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Annex 17: RIIO-ED2 Network Asset Resilience Measures (NARMs)

NARMs is the method by which Ofgem will measure our compliance with the commitments we make to manage our assets through Replacement and Refurbishment. This annex details the basis of the NARMs measurements and how we have developed our proposed targets using the Common Network Asset Indices Methodology (CNAIM).

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1 Glossary

BPDT	Business Plan Data Template
C	A value used in the calculation of probability of failure within CNAIM
CBA	Cost Benefit Calculation
CNAIM	Common Network Asset Indices Methodology
CoF	Consequence of Failure
Delta	the degree of change between two values
DNO	Distribution Network Operator
DPCR5	Distribution Price Control Review 5
ED1	The Electricity Distribution regulatory period between April 2015 and March 2023
ED2	The Electricity Distribution regulatory period between April 2023 and March 2028
EDA	A software programme used for modelling asset condition
EHV	Extra High Voltage
EJP	Engineering Justification Paper
ESQCR	Electricity Safety, Quality and Continuity Regulations
GB	Great Britain
GM	Ground Mounted
HI	Health Index - A measure of probability of Failure
HV	High Voltage
LV	Low Voltage
LV UGB	Low Voltage underground box
NARM and NARMs	Network Asset Resilience Measure
NARM Incentive	An incentive set around the need to manage asset risk in RIIO - ED2
NASD	Network Asset Secondary Deliverable
OHL	Overhead Line
PCD	Price Control Deliverable
PoF	Probability of Failure
QA	Quality Assurance
RIIO	Regulation through Innovation, Incentive and Outputs
Risk Delta	The change in risk over a period of time as measured by CNAIM
RMU	Ring Main Unit
RRP	Regulatory Reporting Pack
WSP	Engineering consultants supporting our Business Plan development

2 Introduction

This annex outlines the development of the Common Network Asset Indices Methodology (CNAIM) and how we have implemented it in ENWL.

It discusses how the methodology is used to develop future risk projections and consequent investment forecasts to manage the future risk to a prescribed target level. These targets form part of the NARMs framework for ED2.

Finally, it sets out detail of the resulting proposed investment programme for ED2 and links to the relevant Engineering Justification Papers (EJPs) which provide further detail by individual asset type.

Based on customer and stakeholder feedback, our plan is to maintain overall network risk (as measured through CNAIM) at its current levels through delivering a balanced portfolio of asset renewal investment across our asset base in RIIO-ED2. We have calculated the expected deterioration of our equipment in RIIO-ED2 and identified the actions required to mitigate this, whilst taking account of the likely incidental benefits of our other investment proposals.

3 Executive Summary

Managing the underlying risk of our network is a key pillar of our overall reliability strategy. A reliable network forms the basis for satisfying customers' current and future demands for electricity and expectations on its availability.

When considering the work we need to undertake on our asset base during a price control period to manage this underlying risk, we need to consider not only the physical condition of the asset and the consequence of what would be the outcome for customers should it fail, but also customers' attitude to and appetite for risk. This is not always straightforward as managing underlying risk is less obviously customer-facing than many of our other outputs and services, however we have used different ways of exploring customer attitudes to risk as outlined in our main narrative and Annex 30 – Stakeholder and Customer Research Approach.

In this we have heard very strongly that customers want us to maintain if not improve the current risk levels of the network as they see base reliability as a fundamental requirement which will only increase with the Net Zero transition. We have sought to satisfy this through a well-judged, balanced portfolio of investment which will ensure this, both in aggregate terms and when considering each of our major equipment types.

To achieve our network risk targets, we gather information relating to both the health and criticality of all our inspectable assets. This information is known as the Network Asset Indices, and these provide an indication of the risk of condition-based failure of network assets.

For most of our asset types or classes, which includes our ground-mounted transformers & switchgear, together with wooden poles, steel towers and our oil- and gas-filled cables, the approach to undertaking this forecast of probability and consequence of failure is specified in the Common Network Asset Indices Methodology (CNAIM). This is a common and systematised approach to assessing asset risk that was established in the early part of RIIO-ED1 and approved by Ofgem. Fundamentally, it uses condition and other data to identify a Probability of Failure (PoF) for an individual asset, which can be combined with an assessment of Consequences of Failure (CoF) to create a total risk score. This score can then be projected through time using common deterioration assumptions within the methodology.

For ED2, this approach has been further developed in the CNAIM2 methodology such that the difference in lifetime risk resulting from an intervention such as replacement of equipment can be measured and compared to the cost of making the intervention to check that the overall benefits outweigh the costs. As part of this approach, we measure the impact of interventions using the metric of risk points, identifying the difference between the pre- and post-intervention risk.

In ED2, this approach to measuring asset risk is used in the Network Asset Resilience Measures (NARMs) framework where we identify:

1. our forecast risk start position in 2023;
2. what would happen to this risk level by 2028 if we did nothing; and
3. what our proposed 2028 outcome would be, and what volumes of work we are proposing to achieve this.

As noted in our Draft Business Plan, submitted in July 2021, we have discussed our approach in this area with customers and stakeholders and explored their attitude to underlying network health and risk more generally. The strong feedback that we received was that we should at least look to maintain

network risk at its current levels, given the increasing importance of electricity in the future with the Net Zero transition.

Our plan looks to achieve just that, through a balanced portfolio of investment in our different asset types. The cost of this plan is also reduced through our use of techniques such as refurbishment, a number of which are the direct result of previous innovation programmes. Our Innovation Delivery Plan (Annex 24) includes further details of proven innovation that we are deploying in ED2, eg oil regeneration of transformers.

In order to identify the appropriate mix of work, we have used our internal modelling tools supported by Cost Benefit Analysis (CBAs) of the different options by individual asset type. More details of this process are set out in this document.

Our overall NARMs proposal for RIIO-ED2 is summarised in the table below. This shows our NARMs target of £416.6m which, when combined with the assumed incidental risk benefits of other planned investment programmes enables us to maintain the overall network risk position across the RIIO-ED2 period. The total cost of delivery is £195.4m, equating to a rate of 47p per £ of lifetime risk benefit achieved, or a benefits ratio of 2.13.

£m lifetime risk points	ED2 opening position	ED2 close position without investment	ED2 close position with investment	NARMs risk points	Closing risk position vs opening
Overhead lines	582.3	786.9	665.9	-121.0	114%
Switchgear	541.9	661.9	541.5	-120.4	100%
Transformers	392.0	476.2	379.0	-97.2	97%
Cables	301.6	363.8	285.7	-78.0	95%
Total	**1,817.8**	**2,288.7**	**1,872.1**	**-416.6**	**103%**
Incidental benefits			-54.3		11.5%
Total risk reduction			-471.0		
Closing risk			**1,817.8**		**100%**

Figure 3-1 Summary of Asset Risk Movements for ED2

4 Application of CNAIM V2.1 and creation of NARMs submission

The NARMs framework has been introduced for the RIIO-ED2 period and replaces the Network Asset Secondary Deliverables (NASD) equivalent that was established for RIIO-ED1. Both the NARM and NASD incentives for the Electricity Distribution Network Operators (DNOs) relate to the measurement and management of asset risk and are based on the requirements of the Common Network Asset Indices Methodology (CNAIM).

4.1 CNAIM v2.1 principles

The principle of the framework is that for the asset register categories stated in the CNAIM methodology V2.1[1], each individual asset has a risk value. This is expressed as a Health Index ranging from 1 – 5. In addition, the consequence of the failure is assessed and expressed as a percentage of the national consequential average for that asset type and ranges from 1 – 4. The risk associated with any asset is expressed as:

Probability of Failure x Consequence of Failure

The asset volumes are expressed in a 5 x 4 matrix where each cell represents a fixed risk value expressed in £s and are therefore monetised.

The matrix can express a number of different values, including:

- The Value of Probability of Failure used in each cell;
- The number of assets assigned to the individual cell;
- The current year risk value assigned to that cell; and
- The Risk Index for long term risk assigned to the cell.

For each of the 61 asset types requiring reporting in the ED2 period, there is an associated risk matrix. In addition, the matrices can be used to show the anticipated future values and the planned movements as a result of the planned interventions within a period. A typical matrix showing the volumes of an asset as assigned within each cell of the matrix at a point in time is as follows;

LV OHL Support		HI 1	HI 2	HI 3	HI 4	HI 5	Totals
	C1						-
	C2	22,736	17,087	7,683	3,239	2,124	**52,869**
	C3	60	35	8	4	4	**111**
	C4						-
		22,796	**17,122**	**7,691**	**3,243**	**2,128**	**52,980**

Figure 4-1Typical 5x4 matrix showing volumes

On this, we can input the programme of interventions we propose to make in a period. This produces a matrix which shows the movements. A typical intervention matrix is as follows:

[1] https://www.ofgem.gov.uk/system/files/docs/2021/04/dno_common_network_asset_indices_methodology_v2.1_final_01-04-2021.pdf

LV OHL Support		HI 1	HI 2	HI 3	HI 4	HI 5	Totals
	C1						**0**
	C2	2,283			-530	-1,753	**0**
	C3	4		-2	-1	-1	**0**
	C4						**0**
		2,287	**0**	**-2**	**-531**	**-1,754**	**0**

Figure 4-2Typical 5x4 matrix showing asset movements due to intervention

This in turn then creates a further matrix which shows the asset distribution post completion of the work plan. The matrix below further illustrates this:

LV OHL Support		HI 1	HI 2	HI 3	HI 4	HI 5	Totals
	C1	-	-	-	-	-	**-**
	C2	25,019	17,087	7,683	2,709	371	**52,869**
	C3	64	35	6	3	3	**111**
	C4	-	-	-	-	-	**-**
		25,083	17,122	7,689	2,712	374	**52,980**

Figure 4-3 Typical 5x4 Matrix showing the resultant volumes of an asset

This process excludes the impact of deterioration between the start and the end of the regulatory period. Deterioration is discussed in section 5.1.

