£)		£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					
	Capital:			from £3k to £5k					
	Operational Expenditure:	£50		Opex associated with relaying the data					
	NPV of Opex:	£71	1	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 I	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 (£):	£5,71	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 the do not, in themselves, have an effect					
Year solution becomes available:		201	2						
	ta (on soln) is available:								
	Source of Data:	Initial esti	mates	•					
Smart Solution	Smart Solution Set:								
Relevance (WS3			supply	enhancements to existing network architecture					
Ph1)	Subset:			oring and waveform correction devices					

Solution	Representative									
Overview	Solution:	ENABLER								
	Variant Solution:	: Monitoring waveform quality (HV/LV Tx)								
	Description:	Device	e to mor	itor th	e waveform at a distribution substation and hence enable LV power quality					
		soluti	ons							
		EHV	HV	LV	Comments					
Headroom	Thermal Cable:	%	0%	0%						
Release (%)	Thermal Transformer:	%	0%	0%	Enablers are installed to facilitate solutions, which in turn release headroom.					
	Voltage Head:	%	0%	0%	Enablers are installed to facilitate solutions, which in turn release nead oom.					
	Voltage Leg:	%	0%	0%						
	Power Quality:		0%							
	Fault Level:		0%							
Cost (£)	Capital:		£10,000		Installation of devices at the substation together with equipment to backhaul the data as necessary					
	Operational		£100		Opex associated with relaying the data					
	Expenditure:									
	NPV of Opex:	£1,421			Based on 20 years of annual operating expenditure @ 3.5% discount rate					
		3			It is envisaged that these devices may be deployed in some numbers (although					
	Cost Curve Type:				not as widespread as phase imbalance monitoring, for example); hence a slight reduction in cost over time is anticipated					
Life I	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-		0		The installation of enablers is a very low disruption activity and does not					
	5):		0		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		0		Enablers do not directly result in additional benefits to other voltage levels					
	Benefits Factor:									
Other	Impact on Fixed		0%		Enablers do not affect the fixed losses within the network					
Benefits	Losses (%):									
	Impact on Variable		0%		Enablers do not affect the variable losses within the network					
	Losses (%):				Eachlara facilitate colutions which may improve the quality of supply, but they					
	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		מט ווטני ווו מוכוווזכועבז, וומעכ מון כווכנו					
Year data (on soln) is available:			2012							
real uat	Source of Data:	Initial	estimat	es						
Smart Solution	Smart Solution Set:									
Relevance (WS3				nlv en	nancements to existing network architecture					
Ph1)			· · ·							
	Subset.	Waveform monitoring and waveform correction devices								

Solution	Representative												
Overview	Solution:	ENABLE	२										
	Variant Solution:	Monitori	ng wave	form qua	lity (EHV/HV Tx)								
	and the second se		-		eform at a primary substation and hence enable LV power quality solutions								
		EHV	HV	LV	Comments								
Headroom	Thermal Cable:	0%											
Release (%)	Thermal Transformer:	0%			Enabless are installed to facilitate colutions, which is two release headsoom								
	Voltage Head:	0%			Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.								
	Voltage Leg:	0%											
	Power Quality:	0%											
	Fault Level:	0%											
Cost (£)					Installation of devices at the substation together with equipment to backhaul								
			£15,000		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								
	Capital:				differential								
	Operational		£150		Opex associated with relaying the data								
	Expenditure:												
	NPV of Opex:		£2,132		Based on 20 years of annual operating expenditure @ 3.5% discount rate								
					It is envisaged that these devices may be deployed in some numbers (although								
	Cost Curve Type:	3			not as widespread as phase imbalance monitoring, for example); hence a slig								
					reduction in cost over time is anticipated								
116-	-				All anothers are assumed to have a 20 year life, at the and of which they will								
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	Totoy (C):		£17,132										
werit Order	Totex (£): Disuption Factor (1-		117,132		Calculated from above The installation of enablers is a very low disruption activity and does not								
	5):	0			adversely affect the public or other stakeholders								
	Disruption Cost (£):				Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)								
	Disruption Cost (L).		£0										
	Flexibility (1-5):		0		It is envisaged that the enablers are fixed once installed								
	Cross Network		_		Enablers do not directly result in additional benefits to other voltage levels								
	Benefits Factor:		0										
Other	Impact on Fixed		0%		Enablers do not affect the fixed losses within the network								
Benefits	Losses (%):		υ%										
	Impact on Variable		0%		Enablers do not affect the variable losses within the network								
	Losses (%):		0/0										
	Impact on quality of	0%			Enablers facilitate solutions which may improve the quality of supply, but they								
	Supply (%):				do not, in themselves, have an effect								
	tion becomes available:		2012										
Year da	ta (on soln) is available:												
	Source of Data:	_	imates										
Smart Solution	Smart Solution Set:		_										
Relevance (WS3					ments to existing network architecture								
Ph1)	Subset:	Waveforr	n monit	oring and	I waveform correction devices								

Solution	Representative									
Overview	Solution:	ENABLER								
	Variant Solution:	Weat	her m	onitor	ing					
		Weather monitoring stations with localised communications for use in RTTR solutions at all								
		voltag								
		(
		EHV	HV	LV	Comments					
Headroom	Thermal Cable:	0%	0%	0%						
Release (%)	Thermal Transformer:	0%	0%	0%						
	Voltage Head:	0%	0%	0%	Enablers are installed to facilitate solutions, which in turn release headroom.					
	Voltage Leg:	0%	0%	0%	Enablers themselves release no headroom.					
	Power Quality:	0%	0%	0%						
	Fault Level:	0%	0%	0%						
Cost (£)	Capital:		£5,000	<u>-</u>	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				Opex associated with data transfer					
	Expenditure:		£50							
	NPV of Opex:		£711		Based on 20 years of annual operating expenditure @ 3.5% discount rate					
					Weather monitoring could well be required in a large number of locations					
	Cost Curve Type:	3			such that the benefits of RTTR at different voltages be relaised; hence the					
					costs are anticipated to reduce slightly over time					
Life I	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		0		Enablers do not directly result in additional benefits to other voltage levels					
	Benefits Factor:		0							
Other	Impact on Fixed		0%		Enablers do not affect the fixed losses within the network					
Benefits	Losses (%):		0,0							
	Impact on Variable		0%		Enablers do not affect the variable losses within the network					
	Losses (%):		070							
	Impact on quality of		0%		Enablers facilitate solutions which may improve the quality of supply, but they					
Supply (%):					do not, in themselves, have an effect					
Year solution becomes available:			2012							
Year dat	a (on soln) is available:									
	Source of Data:			ates						
Smart Solution	Smart Solution Set:									
Relevance (WS3					s reliability, failure mode detection					
Ph1)	Subset:	Dynai	mic rat	tings f	or all plant types and multi-element circuits					

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Solution	Representative	ENABLE	R									
Overview	Solution:											
	Variant Solution:	Dynamic	: Networ	k Prote	ction, 11kV							
	Description:	n: Network protection to support solutions such as temporary meshing										
		EHV	HV	LV	Comments							
Headroom	Thermal Cable:		0%									
Release (%)			0%									
	Thermal Transformer:		0%		Enablers are installed to facilitate solutions, which in turn release headroom.							
	Voltage Head:		0%		Enablers are installed to facilitate solutions, which in turn release neadroom.							
	Voltage Leg:		0%									
	Power Quality:		0%									
	Fault Level:		0%									
Cost (£)					New relays with associated local communications that can respond to varying							
			£7,500		network configurations (and hence varying currents) will be considerably							
	Capital:				more expensive than existing 11kV protection							
	Operational				There will be some opex associated with ensuring the relays are set							
	Expenditure:		£75		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							
					If temporary meshing solutions are adopted, then there could well be							
	Cost Curve Type:		3		widescal roll-out of dynamic HV protection, meaning that costs are likely to							
					reduce over the modelled period							
Life I	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-		0		The installation of enablers is a very low disruption activity and does not							
	5):				adversely affect the public or other stakeholders							
	Disruption Cost (£):		£0		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)							
			0									
	Flexibility (1-5):		0		It is envisaged that the enablers are fixed once installed							
	Cross Network		0		Enablers do not directly result in additional benefits to other voltage levels							
	Benefits Factor:											
Other	Impact on Fixed		0%		Enablers do not affect the fixed losses within the network							
Benefits	Losses (%):											
	Impact on Variable		0%		Enablers do not affect the variable losses within the network							
	Losses (%):											
	Impact on quality of		0%		Enablers facilitate solutions which may improve the quality of supply, but they do not in themselves, have an effect							
Veereelut	Supply (%):		2012		do not, in themselves, have an effect							
	tion becomes available:		2012									
rear dat	ta (on soln) is available:	Initial ca	timatas									
Source of Data: Smart Solution Smart Solution Set:												
Smart Solution				onhair	amonte to existing naturally architectures Consulty of naturally inclusion							
Relevance (WS3	Focus:	-			cements to existing network architecture; Security of networks inc physical							
Ph1)		inreats,	utilising	new ne	twork architectures							
	Subset:	Options	to deplo	y adapt	ive protection and control techniques; Use of meshed rather than radial							

Solution	Representative	ENABLER								
Overview	Solution:									
					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	Thermal Cable:			0%						
Release (%)	Thermal Transformer:			0%	Fooblars are installed to facilitate colutions, which in turn release boodraces					
	Voltage Head:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.					
	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:				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	L	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 dat	ta (on soln) is available:									
	Source of Data:			ates						
Smart Solution	Smart Solution Set:									
Relevance (WS3					nanagement of 2 way power flows					
Ph1)	Subset:	DR se	DR services aggregated for LV and HV network management							

Solution	Representative	ENABLER								
Overview	Solution:									
	Variant Solution:	RMUs	RMUs Fitted with Actuators							
	Description:	11kV RMUs that are equipped with actuators allowing automatic operation in response to								
		netwo	ork trig	ggers	to facilitate Active Network Management solutions					
		EHV	HV	LV	Comments					
Headroom	Thermal Cable:		0%							
Release (%)	Thermal Transformer:		0%		Enablers are installed to facilitate solutions, which in turn release headroom.					
	Voltage Head:		0%		Enablers themselves release no headroom.					
	Voltage Leg:		0%							
	Power Quality:		0%							
	Fault Level:		0%							
Cost (£)					This cost is based on that of an 11kV RMU with an uplift for the additional					
	Construct		£15,000)	actuator that would be required to facilitate the remote/automated operation					
	Capital:				of the device					
	Operational		£150		There is some opex associated with maintaining the equipment over its life					
	Expenditure:				(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					
					Economies of scale are likely for this enabler as DNOs could have standard					
	Cost Curve Type:	3			arranegements with suppliers (built on existing arrangements for RMUs)					
Life Expectancy of Solution:					All enablers are assumed to have a 20 year life, at the end of which they will					
Life t	expectancy of Solution:		20		need to be replaced					
Merit Order	Totex (£):	£17,132		,	Calculated from above					
Went Order	Disuption Factor (1-		217)101	-	The installation of enablers is a very low disruption activity and does not					
	5):		0		adversely affect the public or other stakeholders					
	Disruption Cost (£):	£0			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)					
			0							
	Flexibility (1-5): Cross Network		0		It is envisaged that the enablers are fixed once installed Enablers do not directly result in additional benefits to other voltage levels					
	Benefits Factor:		0		enablers do not directly result in additional benefits to other voltage levels					
Other	Impact on Fixed				Enablers do not affect the fixed losses within the network					
Benefits	Losses (%):		0%							
Denents	Impact on Variable				Enablers do not affect the variable losses within the network					
	Losses (%):		0%							
	Impact on quality of				Enablers facilitate solutions which may improve the quality of supply, but they					
	Supply (%):		0%		do not, in themselves, have an effect					
Year solution becomes available:			2012							
Year data (on soln) is available:										
i cui dut	Source of Data:	Initial	estim	ates	1					
Smart Solution	Smart Solution Set:									
Relevance (WS3				upply	enhancements to existing network architecture					
Ph1)										
· ··· · /	505561.	mem	elligent switching							

