Chiltern Power

CONFIDENTIAL REPORT

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Energy Networks Association

Smart Grid Forum
Work Stream 3 – Phase 3.4

Review of New Enabler Mapping

Authors:
D Yellen
M Sprawson

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EA Technology Limited, Capenhurst Technology Park, Capenhurst, Chester, CH1 6ES; Tel: 0151 339 4181 Fax: 0151 347 2404
http://www.eatechnology.com
Registered in England number 2566313

Summary

This report provides an overview of the impact of the changes proposed by Smarter Grid Solutions (SGS) in their report "Task 3.4: Review of Enablers, Solutions and Top-Down Modelling in the Transform™ model". The GB model has been run using the network data developed under Phase 2 of the Work Stream 3 activity for a range of changes to build up the impact of the SGS amendments, these are:

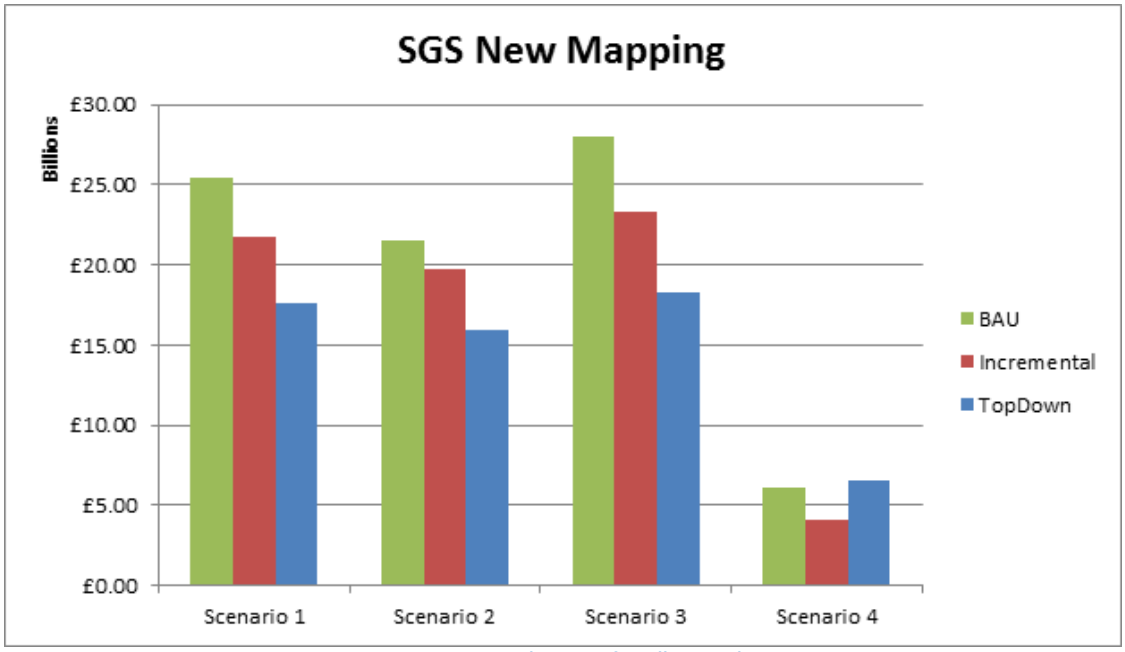
- The Original WS3-Phase 2 dataset
- Adding in only the changes in Capex proposed in the SGS report
- Adding in only the changes in Opex proposed in the SGS report
- Adding in only the new enablers and linkages to solutions
- Adding in only the changes in Optimism Bias proposed in the SGS report
- Running the model with all the proposed changes
- Rerun following a thorough final review of enabler mapping

The data from this review has now been added to the model with the following conclusions:

- The review of the capex and opex of all proposed solutions and enablers has been accepted and these new data sets appear to enhance the model
- The review of the methodology for incorporating Optimism Bias has been modelled and similarly accepted as helping to improve the performance of their model
- The original review of the enabler mapping loaded extra costs in the form of extra enablers onto smart solutions making them uneconomic in most cases. Following a thorough review between EA Technology and SGS it was decided that this extra cost was not realistic. These enablers were all thoroughly reviewed and a final set of enablers, satisfactory to both SGS and EATL were agreed

When run in the Transform™ model the final agreed data gives the following results:

- A significant reduction in predicted costs between BAU and Incremental for all Scenarios except Scenario 4 (Low uptake of HP and EV)
- An equally significant reduction in costs between Incremental and Top Down Scenarios
- The selection of a large number of Smart solutions as the model rolls out to 2050
  The Top-Down investment strategy is significantly more favourable in three of the four strategies, indicating a possible advantage of proactive investment.



Investment requirement for all Scenarios to 2050

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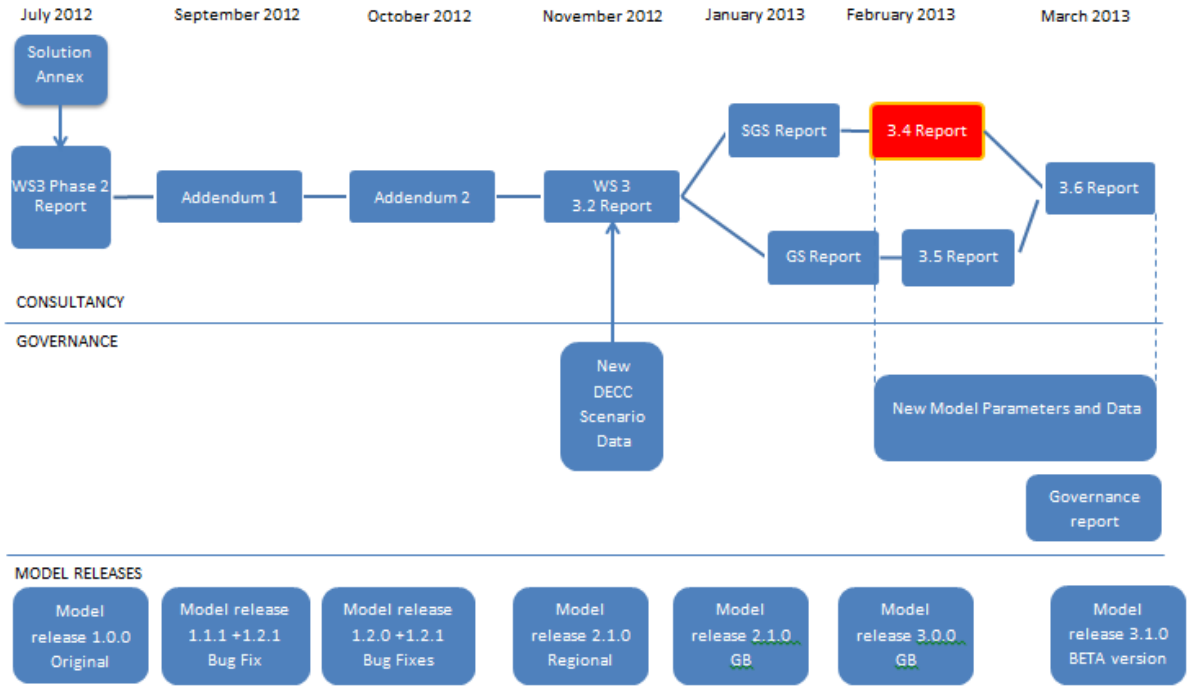
1 Workstream 3 Timeline

The following diagram shows where this report (highlighted in red) fits into the overall work program for the Workstream 3 activity. The top of the diagram indicates the various documents produced throughout the WS3 activity while the middle describes the changes to the model that have been incorporated as scenario data and parameters have been updated, the bottom indicates model releases.