The change in asset risk can be calculated by multiplying the matrix by the risk index values both before and after the interventions to produce the anticipated change in risk prior to the work or the actual risk delta achieved post the completion of the work.

The Risk index for LV OHL Supports is shown below which sets out the monetised risk values for long term risk as defined in CNAIM V2 and expressed in £risk[2]. By multiplying out the volumes in each cell and the monetised risk values, the total value of risk for that asset category can be determined.

ASSET CATEGORY	**RISK INDEX - LONG TERM RISK (£)**					
		HI 1	**HI 2**	**HI 3**	**HI 4**	**HI 5**
LV OHL support	C1	257	1,136	2,297	3,484	4,967
	C2	367	1,623	3,282	4,977	7,096
	C3	550	2,434	4,923	7,466	10,643
	C4	917	4,057	8,205	12,444	17,739

Table 4-1 Long Term Risk Values from CNAIM V2.1

As the asset ages, its probability of failure increases as the asset moves from HI1 to HI5 in the matrix. The consequence of failure is dependent upon several factors which when combined provides an estimate of the overall impact of the failure. We assume for forecasting that these values do not change through time.

Once an asset reaches a high probability of failure, an intervention is typically planned, returning an asset to either a new life cycle for replacement or mid-life for refurbishment. Interventions may also

[2] This is essentially the discounted total future risk of the asset, given its current condition.

focus on reducing the consequences of failure. These actions move the asset within the 5x4 matrix and the difference in risk measured pre and post intervention is taken as a delta value.

We have proposed a mix of asset interventions to maintain our risk level as that at the end of the RIIO-ED1 period. To calculate the risk managed by the intervention programme, the sum of all the proposed interventions is calculated along with the value of risk had no work been carried out. The difference of the values is the delta due to the work carried out and these form our target for managing risk within the NARMs framework.

4.2 Modelling Overview

To comply with the NARMs framework requirements in the ED2 period it has been necessary to modify our CNAIM V1.1 models to calculate the risk of our assets using the updated CNAIM V2.1 approach. At the beginning of the RIIO ED1 period we adopted software from EA Technology to model the CNAIM requirement. We have since replaced that software with a different product, EDA by Arcadis Gen to run our modelling and other associated activities.

In order to create the values to complete the NARM requirements we have retained the CNAIM V1.1 modelling and built a revised Version 2.0 and then later updated this to Version 2.1 when the latter was published. In this way we can use a single data set to deliver both the ED1 annual reporting requirements and create the ED2 NARMs proposal.

The following flow diagram shows the principles of how we generate the outputs required to comply with the NARMs requirements and the use we put the data to.

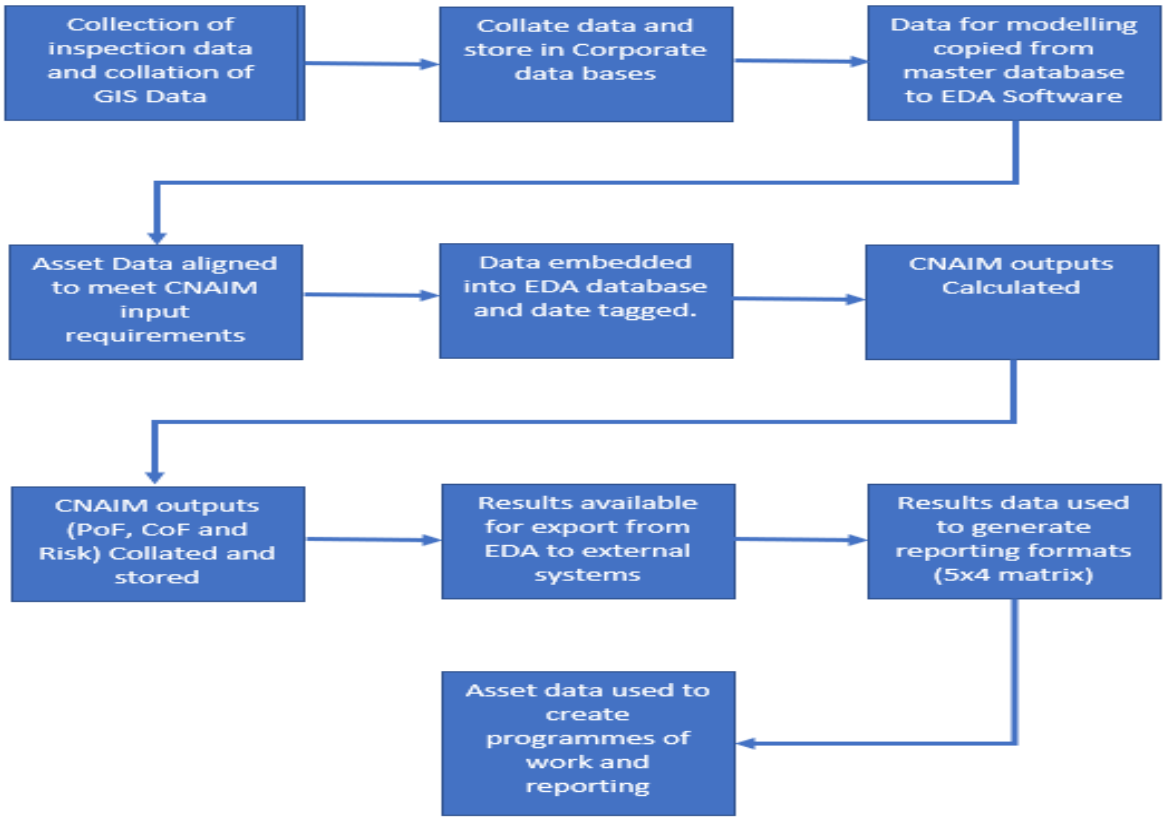

Figure 4-4 Asset Data to CNAIM output Flow Chart

4.3 Modelling Structure and NAIM Overview

In order to deliver the CNAIM requirements we have created our own detailed Network Asset Indices Methodology (NAIM). This sets out how we will collect the data, import it to the modelling software, convert it to the CNAIM inputs, and output the results so a programme of work can be developed and reported against. This process was originally developed in ED1 when we first adopted CNAIM.

On site data collection
The first stage of the process is to collect data from the assets. This is achieved through an inspection of the plant and recording the as-found condition by answering a series of questions aimed at consistent collection of the condition regardless of who carries out the inspection. Inspections are carried out by experienced staff with knowledge of the plant they are carrying out the inspection on. The data is collected on a handheld device and stored in the central asset registry.

Audits of the data take place to ensure the accuracy on a sample basis. The inspection data is specifically tagged as condition data collection and hence not confused with any other inspection data (eg for safety and security of the plant). We inspect our assets at different intervals but aim to carry out a data collection once every price control, although there are some exceptions (eg LV UGB).

Collation of Data for CNAIM Modelling
Condition data required for CNAIM modelling is held in our corporate asset register. We use a separate software package (EDA) to blend this condition data together with other data sources (eg locational data from our GIS system) to carry out the CNAIM calculations. Prior to any calculations being undertaken the required data needs to be loaded to the EDA software platform and formatted to the input values of CNAIM.

Stage 1 – Data
Data collection occurs on site and is aligned to questions which support the CNAIM methodology. These questions permit the data to be used to create the values required in that modelling. The data is then audited and loaded to our corporate database. This aligns so far as possible with the needs of the Good Practice Guide under development by the DNOs. Once published we will wholly align our inspections to the guide.

We then use written searches to collect the data from our corporate data sources, both for static data for assets such as transformers and linear data for cable and conductors. These are held in different systems. The data is held in a separate database in EDA. This records the base input data for every time we run the modelling.

The written searches have been quality assured. This has checked that the data in the corporate database has been properly copied into the EDA software platform consistently and without errors being introduced into it.

Stage 2 – Data Mapping
The raw data we retrieve from the corporate databases is either used directly in the CNAIM model (Asset identifier, age, location) whilst some is not necessarily suitable to directly put into the EDA model. This means that we need to either:

- Combine a number of inputs into one; or
- Apply weighting to the value to prevent it being overly strong when applied to the model.

Once this phase has been completed the modified raw data is used to determine the input value to be used in the CNAIM modelling. This determines which factor the data relates to and the modification factor to be applied. The effect of this stage of the process is to apply a data integration process to our data, therefore creating the input data.