Solution	Representative		ENABLER							
Overview	Solution:	CINAL								
	Variant Solution:	LV feeder monitoring at distribution substation w/ state estimation								
					r the load and voltage observed for each feeder at a distribution substation,					
		makir	ng use	of sta	te estimation					
		EHV	HV	LV	Comments					
Headroom	Thermal Cable:			0%						
Release (%)	Thermal Transformer:			0%	Enablers are installed to facilitate solutions, which in turn release headroom.					
	Voltage Head:			0%	Enablers themselves release no headroom.					
	Voltage Leg:			0%						
	Power Quality:			0%						
	Fault Level:			0%						
Cost (£)					Installation of devices at a distribution substation to record voltage and load					
	Capital:	£500			on each feeder (in this case making use of state estimation) is anticipated to be £500					
	Operational				Small opex associated with any local communications					
	Expenditure:		£5							
	NPV of Opex:		£71							
			1/1		Based on 20 years of annual operating expenditure @ 3.5% discount rate					
					It is likely that LV feeder monitoring will be highly deployed (as large amounts					
	Cost Curve Type:		4		of LCTs will be connected at LV) hence the costs are expected to fall					
	Life Expectancy of Solution:				significantly over time					
Life E			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		0		Enablers do not directly result in additional benefits to other voltage levels					
	Benefits Factor:		0							
Other	Impact on Fixed		0%		Enablers do not affect the fixed losses within the network					
Benefits	Losses (%):		0%							
	Impact on Variable		0%		Enablers do not affect the variable losses within the network					
	Losses (%):		0%							
	Impact on quality of		0%		Enablers facilitate solutions which may improve the quality of supply, but they					
	Supply (%):		070		do not, in themselves, have an effect					
Year solution becomes available:			2012							
Year dat	a (on soln) is available:									
	Source of Data:	Initia	estim	ates						
Smart Solution	Smart Solution Set:	ENAB	LER							
Relevance (WS3	Focus:	DG co	nnect	ions n	nanagement of 2 way power flows					
Ph1)					estimation for observability of flows/voltages					

Solution Overview	Representative Solution:	IENABLEK									
	Variant Solution:										
		Device to monitor the load and voltage observed for each feeder at a distribution substation									
		EHV HV	LV	Comments							
Headroom	Thermal Cable:		0%								
Release (%)	Thermal Transformer:		0%	Fachlars are installed to facilitate colutions, which in turn release bondroom							
	Voltage Head:		0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.							
	Voltage Leg:		0%	Enablers themselves release no headroom.							
	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			Small opex associated with any local communications							
	Expenditure:	£5									
	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 solut	ion becomes available:	2012									
Year dat	a (on soln) is available:										
	Source of Data:	Initial estim	ates								
Smart Solution	Smart Solution Set:	et: ENABLER									
Relevance (WS3 Ph1)	Focus:	Quality of su of 2 way por		enhancements to existing network architecture; DG connections, management ows							
	Subset:	Waveform r	nonite	oring and waveform correction devices; Intelligent voltage control; Sensors and for observability of flows/voltages							

Solution	Representative	ENABLER							
Overview	Solution:								
		 LV Circuit monitoring (along feeder) w/ state estimation 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 							
	Description:								
		EHV	HV	LV	Comments				
Headroom	Thermal Cable:			0%					
Release (%)	Thermal Transformer:			0%	Enablers are installed to facilitate solutions, which in turn release headroom.				
	Voltage Head:			0%	Enablers are installed to facilitate solutions, which in turn release neadroom.				
	Voltage Leg:			0%	Enablers themselves release no headroom.				
	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		£5		Small opex associated with any local communications				
	Expenditure:		ĽЭ						
	NPV of Opex:		£71		Based on 20 years of annual operating expenditure @ 3.5% discount rate				
Cost Curve Typ		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:	Initia	lestim	ates					
Smart Solution	Smart Solution Set:	ENAB	LER						
Relevance (WS	B Focus:	DG co	onnect	ions, i	management of 2 way power flows				
Ph1)					e control; Sensors and state estimation for observability of flows/voltages				

Solution	Representative	ENABLER							
Overview	Solution:								
		n: 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	Thermal Cable:			0%					
Release (%)	Thermal Transformer:			0%	Enablers are installed to facilitate solutions, which in turn release backgoon				
	Voltage Head:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.				
	Voltage Leg:			0%					
	Power Quality:			0%					
	Fault Level:			0%					
Cost (£)			£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 associated with				
	Capital:	-			connecting along a feeder				
	Operational		£10		Small opex associated with any local communications				
	Expenditure:								
	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	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		6		Enablers do not directly result in additional benefits to other voltage levels				
	Benefits Factor:		0						
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:			2012						
i cui ua	Source of Data:	Initia	estim	ates	1				
Source of Data. Smart Solution Smart Solution Set:									
Relevance (WS3 Ph1)		Quali			enhancements to existing network architecture; DG connections, management ows				
	Subset:	Waveform monitoring and waveform correction devices; Intelligent voltage control; Sensors and state estimation for observability of flows/voltages							

Solution	Representative	ENIAE							
Overview	Solution:	ENABLER							
	Variant Solution:	Link boxes fitted with remote control							
	Description:	Devic	es equ	iipped	to link boxes to enable them to be operated remotely to facilitate solutions				
		such a	as Acti	ve Ne	twork Management				
		EHV	HV	LV	Comments				
Headroom	Thermal Cable:			0%					
Release (%)	Thermal Transformer:			0%	Fachlan an iash llad ta fa ilitata a baina wikish ia tum aslang basdan a				
	Voltage Head:			0%	Enablers are installed to facilitate solutions, which in turn release headroom.				
	Voltage Leg:			0%	Enablers themselves release no headroom.				
	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				
	Onemational				There will be some opex associated with maintaining the actuators in the link				
	Operational		£50		box, but this is thought to be very low, together with any necessary				
	Expenditure:				communications opex				
	NDV of Onove		£711						
	NPV of Opex:		£/11		Based on 20 years of annual operating expenditure @ 3.5% discount rate				
					The level of uptake of this enabler is linked to the amount of active network				
	Cost Curve Type:	3			management or meshing that takes place and hence it is expected that there				
					will be a slight reduction in costs over time				
Life I	Expectancy of Solution:	20			All enablers are assumed to have a 20 year life, at the end of which they will				
		20			need to be replaced				
Merit Order	Totex (£):		£5,711		Calculated from above				
	Disuption Factor (1-		0		The installation of enablers is a very low disruption activity and does not				
	5):		0		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		0		Enablers do not directly result in additional benefits to other voltage levels				
	Benefits Factor:		U						
Other	Impact on Fixed		0%		Enablers do not affect the fixed losses within the network				
Benefits	Losses (%):		076						
	Impact on Variable		0%		Enablers do not affect the variable losses within the network				
	Losses (%):		070						
	Impact on quality of		0%		Enablers facilitate solutions which may improve the quality of supply, but they				
	Supply (%):		076		do not, in themselves, have an effect				
Year solution becomes available:			2012						
Year dat	ta (on soln) is available:								
	Source of Data:	Initial	estim	ates					
Smart Solution	Smart Solution Set:	ENAB	LER						
Relevance (WS3	Focus:	Quali	ty of si	upply	enhancements to existing network architecture				
Ph1)	Subset:		· ·						

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Overview	Representative Solution:	ENABLER									
		HV/LV Tx Monitoring									
			Device to monitor the load and voltage observed at a distribution transformer to facilitate								
	2 comption				EAVC at various voltage levels						
		50141	0110 00	0.1. 0.0							
		EHV	HV	LV	Comments						
Headroom	Thermal Cable:	0%	0%	0%							
Release (%)	Thermal Transformer:	0%	0%	0%	Fachlars are installed to facilitate colutions, which is turn release headroom.						
	Voltage Head:	0%	0%	0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.						
	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	£10			Small opex associated with any local communications						
	Expenditure:	EIO									
	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 I	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		0		Enablers do not directly result in additional benefits to other voltage levels						
	Benefits Factor:		0								
Other	Impact on Fixed		0%		Enablers do not affect the fixed losses within the network						
Benefits	Losses (%):		0%								
	Impact on Variable		0%		Enablers do not affect the variable losses within the network						
	Losses (%):		0/0								
	Impact on quality of		0%		Enablers facilitate solutions which may improve the quality of supply, but they						
Supply (%):			- / 0		do not, in themselves, have an effect						
Year solution becomes available:			2012								
Year data (on soln) is available:											
	Source of Data:			ates							
Smart Solution	Smart Solution Set:										
Relevance (WS3	Focus:				management of 2 way power flows						
Ph1)	Subset:	Intelli	igent v	oltage	e control; Sensors and state estimation for observability of flows/voltages						

Solution	Representative	ENABLER							
Overview	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	Thermal Cable:	0%							
Release (%)	Thermal Transformer:	0%		Enablers are installed to facilitate solutions, which in turn release headroom.					
	Voltage Head:	0%		Enablers are installed to facilitate solutions, which in turn release nead oon.					
	Voltage Leg:	0%							
	Power Quality:	0%							
	Fault Level:	0%							
Cost (£)	Capital:	£2,500	I	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:			Small opex associated with any local communications					
	NPV of Opex:			Based on 20 years of annual operating expenditure @ 3.5% discount rate					
	Cost Curve Type:			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 I	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 estim	ates	1					
Smart Solution	Smart Solution Set:								
Relevance (WS3			ions,	management of 2 way power flows					
Ph1)			Intelligent voltage control; Sensors and state estimation for observability of flows/voltages						

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Solution	Representative	ENABLER							
Overview	Solution:								
		HV Circuit Monitoring (along feeder)							
	Description:				r the voltage (and load) along HV circuits to inform solutions such as EAVC by				
		allowi	ng rev	vised s	set points to be calculated based on observed voltages				
		F10							
	The second Callela	EHV	HV	LV	Comments				
Headroom	Thermal Cable:		0%						
Release (%)	Thermal Transformer:		0%		Enablers are installed to facilitate solutions, which in turn release headroom.				
	Voltage Head:		0%		Enablers themselves release no headroom.				
	Voltage Leg:		0%						
	Power Quality:		0%						
(0)	Fault Level:		0%						
Cost (£)					Installation of devices along an HV feeder is expected to be higher cost than at the substation as a result of the logistical issues associated with connecting along a feeder. Furthernore, the cost along an HV feeder is significantly higher				
			£3,000		than along an LV feeder owing to the need for equipment to be higher rated				
	Canitalı				and the more complex logistics in installation				
	Capital: Operational				Small opex associated with any local communications				
	Expenditure:	£30			Sinal opex associated with any local communications				
	NPV of Opex:	£426			Based on 20 years of annual operating expenditure @ 3.5% discount rate				
-		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				
	Cost Curve Type:				of circuits), hence the cost is anticipated to reduce by a smaller amount,				
					applied here as cost curve 3				
Life E	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		0		Enablers do not directly result in additional benefits to other voltage levels				
	Benefits Factor:		Ť						
Other	Impact on Fixed		0%		Enablers do not affect the fixed losses within the network				
Benefits	Losses (%):								
	Impact on Variable Losses (%):		0%		Enablers do not affect the variable losses within the network				
	Impact on quality of				Enablers facilitate solutions which may improve the quality of supply, but they				
	Supply (%):		0%		do not, in themselves, have an effect				
Year solution becomes available:			2012						
Year data (on soln) is available:									
Source of Data:		Initial	estim	ates					
Smart Solution	Smart Solution Set:	ENAB	LER						
Relevance (WS3	Focus:	Qualit	y of s	pply	enhancements to existing network architecture; DG connections, management				
Ph1)		of 2 w	ay po	wer fl	ows				
	Subset:	Wave	form r	nonit	oring and waveform correction devices; Intelligent voltage control; Sensors and				
		state	state estimation for observability of flows/voltages						