The purpose of this report is therefore:

- To show the impact of the changes proposed and subsequently agreed in the SGS report
- To “fix” the modelling inputs ahead of the modelling work on Tipping Points
- To provide interim observations on the enhancements to the model ahead of the main modelling analysis following final changes through Governance

2 Introduction

2.1 Scope

This report details work performed by EA Technology Limited (EATL) and Smarter Grid Solutions (SGS) from October 2012 to February 2013. The work has been closely scrutinised by the DNO's, Grid Scientific and Chiltern Power throughout this review period and we thank all the partners for their helpful input.

The overall aim of the work was the enhancement of and improvement of the data behind the enabler and solution cost assumptions within the WS3 model developed to generate the Phase 2 report: "Assessing the Impact of Low Carbon Technologies on Great Britain's Power Distribution Networks

This report provides an overview of the impact of the changes proposed by SGS on the Transform model. As such, it should be read in conjunction with the SGS report "Task 3.4: Review of Enablers, Solutions and Top-Down Modelling in Transform™.

The GB model has been run for a range of changes to build up the impact of the SGS amendments, these are:

- The Original Phase 2 dataset
- Adding in only the changes in Capex proposed by SGS
- Adding in only the changes in Opex proposed by SGS
- Adding in only the new enablers and linkages to solutions
- Adding in only the changes in Optimism Bias proposed by SGS
- Running the model with all the proposed changes

The impacts of each of these changes are provided in overview below and following this the output of the final model is discussed in more detail.

This report is not intended to be a detailed analysis of the outputs of the model, rather an overview of the impacts of the proposed changes. The model will be further enhanced by forthcoming changes due at the end of February from the analysis being run by Grid Scientific on Tipping Point Analysis and from the further changes due in Mid-March from the first review period of the Governance process. All these changes will then be transferred to the DNO's individual licence area models. Thus it is most important to review the impact of the outputs rather than the outputs themselves.

2.2 Comparing the Results to Phase 2

In comparing the outputs of the model to those from Phase 2 it must be borne in mind that the scenarios have been changed to reflect the current DECC scenarios. These new scenarios are detailed in the table below:

Table 1: Make-up of composite scenarios to align with DECC Carbon Plan

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
New Naming Convention	**High abatement in low carbon heat**	**High abatement in transport**	**High electrification of heat & transport**	**Credit purchase**
PV trajectory	Central	Central	High	Low
HP trajectory	High	Medium	High	Low
EV trajectory	Medium	High	High	Low
Onshore wind trajectory[1]	National Grid's 'Gone Green'	National Grid's 'Gone Green'	National Grid's 'Gone Green'	National Grid's 'Slow Progression'
Biomass trajectory	National Grid's 'Gone Green'	National Grid's 'Gone Green'	National Grid's 'Gone Green'	National Grid's 'Slow Progression'
Previous Name under WS3 Ph2	Scenario 1	N/A	Scenario 0	Scenario 3

For the avoidance of doubt, where we compare the results from the Phase 2 model outputs to the new phase 3 model outputs later in this report. The scenarios in both phase 2 and phase 3 models are the new DECC scenarios outlined above.

In analysing the outputs of the model, most of the emphasis detailed below is on scenario 3 – where both heat pumps and EV's are on their high trajectory. This is the scenario with generally the most LCT impact on the network.

2.3 Summary of Changes Proposed by SGS

SGS has completed a thorough review of the solutions and enablers currently listed in the **Transform™** model of long-term costs associated with the anticipated introduction of Low Carbon Technologies in GB. This review has covered the following distinct areas:

- A review of the capex of all proposed solutions and enablers
- A review of the opex of all proposed solutions and enablers
- A reappraisal of the methodology for incorporating Optimism Bias
- A gap analysis which has highlighted several new enablers/
- A thorough reappraisal of the enabler mapping linking solutions to the enablers required to make the solutions happen.

For a thorough understanding of the changes made the reader should familiarise themselves with the SGS report "Task 3.4: Review of Enablers, Solutions and Top-Down Modelling in TRANSFORM", February 2013.

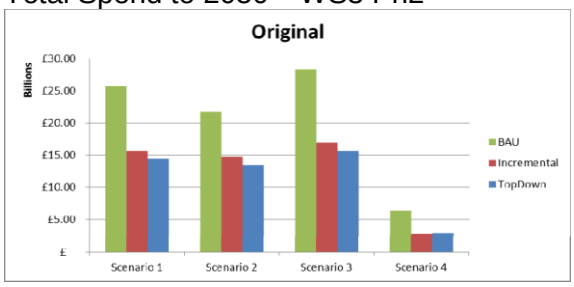
SGS anticipates that the revised cost estimates are likely to cause an overall increase in Transform™ model output costs.

3 Outputs incorporating SGS changes

3.1 Overall impact of the changes proposed by SGS

To examine the impacts of the SGS review all the suggested data changes were entered into the Transform™ model. This produced the output below.

Total Spend to 2050 – WS3 Ph2



Total Spend with SGS data

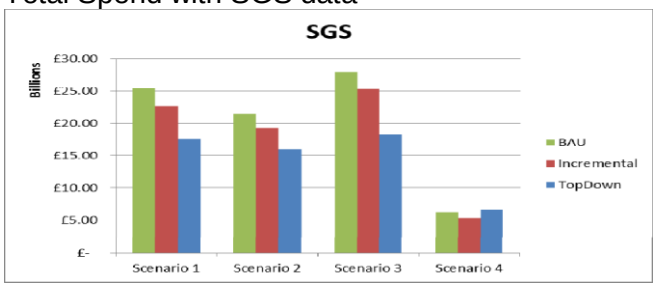


Figure 1. PV of Totex for all Scenarios

It can be seen that the benefit in investing in an incremental strategy has decreased compared to on WS3 Phase 2. The reasons for this increase in costs for the incremental scenario are explored below.

3.2 Changes to Scenario 3 – High Electrification

The graph below details the changes in discounted Totex for the predicted spend to 2050 in scenario 3 (Smart 'incremental' investment strategy).