Model Structure
Within CNAIM there are 25 Asset Category models which cover 61 Asset Register categories. When we adopted EDA as our modelling software we reviewed the structure of the 25 models and determined that we could replicate all 25 in five models using the advanced technology that EDA provided us over our original software product. The five models are:

- Switchgear;
- Transformers;
- Cables;
- Poles and Towers; and
- Conductors and Fittings.

Each model provides the results for all the outputs required by CNAIM and reporting in the ED2 requirements Ofgem specified in their Sector Specific Methodology Decision.

For the ED2 period we have been asked to report against all of the 61 Asset Register Categories that are required in the NARMs methodology, where we operate them. We have ensured that we can report as many as we operate as we have no assets operating at 66 and 20kV, also we don't have certain asset register categories in the HV and LV operating voltage ranges. We will therefore report against 30 of the 61 asset register categories.

Model Outputs
Each model outputs the values required to create an investment programme or report against it. It also provides the values to report against the targets we will be set in the period. Key to the output values for each asset is:

- The probability of failure;
- The consequence of failure;
- The current risk and the risk in any future year or years we require; and
- The Health Index and Criticality Index band both current and future.

From these values we produce the 5x4 matrices and a list of assets which could be considered for intervention. The outputs can be archived or left live for interrogation. Each set of model outputs is saved noting the data set used to create it and the version of the model used. In this way there is an audit trail back to source data etc.

4.4 Software Build and Assurance

Because we are the only DNO to use EDA currently in GB, we have assured our V2.1 model construction by engaging WSP to carry out a QA process on the model build. To achieve this, WSP built a parallel model based on published CNAIM formulae populated with a data set of input values to the model. We have then compared the outputs of both models.

This investigation showed that the two independently built models return identical outputs to the first four decimal places. Based on this assurance we have proceeded to produce the data needed to create our NARM submission.

4.5 Data

We have used the same data to create the NARM submission as we are using to report our ED1 progress. The input values for both the RRP and NARM reporting are the same and are mapped as described earlier in this document. The changes occur when the input values of the data are inputted to the two models. In order to create our NARM submission we have created the 5x4 matrices required to populate NARM tables NARM 2 and 3, we have also created the individual PoF, CoF and hence risk values for assets within the model.

For the ED2 period asset movements due to intervention will be reported as if the work has been carried out on 31 March 2028. The individual data for the assets has been created for this date as has the data for 31 March 2023 (FY23) to permit the end position of the ED1 period to be determined. The data used to create the submission has been taken from our corporate data systems in the week commencing 19 April 2021. We will preserve this data for a minimum duration of the ED2 period within our EDA database. This created data will allow us to understand the asset risk for individual assets which we have already identified as requiring intervention.

4.6 NARM Table completion

The completion of the NARM tables in the Business Plan Data Template creates the value for the risk delta associated with the NARM incentive. We have provided input to these tables for all assets which are in scope of the CNAIM Methodology where we operate assets. The three tables are:

- **NARM 1** – This is a lookup table of risk values created in V2.1. When CNAIM V2.0 was created it was identified that the adoption of Long-term risk meant that effectively the risk values were constant for all DNOs. This was not the case in the V1.1 methodology and for some asset groups the licensee had to calculate these base values. V2.0 and now V2.1 removes this need.

- **NARM 2** – This table requires the licensee using V2.1 to provide:
    - The end of year risk matrices by asset volume for FY21
    - The end of year risk matrices by asset volume for FY23, assuming no intervention and
    - The end of year risk matrices by asset volume including movements due to work predicted to be delivered in the period FY22 and 23.

  These tables show the level of asset planning to the end of ED1 stated in V2.1 "currency" and hence the third data set provided in BPDT, NARM 2 becomes the predicted start position for ED2.

  Because of the short timescales we have been able to identify the assets we will be intervening on and hence their pre-intervention values can be used to inform the outcome of the intervention. This is particularly important for refurbishment work where an asset does not automatically become a HI1 value.

- **NARM 3** – This table records the predicted movements due to our proposed programme of work in the ED2 period. The end of ED1 matrix values become the start of ED2 values. We have provided the numbers of additions and disposals due to asset replacement using the FY28 data and also the pre and post refurbishment values. We have not included any Asset Replacement High Value Projects (HVPs) in our baseline submission hence the associated elements of the NARM3 table have been left blank.

Limitations of Programme Development – 132kV and EHV assets
In developing our programme of work covered by the NARMs framework, these assets being generally of high value and relatively low volume, we have been able to identify the specific assets we will intervene on in the period. The exact year of the intervention may alter from our plan but as the asset benefits are reported for the last day of the period this is not anticipated to be an issue. We do not anticipate any limitations in developing this part of the NARMs submission.

Limitations of Programme Development – LV and HV assets
Unlike the 132kV and EHV assets, the volume of LV & HV assets to be worked on in the ED2 period is much higher. The planning cycle for these assets is also much shorter. The programme is often influenced by on site reports on condition that are not necessarily modelled in CNAIM. The result of this is that we cannot always identify the specific plant items we will work on many years in advance, but model relevant overall volumes of work that for the basis of our plan.

For 11 or 6.6kV primary substation switchboards we treat these as we do our 132kV and EHV assets, so an accurate number of interventions can be represented in the NARM 3 table given our plan today.

Consequential Asset Interventions
In an ideal plan, only those assets with a high value of risk will become subject of an intervention. There are some locations however where this is not always possible to achieve. The drivers for this will be issues such as:

1. Plant design;
2. Plant position within a building;
3. More cost effective to replace multiple assets although not all have a high-risk value; and
4. Replacements using a single asset (RMU) which results in an asset with a lower risk value being changed.

In determining the assets to be worked on we will show in some categories that we are working on lower risk assets. This will more accurately represent the risk reductions we will carry out.

5 Converting CNAIM into an investment forecast

The main aim of the replacement and refurbishment programme is to manage the underlying lifetime risk of the network. This is achieved by intervening on equipment when it is higher risk but before it fails. As equipment deteriorates over time, its risk of failing starts to increase and if it does fail, the consequences can be significant and costly. Judging when to intervene and in what way is a key asset management challenge and one where we have developed sophisticated analytic techniques to assist.

CNAIM covers the vast majority of our above ground equipment including switchgear, circuit breakers and transformers at substations of all voltages; supports for overhead lines (wood poles or steel towers) and the lines themselves at all voltages; underground cables with assisted or pressurised insulation (either gas or oil).

The overall level of investment in ED2 depends on four key assumptions:

- the desired overall risk level to be achieved;
- the assumed incidental impact of other work;
- the balance of interventions across different equipment types; and
- how targeted the programme can be in terms of identifying the very highest risk equipment for priority attention.

5.1 Asset Deterioration

As an asset ages, its condition will deteriorate due to exposure to its environment and the manner in which it is operated. CNAIM modelling takes this into account by the application of a series of deterioration assumptions which are calibrated to represent the average anticipated deterioration the asset will experience in any given year. These deterioration rates vary depending upon the type of material the asset is constructed of and its location. For example, steel cases in an outdoor environment will deteriorate faster than in an indoor environment unless precautions such as paint coverings are applied and maintained.

If no interventions occur on an asset type there will be overall deterioration and an increase in total risk. This is illustrated below in the matrices.

The first matrix shows the condition of the assets at the start of a five-year price control period.

6.6/11kV Transformer (GM) Yr0		HI1	HI2	HI3	HI4	HI5	Totals
	C1	1,386	438	108	151	90	**2,173**
	C2	6,835	3,974	508	711	385	**12,413**
	C3	969	660	101	217	69	**2,016**
	C4	39	12	6	26	3	**86**
		9,229	**5,084**	**723**	**1,105**	**547**	**16,688**

Table 5-1 Asset Condition Distribution in a CNAIM 5x4 Matrix at the Start of ED2

If there is no expenditure on the asset group, then the asset volumes will deteriorate (move from left to right within the matrix) and at the end of the period the matrix will be as follows;

6.6/11kV Transformer (GM) Yr5		HI1	HI2	HI3	HI4	HI5	Totals
	C1	1263	465	111	173	161	**2,173**
	C2	6,344	3,847	713	781	728	**12,413**
	C3	903	592	156	196	169	**2,016**
	C4	34	11	6	18	17	**86**
		8,544	**4,915**	**986**	**1,168**	**1,075**	**16,688**

Table 5-2 Asset Condition Distribution in a CNAIM Matrix at the end of ED2 with on expenditure

The difference between the start and finish points is the deterioration (ie assets moving from lower to higher Health Indices over time). The model calculates the deterioration on an asset-by-asset basis, by predicting the potential Probability of Failure for each future year. The model assumes that the Consequence of Failure is constant throughout the life of the asset.

6.6/11kV Transformer (GM) Deterioration		HI1	HI2	HI3	HI4	HI5	Totals
	C1	-123	27	3	22	71	**0**
	C2	-491	-127	205	70	343	**0**
	C3	-66	-68	55	-21	100	**0**
	C4	-5	-1	0	-8	14	**0**
		-685	**-169**	**263**	**63**	**528**	**0**

Table 5-3 Deterioration of assets in the Ed2 period in a 5x4 Matrix

When considering the volume of assets which need to have an intervention applied to them, the impact of deterioration is factored into the investment decisions.