Solution	Representative	ENABLER							
Overview	Solution:	ENAL							
	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	Thermal Cable:	0%							
Release (%)	Thermal Transformer:	0%			Enablers are installed to facilitate solutions, which in turn release headroom.				
	Voltage Head:	0%			Enablers themselves release no headroom.				
	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 E	xpectancy 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 dat	Year data (on soln) is available:								
	Source of Data:			ates					
Smart Solution	Smart Solution Set:								
Relevance (WS3 Ph1)		of 2 v	vay po	wer fl					
	Subset:				oring and waveform correction devices; Intelligent voltage control; Sensors and for observability of flows/voltages				

Solution Overview	Representative									
Overview	Solution:	on: DSR - Products to remotely control EV charging								
	Description:				ssary at the substation and charging point to remotely control EV charging and					
		hence	e enab	le ma	nagement of thermal and voltage issues on the LV network					
		EHV	HV	LV	Comments					
Headroom	Thermal Cable:			0%						
Release (%)	Thermal Transformer:			0%	Enablers are installed to facilitate solutions, which in turn release headroom.					
	Voltage Head:			0%	Enablers the installed to racintate solutions, which in turn release neadroom.					
	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				There is a small opex cost associated with the communications involved in this					
	Expenditure:		£15		arrangement					
	NPV of Opex:		£213		Based on 20 years of annual operating expenditure @ 3.5% discount rate					
					These solutions are based heavily on communications technology and this is					
	Cost Curve Type:	2			anticipated to remain relatively constant in terms of cost across the modelled					
					period					
Life E	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					
Wient Order	Disuption Factor (1-		21)/10		The installation of enablers is a very low disruption activity and does not					
	5).		0		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				Enablers do not directly result in additional benefits to other voltage levels					
	Benefits Factor:	0								
Other	Impact on Fixed				Enablers do not affect the fixed losses within the network					
Benefits			0%							
bellents	Losses (%): Impact on Variable				Enablers do not affect the variable losses within the network					
	· · · · · · · · · · · · · · · · · · ·		0%							
	Losses (%): Impact on quality of				Enablers facilitate solutions which may improve the quality of supply, but they					
			0%							
	Supply (%):		2012		do not, in themselves, have an effect					
	ion becomes available:		2012							
Year dat	Year data (on soln) is available:			-+						
Concernt Co. L. M.	Source of Data:			atës						
	Smart Solution Smart Solution Set:			<i>(</i> ·						
Relevance (WS3 Ph1)	Focus:	EV ch	arging	/disch	arging (V2G), Network Management, Demand Response and other services					
	Ph1) 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						

Solution Overview	Representative	ENAB	LER					
Overview	Solution:	DCD	DCP. Draducte to remotely control loads at consumer promises					
		DSR - Products to remotely control loads at consumer premises Devices to enable the interaction with customer loads such as smart appliances to facilitate DSR solutions						
		EHV	HV	LV	Comments			
Headroom	Thermal Cable:			0%				
Release (%)	Thermal Transformer:			0%	Fachlan an intellad to facilitate colutions which is two colors has done			
	Voltage Head:			0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.			
	Voltage Leg:			0%	Enablers themselves release no headroom.			
	Power Quality:			0%				
	Fault Level:			0%				
Cost (£)	Capitali		£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			
	Capital: Operational Expenditure:		£5		There is a small opex cost associated with the communications involved in this arrangement			
NPV of Opex Cost Curve Type			£71		Based on 20 years of annual operating expenditure @ 3.5% discount rate			
			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 I	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			
	tion becomes available:		2012					
Year dat	ta (on soln) is available:							
	Source of Data:			ates				
Smart Solution	Smart Solution Set:							
Relevance (WS3 Ph1)					nanagement of 2 way power flows gated for LV and HV network management			

Solution	Representative	ENA	RIFR							
Overview	Solution:									
	Variant Solution:	on: Design tools								
	Description:	New	design	tools ar	nd software with enhanced capabilites; e.g. the inclusion of EES					
		EHV	HV	LV	Comments					
Headroom	Thermal Cable:	0%	0%	0%						
Release (%)	Thermal Transformer:	0%	0%	0%	Enablers are installed to facilitate solutions, which in turn release headroom.					
	Voltage Head:	0%	0%	0%	Enablers are instance to facilitate solutions, which in turn release neadroom.					
	Voltage Leg:	0%	0%	0%						
	Power Quality:	0%	0%	0%						
	Fault Level:	0%	0%	0%						
Cost (£)	Capital:		£10,00	00	Cost based on purchasing a licence for industry specific software tools to ensure modelling of new solutions is avaialble					
	Operational		£100)	Some ongoing support and maintenance costs tht would be charged by the					
	Expenditure:	ure:		, 	software developer					
	NPV of Opex:	£1,421		1	Based on 20 years of annual operating expenditure @ 3.5% discount rate					
Cost (2		There will not be any economies of scale associated with the purchase of					
	Cost Curve Type:		2		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					
			20		need to be replaced					
Merit Order	Totex (£):		£11,42	21	Calculated from above					
	Disuption Factor (1-		0		The installation of enablers is a very low disruption activity and does not					
	5):		Ū		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		0		Enablers do not directly result in additional benefits to other voltage levels					
	Benefits Factor:		0							
Other	Impact on Fixed		0%		Enablers do not affect the fixed losses within the network					
Benefits	Losses (%):		070							
	Impact on Variable		0%		Enablers do not affect the variable losses within the network					
	Losses (%):									
	Impact on quality of	Impact on quality of			Enablers facilitate solutions which may improve the quality of supply, but they					
Supply (%):			0%		do not, in themselves, have an effect					
Year solution becomes available:			2012	2						
Year da	ata (on soln) is available:									
	Source of Data:			ates						
Smart Solution	Smart Solution Set:									
Relevance (WS3	B Focus:	Secur	ity of ı	network	s inc physical threats, utilising new network architectures					
Ph1)	Subset:	Forec	asting	and mo	delling tools for DNOs to manage new demands					

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Solution	Representative	ENABLER									
Overview	Solution:										
			to and from devices								
	Description:	Communications which support remote devices such as RTTR									
		EHV	HV	LV	Comments						
Headroom	Thermal Cable:	0%	0%	0%							
Release (%)	Thermal Transformer:	0%	0%	0%	Enables are installed to facilitate solutions, which in turn release boodroom						
	Voltage Head:	0%	0%	0%	Enablers are installed to facilitate solutions, which in turn release headroom. Enablers themselves release no headroom.						
	Voltage Leg:	0%	0%	0%							
	Power Quality:	0%	0%	0%							
	Fault Level:	0%	0%	0%							
Cost (£)	Capital:		£1,000	I	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	£10			There is an opex cost in maintaining the communications links						
	Expenditure:										
	NPV of Opex:				Based on 20 years of annual operating expenditure @ 3.5% discount rate						
Cost Curve Ty					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 I	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 (£):				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 (%):			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:	Initia	l estim	ates							
Smart Solution	Smart Solution Set:										
Relevance (WS3				ions n	nanagement of 2 way power flows						
Ph1)					domestic, substation and community level; DR services aggregated for LV and						
, Subset.			HV network management								

Solution	Representative									
Overview	Solution:	ENAE	ENABLER							
		Advanced control systems								
		System to intelligently control remote equipment and hence facilitate solutions such as Active								
				anageme						
				0						
		EHV	HV	LV	Comments					
Headroom	Thermal Cable:	0%	0%	0%						
Release (%)	Thermal Transformer:	0%	0%	0%	Enablers are installed to facilitate solutions, which in turn release headroom.					
	Voltage Head:	0%	0%	0%	Enablers are installed to facilitate solutions, which in turn release headroom.					
	Voltage Leg:	0%	0%	0%						
	Power Quality:	0%	0%	0%						
	Fault Level:	0%	0%	0%						
Cost (£)			£15,00	00	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.					
	Capital:									
	Operational				There are some costs associated with maintaining the control system in the					
	Expenditure: £150 NPV of Opex: £2,132		£150)	event of network changes and also the communications links					
			2	Based on 20 years of annual operating expenditure @ 3.5% discount rate						
	Cost Curve Type:	Curve Type: 2			Control systems are not expected to reduce in cost over the modelled period					
Life I	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 (£):		£17,1	32	Calculated from above					
	Disuption Factor (1-		0		The installation of enablers is a very low disruption activity and does not					
	5):	0			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 solut	ion becomes available:		2012	2						
Year data (on soln) is available:										
Source of Data:		Initial	estim	ates	·					
Smart Solution	Smart Solution Set:									
Relevance (WS3 Ph1)		Quali	ty of si	upply en er flows	hancements to existing network architecture; DG connections management of					
	Subset:	Intelligent switching; Options to deploy adaptive protection and control techniques; Utilise storage at domestic, substation and community level								

Solution Overview	Representative Solution:	EHV o	verhe	ad ne	d network					
orentien	Variant Solution:									
		This major works at EHV is primarily composed of significant amounts of overhead line								
	2 coon priorit	construction to create new EHV circuits (because the model does not consider grid transformers								
					is for headroom on existing EHV circuits to increase as load is transferred to the					
		new feeders.								
		EHV	HV	LV	Comments					
Headroom					The very extensive EHV reinforcement by way of several new circuits means					
Release (%)	Thermal Cable:	500%			that the feeders should have their load significantly reduced, shown here as a 500% increase in headroom					
					While the model does not consider grid transformers directly, this is include					
					for completeness to ensure consistency with lower voltages and also ensure					
	TI	5000/			that in the event of load increasing to an unmanageable level, this solution will					
	Thermal Transformer:	500%			provide a suitable level of headroom release to allow the model to continue to					
					function appropriately without throwing an error					
					A marginal benefit may be seen for voltage headroom as the load and					
	Voltage Head:	1%			generation is split across several circuits					
					A fairly significant voltage legroom benefit will arise as the load is distributed					
	Voltage Leg:	8%			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					
					The creation of new circuits and hence addition of multiple infeeds will reduce					
	Fault Level:	-20%			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					
0 (0)					20% reduction in fault level headroom					
Cost (£)					The cost is composed of significant overhead line construction (8km of EHV					
		£3	,000,00	0	and 8km of HV) together with appropriate pole mounted switchgear to					
	Capital				connect these new assets into the existing infrastructure.					
	Capital: Operational				It is assumed that no opex costs are associated with the solution					
	Expenditure:	£0			it is assumed that no oper 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	,000,00	0	Calculated from above					
	Disuption Factor (1-				There will be very high disruption to the public in construction of 16km of new					
	5):		5		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				The benefits will be exclusively to the EHV network as the solution is not					
	Benefits Factor:		0		intended to specifically reduce the loading on associated HV circuits, for					
					example					
Other	Impact on Fixed		0%		Negligible impact on fixed losses					
Benefits	Losses (%):		0%							
	Impact on Variable				A slight reduction in variable losses is envisaged as the numerous new assets					
	Losses (%):		-2%		installed will all be loaded to low levels thereby incurring low losses					
	Impact on quality of				There will be a significant improvement in quality of supply as fewer customers					
	Supply (%):		40%		will be supplied via one circuit or one transformer, hence fewer CIs will arise as					
			40%		a result of an outage. This improvement has been deemed to be of the order					
					of 40%.					
Year solu	tion becomes available:		2012							
Year da	ta (on soln) is available:		2012							
	Source of Data:	DPCR5	unit c	osts a	nd discussion with Network Operators					
Smart Solution	Smart Solution Set:	CONVE	NTIO	NAL						
Relevance (WS3	Focus:									
Ph1)	Subset:									