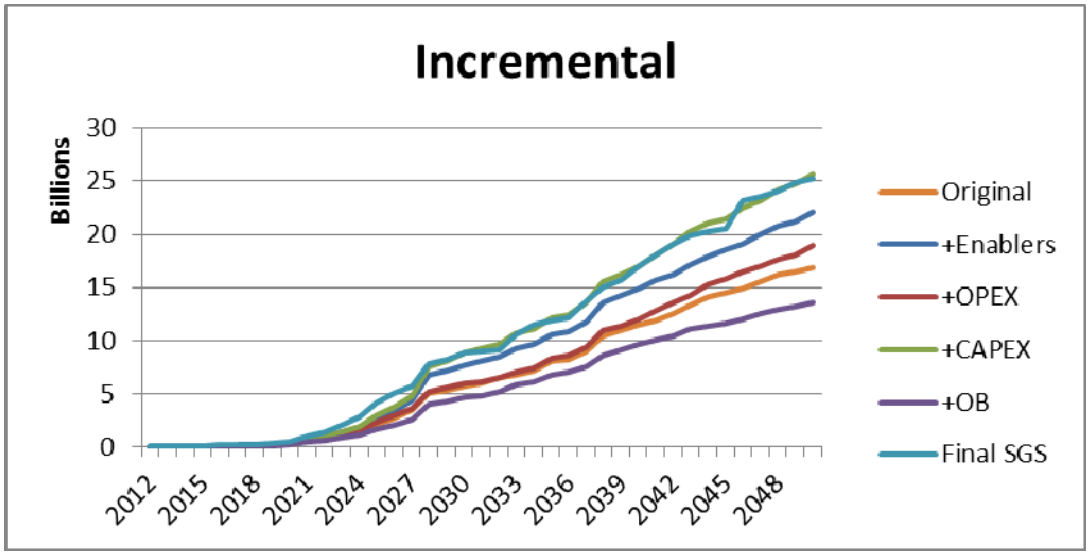


Figure 2. Gross cumulative investment requirement for the smart indremental strategy in Scenario 3 built up for all changes to Phase 2 model

Looking at these in turn:

Original – refers to the expenditure calculated in Phase 2
"+ Enablers" – represents the increased costs purely resulting in the addition of more linkages between enablers and solutions. For a fuller understanding of how these have increased refer to the SGS report section 4. In this scenario this has increased the costs by between 30 - 40%
"+ Opex" refers only to increased expenditure in operating costs as detailed in section 3.2 of the SGS report. It can be seen that this has had a smaller impact. Increasing costs by 0-10%
"+ Capex" refers only to increased expenditure in capital costs. It can be seen that this has the largest impact. Increasing costs by over 50%.
"+ Optimism Bias" (OB) refers only to decreased expenditure in costs, due to a reduction in the optimism bias factor as detailed in section 3.4 of the SGS report. It can be seen that this has reduced costs by 20-30%

Taking all these factors into account, total spend has increased in this scenario from £17bn to £25bn representing an increase of over 50%. Looking further at scenario 3 we can see the predicted impact on spend for the BAU and Top Down scenarios as shown below:

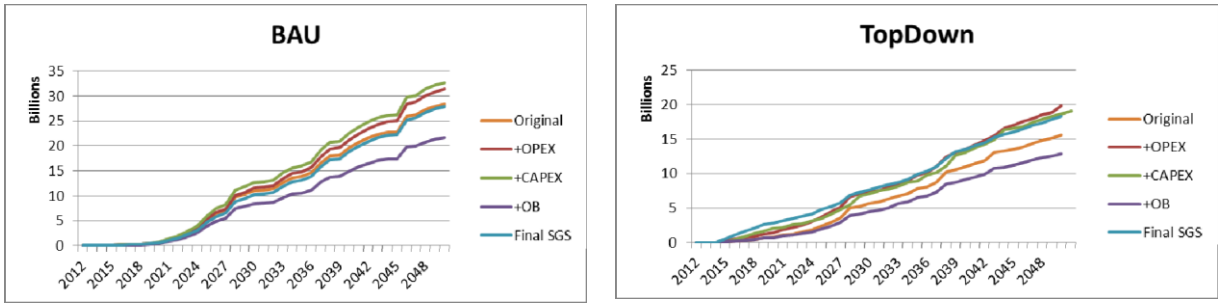


Figure 3 BAU and Top Down gross cumulative investment requirement for Scenario 3 for all changes to Phase 2 model

In the BAU and Top Down scenarios there are no increases for Enablers since in BAU there are no linkages to enablers and in Top Down the enablers are purchased through Capex. For BAU we can see that the final SGS data gives a very similar result with increases in Capex and Opex balancing out the decrease in Optimism Bias. For Top Down we see that costs have risen by around 20% with a relatively equal impact from both capex and opex. Although the impact of each of these factors vary over time the total impact can be viewed as follows:

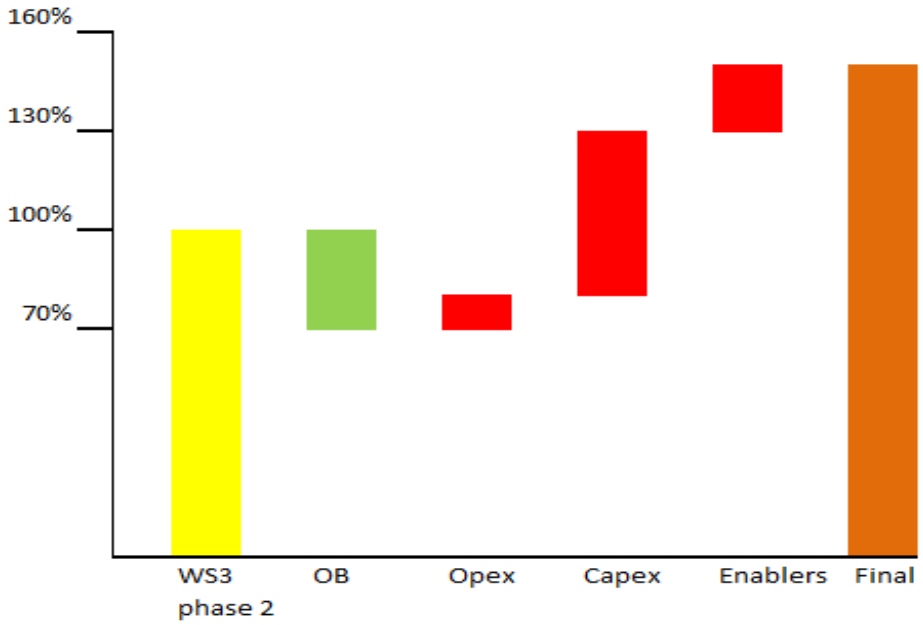


Figure 4 Illustrative waterfall diagram drawing out the changes from WS3 Phase 2

To help further understand where the increasing costs have come from we have analysed the average cost increases to conventional and smart solutions. To do this all opex costs were annualised over 10 years. This gives the following results:

Table 2 Summary of impact on Costs of SGS proposed changes

Solution	Increased Solution Totex	Increase in Solution Costs inc Totex and enablers
Conventional	-1%	-1%
Smart	+35%	+182%

Thus it can be seen that the SGS work has had an impact on the costs of smart solutions but has had a significant impact on the addition of more enablers to make these solutions work, leading to a major increase in the costs of deploying smart solutions. This means that many smart solutions are no longer being selected.

