Northern Ireland Electricity Limited

Transmission and Distribution Price Control for RP5

Capital Investment Requirements for the Fifth Regulatory Period

(Publishable Paper)

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EXECUTIVE SUMMARY

Northern Ireland Electricity Limited (NIE) owns the electricity transmission and distribution network through which electricity is supplied to customers in Northern Ireland (NI). Every five years the Utility Regulator reviews the prices which NIE is allowed to charge for network services. The current transmission and distribution (T&D) price control is scheduled to be reset from 1 April 2012 which will mark the start of the fifth five-year regulatory period (RP5) since NIE was privatised in 1992. As part of the current review NIE has drawn up plans for capital investment in the network during RP5 and submitted them to the Utility Regulator for approval.

Need for Investment

Historically the requirement for investment in the T&D network has been driven mainly by the increased demand for electricity (load related investment) and the need to replace assets that have come to the end of their serviceable lives. Investments for load related and asset replacement purposes are the main components in the 'business as usual' (BAU) element of our RP5 investment plan. In order to ensure the network remains fit for purpose during RP5, the age profile and the condition of our assets is such that there is a need to replace an increasing amount of network assets that were installed in the 1950s to 1970s. NIE therefore needs to step up its programme of targeted asset replacement in order to renew this ageing infrastructure and ensure the safety and reliability of service to customers.

The capital investment plans for the next regulatory period must also take account of the Strategic Energy Framework (SEF) published by the Department of Enterprise, Trade and Investment (DETI) which sets a target for 40% of electricity consumed in NI to be generated from renewable sources by 2020. Without a very substantial investment in NIE's network there will be insufficient network capacity to facilitate this significant increase in renewable generation. This is the principal driver behind the "renewables integration" element of our RP5 plans.

In addition, the 400kV Tyrone–Cavan Interconnector project is included in our RP5 investment plans. There is strong government and regulatory support for increased interconnection between NI and the Republic of Ireland (RoI).

Investment for Business as Usual

Our overall aim is to exercise responsible stewardship of the transmission and distribution network. A key objective of the BAU plan is to manage optimally an increasing level of network risk arising from an ageing asset base which has been compounded by previous under-investment compared with the GB electricity companies. Network risk manifests itself in many ways ranging from supply interruptions to catastrophic failure, and on occasions there may be implications for the safety of the public or our staff. The load related and asset replacement programmes included in our plan therefore take into consideration risks associated with safety, security and quality of supply. Our experience of faults on network equipment during the current regulatory period provides a context which, along with the information we hold on the age and condition of the assets, supports the need for a comprehensive programme of asset replacement in RP5. Expenditure is prioritised towards those assets which present the highest risk and which would cause the greatest impact on the public, customers or staff should they fail.

The RP5 BAU plan has been developed from a bottom-up assessment of investment requirements. It has been subjected to stringent internal scrutiny and robust challenge to arrive at the lowest cost plan consistent with keeping network risk at manageable levels. The plan is presented as the minimal plan required to meet NIE's statutory and licence obligations alongside stakeholder and customer expectations with regard to network safety, security and performance. The plan identifies a BAU investment of £607m[1] as being required for RP5 as follows:

Load related	£ 90m
Asset replacement	£362m
Connections (net)	£ 59m
Other	£ 96m
Total	**£ 607m**

Recent events have emphasised the importance that the public and government of NI place upon ensuring that the people of NI have utility infrastructures that provide services that are reliable and also resilient in times of extreme weather. Following the extensive damage to the network caused by the severe snow and ice storm in March 2010 that caused widespread disruption to electricity supplies, particularly in the Cloughmills area, we have initiated a review of the size of conductor used extensively on our 11kV overhead line network. This will help inform the decision as to whether the 25mm^2 conductor should be replaced with a more robust 50mm^2 conductor in order to improve the network's resilience to similar storm events in future. While our initial view is that there is merit in a phased roll-out of a replacement programme, no provision has been included in the current plan.

The plan includes a relatively small element to bring about a modest improvement in the overall quality of network performance and service which will be targeted on those rural customers who receive the poorest quality of supply. This will help NI keep pace with improvements in quality of service in GB.

The BAU investment also includes expenditure to connect new customers' premises to the network (net of customers' contributions). Other proposed investment includes expenditure associated with metering, IT & telecoms systems which support network operation and business processes, smart grids, and changes to legislation. DETI has been consulting on a possible

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[1] Expenditure on programmes to upgrade 11kV 25mm^2 conductor and to roll-out smart meters is not included in these figures pending further discussions with the Utility Regulator.

roll-out of smart meters in NI. Whilst a decision has yet to be taken and given the issues that still require resolution, we anticipate that although a roll-out may begin in RP5, the bulk of the investment would be incurred in RP6 (2017 – 2022).

Investment for Renewables Integration

The electricity network in NI is facing an unprecedented demand for the connection of new sources of renewable generation. The principal driver for this is Government energy policy which has established clear targets for 2020. We have previously indicated that achievement of Government's renewable energy target is likely to involve of the order of £1bn of network expenditure spread between now and the end of the programme. Government has considered this in establishing the target.

The nature and location of the sources of renewable energy that will require connection will impact on how the network must be developed. The expectation within DETI's SEF is that the majority of the renewable energy required to achieve the 40% target is likely to come from large scale (greater than 250kW) on-shore wind generation.

Off-shore wind, tidal energy, biomass fuelled generation and small scale (less than 250kW) renewable generation will also play a part in meeting DETI's target. However there is considerable uncertainty surrounding these potential sources, their location and timing.

In addition, the number of planning applications being made for the development of small scale more widely distributed renewable generation is rising rapidly. However, it is unclear how many of these projects will be able to meet the costs of connecting to the 11kV network (which was not designed to facilitate such connections and will therefore require development) and be economically viable.

There is no "do nothing" option. The licence obliges NIE to offer terms for the connection of renewable generation sources following a request from the developer. However, the existing network is nearing its operational limit as regards the capacity of renewable generation sources that can be connected. NIE's strategic response to the challenge of integrating renewable generation taking account of the surrounding uncertainty has been to develop, in conjunction with the System Operator for Northern Ireland (SONI), a coordinated network development plan incorporating a combination of short, medium and longer term measures. Within these plans we have developed arrangements for connecting groups of windfarms to new 110/33kV substations connected into the transmission network with a single wood pole 110kV overhead line. These "clustering" arrangements aim to reduce environmental impact and facilitate planning consents by avoiding a proliferation of overhead lines.

The *short term* measures are focused on increasing the capabilities of the existing network and many are already complete or underway.

Medium term measures will require a phased series of 110kV network reinforcements to increase capacity and to remove "bottlenecks", along with the development of wind farm clusters. By the end of RP5 it is intended that it will achieve the maximum connection capacity that can be delivered without dependence on the longer term major 275kV transmission grid reinforcements. We estimate that this will facilitate achievement of around half of DETI's 40% target. The Medium Term Plan is critical to the near term expansion of renewable generation capacity in NI and is therefore an important immediate focus.

Achieving the full 40% target will require substantial expansion of the 275kV transmission system and this is the focus of the *Long Term Plan*. It will present considerable challenges in securing planning consents for overhead tower lines which will add to the uncertainty of the timing of the investment. Without a more supportive policy environment that ensures that all consents processes for new renewable energy infrastructure are efficient and proportionate, particularly in terms of planning consents, it is unlikely that all the 275kV transmission infrastructure can be in place by 2020. The major element of the long term plan relates to the Renewable Integration Development Project (RIDP) - a joint collaboration between NIE, SONI and EirGrid[2] which is work-in-progress. For RP5 purposes we have assumed that the first step of the RIDP execution phase will focus on strengthening the 275kV network transfer capabilities to the west where the majority of wind powered generation locations are apparent. We have included indicative costs in the RP5 plan – but the majority of the long term expenditure will fall in RP6.

Overall, our renewables integration plan for RP5 contains an indicative level of expenditure of £215m which is comprised of:

Medium Term Plan	£ 70m
Clusters (net)[3]	£ 18m
Long Term Plan (RIDP)	£127m
Total	**£215m**

Investment in Additional Interconnection

Government and regulatory policy is supportive of the proposed 400kV interconnector between NI and RoI which will deliver specific benefits for customers. For example it will improve competition in the Single Electricity Market – for 2009/10 the Utility Regulator estimated that inadequate interconnection was costing the all-island market some £20m per annum. In addition the proposed interconnector is critical to supporting the development

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[2] The transmission system operator in the RoI.
[3] Cost of establishing the clusters less contributions from developers.

of renewable power generation and it will improve security of supply on the island.

On 18 August 2010 the Minister for the Environment announced a Public Inquiry into the proposed interconnector. NIE understands the Public Inquiry will not be held until late 2012. Given the strategic benefits of increased interconnection we have asked the Minister to consider requesting the Planning Appeals Commission to regard the project as a priority development.

We have included **£76m** in the plan for expenditure on the 400kV interconnector in RP5.

Overall Investment in RP5

The overall capital investment proposed for RP5 is as follows:

Business as Usual	£607m
Renewables Integration	£215m
Interconnection	£ 76m
Total	**£898m**[4]

We are conscious of the need to minimise the impact of our investment on network prices. To that end we will continue to seek improvements in our asset management and project delivery processes. The improvements we have secured in the past have enabled us to deliver recent capital programmes very efficiently with unit costs consistent with leading industry-wide performance. We believe that stronger incentives to encourage further efficiencies through innovative approaches such as the application of smart technologies are appropriate for RP5 and we have made proposals to the Utility Regulator. We have also proposed a mechanism for managing the uncertainty associated with the renewables integration plan - essentially by seeking regulatory approvals on a project-by-project basis, with appropriate incentives. In addition, we will work with the Utility Regulator to develop practical methods of measuring the outputs to be delivered through the investment programme, whilst retaining flexibility in its implementation. Finally, we will continue to report regularly to the Utility Regulator on progress in delivering the capital programme once the RP5 price control has been agreed.

We welcome comments from stakeholders on the investment plans set out in this paper.

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[4] The figures stated are in 2009/10 price base. We expect that certain input costs will rise faster than RPI and an allowance will be needed to cover ‘real price effects’. We have made a separate submission to the Utility Regulator on this.

1 INTRODUCTION

1.1 General

NIE owns the electricity transmission and distribution network through which electricity is supplied to customers in NI. Every five years the Utility Regulator reviews the prices which NIE is allowed to charge for network services. The current T&D price control is scheduled to be reset from 1 April 2012 which will mark the start of RP5. As part of the current review NIE has drawn up plans for capital investment in the network and submitted them to the Utility Regulator for approval.

This publication sets out for stakeholders the issues which NIE will face during RP5 in continuing to provide a safe, reliable, secure and efficient network, whilst facilitating wholesale electricity market requirements and government policy for renewable energy.

1.2 An Overview of the Present T&D Network

The present electricity network was largely in place by the late 1960s, with an electrically strong transmission network having been developed to link major fossil fuelled power stations and to deliver bulk electricity to the more heavily populated parts of the country. NI has three large fossil fuel power stations, Ballylumford (1213MW mainly gas fired, near Larne), Kilroot (614MW mainly coal fired, near Carrickfergus), and Coolkeeragh (455MW mainly gas fired, near Londonderry). The strong network is therefore predominantly on the east of NI.

There are currently 24 wind farms located mainly in the west, which generate approximately 8% of the electricity consumed in NI.

The peak electrical demand in winter 2010 was 1866MW.

The electricity network can be sub-divided into the transmission and distribution networks. Voltages at or above 110kV are used in the transmission network as they can deliver large quantities of power over long distances, very efficiently.

The transmission network consists of approximately 400km of 275kV overhead line almost all double circuit, developed between 1963 and 1978. The 110kV system consists of 924km of overhead line and 90km of cable, with the majority installed between 1944 and 1958. Figure 1.1, Transmission Network Map shows the location of the transmission network.

The distribution network operates at lower voltages of between 33kV and 230V and distributes electricity to customers’ homes and business premises.

The NI network is connected to the Scottish network via the Moyle Interconnector, which runs from Islandmagee to Ayrshire. Existing interconnection with the RoI is principally achieved by a 275kV double circuit connection between Tandragee and Louth, and there are two smaller 110kV connections at Enniskillen and Strabane.

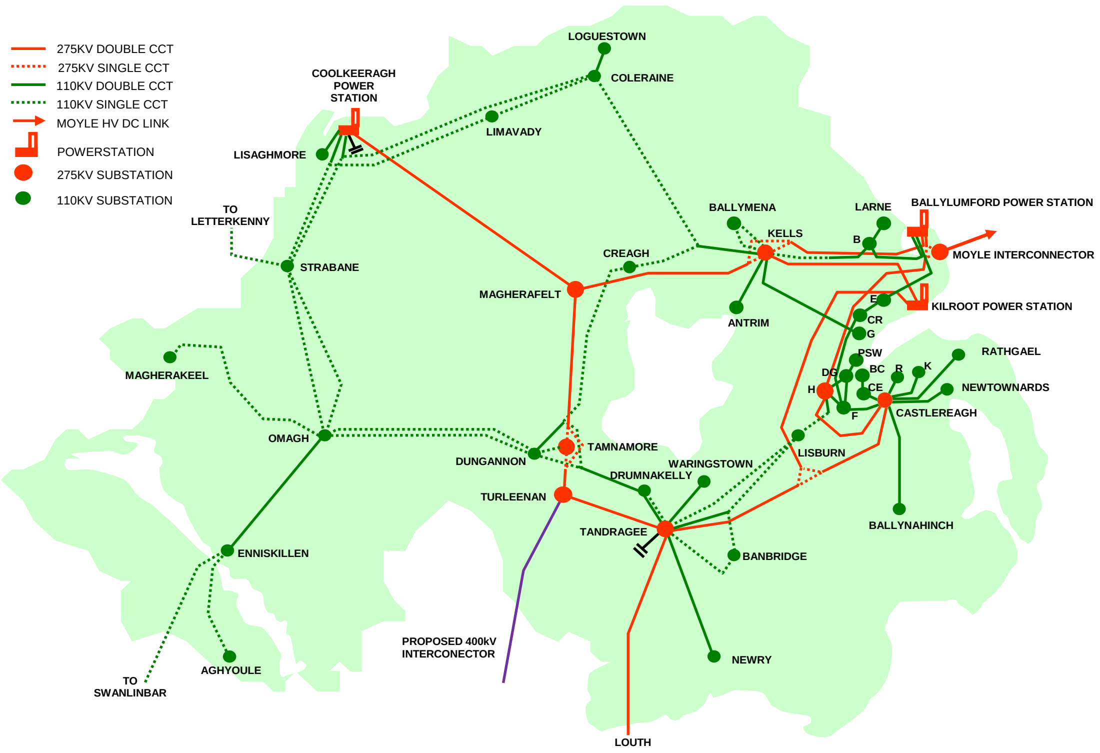

Figure 1.1: Transmission Network Map

1.3 Components of Investment in RP5

We have constructed three elements to our investment plan for RP5 – (i) investment for Business as Usual (which is driven mainly by the increased demand for electricity (load related investment) and the need to replace assets that have come to the end of their serviceable lives), (ii) investment for Renewables Integration and (iii) investment in strengthening Interconnection with the RoI. These are explained in sections 2,3 and 4 respectively. We believe that it is more transparent to show the BAU costs separately from the costs of incrementing the network for renewable energy integration and strengthening interconnection. The network costs associated with the integration of renewables will not only contribute to environmental goals, but will also play an important role in delivering secure and affordable energy supplies in the future and may be viewed as a hedge against fuel price volatility in the coming decades. Recent global events suggest that traditional geopolitical concerns are likely to remain relevant in the future, increasing the importance of affordable, indigenous energy sources.