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Solution	Representative	IEHV overnead network					
Overview	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		10	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		0	Calculated from above		
	Disuption Factor (1-	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 (%):				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 da	ta (on soln) is available:						
	Source of Data:	DPCR5	unit c	osts a	nd discussion with Network Operators		
Smart Solution	Smart Solution Set:	CONVE	NTION	JAL			
Relevance (WS3	Focus:						
Ph1)	Subset:						

Solution	Doprocontativo						
Overview	Representative Solution:	EHV	overh	ead r	network		
		New Split feeder					
		n: Install a new EHV The new feeder n			feeder from a primary substation, part way along the already split EHV feeder.		
					eeds to be connected into the existing network such that one third of the total		
					al 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					By picking up a large amount of load from the already split feeder, the thermal		
Release (%)	Thermal Cable:	80%			headroom is significantly increased		
Keleuse (70)					This solution solves a circuit problem but has no effect on the substation load		
	Thermal Transformer:	0%			This solution solves a circuit problem but has no effect on the substation road		
					Marginal benefit through splitting the load (and any generation present)		
	Voltage Head:	1%			across two feeders		
					Potentially there could be some benefit here as the circuit is reduced in		
	Voltage Leg:	3%			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 (£)	Fault Level.	078			· · · · · · · · · · · · · · · · · · ·		
COST (±)					Cost based on an assumed average length for EHV overhead circuit; meaning		
		£660,000		0	that the solution requires approximately 5km of EHV conductor, a new EHV		
	Construct				circuit breaker and some additional work to connect the new circuit into the,		
	Capital:				already split, existing network		
	Operational	£0			No opex costs incurred once the overhead line is installed		
	Expenditure:			_			
	NPV of Opex:	-					
	Cost Curve Type:	1			Increase over time as metal prices increase		
	Expectancy of Solution:	40			The solution remains valid for the entire modelled period		
Merit Order	Totex (£):	£660,000		0	Calculated from above		
	Disuption Factor (1-	5			Erecting some 5km of overhead line causes significant disruption to the		
	5):				general public in the area		
	Disruption Cost (£):	£100,000		0	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				This solution resolves a problem on a specific EHV feeder, but has no benefit		
	Benefits Factor:	0			to other voltages as the load experienced there will remain constant		
Other	Impact on Fired				No impact on fixed losses anticipated		
	Impact on Fixed		0%		No impact on fixed losses anticipated		
Benefits	Losses (%): Impact on Variable	 			The load carried by the circuit will reduce, therefore reducing the variable		
		-2%			losses (which are proportional to the square of the current)		
	Losses (%):	20%			Having fewer customers connected to one circuit effectively halves the		
	Impact on quality of Supply (%):				number of Cls that would be incurred in the event of an outage		
Year solution becomes available:			2012		number of cis that would be incurred in the event of an outage		
Year da	ata (on soln) is available:	0000	2012				
	Source of Data:				and discussion with Network Operators		
Smart Solution	Smart Solution Set:	CON	/ENTIC	INAL			
Relevance (WS							
Ph1)	Subset:						

Solution	Representative	EHV o	verhe	ad ne	etwork			
Overview	Solution:							
	Variant Solution:							
	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 (£)					Cost based on an assumed average length for EHV overhead circuit; meaning			
		£600,000		n	that the solution requires approximately 5km of EHV conductor, a new EHV			
		1000,000		5	circuit breaker and some work to connect the new circuit into the existing			
	Capital:				network			
	Operational	£0			No opex costs incurred once the overhead line is installed			
	Expenditure:	10						
	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			Erecting some 5km of overhead line causes significant disruption to the			
	5):	5			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				This solution resolves a problem on a specific EHV feeder, but has no benefit to			
	Benefits Factor:	0			other voltages as the load experienced there will remain constant			
Other	Impact on Fixed		0%		No impact on fixed losses anticipated			
Benefits	Losses (%):		070					
	Impact on Variable	20/			The load carried by the circuit will reduce, therefore reducing the variable			
	Losses (%):	-2%			losses (which are proportional to the square of the current)			
	Impact on quality of	f 20%			Having fewer customers connected to one circuit effectively halves the			
	Supply (%):				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 c	osts a	nd discussion with Network Operators			
Smart Solution	Smart Solution Set:	CONVE	NTIO	NAL				
Relevance (WS3	Focus:							
Ph1)	Subset:							

Solution	Representative	EHV underground network						
Overview	Solution:							
	Variant Solution:							
	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					The very extensive EHV reinforcement by way of several new circuits means			
Release (%)	Thermal Cable:	500%			that the feeders should have their load significantly reduced, shown here as a			
					500% increase in headroom			
					While the model does not consider grid transformers directly, this is include			
					for completeness to ensure consistency with lower voltages and also ensure			
	Thermal Transformer:	500%			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			
		10/			A marginal benefit may be seen for voltage headroom as the load and			
	Voltage Head:	1%			generation is split across several transformers			
					A fairly significant voltage legroom benefit will arise as the load is distributed			
	Voltage Leg:	8%			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			
					The creation of new circuits and hence addition of multiple infeeds will reduce			
	Fault Level:	-20%			the source impedance and therefore increase the fault level by a greater			
	Fault Level:	-20%			degree than that observed for minor works. This has been captured here as a			
					20% reduction in fault level headroom			
Cost (£)					The cost is composed of significant cable laying activity (8km of EHV and 8km			
		£5,000,000		00	of HV) together with appropriate switchgear and cable jointing to connect			
	Capital:				these new assets into the existing infrastructure.			
	Operational	£0			It is assumed that no opex costs are associated with the solution			
	Expenditure:							
	NPV of Opex:							
Cost Curve Type		1			The cost of the solution will increase over time as metal prices increase			
Lifo				The lifetime of the assets will be a minimum of 40 years and hence the				
Life	Expectancy of Solution:	40			solution will not expire during the modelled period			
Merit Order	Totex (£):	£5	,000,00	00	Calculated from above			
	Disuption Factor (1-	-			There will be very high disruption to the public in the laying of HV and EHV			
	5):	5			cable at a range of locations across a geographic area.			
	Disruption Cost (£):	£100,000		2	Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)			
	Flexibility (1-5):				This solution connet realistically be required at another location once installed			
	Flexibility (1-5):		1		This solution cannot realistically be re-used at another location once installed			
	Cross Network				The benefits will be exclusively to the EHV network as the solution is not			
	Benefits Factor:	0			intended to specifically reduce the loading on associated HV circuits, for			
					example			
Other	Impact on Fixed		0%		Negligible impact on fixed losses			
Benefits	Losses (%):		0%					
	Impact on Variable				A slight reduction in variable losses is envisaged as the numerous new assets			
	Losses (%):		-2%		installed will all be loaded to low levels thereby incurring low losses			
	Impact on quality of				There will be a significant improvement in quality of supply as fewer customers			
	Supply (%):				will be supplied via one circuit or one transformer, hence fewer CIs will arise as			
	Juppiy (70).		40%		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					
		DPCR5	i unit d	costs a	nd discussion with Network Operators			
Smart Solution	Smart Solution Set:	CONV	ENTIO	NAL				
Relevance (WS3	Focus:							
Ph1)	Subset:							

Solution Overview	Representative Solution:								
	Variant Solution:								
	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 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	,200,00	00	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:	f0			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	,200,00	00	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:				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 (%):				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 solut	tion becomes available:		2012						
Year dat	ta (on soln) is available:		2012						
					and discussion with Network Operators				
Smart Solution	Smart Solution Set:	CONV	ENTIO	NAL					
Relevance (WS3									
Ph1)	Subset:								

Solution	Poprocontativo									
Overview	Representative Solution:	EHV	nd network							
	Variant Solution:	New Split feeder								
	Description:	Lay a new EHV feeder from a primary substation, part way along the already split EHV feeder.								
		Perfo	rm sor	ne cro	oss jointing such that one third of the total load on the original feeder and the					
		split f	eeder	is nov	v transferred to the new split feeder. A diagram showing this is included in 13.2					
		of the	e WS3	Repor	t.					
		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 (£)					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					
		1	E684,86	0	breaker plus some additional cross-jointing to allow for the fact that this is the					
	Capital:				second splitting of the feeder					
	Operational				No opex costs incurred once the cable is installed					
	Expenditure:	£0								
	NPV of Opex:									
	Cost Curve Type:				Increase over time as metal prices increase					
Life F	Expectancy of Solution:		40		The solution remains valid for the entire modelled period					
Merit Order	Totex (£):	f	E684,86	0	Calculated from above					
	Disuption Factor (1-		-		Excavating and laying 2km of cable causes significant disruption to the general					
	5):		5		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				This solution resolves a problem on a specific EHV feeder, but has no benefit					
	Benefits Factor:		0		to lower voltages as the load experienced there will remain constant					
Other	Impact on Fixed		001		No impact on fixed losses anticipated					
Benefits	Losses (%):		0%							
	Impact on Variable		20/		The load carried by the cable will reduce, therefore reducing the variable					
	Losses (%):		-2%		losses (which are proportional to the square of the current)					
	Impact on quality of		2024		Having fewer customers connected to one circuit reduces the number of CIs					
	Supply (%):		20%		that would be incurred in the event of an outage					
Year solut	ion becomes available:		2012							
Year data (on soln) is available			2012							
		DPCR	5 unit	costs	and discussion with Network Operators					
	Smart Solution Set:				·					
Smart Solution										
Smart Solution Relevance (WS3	Focus:									

Solution	Representative	EU\/	ndora	roup	d natwork					
Overview	Solution:	EHV underground network								
	Variant Solution:									
	Description:	Lay a n	iew EH	IV und	lerground feeder out of a BSP to the midpoint of an existing feeder. Break the					
		existin	g feed	er and	pick up the 50% of the load from that feeder onto the new feeder.					
		EHV	HV	LV	Comments					
Headroom					By picking up 50% of the load from the existing feeder, the thermal headroom					
Release (%)	Thermal Cable:	100%			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					
					Potentially there could be significant benefit here as the circuit is reduced to					
	Voltage Leg:	6%			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 (£)					Cost based on an assumed average length of 4km for EHV underground circuit;					
(,		£	622,600)	therefore 2km of EHV cable required, plus some jointing and a new EHV circuit					
	Capital:	,			breaker					
	Operational				No opex costs incurred once the cable is installed					
	Expenditure:	£0								
	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-				Excavating and laying 2km of cable causes significant disruption to the general					
	5):		5		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):				No flexibility as the amount of work requried to move an installed cable					
	,		1		outweighs any benefots this might realise					
	Cross Network				This solution resolves a problem on a specific EHV feeder, but has no benefit to					
	Benefits Factor:		0		lower voltages as the load experienced there will remain constant					
Other	Impact on Fixed		0%		No impact on fixed losses anticipated					
Benefits	Losses (%):		U%							
	Impact on Variable		-2%		The load carried by the cable will reduce, therefore reducing the variable					
	Losses (%):		-2 /0		losses (which are proportional to the square of the current)					
	Impact on quality of		20%		Having fewer customers connected to one circuit effectively halves the					
	Supply (%):				number of CIs that would be incurred in the event of an outage					
Year solut	tion becomes available:		2012							
Year dat	ta (on soln) is available:		2012							
	Source of Data:	DPCR5	unit c	osts a	nd discussion with Network Operators					
Smart Solution	Smart Solution Set:	CONVE	INTIO	NAL						
Relevance (WS3	Focus:									
Ph1)	Subset:									

