ANNEX 2B: CBRM - DETAILS

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Contents

1. Executive Summary

As detailed in section 3 of our business plan, we have led the industry in the development of Condition-Based Risk Management (CBRM) approaches over the last ten years, and the subsequent development of Health Indices in DPCR5. Health Indices allow an overall view of an asset's health to be formed from all available information and Annex 2 to the plan gives more details on the evolution of the CBRM approach.

This document details the development of Health indices into an overall risk framework, and sets out the resulting RIIO-ED1 projections for each major asset type.

2. Development of Health Indices

In CBRM, health scores are calibrated to the expected probability of failure of an asset in a specific state. As an asset ages, its probability of failure does not increase at a steady (linear) rate. The trends are specific to each asset type but generally stay constant for a significant proportion of the asset's life before starting to increase significantly as the asset approaches the end of its life. This is often referred to as the 'bathtub curve' effect and is modelled in CBRM using cubic or exponential functions. For reporting purposes, these scores are reported against a simple 1-5 scale.

There is an underlying probability of failure for all assets due to incidents such as third party damage (even the newest assets can fail, albeit infrequently) and this risk is also included in the CBRM models.

The resulting probabilities of failure (in terms of the likelihood of an asset in that state failing in any one year where 1 = certainty) corresponding to each Health Index state for each asset type are as follows;

Health Index	**HI1**	**HI2**	**HI3**	**HI4**	**HI5**
	Probability of annual failure				
LV Switchgear and Other	0.001	0.002	0.003	0.004	0.013
LV UGB	0.001	0.001	0.001	0.003	0.006
LV OHL Support	0.002	0.002	0.004	0.008	0.013
HV Switchgear (GM) - Primary	0.000	0.001	0.002	0.003	0.006
HV Switchgear (GM) - Distribution	0.001	0.001	0.001	0.003	0.005
HV Transformer (GM)	0.001	0.001	0.002	0.004	0.012
HV OHL Support	0.002	0.002	0.004	0.008	0.012
EHV Switchgear (GM)	0.000	0.001	0.002	0.003	0.006
EHV Transformer	0.001	0.001	0.002	0.004	0.008
EHV UG Cable (Gas)	0.001	0.001	0.003	0.007	0.010
EHV UG Cable (Oil)	0.001	0.001	0.003	0.007	0.010
EHV OHL Support - Towers	0.000	0.000	0.000	0.000	0.001
EHV OHL Support - Poles	0.001	0.001	0.001	0.003	0.004
EHV OHL Fittings and Conductors	0.000	0.000	0.001	0.004	0.010
132kV CBs	0.002	0.002	0.004	0.007	0.013
132kV Transformer	0.002	0.002	0.004	0.008	0.017
132kV UG Cable (Oil)	0.001	0.001	0.003	0.007	0.010
132kV OHL Support - Tower	0.000	0.000	0.000	0.000	0.001

132kV OHL Fittings and Conductors	0.000	0.000	0.001	0.002	0.007

These values have been used in our Risk model and translated into the new CM105 table in the re-submission template.

3. Consideration of Consequences

To develop a full risk model, consideration also has been given to the consequences of the failure of an asset. The combination of the probability of a failure occurring and the consequences of the failure generates an overall failure risk score for an individual asset. These scores can be summated to generate an overall position for the whole asset population which is being measured.

3.1 Measurement

To measure the consequences of an asset failure, it is important to take into account all its potential impacts. It is also important that the same factors are taken into account for all asset types to give the potential for comparisons of risk between asset types. Measurement of the consequences of failure in the Risk model uses the following factors agreed with Ofgem;

Category	Factors considered	Calibration
Safety	Potential impact on safety incidents	£ Published Cost of Life data x probabilities of incident
Environment	Carbon emissions, oil leakage	£ Cost of Carbon (Green Book value), also cost of oil loss
Customer Performance	Loss of supply	£ Value of Lost Load or £ IIS incentive rates
Repair costs	Costs	£ NPV

These represent the potential impacts of asset failure and each is quantified in pounds to give an approximation of the actual financial impact of the failure of an asset.

We have used our historic experience of asset failures, together with wider industry knowledge and third party expertise to apply these factors to our assets and produce the following average consequence of failure values which are also shown in table HI8 of the re-submission.

Asset Type	Average consequence of Failure (£)
LV Switchgear and Other	10,169
LV UGB	11,140
LV OHL Support	7,778
HV Switchgear (GM) - Primary	121,085
HV Switchgear (GM) - Distribution	32,450
HV Transformer (GM)	20,961
HV OHL Support	17,378
EHV Switchgear (GM)	93,604
EHV Transformer	317,306
EHV UG Cable (Gas)	124,983
EHV UG Cable (Oil)	277,966
EHV OHL Support - Towers	428,896

EHV OHL Support - Poles	117,544
EHV OHL Fittings and Conductors	228,326
132kV CBs	824,797
132kV Transformer	858,587
132kV UG Cable (Oil)	127,407
132kV OHL Support - Tower	1,286,083
132kV OHL Fittings and Conductors	682,956

Some of the values for the more strategic assets may appear high. This is because failures, although extremely rare, have potentially high, even catastrophic impacts. We also have to consider that the network at EHV and 132kV levels is duplicated such that those failures that do occur rarely impact customers directly. If we look at the actual impacts of such failures historically, we take for granted the duplication of the network.

In order to ensure we credit it appropriately, we have to consider the potential impact of failures if the duplicate network wasn't there. To do this, we use a metric termed the 'Value of Lost Load' which values the potential economic impact of the loss of electricity supply. This approach mirrors that developed by Ofgem in RIIO-T1 where a similar approach was used.

3.2 Asset Criticality

In presenting our proposals for RIIO-ED1, we have allocated all assets within a population to one of four Criticality 'bands' to reflect the criticality of an individual asset's failure with respect to the average for the asset type. This is based on the assessed consequences of failure for that particular asset relative to the average for the asset type.

This allows us to take into account the fact that assets which are superficially similar and perform a similar function may have quite different consequences of failure due to their size, location, number of connected customers, type of construction, accessibility etc.

For the purposes of building the risk model, we use representative values for each band as detailed below;

Criticality Band	Minimum value	Maximum value	Used for model
1	0%	75%	70%
2	75%	125%	100%
3	125%	200%	150%
4	200%	>200%	250%

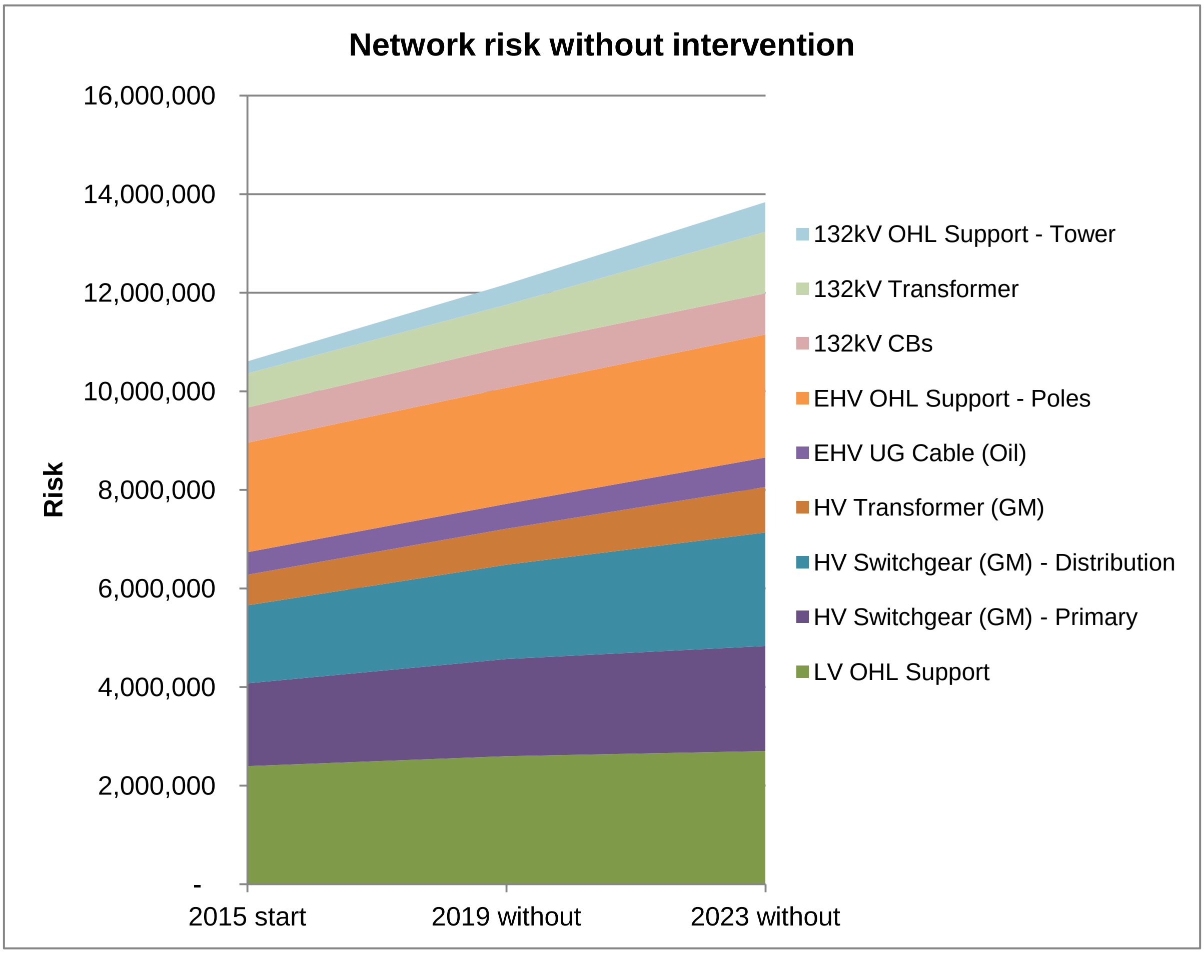
4. Modelling Deterioration

Having set the framework in place, it is important to establish a baseline for the comparison of investment options. This baseline represents the 'do nothing' option, ie what would the impact on risk be if we just left the current network alone (apart from routine inspection and maintenance activities), fixed faults as they occurred and saw what happened?

In general terms, the consequences of asset failure stay the same; however the probability increases – as assets age and deteriorate, their condition progressively worsens and hence their probability of failing increases. Using the risk model, we can predict what the likely impact on future failure rates would be for each asset type, and the consequent level of overall risk.

Using the framework outlined above, our forecast is that overall network risk will increase by 14% from its 2015 level by 2019 and by 29% by 2023 if we make no further proactive investment.

This can be seen, both in totality and by asset type using our consolidated risk framework;



5. Impact of Investment

Having established the ‘do nothing’ baseline, we can then overlay the impact of potential investment programmes using the same calibrated factors. Investment will potentially impact either the probability of an asset failing, or mitigate the consequences if it does fail.

In many cases, there are a number of potential options with different costs. It may, for example, be possible to achieve a small improvement in an asset’s health by refurbishing a small number of components. A more significant improvement could be achieved by a more expensive refurbishment of the complete asset and replacement of the entire asset would gain the greatest benefit, but at the highest cost.

Not all these options are available for all asset types; however where they do exist, it is important to ensure the appropriate trade-off is made to ensure we get the best value for money from our investment. To help us make these decisions, we use Cost Benefit Analysis (CBA) to evaluate different costs and benefits over a longer timeframe. In order to ensure consistency, our CBA models use exactly the same factors and calibration as our Risk model. Annex 3 details our approach to CBA in more detail and presents a specific CBA for each HI category. The options modelled are presented in terms of the Health and Criticality matrices used in tables HI2-8.

Increasing network risk is not necessarily a bad or inappropriate thing. There are three generic options for setting future risk levels;

- Decide on a preferred level of future risk and build an investment programme to achieve it
- Decide on the level of an input constraint (eg volume of work or amount of investment) and see what level of risk results, or
- Determine the lowest whole-life cost approach for managing the asset base and allow the level of risk to ‘float’ around this.

In line with our Asset management policy (see Annex 11), our approach is to assess the most efficient approach to those assets identified as requiring intervention (which ranges from ‘do nothing’ to full replacement) and collate those requirements into an integrated delivery plan. The overall level of network risk post-investment can then be forecast.