5.2 Programme Optimisation

By using optimisation techniques, we can deliver a set target by flexing the number of any specific assets within the plan using the following inputs:

- Cost of delivery;
- Cost of risk reduction (£/risk point removed);
- Minimum volumes; and
- Any specific assets which are judged as mandatory requirements.

By using these techniques, we seek to deliver more for less, therefore targeting assets which are poorly performing in each asset register category whilst reducing investment in areas where the benefits are lower. This approach means for example that stable overall asset risk does not necessarily mean stable risk for all asset types – it may be more effective to tolerate deterioration in some whilst making material improvements in others to balance overall total risk. With optimisation we seek to deliver the best portfolio of interventions and minimise any impact on customer bills.

We have optimised our investment forecast to ensure the most efficient delivery against the risk target. This optimisation involves three aspects:

- reviewing the balance of investments across asset types;
- re-evaluating the refurbishment vs replacement trade-offs by asset type; and
- ensuring optimal targeting at the highest risk examples of each asset category.

As the network risk is a sum of the risks for all the individual equipment types, it could be possible to manage overall risk by significantly over-investing in one type of equipment and completely ignoring another such that its rate of failures begins to increase significantly. This might achieve short-term objectives but would result in longer-term issues.

Based on customer and stakeholder feedback, our plan aims to deliver a level of lifetime risk in 2028 at the same level as 2023, taking into account the expected incidental impacts on risk of our other proposed programmes (which may also replace poorer-condition assets). As a consequence, we have developed a balanced programme which seeks to deliver stable underlying risk levels at an efficient cost.

This programme also takes into account the incidental benefits in terms of lifetime risk that are made by other programmes which have other outcomes as their key driver. For example, replacing a transformer with a larger example to satisfy load demands has the incidental benefit of removing a higher risk (older) asset from the system and replacing it with a lower (newer) one.

In RIIO-ED1, these incidental benefits account for 11.3% of the total reduction in network risk resulting from our investment programmes. As much of our totex increase in RIIO-ED2 relates either to the first-time installation of new equipment, or assets not within the NARMs framework (eg LV services, pole-mounted planet etc.), we assume that this level of incidental benefit contribution will continue in RIIO-ED2.

As a consequence, the NARMs programme is aimed at achieving the remaining 88.5% required risk reduction to ensure we mitigate the forecast deterioration and maintain risk at its start of ED2 levels.

The table below sets out the starting positions, forecast deterioration and planned intervention impacts in RIIO-ED2 by major equipment type;

£m lifetime risk points	ED2 opening position	ED2 close position without investment	ED2 close position with investment	NARMs risk points	Closing risk position vs opening
Overhead lines	582.3	786.9	665.9	-121.0	114%
Switchgear	541.9	661.9	541.5	-120.4	100%
Transformers	392.0	476.2	379.0	-97.2	97%
Cables	301.6	363.8	285.7	-78.0	95%
Total	**1,817.8**	**2,288.7**	**1,872.1**	**-416.6**	**103%**
Incidental benefits			-54.3		11.5%
Total risk reduction			-471.0		
Closing risk			**1,817.8**		**100%**

Table 5-4Summary of Asset Risk Movements in ED2

The overall contributions of the major asset groupings to the three different risk positions is represented on the graph below. This shows that the NARMs programme mitigates the majority of the deterioration, with the balance being made up by the forecast incidental benefits of other investment programmes:

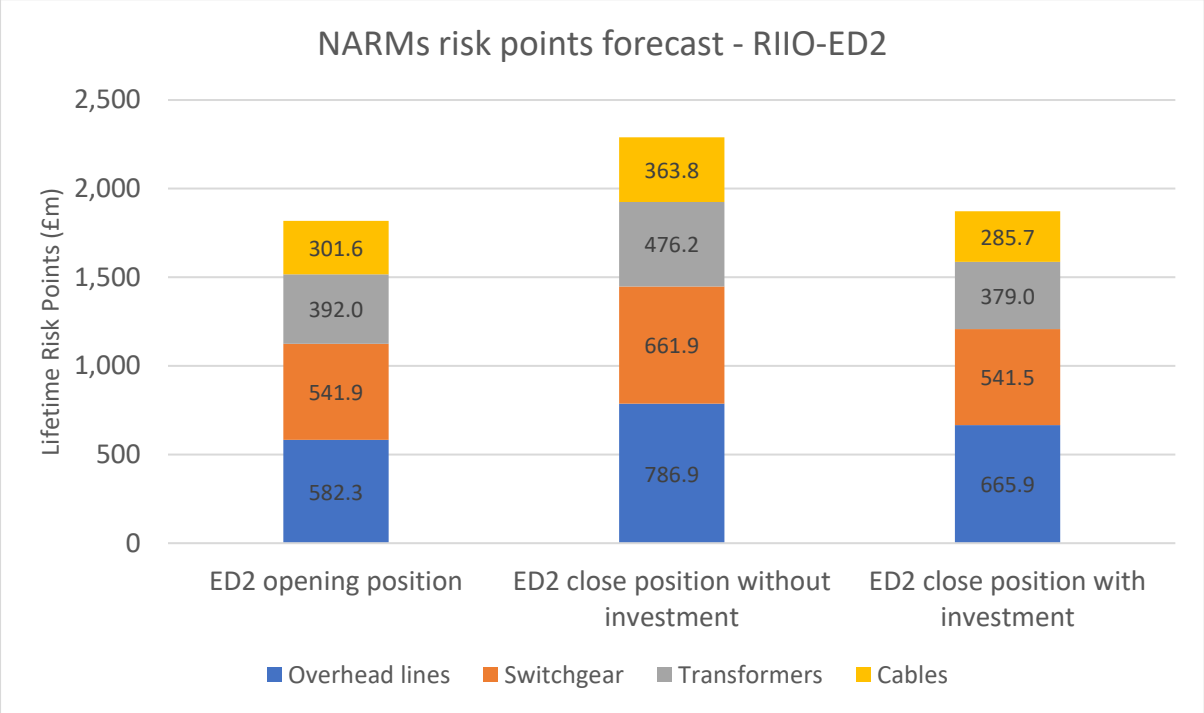

Figure 5-1Summary of Lifetime risk in RIIO-ED2

The position by major asset group is as shown below, revealing that some show overall improvement whereas others show net deterioration within our programme to maintain overall network risk. As noted earlier, tolerating these variances allows us to deliver the goal of stable risk at lower cost than a programme which rigidly maintains each asset group at constant risk, without considering the trade-offs between categories:

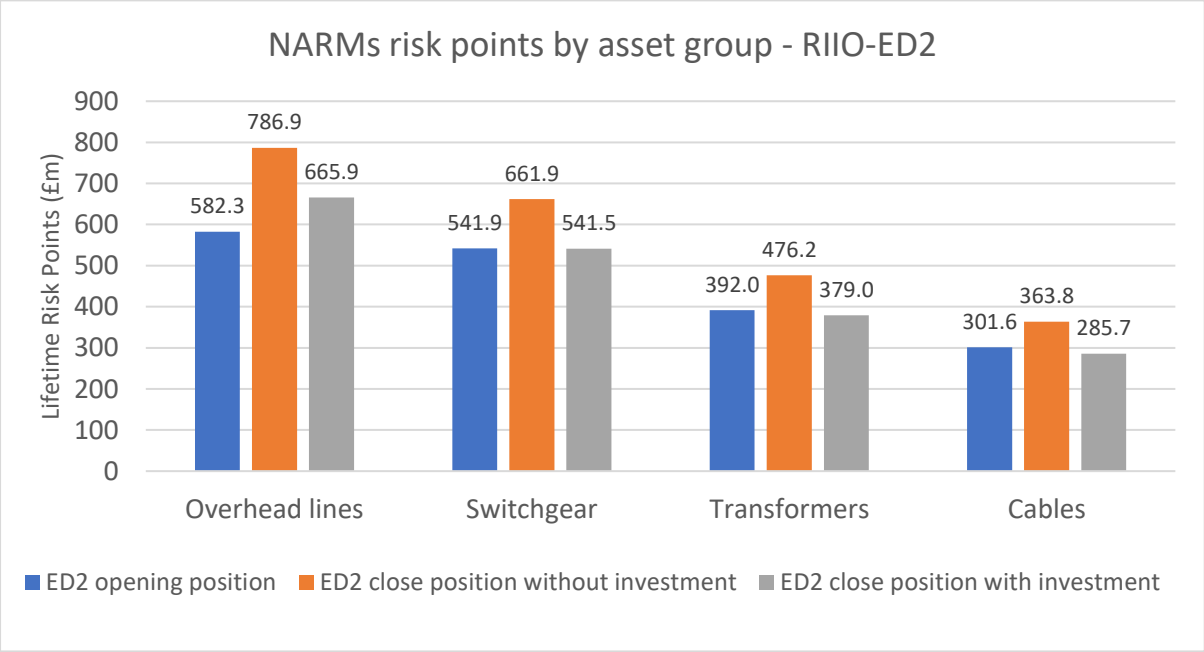

Figure 5-2Summary of Lifetime risk by asset group in RIIO-ED2

Of note is that the closing risk for overhead lines is higher than the start, whereas the other major categories show stability or a slight reduction. This is a function of two considerations;

1. The opening position for overhead lines is relatively low compared to its historic position due to a number of significant investment programmes on these assets in DPCR5 and RIIO-ED1, eg ESQCR clearance rectification; and
2. The incidental impacts on overhead lines are generally higher than the other categories due to the number of other overhead-line focused programmes in RIIO-ED2.