Solution Overview	Representative Solution:	HV overhead network									
	Variant Solution:										
		The major works option here is composed of the construction of several new substations (with									
			-		erhead lines) in an area that has seen significant load growth and requires						
					ent. An example of how this might be represented can be seen in section 13.2						
			e WS3 r								
		EHV	HV	LV	Comments						
Headroom					The new transformers and associated circuits mean that the feeders should						
Release (%)	Thermal Cable:		500%		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						
					The addition of mulitple transformers will reduce the source impedance and						
	Fault Level:		-20%		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 (£)					The cost is composed of two new ground mounted primary transformers, 2km						
(_)			£900,000)	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.						
	Capital:										
	Operational				It is assumed that no opex costs are associated with the solution						
	Expenditure:		£0								
	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				The benefits will be exclusively to the LV network as it is envisaged that the						
	Benefits Factor:		0		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 solu	tion becomes available:		2012								
Year da	ta (on soln) is available:		2012								
	Source of Data:	DPCR	5 unit c	osts a	nd discussion with Network Operators						
Smart Solution	Smart Solution Set:	CONV	/ENTIO	NAL							
Relevance (WS3	Focus:										
Ph1)	Subset:										

Solution	Representative		arboz	d no	twork					
Overview	Solution:	HV overhead network								
	Variant Solution:									
	Description:				the form of an additional primary transformer at, or near to, the location of					
			•		ormer. A small amount of EHV overhead line is allowed for, while the solution					
			•		the construction of several HV overhead circuits to connect to the existing HV					
		infrast	ructur	e.Ao	liagram showing the solution can be found in section 13.2 of the WS3 report.					
		EHV	HV	LV	Comments					
Headroom	Thermal Cable:		100%		The new transformer and associated circuits mean that the feeders should					
Release (%)			100%		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)					
	Voltago Hoad:		1%		A marginal benefit may be seen for voltage headroom as the load and					
	Voltage Head:		170		generation is aplit across two transformers					
	Voltage Leg:		6%		Some voltage legroom benefit will arise as the load is distributed across two					
	Voltage Leg.		070		transformers and more circuits					
	Power Quality:		0%		There will be no effect on power quality					
					The addition of a second transformer will reduce the source impedance and					
	Fault Level:		-15%		hence increase the fault level by a greater degree than merely if the					
	radit Eevel.		1570		transformer were replaced. This has been captured here as a 15% reduction in					
					fault level headroom					
Cost (£)					The cost is composed of a new primary transformer, 500m of EHV conductor					
		f	500,000)	to supply the new transformer and associated jointing to connect this to the					
		-	.500,000	,	network; 1km of new HV overhead line to stitch the new transformer into the					
	Capital:				existing HV infrastrructure.					
	Operational	£0			It is assumed that no opex costs are associated with the solution					
	Expenditure:	10								
	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-				There will be very high disruption to the public in the construction of new EHV					
	5):		5		and HV overhead lines and the installation of a new primary transformer either					
			5		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 Notwork				The herefits will be evaluated to the UV network as it is environzed that the					
	Cross Network		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					
	Benefits Factor:		U		transformer will be connected to the same EHV circuit as the existing					
Other	Impact on Fixed				Negligible impact on fixed losses					
Other Benefits	Losses (%):		0%		inegrigiore impact on incer iosses					
Denents	Impact on Variable				Negligible impact on variable losses as there will be more equipment installed					
	•									
	Losses (%):		0%		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				There will be a significant improvement in quality of supply as fewer customers					
	Supply (%):				will be supplied via one circuit or one transformer, hence fewer CIs will arise as					
	Suppry (70).		30%		a result of an outage. This improvement has been deemed to be of the order					
					of 30%.					
Year solu	tion becomes available:		2012							
	ta (on soln) is available:		2012							
rear ua	· /			Octo -	I Ind discussion with Network Operators					
Smart Solution	Smart Solution Set:									
		CONVI		NAL						
Relevance (WS3										
Ph1)	Subset:									

Solution	Representative										
Overview	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									
				n as a 12/24MVA Tx). Note that this replacement results in a smaller Tx than							
		that for a co	mpar	able underground network.							
Headroom		EHV HV	LV	Comments This solution resolves an issue regarding the transformer (substation) load and							
Release (%)	Thermal Cable:	0%		has no effect on individual HV feeders							
				Replacing the transformer with a larger unit will release significant headroom							
	Thermal Transformer:	80%		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							
				The larger Tx will have a lower impedance and will result in an increase in fault							
	Fault Level:	-10%		level, captured here as a 10% reduction in headroom							
Cost (£)				This cost is based on the cost of a new primary transformer, split across the							
		£97,500		average number of HV feeders supplied by that transformer							
	Capital:										
	Operational	£0		It is assumed that there is no opex associated with the new transformer							
	Expenditure:										
	NPV of Opex:										
1.6	Cost Curve Type:	1 40		Costs are assumed to increase with metal prices							
Lite	Expectancy of Solution:			The transformer has a life of 40 years, meaning it will not require replacement during the modelled period							
Merit Order	Tatoy (C)	£97,500		during the modelled period Calculated from above							
Werit Order	Totex (£): Disuption Factor (1-	197,300		The disruption is fairly high, owing to the potential civil works involved etc, but							
	5):	: 4		it is likely that the new transformer will fit in the same location as the old							
	5).			transformer							
	Disruption Cost (£):			Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)							
	Flexibility (1-5):			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							
		2		are some costs associated with removal and transportation of the transformer							
				hence the low factor							
	Cross Network	0		This provides a solution to a specific problem and does not directly alleviate							
	Benefits Factor:	0		load on other circuits or at other voltage levels							
Other	Impact on Fixed	0%		Negligible impact on fixed losses							
Benefits	Losses (%):	0,0									
	Impact on Variable	1%		A slight increase may be seen in variable losses through the larger transformer							
	Losses (%):										
	Impact on quality of			There will be no impact on quality of supply measures							
	Supply (%):										
	ution becomes available:	2012									
Year da	ata (on soln) is available:	2012									
				and discussion with Network Operators							
Smart Solution	Smart Solution Set:	CONVENTIO	NAL								
Relevance (WS											
Ph1)	Subset:										

Solution	Representative									
Overview	Solution:	HV overhead network								
	Variant Solution:	New Split feeder								
		Install a new HV feeder from a primary substation, part way along the already split HV feeder.								
					eeds to be connected into the existing network such that one third of the total					
					al feeder and the split feeder is now transferred to the new split feeder. A					
				-	this is included in 13.2 of the WS3 Report.					
		ulugi ulli si	10 001	1115	this is included in 15.2 of the W55 heport.					
		EHV HV		v	Comments					
Headroom					By picking up a large amount of load from the already split feeder, the thermal					
Release (%)	Thermal Cable:	80%			headroom is significantly increased					
neicuse (707	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 (£)					Cost based on an assumed average length for HV overhead circuit; meaning					
		£346,500			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,					
	Capital:				already split, existing network					
	Operational	f0	£0		No opex costs incurred once the overhead line is installed					
	Expenditure:									
	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 (£):	£346,5	00		Calculated from above					
	Disuption Factor (1-	4			Erecting some 7km of overhead line causes significant disruption to the					
	5):	4			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					
		1			outweighs any benefots this might realise					
	Cross Network				This solution resolves a problem on a specific HV feeder, but has no benefit to					
	Benefits Factor:	0			other voltages as the load experienced there will remain constant					
Other	Impact on Fixed	0%			No impact on fixed losses anticipated					
Benefits	Losses (%):									
	Impact on Variable	-2%			The load carried by the circuit will reduce, therefore reducing the variable					
	Losses (%):				losses (which are proportional to the square of the current)					
	Impact on quality of	20%			Having fewer customers connected to one circuit effectively halves the					
	Supply (%):				number of CIs that would be incurred in the event of an outage					
	tion becomes available:	2012								
Year da	ita (on soln) is available:	2012								
					and discussion with Network Operators					
Smart Solution	Smart Solution Set:	CONVENTI	ONA	۹L						
Relevance (WS3	B Focus:									
Ph1)	Subset:									

Solution Overview	Representative Solution:	HV overhea	d net	work							
overview	Variant Solution:	Chlit foodor									
	-	Install a new HV overhead feeder out of a primary substation to the midpoint of an existing feeder.									
	Description.	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 (£)				Cost based on an assumed average length for HV overhead circuit; meaning							
		£315,000		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							
	Capital:			network							
	Operational	£0		No opex costs incurred once the overhead line is installed							
	Expenditure:	20									
	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-	. 4		Erecting some 7km of overhead line causes significant disruption to the							
	5):			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							
		1		outweighs any benefots this might realise							
	Cross Network			This solution resolves a problem on a specific HV feeder, but has no benefit to							
	Benefits Factor:	0		other voltages as the load experienced there will remain constant							
Other	Impact on Fixed	0%		No impact on fixed losses anticipated							
Benefits	Losses (%):	078									
	Impact on Variable	-2%		The load carried by the circuit will reduce, therefore reducing the variable							
	Losses (%):	-2.70		losses (which are proportional to the square of the current)							
	Impact on quality of	20%		Having fewer customers connected to one circuit effectively halves the							
	Supply (%):			number of CIs that would be incurred in the event of an outage							
	tion becomes available:	2012									
Year da	ta (on soln) is available:	2012									
	Source of Data:	DPCR5 unit co	osts a	nd discussion with Network Operators							
Smart Solution	Smart Solution Set:	CONVENTION	IAL								
Relevance (WS3	Focus:										
Ph1)	Subset:										

Solution	Representative	HV ur	ndergi	ounc	l network						
Overview	Solution:										
	Variant Solution:										
	Description:		-		option here is composed of the construction of several new substations (with						
				-) in an area that has seen significant load growth and requires wholesale						
				An ex	ample of how this might be represented can be seen in section 13.2 of the WS3						
		report									
		EHV	HV	LV	Comments						
Headroom					The new transformers and associated circuits mean that the feeders should						
Release (%)	Thermal Cable:		500%		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						
					The addition of mulitple transformers will reduce the source impedance and						
	Fault Level:		-20%		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 (£)					The cost is composed of two new ground mounted primary transformers, 2km						
					of EHV cable to supply the new transformers and associated jointing to						
		£	1,500,00	00	connect these to the network; 4km of new HV cable to supply multiple circuits						
					that will connect to the existing HV infrastructure.						
	Capital:				, and the second s						
	Operational				It is assumed that no opex costs are associated with the solution						
	Expenditure:		£0								
	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						
		40			solution will not expire during the modelled period						
Merit Order	Totex (£):	£	1,500,00	00	Calculated from above						
	Disuption Factor (1-				There will be high disruption to the public in the laying of HV and EHV cable						
	5):		5		and the installation of new primary transformers at new substation sites.						
	Disruption Cost (£):	f	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				The benefits will be exclusively to the HV network as it is envisaged that the						
	Benefits Factor:		0		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				A slight reduction in variable losses is envisaged as the numerous new assets						
	Losses (%):		-2%		installed will all be loaded to low levels thereby incurring low losses						
	Impact on quality of				There will be a significant improvement in quality of supply as fewer customers						
	Supply (%):	40%			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%.						
Voor colui	tion becomes available:		2012		01 40%.						
			2012								
rear dat	ta (on soln) is available:	DDCD		octo -	and discussion with Natwork Operators						
Smooth Colution	Smart Solution Set:				and discussion with Network Operators						
Smart Solution		CONV		NAL							
Relevance (WS3											
Ph1)	Subset:										

