Project EPIC

Work Package 6:

Analysis for Use Case 5: ‘Flexibility Services’ parameter sensitivity

Final Draft

EPIC

Energy Planning Integrated with Councils

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1. Glossary of Terms

Abbreviation	Term
BEZ	Bath Enterprise Zone
BU	Bottom Up: Bottom Up analysis starts by modelling the load at individual distribution substations and aggregating up to HV feeder level.
CAPEX	Capital Expenditure
CBA	Cost Benefit Analysis
DFES	Distribution Future Energy Scenarios
DNO	Distribution Network Operator
DUoS	Distribution Use of System charges
ENA	Energy Networks Association
ESA	Electricity Supply Area
EPIC	Energy Planning Integrated with Councils
EV	Electric Vehicle
HV	High Voltage
HV NAT	High Voltage Network Analysis Tool
INM	Integrated Network Model
LCT	Low Carbon Technology
LV	Low Voltage
LV NIFT	Low Voltage Network Investment Forecasting Tool

Abbreviation	Term
MWh	Megawatt Hour i.e. the energy used by consuming 1MW of power for an hour.
NPC / NPV	Net Present Cost / Net Present Value
OPEX	Operational Expenditure
SPA	Strategic Planning Area
TD	Top Down: Top Down analysis uses monitored HV feeder load profiles as a starting point to add the impact of LCT uptake.
TOTEX	Total Expenditure, the sum of all cost categories on either the network or society.
WECA	West of England Combined Authority
WP	Work Package
WPD	Western Power Distribution
WS CBA	Whole System Cost Benefit Analysis
WWU	Wales and West Utilities

2. Project EPIC background

The aim of the EPIC project is to develop an energy planning process that considers impacts on both the electricity and gas networks and reflects the strategic ambitions of the local authority, enabling better investment outcomes. These outcomes may lower overall cost to the consumer, offer improved risk management and also enable local partners to realise their own strategic outcomes including net zero decarbonisation, economic growth, industrial strategy and wider societal benefits. A number of previous work package deliverables have documented in detail the process of the EPIC trial, the flow chart below summarises those work packages. In light of the progress of the trial process so far, the "integrated energy development plan" output has been replaced by results reports and a series of workshops with Local Authority stakeholders which will communicate findings and discuss their impact on local energy planning.

3. Document purpose and associated project deliverable

The Energy Planning Integrated with Councils (EPIC) Project trial is investigating the whole systems impact of a number of Low Carbon Technology (LCT) deployment strategies and investment approaches. Five use cases, set out in Work Package 2 (WP2) are being investigated, these are summarised in Table 1, below. For the majority of use cases, results are passed from High Voltage (HV) and Low Voltage (LV) network analysis tools, specified in WP4, through a Whole System Cost Benefit Analysis (WS CBA) tool. This WS CBA tool was developed outside of project EPIC by the Energy Networks Association (ENA) as part of their 'Open Networks' project, its specification and usage are detailed in WP3.

This document forms part of WP6 of the EPIC Trial. It describes the results of this whole systems cost benefits analysis for **Use Case 5**, assessing the impact of varying levels of use of flexibility services as an alternative to traditional reinforcement.

Table 1: The project EPIC Trial use cases

Use Case 1: EV charger deployment	Comparing the network impact two EV charger deployment strategies, one with a greater reliance on LV connected on-street residential chargers, the other with a greater reliance on HV connected rapid charging hubs.
Use Case 2: Energy Efficiency	Comparing the network impact of a high, low and medium standard of energy efficiency across residential and commercial customers.
Use Case 3: Hybrid Heat pumps	Exploring the impact of using the gas network and hybrid heat pumps to reduce peak electricity demand and electricity network costs.
Use Case 4: Just in Time vs. Fit for Future	Comparing a BAU network upgrade to meet immediate demand growth, or an investment in upgraded assets to meet longer term future demand growth.
Use Case 5: Flexibility	**Invest in an asset upgrade or contract a flexibility solution to delay or avoid the upgrade requirement.**
Use Case 6: Solar	Investigating the network impact of a higher deployment of large scale ground mounted solar. This is only tested in one Strategic Planning Area (SPA) (South West Bristol)
Use Case 7: Heat Network	Exploring the whole systems impact of using a heat network to meet all heating demand from new developments in the SPA. This is only tested in one SPA (Bath Enterprise Zone).

Not contained within this report are project learnings, which will be collated for all the use cases within the WP7 learnings report and largely focus on procedural and systemic learnings rather than conclusions drawn from individual results. More detailed discussion around individual LV and HV results, and their origins in network modelling assumptions, will be covered within the LV NIFT and HV NAT results which will be produced as part of WP5.

4. Key outcomes and conclusions

1. **The Low Flex Scenario vs. the Base Case**: It is observed that as we are using lower threshold values compared to the Base Case, we started to see higher overall CAPEX and zero flexibility service requirements, which is what we would expect. CAPEX is increased in this case by 6.6%.

2. **The High Flex Scenario vs. the Base Case**: It is observed that as we are using high threshold values compared to the Base Case, we saw higher overall flexibility service requirements and the same overall CAPEX values compared to the Base Case. However, using higher threshold values deferred the upgrade of equipment from one year to the next year i.e. delay of CAPEX from one year to the next year.

3. As expected, similar patterns were seen in related metrics such as the number of interventions, feeder length for roadworks and CAPEX.

4. Metrics for overall demand and losses were not altered by different flexibility service thresholds being applied.

5. If the cost of flexibility services and the value of CAPEX deferral are considered alongside each other:

   - In **moving from the Low Flex strategy to the Base Case**, the additional cost of flex is not outweighed by the value of CAPEX deferral. It does not represent a good value for money solution.