In this publication we are able to be clear about our plans for BAU investment, the development for renewables integration on our 110kV network and our work on additional interconnection. However, we have a large number of other renewables integration schemes still under consideration, particularly for the 275kV transmission network. Whilst we can give general information on the shape and level of 275kV development we do not want to prejudice the impartiality of the further stakeholder consultation to be carried out later in 2011. This publication therefore advises on our RP5 plans for renewables integration which comprise investment in the 110kV network together with some limited elements of 275kV development and sets that within the context of the shape and likely cost of longer term developments which will fall into RP6.

2 BUSINESS AS USUAL INVESTMENT

2.1 Overview

NIE’s overall aim is to exercise responsible stewardship of the transmission and distribution network. Our primary focus is on maintaining and where appropriate improving the safety, reliability and level of customer service provided by our network. Our plan for ‘business as usual’ expenditure in RP5 has been prepared on this basis.

While we have sought to minimise the impact on network prices of the planned BAU investment by thoroughly examining the need for each project, there remains a requirement for a significant increase in expenditure compared to the present regulatory period. There are several reasons for the increase. Firstly, the increased investment in asset replacement reflects the increasing level of risk on the network, due primarily to the ageing asset base. Secondly, it reflects a level of under-funding during RP3 and RP4 (2002 – 2012) when the level of funding available to NIE was comparatively less than that allowed to the GB distribution companies.

Our investment plans are designed to keep network risk to an acceptable and manageable level. Network risk manifests itself in many ways ranging from periodic interruptions of supply to sudden, catastrophic failures of equipment which, on occasions give rise to safety incidents. Risk can also arise as a result of growth in demand on the network causing equipment to become overloaded and fail. Although the incidents that can occur when these risks materialise are normally contained and well managed, their frequency and impact are very dependent on the level of investment a network receives over a period of time. Under-investment will eventually lead to more frequent failures and an increase in the number of potentially hazardous incidents.

In developing the BAU Plan for RP5 we have undertaken a number of iterations to ensure that it reflects the minimum level of investment necessary to adequately manage network risk. We would therefore caution strongly that any further reductions in the volumes of asset replacement or further deferral of works, will lead to increased risk and impact on NIE’s ability to deliver a fit-for-purpose network (as defined by our objectives, stated below). This plan is thus deemed to be the minimal plan required to meet stakeholder and customer expectations with regard to network safety, security and quality of supply.

2.2 Objectives

We invest in the network in order to comply with all statutory and licence requirements and to provide our customers with the appropriate quality of service. Specifically we invest to:

- develop the network to allow new customers to be connected and to accommodate growth in demand for electricity from within the existing customer base;

- maintain a resilient network that ensures a reliable supply of electricity and avoids prolonged losses of supply to large groups of customers;

- maintain or improve existing levels of network performance to reduce the number of more frequent supply interruptions experienced by smaller groups of customers;

- maintain a network compliant with statutory safety and environmental obligations, and to prevent catastrophic failures of high voltage equipment and ensure the integrity of assets in customers' premises such as domestic cut-outs and other low voltage equipment etc;

- control the level of equipment on the network approaching the end of its serviceable life to prevent an unsustainable build-up of an ageing asset base; and

- reduce operating and maintenance costs to an optimal level of expenditure on inspection, maintenance, and fault & emergency activity.

2.3 The Need for Investment

Our submission to the Utility Regulator sets out our proposals for the efficient delivery of these objectives. Our plan identifies the need for a 72% increase in asset replacement expenditure during RP5 compared to RP4. This reflects a continuation of the ramp up of asset replacement activity which commenced in RP4 and it addresses the increasing numbers of ageing network assets which were installed from the 1950s through to the 1970s and which are approaching the end of their serviceable lives.

The need for this investment has been evaluated on the basis of an assessment of the condition of the assets as well as the risk and consequences of their failure. For some categories of assets we are proposing to make increasing use of 'Smart' technology to allow them to remain in service for longer and so defer expenditure.

High profile events affecting utility infrastructure systems have reinforced the message that asset replacement programmes must be timely and commence before the onset of repetitive failures within asset groups, otherwise the task of recovery, the cost of recovery and the impact on customer service can become unacceptably high.

The investment plan also recognises an increased requirement for load related expenditure specifically on the transmission network. Although there was been only modest overall load growth during RP4, there has also been very limited load related investment. This has resulted in demand on parts of the network approaching capacity limits. A significant proportion of the load related investment in RP5 relates to a small number of relatively high cost schemes, particularly on the transmission network, where there is a need to make significant investment to ensure satisfactory voltage levels are maintained and to provide increased transformer capacity to meet demand and avoid overloading. NIE and SONI operate a Transmission Interface Agreement (TIA) to ensure the efficient planning, development and operation of the transmission network. Through this process, NIE and SONI together keep under review and agree changes to the Transmission Investment Plan (TIP). The TIP, on which the transmission element of NIE's proposed RP5 capex plan is based, has been prepared in conjunction with SONI and in line with the required TIA process.

In addition to the need for increased investment in network infrastructure, other investment drivers include:

- the increasing number of embedded generators connecting to the distribution network. This creates new challenges for the safe and efficient operation of the network on a 24/7 basis and a requirement for an enhanced real-time network management system and operational communications network; and

- changes to, and the introduction of new legislation, in particular Roads and Street Works legislation and Electricity Safety, Quality and Continuity Regulations.

We are also planning a relatively modest amount of network performance expenditure to improve the quality of supply to some of our rural customers through an increased roll-out of remote control devices.

2.4 Historical Background

NIE's proposals for investment in RP5 should be considered against the levels of investment since privatisation in 1992.

During the first regulatory period, RP1 (1992 to 1997), NIE's focus was on development of the electricity infrastructure by addressing 'capacity holes' in the network arising from the deficit inherited as a result of under-funding in the pre-privatisation period under government ownership. This involved establishing new 33/11kV substations and associated circuits to strengthen the backbone of the network and provide new primary distribution supply nodes.

In RP2 (1997 to 2002), further development of the network was required to improve its electrical integrity and to improve security of supply to customers. Significant refurbishment of the overhead line network commenced after the major storm of Boxing Day 1998 when the resilience of the rural network was severely tested and found wanting.

In RP3 (2002 to 2007), the focus of investment moved from overhead lines to substation plant. However, the level of investment was constrained by a 26% reduction in funding compared to RP2. At the same time, investment by the distribution companies in GB exhibited an increasing trend, leading to a relative underfunding of investment in NIE's network.

The focus of our investment in RP4 (2007 – 2012) was to begin to ramp up our asset replacement programmes and to increase the overhead line programme to address age and condition issues. The capital budget set by the Utility Regulator for RP4 represented a 21% increase on RP3. However, in GB the distribution companies secured increases in outturn expenditure for the equivalent regulatory period of 34%, in effect widening the gap between the investment levels allowed to NIE relative to GB.

NIE considers that over the course of RP4 and the previous regulatory period, its level of investment has not been adequate relative to the increasing level of risk on the network, due particularly to the ageing asset base. Whilst the proposed increase in RP5 investment is significant, it should be viewed against the RP3 and RP4 funding levels which were comparatively less than the equivalent levels in GB.

2.5 Network Risk

A key objective of NIE's RP5 capital investment plan is to manage optimally the increasing level of network risk arising from the ageing asset base. The load related and asset replacement programmes included in our plan take into consideration risks associated with safety, security and quality of supply. Expenditure is prioritised towards those assets which present the highest risk and which would cause the greatest impact on the public or customers should they fail.

It is not possible to predict accurately the extent and timing of the failure of individual assets. Nor is it possible to predict accurately the probability and the location or the impact of severe weather events which damage the network and cause loss of supply. By way of context a sample of the unplanned events and incidents which have occurred during RP4 is presented below.

Major Plant Failures

NIE has had to deal with a number of significant plant defects and failures on the network during RP4. The following events are particularly notable:

- A catastrophic failure occurred on a 110/33kV transformer due to a bushing failure resulting in irreparable damage to the main winding. The transformer was replaced and subsequently an inspection and test programme was initiated on transformers with similar type bushings.

- A series of defects associated with transmission wall bushings and transformer bushings were identified as a result of oil leaks and insulation degradation. As we have experienced previously on transformers, failure of bushings can result in catastrophic damage not only of the bushing but also the transformer itself.

- Voltage transformers (VT) are large oil filled plant connected to the substation circuits to measure voltage for electrical protection purposes. A catastrophic failure of an oil filled voltage transformer caused major damage to adjacent switchgear equipment. The population of this type of VT was of similar age and condition, and due to the assessed risk of further catastrophic failure, a complete change-out programme of the entire population of 75 units was completed during RP4.

These failures are symptomatic of an ageing and deteriorating asset base. Some assets failed in service despite our ongoing asset replacement and condition monitoring programmes. Some ‘reactive’ expenditure was targeted following defects identified during routine inspections and maintenance. The knowledge gained as result of such failures and from failures reported by other network operators is used to inform our investment priorities. The failures during RP4 provide a context that supports the need for a comprehensive programme of asset replacement across each of the network asset categories in RP5.

Public Safety

Whilst the plant failures discussed above not only pose risk to the security and performance of the transmission and distribution network, they also pose safety risks, particularly when the failure mode is of a catastrophic nature. In general, the safety risks associated with high voltage plant are primarily confined to those most often in proximity of the equipment, i.e. NIE staff and in some cases contractors. However there is also a level of risk to the public particularly in respect of all overhead lines and plant connected to the LV network which serves some 800,000 customers’ premises. This risk requires to be managed carefully and diligently.

In addition, the network experiences approximately one hundred third party cable strikes per month with 90% of these occurring on the low voltage network. Vandalism of substations or NIE street furniture such as mini-pillars accounts for a significant number of incidents, usually involving children. A worrying trend is the number of farmers and contractors who are injured as a result of contact, or near contact, with overhead line systems.

Storm damage

Between 30 March 2010 and 2 April 2010 a severe snow and ice storm caused widespread disruption across NI. Areas to the north and west of Lough Neagh were the most severely affected and many roads across the province were impassable.

The worst affected area of network damage and disruption to electricity supplies was the greater Cloughmills region located on the western upper slopes of the Antrim mountains. The severity of the wind and snow, allied to the particular climatic conditions experienced on 30 March, led to the accretion of wet snow on overhead conductors. As a result there was severe mechanical loading of the overhead conductors and poles leading to mechanical failure of the lines. None of the eleven individual 11kV overhead circuits supplying this region remained intact.

As a result of the specific (and infrequent) effect of wet snow accretion, this particular storm caused much greater damage per kilometre of circuit affected than would generally be the case for events associated with severe winds alone.

The risk imposed by such weather supports the need for continued investment in overhead line refurbishment. It is particularly significant that almost 90% of the circuits that failed were constructed with 25mm^2 conductor. Our present design standard is 50 mm^2. NIE has had concerns over the resilience of 25mm^2 conductor for some time now. Had the ice accretion been much more widespread then it is likely that there would have been even greater loss of supplies perhaps lasting into weeks.

The 11kV network was constructed to make supplies available to a large number of rural customers. Rural customers had small individual loads and while there were many km of network, loads on circuits were not high. This led to a design based upon a light construction and a large amount of single phase network.

The requirements placed on the network are changing, driven in part by the intensity of electrical equipment on farms and in houses and more sharply by the Government incentives for small scale generation. Added to this, NIE believes that it is approaching the limits of improvement in storm performance which can be achieved from such a light network. NIE is reviewing the options on the way forward for gradually increasing the robustness and utility of the 11kV network for discussion with the Utility Regulator.

2.6 RP5 Capital Investment Plan (BAU)

Table 2.1 presents the latest forecast for expenditure in RP4 together with the forecast expenditure for RP5 and RP6.

2009/10 price base	**RP4** **Total £m**	**RP5** **Total £m**	**RP6** **Total £m**
ASSET REPLACEMENT	210.4	361.7	381.6
Transmission	43.9	107.4	94.5
Distribution	166.5	254.2	287.1
LOAD RELATED	43.4	90.0	83.8
Transmission	22.8	65.4	57.0
Distribution	20.6	24.6	26.8
IT & COMMS REPLACEMENT	2.9	6.8	9.0
METERING	11.0	10.4	12.5
CHANGES TO LEGISLATION	0.0	29.4	74.6
CAPITALISED OVERHEADS	28.1	27.2	26.5
CUSTOMER CONNECTIONS NET CAPEX	63.6	59.3	60.9
CUSTOMER AND GOVERNMENT PRIORITIES	4.9	21.9	23.1
OVERALL TOTAL	**364.2**	**606.6**	**672.1**

Table 2.1: RP4 LBE, RP5 Submission, RP6 Projected Expenditure (BAU)

The capital expenditure profile as outlined in Table 2.2 below is phased to ramp up from existing levels to a level consistent with the expected steady state level of expenditure by the commencement of RP6.

RP5 £(m)					RP6 £(m)				
2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/12	2021/22
97.0	117.3	127.0	131.6	133.6	134.4	134.4	134.4	134.4	134.4

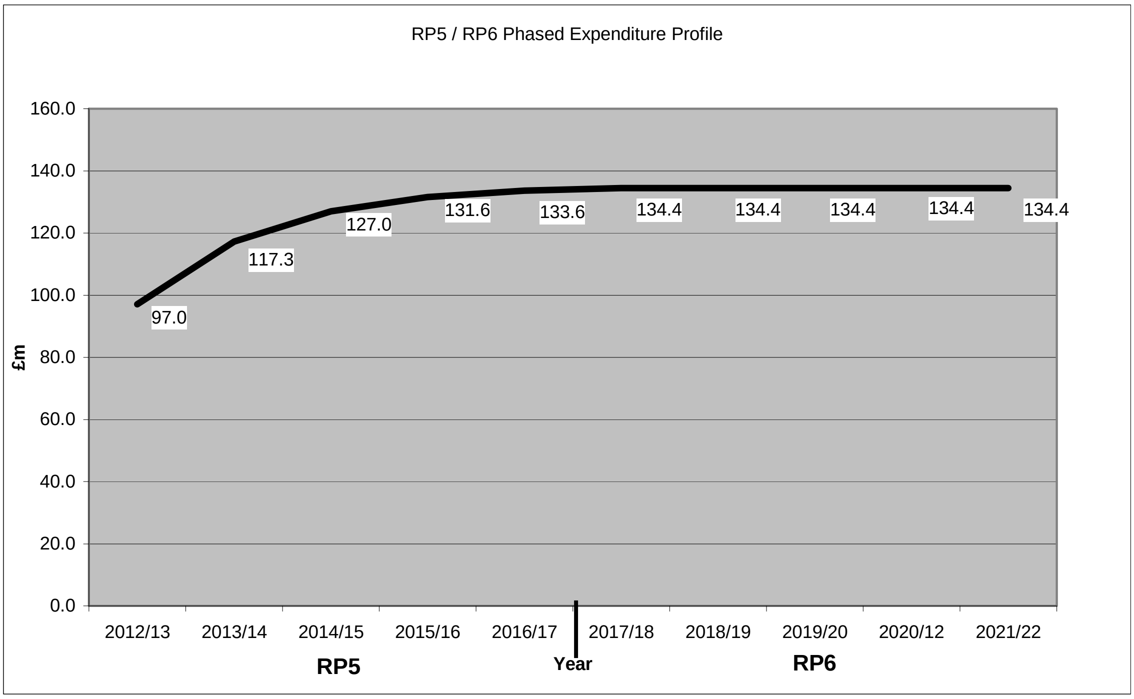

Table 2.2: Phased Capital Investment Plan for RP5 and RP6 (BAU)
2009/10 price base

The most significant components of expenditure within our plan relate to asset replacement investment and load related investment.