As an extreme example of this we can look at the case of DSR to residential customers. In WS3 phase 2, DSR was assigned only two enablers (Comms last mile and Products to control devices). This gave a total cost per feeder of around £6,000 which instinctively feels light. The SGS review suggests a further 5 enablers:

- Products to remote control EV charging
- DNO Data Architecture
- Comms to Aggregator
- Comms Fabric
- Comms Back Haul

Increasing the cost to £133k per feeder and making this an unattractive solution. This is further emphasised when we look at which solutions are being selected by the model. These are summarised in the table below, for scenario 3 running the model out to 2050. Old (WS3 Ph2) and new (all SGS Changes) costs (including enabler costs) listed per feeder.

Table 3 Summary of solutions selected to 2050 with all SGS proposed changes in Scenario 3

Solutions	Times deployed	% of total	£ Cost per solution SGS	£ Cost per solution original	Increase in cost
LV Ground mounted 11/LV Tx	461,931	39	6,849	6,424	7%
LV Underground network Split feeder	448,467	38	46,054	43,200	7%
LV underground Minor works	114,047	9.7	153,514	144,000	7%
Generator (HV) Network Support	23,794	2	17,418	75,962	-78%
Generator (LV) Network Support	20,201	1.7	3,483	15,900	-75%
LV Pole mounted 11/LV Tx	16,096	1.4	4,605	2,088	122%
Large 33/11 Tx	13,006	1.1	172,959	162,240	7%
LV overhead Minor works	12,353	1.1	30,702	28,800	7%
RTTR for HV Overhead Lines	9,594	0.8	38,462	11,022	250%
Small 33/11 Tx	8,820	0.7	194,579	182,520	7%

The only smart solutions now being selected are Generator Providing Network Support where SGS have reduced costs substantially and RTTR for HV Overhead Lines, despite an increase in costs of 250%.

3.3 Impact on all 4 Scenarios by Spending Review Period

We have looked at each of the 4 scenarios to examine the impact on spend during each review period. These are shown below.

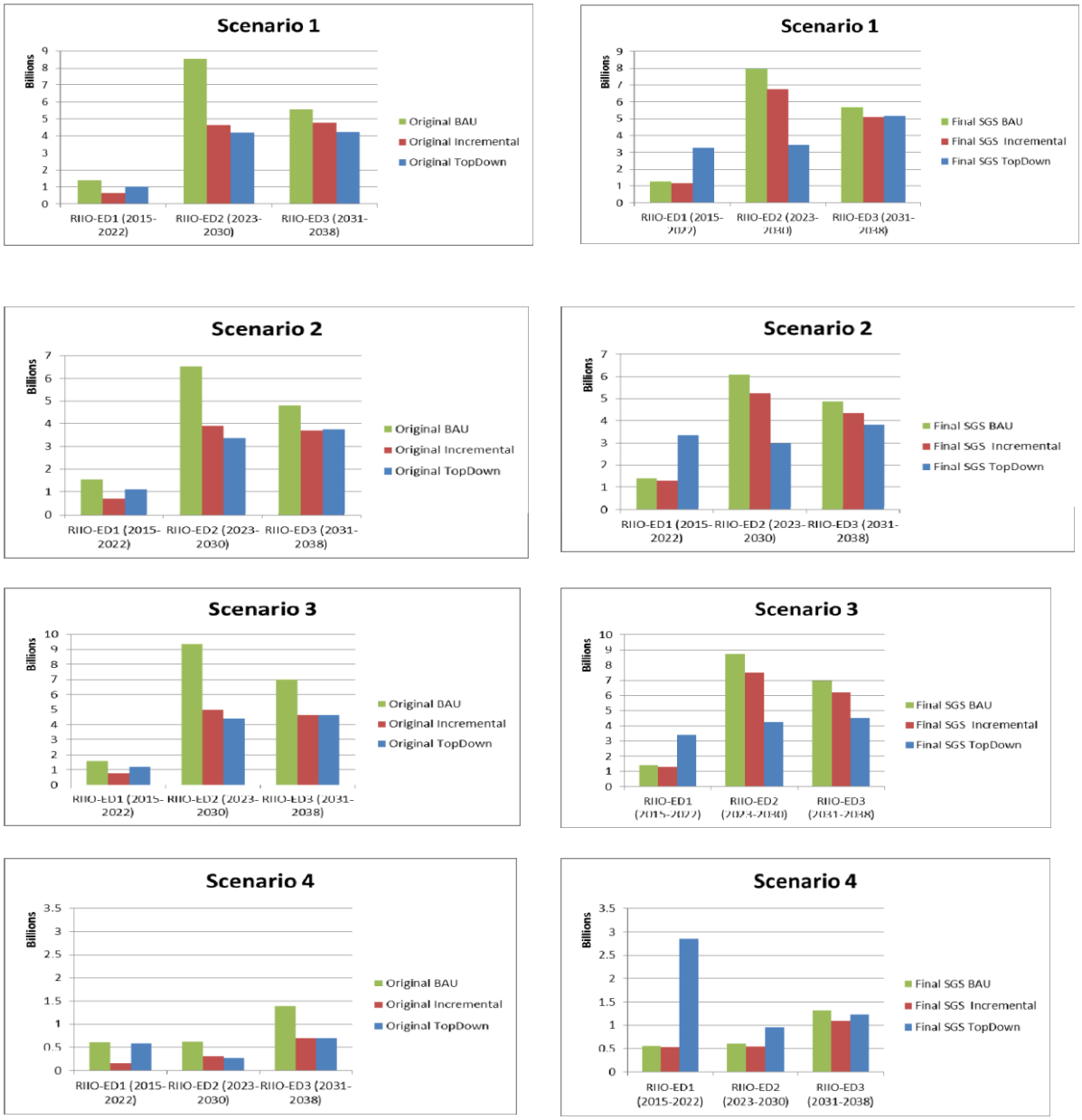


Figure 5 Model gross cumulative investment results for all scenarios in the next 3 price control periods

We can see that overall, the changes have had very little impact on Business As Usual spending in all the scenarios. Whilst Incremental has risen substantially, although in all circumstances it is still less than BAU. The largest impact has been on Top Down, where in ED1 spend is predicted to be higher than for BAU in all 4 scenarios. This reduces through ED2 and ED3 . In all cases the selection of smart solutions is low due to the high linkage to enablers

3.4 Commentary

At this point following discussion it was decided to stop analysis and refer back to SGS. Following discussions with SGS it was decided to rerun the model without the enabler mapping but incorporating all other changes as suggested by SGS. The enabler mapping would then be thoroughly reviewed before remodeling (see section 4).