   - In **moving from the Base Case to the High Flex strategy**, the additional cost of flex is outweighed by the value of CAPEX deferral. It does represent a good value for money solution.

6. There are a number of practical issues that will need to be overcome before flexibility services are a practical solution to manage constraints on the HV and LV networks. These reflect features that will not change such as the lower value of assets and therefore lower value of reinforcement deferral and the reduced pool of potential flexibility service providers. This means that the costs of service provision will need to be lower than they are for EHV and 132kV networks before a business case can be shown.

4.1. Limitations of the modelling

1. CBA output files & charts

This report is different to those produced for the other use cases. While for the other use cases the Whole System Cost Benefit Analysis (WS CBA) tool includes the output files from both the Network Investment Forecasting Tool (NIFT) and the HV Network Assessment Tool (HV NAT) the use of flexibility services is not modelled in the NIFT. Given the limitations of the modelling it would not be appropriate to provide the full set of CBA related output charts that have been provided in the other use case reports.

2. Future looking rather than a currently deployable option

The reason flexibility services are not currently modelled in the NIFT is that this reflects the current limits of these services. Flexibility services are used to manage constraints where there are high value assets that result in deferring reinforcement having a high value. The value associated with deferring the replacement of a transformer at a Bulk Supply Point would be considerable compared to a distribution substation. Additionally, for constraints on the Extra High Voltage (EHV) and 132kV networks the number of customers that could potentially impact the load at the constraint is very large. Current flexibility services deployed within WPD would be considered as an option to resolve constraints at a primary transformer but would not be considered for constraints on HV feeders, distribution substations or LV feeders. However there is an ambition to employ flexibility services at these levels if possible in the future, therefore the inclusion of features to model the use of flexibility services and to determine the impact of changing these thresholds has been to provide a view of potential future impact and to help assess the potential financial impact.

3. Primaries modelled

Given the limitations of the modelling a simpler comparison has taken place using the Cribbs Causeway substation associated with the North Fringe Strategic Planning Area (SPA), rather than all three of the primaries modelled for other use cases.

4. Top-Down only comparison

The Bottom Up analysis relies on data being passed from the NIFT to the HV NAT tool. As there was no output from the NIFT in this case, only the Top Down modelling option has been used in the analysis.

5. Results - Use Case 5: 'Flexibility Service' parameter sensitivity.

The results below convey the final iteration of network analysis runs which were able to be conducted in the timescale of the EPIC trial process. The use of flexibility services to defer traditional reinforcement only applies to upgrades to the electricity network. This has not been modelled for the gas network where no upgrades were required.

5.1.1. Setting the 'Flexibility Service' parameters in the HV NAT

The user interface for the HV Network Assessment Tool is given below in Figure 1. The parameters affecting flexibility services are given in the "Other Settings" box on the right of the screen. The settings are described in Table 2 below:

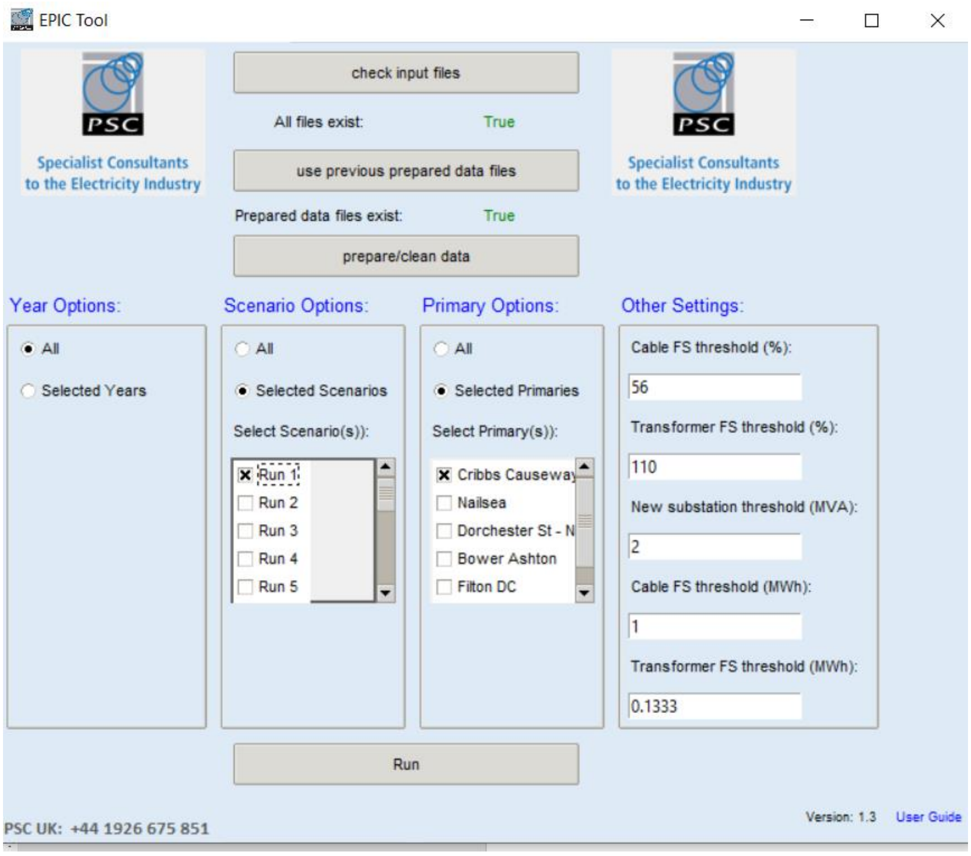

Figure 1: User interface for HV Network Assessment Tool

Table 2: Settings used the HV HAT in the flexibility use case

Setting Name	Setting Description
Cable FS Threshold (%)	This is the degree of loading at which an intervention is considered necessary for a cable/ overhead line. If flexibility MWh thresholds are set to zero it becomes the trigger point for traditional reinforcement
Transformer FS Threshold (%)	As above for a transformer
Cable FS Threshold (MWh)	This is the limit for use of flexibility services for a constraint on a cable /overhead line and is intended to reflect the existing practice where flexibility is used to defer reinforcement but not indefinitely. If flexibility payments were to continue indefinitely then there is a risk that the OPEX spend would outweigh the CAPEX benefits and network operability would be affected by a large number of constraints.
Transformer FS Threshold (MWh)	As above for a transformer

A description of how flexibility services are modelled in the HV NAT is included as Appendix 1. This has been reproduced from the HV NAT specification document.

5.1.2. Parameter values used in the comparison

For comparison, a High and Low Scenario were added to the Base Case scenario. The values of the settings for the scenarios are given below in Table 3:

Table 3: HV NAT flexibility settings used for comparison.

Setting Name	Base Case	High Scenario	Low Scenario
Cable FS Threshold (%)	56	56	50
Transformer FS Threshold (%)	110	110	105
Cable FS Threshold (MWh)	1	1.5	0
Transformer FS Threshold (MWh)	0.1333	0.2	0

The High Scenario assumes that flexibility services are cheap and easily available and therefore threshold values are higher. The MWh flexibility thresholds have been multiplied by 1.5.

The Low Scenario assumes that flexibility services are unavailable and sets values so that traditional reinforcement is triggered directly without any period where flexibility services are used to defer reinforcement. The MWh flexibility thresholds have been set to zero.

5.1.3. Flexibility Requirements

As expected, allowing a higher threshold for flexibility service results in a greater value of flexibility services being procured compared to the baseline for the High Scenario. The Low Scenario has eliminated the use of flexibility services.

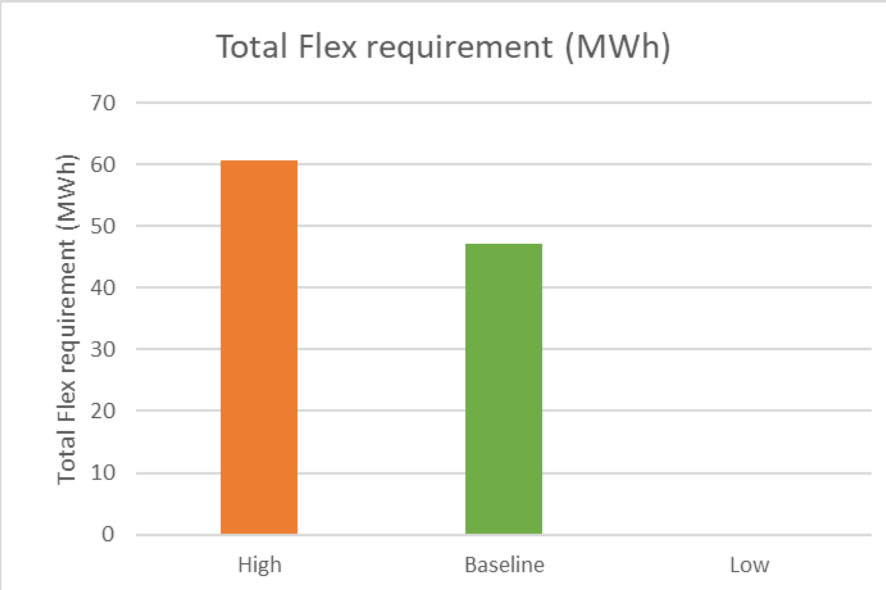

Figure 2: Total Flex Service requirement (MWh)

The overall pattern of flexibility requirements is similar between scenarios but there is significant difference in values for 2035.