6. Overall Results

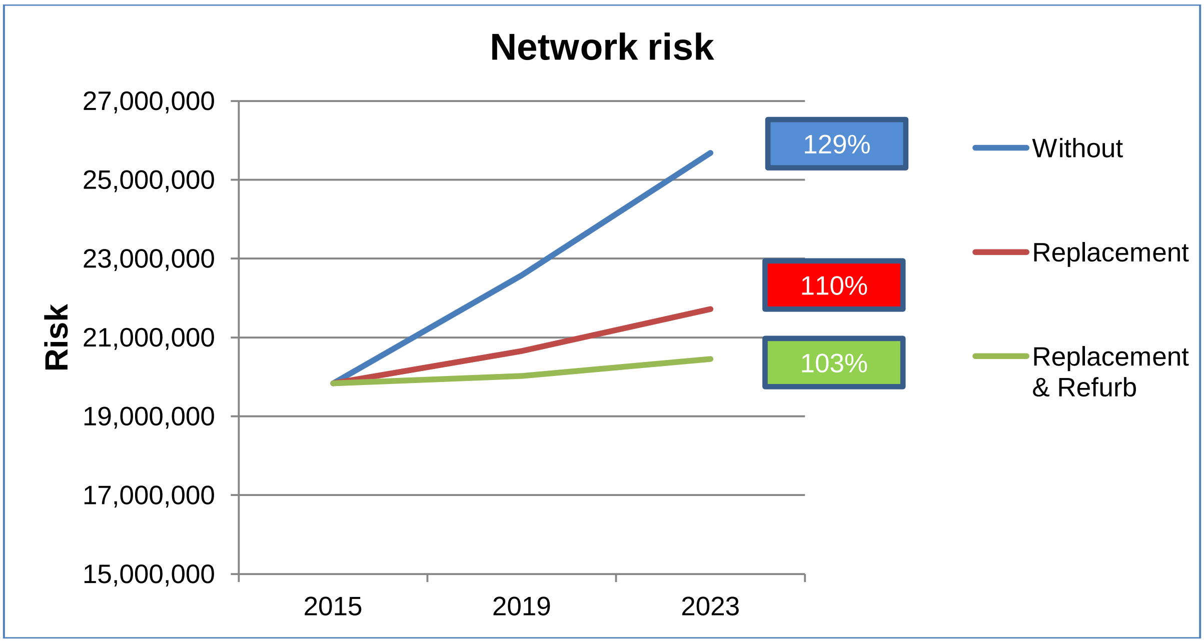
Using the risk framework allows us to see the impact of proposed investment programmes and calibrate the overall risk level.

As noted above, the forecast ‘do nothing’ position is forecast to see a 14% increase in network risk by 2019, rising to 29% by 2023.

Our proposed replacement programme mitigates this deterioration to 4% by 2019 and 10% by 2023.

In addition, our proposed refurbishment programmes will restrict the increase in risk further such that we are forecasting a risk position of 101% by 2019 and 103% by 2023 as a result of our planned programme.

We could have added further volumes to the programme to bring this risk to 100% of its 2015 level in 2023. Based on the average cost of risk reduction in the programme, we estimate that this would have cost an additional £42m which we consider would not represent good value to the customer. The resulting slight increase in the probability of future failure to 2023 is not likely to manifest itself in customer impacts given the increased investment in mitigating the impact of any faults that do occur through additional Quality of Supply improvements as detailed in the main narrative.



We will report on our progress on achieving this metric each year and commit to maintaining the overall level of network risk within 3% of its 2015 position during the RIIO-ED1 period.

7. Details by Asset Type

The following section sets out the results of the risk approach for each of the 19 asset categories for which projections have been included in the RIIO-ED1 forecasts. These projections can be found on tables HI2, 3 & 4 of the BPDT template pack.

In each case, the overall volumes of work and expenditure have been set alongside the resultant change in risk. There is a range of costs of risk reduction and we use these figures to check the calibration of the programme across the different assets types (such that we are not over-investing in an asset type with relatively high costs of risk reduction).

We have also included a comparison of the resulting intervention rates with those representing the industry medians used by Ofgem in their fast-track analysis for asset replacement.

Depending on the starting position of the asset population, the forecast deterioration and the proposed intervention plan, the risk at the end of the period can be lower, greater or broadly the same as the starting position. We have not artificially changed the programme to achieve pre-determined levels of risk by asset type.

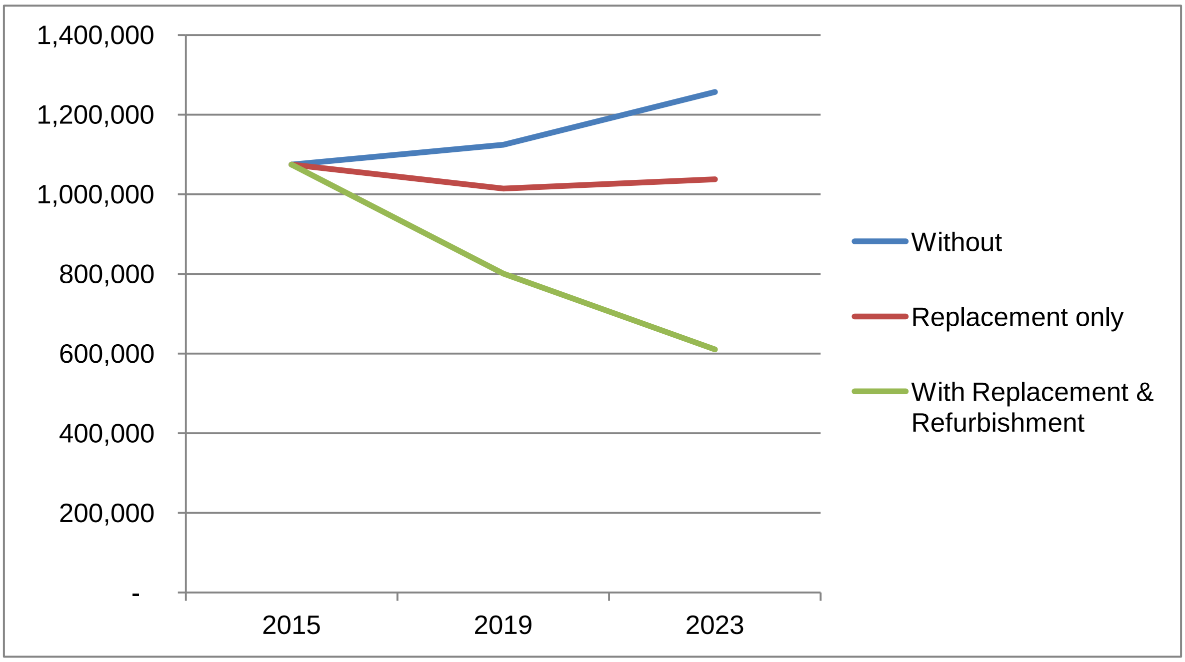
7.1 LV Switchgear and Other

These assets control the outgoing LV circuits from distribution substations.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
LV Pillar (ID)	3,728	198	560	15%	6%	1.0	4.4
LV Pillar (OD at Substation)	6,804	536	896	13%	15%	2.9	7.6
LV Board (WM)	6,083	144	400	7%	15%	1.5	6.5

CBRM modelling has been used to identify LV switchgear in poor condition with an expected end of life occurring prior to the end of RIIO ED-1. These condition-related replacements have been combined with those assets identified for intervention due to their specific operational issues and those consequential to other work to produce the forward programme whose impact is further explained below.

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
16,615	1,856	18.5	3,445	2.0	645,904	32

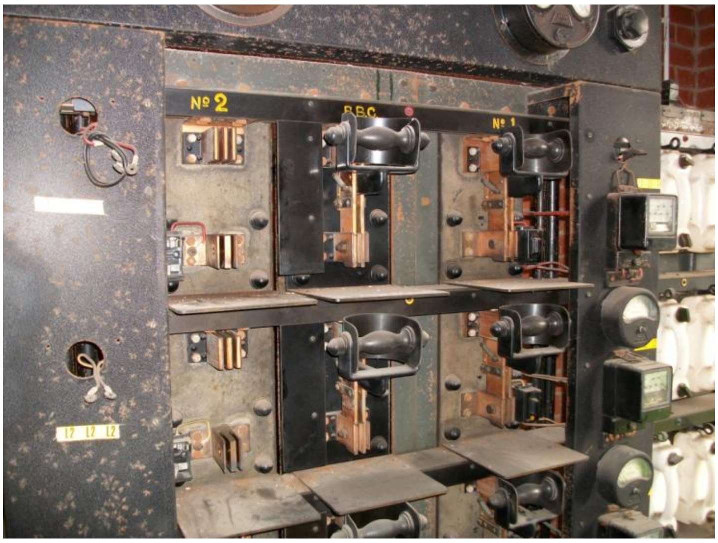


Our internal policy Code of Practice 352 (Guidance Note 4) describes the strategy to be applied in the management of LV switchgear at substations.

This strategy identifies intervention options for the various types of LV switchgear asset on the ENWL network. In addition to condition related interventions, it includes a strategy for those types or groups which present generic onerous operability conditions and where modern fault restoration equipment (eg Fusemates and Rezaps) cannot be accommodated delaying restoration time thus increasing CMLs. This is mainly prevalent for the Wall Mounted LV Boards identified in our RIIO-ED1 plan for replacement, the number of these assets leading to a higher than median intervention rate.
These types and groups include:

- Spring clip boards.
- Spring Contact Transformer Isolators.
- Boards, pillars and cabinets which do not have full interphase and phase-neutral barriers at fuse-ways and the incoming isolators.
- Manchester Boards.
- Other Norweb manufactured LV Fusegear.

Examples of some of these board types are shown below.



Spring Contact Transformer Isolators

Spring clip board

Manchester Board

The majority of the LV switchgear replacement volumes have been identified using the CBRM process and our internal policy which details the intervention strategy for specific LV plant types. This category is dominated by a particular type defect that has been identified with units manufactured by ABB and its predecessor companies post 1992.

ABB/Nitran/Bonar Long boards and cabinets with fragile test sockets pose a specific risk and a modification has been developed to replace these defective test sockets. This modification is suitable for around 90% of the affected LV boards and will remove the defect and enable continued safe operation. We issued a Suspension of Operational Practice (SOP 2012/0380/00) through the Energy Networks Association NEDERS system on 25 January 2012 describing the type defects with such equipment.

However, approximately 10% of the affected ABB Nitran/Bonar Long boards are anticipated as not being suitable for refurbishing due to several variants of the test socket arrangement that exist and have been included in the LV switchgear replacement numbers.

These make up approximately 39% of the LV Pillar (ID) volume and 18% of the LV Pillar (OD at Substation) volume contributing to the higher than median intervention rate.

Volumes associated with consequential outputs

In addition to those LV boards identified for replacement due to their condition or unsatisfactory operability characteristics, consideration has been made of the number of LV boards which will need to be replaced as a consequential output when carrying out transformer replacements.

Experience has shown that due to substation and plant assembly arrangements and the space available in the substation, it is not always practicable to replace distribution transformers in isolation. There is sometimes a need to replace the existing LV switchgear as well, even if its condition would not normally necessitate replacement. These replacements are only sanctioned when all other solutions have been explored eg re-mounting the existing LV cabinet to the new transformer.

Based on current experience we forecast that 25% of the distribution transformer changes will require the replacement of the LV switchgear as well. This has led to an anticipated volume of 277 consequential LV switchgear replacements being added with a circa 50/50 split to the LV Pillar (ID) and LV Pillar (OD at Substation). This additional replacement volume further contributes to a higher than median intervention rate.

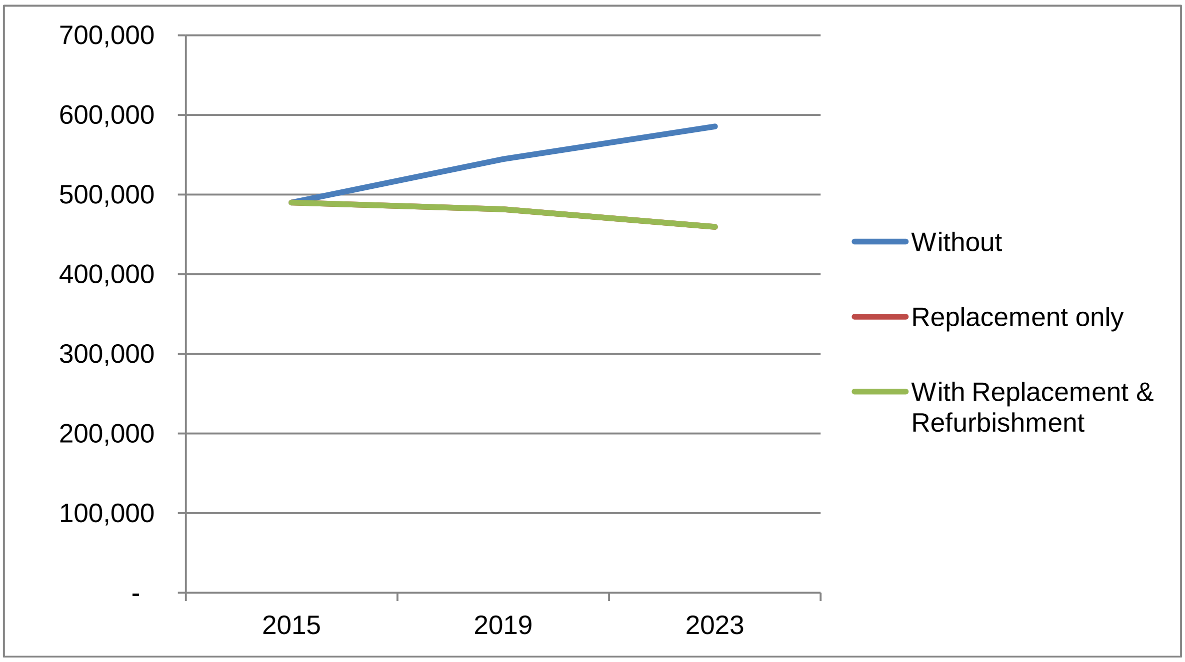
This investment forecast will result in a reduction of risk of 43% over the RIIO-ED1 period compared to the starting position due to the resolution of the ABB Board issue which is increasing the risk for this asset type above the level we would normally expect.

7.2 LV Link Boxes and Outdoor Pillars

This category covers underground link boxes and multiway pillars located outside of substations. These assets permit access to cable systems and hence are invaluable aids to operating the LV system.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
LV UGB & LV Pillars (OD not at Substation)	20,062	1,150	1,752	9%	9%	4.0	8.0

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
20,062	1,752	8.0	-	-	126,116	64



We have a considerable numbers of these assets which we have identified as approaching an end of life condition. For link boxes this can include;

- No compound due to frame distortions;
- No barrier board;
- Obsolete fuse ways and centres;
- Over deep boxes;
- Oversize pavement covers;
- Expanded compound covering contacts; and
- Burnt contacts etc.