The result is that we are satisfied that allowing the overall risk of the overhead line population to increase over the period allows us to develop a more balanced investment programme. The resulting outcome in terms of investment by major equipment type is as follows:

Asset Class	Asset Register Category	Replacement	Refurbishment	Total	Asset Class Total
Cable	33kV UG Cable (Non-Pressurised)	16.0		16.0	30.9
	132kV UG Cable (Non-Pressurised)	14.9		14.9	
Overhead Pole Line	LV Poles	11.4		11.4	22.7
	6.6/11kV Poles	9.4		9.4	
	33kV Pole	1.8		1.8	
Overhead Tower Line	33kV OHL (Tower line) Conductor	0.6		0.6	28.1
	33kV Tower	0.7	2.6	3.2	
	33kV Fittings	0.9		0.9	
	132kV OHL (Tower Line) Conductor	9.7		9.7	
	132kV Tower	4.6	7.9	12.5	
	132kV Fittings	1.2		1.2	
LV Switchgear	LV Pillar (ID)	1.2		1.2	13.2
	LV Pillar (OD at Substation)	1.6		1.6	
	LV Pillar (OD not at a Substation)	0.0		0.0	
	LV Board (WM)	1.1		1.1	
	LV UGB	9.3		9.3	
HV Primary Switchgear	6.6/11kV CB (GM) Primary	11.3	2.9	14.2	14.2
HV Distribution Switchgear	6.6/11kV CB (GM) Secondary	3.7	0.1	3.8	23.9
	6.6/11kV Switch (GM)	5.0	0.4	5.4	
	6.6/11kV RMU	6.2	8.6	14.8	
EHV Switchgear	33kV CB (Gas Insulated Busbars) (ID) (GM)	9.2		9.2	9.2
132kV Switchgear	132kV CB (Air Insulated Busbars) (OD) (GM)	1.5		1.5	5.1
	132kV CB (Gas Insulated Busbars) (ID) (GM)	3.6		3.6	
HV Transformer	6.6/11kV Transformer (GM)	7.3		7.3	7.3
EHV Transformer	33kV Transformer (GM)	14.6	5.9	20.5	20.5
132kV Transformer	132kV Transformer (GM)	18.9	1.3	20.2	20.2
	TOTAL	**165.8**	**29.6**	**195.4**	

Table 5-5 Summary of Expenditure Proposed by Asset Register Category for Replacement or Refurbishment in ED2

In summary, the expenditure and risk points by major asset category are as follows:

Asset category	Risk points (£m)	Expenditure (£m)	(£/point)
Transformers	97.2	48.0	0.49
Switchgear	120.4	65.6	0.55
Overhead Lines	121.0	50.8	0.42
Underground Cables	78.0	30.9	0.40
NARMs total	**416.6**	**195.4**	**0.47**

Table 5-6 Summary of Proposed Expenditure by Asset Category, Risk Points achieved and Cost per Risk Point mitigated.

Following this slight adjustment to the relative position of the overhead line asset population, the balance of risk across the entire asset base is likely to be in a broadly sustainable state at the end of ED2 and will place us in a good position to maintain and manage the risk across each asset category in ED3 and ED4.

5.3 Pricing of the programme

As set out in Annex 20, the unit costs used in our submission are largely based on our experience over the first six years of ED1, benchmarked against the performance of the thirteen other DNOs.

Additional unit cost assumptions have been included associated with EU Ecodesign Transformers and the removal of SF_6 options from newly-installed switchgear.

The refurbishment element of this plan largely reflects the continuation of programmes at their current rates including oil regeneration in transformers, tower painting, switchgear refurbishment and oil cable joint renewals. These options have all been individually modelled and shown to generate better risk reduction per £ than replacement where they are applicable.

6 PCD proposal

Delivering the risk points reduction under the NARMs framework is one of the most significant and material outputs within our RIIO-ED2 Business Plan, as it forms the bedrock of our long-term reliability strategy.

As a key output, Ofgem have considered the most appropriate output mechanism for the treatment of NARMs in RIIO-ED2 and concluded that it forms one of a limited number of Common Price Control Deliverables (PCDs)[3]. The key aim of a PCD is to set out the outcomes or other conditions that apply to the associated totex allowances, and also the redress arrangements that operate should the output not be delivered.

For NARMs, the output delivery is measured through lifetime risk points as calculated through CNAIM v2.1. This has the advantage of being a common, consistent approach across all DNOs, enabling comparability. We are conscious however, that the NARMs programme is a significant element of the overall RIIO-ED2 forecast, and that trade-offs can be made in terms of the balance of the investment programme versus short-term optimisation for lowest cost risk points.

As set out in this document, we have looked to strike the appropriate balance between continuing to invest across our different equipment types and seeking an efficient outcome in terms of the overall cost to customers of maintaining network risk.

In order to mitigate against the potential risk of windfall gains that could be achieved if the NARMs PCD was constructed solely on the single high-level risk points target[4], we propose that the PCD includes subsidiary targets for the four major asset groups identified (Transformers, Switchgear, Overhead lines and Underground cables) with a minimum percentage achievement set. Failure to achieve these minimum levels would attract a pro-rated clawback of allowances, even in the circumstance of the overall target having been met.

This approach would give protection against windfall gains to customers, but also retain the incentive for DNOs to develop and continue to innovate their asset interventions in RIIO-ED2 to deliver at lower cost. A potential framework for this PCD is set out below;

[3] https://www.ofgem.gov.uk/sites/default/files/docs/2020/12/riio_ed2_ssmd_annex_1_delivering_value_for_money_services_for_customers.pdf, p6 & Chapter 8

[4] Which in theory would allow a DNO to deliver a completely different mix of work from that proposed; one solely focused on achieving the short-term risk points at the lowest possible cost.

Overall target	Sub-targets	Consequence
Exceeded	Met or Exceeded	Potential cost recovery of over-delivery
Exceeded	Not met	Potential cost recovery but offsetting clawback for under-delivery against sub-target
Met	Met or Exceeded	No adjustment
Met	Not met	Individual clawback rates apply
Not met	Met or Exceeded	Overall clawback rate applies
Not met	Not met	Overall clawback rate applies

Table 6-1Illustration of the structure of the PCD Proposal

We look forward to discussing the design of this mechanism further with Ofgem.

7 EJP references

In our submission, we have included supplementary Engineering Justification Papers (EJPs) which give further detail on each of these equipment types and the proposed programmes to deliver the appropriate level of risk reduction.

In supporting our NARMs submission with EJPs we have written two categories, one to support a programme of works, such as LV Switchgear where numerous small interventions add up to a material programme, and another for high cost (>£2m) individual projects. The relevant EJPs, and the value of expenditure in each is as follows;

Asset Class	EJP Reference	Scope	NARM Asset Value (£m)
Cable	NARM EJP 7	Intervention strategy for EHV and 132 kV cables	30.9
	PRO EJP 4	A project-specific EHV cable replacement project in Lancaster, where multiple solutions have been tested and will cost more than £2m.	
	PRO EJP 8	A project-specific cable replacement project in East Manchester, where multiple solutions have been tested and will cost more than £2m.	
	PRO EJP 10	A project-specific cable replacement project in Western Salford, where multiple solutions have been tested and will cost more than £2m.	
	PRO EJP 11	Reconfiguration of three EHV tower lines by placing the circuits underground to resolve a number of issues associated with access and development in the Huncoat area of east Lancashire	
Overhead Pole Line	NARM EJP 4	Intervention strategy for woodpoles and associated fittings and conductor, includes some non NARM assets	22.7
Overhead Tower Line	NARM EJP 5	Intervention strategy for EHV and 132kV towers and associated fittings and conductor, al assets are NARM related	28.1
	PRO EJP 5	A project-specific overhead line 132kV (Tower, Fittings and Conductor) in south Cumbria, needing asset intervention in the ED2 period.	
	PRO EJP 6	A project-specific overhead line 132kV (Tower, Fittings and Conductor) in south Cumbria, needing asset intervention in the ED2 period.	
LV Switchgear (GM)	NARM EJP 2	Intervention strategies for all LV switchgear assets	13.2

Asset Class	EJP Reference	Scope	NARM Asset Value (£m)
HV Primary and Distribution (GM) Switchgear	NARM 2A	Intervention strategies for all HV switchgear assets	38.1
EHV Switchgear (GM)	NARM EJP 3	Intervention strategies for all EHV switchgear assets	9.2
Transformers (GM) - All voltages	NARM EJP 1	Intervention strategies for 132kV, EHV and distribution ground mounted transformers	48.0
		Total[5]	**195.4**

Table 7-1 Summary of Asset Classes and Engineering Justification Papers supporting the Proposed Expenditure

5 We have not written a paper to cover the replacement planned for 2 x 132kV CBs at a value of £1.5m due to it not meeting Ofgem's criteria hence EJPs cover 99% of the NARM submission assets. Additionally, our proposal to replant the 132kV Switchboard at South Manchester due to condition is now the subject of an uncertainty mechanism proposal and is therefore outside our NARMs proposal.