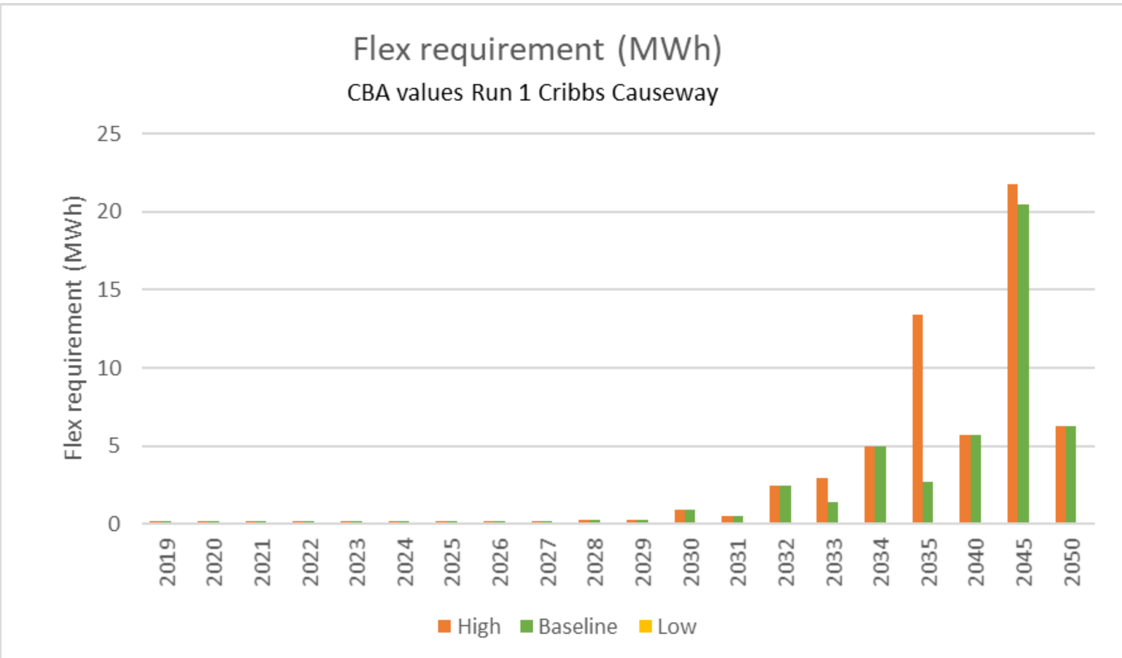

Figure 3: Flex Service requirement (MWh) by year

5.1.4. Demand & Losses

Annual demand and losses were not affected by the flexibility scenario.

5.1.5. CAPEX

As expected, CAPEX under the Low Flexibility Scenario was higher than for the baseline assumptions. The difference of approximately £160k equates to an additional 6.6% of the baseline costs. Unexpectedly, there was no reduction of CAPEX for the High flexibility scenario relative to the Base Case. However looking at the capital spend by year in Figure it appears that the costs are merely deferred so the difference seen would be highly reflective of the year at which the assessment ended. If there were a large capital investment in the final year under the Base Case that was deferred until after the end of the assessment under the high flexibility case then there would be a difference in the total capital.

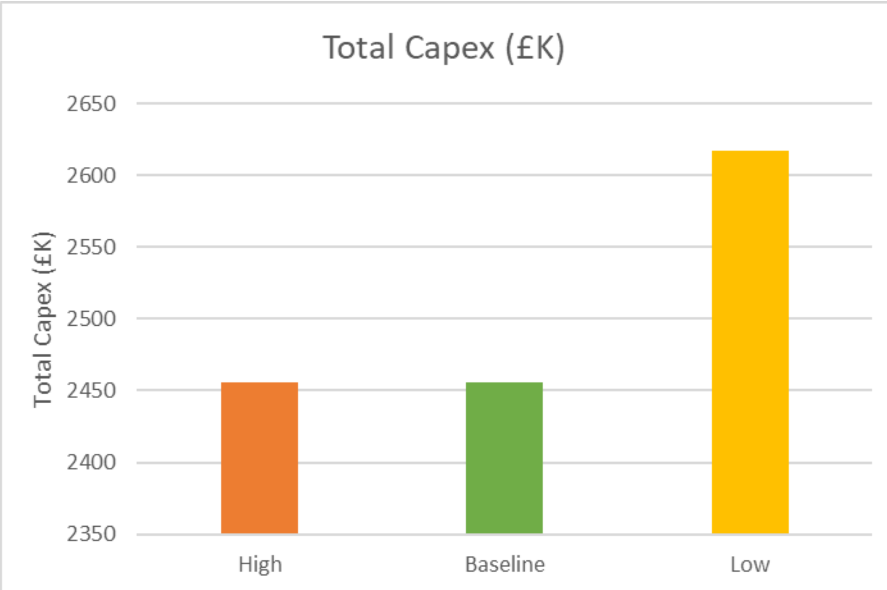

Figure 4: Total CAPEX (£k)

Once again we see the pattern of a large amount of investment in 2019 followed by relatively low investment levels until the mid-2030's. The first increase in CAPEX occurs for the Low Flexibility Scenario in 2034 which then is followed by a similar scale spike in 2035 for the Base Case and then in 2040 for the High Flexibility Scenario. A similar picture is seen with a higher value of CAPEX in 2045 under the Low Flexibility Scenario in 2045 relative to the other two scenarios which is then reversed in 2050 as the other scenarios "catch up".