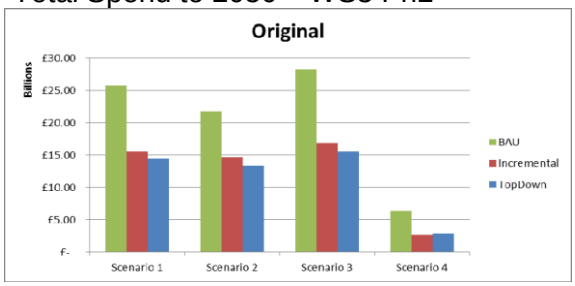
The next section looks at a rerun of the model with the old enabler mapping but with all other recommended changes by SGS incorporated.

4 Model Rerun without new enabler mapping

4.1 Impact on total spend

Firstly looking at total spend to 2050 and then looking at spend by review period:

Total Spend to 2050 – WS3 Ph2



Total Spend with SGS data minus enabler mapping

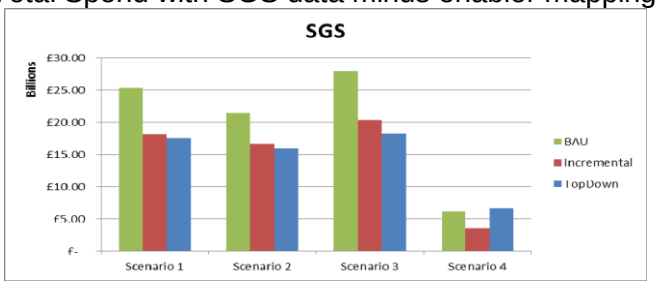


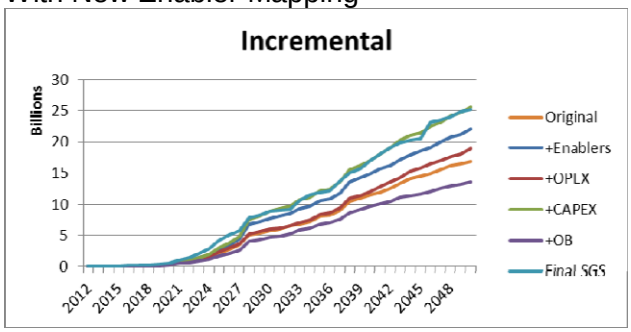
Figure 6. Gross cumulative investment requirement for all Scenarios to 2050 – SGS data minus enabler mapping

It can be seen that by removing the enabler mapping the benefit in investing in an incremental strategy is quite similar to that found in WS3 Phase 2. This is further explored in the sections below.

4.2 Scenario 3 – High Electrification of Heat and Transport

The graph below details the changes in discounted Totex for the predicted spend to 2050 in scenario 3 (incremental), splitting out the increases or decreases for each of the changes proposed by SGS (Capex, Totex, Optimism Bias) and demonstrates the changes caused by the new enabler mapping.

With New Enabler Mapping



Without New Enabler Mapping

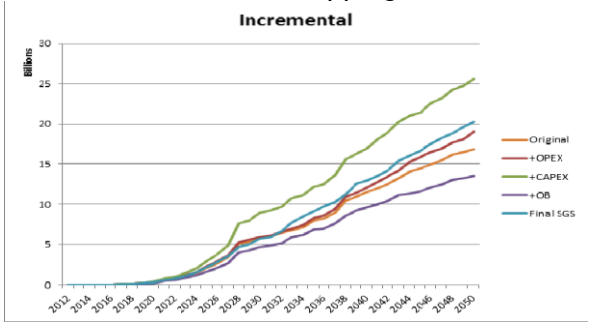


Figure 7. Incremental gross cumulative investment requirement for Scenario 3 built up for all changes to Phase 2 model

From the graphs above we can see that total spend has now reduced from £25 billion with enabler mapping to £20 billion, providing confidence that more smart solutions are now being selected. For comparison, the original phase 2 predicted costs were about £17 billion so costs have risen 15-20%.

The selection of an increased number of smart solutions is further emphasised when we look at which solutions are being selected by the model. These are summarised in the table below, for scenario 3 running the model out to 2050. Old (WS3 Ph2) and new (all SGS Changes. But without new enabler mapping) costs (including all enabler costs) are listed on a per feeder basis.

Solutions	Times deployed	% of total	£ Cost per solution SGS	£ Cost per solution original	Ratio SGS/Original
Generator Providing Network Support- LV	1,440,409	49	5,929	15,900	-63%
DSR - DNO to residential	390,037	13	37,571	5,393	697%
LV Ground mounted 11/LV Tx	252,915	9	6,113	6,425	95%
Local smart EV charging infrastructure_Intelligent control devices	250,363	9	41,212	27,603	149%
Permanent Meshing of Networks - LV Sub-Urban	162,217	6	29,319	34,281	86%
Permanent Meshing of Networks - LV Urban	141,404	5	29,319	34,281	86%
RTTR for HV/LV transformers	110,073	4	12,426	17,107	73%
LV Underground network Split feeder	45,664	2	41,106	43,200	95%
Generator Providing Network Support - HV	26,954	1	52,633	75,962	69%
LV Pole mounted 11/LV Tx	15,222	1	4,111	2,088	197%

Table 4 . Summary of solutions selected in Scenario 3 with SGS data minus enabler mapping

Now we see seven of the top 10 solutions (by number of times used) are smart. The actual solutions selected will of course vary network to network and further refinement can be expected through re-examining the enabler mapping. This will provide more improvements via the Governance process.

4.3 Impact on all 4 Scenarios

We have looked at each of the 4 scenarios to examine the impact on spend during each review period. These are shown below.