Appendix 1 - CNAIM Development in DPCR5 and RIIO-ED1

CNAIM was developed jointly by the six DNOs and Ofgem, together with assistance of EA Technology. The principle of the model is to;

1. identify the potential age at which an asset can be considered as giving potentially a poor performance which will compromise network performance and hence deliver an inadequate customer service;
2. Identify factors, either measured, observed or reliability related, that influence an asset being at an end of life condition such as oil condition in a transformer or rust levels on exterior metalwork on metal clad plant; and
3. Factors that impact the consequence of failure calculation such as finance (cost of replacement), environmental issues such as waste disposal, safety related issues such as a propensity to cause injury at the time of a failure and the performance of the network due to interruption to supplies or reduction in network resilience for the time of the fault.

By combining these measures, we can calculate an estimate of risk either as an instantaneous value or as a long-term (whole life) value.

Distribution Price Control Review 5 (2010-2015)

The DNOs and Ofgem have been measuring asset condition and latterly risk since the beginning of the Distribution Price Control Review period five. At this time there was no common method of measuring risk, although four of the six DNOs had adopted the EA Technology product known as Condition Based Risk Management (CBRM), the main use of the model was to measure the probability of failure only. The CBRM product was tailored to the needs of the individual company and used their values to calibrate it. The two remaining companies that had not adopted a formal method of measuring either the probability of failure or the associated consequence used other techniques.

Ofgem sought a measure to ensure that allowances associated with Asset Replacement and Refurbishment were used to deliver these activities. They also saw the measure to compare the relative performances between the DNOs. To do a simple 5x1 matrix system was devised.

The system relied on a spread of Health Index (HI) of 1 to 5, compared to the CBRM HI spread of 1 - 10. This required the DNOs to convert their HI to the Ofgem system. For each HI a value was assigned where the HI5 was 100 and HI1 1. When an asset had an intervention, the new HI was calculated and an improvement of the Pre-intervention less the post intervention was calculated. An asset replacement of a HI5 asset to HI1 generated 99 points.

To rationalise this across the diverse range of assets under the CBRM banner the HI score movement was multiplied by a value to represent the cost of the intervention which was set by Ofgem. The sum of all interventions was a measure of the activity in these areas and the targeting of the poorest performing assets.

Towards the end of the DPCR5 period it became apparent that the system did not deliver the required outputs because:

1. There was no consistent model to derive the DNO values of HI
2. Only four of six DNO Groups used the CBRM model, the other two using non-mathematical techniques
3. Extensive use of engineering judgement was being used

4. The conversion of the DNO HI to the Ofgem 1 – 5 scale was at the sole discretion of the DNO
5. The boundaries between the DNO HI bands was set in a DNO specific way introducing a unique number for each model
6. The derivation of the PoF values was DNO specific hence each model was calibrated differently
7. The assets covered by the model varied from DNO to DNO and hence not every asset was being reported
8. Condition modification data from inspections varied from Company to Company so no consistent method existed.

Additionally, whilst a rudimentary method of calculating the Consequence of Failure values had been devised it had not been widely deployed by the Companies and neither were the values required in the reporting, although these would permit the evaluation of asset risk due to condition and not just condition, a far better way of monitoring the network.

Prior to the commencement of the RIIO1 period a high-level methodology for the determination of risk was agreed and used to complete the RIIO-ED1 submission. This submission was therefore made using a 5x4 matrix rather than 1x5, but the systematic failings identified above continued, plus a range of similar issues existed when the DNOs calculated their Consequence of failure values. The outcome of these issues was that there was no consistence of submitted data across the licences and this made direct comparison of performance impossible.

Ofgem determined that a common system of modelling was required and directed its creation.

RIIO-ED1 Creation of the Common Network Asset Indices Methodology

The need to create a mechanism to measure the benefits and effectiveness of the condition asset intervention plan had been recognised as a need in the RIIO1 period as more and more organisations had built systems to better understand the risks associated with their assets due to condition. This was made a licence condition for all sectors.

For the Distribution sector a working party was established to create a methodology to calculate and record the asset condition, consequences and hence risk assets present. The methodology would need to be agreed by all participants and address the issues identified in the DPCR5 period that was causing the inability to report on a single platform.

For the RIIO-ED1 price control submission an incentive was introduced to encourage Companies to meet commitments made in their submission as to the delivery of condition related asset interventions. Prior to the Final Determination each licensee submitted a table of proposed intervention and their pre and post asset risks based on the modelling in use at the time. As part of Ofgem's direction within RIIO-ED1 standard licence condition 51 to establish a common method of reporting an asset's condition these asset risks were to be recalculated and as a result of this work the asset risk submitted pre Final Determination submitted, hence a restatement of the proposed asset risk reduction in the ED1 period.

The DNOs agreed that the CBRM methodology was a base model that could be adapted to provide the common model. The creator of the model, EA Technology was invited to participate in the working group.

To create a common model based on CBRM, several issues needed to be overcome and associated revisions to individual methodologies would be required, these included:

1. Agreement from EA Technology to base the model on their product;

2. Agree a GB view on:
    a. Assets to be included in the scope of the model
    b. Expected life of assets and their sub-groups
    c. A value for the probability of failure of the "average" asset within the scope
    d. Define the Functional Failure modes
    e. Establish the range of the Health Index and Criticality Bands
    f. Variations to the base methodology for specific assets
    g. PoF modification questions sets and values
    h. Reference Cost of failure for the consequence of failure calculations

By agreeing these issues and aligning the CBRM methodology with them it would be possible to create a common methodology which would permit all participants to report the assets within the scope in a common manner.

Whilst most of the issues identified are associated with the calibration of the model the one area that required DNOs to make decisions is that of aligning their inspection policies to the PoF modification question.

Each DNO has developed its own asset inspection regime and frequency. They collect a range of data associated with the asset condition as well as non-condition aspects, such as the safety and security of the site. There are two types of inspection Observed and Measured data, both asset data types can be used to influence the value of the PoF and hence the Health Index of the asset. There is a disconnect between the data collected by the DNO and the input values to the model, therefore the DNO needed to relate its available data to the input questions. In addition, there was a need to apply weightings to the potential multiple data inputs making up one modification value for the CNAIM model.

The combination of the initial health score created from the age, environment and location creates an initial value of the health of the asset. Then modifiers are applied to create a Health Score (valued 1 – 10 for the current year). Table 1 shows how these values are converted to the HI used in the methodology.

Health Index Band	Health Index Banding Criteria	
	Lower Limit of Health Score	Upper Limit of Health Score
HI1	≥0.5	<4
HI2	≥4	<5.5
HI3	≥5.5	<6.5
HI4	≥6.5	<8
HI5	≥8	≤15

Table 0-1 Relationship between Health Index and Health Score Banding

The condition of the asset follows a mathematical curve that approximates to an exponential, over time and more appropriately a reliability "bath tub" curve. However, in earlier years an asset follows the flat portion of the bath tub curve. This makes the value of the assets probability of failure in early years more appropriate given the deterioration observed over time. The graph in figure 1 illustrates the HI banding against the PoF. The shape of the curve is dependent upon the individual asset and the way it deteriorates over time.

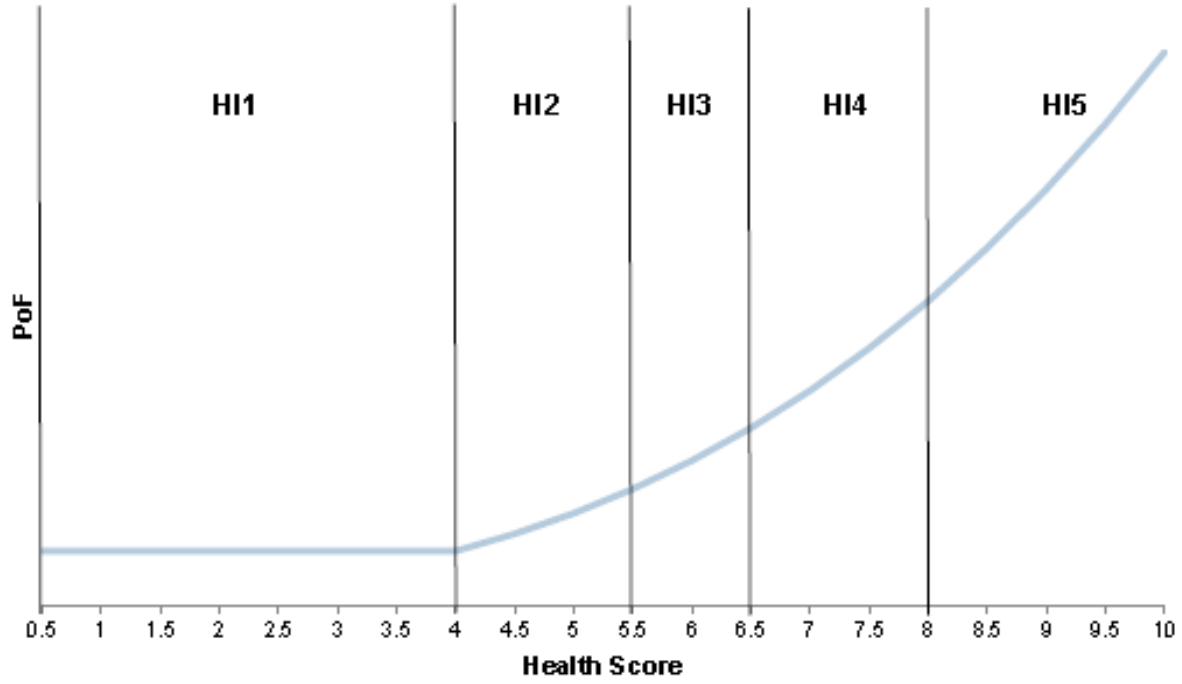

Figure 0-1 Relationship between PoF and Health Score

The creation of the consequence of failure values starts with a GB average made up of four individual factors, Financial, Safety, Environmental and Network Performance. The total of these factors creates a value for the average asset whose value can be modified if the assumptions associated with the average are not appropriate. The value for the asset is then expressed as a percentage of that average. The values are created from DNO data and modified from asset specific data as described. Table 2 shows how the values are depicted in the 5x4 matrix.