Asset Replacement Investment

Asset replacement investment seeks to address ongoing deterioration in the condition of network assets e.g. due to ageing or prolonged exposure to the weather. Without such intervention deterioration has the potential to increase the risk of failure, compromise the safety of NIE staff and the public, impact on the performance of the network, create adverse environmental impacts and compromise compliance with legislative requirements.

A range of plant replacement programmes, all ongoing in RP4, will need to continue through RP5 including the requirement to replace approximately eighty transmission and primary distribution transformers, five hundred units of transmission switchgear and primary distribution switchgear and associated outdoor structures, and a significant quantity of secondary distribution plant. With respect to overhead lines NIE has identified the need to refurbish or re-conductor a number of transmission towerline circuits and continue the cyclical refurbishment of the high voltage distribution woodpole network taking account of lessons learned from the March 2010 ice storm. We also intend to commence a major programme of refurbishment of the LV network with a proposal to replace portions of overhead line with aerial bundled conductor and to underground sections of line which are not amenable to refurbishment due to access restrictions. The need to apply a more proactive approach to the replacement of underground cable has also been identified.

The detailed assessment of the investment that will be required to replace network assets during RP5 has been based upon an individual consideration of each of the asset categories. As summarised in Appendix 1, the investment strategy for each asset category has been set out in a series of supplementary submissions that have been provided to the Utility Regulator.

Load Related Investment

Load related investment seeks to manage the risk to the integrity of the network in respect of equipment ratings, voltage performance and system stability as a result of increased electrical demand as well as changes in the power flows due to generation and interconnection. The consequences of not adequately managing these risks would be an adverse impact on security, operability and performance of the network, increased generation costs as a result of constraints, as well as the safety of staff and the public.

While there is uncertainty over the level of load growth in RP5, the relatively modest level of load related investment during RP4 means that a number of sections of the network are now at their electrical limit, necessitating investment. In terms of determining forecast load growth both NIE and SONI have sought to take into account uncertainty over economic growth in NI. NIE has provided the Utility Regulator with a submission detailing its assessment of future growth in demand. SONI’s forecast is detailed in its current Generation Capacity Statement. Both forecasts are generally consistent. In addition anticipated power flows on the transmission network resulting from the forecast generation dispatches that have been advised to us by SONI will, under certain outage conditions, result in a risk of overloads and reductions in system voltage.

The load related element of the plan includes the following projects:

On the transmission network a total of 16 projects have been identified. There is a need to make significant investment in voltage support, establish three new 110/33kV substations, complete the uprating of transformer capacity at Castlereagh grid supply substation and replace switchgear and cabling that are at the limit of their fault ratings. A number of smaller schemes are also included in the RP5 programme.

On the distribution network there is a need for up to twenty individual 33kV developments including the works associated with the proposed 110/33kV transmission substations mentioned above. There are also over twenty specific instances on the 11kV network where there is a risk of overload and/or inadequate voltage levels. In addition, a significant number of town centre low voltage networks require reinforcement due to the previous build-up of demand. The replacement of overloaded HV/LV ground-mounted distribution transformers and the resolution of voltage issues at customers' premises will also need to be undertaken.

The detailed assessment of the investment that will be required during RP5 has been based upon an individual but coordinated consideration of each of the voltage levels of the transmission and distribution network. As summarised in Appendix 1, the load related investment requirements have been set out in a series of supplementary submissions that have been provided to the Utility Regulator.

Reliability of Supply

We have presented analysis to the Utility Regulator that demonstrates that the recent performance of the NIE distribution network compares favourably with benchmarks for comparable GB distribution companies, particularly when considered in terms of the number of customer supply interruptions. This is despite the greater exposure of NIE's network to weather-related faults as a consequence of the high voltage network being mainly rural and therefore more extensively comprised of overhead line than our closest GB comparators.

However, there is evidence that some GB distribution companies have significantly out performed against the benchmarks for the duration of supply interruptions (customer minutes lost - CML) in response to the incentive measures that have been applied by Ofgem over recent regulatory periods. As a result of significant investment in remote control facilities over several years, the GB companies have been able to achieve shorter average supply restoration times.

To keep pace with improvements in quality of service being achieved in comparable GB regions, NIE proposes to carry out a £9m programme of investment during RP5 to improve average supply restoration times. This investment will be targeted mainly through greater investment in the provision of remote control devices on the rural 11kV overhead network. As the overhead network typically supplies rural customers experiencing the poorest quality of service (in terms of CML), this investment aims to produce significant improvements in quality of service for these customers (by the end of RP5 there will be a modest incremental improvement in overall network performance estimated at 5 CML). Other than this £9m investment the focus of the RP5 plan is on maintaining the current level of network performance and customer service.

The planned increase in the RP5 investment programme will increase the level of planned interruptions of supply that will be necessary for outage reasons to permit this planned work to be delivered.

IT and operational telecoms

Network IT comprises expenditure relating to IT infrastructure to support the efficient and effective operation of the electricity network. It includes the SCADA[5] systems and associated field devices, and network/outage management systems. These applications and their associated infrastructure play a critical role in NIE's network operations and ongoing investment will be required to maintain and develop their functionality.

The need for investment in RP5 is in part due to a refresh of SCADA communication equipment which requires to be replaced in this period. It also includes a planned upgrade to NIE's Network Management System to cope with the increasing amounts of embedded generation and the transition from a passive network to an active network and to facilitate smart grid functionality. The operational telecoms network delivers network data from substations and pole mounted devices to the control centre. Continued investment will be required to refresh and develop the operational telecoms network to meet evolving requirements, in particular, the implementation of additional fibre assets to address communications problems introduced by BT's 21st century initiative.

Smart Technology

Through the wider application of smart technology NIE aims to (i) increase the level of network investment that can be deferred and (ii) maximise the capacity of the existing network to facilitate further connection of renewable generation.

Smart technologies are already utilised to monitor the condition of assets with a view to asset life extension. For example, monitoring equipment attached to transformers can give a real time view of the condition of the transformer. The BAU investment plan takes account of the scope to reduce the investment requirements through deployment of more advanced on-line condition monitoring. In RP5, we intend to increase the amount of condition monitoring equipment installed on the network and to set up the supporting software platform through which the monitoring and condition information is collated and managed.

We also propose to trial newer smart technology that is not yet ready for wide-scale adoption; either because further development is required or modifications are necessary to adapt the technology to the NI network. The trials will address a range of issues such as:

- deferring the need for load related investment e.g. application of a distribution active network management in Armagh,

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[5] Supervisory Control and Data Acquisition.

- facilitating further connection of renewable generation on existing network assets e.g. application of dynamic ratings to transformers and dynamic ratings to several overhead lines, and

- improved management of reactive power on the network.

2.7 Optimising and Resourcing the Plan

Optimising the Plan

The RP5 BAU plan has been developed from a bottom up assessment of investment requirements. It has been subjected to stringent internal scrutiny and robust challenge to arrive at the lowest cost plan consistent with managing network risk. The process of optimising the plan involved three steps:

As a first step an *'Initial Plan'* was prepared based on an assessment of the needs of the network against our current network planning and asset replacement policies. Whilst this plan is a prudent assessment of the asset replacement and load related requirements it resulted in an investment level in excess of £800m for RP5.

The first stage of internal challenge assessed the scope for reducing this plan by:

- the application of Smart technology to minimise asset replacement volumes; and
- further analysis of load related requirements taking a more challenging view on risk, forecast uncertainty and project phasing.

Reductions in load related investment were achieved by:

- deferring elements of transmission load related expenditure to RP6 on the grounds of uncertainty over project timing and costs;
- deferring reinforcement associated with transformers forecast as becoming overloaded in the final year of RP5;
- operating parts of the network closer to the limits of loading; and
- managing the risk of deferral by network monitoring and reconfiguration.

Reductions in asset replacement investment were achieved by:

- a reduction in transformer replacement through the adoption of Smart technology which permits better monitoring of condition;
- a reduction in switchgear replacement by considering deferrals and alternative solutions; and

- other deferrals based on the assumption that better information gathered on asset condition during RP5 will permit a reduction in investment.

The resulting *‘Reduced Plan’* required a forecast expenditure of £718m having removed approximately £100m from the ’Initial Plan’.

Nevertheless NIE recognises that however robust this ‘Reduced Plan’ is, it does present a challenge to the company in terms of:

- ramping up resource levels to deliver this amount of investment;
- securing network outages to ensure safe working;
- recognition that the ‘business as usual’ investment needs to be considered alongside the additional investment for renewables integration; and
- recognition of the impact that higher levels of capital expenditure has on customer tariffs.

In recognition of these factors, the following strategies were adopted to arrive at the ‘*Submission Plan’*;

- deferral to RP6 through:
    - stretching programmes over 6 years rather than 5,
    - equalising programmes between RP5 and RP6,
    - ramping some programmes over the first 3 years of RP5 to a steady state in the latter half of RP5,
    - ramping through the 2 periods of RP5 and RP6;
- maximising further project deferral opportunities which in some cases has led to an increased requirement for Smart technology and an increased R&M burden; and
- back-ending the delivery of some major projects in RP5 and carrying over a proportion of the expenditure into RP6.

In prioritising programmes for deferral, investment drivers were a very significant consideration. In particular, protection was afforded to those asset categories where the principal driver is public safety such as replacement of undereaves conductors, LV minipillars and cutouts in domestic premises.

The resultant ‘Submission plan’ of £607m which is presented in Table 2.3 has removed a further £111m of investment, albeit with a corresponding increase in network risk.

	RP5 Reduced Plan Total £m	**RP5 Submission Plan Total £m**
ASSET REPLACEMENT	423.2	361.7
Transmission	133.8	107.4
Distribution	289.4	254.2
LOAD RELATED	105.1	90.0
Transmission	76.6	65.4
Distribution	28.5	24.6
IT & COMMS REPLACEMENT	6.8	6.8
METERING	10.2	10.4
CHANGES TO LEGISLATION	58.1	29.4
CAPITALISED OVERHEADS	29.1	27.2
CUSTOMER CONNECTIONS NET CAPEX	67.2	59.3
CUSTOMER AND GOVERNMENT PRIORITIES	18.6	21.9
OVERALL TOTAL	**718.3**	**606.6**

Table 2.3: Reduced Plan and Submission Plan (BAU)

The Submission Plan represents a significant challenge for NIE's Investment Engineers and Network Planners. It severely tests their assessment processes and their concepts on risk management and will require a very diligent regime of asset management to prevent network risk increasing to unacceptable levels.

In presenting this Submission Plan, NIE would caution strongly that any further reductions in volumes or deferral of works, will lead to increased and potentially unmanageable risk on the network and impact on NIE's ability to deliver against its stated objectives. This plan is thus deemed to be the minimal plan required to meet NIE's statutory and licence obligations alongside stakeholder and customer expectations with regard to network safety, security and performance.

Resourcing the Plan

Over previous regulatory periods NIE has sought to reduce controllable costs through efficiency programmes which included reductions in the size of the workforce. However, without significant recruitment, the age profile of the organisation has increased and that, together with the increased capital programme for RP5, now poses a challenge.

'Workforce renewal' will be crucial due to the significant ramp-up in investment and the increasing rate of retirement of our workforce during RP5 combined with a more competitive labour market and a shortage of skilled specialist labour. We estimate that we will need to recruit 675 employees over RP5. Of these, 103 need to be recruited to replace retirees, 190 to replace other leavers, 362 to meet the RP5 programme and 20 to deliver the renewables integration programme.

NIE operates succession and development from within, through career progression and filling vacancies through internal appointments. Therefore, a considerable proportion of the new employees will join as apprentices (200) and graduates (30) with significant recruitment, training and development costs. In addition, those employees who develop their skills and competence and are promoted will require further up-skilling, so that they can perform their new roles and supervise more junior staff. We have made a separate submission to the Utility Regulator on the workforce renewal costs we expect to incur in RP5.

3 INTEGRATION OF RENEWABLE ENERGY

3.1 Background

The electricity network in NI is facing an unprecedented demand for the connection of new sources of power generation. The principal driver for this demand (which arises almost exclusively in relation to wind powered generation) is Government energy policy, which has now established clear renewable energy targets for 2020. There is a strong economic incentive for renewable energy production underpinned by the Northern Ireland Renewables Obligation (NIRO), and this and other renewable energy support mechanisms are a key enabler for the delivery of Government energy policy targets for increasing the development and application of renewable energy sources in NI.

Additional generation connected at any voltage level will contribute to power flows on the transmission network. These additional connections are presenting challenges in terms of the connections themselves, and also in terms of the need to develop the backbone network to cope with significant additional west to east power flows resulting from increasing amounts of renewable generation locating principally in the west and north of the province.

3.2 The Strategic Energy Framework and Renewable Energy Targets

During 2005 the Governments of NI and the RoI initiated a joint study[6] on the impact of increased levels of renewable energy sources on the economic and technical aspects of electricity generation and transmission on the island of Ireland. The study was conducted in four phases by a range of consultants (UCD, RISO, TNEI and Ecofys). This ‘All Island Grid Study’ was completed in 2008 and showed that significant investment would be required in the electricity network. The study indicated that it is possible and economic for 42% of electrical energy needs on the island to be delivered from renewable energy sources (mostly wind). The results of this study informed the NI and RoI Governments’ respective energy policies.

The latest NI Government targets are set out in DETI’s SEF published in September 2010. The SEF requires increased levels of renewable power generation and associated new infrastructure to improve security and diversity of energy supply in NI. In addition, it sets challenging renewables targets to guide market participants, recognising that there will be cost implications in moving NI into this new energy future and the need to plan carefully to help manage and minimise the cost impact on consumers.