Any and all of the above condition issues can result in a dangerous situation for both staff and members of the public due to the potential for explosion. Due to their location (eg on street corners), Outdoor pillars are also often vulnerable to third party interference and vandalism.

Our link box CBRM model has been developed using data as at 31 March 2012 which contains condition data for approximately 40% of installations. It has been assumed the data set is representative of the condition of the link box population as a whole and therefore the number of assets identified by the CBRM model for replacement during the RIIO-ED1 period has been extrapolated to represent the total link box asset population.

The LV Pillar (Outdoor not at substation) CBRM model has also been developed using data accurate as at 31 March 2012 which contains condition data for approximately 80% of installations. The total number of assets identified by the CBRM model for replacement during the RIIO-ED1 period has been extrapolated to represent the total LV Pillar asset population.

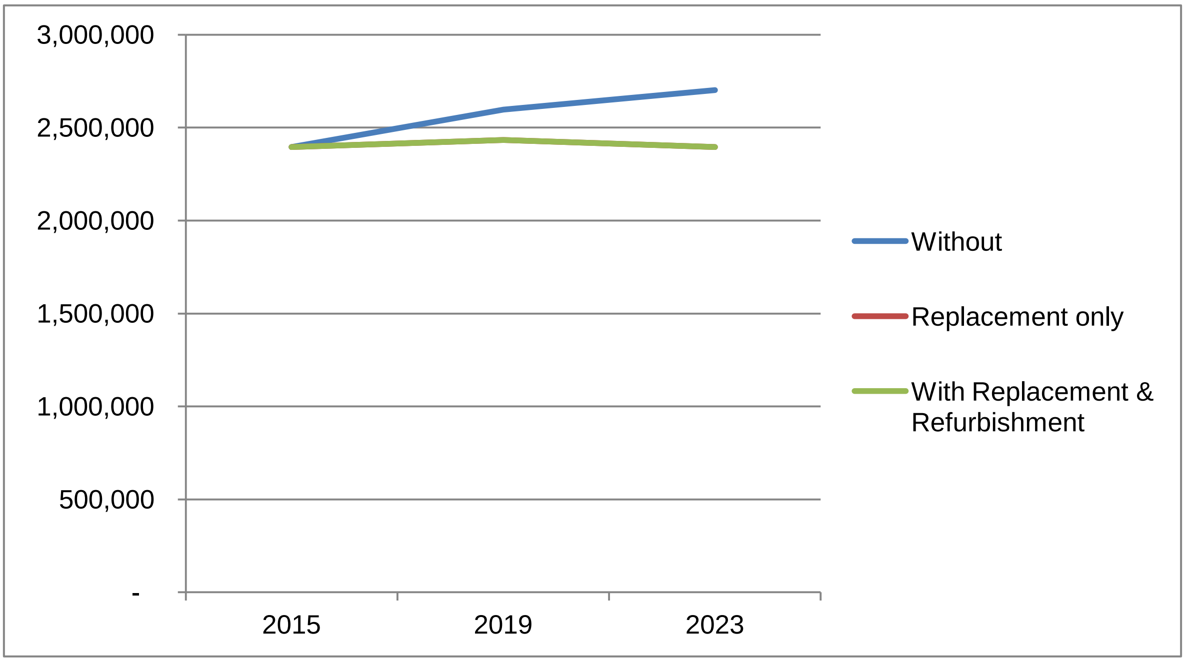
Our proposed programme of work will reduce the risk by 6% compared to the 2015 level.

7.3 LV Woodpoles

These are the wooden poles which support the LV conductors and are predominantly sited in rural areas.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
LV Poles	59,297	5,678	4,162	7%	13%	8.5	5.4

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
59,297	4,162	5.4	12,710	5.2	307,010	34



In DPCR5, we have concentrated on replacing a significant number of poles which have a residual strength calculation of =<80% as part of our ESQCR compliance programme.

This means that we believe we will have replaced the majority of poles that cause any form of non-compliance with ESQCR and therefore in RIIO-ED1 have planned lower replacement volumes on a defect management regime.

With most of the decayed poles removed, the deterioration rate forecast in RIIO-ED1 is modest. In the period we will replace any pole which on inspection has a calculated residual strength value of =<80% at the time of test.

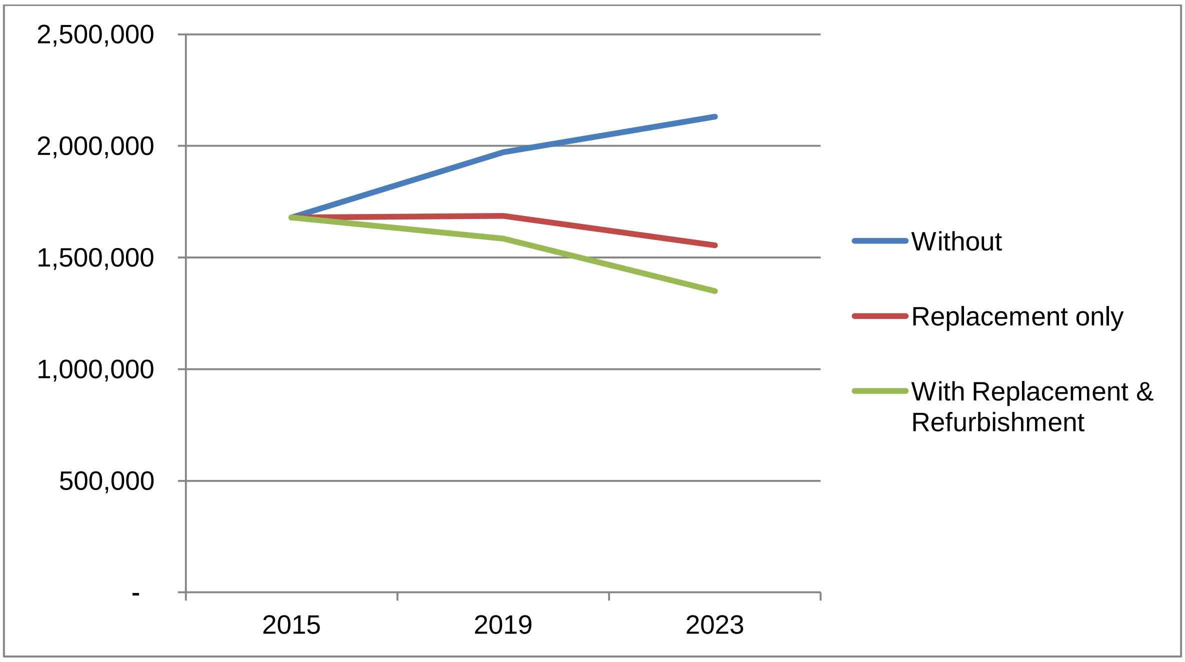
We are already aware from our ESQCR work which poles have a residual strength of in the 81-90% range. We have assumed that these will require replacement in the period and the result of this approach is that risk will be held broadly at its 2015 level across the period.

7.4 HV Switchgear – Primary

These are the units which control the outgoing HV circuits from Primary substations. Although operating at HV, they are usually considered as part of the EHV network.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	Asset register	DPCR5	RIIO-ED1	Planned	DNO median	DPCR5	RIIO-ED1
6.6/11kV CB (GM) Primary	4,618	240	866	19%	12%	9.0	26.7

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
4,618	866	26.7	358	5.2	781,195	41



For HV primary switchgear, we assess the condition of the fixed and moving portions of our plant. Where the condition of the switchgear has been assessed to be fair except for the moving portion, these have been identified for refurbishment through retrofitting circuit breakers, whose unit costs are lower than asset replacement.

Replacement occurs if the fixed, or fixed and moving portions meet the HI=5 threshold. Refurbishment usually requires replacement of the moving portion with a modern retrofit circuit breaker employing vacuum breaker technology.

Where the fixed portions are at end of life this will either be wholly on current condition such as rusting or distortion of panels etc., or due to issues which place the operator in danger, and hence the switchboard is classed as a safety hazard.

Loss of a panel associated with these multipanel switchboards typically results in a widespread loss of supply and customer inconvenience and takes significant time to restore the system back to the normal running arrangement.

Our intention to use a greater proportion of refurbishment is based on the availability of these techniques and represents a change from our previous practice where virtually every switchboard was replaced.

The CBRM model has been used to identify the HV primary circuit breakers due for intervention. The initial run resulted in approximately 2,000 requiring some form of intervention. This was a result of the exponential ageing of the health of the asset which led to acceleration of HIs. More than 53% of the total asset count are between 40 and 60 years old and are reaching the end of their economic life.

We carried a further review of operability scores of all the assets and this resulted in the reduction of the number of units that required intervention. We then carried out a CBA to determine the appropriate replacement/refurbishment split.

We identified which of the circuit breakers would benefit from refurbishment (retro fit) provided there is no partial discharge and no truck problem.

This asset type had a particularly high peak of installation in the 1960s and a large number of assets are showing signs of coming to the end of their life. As a result, we will be replacing approximately 20% and refurbishing a further 7% of the population in RIIO-ED1 resulting in a reduction in the overall risk score for this asset type.

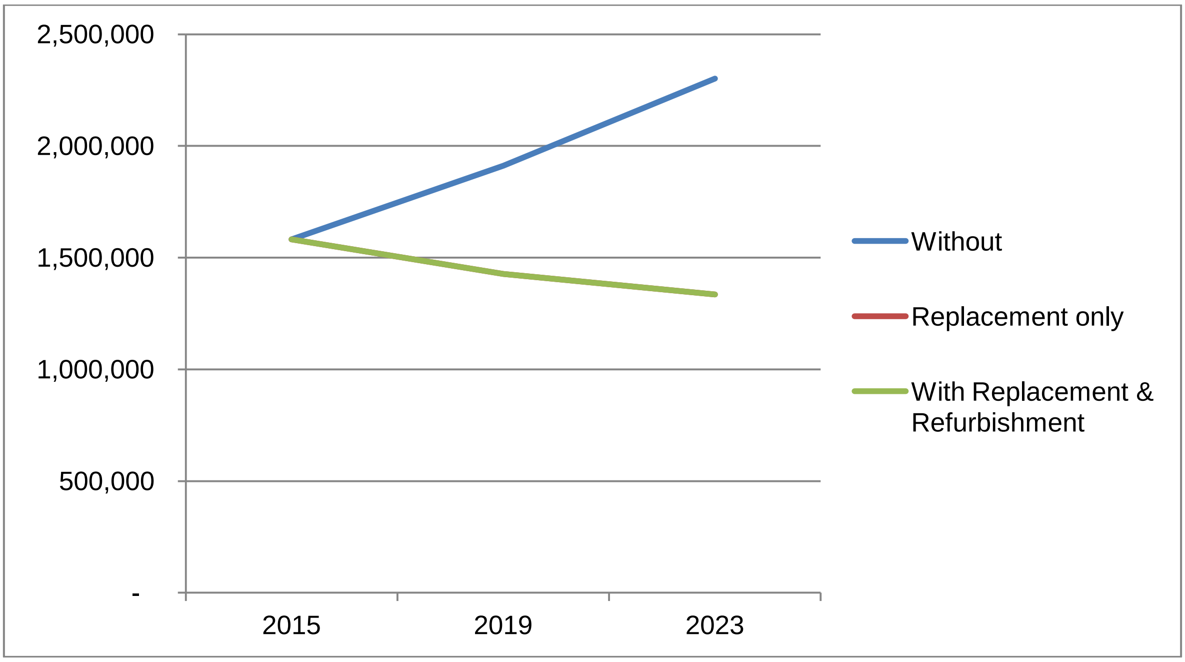
7.5 HV Switchgear – Distribution

These are the switches that operate the transformers at distribution (HV) substations. They are the prime means of controlling the HV network through switching substations on and off.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
6.6/11kV CB (GM) Secondary	5,967	306	1,265	21%	7%	3.2	8.3
6.6/11kV Switch (GM)	13,449	359	2,544	19%	5%	2.4	13.6
6.6/11kV RMU	11,040	871	2,519	23%	8%	9.9	26.2

The category of HV Switchgear - Distribution has been assessed in overall terms (i.e. Switches, Circuit Breakers and Ring Main Units) as the practical solution is to address the entire switchboard on site as the individual items are interrelated. It is not possible to replace individual units (switches and circuit breakers) due to non availability of compatible plant.

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
30,456	8,120	48.1	70	0.6	966,888	50



The HV Switchgear replacement volumes have been identified using the CBRM process and our internal policy (CP352). This details the intervention strategy for specific HV switchgear types.

Partly as a result of a type defect identified on the Long & Crawford/GEC/Alstom GF3 family of oil insulated fuse switches and RMUs, the volume of switchgear replacements required in RIIO-ED1 has increased from that in DPCR5.

In early January 2013, a disruptive failure of a GF3 fuse switch unit occurred shortly after re-energisation following maintenance (see Fig 1 below). A Suspension of Operational Practice (SOP 2013/0383/00) was issued via the Energy Networks Association NEDeRS system on 7th January 2013, pending further investigation. There have been three incidents in Electricity North West where this type of switchgear has failed disruptively.

This SOP prohibits any manual operation of the fuse switch when any part of the unit or switchboard is live.

Aftermath of disruptive failure of GF3 fuse switch at Scale Howe s/stn, Ambleside.