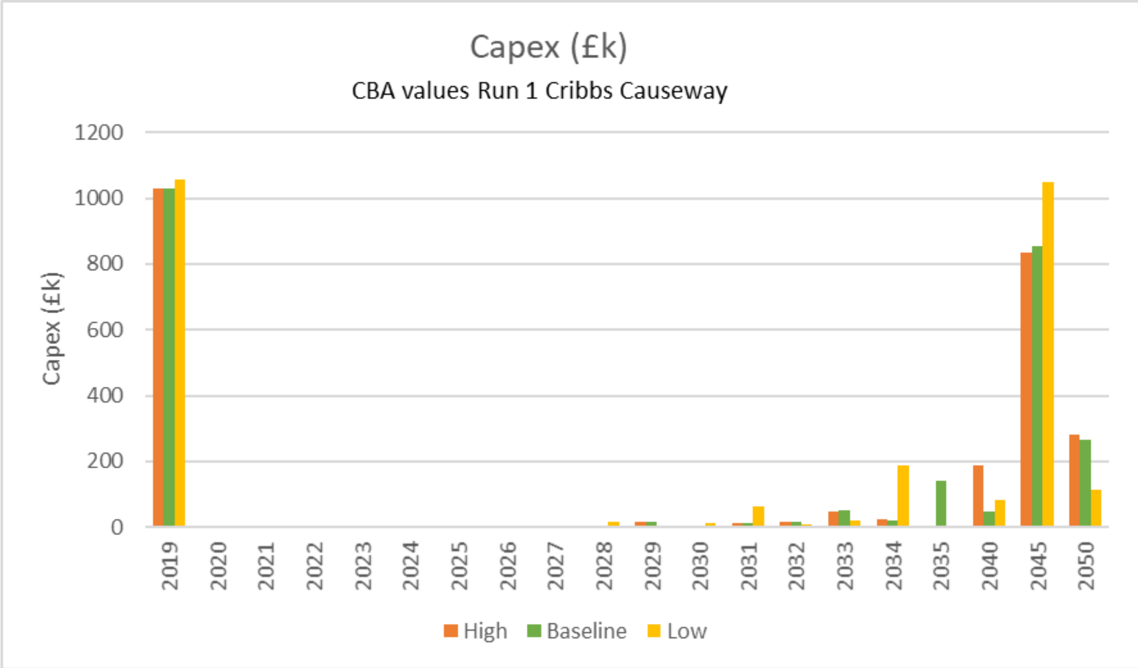

Figure 5: CAPEX (£k) by year

Using the first example of CAPEX "spikes" that occurs for all scenarios but at different times, the value of deferral, calculated though application of depreciation and discounting to gain a Net Present Value (NPV), can be compared to the additional costs of flexibility services.

Table 4: Value of deferral vs additional flexibility costs

Scenario	CAPEX(£k) 2034	CAPEX(£k) 2035	CAPEX(£k) 2040	NPV (£k)	Flex Costs 2034-2040 (£k)
Low Flexibility	190	0	0	**112**	0
Base Case		140	50	**104**	13.4
High Flexibility			190	**91**	24.1

Comparing the Low Flexibility Scenario to the Base Case, a £13.4k increase in flex costs is offset by an £8k saving from CAPEX deferral. In this case, the increase in flexibility is bad value for money.

Comparing the High Flexibility Scenario to the Base Case, flex costs are increased by £10.7k (£24.1k-£13.4k). This is offset by a value of reinforcement deferral of £13k. In this case, the increased flexibility is good value for money.

Comparing the Low Flexibility Scenario to the High Flexibility Scenario, the value of deferring the Capex investment is £21k (£112k-£91k), however this is outweighed by the additional cost of flexibility services at £24.1k so once again this represents poor value for money.

In all the assessed comparisons the benefit from deferral and the flexibility costs are of the same magnitude rather than one value being consistently double the value of the other or more. This suggests that careful selection of sites to ensure the best capex benefits and/or driving down the cost of flexibility services (for example to 70% of their current value) could result in a positive business case for flexibility services at LV. However it does need to be noted that the flexibility service costs included in this analysis only reflect the services delivered and not the overheads of managing the purchase, dispatch, evaluation of performance and processing payments. These additional costs would need to be taken into consideration.

This analysis needs to be repeated with a larger sample size before firmer conclusions can be drawn.

5.1.6. Feeder length / Roadworks

The total feeder length replaced follows the same overall pattern as CAPEX, which is expected.

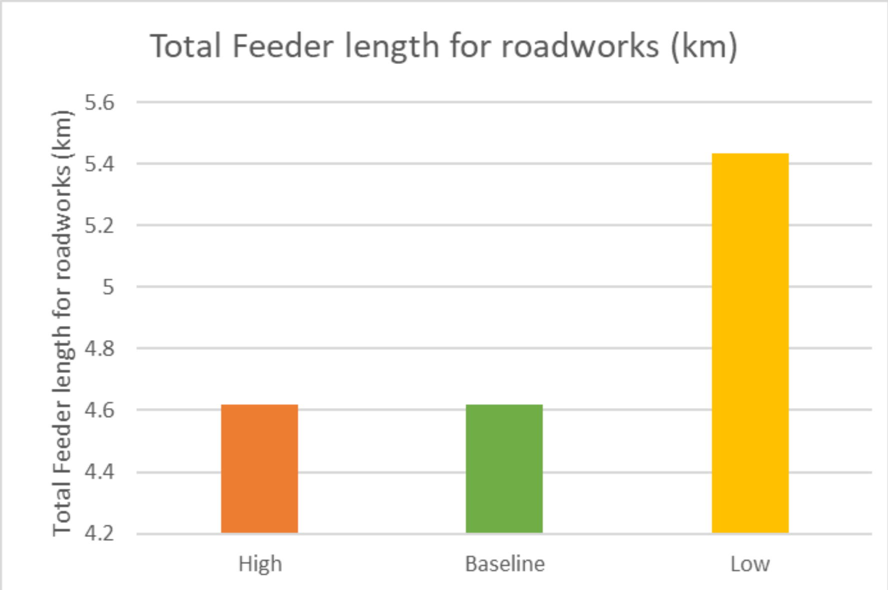

Figure 6: Total Feeder Length (km)

A similar pattern to that seen in the CAPEX charts of investment being seen on the different scenarios at different years is evident in the years 2034 – 2040. A similar pattern is seen in 2031 and 2033 where it appears that reinforcement that takes place in 2031 under the Low Flexibility Scenario occur in 2033 under the other two scenarios. Similarly, it appears that the upgrades seen under the Low Flexibility Scenario in 2030 occur in 2031 under the other two scenarios.