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[6] http://www.dcenr.gov.ie/NR/rdonlyres/1B7ED484-456E-4718-A728-97B82D15A92F/0/AllIslandGridStudyStudyOverviewJan08.pdf

The SEF establishes a target for 40% of NI's electricity consumption to be met from renewable sources by the year 2020. This is a significant increase from the previous target of 12% as set in 2004. The current level of renewable generation within NI is closer to 8%, and already there are difficulties in accommodating it on the existing network.

The 40% DETI target presents a major challenge for the future development and expansion of NIE's network infrastructure in order to facilitate increasingly high levels of renewable power generation over the next decade and beyond.

3.3 Renewable Resources

Electricity networks, like road, rail and gas infrastructure, require a long term strategy to maximise the efficiency of long term infrastructure investment. The process of planning and designing the network, applying for planning permission and building the infrastructure can take many years, and it is therefore prudent to examine long term strategic issues as a fundamental part of planning major network expansion to meet future needs. In particular in planning the network to integrate renewable generation due consideration must be given to the potential sources, their technology, location and timing.

The SEF states an expectation that the majority of the renewable energy required to achieve the 40% target is likely to come from large scale on-shore wind generation. However, off-shore wind, tidal energy, biomass fuelled generation and small scale generation will also play their part in meeting the target and will be part of the overall mix of long term resources to be accommodated in the future.

Table 3.1 sets out the capacity of renewable generation sources connected to the network as at January 2011, together with our forecast of the capacity and type of renewable generation sources that will require connection going forward.

Taken together the 2754MW of theoretical renewable energy resources in NI shown in the table can more than meet DETI's 40% target which requires some 1700MW in total by 2020. (The installed capacity needed to meet the target varies with the mix and size of renewable generators - e.g. small biomass generators might have a load factor of 0.6 whereas larger generators may have significantly larger load factor).

Energy Source	**Quantity MW**
Existing	
On-shore wind connected	340
Small scale connected	12
Future	
On-shore wind approved	452
On-shore wind in planning	720
Off-shore Tunes Plateau	300
Off-shore Irish Sea	300
Tidal at Rathlin	300
Biomass	230
Small scale	100
TOTAL MW	2754
Assessed 10 January 2011	

Table 3.1: Potential demands for connecting Renewable Generation before 2020

As explained in the following sections, the investment in the 110kV network planned for RP5 (as set out in our Medium Term Plan) will facilitate the maximum amount of onshore wind generation that can be connected without major reinforcement of the 275kV network (which drives our Long Term Plan). The investment will permit the connection of 750 to 800MW of on-shore wind by 2015/2016 - around half of DETI's 40% target.

The connection of further renewable generation in the form of onshore wind, off shore wind, tidal sources and biomass will require investment in the 275kV network. This further investment is the subject of our Long Term Plan of which the RIDP forms a key part. The investment planned for RP5 includes an indicative provision for the first step of the RIDP delivery phase which we expect will focus on strengthening the 275kV network in the west where the majority of locations for wind powered generation are apparent. The RP5 plan contains no provision for the connection of off shore renewable generation (on the north coast and the east coast) or large scale biomass. As shown later in Table 3.4, the majority of the long term RIDP expenditure will fall in RP6.

The following paragraphs provide some background to the renewable resources shown in Table 3.1.

Large Scale On-shore Wind

The first wind farm became operational in NI in 1994. As at 10 January 2011 there were 24 wind farms connected to the NIE network with a total combined output of 340MW. This level of wind-powered generation provides about 8% of the electricity consumed in NI. As at the same date a further 452MW of wind power (24 wind farms) had obtained planning approval and were awaiting connection. In addition, there are 42 windfarms in the planning system – which, together with the 24 wind farms awaiting connection, makes 66 onshore wind farms awaiting connection or still in the planning system. This amounts to a potential 1172MW still to be connected, in line with the large potential identified in resource studies.

It can be seen from Figure 3.1 below that the majority of wind farm applications are located in the north and west, in areas with higher wind speeds, but which are the most remote from major demand centres and with relatively sparse human habitation.

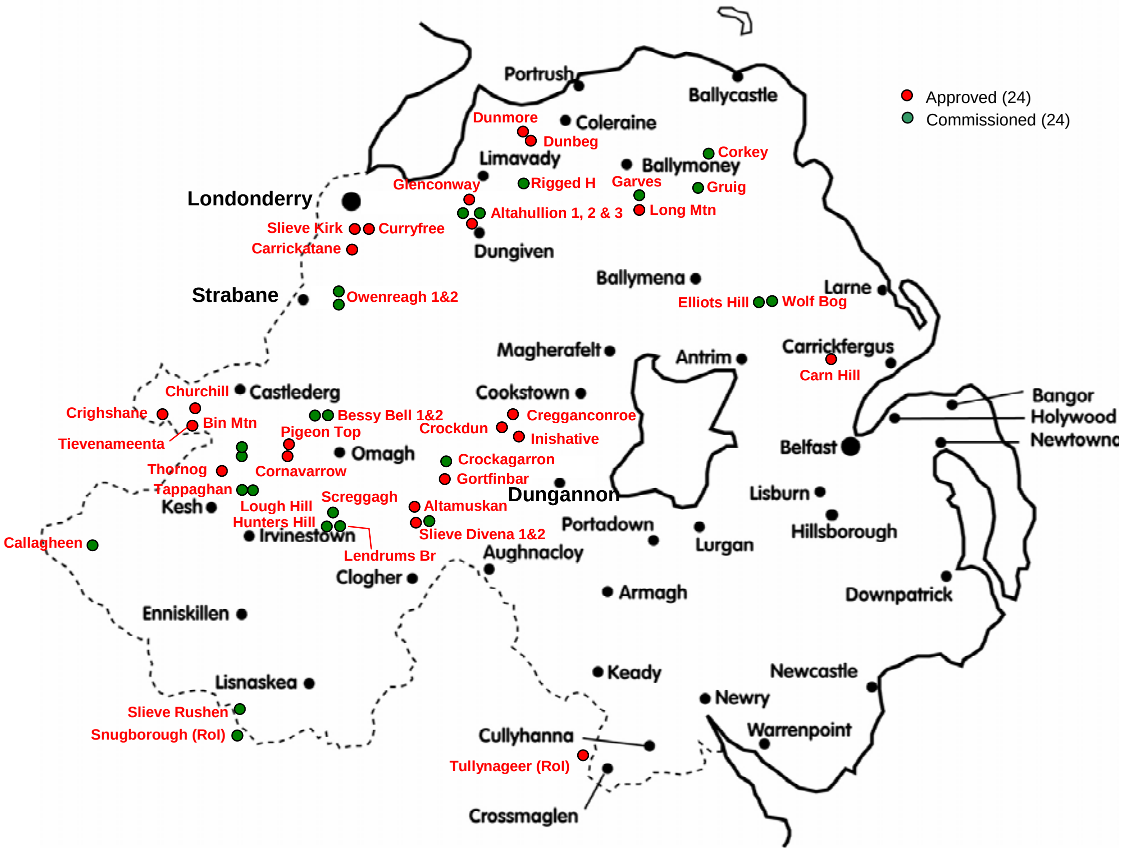

Figure 3.1: Commissioned and approved large on-shore wind farms

Almost all on-shore wind farms in NI are of a size to connect to NIE's 33kV network. For this reason the majority of wind farms have been connected using individual 33kV overhead lines. If NIE was to connect all future wind farms by this method this would lead to a large number of overhead lines crossing the landscape, often closely spaced. In order to reduce the environmental impact of these lines we have developed a system of connecting groups of wind farms into newly established 110/33kV substations or ‘hubs’. The new substations will be connecting into the transmission network with single wood pole 110kV overhead lines. Individual wind farm connections will be provided by a short 33kV overhead line or by underground cable. These arrangements are referred to as clusters and NIE envisages nine or ten such clusters to cope with the known amount of wind farms seeking planning approval.

Of course, there are still wind farms remote from other developments and these will continue to be connected using individual 33kV wood pole overhead lines.

NIE and the Utility Regulator have consulted on the method of access charging for connection to these clusters. Cluster infrastructure has a significant cost (of the order of £150m) and the objective has been to recover that cost from wind farm developers without posing a barrier to the first wind farms needing to connect. Whilst there will be an initial imbalance between the investment cost of any given cluster and the net payments received from wind farm developers wishing to connect to that cluster, this imbalance will be redressed as further wind farms connect to the clusters in future years. The proposed cluster locations are shown in Figure 3.2 below.

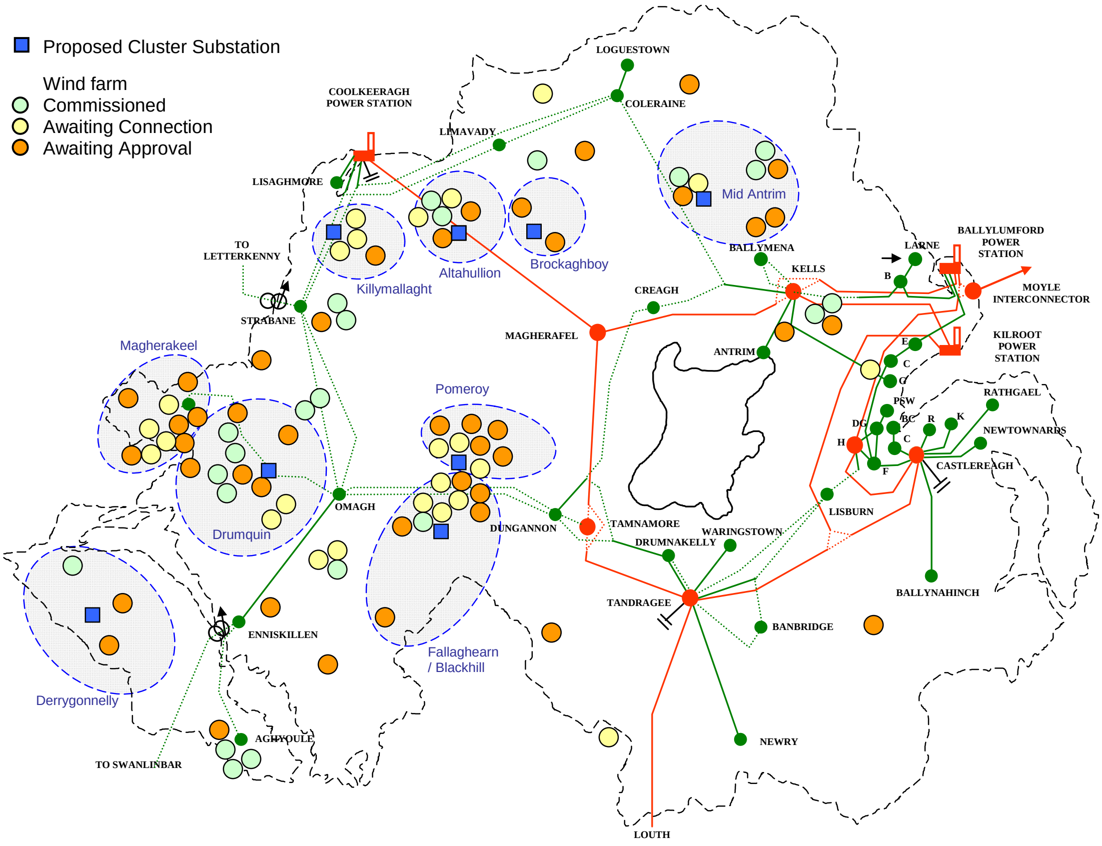

Figure 3.2: Proposed 110/33kV wind farm clusters

Offshore Energy

The Renewable Obligation Order of 2009 provides increased financial support for offshore renewable energy technologies and it is expected that this will encourage both offshore wind and tidal power around the coast of NI. Changes proposed in 2011 are expected to further support off-shore developments. The Sustainable Development Commission's Tidal Resource Assessment in 2007 shows the potential for 784MW of tidal energy off the north and north-east coast.

DETI has recently completed an off-shore Strategic Environmental Assessment (SEA) which highlights opportunities to exploit up to 1200MW of off-shore energy. This is made up of 300MW of tidal energy mostly in the north and north east coastal areas, a further 300MW of off-shore wind energy around Tunes Plateaux, and up to 600MW of off-shore wind energy off the east coast close to the border with RoI near the mouth of Carlingford Lough.

NIE has advised DETI that it will be a very significant challenge to connect as much as 600MW of potential east coast off-shore generation to the NIE network because this would require additional major electrical circuits traversing the Mourne Mountains. In Table 3.1 we have assumed only 300MW of east cost off-shore generation will be developed. The location of potential off-shore energy is shown in Figure 3.3 below.

Biomass / Energy from Waste

There are a number of commercially attractive approaches to electricity generation from wood. Wood can be burnt either alone or in combination with other fuels in traditional power stations. Smaller scale generation can use wood or the parts of trees not suitable for the commercial applications. Sites of existing or demised power stations have the coastal and electrical infrastructure to facilitate biomass generation. The map (Figure 3.3) below shows existing or demised power station sites where biomass generation could be viable. It is also possible to coppice crops like willow and use the prunings every few years. In general unless generation is located close to coastal routes or very large forest masses, the generation will be small scale and local.

Farming animals and birds produces a variety of bi-products. Traditionally these have been spread to enrich soils used for crop production by adding nitrogen, but European Directives limit nitrogen escape to water courses and therefore farmers are seeking alternative ways to use waste products. Generation of electricity is possible using a variety of approaches, including bacterial digestion of the solids. This produces methane gas which can be used as a fuel for electricity generation.

In Table 3.1 we have assumed up to 230MW of large scale biomass generation in the locations shown in Figure 3.3. The additional potential for small scale biomass is described more fully in the section on small scale generation.