Solution	Representative										
Overview	Solution:	HV underground network									
	Variant Solution:										
	Description:	This solution takes the form of an additional primary transformer at, or near to, the location of									
			•		ormer. A small amount of EHV cabling is allowed for, while the solution also						
					onstruction of several HV circuits to connect to the existing HV infrastructure. A						
		diagra	m sho	wing t	he solution can be found in section 13.2 of the WS3 report.						
		EHV	HV	LV	Comments						
Headroom	Thermal Coble		100%		The new transformer and associated circuits mean that the feeders should						
Release (%)	Thermal Cable:		100%		have their load halved						
	Thermal Transformer:		100%		The new transformer means that the existing transformer will have its load						
			100/0		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						
	Devuer Quelitur		00/		transformers and more circuits						
	Power Quality:		0%		There will be no effect on power quality 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						
	Fault Level:		-15%		transformer were replaced. This has been captured here as a 15% reduction in						
					fault level headroom						
Cost (£)					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						
		f	450,000)	network; 1km of new HV cable to stitch the new transformer into the existing						
	Capital:				HV infrastrructure.						
	Operational	£0			It is assumed that no opex costs are associated with the solution						
	Expenditure:										
	NPV of Opex:	1									
	Cost Curve Type:				The cost of the solution will increase over time as metal prices increase						
Life					The lifetime of the assets will be a minimum of 40 years and hence the						
Lite	Expectancy of Solution:		40		solution will not expire during the modelled period						
Merit Order	Totex (£):	f	450,000)	Calculated from above						
Ment Order	Disuption Factor (1-	,		-	There will be very high disruption to the public in the laying of EHV and HV						
	5):				cable and the installation of a new ground mounted transformer either at a						
	· ·		5		new substation site, or adjacent to an existing transformer						
	Disruption Cost (£):	f	100,000)	Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)						
					- 1						
	Flexibility (1-5):		1		This solution cannot relaistically be re-used at another location once installed						
	Cross Network				The benefits will be exclusively to the HV network as it is envisaged that the						
	Benefits Factor:		0		new transformer will be connected to the same EHV circuit as the existing						
					transformer						
Other	Impact on Fixed		09/		Negligible impact on fixed losses						
Benefits	Losses (%):		0%								
	Impact on Variable				Negligible impact on variable losses as there will be more equipment installed						
	Losses (%):		0%		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				There will be a significant improvement in quality of supply as fewer customers						
	Supply (%):		30%		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						
Voarsolu	tion becomes available.		2012		of 30%.						
	tion becomes available: ta (on soln) is available:		2012								
rear ua				nsts a	nd discussion with Network Operators						
Smart Solution	Smart Solution Set:	CONV									
Relevance (WS3		22.47	0								
	Subset:										

Solution	Representative										
Overview	Solution:	HV undergro	ound network								
	Variant Solution:										
		Replacement of a ground mounted primary transformer (such as a 12/24MVA Tx) with a higher									
		-	rmer in the same location (such as a 19/38MVA Tx). Note that these transformers								
			in those observed for a comparable overead network.								
		0	· · · · · · · · · · · · · · · · · · ·								
		EHV HV	LV Comments								
Headroom	The survey of Calalas	0%	This solution resolves an issue regarding the transformer (substation) load and								
Release (%)	Thermal Cable:	0%	has no effect on individual HV feeders								
	Thermal Transformer:	80%	Replacing the transformer with a larger unit will release significant headroom								
	mermai transformer:	80%	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								
			The larger Tx will have a lower impedance and will result in an increase in fault								
	Fault Level:	-10%	level, captured here as a 10% reduction in headroom								
Cost (£)			This cost is based on the cost of a new primary transformer, split across the								
		£86,667	average number of HV feeders supplied by that transformer								
	Capital:										
	Operational	£0	It is assumed that there is no opex associated with the new transformer								
	Expenditure:	-									
	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-	_	The disruption is high, owing to the potential civil works involved etc as the								
	5):	5	new, larger transformer may require additional space to be accommodated								
	Disruption Cost (£):		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)								
		£100,000	The based of Distription racio (taken non rable 15.7 in the Was heport)								
	Flexibility (1-5):		There is a limited amount of flexibility with this solution in that the								
		2	transformer could be re-used in another location if necessary; however there								
		2	are some costs associated with removal and transportation of the transformer								
			hence the low factor								
	Cross Network	0	This provides a solution to a specific problem and does not directly alleviate								
	Benefits Factor:		load on other circuits or at other voltage levels								
Other	Impact on Fixed	0%	Negligible impact on fixed losses								
Benefits	Losses (%):	0,0									
	Impact on Variable	1%	A slight increase may be seen in variable losses through the larger transformer								
	Losses (%):										
	Impact on quality of	0%	There will be no impact on quality of supply measures								
	Supply (%):										
	ition becomes available:	2012									
Year da	ata (on soln) is available:	2012									
	Source of Data:	DPCR5 unit co	osts and discussion with Network Operators								
Smart Solution	Smart Solution Set:	CONVENTION	IAL								
Relevance (WS3											
Ph1)	Subset:										

Solution	Poprocontativo							
Overview	Representative Solution:		HV underground network					
	Variant Solution:							
	Description:	Lay a n	ew H	V fee	der from a primary substation, part way along the already split HV feeder.			
		Perform	n sor	ne cro	oss jointing such that one third of the total load on the original feeder and the			
		split fee	eder	is nov	v transferred to the new split feeder. A diagram showing this is included in 13.2			
		of the \	WS3	Repor	t.			
		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 (£)					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			
		£2	39,36	0	plus some additional cross-jointing to allow for the fact that this is the second			
	Capital:				splitting of the feeder			
	Operational				No opex costs incurred once the cable is installed			
	Expenditure:	£0			the opex costs meaned once the cable is instance			
	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 (£):	f2	39,36	0	Calculated from above			
Ment order	Disuption Factor (1-			-	Excavating and laying 2km of cable causes fairly significant disruption to the			
	5).		5		general public in the area			
	Disruption Cost (£):	£1	£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				This solution resolves a problem on a specific HV feeder, but has no benefit to			
	Benefits Factor:		0		other voltages as the load experienced there will remain constant			
Other	Impact on Fixed		0%		No impact on fixed losses anticipated			
Benefits	Losses (%):		570					
	Impact on Variable		-2%		The load carried by the cable will reduce, therefore reducing the variable			
	Losses (%):		2/0		losses (which are proportional to the square of the current)			
	Impact on quality of		20%		Having fewer customers connected to one circuit reduces the number of CIs			
	Supply (%):		2070		that would be incurred in the event of an outage			
Year solu	tion becomes available:	2	2012					
Year da	ta (on soln) is available:	2	2012					
		DPCR5	unit	costs	and discussion with Network Operators			
Smart Solution	Smart Solution Set:	CONVE	NTIC	NAL				
Relevance (WS3								
Ph1)	Subset:							

Solution Overview	Representative Solution:	HV ui	ndergr	ound	network				
	Variant Solution:								
		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.							
		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 (£)	Cost (£) Capital: Capital: Capital: Coperational £0 £0 £0 £0 Coperational £0 Cost Curve Type: 1		£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				
			£0		No opex costs incurred once the cable is installed				
				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 (£):	otion 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 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 solu	tion becomes available:		2012						
Year da	ta (on soln) is available:		2012						
					nd discussion with Network Operators				
Smart Solution	Smart Solution Set:	CONV	ENTIO	NAL					
Relevance (WS3									
Ph1)	Subset:								

a 1	.		_	
Solution Overview	Representative Solution:	LV overh	ead net	work
orenten	Variant Solution:	Major works		
		The majo substation requires v	r works o ns (with a vholesale	option here is composed of the construction of several new pole mounted associated conductoring) in an area that has seen significant load growth and e investment. An example of how this might be represented can be seen in e WS3 report.
		EHV H	/ 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 I	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:	C	1	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 (%):			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:		20		
Year dat	a (on soln) is available:	20		discussion with Natural On-ant-an
Smart Solution	Source of Data: Smart Solution Set:	DPCR5 un CONVENT		and discussion with Network Operators
Relevance (WS3	Smart Solution Set: Focus:	CONVENT	IUNAL	
Ph1)	Subset:			

Solution	Representative		erhea	ad net	etwork				
Overview	Solution:								
Variant Solution		-	-	-					
	Description:				portaes the installation of a new pole mounted transformer, close to an exiting				
				-	loaded pole mounted transformer. The solution involves HV and LV lines as				
		report		iew tra	nsformer. A representative diagram can be found in section 13.2 of the WS3				
		EHV	HV	LV	Comments				
Headroom					The new transformer and associated circuits mean that the feeders should				
Release (%)	Thermal Cable:			100%	have their load halved				
					The new transformer means that the existing transformer will have its load				
	Thermal Transformer:			100%	halved (i.e. its headroom doubled)				
) (alta an Ulandi			1%	A marginal benefit may be seen for voltage headroom as the load and				
	Voltage Head:			1%	generation is aplit across two transformers				
	Voltage Leg:			6%	Some voltage legroom benefit will arise as the load is distributed across two				
	voltage Leg.			0%	transformers and more circuits				
	Power Quality:			0%	There will be no effect on power quality				
					The addition of a second transformer will reduce the source impedance and				
	Fault Level:			-15%	hence increase the fault level by a greater degree than merely if the				
	rauit Level.			1570	transformer were replaced. This has been captured here as a 15% reduction in				
					fault level headroom				
Cost (£)					The cost is compoased of a new pole mounted distribution transformer, 100m				
					of HV conductor to supply the new transformer and associated jointing to				
			£20,00	0	connect this to the network; 800m of new LV conductor to supply two new				
					circuits at an average length of 400m each.				
	Capital:								
Operational			£0		It is assumed that no opex costs are associated with the solution				
	Expenditure:								
	NPV of Opex:								
Cost Curve Type: Life Expectancy of Solution:			1		The cost of the solution will increase over time as metal prices increase				
					The lifetime of the assets will be a minimum of 40 years and hence the				
	40			solution will not expire during the modelled period					
Merit Order	Totex (£):		£20,00	0	Calculated from above				
	Disuption Factor (1-				There will be high disruption to the public in the erection of new poles and the				
	5):		4		construction of new HV and LV circuits together with the installation of a new				
	_				pole mounted transformer				
	Disruption Cost (£):		£30,00	0	Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)				
					This solution connet relaistically be rejused at another location and installed				
	Flexibility (1-5):		1		This solution cannot relaistically be re-used at another location once installed				
	Cross Network				The benefits will be exclusively to the LV network as it is envisaged that the				
	Benefits Factor:		0		new transformer will be connected to the same HV circuit as the existing				
					transformer				
Other	Impact on Fixed		0%		Negligible impact on fixed losses				
Benefits	Losses (%):		070						
	Impact on Variable				Negligible impact on variable losses as there will be more equipment installed				
	Losses (%):		0%		via which losses may arise, but the assets will be loaded to lower levels thereby				
			070		reducing the level of losses within them				
					l				
	Impact on quality of				There will be a significant improvement in quality of supply as fewer customers				
	Supply (%):		30%		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				
			2011		of 30%.				
Year solution becomes available:			2012						
Year da	ta (on soln) is available:		2012						
					nd discussion with Network Operators				
Smart Solution	Smart Solution Set:	CONV	ENTIO	NAL					
Relevance (WS3									
Ph1)	Subset:								

Solution	Representative	LV ove	rhea	ad ne	twork
Overview	Solution:	_ •			h _
	Variant Solution:				
	Description:				pole mounted distribution transformer with a larger pole mounted
		transfo	rmer		
		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
					The larger Tx will have a lower impedance and will result in an increase in fault
	Fault Level:			-10%	level, captured here as a 10% reduction in headroom
Cost (£)					This cost is based on the cost of a new distribution transformer, split across
		£	1,450		the average number of LV feeders supplied by that transformer (2)
	Capital:				
	Operational		£0		It is assumed that there is no opex associated with the new transformer
	Expenditure:		10		
	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-		4		The disruption is fairly high, owing to the potential civil works involved In
	5):				erecting a suitable pole etc
	Disruption Cost (£):	£3	£30,000		Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report)
	Flexibility (1-5):				There is a limited amount of flexibility with this solution in that the
			2		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		0		This provides a solution to a specific problem and does not directly alleviate
	Benefits Factor:		5		load on other circuits or at other voltage levels
Other	Impact on Fixed		0%		Negligible impact on fixed losses
Benefits	Losses (%):				
	Impact on Variable		1%		A slight increase may be seen in variable losses through the larger transformer
	Losses (%):				
	Impact on quality of		0%		There will be no impact on quality of supply measures
	Supply (%):				
	tion becomes available:		012		
Year da	ta (on soln) is available:		012		
					and discussion with Network Operators
Smart Solution	Smart Solution Set:	CONVE	NTIO	NAL	
Relevance (WS3					
Ph1)	Subset:				