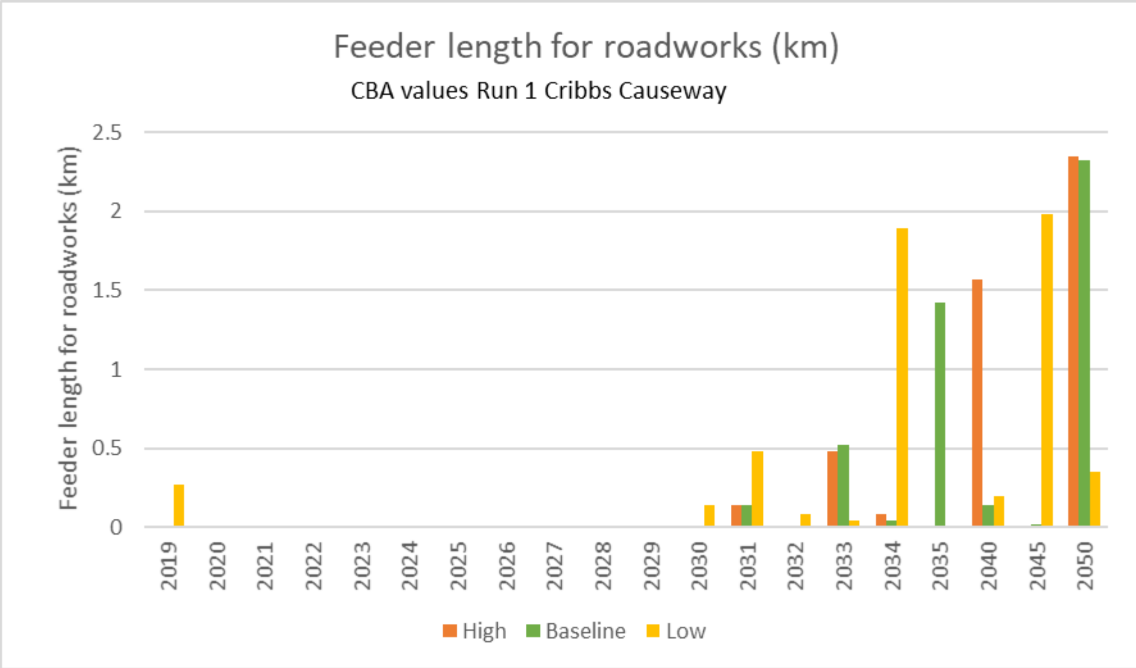

Figure 7: Feeder Length (km) by year

5.1.7. Capacity Index

The greatest Capacity Index is seen under the Low Flexibility Scenario which reflects that it also sees the greatest CAPEX which would result in additional network capacity. The values for the Base Case and High Flexibility Scenarios are similar, as with the CAPEX values.

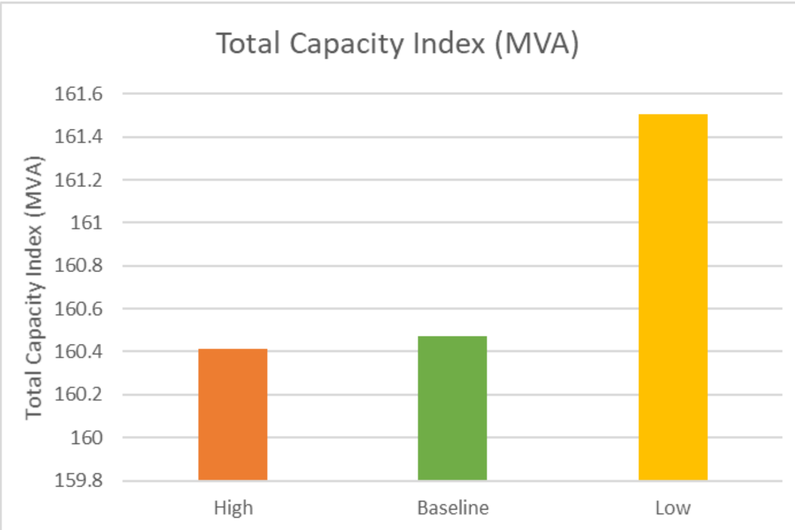

Figure 8: Total Capacity Index

The difference in Capacity Index by year for the different scenarios is not as clear as the difference in CAPEX as to a certain degree it reflects the existing asset base, however, the point at which the values diverge is the mid 2030's reflecting the timing of network upgrades with the differences becoming more marked in the later years.

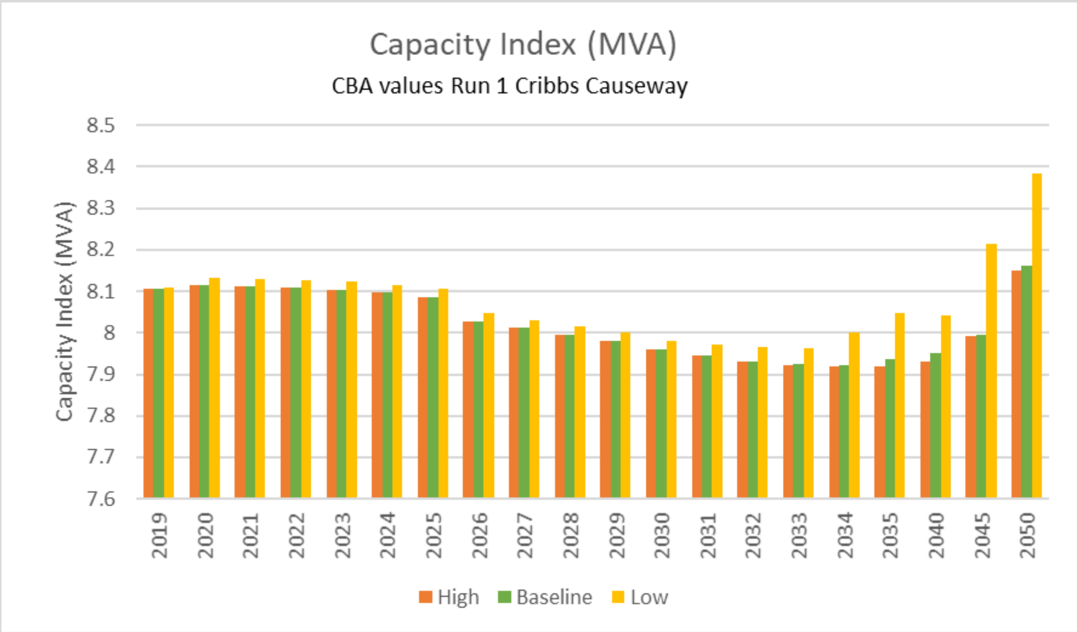

Figure 9: Capacity Index by year

5.1.8. Total number of interventions

As expected, the number of interventions reflects the general patterns already seen in terms of the CAPEX and Feeder Length. Under the Low Flexibility Scenario there are more interventions than for the other two scenarios.