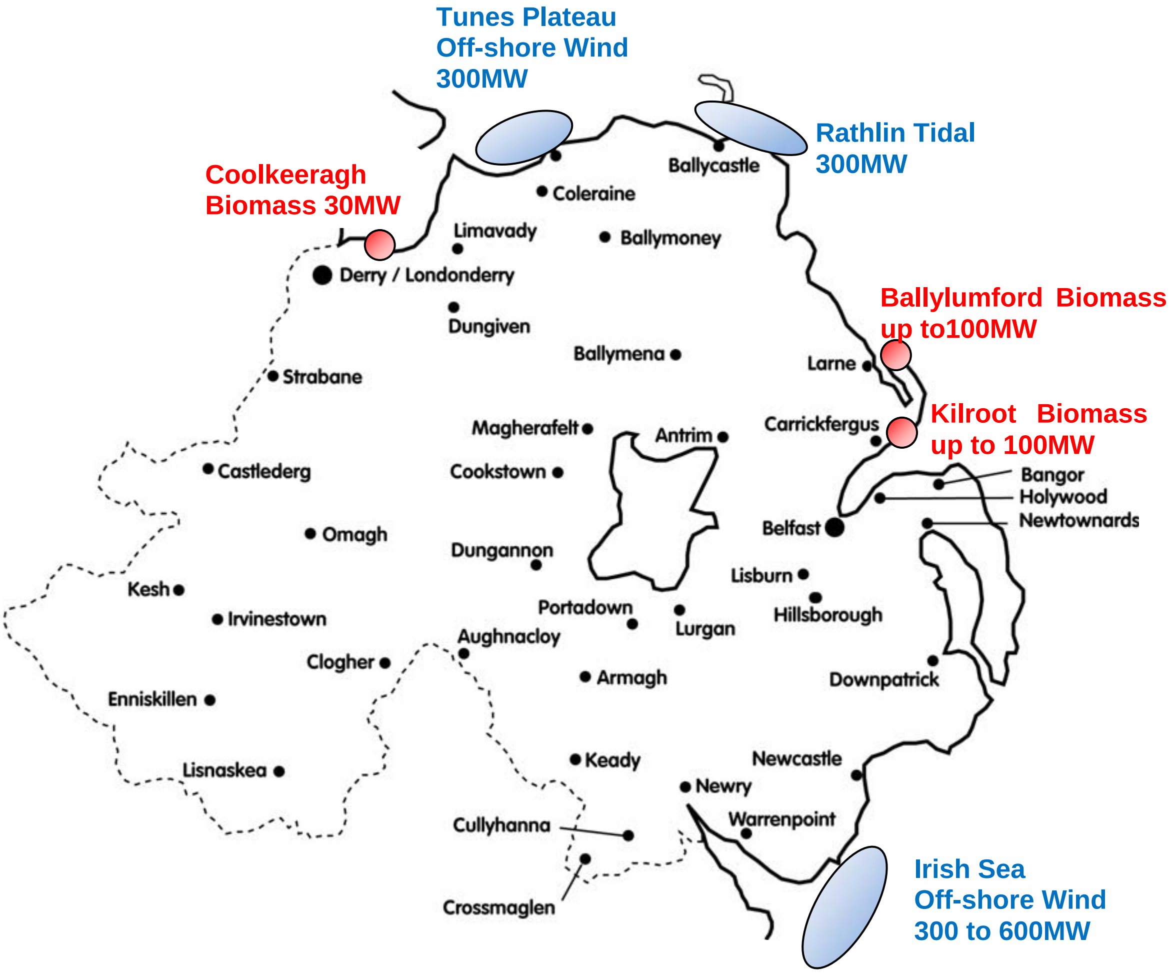

Figure 3.3: Location of potential off-shore and biomass generation sites

Small Scale Generation

The UK and the NI governments have strongly incentivised small scale generation (less than 250kW). This has stimulated a very large interest from farmers and others throughout NI who now wish to become small scale electricity producers.

The majority of applications to date have related to small wind turbines (120 to 250kW) but it is expected that as technology improves and additional incentives are applied there will be considerable interest in production of energy from biomass and farm waste. It should be noted that the load factor of small scale wind generation is less than large wind generators because the hub height is lower. Surface features "spoil" the wind so that small scale generators might have a load factor of less than 20% depending upon location (compared with 30-35% for large scale wind). In comparison, large scale biomass might have a load factor of 60% depending upon the availability of the fuel.

Each application to NIE for connection to the system needs to be accompanied by a valid planning consent for construction of the facility.

It is not simple to connect these generators to our 11kV distribution network, which was designed to supply load rather than to export generation. Consideration is required as to what degree it is a public good to extend the capability of that network such that it would facilitate the distributed connection of small scale generation. Large scale replacement of single phase rural networks with three phase heavier construction would be expensive and would take considerable time, but may offer opportunities and reliability benefits to all network users.

It is expected that if the present trend of applications to the Planning Service continues, then some 300MW of small scale wind and biomass generation could seek terms for connection before 2020. However, unless the Utility Regulator determines that the costs of network enhancement (as described above) should be spread across all network users as a common good, then the connection charge will in many cases be prohibitive, and it may only be economic for a small portion of the consented small scale generation to proceed with actual development and connection. We have presumed that 100MW in total might be connected in line with present connection charging policy. However, owing to the prevailing uncertainty in this area, our plans do not currently include any provision for expenditure associated with extending the existing network capability to facilitate the connection of small scale renewables.

Renewables beyond 2020

International agreements such as the Kyoto Protocol recognise the need for ambitious long term targets to reduce carbon dioxide emissions. The UK 2008 Climate Change Act set a target to reduce carbon dioxide emissions by 80% from 1990 levels by 2050.

It seems reasonable to assume that post the SEF 2020 targets there will be continued growth in renewable energy particularly offshore. The planning and design of the grid will be reviewed in the future when the government sets further energy and renewable energy targets.

3.4 Network Reinforcement

All-Island Grid Study

The All-Island Grid Study was completed in 2008. It was the first comprehensive assessment of the electrical network on the island of Ireland with large amounts of renewable energy. The study assumed six scenarios of renewable energy on the island of Ireland, varying from 17% to 54%. The study reported that some 198km of new transmission network (110kV and 275kV) was likely to be required in NI to accommodate up to 42% of power generation from renewable sources. The grid study also identified that some 1500km of network connection would also be necessary to connect renewable generation plant to the closest 110kV network nodes. At the moment the precise quantities are less important than drawing attention to the scale of work needed.

The study showed that in NI, with the smallest renewable energy scenario of 17%, the existing Omagh to Dungannon transmission line became overloaded. With the highest level of renewable energy used in one of the study scenarios, that is 54%, the majority of the 110kV circuits in a ring from Dungannon to Kells via Omagh, Strabane, Coolkeeragh and Coleraine, became overloaded indicating significant reinforcement in all these areas would be required.

Reinforcement Strategy

Substantial network reinforcement is required to accommodate the government's renewable energy targets. A balance has to be struck between the costs to customers of the network reinforcement, its reliability and its impact on the environment. Planning a network over a time frame to 2020 / 2025 allows the most efficient, affordable, reliable and environmentally sensitive network to be developed.

NIE recognises that there is particular concern about the visual and landscape impact of new transmission infrastructure and endeavours to reduce this impact (whilst maintaining a balance with cost and reliability) by minimising the length of new overhead lines through a mix of the approaches described below:

> *Up-rating.* Much of the existing transmission system was built over 30 years ago, and technological advances in new metals and manufacturing techniques have given rise to high capacity conductors. For example, replacing aluminium/steel overhead line with visibly similar, modern conductors, can add at least 50% to the capacity of an overhead line. There are two issues with up-rating. Firstly, removal of the circuit from service for the work for long periods may temporarily reduce network reliability. Secondly, there is a limit to the transfer of power which can be stably managed on very few circuits. Thirdly, market constraint costs will be high when taking existing, well utilised circuits out of service.
>
> *Increasing voltage.* The refurbishment of existing lines by increasing the voltage brings significant increases in capacity, for example an increase from 110kV to 275kV can increase capacity by up to 300%. However, this type of refurbishment of overhead line may require a change from wooden poles to steel lattice towers.
>
> *Double circuits.* An increase in capacity can be obtained by replacing a single circuit with a double circuit. This is somewhat less reliable than having two separate lines but avoids building a new line on a separate

route. In NI this only applies to the 110kV system because the existing 275kV system is wholly double circuit.

The environmental impact of new overhead lines can be mitigated by carefully locating individual supports and through the use of new smaller, less visually obtrusive overhead line tower designs.

It should be noted that there are no current plans to upgrade or reinforce the 11kV network to provide for the expanded connection of small scale renewable generation.

Licence Standards and the design of Wind Farm Connections

The transmission planning licence standards establish technical guidelines for designing the electricity network to provide established levels of electricity supply security. The backbone transmission system is designed to ensure that sources of generation are securely matched to centres of demand under a variety of circumstances, and in many cases these standards require the use of multiple circuits in order to maintain the required security levels.

Wind farms are by their nature very different from the traditional sources of generation around which the design standards were initially created. They are in general smaller, more widely distributed, and operate at far lower load factors owing to wind intermittency. In designing the approaches to the connection of wind farms, NIE has generally taken a view that wind farm clusters are unlikely to extend beyond 200MW per cluster, and can therefore be connected by a single link to the transmission system.

Construction Technology

It is standard practice to use overhead line in transmission networks around the world. AC lines are used unless the length of the line is very long (several hundreds of km, when the cost of electrical losses requires consideration of DC technology). At transmission voltages such as 275kV only 1.9%[7] of the transmission network in Europe is underground cable, the remainder is overhead line. The main reason why underground cable is used so infrequently is because it has a high cost and poor technical performance compared to overhead line.

The higher the operating voltage the stronger the case for choosing overhead line technology instead of cables. Extra high voltage cables are generally only considered in certain limited circumstances and usually applied only in relatively short lengths, notably, urban areas, areas with multiplicity of overhead lines or in areas of special scientific interest or outstanding natural beauty.

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[7] Comparison of High Voltage Transmission Options – Cavan-Tyrone and Meath-Cavan 400kV Transmission Circuits. Parsons Brinckerhoff for NIE and Eirgrid.

Underground cables on land have many joints because less than 1km of one phase can be transported on the road network. Cables laid underwater can be in long lengths because they are continuously laid from a ship.

The studies we are undertaking for renewables integration will seek to recommend a scheme which matches Minister Foster’s brief to achieve the grid integration of the target amount of renewable energy as economically as possible. The studies will have a very high regard for the environmental impacts and will seek to balance stakeholder views in this regard.

3.5 Grid Development Strategy

The circumstances described in earlier parts of this section demonstrate the considerable degree of uncertainty that exists in regard to the location, timing and nature of renewable generation developments over the coming years that will seek network connections. However, it is fundamentally apparent that infrastructure development is required. There is no “do nothing” option.

Examples of uncertainty are as follows. There is an observed high level of current demand for the connection of on-shore wind powered generation in NI, but with uncertainties around which of the individually proposed wind powered projects will eventually achieve planning consent, and when. Also, as mentioned above, studies by DETI have demonstrated the possibility of future off-shore / marine energy resources that may bring demand for the connection of up to a further 1200MW of generation, but there is no immediate evidence of these potential developments becoming a reality. In addition, there is a recognised possibility that a significant level of biomass fuelled power generation sources may be developed in the future, but no evidence so far of real commercial interest in this prospect. And furthermore, there is a currently fast rising number of planning applications being made for the development of small scale, more widely distributed renewable generation, but considerable uncertainty exists about how many of these projects will be able to meet the practical costs of a safe and acceptable connection to the electricity network.

Faced with these high levels of uncertainty, NIE recognises the need to plan and develop its electricity network in a balanced fashion that recognises the need to encourage and support the widest practical range of new renewable generation developments, whilst also limiting the possibility of building excessive infrastructure that would be under-utilised in the future. This is not an easy balance to strike, given the levels of uncertainty noted above and the fact that major transmission infrastructure can take many years to deliver. For this reason, NIE particularly welcomes the opportunity to engage with a wide range of stakeholders on the issues affecting the strategic choices that must be made in this context. NIE is convinced that, difficult as they are, these choices have to be made reasonably quickly in order to provide the economy of NI with the greatest potential for development and for future growth.

NIE’s response to the challenge of renewables integration has been to develop, and propose for RP5, a coordinated network development plan incorporating a combination of short, medium and longer term measures designed to increase the capacity of the network to accommodate renewable generation sources over the coming years. The shorter term measures are focused on increasing the capabilities of the existing network. Medium term measures will require a phased series of 110kV network reinforcements to increase capacity and to remove “bottlenecks”. The longer term plans will require substantial expansion of the 275kV transmission grid system, and the proposed 400kV Tyrone to Cavan Interconnector will enable the overall plan by forming a critical second interconnection between NI and the RoI. Many of the shorter term measures are already complete or underway, whilst medium and longer term measures are in various stages of development.

NIE’s proposals for the RP5 period include a detailed Capital Expenditure Plan for Renewables Integration that has been established to cover all of the proposed new investment activity related to the 2012-2017 period. The plan sets out the predicted levels of demand for the connection of renewable generation throughout the period, the effect that these additional connections will have on the transmission network, and the steps that NIE intends to take to provide for these new grid connections in a timely fashion.

In addition to the strategically significant need for construction of the planned Tyrone – Cavan Interconnector (see Section 4 below) a major element of NIE’s longer term plan is based upon the Renewable Integration Development Project (“RIDP”). The RIDP is currently searching for viable long term solutions for a major expansion of the 220/275kV transmission system in the north and west of the island. The RIDP planning is based upon a range of future renewable generation scenarios that have been established and tested with the assistance of international consultants and peer reviewers. Detailed technical and environmental studies are already underway, and these will be supplanted by stakeholder consultation in the near future. When a viable solution emerges from this process then it will be further developed and tested by the rigour of detailed environmental impact assessment and further detailed public consultation before any eventual submission to planning authorities.

Other aspects of NIE’s longer term planning include the recognition of additional scenarios for further and more extensive off-shore power generation in the north and the east, the possibility of biomass fuelled power generation potentially located on brown-field sites in the east, and the impacts arising from distributed and aggregated small scale power generation connected to the distribution system.

NIE’s RP5 Plan includes sample estimated costs for one of the possible RIDP solutions. However, it is important to note that actual RIDP developments and costs will be dependent upon conclusions to be drawn from the ongoing process, and which will be presented to the Utility Regulator for specific approval at a later date.

Further key elements of the short, medium, and long term plans are described more fully below. The overall objective of NIE's capital expenditure plan for renewables integration is to provide an ordered and co-ordinated set of transmission developments that are each critical to the managed expansion of NIE's network capability - as part of an overall objective to facilitate Government renewable targets as quickly as possible.

Short Term Plan

The short term plan sets modest targets for increasing capacity on the most constrained parts of the network by developing and applying Smart techniques. One example of this is the application of dynamic line ratings, which permit increased power flow on overhead conductors under certain conditions – most notably windy conditions – and which therefore provide increased network connection capacity for wind related power generation projects. This work is now almost complete, and has enabled NIE to maximise the utilisation of its existing assets and to therefore limit the need for additional new infrastructure development. The programme has also enabled an expansion of NIE's knowledge and understanding of proven techniques that will be beneficial in the future.

Medium Term Plan

The medium term plan for 110kV network reinforcement (along with the development of wind farm clusters) is intended to achieve the maximum connection capacity that can be delivered without building additional 275kV transmission grid network. The medium term plan is critical to the near term expansion of renewable generation capacity in NI, and is therefore an important immediate focus for NIE.

NIE believes that the medium term plan can deliver the network reinforcements required to permit the connection of 750 to 800MW of wind powered generation to the network by 2015/16. This will permit some 18 to 20% of electricity in NI to be derived from renewable power generation sources, representing a move approximately half way towards meeting the 40% target set by Government for 2020.

NIE will ensure that the medium term plan is compatible with longer term plans. This means that NIE will minimise, to the greatest extent practicable, any expenditure on 110kV developments that will no longer be necessary when major new developments are eventually delivered under the longer term major transmission system plan. However this will not preclude expenditure on the 110kV network that provides an economic benefit in delaying 275kV reinforcement.