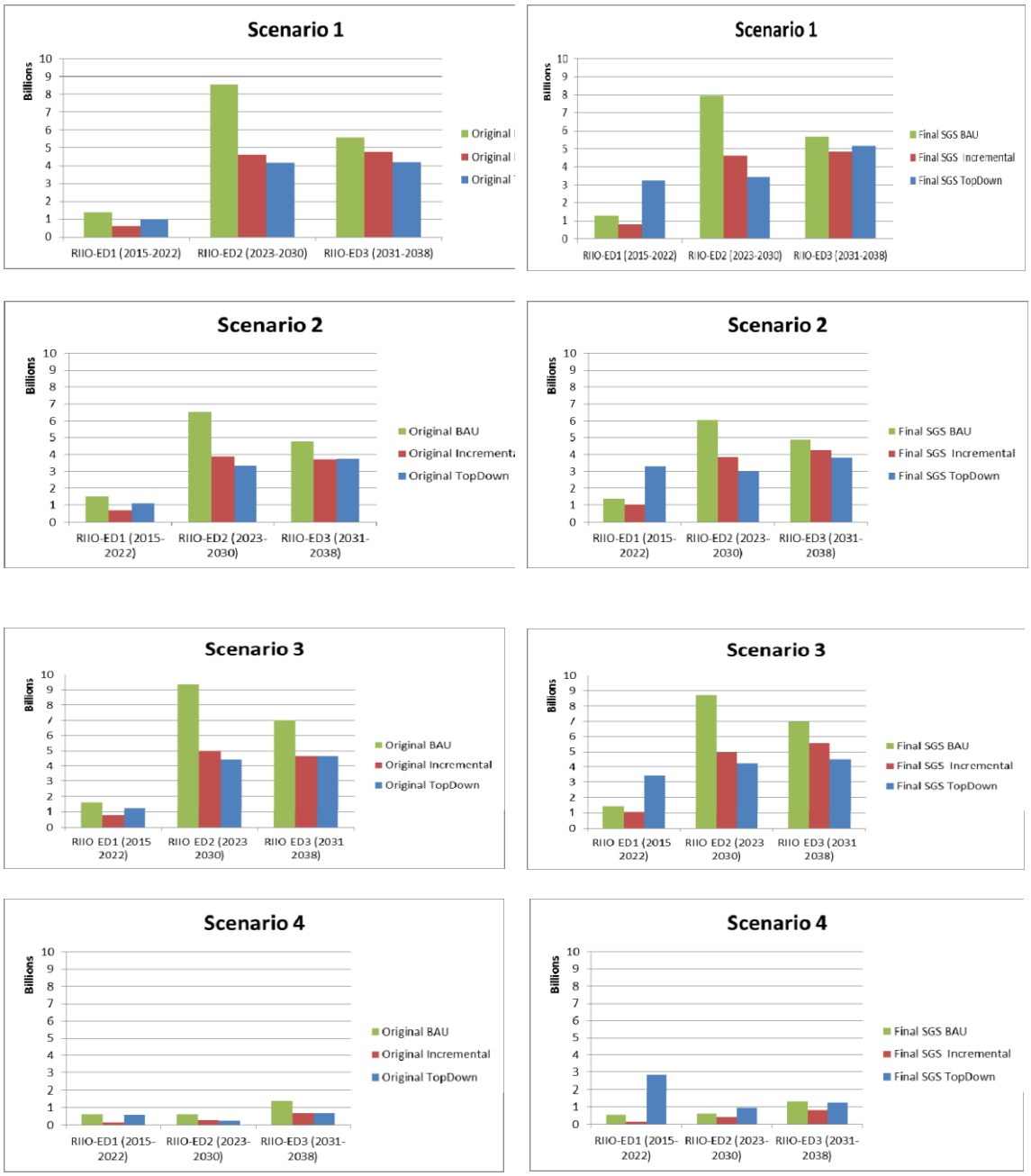


Figure 8. Gross cumulative investment requirement for all scenarios based on SGS data minus enabler mapping

We can see that these results now look quite similar to the WS3 Phase 2 with some obvious variances:

- Initial ED1 costs for Top Down have increased substantially through the addition of more enablers and generally higher costs per enabler
- Top Down smart is the favoured long term solution in most but not all scenarios
- Incremental smart offers large advantages to BAU in almost all cases.

5 Model rerun with final enabler mapping

A thorough review of the enabler mapping by EATL and SGS was conducted, with support from the stakeholders. From this a new version of enabler mapping was agreed that was approved as being satisfactory to all stakeholders. All changes to Capex, Opex, Optimism Bias and Enabler mapping have now been agreed by both EATL and SGS. The results are presented in detail below and the new enabler mapping is provided for review as a separate appendix.

5.1 Impact on total spend

Firstly looking at total spend to 2050 and then looking at spend by review period:

Total Spend to 2050 – WS3 Ph2 *Total Spend with SGS finalised enabler mapping*

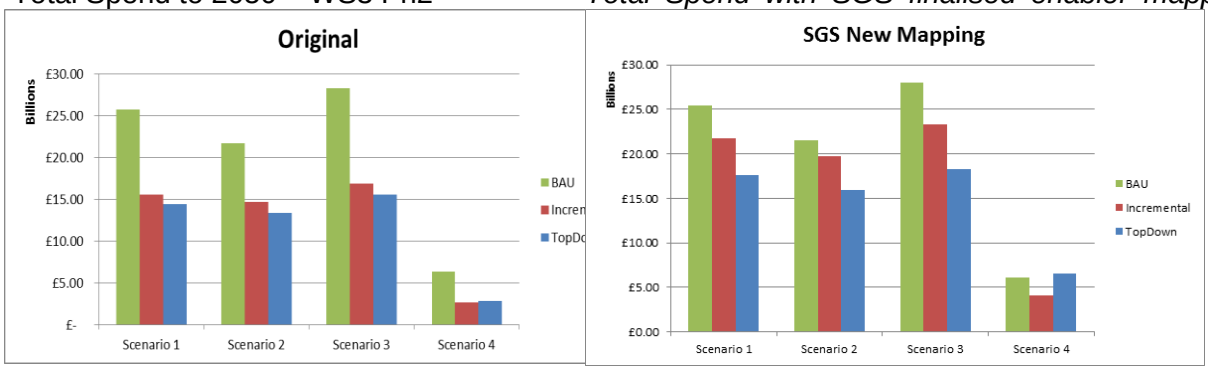


Figure 9. PV of Totex investment requirement for all Scenarios to 2050 – SGS data with new enabler mapping

It can be seen that by refining the enabler mapping as suggested, the benefit in investing in an incremental strategy is now lower than that found in the WS3 Phase 2 report, but still significant, c.£4bn in scenario 1 for example.

In all scenarios except scenario 4 there is significant benefit in investing in a Top Down manner indicating a possible advantage of proactive investment when considering the needs of the network over the longer term. The exact enablers in which to invest over the RIIO-ED1 period will be explored in further detail under WS3 Phase 3 - activity 3.6.

The results are further explored in the sections below.

5.1 Scenario 3 – High Electrification of Heat and Transport

The graph below details the changes in discounted Totex for the predicted spend to 2050 in scenario 3 (incremental), splitting out the increases or decreases for each of the changes proposed by SGS (Capex, Totex, Optimism Bias) and demonstrates the changes caused by the new enabler mapping.

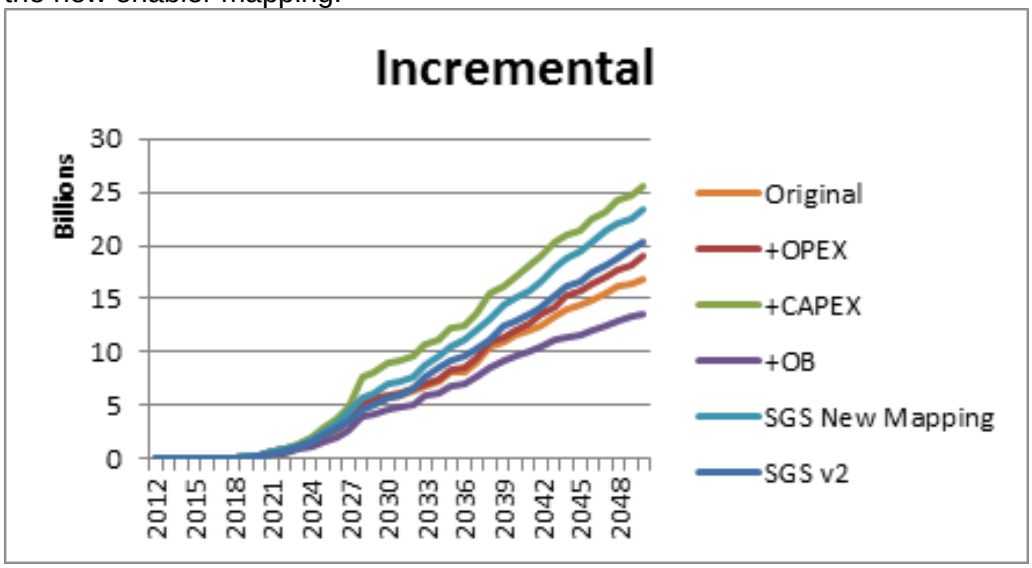


Figure 10. PV of cumulative investment for the Smart Incremental Strategy for Scenario 3, showing the magnitude of change compared with the Phase 2 model results