A local remote operation method has since been developed to be used (with restrictions) where remote operation to de energise/energise the fuse switch will result in disconnection of significant numbers of customers or sensitive customers. However, this GF3 fuse switch problem is still causing restrictions in normal operations.

As yet, no modification has been developed to remove the problem and therefore the SOP remains in place.

This defect potentially affects around 11,000 individual switchgear units in our switchgear portfolio which have the GF3 fuse switch mechanism. Further investigation has suggested that fuse switches feeding transformers with a rating of 1,000kVA and above and those feeding radial circuits are at highest risk of failure. This assessment identifies around 2,200 units potentially requiring replacement with an estimated total replacement cost in the order of £20M.

However, as investigations are continuing to positively identify the failure mode and potentially develop a modification, a decision has been taken to only include a portion of the total replacement cost in our RIIO-ED1 submission.

To this end, an additional £12m has been included in our submission to facilitate replacement of the highest risk GF3 units should this prove necessary. This equates to around 1,200 additional assets installed and contributes to the higher than median planned intervention rate.

Replacement ratios

When identifying switchgear replacement solutions, account has been taken of the configuration of the switchgear being disposed of in each substation. Where possible, an existing multiple panel switchboard consisting of two network switches and a transformer circuit breaker will be replaced with a single Ring Main Unit. This results in a higher ratio of switchgear disposals, particularly switches and circuit breakers, to RMU installations.

Replacement of extensible 3 panel switchboard (1 x CB & 2 x Switches) replaced with RMU

The replacement solution for many of the GF3 fuse switches is to replace with a circuit breaker e.g. where a multi-panel switchboard solution is required (more than the typical 2 switch/1 fuse switch configuration) and an RMU solution is not appropriate. This has led to a higher proportion of circuit breakers being installed than would normally be expected from condition based replacement.

For multi-panel boards that require intervention and which have an extensible switchgear configuration with 4 or more units (switches or circuit breakers), it is not practicable to replace individual assets and a total replacement approach is required. This will attract some consequential replacements of units with a Health Index less than 5.

HV switchgear panel requiring extensible switchgear replacement solution

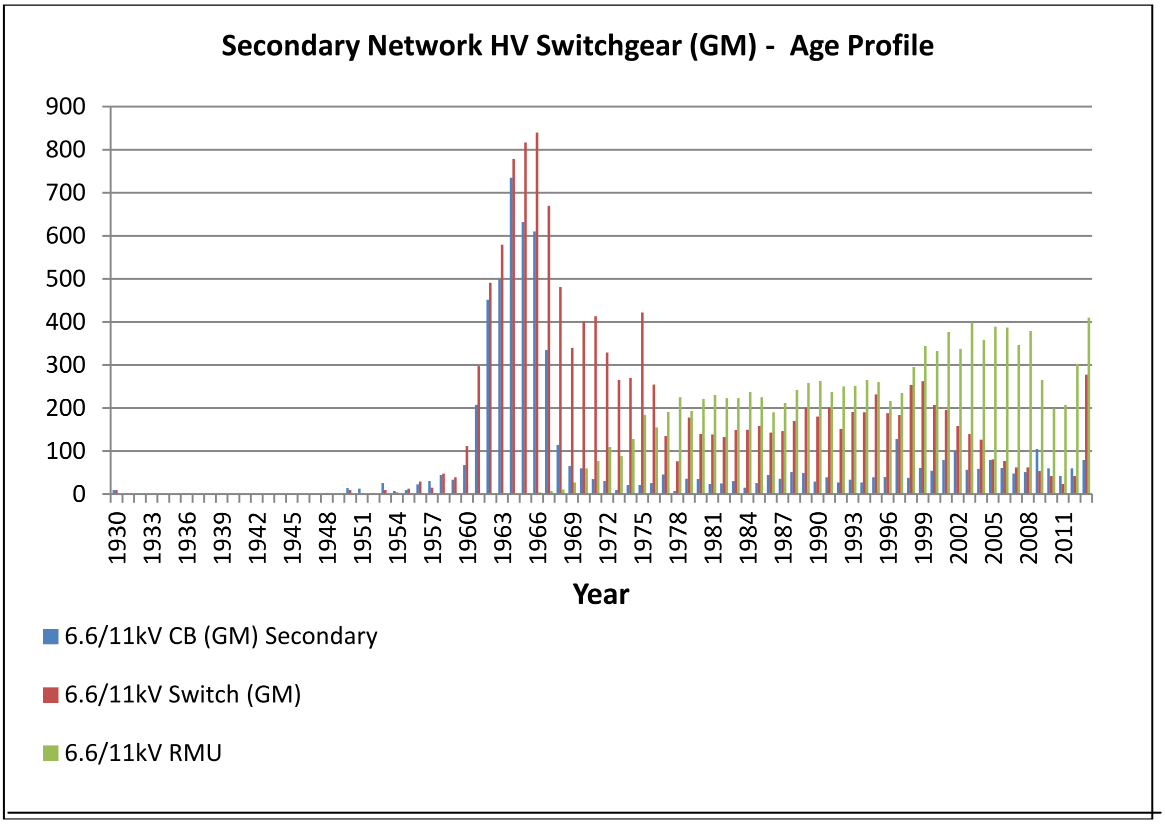
The mix of switchgear types for replacement in RIIO-ED1 is weighted more towards switches and circuit breakers than RMUs which is as a result of the switchgear intervention profile in DPCR5.

During DPCR5, there has been a weighting towards RMU replacements with specific type replacements taking place for operability[1] reasons e.g. Reyrolle ROKSS units due to multiple catastrophic failures and Long & Crawford T3GF3 units manufactured prior to 1973 due to unreliable HV fuse clips.

It should be noted that, whilst switchgear age is not in itself a driver for asset replacement, around 70% of the circuit breaker and switch population will be 45 years of age and older at the end of RIIO-ED1 with a quarter of the circuit breakers being at least 60 years old at that point (see graph below).

In September 2012, Parsons Brinckerhoff (PB) undertook a technical review of our initial RIIO-ED1 submission. Through meetings with staff, and a review of documentation provided, they reviewed our investment plan. In their review of HV switches and RMUs, PB concluded that our expenditure proposals were less than would be expected from an age only view.

[1] Operability is a term used within the Electricity North West Condition-Based Risk Management (CBRM) models to describe a function used to modify the model's output of Health Index as a result of data associated with the plant's reliability.



HV switchgear (GM) age profile

The current issues with the GF3 fuse switch units increase the risk for this asset type above the level we would normally expect. The planned resolution of these issues, together with the replacement of 20% of the asset population over the RIIO-ED1 period results in a 16% improvement in risk from the 2015 position.

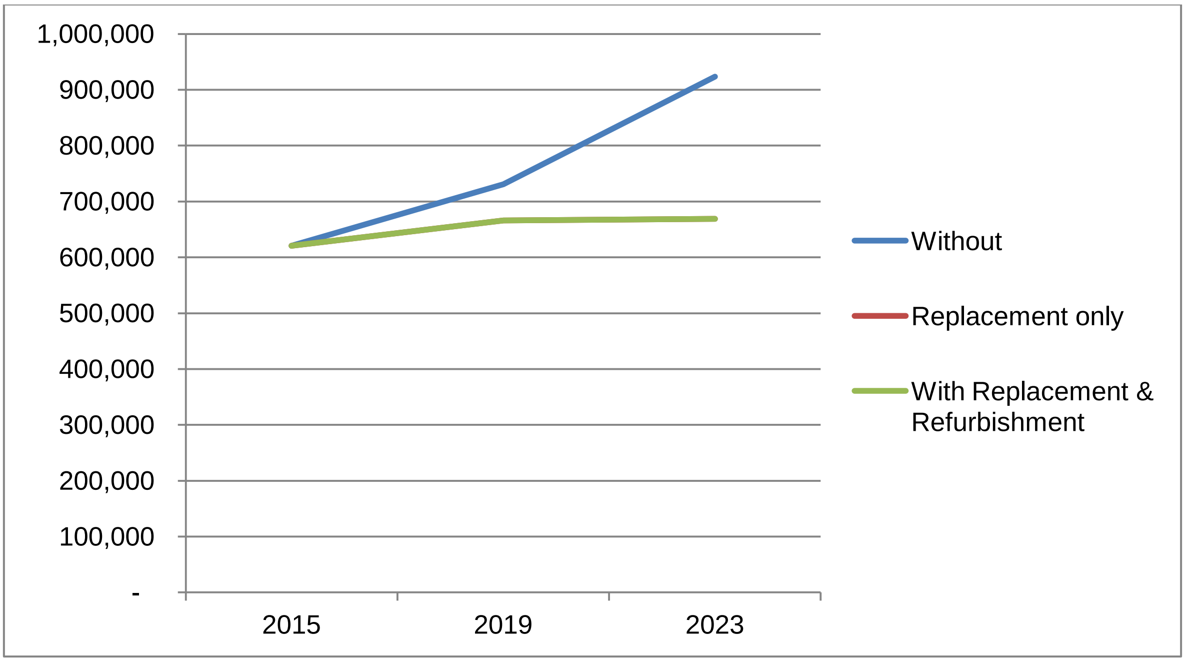
7.6 HV Transformers (GM)

These are the assets that transform the voltage from 33kV to 11 or 6.6kV for onward transmission through the HV network.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
6.6/11kV Transformer (GM)	16,679	742	1,408	8%	5%	8.1	18.3

Electricity North West Code of Practice 352 (Guidance Note 3) describes the strategy to be applied in the management of distribution transformers. CBRM modelling has been used to identify ground mounted transformers in poor condition with an expected end of life occurring prior to the end of RIIO-ED1.

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
16,679	1,412	18.3	-	-	254,240	72



Transformer condition is assessed at substation inspection with specific questions being asked about particular condition points. The answers to these questions contribute to the asset Health Index and are weighted to reflect their relative importance with the highest weighting applied to significant corrosion of the main tank and radiators. Oil tests are not routinely taken of distribution transformers.

In addition to those transformers identified for replacement due to their condition, consideration has been given to the number of transformers which will need to be replaced as a consequential output when carrying out LV board and pillar replacements.

Experience has shown that, due to substation and plant assembly arrangements and the space available in the substation, it is not always practicable to replace LV boards and pillars in isolation. There is sometimes a need to replace the existing transformer as well, even if its condition would not normally necessitate replacement.

These replacements are only sanctioned when all other solutions have been explored eg replacing existing LV switchgear with a standalone pillar

Analysis of completed projects shows that around 25% of LV switchgear changes have required the replacement of the transformer as well. This has led to an assumption of 312 consequential transformer replacements being added to the number identified for replacement from CBRM.

The volumes also includes an assumption for consequential transformer replacements from the associated LV board replacement programme due to engineering and compatibility issues for the modern equivalent transformer replacement to accept the existing LV board. From current experience, an assumption has been made that for every ten LV board replacement we anticipate four consequential transformer replacements.

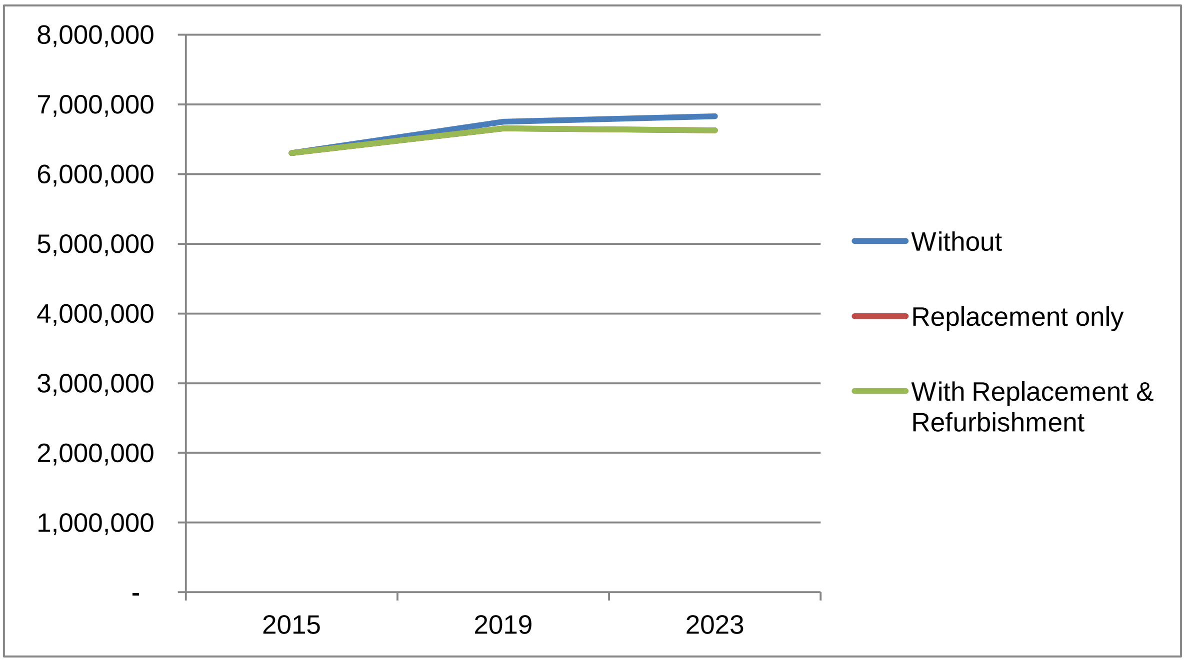
There are no particular special factors in this category and hence the planned programme results in a slight increase in overall risk from that in 2015.