Criticality Index Band	Criticality Index Banding Criteria		Value to be used to calculate Risk Index (stipulated in the NAW)
	Lower Limit of Overall CoF (as % of Average Overall CoF for the Asset Category)	Upper Limit of Overall CoF (as % of Average Overall CoF for the Asset Category)	
C1	-	< 75%	70%
C2	≥ 75%	< 125%	100%
C3	≥ 125%	< 200%	150%
C4	≥ 200%	-	250%

Table 0-2 Criticality Banding Criteria

Each asset now has a value for the probability of failure, expressed as a Health Score and created from the actual PoF of the asset and a value for the consequence of failure created from the static data for the asset and expressed as a percentage of dereference cost. Assets can therefore be placed in the 5x4 matrix and hence we can model the movements due to the investments made, thus meeting the Ofgem requirements.

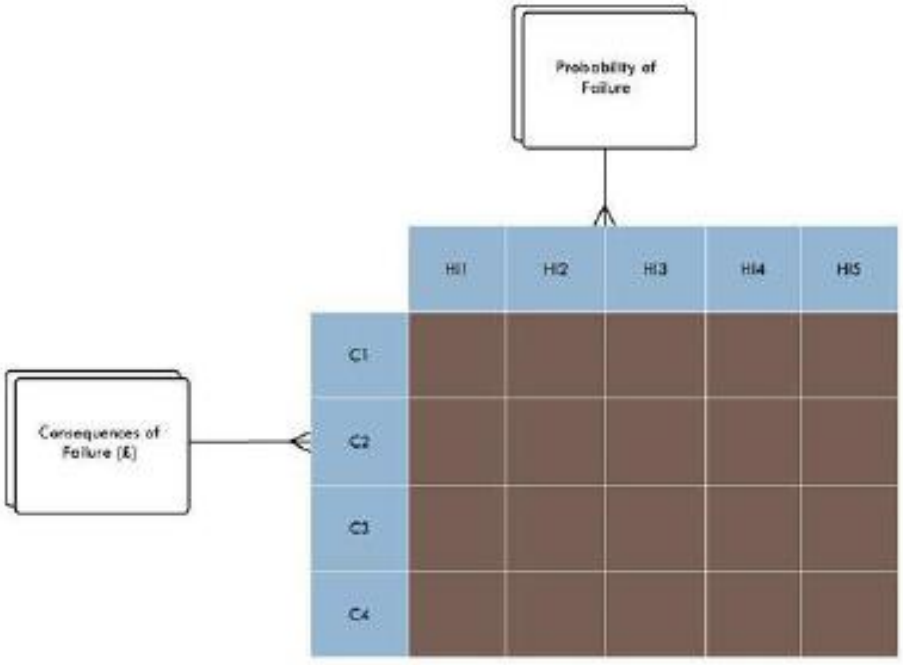

Figure 0-2 Risk reporting matrix

To calculate the risk an asset class represents the 5x4 matrix was established. To do this there is a need to establish a value that will be used to calculate the risk in each cell. For the Health Index value table 3 provides it. The PoF for the value shown is taken from the modelling for each asset category.

Health Index Band	Health Score to be used to derive Average PoF
HI1	4
HI2	4.75
HI3	6
HI4	7.25
HI5	10

Table 0-3 Health Score used to derive PoF in the risk calculation

The consequence of failure value is derived from the value shown in Table 2. The total asset risk due to condition in a cell is calculated for an asset group as:

PoF x CoF x Volume in Cell

The total asset risk is the sum of all the individual cells.

For the RIIO-ED1 period CNAIM was created at Asset Category level in the reporting regime. The CNAIM methodology was presented to Ofgem for approval. After that approval, rebasing of the Asset Risk incentive targets took place. Initial submission of the rebasing of the incentive discovered an anomaly in the calibration of the Pressure cable and Tower elements of the modelling. Recalibration resulted in these anomalies being removed and the establishment of an equally challenging incentive target to that submitted prior to development of CNAIM tool.

A copy of the CNAIM V1.1 as used for the ED1 period is available on the Ofgem website.

Appendix 2 - Development of CNAIM for RIIO-ED2

In preparation for the RIIO-ED2 period Ofgem reviewed the CNAIM V1.1 and identified several additional areas where they believed the methodology should be developed. This was partly driven by a desire to have a methodology that is consistent across all four energy sectors which they regulate[6]. The diversity of the equipment used in these sectors means that total alignment is not possible but a degree of alignment of the principles in the period could be incorporated into the ED2 period.

Ofgem also renamed the incentive for the ED2 period NARM to better reflect the overall requirements of the incentive. The objectives of the incentive are still generally aligned to those established in the ED1 period. Both Ofgem and the DNOs agreed that CNAIM V1.1 needed revision as it was not fit for purpose in the ED2 period given that Ofgem wished to see several changes and the DNOs also wished to improve several aspects of the V1.1 model.

Regulatory Driven Changes

Ofgem identified the following changes:

- Alignment of reporting - Ofgem require that for the RIIO-ED2 period that all DNOs report against the full 61 Asset Register Categories in the Methodology
- Incorporate Long Term Risk to Risk Index - Assign new weightings to each Health Index Band, when deriving the monetised risk (or Risk Index) from the Risk Matrices, so that the value of monetised risk produced represents a longer-term view of the asset risk ('Long Term Risk''). The new weightings produce a value of risk that represents cumulative risk in the current year and all future years, in present value terms.

As work progressed on these changes the Working Group identified several consequential changes, these are:

- HI Banding Criteria Revision (Consequential change) - Revise the upper limit of the banding criteria for the HI1 Health Index Band;
- Revision of typical Health Score bandings to assign assets to HI bandings - Update the Health Score Used to Derive Average PoF;
- Changes to the Criticality Banding Criteria - Revise the method of allocating assets to Criticality Index Bands, such that banding is performed based upon a reference value that is common to each DNO;
- Revision of Customer Numbers and Maximum Demands used in the Network Performance Cost of Failure - Revision to the typical Customer Numbers/ Maximum Demand used in the derivation of Network Performance Cost of Failure;
- Update all variable cost to the RIIO-ED2 price base - Current price base is 2012/13, revise to 2018/19; and
- Reclassification of Refurbishment Activities - Reclassification of some refurbishment activities between Refurbishment (SDI) and Refurbishment (No SDI) categorisations.

DNOs identified improvements driven by:

1. Better alignment to National and International Standards

[6] The four sectors are Electricity Transmission, Gas Transmission, Gas Distribution and Electricity Distribution

2. Revision of the Methodology Modelling to align with changes in practice since the creation of V1.1
3. The introduction of Asset Condition modifiers, where these were omitted in earlier version.
4. Changes to the way Consequence of Failure values are calculate following changes to both practices and a reduced tolerance to the use of SF_6 gas

The base principles established in CNAIM V1.1 as to the way in which the PoF and CoF values are unchanged because of these changes. The main difference has been brought about by the adoption of Long-term risk and the consequential changes identified in progressing these changes.

Adoption of the 61 Asset Register Categories

In the RIIO-ED1 period the assets against which a licensee reported their asset movements were at the discretion of that licensee. This made inter licence and hence company comparisons more difficult than it could have been. Ofgem wished to see the methodology expanded to as many asset register categories as possible. For ED1 reporting had already been established against Asset Register Categories, although the methodology was based on Asset Categories.

Agreement was reached that for the ED2 period the NARM Incentive would be established by each licensee reporting asset risk for all asset categories they operate assets in. We do not operate assets at voltages of 20 or 66kV, nor do we operate X-type assets. We will not therefore report any volumes for these asset areas. All other assets we will report against, this will include Solid cables at 132kV and 33kV and LV circuit breakers.