From the graphs above we can see that total spend in 'SGS New Mapping' is now forecast at £24 billion up from £21 billion without enabler mapping (SGS v2), but still lower than the BAU investment strategy. For comparison, the original phase 2 predicted costs were about £17 billion so costs have risen just over 30%. The selection of solutions is summarised in the table below, for scenario 3 running the model out to 2050. These are listed on a per feeder basis.

Solutions	Times deployed	% of total	£ Cost per solution SGS	£ Cost original	Ratio SGS/Original
Generator Providing Network Support - LV	1,448,772	50	10,558	15,900	0.66
DSR - DNO to residential	273,490	9	58,887	5,393	10.92
LV Ground mounted 11/LV Tx	255,914	9	6,113	6,425	0.95
Local smart EV charging infrastructure_Intelligent control devices	249,206	9	46,608	27,603	1.69
RTTR for HV/LV transformers	202,635	7	9,392	17,107	0.55
Permanent Meshing of Networks - LV Sub-Urban	158,534	5	39,281	34,281	1.15
Permanent Meshing of Networks - LV Urban	146,458	5	29,319	34,281	0.86
LV Underground network Split feeder	45,896	2	41,106	43,200	0.95
Generator Providing Network Support - HV	33,291	1	56,497	75,962	0.74
LV Pole mounted 11/LV Tx	14,723	1	4,111	2,088	1.97

Table 5 . Summary of solutions selected in Scenario 3 with SGS data including revised enabler mapping

Now we see seven of the top 10 solutions (by number of times used) are smart. The actual solutions selected will of course vary from network to network.

5.2 Impact on all 4 Scenarios

We have looked at each of the 4 scenarios to examine the impact on spend during each review period. These are shown below.

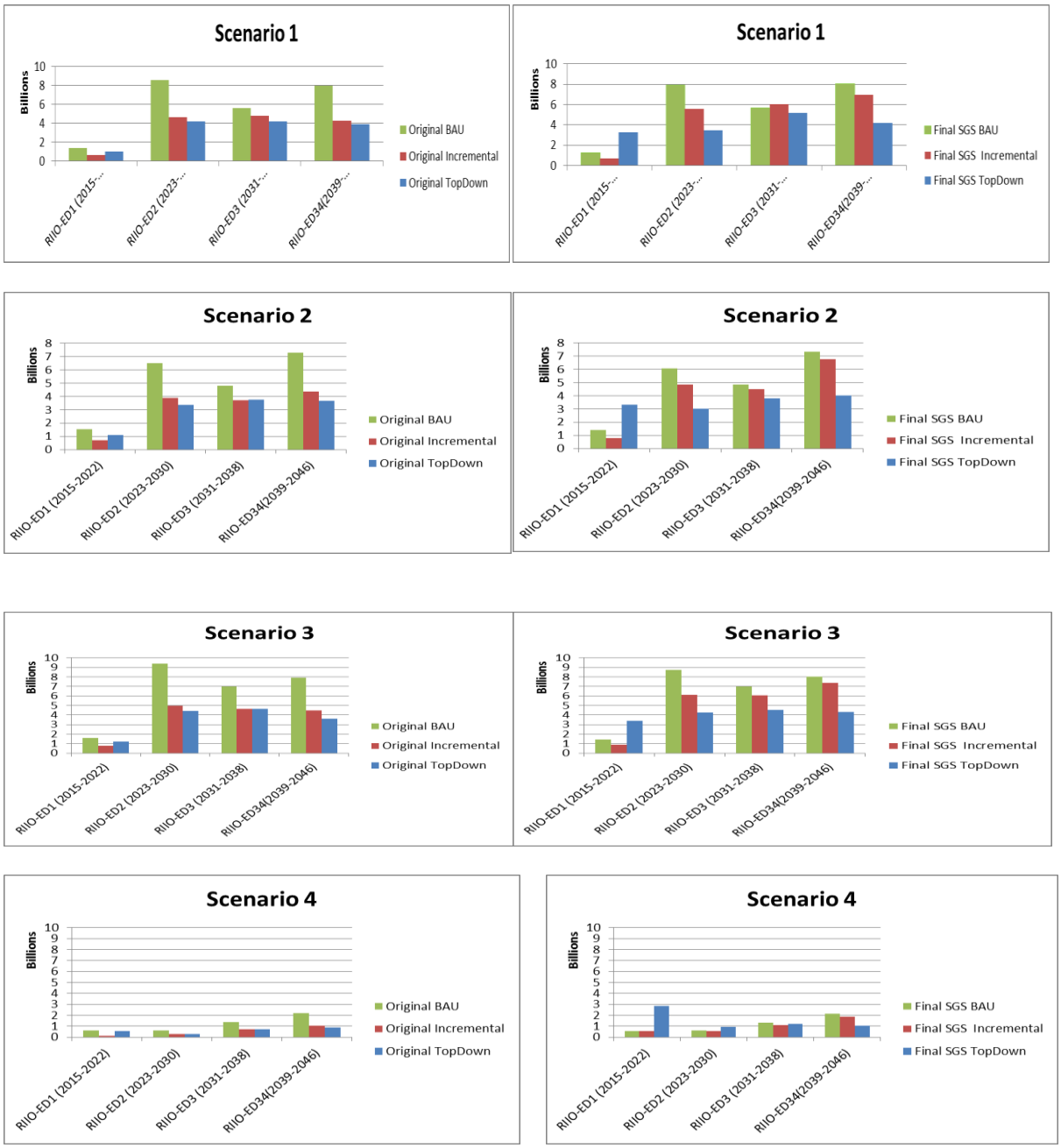


Figure 11. PV of Totex investment requirement for all scenarios based on SGS data including refined enabler mapping

We can see that these results now look quite similar to the WS3 Phase 2 with one obvious change, where there is more of an obvious step down from BAU to incremental to Top Down once the initial ED1 investment has been made in ED1 top down.