The tables set out below show the various 110kV projects that have been identified as forming the components of the medium term plan (as applicable within the RP5 period) and which have been described to the Utility Regulator in detail as part of the RP5 submission. The first table describes projects relating to proposed reinforcement works on the 110kV transmission system, and the second table lists the nine separately identified 110kV clusters that are currently proposed to facilitate the grouped connection of wind-farms as described above.

Project	Overview of Work	Expected Completion	Estimated Cost £m[8]
Tamnamore Phase 2.	Install a second transformer and connect six 110kV circuits	2014/15	21.74
Dungannon to Omagh A&B Phase 2	Up-rate existing line to 200MVA	2012/13	1.63
Kells to Coleraine Phase 1	Up-rate existing line to 200MVA	2012/13	2.30
Tamnamore to Omagh new circuit.	New 200MVA 110kV circuit	2013/14	14.35
Kells to Coleraine Phase 2	Up-rate existing line to 200MVA	2014/15	2.87
Kells to Coleraine Phase 3	Up-rate existing line to 200MVA	2014/15	1.43
Omagh to Enniskillen A&B	Up-rate existing line to 200MVA	2014/15	6.70
Coleraine to Limavady	Up-rate existing line to 200MVA	2014/15	2.00
Coolkeeragh to Limavady	Up-rate existing line to 200MVA	2014/15	2.00
Limavady Substation	Connect the existing Coolkeeragh to Coleraine circuit into Limavady	2015/16	11.48
Coolkeeragh to Coleraine	Up-rate existing line to 200MVA	2014/15	3.83
Total			**£70.33m**

Table 3.2: 110kV Projects proposed within the Medium Term Plan for RP5

Cluster	Estimated Cost
Magherakeel	£18.9m
Killymallaght	£3.3m
Fallaghearn	£6.2m
Pomeroy	£6.2m
Mid Antrim	£8.5m
Altahullion	£9.4m
Drumquin	£9.4m
Brockaghboy	£13.1m
Derrygonnelly	£9.9m

Table 3.3: 110kV Clusters proposed within the Medium Term Plan for RP5

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[8] RP5 costs are stated in 2009/10 prices.

As explained in section 3.3 above, the net expenditure on cluster establishment at any given point in time is highly dependent upon the timing and extent of individual wind farm developments connecting to any given cluster. The costs set out above are currently estimated total costs for the shared assets applicable to each cluster. As wind farm developers connect to each cluster, they each bear the whole cost of their own unique connection and additionally contribute toward the "shared asset" in proportion to their use of the overall design capacity of the asset. Thus, these shared asset costs will be offset by developer's contributions over time as and when additional wind farms are connected. The total net costs to be expended within the RP5 period, after taking account of estimated receipts from developers, are estimated to be £17.59m, but the net costs actually expended may vary substantially since the estimate is dependent on which wind farms actually come forward for connection and when. All cluster expenditures will be subject to specific regulatory approval as and when they occur.

Long Term Plans and RIDP

As described above, the major element of NIE's long term plan is built upon the RIDP, which has the overall objective of identifying transmission development options to accommodate increasing levels of renewable generation (primarily on-shore wind generation) which are anticipated in the north west of NI and in County Donegal in the RoI (collectively known as the "North West").

The RIDP project group is a joint collaboration between NIE, SONI and EirGrid. The initial study phases of the project are funded by a combination of EU funds and agreed regulatory allowances.

NIE's primary objective within the RIDP is to examine the further major transmission system investment needed beyond the 110kV Medium Term Plan in order to achieve the 40% renewable target. The RIDP is being completed in five distinct phases.

The first phase was an initial screening and technical scoping study, which also investigated the geographic boundaries within which efficient network developments could be planned. This phase has been completed.

The second phase of the work was carried out in two stages. The first of these was a high level technical and environmental study, incorporating the consideration of significant environmental constraints within the overall identification of a range of broadly feasible options for expansion of the transmission system. In the second stage, these identified options were optimised with local knowledge and emerging wind farm locational guidance to develop a range of transmission reinforcement schemes that are each capable of performing electrically, but which require further economic and environmental study for identification and separation of the best overall choice.

The third phase is currently underway and will be completed in 2011. It will consider all of the issues that are needed to reduce the options to a single “preferred option” and in so doing will seek to balance the key elements of technical performance, environmental impact and cost to achieve the best overall choice for future development. Phase 3 will include a wide range of stakeholder participation as part of the overall selection process.

The fourth phase will advance the selected option into detailed pre-construction development, and will involve (for each separately identified component project) detailed engineering design and route selection, comprehensive community consultation, detailed Environmental Impact Assessment (EIA), submissions for planning approval, the procurement of land-owner consents for construction, and the identification of firm construction costs ahead of the final construction phase.

The RIDP development process is summarised below.

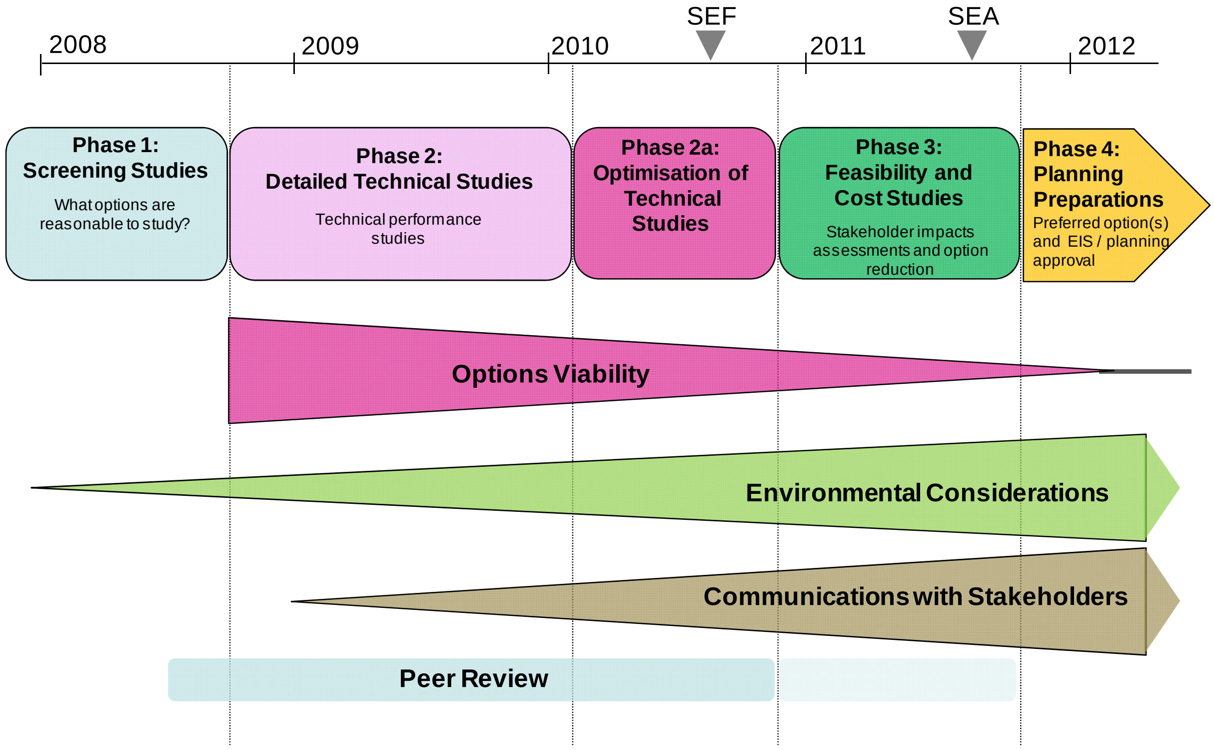

Figure 3.4: RIDP Process

The projects that make up the finally selected RIDP solution will not be developed in detail until after Phase 3 has been concluded. However, for indicative and budgetary purposes an indicative list of projects required to deliver a typical solution consisting of AC overhead lines only is presented in Table 3.4 below. These costs are based on high level menu pricing using assumed line lengths and substation positions, but will be updated and closely defined for presentation to, and approval by, the Utility Regulator as part of the fourth phase of RIDP activity.

Project	**Projected Capital Expenditure £m**							
	RP4	**RP5**					**RP6**	**Total**
		12/13	**13/14**	**14/15**	**15/16**	**16/17**		
Turleenan to Border new 275kV single circuit	0.05	0.05	0.51	0.76	16.87	25.31	42.19	**85.74**
2x 275/110kV substations	-	0.24	0.66	0.87	16.72	25.08	41.80	**85.37**
Coolkeeragh to Strabane New 110kV line	-	0.10	0.39	0.61	6.89	10.33	-	**18.32**
Coolkeeragh to Strabane C Up-rate	-	-	-	-	0.38	0.56	2.68	**3.62**
Border to Coolkeeragh new 275kV single circuit	-	**-**	**-**	0.10	0.48	0.76	68.2	**69.54**
Kells to Coleraine new 110kV circuit	-	0.10	0.39	0.61	7.75	10.33	7.75	**26.93**
Kells to Coleraine 2x 275kV circuits	-	**-**	**-**	**-**	0.10	0.39	121.15	**121.63**
Total	**0.05**	**0.48**	**1.94**	**2.95**	**49.18**	**72.76**	**283.77**	**411.13**
		RP5 Total = £127.32m						

Table 3.4: Projected capital expenditure (Renewables Integration)

A further significant element of the long term plan is the need for construction of the Tyrone – Cavan Interconnector (see Section 4 below), the presence of which is fundamental to the performance and delivery of the wind powered renewable generation scenarios that have led to the development of the RIDP.

Other aspects of NIE's long term planning outside of the RIDP are heavily dependant upon the need to connect additional off-shore wind power and tidal energy. This area is more complex in decision making terms, because the timing uncertainty is greater and marine options bring increased infrastructure costs. NIE's long term planning in this complex area will continue to emerge as circumstances develop.

Connection of Off-shore Generation - North Coast

The backbone network development required for on-shore wind is included in RIDP, however there may be additional challenges associated with collecting large amounts of off-shore generation at the coast and connecting it to the nearest strong point on the NIE network.

When tidal energy does come forward in more than experimental quantity, it will also be necessary to connect this to the network.

Owing to the inherent uncertainties involved, including the development timescale for the 275kV infrastructure that will emerge from the RIDP process, NIE has made no specific long term plan or indicative capital estimate for this category of work. Accordingly, the capital investment costs that may be associated with the connection of off-shore generation on the north coast have not been included in the RP5 submission.

Connection of Off-shore Generation East Coast

It is possible that some level of off-shore wind energy development will be undertaken off the East cost between about Gun’s island and the mouth of Carlingford Lough. The pace of that development is uncertain and the appropriate infrastructure development will depend upon the location of the developments.

If the development occurred close to Carlingford Lough it would seem sensible to extend the network from Newry whereas if it occurred closer to Strangford Lough it might be more appropriate to develop network from Ballynahinch. Again the size of developments is a significant variable, and because of the level of uncertainty involved, NIE’s submission for RP5 has not included capital investment estimates for the connection of off-shore generation on the east coast.

Large Scale Biomass Connections

The RIDP study scenarios include a small amount of biomass generation (30MW as shown in Figure 3.3 above) within the RIDP study area (north and west) but at this point make no provision for the possibility of the larger scale biomass power generation on the east coast. If developments of this nature emerge then they will be treated as normal large generation connections, and NIE does not envisage a substantial difficulty in making the appropriate infrastructure provisions to accommodate additional generation of this nature. However, and again owing to the uncertainties involved, NIE’s submission for RP5 has not included capital investment estimates for the connection of large scale biomass generation on the east coast.

Reactive Power

Traditional generators produce both active (or real) power and reactive power. Reactive power supports stable voltage conditions across the network. A certain amount of reactive power is needed all the time (static conditions) and rather more is needed during and after a system disturbance (dynamic conditions). If the future dispatch of power generators changes, as might be expected, to favour a significantly increasing proportion of wind powered generation, then there will be a corresponding need to invest in reactive compensation devices to adjust either the static or dynamic reactive power conditions on the network.

NIE plans to add about 300MVAr of reactive power compensation to the transmission network during RP5. This compensation equipment will more than double the capacity of similar equipment already connected to the network, and will be located at NIE substations and generally connected at 110kV. Any extensions to substation sites to facilitate this will be subject to appropriate consents. A provision of £28m has been made for this type of investment within the RP5 BAU capital expenditure plan, but if studies associated with the RIDP demonstrate the need for further provision, then appropriate regulatory approval for additional expenditure will be sought at the relevant time.

3.6 Overall Expenditure on the Renewables Integration Programme for RP5

Overall net expenditure forecast for the RP5 period is shown in the table below.

Medium Term Plan	£70.33m
Clusters (Net)	£17.59m
RIDP	£127.32m
TOTAL	**£215.24m**

Project	**RP5**					**Total**
	12/13	**13/14**	**14/15**	**15/16**	**16/17**	
MT Plan						
Tamnamore Phase 2.	10.91	7.65	3.18	-	-	**21.74**
Dungannon to Omagh A&B Phase 2	1.63	-	-	-	-	**1.63**
Kells to Coleraine Phase 1	2.30	-	-	-	-	**2.30**
Tamnamore to Omagh new circuit.	5.74	8.61	-	-	-	**14.35**
Kells to Coleraine Phase 2	0.19	1.34	1.34	-	-	**2.87**
Kells to Coleraine Phase 3	-	0.10	1.34	-	-	**1.43**
Omagh to Enniskillen A&B (Option 2)	1.72	3.25	1.72	-	-	**6.70**
Coleraine to Limavady	0.10	0.95	0.95	-	-	**2.00**
Coolkeeragh to Limavady	0.10	0.95	0.95	-	-	**2.00**
Limavady Substation	0.77	1.82	4.50	4.40	-	**11.48**
Coolkeeragh to Coleraine	0.19	1.82	1.82	-	-	**3.83**
Cluster Plan						
All Wind Farm Clusters	0.16	1.63	1.25	6.19	8.36	**17.59**
RIDP						
Turleenan to Border new 275kV single circuit	0.05	0.51	0.76	16.87	25.31	**43.50**
2x 275/110kV substations	0.24	0.66	0.87	16.72	25.08	**43.57**
Coolkeeragh to Strabane New 110kV line	0.10	0.39	0.61	6.89	10.33	**18.31**
Coolkeeragh to Strabane C Up-rate	-	-	-	0.38	0.56	**0.94**
Border to Coolkeeragh new 275kV single circuit	**-**	**-**	0.10	0.48	0.76	**1.34**
Kells to Coleraine new 110kV circuit	0.10	0.39	0.61	7.75	10.33	**19.18**
Kells to Coleraine 2x 275kV circuits	**-**	**-**	**-**	0.10	0.39	**0.49**
Total	**24.30**	**30.07**	**20.00**	**59.78**	**81.12**	
	RP5 Total = £215.24					

Table 3.5: Estimated Phasing by Year (Renewables Integration)

4 ADDITIONAL INTERCONNECTION

This section of the paper briefly describes one highly significant transmission infrastructure project that has been designed to increase transfer interconnection capacity between the electricity networks in NI and the RoI from about 450MW to 1500MW.