Solution	Representative		rhod	. d. n. o	twork			
Overview	Solution:	LV OVERNEAU NELWORK						
	Variant Solution:	New Sp	Vew Split feeder					
	Description:	Install	a nev	v LV fe	eeder from a distribution substation, part way along the already split LV feeder.			
		The ne	w fee	eder n	eeds to be connected into the existing network such that one third of the total			
		load or	n the	origin	al feeder and the split feeder is now transferred to the new split feeder. A			
		diagrar	m shc	owing	this is included in 13.2 of the WS3 Report.			
		EHV	HV	LV	Comments			
Headroom	The second Calala			80%	By picking up a large amount of load from the already split feeder, the therma			
Release (%)	Thermal Cable:			80%	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			
					Potentially there could be significant benefit here as the circuit length is			
	Voltage Leg:			6%	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 (£)	Tuun Leven.			0,0	Cost based on an assumed average length of 500m for LV overhead circuit;			
cost (1)					therefore 250m of LV conductor required plus some additional cost for			
		£11,000)	connecting the new split feeder into the existing network			
	Capital:				connecting the new split recuer into the existing network			
	Operational				No opex costs incurred once the conductor is installed			
Expenditure: NPV of Opex:		£0			no opex costs meaned once the conductor is instance			
	Cost Curve Type: 1			Increase over time as metal prices increase				
Lif	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-		,		Erecting 250m of new overhead circuit causes fairly high disruption to the			
	5):		4		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				This solution resolves a problem on a specific LV feeder, but has no benefit to			
	Benefits Factor:		0		higher voltages as the load experienced there will remain constant			
Other Benefits	Impact on Fixed Losses (%):		0%		No impact on fixed losses anticipated			
Serients	Impact on Variable				The load carried by the circuit will reduce, therefore reducing the variable			
	Losses (%):		-2%		losses (which are proportional to the square of the current)			
	Impact on quality of				Having fewer customers connected to one circuit effectively halves the			
Supply (%):			number of Cls that would be incurred in the event of an outage					
Year sol	lution becomes available:		2012					
	data (on soln) is available:		2012					
Teal C				COSte	l and discussion with Network Operators			
Smart Solution		CONVE						
Relevance (WS		CONVE		INAL				
Ph1)	Subset:							
	Subset.							

Solution	Representative	LV ov	/erhea	ad net	work			
Overview	Solution:	_						
	Variant Solution:							
	Description:	Instal	l a nev	v LV ov	erhead feeder out of a distribution substation to the midpoint of an existing			
		feede	er. Brea	ak the e	existing feeder and pick up the 50% of the load from that feeder onto the new			
		feede	er.					
		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			
					Potentially there could be significant benefit here as the circuit is reduced to			
	Voltage Leg:			12%	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 (£)			C10.00	0	Cost based on an assumed average length of 500m for LV overhead circuit;			
	Capital:		£10,00	0	threfore 250m of LV conductor required			
	Operational	£0			No opex costs incurred once the conductor is installed			
	Expenditure:							
	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		0	Calculated from above			
	Disuption Factor (1-		,		Erecting 250m of new overhead circuit causes fairly high disruption to the			
	5):		4		general public in the area			
	Disruption Cost (£):		£30,00	0	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				This solution resolves a problem on a specific LV feeder, but has no benefit to			
	Benefits Factor:		0		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				The load carried by the circuit will reduce, therefore reducing the variable			
	Losses (%):		-2%		losses (which are proportional to the square of the current)			
	Impact on quality of				Having fewer customers connected to one circuit effectively halves the			
	Supply (%):			number of CIs that would be incurred in the event of an outage				
Year solution becomes available:		2012						
	ata (on soln) is available:		2012					
i cai ua	Source of Data:	ПРС₽	-		nd discussion with Network Operators			
Smart Solution	Smart Solution Set:							
Relevance (WS3		CONV		INAL				
Relevance (WS3 Ph1)	S Focus: Subset:							
r 111)	Subset:							

120

Solution	Representative	LV UI	nderg	round	network				
Overview	Solution:								
Variant Solution:		,							
	Description:		-		ption here is composed of the construction of several new substations (with				
					in an area that has seen significant load growth and requires wholesale				
				. An exa	imple of how this might be represented can be seen in section 13.2 of the WS3				
		repor							
		EHV	HV	LV	Comments				
Headroom					The new transformers and associated circuits mean that the feeders should				
Release (%)	Thermal Cable:			500%	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				
	· · · · · ·				The addition of mulitple transformers will reduce the source impedance and				
	Fault Level:			-20%	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 (£)					The cost is composed of two new ground mounted distribution transformers,				
.,					400m of HV cable to supply the new transformers and associated jointing to				
			£250,0	00	connect these to the network; 1.8km of new LV cable to supply six new circuits				
			, -		at an average length of 300m each.				
Capital									
	Operational				It is assumed that no oney casts are associated with the solution				
		£0			It is assumed that no opex costs are associated with the solution				
	Expenditure:								
	NPV of Opex:				The sect of the columbian will be an even time on a model with a firm of				
	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 (£):		£250,0	00	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 (£):		£30,00	00	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				The benefits will be exclusively to the LV network as it is envisaged that the				
	Benefits Factor:	0			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				A slight reduction in variable losses is envisaged as the numerous new assets				
	Losses (%):				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	2					
			2012						
Year data (on soln) is available:					I nd discussion with Network Operators				
Smart Calution									
Smart Solution	Smart Solution Set:	CONV		JINAL					
Relevance (WS									
Ph1)	Subset:								