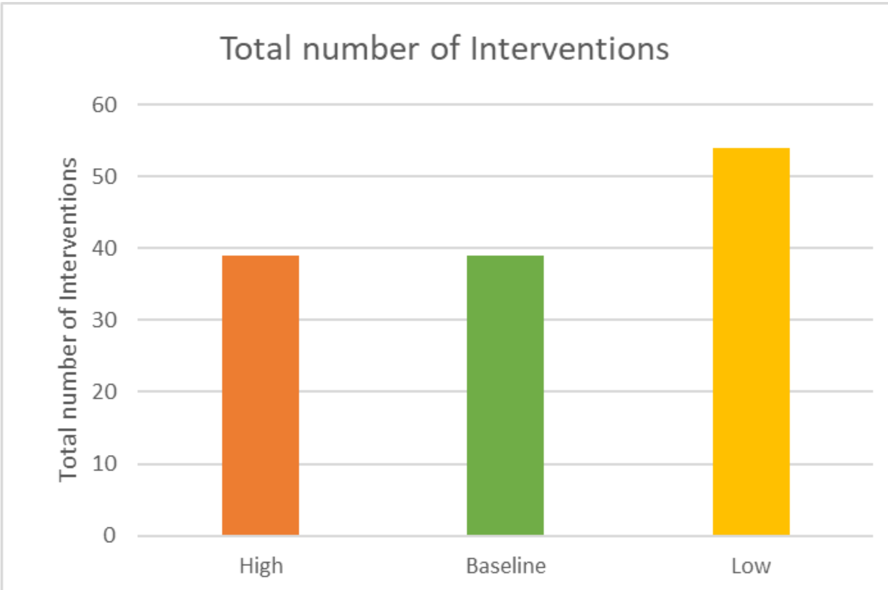

Figure 10: Total number of interventions

The number of interventions per year shows that there are often a set of interventions that first occur under the Low Flexibility Scenario that then occur on the other two scenarios after a year or two, however the pattern is not as clear as for CAPEX or Feeder length.

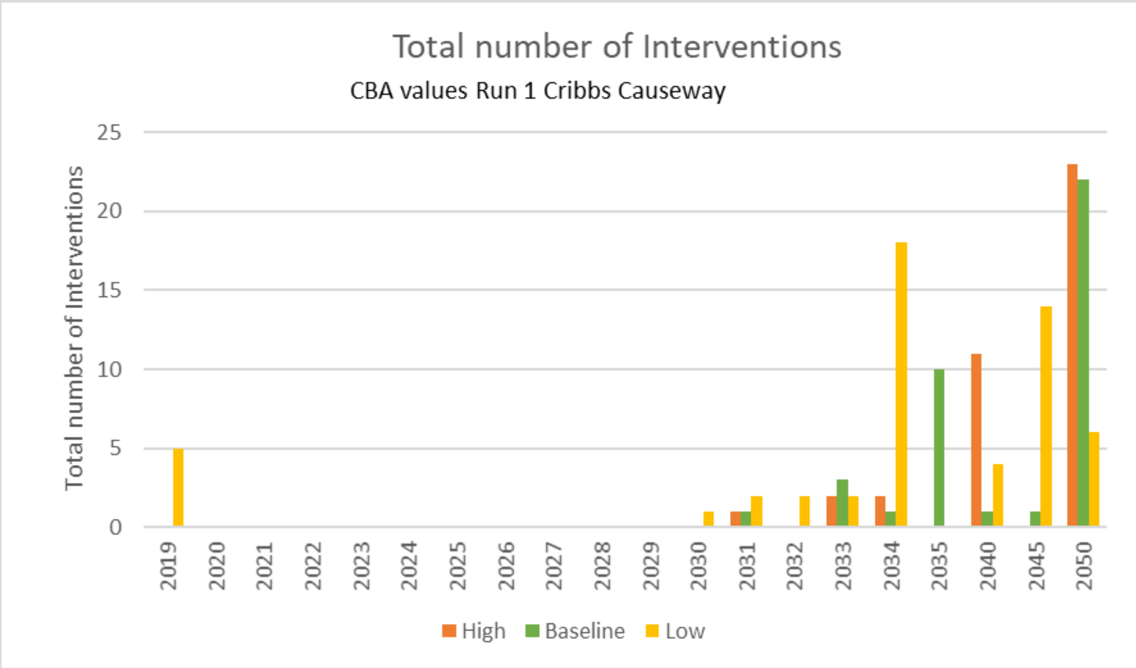

Figure 11: Number of interventions by year

6. Flexibility market extension to manage HV and LV network constraints

While it is an aim to extend the use of flexibility services to defer reinforcement where this adds value, there are some differences in the nature of the network that bring additional challenges. Rolling out flexibility services to lower voltage levels will not be simple case of replicating existing service provision. It is likely that flexibility service costs would need to fall before a business case for their use at lower voltages would demonstrate value for money.