7.7 HV Woodpoles

These are the wooden supports that carry conductors at HV. These are typically found in more rural areas and run between Primary and Distribution substations.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	Asset register	DPCR5	RIIO-ED1	Planned	DNO median	DPCR5	RIIO-ED1
6.6/11kV Poles	98,922	8,153	1,272	1%	7%	13.7	2.1

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
98,922	1,272	2.1	28,212	2.4	199,280	73



The replacement and refurbishment volumes are based on observed condition from on site inspection with intervention determined in line with our internal policy.

Line inspections are carried out by experienced contractors equipped with specialist pole inspection and test equipment. Along with the inspection data collected on hand held devices, photographs are taken of each pole for reference and audit purposes. These photographs are then stored on a central server accessible to those who require it.

Ensuring legal compliance and overall public safety, as well as asset and customer performance, requires a combination of asset replacement and refurbishment appropriate to the risks involved. Efficient asset management relies on the co-ordination of these activities such that maintainable units of overhead line have intervention strategies applied that meet all performance needs.

In DPCR5, we have concentrated on replacing a significant number of poles which have a residual strength calculation of =<80% as part of our ESQCR compliance programme.

This means that we believe we will have replaced the vast majority of poles that cause any form of non compliance with ESQCR and therefore in RIIO-ED1 have planned lower replacement volumes on a defect management regime.

With most of the decayed poles removed, the deterioration rate forecast in RIIO-ED1 is modest. In the period we will replace any pole which on inspection has a calculated residual strength value of =<80% at the time of test.

We are already aware from our ESQCR work which poles have a residual strength of in the 81-90% range. We have assumed that these will require replacement in the period. The result of this approach is that risk will be held broadly at its 2015 level across the period

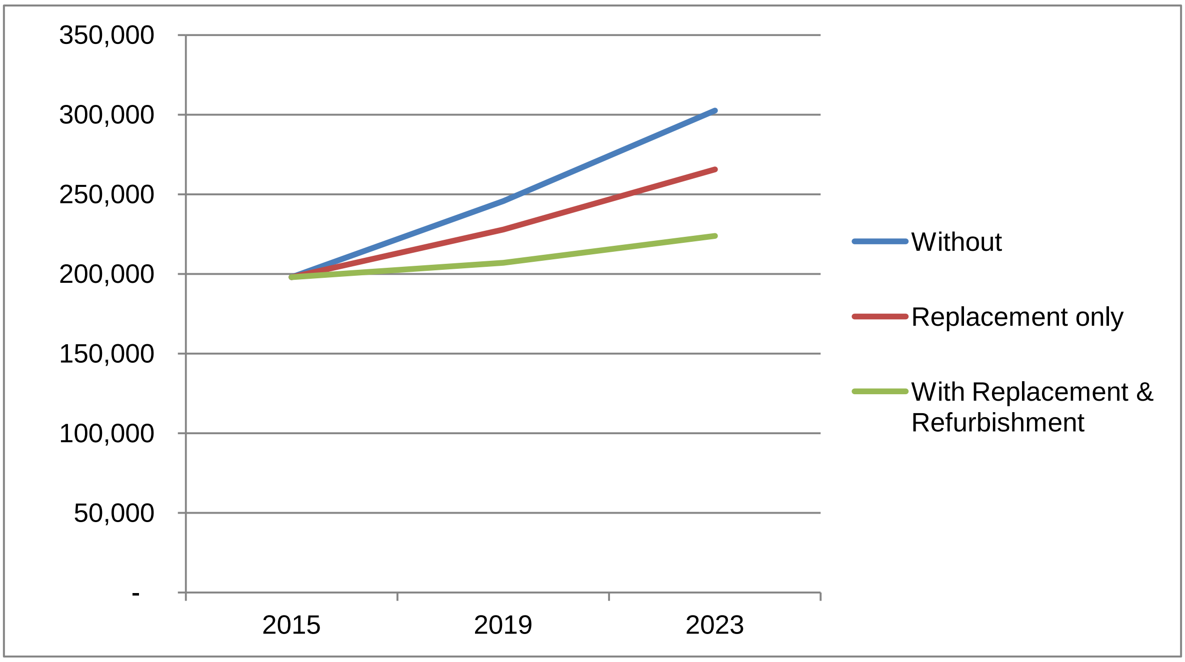
The volumes identified for intervention have been grouped by poles into maintainable units for efficient delivery and to maximise the benefits of investment on those lines in most need of intervention. At the delivery stage, intervention on a section of line will be a mix of replacements and refurbishment.

7.8 EHV Switchgear

This is the switchgear that controls the Primary (eg 33kV) substation and can move supplies from one circuit to another.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
33kV switchgear	1,746	39	69	4%	13%	5.1	5.0

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
1,746	69	5.0	88	1.2	78,793	79



In this category, we are planning to replace switchgear at Lancaster, Lamberhead, Kirkby Lonsdale and Windermere Primary substations.

The majority of our EHV plant is in reasonable condition with few operability issues. This is partly due to the relatively few operations they undertake when compared with HV Primary boards.

The replacement volumes in RIIO-ED1 reflect the fact that in the past ten years we have refurbished our entire stock of Reyrolle L42T circuit breakers and these in the main are continuing to give good service.

Replacement continues to be the favoured option in most cases as retrofit Circuit Breakers are not available for this category.

With our selective intervention policy, a marked deterioration in the risk position can be seen due to approximately 40 panels of L42T plant which will attain a HI=5 status in the period. These will be reviewed during RIIO-ED1 and an appropriate intervention strategy implemented in RIIO-ED2.

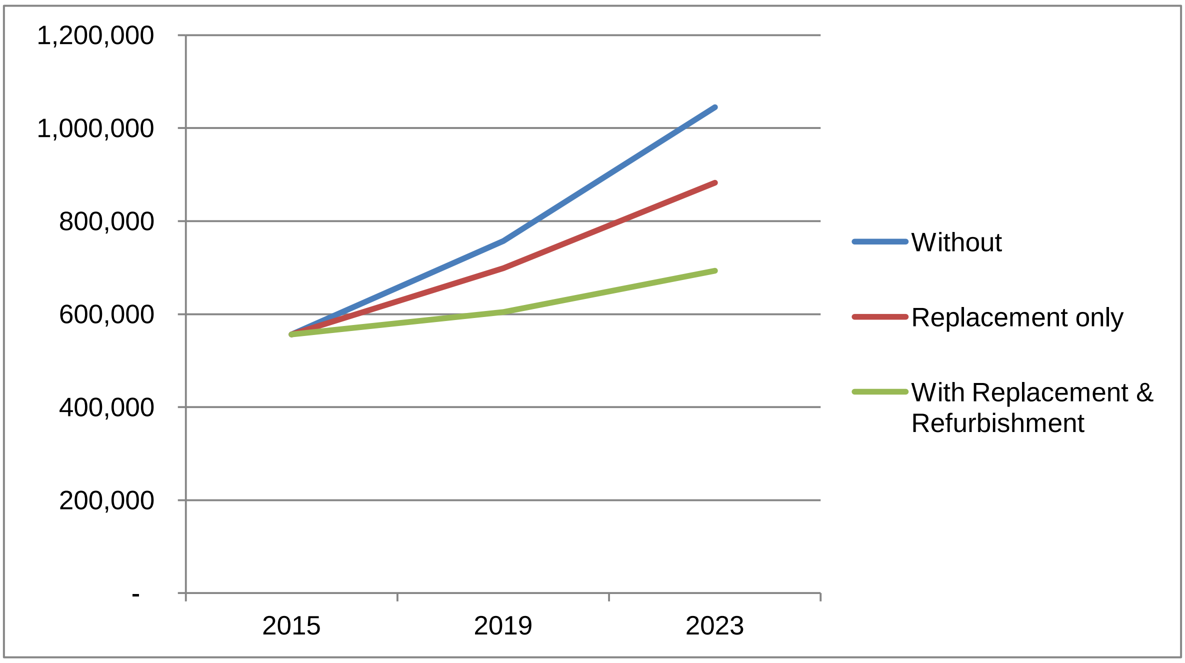
This investment programme is forecast to result in risk increasing by 13% over the RIIO-ED1 compared to the starting point.

7.9 EHV Transformers

These units transform electricity from 33kV to HV (either 11 or 6.6kV) for onward transmission through the HV network.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
33kV Transformer (GM)	718	26	87	12%	8%	8.0	29.4

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
718	87	29.4	109	5.8	352,174	100



In general 33kV GM Transformers for intervention in RIIO-ED1 have been identified using the same process and criteria as used for our 132 kV Transformer population.

A number of differences between the two populations have however become apparent as a result of our investigations into the asset group and these are detailed below.

The CBRM modelling identified approximately 330 out of an asset base of 718 (46%) 33kV transformers which have or will have a Health Index => 5 in the RIIO-ED1 period and hence require intervention. Examination of the specific data has been undertaken and we have identified that due to the exponential ageing system of the model and our life expectancy of a unit which is 60 years coupled with moderate levels of deterioration we have high HI predictions. 59% of our 33kV transformers have been in service for between 40 and 60 years.

The replacement of such high numbers of transformers is neither economically viable nor logistically possible within one RIIO period. As a result, we have carried out further analysis on the transformer HI results based on the set of criteria we jointly developed with Manchester University under the IFI project “Examining Life Extension post Transformer Regeneration.”

This project confirmed that transformer life for Grid and Primary transformers can be extended by an average of 10 years should the oil regeneration be carried out at the right time. We have therefore taken this conclusion into account and only identified transformer units that need to be changed as refurbishment alone will not gain the expected life extension and HI reduction. This process resulted in 87 33kV transformers being identified for asset replacement.

The scope of 33kV transformer replacement includes:

- new transformer,
- a new tap changer,
- replacement of 33kV busbar or cable connections,
- replacement of 6.6/11kV busbar or cable connection,
- new voltage regulation and
- new transformer protection.

It should be noted that in developing our HI for both 132 and 33kV units, the HI of a transformer is a weighted combination of the health index of transformer main tank and on-load tap changer. In determining the intervention required we take into account the following:

- Condition of the unit, both internal and external
- The predominant driver of the overall HI
- Our ability to refurbish against replace the unit
- The potential life extension the proposed intervention will produce
- The impact on the risk presented to the company post intervention and
- The cost benefit from the proposed solution.

In table CV3 we have represented out replacement volumes and costs and in table CV5 our refurbishment volumes and costs. The split is based on a CBA carried out for this asset group.

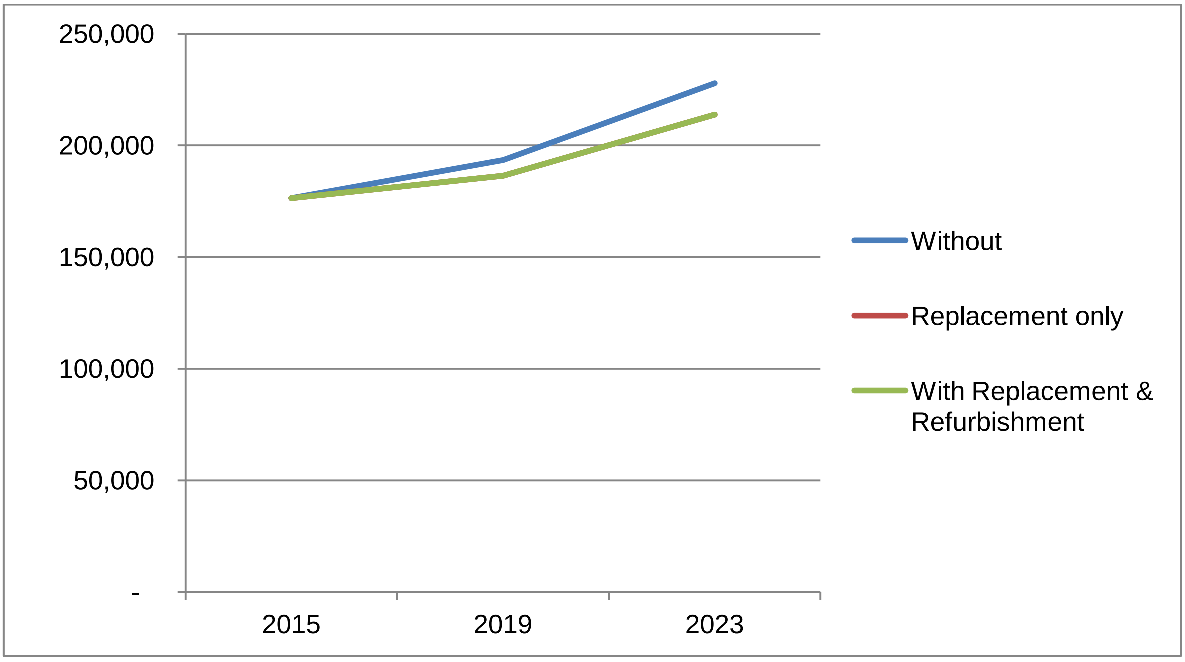
This intervention will result in a risk increase of 25% over the RIIO-ED1 period compared to that at the start of the period.

7.10 EHV UG Cable (gas)

These are 33kV cables that connect major substations and where the insulation is assisted with pressurised nitrogen. These assets were generally installed in the 1950s and 1960s. When replaced, a modern cable of solid construction is used.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
33kV UG Cable (Gas)	234	0	0	0%	0%	0.4	0.0

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
234	16	0.0	264	4.6	13,998	328



This cable type was installed in the 1960s and 1970s and is now obsolete. No manufacturers exist in the EU and jointing accessories are becoming increasingly difficult to source.