6 Conclusions

This report provides a review of the impact of the changes proposed by Smarter Grid Solutions (SGS) in their report “Task 3.4: Review of Enablers, Solutions and Top-Down Modelling in the Transform™ model”. The GB model has been run using the network data developed under Phase 2 of the Work Stream 3 activity for a range of changes to build up the impact of the SGS amendments, these are:

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The data from this review has now been added to the model with the following conclusions:

- The review of the capex and opex of all proposed solutions and enablers has been accepted and these new data sets appear to enhance the model
- The review of the methodology for incorporating Optimism Bias has been modelled and similarly accepted as helping to improve the performance of their model
- The original review of the enabler mapping loaded extra costs in the form of extra enablers onto smart solutions making them uneconomic in most cases. Following a thorough review between EA Technology and SGS it was decided that this extra cost was not realistic. These enablers were all thoroughly reviewed and a final set of enablers, satisfactory to both SGS and EATL were agreed

When run in the Transform™ model the final agreed data gives the following results:

- A significant reduction in predicted costs between BAU and Incremental for all Scenarios except Scenario 4 (Low uptake of HP and EV)
- An equally significant reduction in costs between Incremental and Top Down Scenarios
- The selection of a large number of Smart solutions as the model rolls out to 2050 The Top-Down investment strategy is significantly more favourable in three of the four strategies, indicating a possible advantage of proactive investment.

7 Appendix – Enabler Mapping Final

154	Advanced control systems	Communications LAST MILE	Comms BACK HAUL	Comms FABRIC	DATA SYSTEMS	Design tools	DSR - at consumer premises	DSR - EV charging	EHV Circuit Monitoring	HV Cct Monitor feeder	HV Cct Monitor - feeder & SE	HV/LV Tx Moniroting	Link boxes / remote control	LV Cct Monitor/ feeder	LV cct monitor feeder & SE	LV feeder monitoring at S/S	LV feeder monitor - S/S & SE	RMUs Fitted with Actuators	Comms to DSR aggregator	Dynamic Net Protection, 11kV	Weather monitoring	Monitoring PQ (EHV/HV Tx)	Monitor PQ (HV/LV Tx)	Monitor PQ (HV feeder)	Monitor PQ (LV Feeder)	S.Meter: DCC-DNO 1 way	S.Meter: DCC-DNO 2 way A+D	S.Meter: DCC-DNO 2 way control	Phase imbalance - LV dist s/s	Phase imbalance - LV circuit	Phase imbalance via smart meter	Phase imbalance - 3ph LV cust.	Phase imbalance -HV circuit
Active Network Management - Dynamic Network Reconfiguration - EHV	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Active Network Management - Dynamic Network Reconfiguration - HV	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Active Network Management - Dynamic Network Reconfiguration - LV	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D-FACTS - EHV connected STATCOM	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D-FACTS - HV connected STATCOM	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D-FACTS - LV connected STATCOM	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Flexible AC Transmission Systems (D-FACTS) - EHV	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Flexible AC Transmission Systems (D-FACTS) - HV	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution Flexible AC Transmission Systems (D-FACTS) - LV	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DSR_DNO to Central business District DSR	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DSR - DNO to residential	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DSR_DNO to aggregetor led EHV connected commercial DSR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DSR_DNO to EHV connected commercial DSR	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DSR_DNO to aggregetor led HV commercial DSR	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DSR_DNO to HV commercial DSR	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electrical Energy Storage_HV Central Business District (commercial building level)	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electrical Energy Storage_EHV connected EES - large	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electrical Energy Storage_EHV connected EES - medium	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electrical Energy Storage_EHV connected EES - small	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electrical Energy Storage_HV connected EES - large	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electrical Energy Storage_HV connected EES - medium	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electrical Energy Storage_HV connected EES - small	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electrical Energy Storage_LV connected EES - large	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electrical Energy Storage_LV connected EES - medium	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electrical Energy Storage_LV connected EES - small	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLANK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Embedded DC Networks_Embedded DC@EHV	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Embedded DC Networks_Embedded DC@HV	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Embedded DC Networks_Embedded DC@LV	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLANK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EAVC - HV/LV Transformer Voltage Control	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EAVC - EHV circuit voltage regulators	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EAVC - HV circuit voltage regulators	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
EAVC - LV circuit voltage regulators	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EAVC - LV PoC voltage regulators	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fault Current Limiters_EHV Non-superconducting fault current limiters	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fault Current Limiters_EHV Superconducting fault current limiters	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fault Current Limiters_HV reactors - mid circuit	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fault Current Limiters_HV Non-superconducting fault current limiters	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fault Current Limiters_HV Superconducting fault current limiters	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Generator Constraint Management GSR - EHV connected generation	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Generator Constraint Management GSR - HV connected generation	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Generator Constraint Management GSR - LV connected generation	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Generator Providing Network Support e.g. Operating in PV Mode - EHV	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Generator Providing Network Support e.g. Operating in PV Mode - HV	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Generator Providing Network Support e.g. Operating in PV Mode - LV	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Local smart EV charging infrastructure_Intelligent control devices	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Types Of Circuit Infrastructure_Novel EHV tower and insulator structures	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Types Of Circuit Infrastructure_Novel EHV underground cable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Types Of Circuit Infrastructure_Novel HV tower and insulator structures	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Types Of Circuit Infrastructure_Novel HV underground cable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Permanent Meshing of Networks - EHV	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Permanent Meshing of Networks - HV	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Permanent Meshing of Networks - LV Urban	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Permanent Meshing of Networks - LV Sub-Urban	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLANK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RTTR for EHV Overhead Lines	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
RTTR for EHV Underground Cables	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RTTR for EHV/HV transformers	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RTTR for HV Overhead Lines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RTTR for HV Underground Cables	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RTTR for HV/LV transformers	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RTTR for LV Overhead Lines	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
RTTR for LV Underground Cables	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Switched capacitors - EHV	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Switched capacitors - HV	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Switched capacitors - LV	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temporary Meshing (soft open point) - EHV	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temporary Meshing (soft open point) - HV	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Temporary Meshing (soft open point) - LV	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLANK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLANK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV Underground network Split feeder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV New Split feeder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV Ground mounted 11/LV Tx	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV underground Minor works	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV underground Major works	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV overhead network Split feeder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV overhead network New Split feeder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV Pole mounted 11/LV Tx	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV overhead Minor works	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV overhead Major works	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HV underground network Split feeder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HV underground New Split feeder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Large 33/11 Tx	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HV underground Minor works	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HV underground Major works	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HV overhead network Split feeder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HV overhead New Split feeder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small 33/11 Tx	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HV overhead Minor works	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HV overhead Major works	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EHV underground network Split feeder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EHV underground New Split feeder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EHV underground Minor works	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EHV underground Major works	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EHV overhead network Split feeder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EHV overhead New Split feeder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EHV overhead Minor works	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EHV overhead Major works	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

EA Technology Limited
Capenhurst Technology Park
Capenhurst, Chester UK
CH1 6ES

tel +44 (0) 151 339 4181
fax +44 (0) 151 347 2404
email sales@eatechnology.com
web www.eatechnology.com

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