6.1.1. Pool of customers relevant to the network issue

The number of customers supplied by a distribution transformer is far lower than the number of customers supplied by a primary transformer. Therefore there are fewer customers that are able to have an impact on the transformer load and it may be that there are simply not enough customers willing to provide services.

6.1.2. Lower average demand per customer

Similarly the average demand of a customer supplied by a distribution transformer will be relatively low compared to a Primary substation which would be expected to supply a number of large industrial/ commercial customers. This suggests that to overcome the relatively small scale response that more customers would be needed to provide services which may be an issue where there are few customers to select from.

6.1.3. Lower customer diversity / greater variability in load profiles

With a large number of customers there is an averaging effect that tends to smooth out the impacts of different behaviour of individual customers. As the number of customers reduces and there is less diversity in behaviour, then the volatility of the demand at any one point in time increases and the ability to predict the demand accurately reduces. This may result in larger safety margins being required when evaluating assets to be overloaded and therefore larger requirements for flexibility services.

6.1.4. Time of Use tariffs vs Flexibility Services

Time of Use tariffs will be designed to incentivise demand at a time that is favourable to the wider electricity system. This may not coincide with the timing of local peaks. Managed charging / managed use of heat pumps may involve a control system that manages the related assets and does not allow for additional control signals for flexibility services which may not complement the managed charging schedule.

6.1.5. Conflicts with other services

Customers connected in the same area may be providing flexibility services for assets connected at a higher level or for NG ESO so it may be that the benefits of flexibility services provided to manage local constraints are counteracted by other service provision, similarly Time of Use tariffs may be more effective at encouraging the use of loads which can be time-shifted in comparison with extending flexibility services.

7. Appendix 1: Modelling of flexibility services

This Appendix includes an extract from the HV NAT specification intended to give a high level overview of how the use of flexibility services is modelled.

The HV NAT identifies the investment options for network equipment in terms of Flexible Services (FS) or Network Investment (NI) covering reinforcement of existing assets and new assets. Investment options would be covered for major HV connected equipment including the distribution transformers for TD approach but excluding it for BU approach as that would be captured as part of the NIFT assessment.

As described in section 7.1.1, there are two thresholds, one is energy (MWh) based and the other is peak power (MW). These thresholds are utilised to allow a quick decision on whether investment should follow a FS or NI pathway whilst avoiding analysis every possible option due to the computation effort (N^2) that would bring. This is illustrated for a typical feeder is shown in Figure 7-1 wherein MWh and MW thresholds are denoted by "T".

The default investment path is assumed to be Flexible Services unless any of these thresholds (T) are exceeded. As can be seen, for year 1 FS was preferred over NI as the FS requirements did not exceed the pre-defined thresholds. However, for year 2 NI becomes the preferred investment option due to exceeding the threshold.

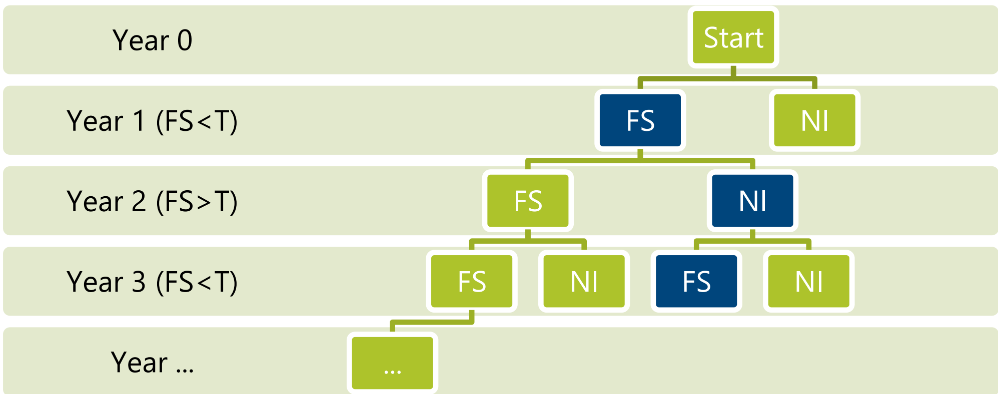

Figure 7-1: Investment Options Pathway

7.1.1. Flexible Services (FS)

Load flow analysis will be carried out for each HH window and will be compared against pre-defined circuit utilisation ratings which will be 50% of thermal loading throughout the network (66% of thermal loading for the West Midland region). Exceedance of the load beyond the utilisation rating would be recorded. In order to avoid overly complex HV analysis from the circuit rating point of view cyclic rating of circuits would be ignored.

Depending on the number of times the utilisation rating exceedance is observed, and the total exceedance in each window, the energy unit calculation is carried out to determine the FS requirement. Initially the intention of approach to FS at HV network was meant to work out the FS cost on an annual basis by extrapolating the FS cost from five representative days to an annual estimated figure. Types of data that would be needed to model the flex requirements properly was considered e.g. fully monitored substations and a means to categorise them to get representative load duration curves. However, considering the challenges and complexities in this approach an assumption has been made that we would only use flex services on HV networks to support the Restore service. This would therefore not be a service that would be routinely called every day and therefore modelling a year's worth of data is not required, but modelling the peak days gives us indicative values of the service capacity requirements, including the worst case. With this analysis insights will be obtained about potential flexibility requirements to inform future policy developments.

User input threshold is defined on when procuring FS no longer remains the default investment path. This may be on the basis of the ratio of MW exceedance to actual circuit capacity. Flexible services will be procured as long as the threshold figure is not exceeded.

In cases where either the peak power or energy threshold for FS is exceeded, NI options will be considered instead.