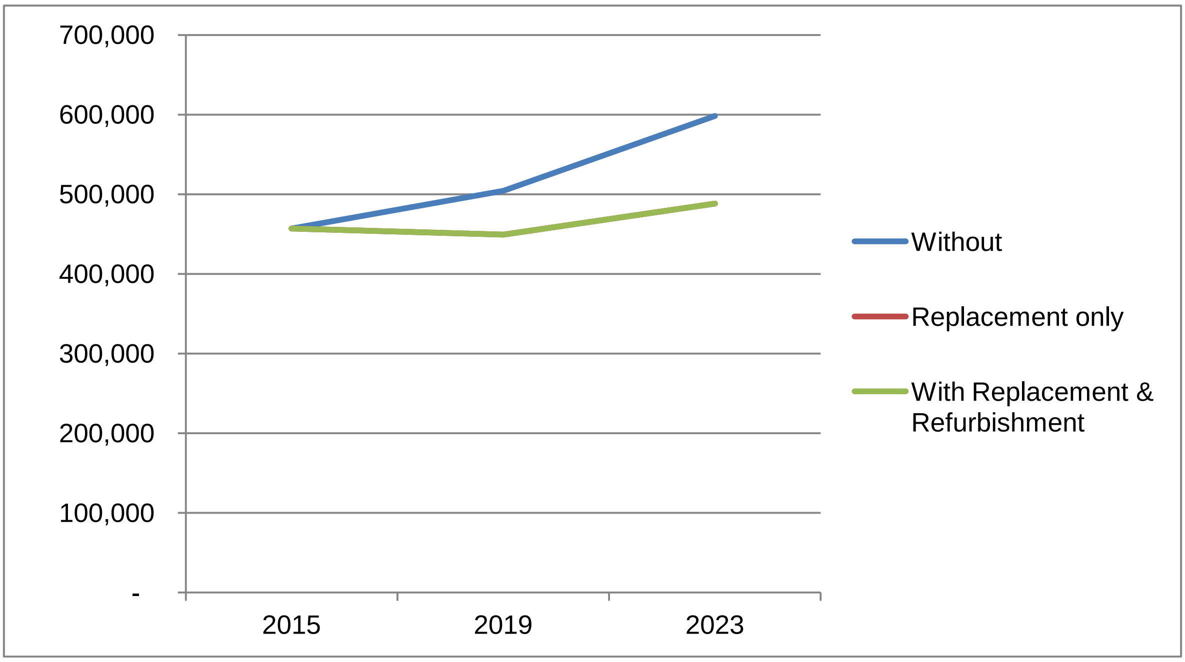
The gas-filled cable system is approaching the end of its design life and has an increasing risk of failure due to lack of expertise, lack of spares, safety issues and the further anticipated deterioration in the reliability of the cables. A programme of replacement of gas cable has been planned for RIIO-ED1 based on leak performance and prioritised on those cables with lead sheaths and phosphor bronze tape reinforcing which experience has shown to be most susceptible to deterioration and leaks.

7.11 EHV UG Cable (oil)

These are 33kV cables that connect major substations and the insulation is assisted with mineral oil under pressure. These assets were generally installed in the 1950s and 1960s. When replaced, a modern cable of solid construction is used.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
33kV UG Cable (Oil)	360	0	0	0%	0%	0.1	0.0

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
360	45	0.0	160	4.6	109,881	42



As with the gas equivalent, this cable has not been installed for a number of decades, is obsolete and no manufacturers exist in the EU. We are still able to repair faulted cable sections and source jointing accessories but this is becoming increasingly difficult.

At the moment, this asset type is performing very reliably so we are planning a programme of selective replacement based primarily on the risk of environmental contamination from oil leaks.

The majority of the incidents that occur are not as a result of the primary conductor faulting but are associated with the loss of oil. As such, the environmental consequences of faults can be high and this drives the prioritisation of sections for complete replacement.

In terms of interventions, we are able to refurbish joints where oil leaks occur as a result of vibration or land movements.

In RIIO-ED1, we are planning to replace 45km of these assets where they pose a significant risk to the environment and refurbish the majority of the remaining asset base such that it can remain in service until its eventual replacement over the long-term. The result of this planned programme is a restriction in the rise in network risk to 7% from the 2015 position.

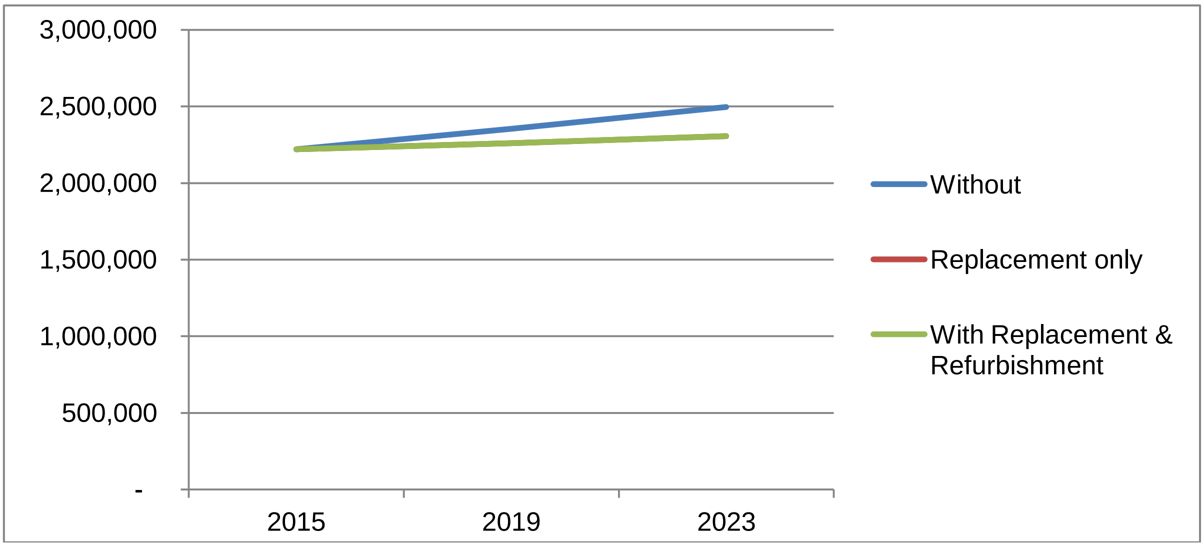
We have produced a CBA which supports our long-term aim of removing all the oil cable on our network at this voltage over the RIIO-ED1, 2 and 3 periods.

7.12 EHV Woodpoles

These are the wooden supports that carry conductors at 33kV.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
33kV Pole	12,567	462	494	4%	12%	1.2	1.5

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
12,567	494	1.5	2,540	1.9	190,026	18



As with LV and HV woodpoles, we have replaced a significant quantity in the DPCR5 period as part of our ESQCR compliance programme. However, due to their nature, EHV woodpoles do not tend to suffer from clearance issues and so the relative volumes replaced are lower than at HV and LV.

Our policy for maintenance and refurbishment of overhead lines was revised and issued in July 2012 and further reviewed in December 2012 to cater for the change from ESQCR compliance investment to intervention and rectification based on observed condition. Development of this policy included review of industry best practice and cost benefit analysis of the modified approach.

For RIIO-ED1, the replacement and refurbishment volumes identified in our plan are based on observed condition from on site inspection with intervention determined in line with our policy.

Line inspections are carried out by experienced contractors equipped with specialist pole inspection and test equipment. Along with the inspection data collected on hand held devices, photographs are taken of each pole for reference and audit purposes. These photographs are then stored on a central server accessible to those who require it.

The volumes identified for intervention have been grouped by poles into maintainable units for efficient delivery and to maximise the benefits of investment on those lines in most need of intervention. At the delivery stage, intervention on a section of line will be a mix of replacements and refurbishment.

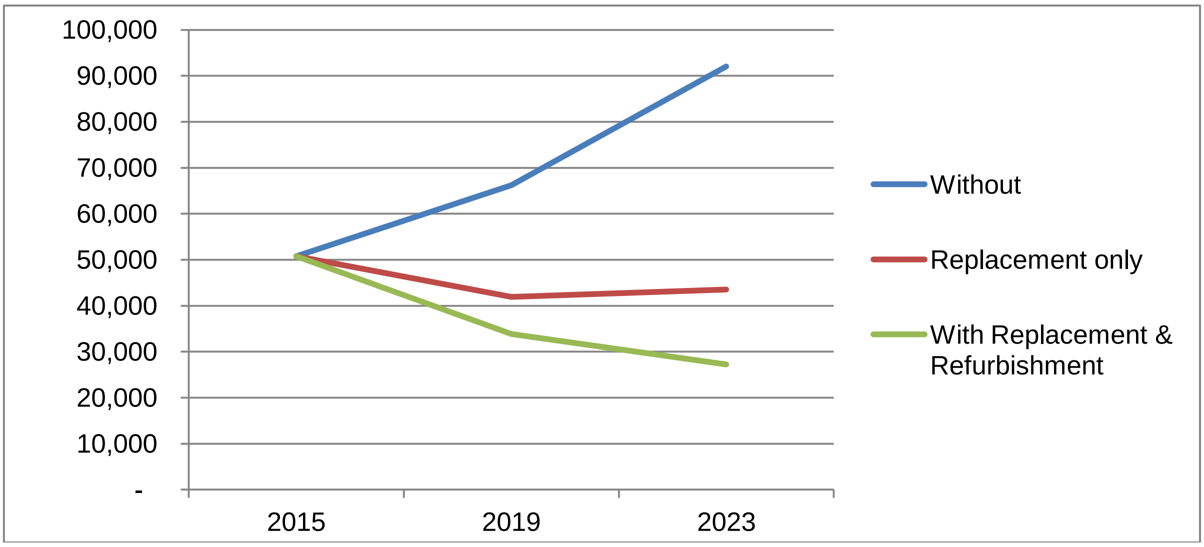
As the forecast deterioration of this asset type is relatively modest, the programme of replacement has been profiled towards the end of RIIO-ED1. Refurbishment of identified poles will take place throughout the period such that the risk will be held broadly constant over the RIIO-ED1 period.

7.13 EHV Towers

These are steel lattice towers that do the same job as EHV woodpoles but are able to carry circuits of a higher rating. Due to their height, they can also be used in areas where woodpoles cannot due to clearance issues.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
33kV Tower	930	1	200	22%	2%	0.0	8.1

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
930	200	8.1	364	5.7	64,844	213



Steel lattice tower replacement numbers are based on safety and security data from a full condition survey undertaken in 2012 and used to calculate asset Health Indices using the CBRM model.

The health index for our tower assets can be grouped to allow efficient delivery of interventions at;

- a component level eg insulators, conductor, tower; or
- a circuit level eg a number of towers.

This approach has been used to develop the programme of intervention which has been targeted at reducing probability of failure of individual towers and components. This consists of structures and components being replaced in their entirety where the tower or mast is at end of life and all the bars of the structure require replacement. In addition, the tower's fittings and fixtures are also replaced at this time. It is highly unusual for the entire line to be replaced and intervention is typically a mixture of replacement and refurbishment depending upon the severity of the deterioration. Interventions are usually initiated as a result of the overall line of towers being sufficiently deteriorated to warrant intervention. Replacement may occur when the tower is at HI=4 or 5 and asset refurbishment at HI=4.

In addition, we have a small number of towers (approximately 20 in the DPCR5 period) which need specific and targeted intervention. In this small number of cases (25 estimated for RIIO-ED1) there will be small remediation projects raised to deal with the single structures.

The probability of a complete tower failure is extremely low hence the low starting level of risk. Many of our towers are in exposed conditions and hence it is vital to maintain appropriate painting and refurbishment regimes to ensure a long operating life.

Our strategy incorporates Inspection and Maintenance in accordance with existing policies plus a planned CBRM targeted refurbishment programme matched to the varying life of the overhead line components. Additionally, targeted asset replacement is incorporated into the programme strategy also based on CBRM based condition monitoring of the 33kV Tower assets. This strategy is planned to ensure that tower failures will be minimised even during severe weather conditions, hence ensuring CIs and CMLs are not incurred due to deterioration of the towers. The strategy is also aimed at ensuring that the risk of injury and/or fatality being caused to staff or members of the public due to tower failure is also minimised, even in severe weather conditions.

The tower replacement plan over the last three regulatory periods has focused mainly on the replacement of 132kV towers. Modelling the 33kV tower condition from CDC surveys which took place in 2012 has shown that a number of 33kV towers are required to be intervened on. These can generally be characterised as a mix of tower, fittings and conductor replacements, coupled with a level of tower refurbishment.

The CDC data enables us to study the available photographs of the towers (see above) to determine the number of towers which need to be either replaced or refurbished. Our modelling and investigation shows that we have 222 towers with a health index of 5 that require replacement, however due to system limitations we are unable to achieve this volume of changes. This is because in studying our network we are unable to take the double circuit outages we require to change towers, in the most cost effective manner. It is possible to change towers by the use of temporary structures but this significantly increases the cost to the customer. Our preferred option is to use a refurbishment option as described in our commentary to table CV5. The 33kV towers on our network are small in comparison with the 132kV towers, and as a result we require full outages when replacement or refurbishment work takes place.

Our volumes for the period are further influenced by the deterioration in condition over the last period caused in part by previous painting patterns and the highly corrosive atmosphere of the west coast due to prevailing winds and salt pollution.