Adoption of Long-Term Risk

The methodology already has an established method to predict the PoF of an asset in future years due to degradation. This is done by using the formula:

$$\textit{Present value of future risk}_{0-n} = \left[\sum_{i=0}^{n} (PoF_i \times (1+\mathrm{r})^{-i})\right] \times \mathrm{CoF}$$

EQ. 1

Where:

- *i = number of years subsequent to current year (where current year is year 0)*
- *n = number of future years considered;*
- *PoF_i = the expected number of functional failures in year i;*
- *CoF = the Consequence of Failure and*
- *r is the discount rate.*

If we assume that the CoF value is constant during this period, then a risk value can be calculated for any time period in the future. In order to make this relevant to the NARM incentive, these values are discounted in accordance with the values in the HM Treasury Green book to provide a current value. These values have been used to recalibrate the 5x4 matrices to represent risk over the remaining years of the assets' life.

The methodology providing an explanation is provided in the CNAIM V2.1[7] version on the Ofgem website. A fuller explanation is provided in the *"DNO CNAIM V2.0 Methodology Changes Explained"*, issued as part of the consultation undertaken prior to final publication. This document provides a full explanation of the changes between V1.1 and V2.0 and an impact assessment of each of them.
The modelling can now report the asset risk in either the current year of a long-term risk approach.

A measure that considers the risk in a single year (as ED1) does not consider the longer-term risk associated with an asset. When an intervention is performed that reduces risk, this intervention does not only reduce the risk in the year that the intervention is undertaken, but also addresses the risk that would be held in future years if the intervention were not undertaken. This is illustrated in the diagram below, which again considers the risk reduction benefit associated with removal of an asset in year *n*.

Ofgem proposes that the monetised risk measure used in the RIIO-ED2 Network Asset Risk Metric (NARM) should consider the long-term condition-based risk associated with assets. Long Term Risk provides a measure that that facilitates clearer visibility of the cost-benefit justification associated with interventions.

The requirement to consider Long Term Risk in the RIIO-ED2 NARMs requires changes to be introduced to CNAIM v2.1 to reflect this requirement within the Risk Index.

The working group identified the changes required to ensure that the revised methodology could demonstrate alignment with the previous version. This includes the revision of the banding upper and lower scores for PoF, see table 4 and figure 3 that illustrates this point.

Health Index Band	Health Index Banding Criteria	
	Lower Limit of Health Score	Upper Limit of Health Score
HI1	≥0.5	<3
HI2	≥3	<5.5
HI3	≥5.5	<6.5
HI4	≥6.5	<8
HI5	≥8	≤15

Table 0-1 RIIO-ED2 HI banding revision

[7] CNAIM V2.0 is calibrated in FY13 values and V2.1 is in FY21 values, as instructed by Ofgem.

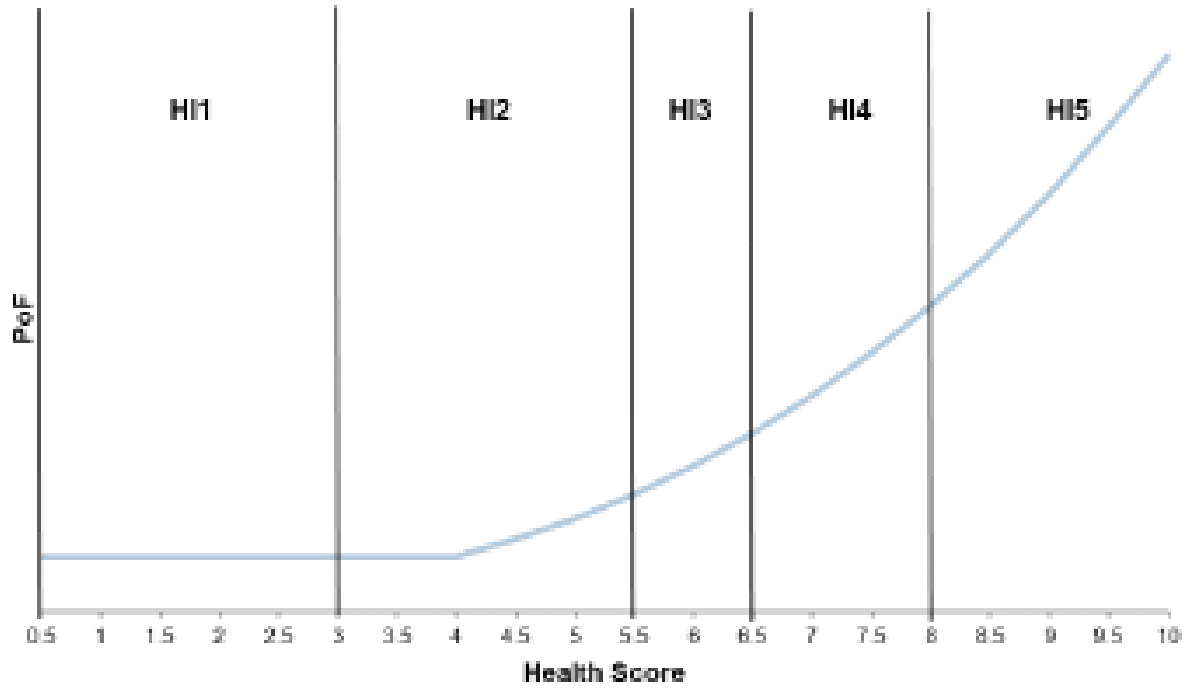

Figure 0-1 Revised HI banding for RIIO-ED2

A further change in this area is that the Health Scores used to determine the PoF score for the 5x4 risk values has been revised. Table 3 shows the ED1 value and table 5 the ED2 values;

Health Index Band	Health Index Banding Criteria		Health score that an asset would be at if it was 50% of its time in the HI Band
	Lower Limit of Health Score	Upper Limit of Health Score	
HI1	≥0.5	<3	1.23
HI2	≥3	<5.5	4.06
HI3	≥5.5	<6.5	5.74
HI4	≥6.5	<8	7.20
HI5	≥8	≤15	10.90 (8.94 * using HI limit of 10.0)

Table 0-2 RIIO-ED2 Health Score for PoF determination

The bandings for the CoF tables have been reviewed but not revised. Other consequential changes due to the adoption of long-term risk are:

- The typical number of customers associated with Network Performance was reviewed and revised to ensure alignment between CNAIM V1.1 and V2.1
- Update of key cost parameters from the FY13 base in V1.1 to FY21 in V2.1
- Reclassification of Refurbishment activities. Within the Regulatory Reporting Pack (RRP) activities are classified as Repair and maintenance, Replacement/refurbishment with or without Secondary Deliverable incentive values. The working group reviewed these classifications and provided further guidance to Ofgem as to how these activities are to be

reported. This has a potential impact of the way a DNO will report these values both in establishing the NARM target and reporting against it.

- Alignment of asset components (eg cable boxes). In CNAIM V1.1 a mismatch between the treatment of certain components of the assets was identified when considering the PoF modifiers. These have been realigned to create a consistent method for assessment.

DNO Driven Changes

The DNOs carried out a full review of the methodology and identified several areas where improvement could be made. These are summarised below. A full explanation of these changes is in the *"DNO CNAIM V2.0 Methodology Changes Explained"* document[8].

- **Safety Risk Reduction Factor** – Since the adoption of V1.1 an issue has been identified with the safety of Underground link boxes (LV UGB). This required an addition to the safety consequence of failure for this asset.
- **Wall Mounted LV Boards and LV Pillars** – The PoF modifier values were reviewed and it was recognised that an integral part of the boards (the cable termination) was not included in these assessments. Additionally, caps and collars were in need of review and a number of additions were made.
- **SF_6 Environmental Factors, CoF calculation** – The impact of SF_6 in the environment had been significantly underestimated in V1.1. The impact of the use of this gas in switchgear was recognised and the impacts increased through recalibration
- **HV Transformer oil tests** – In V1.1 a very limited use of test results was included in the methodology, in V2.1 these tests were aligned with the treatment of EHV and 132kV transformers.
- **132kV and EHV oil tests** – These were aligned to the requirements of IEC 60422 (Mineral insulating oils in electrical equipment) for oil condition tests. In V1.1 a single standard had been adopted for both voltage levels.
- **Copper Salt treated poles** – This category of pole which as a proven much shorter life expectancy that poles treated with oil-based preservatives was included in V2.1.
- **Tower Painting Banding** – In V1.1 under certain conditions tower painting provided little change to the risk profile of the asset. This anomaly has been addressed to provide a more appropriate risk reduction. This particularly applies to towers with high HI values pre-painting
- **Additional Condition point for Pressure Cables** – A further condition point was added for crystalline lead in the structure of the cable. Where this is found the cable section is collared at HI5 as the asset is in need of replacement.
- **Cable Box Replacement** – All plant with cable boxes had this aspect of the asset added to the assessment methodology
- **Condition Collar Review** – From the experience of operating with V1.1 the use of collars in the determination of the HI was found to be inconsistent. A full review of the methodology has been undertaken and revised values applied to the modifiers to be used.
- **Observed Condition Modifiers** – The condition descriptors in V1.1 had been identified as potentially confusing for data collectors or anyone unfamiliar with the methodology. A revision of these descriptors removes the potential for inaccurate data collection from this source.

8 https://www.energynetworks.org/assets/images/Resource%20library/Proposed%20CNAIM%20v2.0%20Methodology%20Changes%20explained%20Final%20v1.1.pdf