The 400kV Tyrone – Cavan Interconnector project was initially foreseen primarily as an instrument for achieving competitive market facilitation by removing the current constraint in transfer capacity between the two separate networks. However, in recent times its secondary advantage – that of facilitating the expansion of renewable energy – has become of increasing importance because additional interconnection capacity is critically required for the secure operation of an interconnected network with an increasing proportion of wind powered generation.

The Tyrone – Cavan Interconnector is therefore now urgently required as a central element of NIE's plan for the facilitation of renewable energy targets. It is expected that NIE's participation in the project will require a capital investment of £84m.

4.1 The Proposed Tyrone - Cavan Interconnector

The proposed Interconnector is an infrastructure development of long term importance for NI, and will deliver specific benefits for electricity customers in the following key areas:

Improving competition: by exerting downward pressure on electricity prices by reducing transmission system constraints that are currently restricting the efficient performance of the all-island Single Electricity Market (SEM);

Supporting the development of renewable power generation: by enhancing the flexible exchange of power flows over a large area of the island. This will enable the connection and operation of larger volumes of renewable power generation (especially wind powered generation) throughout the island; and

Improving security of supply: by providing a dependable high capacity link between the electricity transmission systems of NI and the RoI.

The project as proposed by NIE and described in this section, forms the NI portion of the "Tyrone to Cavan Interconnector", a major cross-border electricity transmission infrastructure project which is being jointly developed by NIE and EirGrid. The proposed Interconnector is a large unique project involving the development of a new 275/400kV substation at Turleenan (near Moy) and the construction of a new 400kV single circuit overhead line for a distance of some 34km to a point where the proposed new overhead line crosses the border with the RoI before continuing on a route being proposed by EirGrid within the RoI.

The new interconnector has been specifically designed to operate as a normal synchronous AC circuit within the overall “all-island” electrical power system, and this duty is a central feature of its purpose.

The circumstances and details surrounding the design and development of this important project are set out within an Environmental Statement published by NIE for the purposes of a planning application made in December 2009, and which application remains subject to ongoing due process within the DOE.

The Minister for the Environment announced a Public Inquiry on 18 August 2010 and NIE understands that a public inquiry will not be held until late 2012. Owing to the need for wayleaving matters to conclude after all relevant planning approvals are obtained, a “clear to construct” consent is not at this stage expected before the end of 2013. This includes, inter alia, planning and landowner consent both in NI and RoI with subsequent NIE and Utility Regulator financial approval for the associated investment. Based on a three year construction programme, project completion is not expected before the end of 2016.

A capital expenditure budget of £84m (in a 09/10 price base) for the delivery of the NI elements of the project has been estimated based on €180m (06/07 prices) budget for the total project with NIE and EirGrid sharing the costs equally. c £76m is included in the plan for RP5.

The projected phasing of expenditure is detailed in the table below.

Project	**Projected Capital Expenditure £m**						
	RP5					**RP6**	**Total**
	12/13	**13/14**	**14/15**	**15/16**	**16/17**		
Interconnector Construction	-	11.11	21.62	21.62	21.62	8.11	**84.08**
	RP5 Total = £75.97m						

Table 4.1: Projected capital expenditure (Interconnection)

5 OVERALL RP5 PLAN

The overall capital investment proposed for RP5 is as follows:

Business as Usual	£607m
Renewables Integration	£215m
Interconnection	£ 76m
Total	**£898m**

The figures provided in this paper are stated in 2009/10 price base. We expect that certain input costs will rise faster than RPI and an allowance will be needed to cover 'real price effects'. We have made a separate submission to the Utility Regulator on this.

We are conscious of the need to minimise the impact of our investment on network prices. To that end we will continue to seek improvements in our asset management and project delivery processes. The improvements we have secured in the past have enabled us to deliver recent capital programmes very efficiently with unit costs consistent with leading industry-wide performance. We believe that stronger incentives to encourage further efficiencies through innovative approaches such as the application of smart technologies are appropriate for RP5 and we have made proposals to the Utility Regulator. We have also proposed a mechanism for managing the uncertainty associated with the renewables integration plan - essentially by seeking regulatory approvals on a project-by-project basis, with appropriate incentives. In addition, we will work with the Utility Regulator to develop practical methods of measuring the outputs to be delivered through the investment programme, whilst retaining flexibility in its implementation. Finally, we will continue to report regularly to the Utility Regulator on progress in delivering the capital programme once the RP5 price control has been agreed. These elements are discussed further below.

5.1 Asset Management and Programme Delivery Initiatives

NIE continually seeks to identify innovative approaches and efficiencies in the identification of the optimal capital programme. We do this by implementing improvements in our approach to the appraisal of network risk and by gaining a better understanding of the condition of the asset base (driving asset replacement priorities). In addition we work towards improved assessment of the constraints in the capacity and configuration of the network (driving load-related investment priorities); and we seek minimum cost solutions to specific network needs.

The improved quantification of risk allows both the prudent deferral of investment along with more effective targeting of the available capital. We have developed asset risk models to rank the investment needs of each transmission and primary distribution substation according to the probability and consequence of equipment failure. Furthermore, the utilisation of real time information collated from the network control system database has significantly improved our understanding of load-related risk, allowing improved prioritisation of associated investment.

Savings are also pursued through continuous improvements in each of the phases of the project delivery process as follows:

- project design – in RP4 we introduced an enhanced project design process which ensures projects are more thoroughly assessed, designed and costed prior to project approval;
- project planning – all planning and consent information is determined and assessed in a timely manner;
- project delivery – there is a strong focus on minimising network outages, the efficient deployment of resources and cost control;
- project closure and reporting – we look for timely closure of completed projects, updating of records and reporting of outputs and costs; and
- investment appraisal – investment programmes and all individual projects in excess of £250k are subject to post investment appraisal.

These processes seek to reduce all aspects of cost i.e. labour, material and bought in service costs: reductions in labour costs are achieved through the continued focus on productivity and unit costs and reductions in material and bought in service costs come from savings delivered through our procurement processes. This is being done against the background of increases in worldwide commodity prices.

The success of these initiatives is measured in part by the results of the recent benchmarking we have undertaken as explained in the next section.

5.2 Benchmarking and input costs

Parsons Brinckerhoff Ltd (PB) was appointed by NIE to undertake a benchmarking exercise of the unit costs on which NIE's RP5 submission is based. Unit costs were compared for overhead lines, underground cables, transformers, substation ancillary items, switchgear and secondary distribution at the various voltage levels.

PB's report confirms that NIE's capital expenditure in 2009/10 was delivered at unit costs consistent with leading industry-wide performance. In particular, NIE's unit costs are generally lower than both the values published by Ofgem and the GB distribution companies' average values. Specifically NIE's unit costs were below benchmark for 83% of benchmarked categories. Where NIE's unit costs were above benchmark, there was typically an obvious explanation arising from differences in the presumed scope of work and specification. PB's work also assessed NIE's tree cutting costs (an important element in our overhead lines programmes) and found them to be the third lowest of the UK DNO group and approximately half the average cost.

5.3 Incentives

Incentives have been applied successfully to numerous network monopoly businesses around the world for many years and have delivered material benefits to customers. However the capex arrangements in place for RP4 place relatively weak incentives on NIE to develop innovative approaches that could aid the delivery of capex programmes at lower cost to customers.

Capex incentives for RP5 should be widened to encourage further efficiencies through innovative approaches such as the application of smart technology. We have developed proposals for an alternative framework for capex incentives during RP5, which we have termed the “three pot model”. This model involves NIE bearing a set proportion of under spend or over spend relative to the allowance for “business as usual” (BAU) capex, in order to encourage efficiencies through innovative approaches such as smart technology. Under our proposal, capex activities are grouped according to their “certainty” at present, with different incentive arrangements applying to each of the three “pots”. We have submitted our proposals to the Utility Regulator.

5.4 Outputs

The Utility Regulator is considering the introduction of load indices and health indices as measures of (i) the risk to network availability from network loading and (ii) the risk to network reliability from asset condition respectively. The Utility Regulator considers output measures such as these would help it hold NIE to account for how the capex allowance has been spent. It will take time and investment in IT systems to establish these indices and we believe that in moving towards output measures, the Utility Regulator should follow the very tentative approach adopted in GB in which Ofgem acknowledges the need for network owners to retain flexibility in implementing their capex programmes. Ofgem noted there is a risk that the distribution companies treat the outputs as ‘hard targets’ and fail to adapt their investment to the real-time needs of the network, which would not serve the interests of the network, customers or the DNOs themselves.

5.5 Reporting

We will continue to report regularly to the Utility Regulator on the implementation of the RP5 investment plan to enable the Utility Regulator to monitor the delivery of outputs and ensure that changes to the investment plan established at the outset of RP5 plan are transparent. This will enable the Utility Regulator to challenge the decisions and trade-offs we have made to re-optimise the plan when necessary. However, as indicated above, NIE must retain the flexibility to vary the plan when to do so is in the interests of customers.

APPENDIX 1

SUMMARY OF BAU RP5 ASSET REPLACEMENT AND LOAD RELATED INVESTMENT REQUIREMENTS

NIE has provided the Utility Regulator with a series of submissions covering the RP5 asset replacement and load related investment requirements. This appendix provides a summary of those submissions.

1 Asset Replacement Requirements

Transmission Plant Asset Replacement

Transmission plant comprises transformers, switchgear and a range of ancillary equipment.

110kV Switchgear

The 110kV switchgear equipment controls the secondary side of 275kV substations, the primary side of 110/33kV substations and the connected 110kV overhead and underground transmission circuits. The primary purpose of switchgear is to isolate faulted circuits and thereby prevent damage to plant and equipment as far as possible. The circuit breakers are provided with protection equipment that automatically detects faults and trips the switchgear to disconnect the affected circuits. It is of prime importance that this equipment functions safely and with certainty when required to do so, otherwise larger numbers of customers will be disconnected than is necessary and plant and equipment will sustain damage unnecessarily. In total there are 222 110kV circuit breakers. Equipment installed in the 1950s, 1960s and 1970s were of the small oil volume (SOV) type. The circuit breakers installed since then have been of the SF6 insulated type.

Transmission switchgear failures are primarily associated with insulation, bushing and mechanism failure. Recorded numbers of catastrophic failures are low; however the number of minor failures is rising due to the continued operation of aged circuit breakers, increased loading and rising fault levels. Particular condition issues that have defined the requirement for replacement include; SOV circuit breakers have extensive corrosion on control cubicles, air receivers and interrupter heads; air systems in poor condition; spares availability is extremely limited; the incidence of circuit breaker porcelains identified with surface cracking is increasing; increasing fault levels are placing additional demands upon these circuit breakers; it is difficult to ensure the ongoing fault level rating of aged air/spring operated circuit breakers and the original equipment manufacturer (OEM) no longer supports this equipment. Based on detailed condition assessments, there is a requirement to replace 16 SOV circuit breakers during RP5.

Transmission Ancillary systems

This asset category includes a range of ancillary equipment and structures within NIE's transmission substations that require investment. The range includes:

- Buildings (including drainage, roofing, bunding, fencing, doors and asbestos removal)
- High Voltage Structures (A-frames and busbar supports)
- High Voltage Electrical Plant (including Voltage and Current Transformers, Busbars, Overhead Conductors, Surge arrestors, Fittings and Insulators)
- 230/400 Volt A.C. Services (including Distribution boards, Heating, and Flood Lighting)
- D.C. Standby Systems (including Battery chargers, Batteries, Distribution boards and Emergency lighting)
- Fire Detection
- Compressed Air Systems
- Transformer oil containment and interceptors
- Bushing Water Washing Systems
- Cable Tunnels
- Standby generators
- Security Systems
- Protection
- Earthing
- Flood Protection

All of this equipment dates from the period between the 1950s to the 1970s when our transmission substations were established. The condition of the equipment gives rise to legislative, safety, plant reliability and availability liabilities together with environmental liabilities.

Transmission Transformers

Transmission transformers include 275/110kV interbus transformers and 110/33kV bulk supply transformers.

275/110kV transformers are very significant high cost (purchase cost is in excess of £2m) items of plant with associated auxiliary systems including transformer cooling plant, control and protection equipment and battery and charger equipment. The civil works associated with the transformers include foundations, sumps, access roads and secondary cabling systems. In addition, 7 of the 16 275/110kV transformers have shunt reactors and associated switchgear connected to their tertiary windings. A large number of the current population of 17 were installed between the early 1960s and the mid 1970s. In terms of 110/33kV transformers, a large number of the current population of 72 were installed between the mid 1950s and the mid 1970s.

A condition assessment and risk-based methodology is used to determine both 275/110kV and 110/33kV transformer asset replacement requirements. In addition, replacement requirements are considered over a longer period (15 years) and efforts have been made to smooth expenditure requirements. The condition of each of these transformers is monitored regularly. Condition assessment techniques include regular Dissolved Gas Analysis (DGA) of insulating oil and Infra-red surveys together with visual examinations, high voltage insulating testing including bushings and intrusive inspection data from maintenance or post fault investigations. In addition, acoustic methods are being investigated to determine if they can provide useful information in terms of measured levels of surface partial discharge. Transformer failures are normally associated with insulation failure. This includes core and windings, tap-changer and bushing failures. Overall recorded numbers of catastrophic failures are low. However, this trend is rising due to the continued operation of aged transformers and increased loading. In addition, corrosion related defects and failures are occurring more frequently. A review of recent transformer failures in NIE is provided in our supplementary paper to the Utility Regulator. The timing for replacement is based upon set risk and consequence criteria. Risk criteria include age, condition, DGA and loading. Consequence criteria include number of connected customers, whether the transformer is at a Generator site and the extent to which it supplies major customers

These criteria are applied to a risk-ranking table and transformers are individually scored providing a prioritised list of replacement requirements. In RP5 a total of three 275/110kV and eight 110/33kV replacements is proposed.

Distribution Plant Asset Replacement

Distribution plant comprises HV/LV transformers, HV switchgear LV plant and a range of ancillary HV and LV equipment.

33/11kV and 33/6.6kV Transformers

33/11 and 33/6.6kV transformers are connected to the 33kV network and provide supply to the 11kV and 6.6kV secondary distribution systems. These systems in turn are connected to 11 or 6.6kV/LV transformers for connection to customers' premises. There are some 396 33/11kV and 33/6.6kV transformers on the network, the majority of which were installed between the early 1950s and late 1970s. These units are sizeable plant items with a range of auxiliaries including tap-changers and coolers and are supported by a number of auxiliary systems such as batteries and chargers, protection and communication systems. The civil works associated with the transformers include foundations, sumps, access roads and secondary cabling systems.