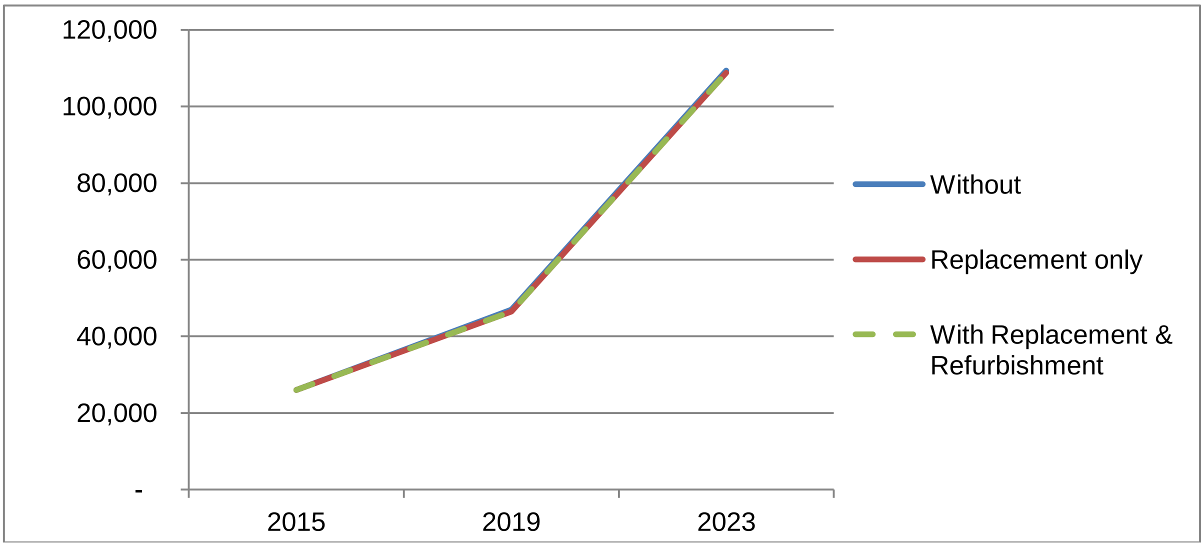
Another consideration which may change our tower replacement / refurbishment requirements is the application by NuGen to National Grid Electricity Transmission for the connection of a 3.6GW nuclear power station, at Moorside near Sellafield. To enable this connection National Grid will need to provide 4 x 400kV transmission circuits. At present, no firm commitments on the timing of the connection works or the route for the transmission circuits have been made.

7.14 EHV Fittings and Conductors

These are the conductors between towers which carry the electricity at 33kV and the fittings that attach the conductors to the towers.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
33kV OHL (Tower line) Conductor	338	15	3	1%	10%	0.6	0.1

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
338	3	0.1			536	243



This is a composite category of conductors and fittings.

Where a tower is replaced, a full set of fittings are changed at the same time. Where fittings only are required these are installed as a separate job.

For 33kV, the volumes of interventions have been relatively low in the period to the end of DPCR5. Inspection data and CBRM modelling now indicates that there are a significant volume of fittings which need to be intervened on.

We have delayed some intervention in DPCR5 as the potential impact of the Moorside nuclear development impacts on many of the lines in the West Cumbria. As the likely date of the commissioning of the new power station has slipped back, there is now a need to intervene on a number of lines. The development of the Moorside project has allowed us to understand the likely retention of the 33kV tower systems in the Cumbria area and hence we are convinced of the need to change this volume of fittings.

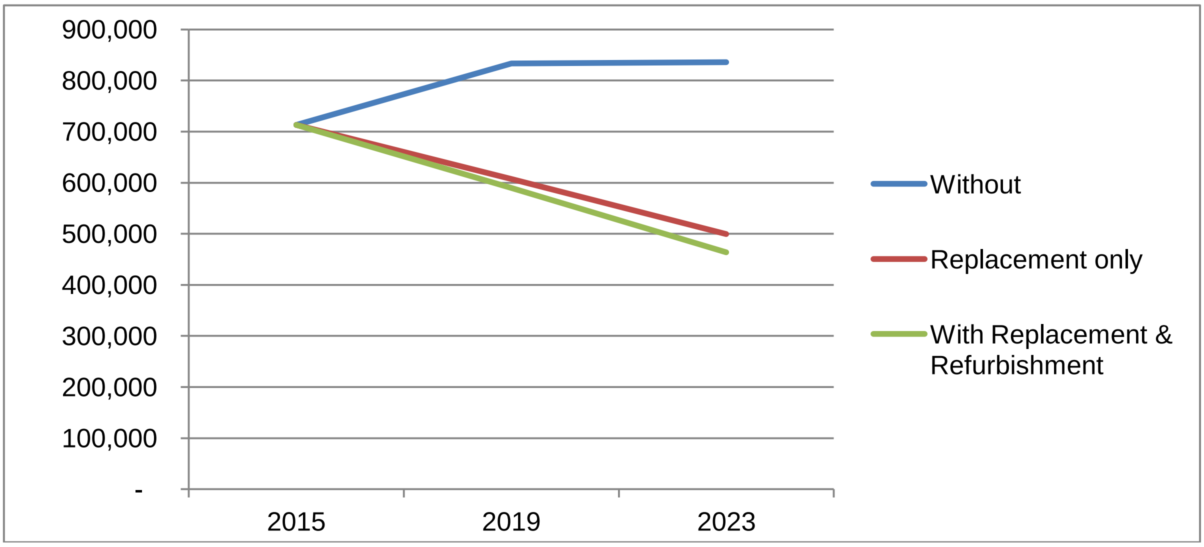
However, as the HI calculation is based on the length of conductor and we are not currently planning to proactively replace any conductor lengths in RIIO-ED1 following the completion of a re-stringing programme in DPCR5, the risk profile shows no reduction from investment over RIIO-ED1.

7.15 132kV CBs

These are our largest units of switchgear, controlling our largest substations where the voltage is transformed down from 132kV to 33kV for onward transmission.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
132kV CB	186	2	31	17%	11%	11	23

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
186	33	23.4	8	0.2	372,202	63



This category covers 132kV CB (Air Insulated Busbars) (ID) (GM), 132kV CB (Air Insulated Busbars) (OD) (GM), 132kV CB (Gas Insulated Busbars) (ID) (GM), 132kV CB (Gas Insulated Busbars) (OD) (GM).

The 132kV switchgear CBRM model was run to identify which assets required replacement. Specific site visits were taken to carry out a physical condition survey to confirm the condition and photos of conditions were taken. Checks were carried out in the DINS and NeDers systems to find out if there were any known type problems for the specific switchgear type.

We have aligned the delivery of the 132kV switchgear replacement programme to the NGET asset replacement works where applicable due to their system outage restrictions.
For 132kV, using the CBRM process, we have identified switchgear at Padiham GSP, Harker GSP (all breakers), Stanah GSP (a specific single breaker) and Peel BSP (all equipment) as requiring replacement.

The 132kV CBs intervention solutions were reviewed following the fast track decision and this has resulted in the reduction of number of CBs installed from 35 to 31. It was judged that whilst the reconfiguration at Peel switching station, with resultant additional CBs, would improve the security of supply to the customers in the Lytham and Blackpool areas it was not cost effective. Notwithstanding the saline environment at Peel, it was decided based on CBA that the solution will be 132kV AIS with associated disconnectors and earth switches. This solution will lead to higher inspection and maintenance costs but the CBA has shown that this is the most cost effective solution.

The intervention solutions for the other two sites at Harker and Padiham were also reviewed. At Harker due to space limitations on site the GIS solution was found to be most cost effective one. At Padiham, space limitations and fluvial flood risk resulted in a GIS solution being the most cost effective. Latest estimates on the costs of the flood alleviation works for the AIS substation are £3.5 million. A GIS solution would design the flood protection into the building at a fraction of this cost. A GIS solution therefore is by far the least cost solution on this site.

Refurbishment is based on historic expenditure on 132kV switchgear. This would traditionally cover CT changes, circuit breaker mechanism and bushing refurbishment.

The potential consequences of a failure at this level of the network results in us taking a considered view of the failure risk compared with other assets, especially due to the potential impact of an N-2 condition existing, which whilst we will be P2/6 compliant we may not be able to adequately restore customer supplies. As a result, the risk for this asset type will reduce significantly over RIIO-ED1; however this is largely due to the planned intervention at a small number of higher risk sites.

We have found limited opportunity to deploy refurbishment solutions as many of the 132kV types of plant which we are using are long out of manufacturer support and often quite bespoke in their design.

Heavily corroded marshalling kiosk at Peel

SF_6 Receiver showing corrosion at Peel

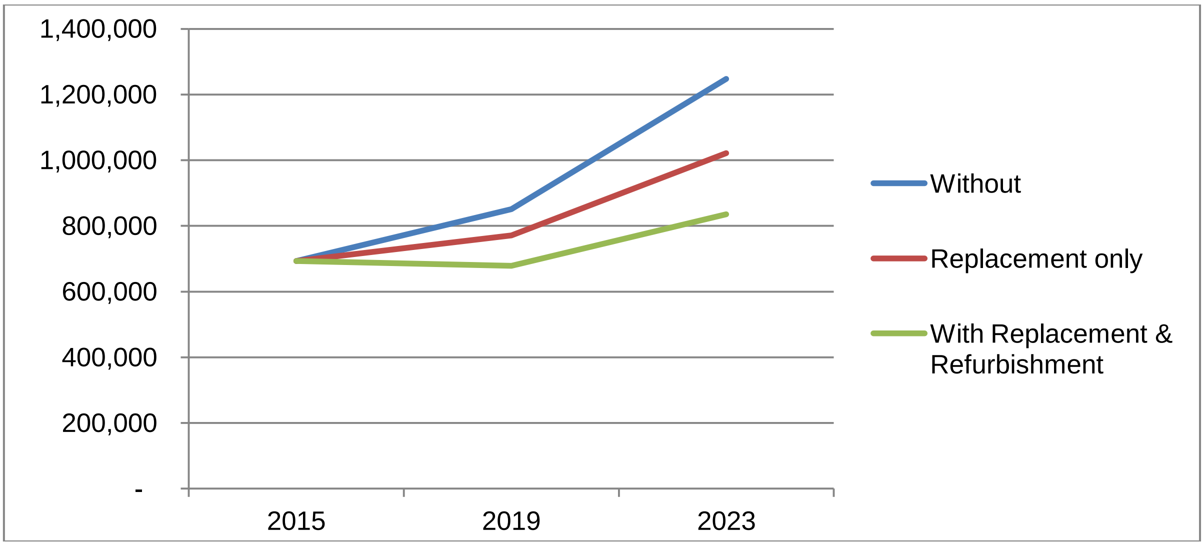
Corroded circuit breaker tank at Padiham

7.16 132kV Transformers

These units transform electricity from 132kV to 33kV where it is transported along EHV circuits to Primary substations.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
132kV Transformer	160	19	17	11%	11%	20.4	17.8

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
160	17	17.8	14	1.1	412,430	46



132kV transformers for intervention are identified through the Grid transformer CBRM model. This uses the data as described in the CBRM explanation at the beginning of this commentary to the CV3 table.

Our CBRM modelling showed a high percentage (29 of 160 or 18%) of Grid Transformer population requiring an intervention in RIIO-ED1 with an additional seven reaching HI5 in the first year of RIIO-ED2. This assessment is based on the as found condition of the units, their operating environment and duty, all of which have significant influence on their ability to perform in a satisfactory manner. The as-found condition includes current oil condition which allows the condition of the internal papers and core to be assessed

This volume assessment is generally in line with median rate for the RIIO-ED1 period. For RIIO-ED2 however, the increase is to some part related to the manner in which our modelling uses an exponential aging system which reflects the experience the industry has gained in over 100 years of existence.

The examination of our data has been carried out in the same manner as detailed in our commentary for our 33kV GM transformer population.

Our Grid transformers are assessed on a unit by unit basis to confirm what level of intervention is required for each unit. We have adopted this approach because the volume of assets is low and the capital cost of replacement is high when compared to other transformer assets.

The unit cost reflects exactly the scope that is required for each unit. The scope of the Grid Transformers to be replaced in RIIO-ED1 includes:

- a new transformer inclusive of cooling system, and as appropriate earthing/ Unit auxiliary transformer,
- new tap changer,
- replacement of 132kV busbar connections so as to marry to the new configuration of the replacement main transformer
- replacement of 33kV busbar connections again to marry to the existing cable connections
- new voltage regulation equipment and
- new transformer protection.

Where there is a need for changes to plinths, fire walls, the addition of bunding or other civil engineering activities the volumes and cost for these activities have been excluded from this table and can be found in table CV6 under the appropriate category for these activities.

It should be noted that in developing our HI for both 132 and 33kV units, the HI of a transformer is a weighted combination of the health index of transformer main tank and on-load tap changer. In determining the intervention required we take into account the following:

- Condition of the unit, both internal and external
- The predominant driver of the overall HI
- Our ability to refurbish against replace the unit
- The potential life extension the proposed intervention will produce
- The impact on the risk presented to the company post intervention and
- The cost benefit from the proposed solution.

In table CV3 we have represented our replacement volumes and costs and in table CV5 our refurbishment volumes and costs. A CBA was carried out to determine the split between replacement and refurbishment.