Capital: at an average length of 300m each. Operational Expenditure: E0 NPV of Opex: It is assumed that no opex costs are associated with the solution NPV of Opex: It is assumed that no opex costs are associated with the solution Life Expectancy of Solution: 40 Addition of the solution will increase over time as metal prices increase Life Expectancy of Solution: 40 Solution will not expire during the modelled period Merit Order Totex (£): Espectancy of Solution: 40 Solution will not expire during the modelled period Merit Order Totex (£): Espectancy of Solution: 40 Calculated from above There will be high disruption to the public in the laying of HV and LV cable an the installation of a new ground mounted transformer either at a new substation site, or adjacent to an existing transformer Disruption Cost (£): £30,000 Flexibility (1-5): 1 This solution cannot relaistically be re-used at another location once installed new transformer Ubsers (%): 0% Negligible impact on fixed Losses (%): 0% Impact on quality of Supply (%): 30%	Solution Overview	Representative Solution:	LV Ur	nderg	round	network					
Control First Source Sour			Minor	work	s						
Control First Source Sour											
Incorporates the construction of several LV circuits. A diagram showing the solution can be four in section 12.0 of the W3 report. Env Iv Iv Iv Iv Comments Thermal Cable In the new transformer and associated circuits mean that the feeders should have their tota haved their have heir tota formation and haved their have heir have he											
In section 13.2 of the W3 report. EW W W Comments Headroom Release (%) Thermal Cable It we ther load halved Thermal Transformer It are we transformer mans that the existing transformer will have its load halved (.e. its headroom doubled) Voltage Leg: It are we transformer mens that the existing transformer will have its load and generation is apilit across two transformers Voltage Leg: It are well tabe not first owe routage headroom as the load and generation is apilit across two transformer will reduce the source impedance and hence increase the fault level by a greater degree than merely if the transformer were replaced. Fault Level The cost is composed of a new ground mounted distribution transformer. Cost (£) Capital The cost is composed of a new ground mounted distribution transformer. Cost (£) The cost is composed of a new ground mounted distribution transformer. Cost (£) Cost Corve Type The cost is composed of a new ground mounted distribution transformer. Life Expectancy of Solution: <th as="" cost="" increase="" metal="" of="" over="" pr<="" solution="" td="" the="" time="" will=""><td></td><td></td><td>-</td><td></td><td></td><td>-</td></th>	<td></td> <td></td> <td>-</td> <td></td> <td></td> <td>-</td>			-			-				
EHV HV LV Comments Meadroom Thermal Cable: Joon The new transformer and associated circuits mean that the feeders should have their load halved (i.e. is headroom doubled) Thermal Transformer: Joon The new transformer means that the existing transformer will have its load halved (i.e. is headroom doubled) Voltage Leg: Joon Amarginal benefit may be seen for voltage headroom as the load and generation is apilit across two transformers Some voltage legroom benefit will arks as the load is distributed across two transformers: and more circuits. There will be no effect on power quality. Fault Level: Joon The addition of a second transformer will reduce the source impedance and hast the elevel headroom for the value to source impedance and hast transformer were replaced. This has been captured here as a 15% reduction fault level headroom Cost (£) £80,000 The cost is compoased of a new ground mounted distribution transformer, 1000 m of two Cable to supply two new circuit at an avascale length of 3000 m each. UPV of Opex: The cost of the solution will increase over time as metal prices increase Cost Curve Type: 1 The lefterime of the assets will be a minimum of 40 years and hence the colution will not expire during the modelled period Merit Order Totx (£): £80,000 Figure based on Disruption Factor (Leken from Table 13.7 in the WS						5 S					
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: 100% The new transformer means that the existing transformer will have its load halved (i.e. its headroom doubled) Voltage Leg: 6% Some voltage legroom beentki will arke as the load is distributed across two transformers and more circuits. Power Quality: 0% The rewill be no effect on power quality. Fault Level: -15% There will be no effect on power quality. Fault Level: -15% The exit score. The addition of a second transformer will reduce the source impedance and hence increase the fault level by agreater degree than merely if the transformer were replaced. The exit is composed of a new ground mounted distribution transformer, 100m of HV cable to supply the new transformer and associated jointing to connect this to the networks 600m of new U cable to supply two new circuit at an average length of 300m each. Life Expectancy of Solution 40 The cost of the solution will increase over time as metal prices increase Life Expectancy of Solution 40 The iffetime of the assets will be a minimum of 40 years and hence the solution will not expire during the modelled perind. <th></th> <th></th> <th></th> <th></th> <th></th> <th></th>											
Release (%) Thermal Transformer: 1005 have their load halved The new transformer means that the existing transformer will have its load halved (1, it is headroom doubled) A marginal benefit may be seen for voltage headroom as the load and generation is apilit across two transformers Voltage Leg: 68 Some voltage legroom benefit will arise as the load is distributed across two transformers and more circuits. Power Quality: 08 There will be no effect on power quality. Fault Level: 155 The diltion of a second transformer will reduce the source impedance and transformer were replaced. This has been captured here as a 155 reduction fault level headroom Cost (£) Capital: 200 The cost is composated of a new ground mounted distribution transformer, 1000 moth V cable to supply the new transformer and associated pointing to connect this to the network; 600m of new LV cable to supply to new tracust at an average length of 300m each. Operational £0 The lifetime of the solution will increase over time as metal prices increase IVF Ord Opex: The lifetime of the solution will not expire during the modelled period Merit Order Totex (£): 200.00 Situation of a new ground mounted distribution transformer 100 moth transformer Jupption Factor (1+ The isolution will increase to a taik group on the solution will not expire dur			LUA	пv	LV						
Intermal transformer: 100h halved (i.e. its beadroom doubled) Voltage Head: 115 A marginal benefit may be seen for voltage headroom as the load and generation is apilit across two transformers Voltage Leg: 6 Some voltage legroom benefit will arise as the load is distributed across two transformers 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 fault level headroom Cost (f) fmer addition of a scoupply the own transformer and associated jointing to compete the average length of 400 depetees. Cost (f) fmer addition of a scoupply the own transformer and associated jointing to compact of 100 mer. Cost (f) fmer addition of a scoupply the own transformer and associated jointing to compact of 100 mer. Cost (f) fmer addition of a scoupply the own transformer and associated jointing to compact of 100 mer. Cost Curve Type: 1 The cost of the solution will increase over time as metal prices increase Uife Expectancy of Solution 40 Solution factor (1; Solution factor (2; Solution facto		Thermal Cable:			100%	have their load halved					
Voltage Head 1/3 generation is apilt across two transformers Voltage Leg: 6/6 Some voltage legroom benefit will arise as the load is distributed across two transformers and more circuits Power Quality: 10/6 There will be no effect on power quality Fault Level: 15/5 There will be no effect on power quality Fault Level: 15/5 The cost is composed of a new ground mounted distribution transformer, the transformers and associated jointing to compact of the transformer and associated jointing to compet the wet transformer and associated jointing to compact this to the network; 600m of new LV cable to supply the we new circuit at an average length of 300m each. Operational Cost (£) Expenditure: 10 Expenditure: 10 The cost is composed of a new ground mounted distribution transformer, to cost scare associated with the solution Expenditure: cost (Corure Type: 1 The cost of the solution will increase over time as metal prices increase Urite 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 Discuption Factor (1): F800.00 Calcularet from above There will be high disruption to the public in the laying of HV and LV cable an the installation site, or adjacent to an existing transformer will be connected to		Thermal Transformer:			100%	_					
Voltage Leg: Some voltage legroom benefit will arise as the load is distributed across two transformers and more circuits Power Quality: 0% Fault Level: 1%		Voltage Head:			1%						
Power Quality ox. 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 fault level beadroom Cost (£) -5% The cost is composed of a new ground mounted distribution transformer, 100m of HV cable to supply the new transformer and associated joining to connect this to the network; 600m of new LV cable to supply two new circuit at an average length of 300m each. Operational 60 It is assumed that no opex costs are associated with the solution If Expectancy of Solution 40 solution will not expire during the modelled period Merit Order Totex (£) f80.000 Calculated from above Disruption Factor (1) 5% 4 The solution will not expire during the modelled period Disruption Cost (£) £30.000 Figure based on Disruption Factor (taken from Table 13.7 In the WS3 Report) Impact on variable 0% Neeligible impact on variable losses at the avert will be an entile prover as the easing transformer Other Impact on Fixed 0% Neeligible impact on variable losses at the evelide to lower levels there reducing the souted to lower levels there reducing the asset will be connected to the same HV circuit		Voltage Leg:			6%						
Fault Level: 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 fault level headroom Cost (£) Cost (£) Status Status <td></td> <td>Power Quality:</td> <td></td> <td></td> <td>0%</td> <td></td>		Power Quality:			0%						
Fault Level: -15% 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 fault level headroom Cost (£) Capital The cost is composed 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 circuit at an average length of 300m each. Operational £0 The cost is composed 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 circuit at an average length of 300m each. Operational £0 The cost is composed of a new ground mounted distribution transformer. Infe Expenditure: £0 The cost of the solution will increase over time as metal prices increase Life Expectancy of Solution: 40 Solution will not expire during the modelled period Merit Order Totex (£) £80.000 Calculated from above Disruption Cost (£): £30.000 Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report) Isoution cannet relaistically be re-used at another location once installed Losses (%): 0% Impact on Variable 0% Negligible impact on fixed losses Losses (%): 0% Negligible impact on variable losses as there will be more equipment installe Losses (%): 0%		Tower Quanty.			070						
Fault Level: -15% Cost (f) fault Verel headroom Capital: at an average length of 300m of new UV cable to supply two new circuit at an average length of 300m each. Operational for Expenditure: for an average length of 300m each. Cost Curve Type: 1 The cost of the solution will increase over time as metal prices increase Life Expectancy of Solution: 40 The cost of the solution will increase over time as metal prices increase Disuption Factor (1: fault Vere will be high disruption to the public in the laying of HV and LV cable an the installation of a new ground mounted transformer either at a new substation site, or adjacent to an existing transformer Disruption Cost (f): f30.000 Flexibility (1-5): 1 This has olution cannot relaistically be re-used at another location once installed new transformer will be connected to the same HV circuit as the existing transformer Other Impact on Fixed 0% Losses (%): 0% Impact on quality of Suppl											
Cost (£) Cost (£) Cost (£) Cost (£) Cost Capital: Capital: Capital: Capital: Capital: Capital: Capital: Capital: Cost Carve Type: Cost Curve Type: Cost Curve Type: Life Expectancy of Solution: Cost Curve Type: Life Expectancy of Solution: Cost Curve Type: Cost Cost Cost Cost Cost Cost Cost Cost		Fault Level:			-15%	, , , , ,					
Cost (£) 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 circuit at an average length of 300m each. Operational Expenditure: E0 It is assumed that no opex costs are associated with the solution Image: Cost Curve Type: 1 The cost of the solution will increase over time as metal prices increase Uife Expectancy of Solution: 40 Solution will not expire during the modelled period Merit Order Totex (£): E80,000 Calculated from above Disuption Factor (1- 5): 4 The solution will not expire during the modelled period Merit Order Totex (£): £80,000 Calculated from above Disuption Factor (1- 5): 4 The solution will not explice during the modelled period Merit Order Totex (£): £30,000 Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report) Issuption Cost (£): £30,000 Figure based on Disruption Factor (taken from Table 13.7 in the WS3 Report) Issupple to no narisformer 0% Negligible impact on fixed losses Under the asset (5): 0% Negligible impact on size, but the assets will be more equipment inst											
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Solution Overview Representative Solution V Underground network Variant Solution Ground mounted 11/LV Tx Description Replacement of an existing distribution transformer with a larger unit Headroom Release (%) Thermal Cable: 0% Thermal Transformer: 8% Voltage Leg: 0% Notage Leg: 0% Power Quality: 0% Voltage Leg: 0% Power Quality: 0% No impact on power quality 0% Power Quality: 0% Fault Level: 10% Cost (£) Capital: Cost (£) Totage Leg: Cost (£) Totage Leg: Cost (£) Totage Leg: Dispution Factor (1: 40 Cost (£) Totage Leg: Cost (£) Totage Leg: Cost (£) Totage Leg: Cost Courve Type: Cost Courve Type: Life Expectancy of Solution: 40 The ransformer has a life of 40 years, meaning it will not require repl during the modelled period						Representative	Solution
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2 are some costs associated with removal and transportation of the transport of the transpor	5	e is a limited amount of flexibility with this solution in that the	There is a lim			Flexibility (1-5):	_
2 are some costs associated with removal and transportation of the transport of the transpor		-			2		
Cross Network Benefits Factor: 0 This provides a solution to a specific problem and does not directly all load on other circuits or at other voltage levels Other Benefits Impact on Fixed Losses (%): 0% Negligible impact on fixed losses Impact on Variable 1% A slight increase may be seen in variable losses through the larger training	transformer	some costs associated with removal and transportation of the trans	are some cos		2		
Benefits Factor: U load on other circuits or at other voltage levels Other Impact on Fixed 0% Negligible impact on fixed losses Benefits Losses (%): 0% A slight increase may be seen in variable losses through the larger training		ce the low factor	hence the lov				
Benefits Impact on Fixed 0% Benefits Losses (%): Negligible impact on fixed losses Impact on Variable 1% A slight increase may be seen in variable losses through the larger tra	y alleviate	provides a solution to a specific problem and does not directly allev	This provides		0	Cross Network	_
Benefits Losses (%): 0% Impact on Variable 1% A slight increase may be seen in variable losses through the larger training of the larger traning of the larger training of the larger training of		on other circuits or at other voltage levels	load on othe		U	Benefits Factor:	
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					U%	Losses (%):	Benefits
Losses (%):	transformer	ght increase may be seen in variable losses through the larger trans	A slight incre		10/	Impact on Variable	
					170	Losses (%):	
Impact on quality of 0% There will be no impact on quality of supply measures		re will be no impact on quality of supply measures	There will be		00/		
Supply (%):					U%		
Year solution becomes available: 2012					2012	tion becomes available:	Year solutio
Year data (on soln) is available: 2012					2012	ta (on soln) is available:	Year data
Source of Data: DPCR5 unit costs and discussion with Network Operators		liscussion with Network Operators	and discussior	costs a	DPCR5 unit	Source of Data:	
Smart Solution Smart Solution Set: CONVENTIONAL				NAL	CONVENTIC	Smart Solution Set:	Smart Solution
Relevance (WS3 Focus:						Focus:	Relevance (WS3
Ph1) Subset:						Subset:	Ph1)

Solution	Representative							
Overview	Solution:	LV U	V Underground network					
	Variant Solution:	New Split feeder						
	Description:	Lay a	new L	V feed	ler from a distribution substation, part way along the already split LV feeder.			
		Perfo	rm sor	ne cro	oss jointing such that one third of the total load on the original feeder and the			
		split f	eeder	is nov	v transferred to the new split feeder. A diagram showing this is included in 13.2			
		of the	e WS3	Repor	t.			
		EHV	HV	LV	Comments			
Headroom	Thermal Cable:			80%	By picking up a large amount of load from the already split feeder, the thermal			
Release (%)					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			
					Potentially there could be reasonable benefit here as the circuit is reduced to			
	Voltage Leg:			6%	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 (£)					Cost based on an assumed average length of 300m for LV underground circuit;			
			£33,000		therefore 150m of LV cable required, plus some additional cross-jointing to			
			133,000	,	allow for the fact that this is the second splitting of the feeder			
	Capital:							
	Operational	Operational Expenditure:			No opex costs incurred once the cable is installed			
	Expenditure:							
	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-		4		Excavating and laying 150m of cable causes fairly high disruption to the			
	5):				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				This solution resolves a problem on a specific LV feeder, but has no benefit to			
	Benefits Factor:		0		higher voltages as the load experienced there will remain constant			
Other	Impact on Fixed		0%		No impact on fixed losses anticipated			
Benefits	Losses (%):		0%					
	Impact on Variable		-2%		The load carried by the cable will reduce, therefore reducing the variable			
	Losses (%):		-270		losses (which are proportional to the square of the current)			
Impact on quality of		20%		Having fewer customers connected to one circuit reduces the number of CIs				
Supply (%):			2070		that would be incurred in the event of an outage			
Year solution becomes available:			2012					
Year da	ata (on soln) is available:		2012					
	Source of Data:	DPCR	5 unit	costs	and discussion with Network Operators			
Smart Solution	Smart Solution Set:	CONV	/ENTIC	NAL				
Relevance (WS3	B Focus:							
Ph1)	Subset:							

Solution Overview	Representative Solution:	LV Ur	nderg	round	network				
Variant Solution:		Split feeder							
	Description:	feede	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:	tional tiure: Dpex: Type: 1		0	Cost based on an assumed average length of 300m for LV underground circuit; threfore 150m of LV cable required, plus some jointing				
	Operational Expenditure:				No opex costs incurred once the cable is installed				
	NPV of Opex:								
Lif	Cost Curve Type: e Expectancy of Solution:				Increase over time as metal prices increase The solution remains valid for the entire modelled period				
Merit Order	Totex (£):	40 £30,000		0	Calculated from above				
Went Order	Disuption Factor (1- 5):		4	0	Excavating and laying 150m of cable causes fairly high disruption to the general public in the area				
	Disruption Cost (£):		£30,00	0	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 (%):			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 (%):	ity of			Having fewer customers connected to one circuit effectively halves the number of CIs that would be incurred in the event of an outage				
	lution becomes available:		2012						
Year d	lata (on soln) is available:		2012						
					nd discussion with Network Operators				
Smart Solution		CONV	ENTIC	DNAL					
Relevance (WS									
Ph1)	Subset:								

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