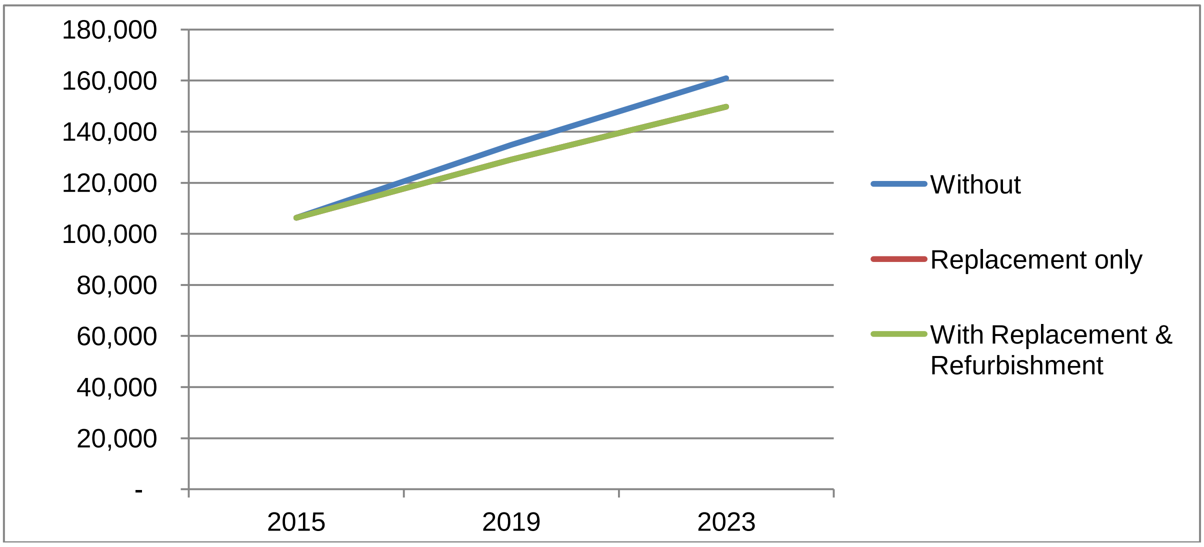
This intervention will result in a risk increase of 20% as it is not economically viable to replace all the transformers that would have reached end of life during RIIO ED1.

7.17 132kV UG Cable (oil)

These are 132kV cables that connect major substations and are insulated with mineral oil. These assets were generally installed in the 1950s and 1960s. When replaced, a modern cable of solid construction is used.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
132kV UG Cable (Oil)	161	0	0	0%	0%	2.2	0.0

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
161	12	0.0	8	0.6	11,160	51



This asset is managed together with the 33kV equivalent hence the comments set out there also apply to 132kV.

In RIIO-ED1, we have identified EHV cable lengths as being the priority hence the programme for 132kV is comparatively modest. Due to their more robust construction and generally more settled environments (mainly due to being laid more deeply in the ground), these assets generally perform better than their 33kV counterparts.

As a result, despite a programme of selective overlay and refurbishment, risk will rise by 40% over the period; however this should be viewed in the context of recent overlay programmes which have reduced the risk from its previous levels.

Fault information and laboratory reports of cable condition (post fault) are used to identify those cables in worst condition and in most need of intervention. This information is used in conjunction with an assessment of network risk and customer impact to develop the asset replacement programme.

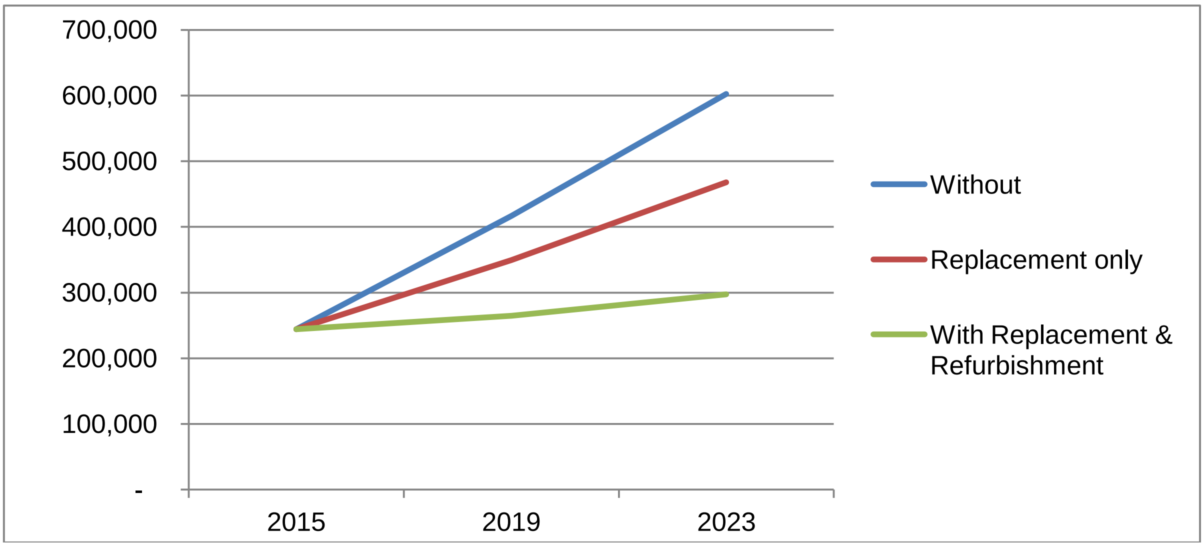
In conjunction with EA Technology, we reviewed our underground cable asset information, via an IFI project, and identified the areas where there is limited health condition information. EA Technology has also identified options to improve the cable asset data information via improved recording of fault information, sample testing, etc. Over the RIIO-ED1 period, we will be investigating ways of improving our knowledge about the performance and degradation behaviour of these assets.

7.18 132kV Towers

These are the large steel lattice towers which support conductors transmitting electricity between major substations at 132kV.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
132kV Tower	3,123	140	200	6%	1%	8.9	15.9

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
3,123	200	15.9	1,892	30.1	304,624	151



Steel lattice tower replacement numbers are based on safety and security data full condition survey data collected in 2012 and used to calculate asset Health Indices using the CBRM model.

The health index for our tower assets can be grouped to allow efficient delivery of interventions at;

- a component level eg insulators, conductor, tower; or
- a circuit level eg a number of towers.

This approach has been used to develop the programme of intervention which has been targeted at reducing probability of failure of individual towers and components. This consists of structures and components being replaced in their entirety where the tower or mast is at end of life and all the bars of the structure require replacement. In addition, the tower's fittings and fixtures are also replaced at this time. It is highly unusual for the entire line to be replaced and intervention is typically a mixture of replacement and refurbishment depending upon the severity of the deterioration. Interventions are usually initiated as a result of the overall line of towers being sufficiently deteriorated to warrant intervention. Replacement may occur when the tower is at HI=4 or 5 and asset refurbishment at HI=4.

The probability of a complete tower failure is extremely low hence the low starting level of risk. Many of our towers are in exposed conditions and hence it is vital to maintain appropriate painting and refurbishment regimes to ensure a long operating life.

We have identified a number of our 132kV tower circuits as being in need of refurbishment and this comprises the bulk of the investment programme on these assets in RIIO-ED1. Completion of this work will result in the overall risk increasing by 20% on its 2015 level through the period.

Our strategy incorporates Inspection and Maintenance in accordance with existing policies plus a planned CBRM targeted refurbishment programme matched to the varying life of the overhead line components. Additionally, targeted asset replacement is incorporated into the programme strategy also based on CBRM based condition monitoring of the 132kV tower assets. This strategy is planned to ensure that Tower failures will be minimised even during severe weather conditions, hence ensuring CIs and CMLs are not incurred due to deteriorated of the 132kV towers. The strategy is also aimed at ensuring that the risk of injury and/or fatality being caused to staff or members of the public due to tower failure is also minimised, even in severe weather conditions.

We have had an extensive programme of tower replacement over the last three regulatory periods. These can generally be characterised as a mix of tower, fittings and conductor replacements, coupled with a level of tower refurbishment, therefore all the volumes for our RIIO-ED1 submission need to be considered in the round, and table CV3 volumes and costs need to be read and modelled with table CV5 volumes and costs.

The CDC data enables us to study the available photographs of the towers to determine the number of towers which can either be replaced or refurbished. Our modelling and investigation shows that we have 430 towers with a Health Index of 5 that require replacement, however due to system limitations we are unable to achieve this volume of changes. This is because in studying our network we are unable to take the double circuit outages we require to change towers, in the most cost effective manner. It is possible to change towers by the use of temporary structures but this significantly increases the cost to the customer. Our preferred option is to use a refurbishment option as described in our commentary to table CV5.

Our volumes for the period are further influenced by the deterioration of the condition over the last period caused in part by previous patterns of painting and the highly corrosive atmosphere of the west coast due to prevailing winds and salt pollution. We anticipate that by the end of the RIIO-ED1 period we will have carried out the vast majority of tower changes required for the foreseeable future based on the condition of the remaining stock.

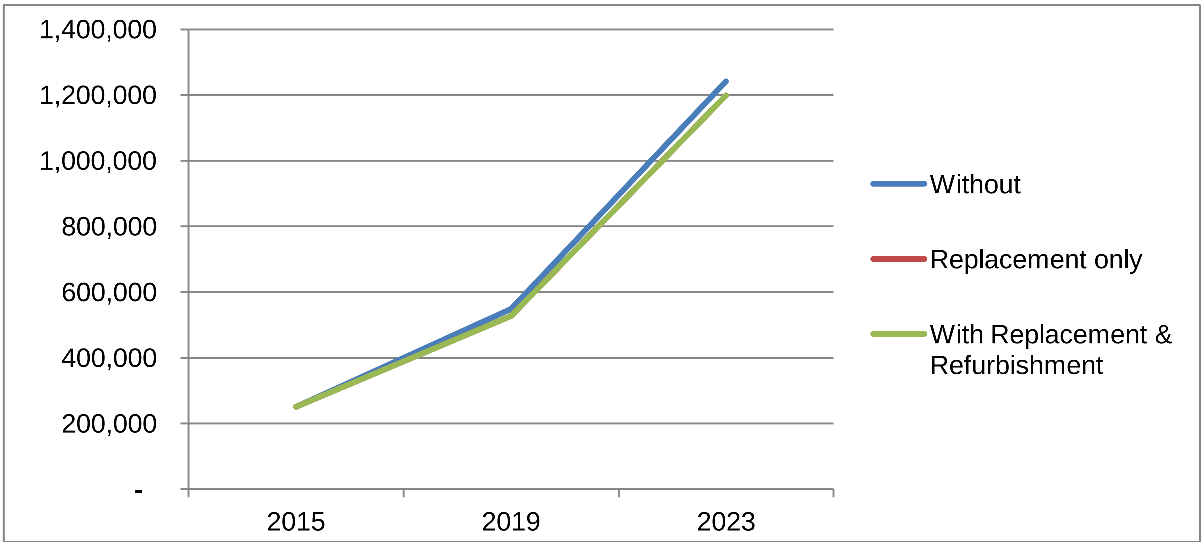
Another consideration which may change our tower replacement / refurbishment requirements is the application by NuGen to National Grid Electricity Transmission for the connection of a 3.6GW nuclear power station, at Moorside near Sellafield. To enable this connection National Grid will need to provide 4 x 400kV transmission circuits. At present, no firm commitments on the timing of the connection works or the route for the transmission circuits have been made.

7.19 132kV Fittings and Conductors

These are the conductors between towers which carry the electricity at 132kV and the fittings that attach the conductors to the towers.

		Volumes (additions)		Intervention Rate		Spend (£M)	
Asset type	**Asset register**	**DPCR5**	**RIIO-ED1**	**Planned**	**DNO median**	**DPCR5**	**RIIO-ED1**
132kV OHL (Tower Line) Conductor	1,595	128	90	6%	17%	9.9	7.0

Population	Planned disposals	£M	Planned refurbishments	£M	Risk points delivered	£/point
1,595	90	7.0			42,556	164



This is a composite category of conductors and fittings.

Where a tower is replaced, a full set of fittings are changed at the same time. Where fittings only are required these are installed as a separate job.

A failure of a conductor or fitting has a lower customer service consequence than a failure of the support itself and is relatively easily repaired without interruption to customers. As a result, ensuring the population of supports is in an appropriate state is the priority for the RIIO-ED1 period. Consideration has also been made of the possibility of significant conductor dismantlement as a result of supplies to the new nuclear power station at Moorside, such that significant re-stringing could result in abortive work. This approach will be kept under review during RIIO-ED1 when greater certainty over the Moorside proposals emerges.

During the DPCR5 period the Health and Safety Executive (HSE) served improvement notice on EDF (now UK Power Networks (UKPN)) following the failure of a number of 132kV insulator strings. As a result of this notice UKPN shared the information with other companies. We reviewed the requirements of the HSE and determined that we would follow suit with UKPN as the HSE made it very clear that this was a course of action they would expect and support. As a result of this, we have created a programme of fitting changes on suspension towers, where the problem has manifested itself in UKPN to mitigate any such issues. This policy is CP430.

As a result of this policy our volumes have been increased to include fittings which need to be changed as a result of routine asset replacement of towers and fittings as well as the conductor fall prevention policy. The basic scope of work in this part of the submission is to replace the insulation strings on both single and double, intermediate, section and terminating towers due to their condition.

The issue documented above only applies to the 132 kV system; we do not have a similar issue with our 33kV networks.

As a result, we are planning to proactively replace around 6% of the current fittings in RIIO-ED1 and this has the effect of reducing the risk from that which it would otherwise have been; however as the HI calculation is based on the length of conductor and we are not currently planning to proactively replace any conductor lengths in RIIO-ED1 following the completion of a re-stringing programme in DPCR5, the risk profile shows little reduction from investment over RIIO-ED1.