A condition assessment and risk-based methodology is used to determine asset replacement requirements. In addition, replacement requirements are considered over a wider period (15 years) and efforts are made to smooth expenditure requirements. The condition of all 33/11kV and 33/6.6kV transformers is monitored regularly. Condition assessment techniques include regular Dissolved Gas Analysis and Infra-red surveys together with visual examinations and intrusive inspection data from maintenance or post fault investigations. Primary transformer failures are normally associated with insulation failure. This includes core and windings, tap-changer and bushing failures. Overall recorded numbers of catastrophic failures are low. However, this trend is rising due to the continued operation of aged transformers and increased loading. The need for, and timing of replacement is based upon set risk and consequence criteria. Risk criteria include age, condition, DGA and loading. Consequence criteria include number of connected customers, whether it is at a Generator site and the extent to which it supplies major customers. These criteria are applied to a risk-ranking table and transformers are individually scored providing a prioritised list of replacement requirements. In RP5 a total of thirty two 33/11kV and 33/6.6kV transformer replacements is proposed.

33kV Indoor Switchboards

The 33kV switchgear equipment controls the secondary side of 110/33kV substations, the primary side of 33/11kV substations and the connected 33kV high voltage overhead and underground distribution circuits. For the same reasons explained previously in respect of 110kV switchgear it is of prime importance that this equipment functions safely and with certainty when required to do so.

There are currently fifty nine 33kV switchboards comprising 143 oil and 389 gas/vacuum circuit breakers installed on the system. Approximately 27% of our 33kV indoor switchboards were installed between the mid 1950s and the late 1970s.

A particular asset of concern is our Reyrolle L42T switchboard. The majority of these switchboards, with the exception of three, were subject to a programme of minor refurbishment during RP3. The three switchboards were excluded due to their very poor condition and limited upgrade potential. The retention of this equipment on the network gives rise to safety, reliability and availability liabilities; it is proposed to replace two of the above mentioned switchboards comprising a total of 29 switchgear panels during RP5.

Outdoor 33kV Meshes and Circuit Breakers

Currently there are 136 no. 33kV open terminal mesh substations on the NIE system. Predominately they are used in rural locations although some are in urban areas. Mesh equipment consists of wood pole structures, open-terminal busbars, air break switches and circuit breakers. At the start of RP5 it is estimated that there will be a total of 540 33kV outdoor circuit breakers installed in meshes of which 178, installed between 1956 and 1975, will be bulk oil circuit breakers. These units are now considered obsolete.

The factors that influence the condition and performance of 33kV mesh equipment include the following; location/environment, loading, duty of operation, spares, fault levels and pole decay. In particular there has been an increase in the number of operational difficulties associated with older 33kV mesh Air Break Switches. Failures associated with Bulk Oil 33kV Outdoor Circuit Breakers are primarily associated with insulation, bushing and mechanism failure. Due to the use of oil to extinguish an arc under normal load and fault break switching, circuit breaker failures have an associated risk of explosion and fire.

Mesh refurbishment and switchgear replacement is an ongoing programme of activity. There are currently 33 open mesh substations that have not yet been refurbished. Twenty two of these substations have pole decay and equipment that has suffered from wear and tear and corrosion and require the mesh equipment to be replaced in order to minimise network and safety risks. It is proposed to refurbish these sites in RP5, including the replacement of 86 circuit breakers. Three of the meshes require to be replaced by switchboards due to space considerations and construction risk.

Primary and secondary 11kV and 6.6kV Switchboards

The 11kV & 6.6kV primary switchgear equipment controls the secondary side of primary substations and the 11 and 6.6kV high voltage outgoing overhead and underground distribution circuits. Currently there are 215 11kV and 6.6kV primary switchboards comprising 1,956 circuit breakers installed on the system. Approximately 40% of this population was installed between the early 1940s and late 1970s.

Due to the age and design of this equipment it is not possible to operate this switchgear remotely, which increases the risk of injury to operational staff should this equipment fail during switching. Switchgear failures are primarily associated with insulation, bushing, operating mechanisms and bus bars. Recorded numbers of catastrophic failures are low when compared to the number of units installed; however the trend in the number of more minor failures is rising due to the continued operation of aged poor condition circuit breakers, increased loading and rising fault levels.

These circuit breakers are located in either metal clad or brick buildings. Asset condition assessments have shown that metal enclosures associated with aged Reyrolle circuit breakers are extensively corroded, which has resulted in an increased level of deterioration. In addition, aged Reyrolle B and C Gear switch boards, located in brick buildings, have compound filled bus bars and current transformer chambers which are prone to leaks resulting in primary insulation degradation and failure. There is an increasing concern that as a result of age-related wear in the circuit breaker mechanisms and operating shafts that the speed of operation may be reduced, which would have a corresponding reduction in the assigned rating of the switchgear. These issues have a significant impact on the level of risk associated with this equipment and highlight the need for the continuation of a prioritised replacement programme during RP5 and RP6. Based on the prioritisation of the switchgear types discussed above it is proposed to replace 261 primary and 18 secondary circuit breakers in RP5.

Secondary Ring Main Unit Substations

There are currently 6,532 secondary distribution substations on the system containing 8,098 switchgear units including oil, SF6 and air insulated Ring Main Units (RMUs), fused switches, switches and circuit breakers. Approximately 13% of these assets were installed between 1936 and 1970.

The primary purpose of secondary distribution RMU switchgear is to facilitate operation and control of the 11 and 6.6kV distribution underground network. In the event of a circuit fault this switchgear is used to help locate the faulty section, reconfigure the network to restore supplies and isolate safely the necessary section of circuit to enable repairs. The RMU transformer switches (and in some cases certain feeder switches) are equipped with basic protection modules to detect faults to isolate the affected circuit. It is therefore of prime importance that this equipment functions properly when required to do so, otherwise larger numbers of customers will be disconnected than is necessary and plant and equipment will sustain damage unnecessarily. Due to the age and design of this equipment it cannot be equipped for remote operation and must be operated locally; this increases the risk of injury to staff should this equipment fail during operation. In addition, a substantial number of RMUs are currently subject to operational restrictions which cause delay during restoration of supply following a fault.

Secondary distribution switchgear failures are primarily associated with corrosion, moisture ingress, insulation degradation and metal fatigue. In particular, equipment located outdoors is particularly prone to failure due to increased levels of corrosion and moisture ingress. Based on the prioritisation of the replacement of the switchgear that is in the poorest condition it is proposed to replace 510 RMUs in RP5.

Outdoor Secondary Substations

There are almost 2,500 large outdoor distribution secondary substations on the NIE network. Approximately 1,500 of these substations are overhead-fed and are situated on either 4-pole or H-pole structures. The remainder are ground-mounted, cable fed and generally located within a fenced enclosure.

4 pole structures

There are 603 4-pole structures on the NIE network. These structures support large capacity transformers. The majority of these structures have wooden kiosks at the base of the pole. The design was adopted in the 1940s and 50s as a way of establishing a high capacity substation site without the requirement to purchase or lease ground since the sites are held on wayleaves. The primary safety risk associated with 4 pole structures is accessibility of the public to high voltage equipment and as an interim measure anti-climbing devices (Vanguard) have been installed above the LV cabinet. There is also a concern over the stability of a large transformer held up on wooden poles, particularly when one takes account of the degree of pole decay that is now evident at a number of sites. An inspection of all 4 pole sites has now been completed. In addition to a condition assessment consideration was given to the nature of the buildings within a 200m radius of the structure. Those 4-pole structures, which are located near schools, churches and halls, and hence are higher risk for reasons of public safety have been identified. The replacement of 4-pole substations is an ongoing programme of work and it is necessary for a programme, encompassing 190 substations, to continue in RP5.

H pole structures

There are 927 H-Pole structures currently on the NIE network. These structures are designed to support medium capacity transformers. Many of these incorporate a metal or wooden kiosk attached to the base of the pole which houses the LV cable connections. Installation of H-pole structures peaked in the mid 1970s and remained steady throughout the 1980s and 1990s. The structures are assessed as part of a condition monitoring programme. The strategy for asset replacement or refurbishment is determined from a risk rating based on the following issues; transformer tank corrosion and moisture ingress, pole decay, kiosk condition, location of structure, i.e. near school or public area and overall asset life. As with the 4-pole structures, the replacement of these substations is an ongoing programme of work and it is necessary for a programme, encompassing 110 substations, to continue in RP5.

Ground mounted overhead fed substations

Currently there are 926 Ground Mounted Distribution Transformer Substations on the NIE network. These substations are mainly cable connected to the HV overhead network and protected by a set of fuse isolators. The LV side of the transformer is connected either to a separate fuseboard by single core cables or to a transformer flange mounted LV cabinet. The majority of these substations are located outdoors in Lochrin fence enclosed areas. Installation of ground mounted transformer substations peaked during the 1970s and remained steady throughout the 1980s and 1990s, used mainly to supply small developments in rural areas. They are no longer a standard construction with new supplies provided by ESI package substations, H-pole mounted transformers and more recently Pad-Mount substations. The structures are assessed as part of NIE's substation inspection and condition monitoring programme. On the basis of those assessments a programme of replacement, encompassing 60 ground mounted transformer substations that are located outdoors and without steel/fibreglass shells, is required in RP5.

Sectionalisers

11kV sectionalisers are pole mounted switching devices that are used in conjunction with 11kV reclosing switchgear to isolate faulty sections on overhead line circuits and thereby allow supply to be automatically restored to healthy sections. The reliable operation of 11kV sectionalisers is therefore critical to the operation of the 11kV overhead network. Traditionally sectionalisers used oil as the insulation medium. Over the last decade SF6 insulated units have been introduced onto the 11kV overhead system. Oil sectionalisers still account for the majority of units with 202 oil sectionalisers in operation. All of these units were installed between 1964 and 1967. Due to their outdoor location, they have been subjected to severe environmental and weather conditions for this length of time and this has increased the incidence of failure due to insulation breakdown, corrosion and moisture ingress.

It is planned that a proportion of sectionalisers will be replaced as a result of NIE's plans to continue its programme of increased remote control. In conjunction with that programme, it is planned to replace all oil sectionalisers over the next two regulatory periods, with a target to replace 50 in RP5. While assets in excess of 50 years will remain operational for that period the risks will be managed by a continuation of the extensive maintenance programme, although the availability of spares remains a risk with this option.

LV Plant

LV plant includes Section Pillars, Underground Distribution Boards (UDBs) and Mini pillars. In total, NIE has approximately 11,000 of these assets. Section pillars and UDBs are used for the connection, interconnection and reconfiguration of LV mains cables whereas the latter are primarily used for the connection of service cables to the mains circuits. The age of the equipment ranges from 70 years old to present day. The main risks relating to deterioration of LV plant are; corrosion of pillar walls and doors, breakage of door locks and hinges, breakage of UDB manhole and fusebox covers, deterioration of electrical contacts, ingress of water and debris into UDB chamber and deterioration and leakage of compound from UDB.

As a result of their required functionality LV plant is generally located in areas open to the public. As a result, the primary safety risks associated with pillars and UDBs are exposure of the public to live equipment and the possible failure of plant that may result in explosion or combustion. In both cases there is risk of serious injury. In addition there is also a risk to the safety of operational staff. There are a number of options to address the ongoing deterioration of this asset category including replacement, removal/LV reconfiguration and refurbishment. In RP5 it is proposed that approximately 1170 units be removed or replaced and that the remainder be subject to a programme of refurbishment as required.

Primary and Secondary Distribution Ancillary Equipment

This asset category includes a range of ancillary equipment and civil installations associated with NIE's Primary and Secondary Distribution substations that require investment.

The range includes:

- Buildings and other civil engineering works (including Drainage, Roofing, Bunding, Fencing, Doors, etc.);
- A/C Services (including Heating, Lighting, Emergency lighting, Flood lighting, etc);
- D/C Standby Systems (including Battery chargers, Batteries and Distribution boards);

- Fire Detection Systems;
- Earthing; and
- Flood Protection.

Much of this equipment dates from the period between the 1950s to the 1970s when the majority of our distribution substations were established. The condition of the equipment gives rise to legislative, safety, plant reliability and availability liabilities together with environmental liabilities.

LV Wall Mounted Distribution Boards

Scaltex and Brush wall mounted distribution boards are located mainly in high load densely populated areas in Belfast. These types of LV board were installed from the mid 1930s to the early 1970s. The primary purpose of LV distribution boards is to provide operation and control facilities for the LV distribution network. They are connected to the LV side of 11 & 6.6/.4kV distribution transformers and they allow the outgoing LV circuits to be reconfigured as required either to maintain supply to customers under fault conditions or to control the loading of LV circuits. These boards are of a 'live' open frame non-insulated design and pose a significant to staff during operation. The equivalent modern equipment is fully shielded to minimise the risk of phase to phase flash over. In addition, all new LV equipment is rigorously tested in accordance with national and international standards to ensure that it meets minimum requirements of load carrying capacity and fault level capability. The LV cable circuit terminations to these boards are insulated using bitumen compound filled 'break out' end boxes. Increased circuit loading over time has caused the compound to degrade resulting in a greater susceptibility to moisture ingress and subsequent insulation failure.

Asset Replacement Of Overhead Lines And Cables

The primary drivers for investment in the overhead line and underground cable asset base are safety, network performance, resilience and compliance with legislation. In general, unlike asset replacement of plant, refurbishment of the assets is planned rather than complete replacement or rebuild of circuits.

Transmission Overhead Lines

The transmission networks operate at 2 voltage levels. The higher voltage 275kV network comprises of 400km route length of 275kV double tower circuit overhead line in 11 separately identifiable sections of line. The majority of the 275kV network was constructed in 1966-70 and final circuits completed in 1978. The 110kV network comprises of 924km route length. This is made up of 348km of double tower circuit overhead line and 576km route length of single circuit overhead pole line mainly of portal construction although there is some single pole construction. The majority of towers were constructed from the 1940s up to the late 1970s with the majority of wood pole lines erected in the 1950s up to the late 1970s.

The condition of the 275kV and 110kV overhead lines is influenced by a number of environmental factors depending on their location particularly with respect to elevation and proximity to the coast. For example, overhead lines located in exposed locations can be subject to increased wear on insulator fittings due to increased conductor movement caused by high winds. Similarly, exposure to higher levels of pollution can increase the levels of corrosion.

The transmission overhead lines network can be considered as a number of discrete assets; Insulators and fittings, conductors and fittings, earthwire and fittings, steelwork, foundations and poles. Each of these component groups deteriorate in different timeframes and from different effects. Also the consequence of the failure of will depend on the function of the component. Foundations can deteriorate as concrete ages and galvanised steel suffers from corrosion depending on the environment and the efficacy of tower painting. Foundations and steelwork seldom fail catastrophically since they deteriorate relatively slowly and may be closely monitored. However, the repair of foundations and steelwork usually requires a long double circuit outage which can often be problematical due to network loading. Fittings erode with wear due to movement caused by wind and the steel cores of conductor also corrode depending on the environment. Conductor can also suffer from ‘conductor galloping’ and ice loading. It is more difficult to monitor conductor and fittings and condition is normally established by a detailed condition survey.

When either fittings or conductors fail, it is likely to be a catastrophic event with the risk of loss of supply to a large number of customers and long repair times. During both the third and fourth regulatory periods, several significant failures of these assets have occurred highlighting the requirement for increased asset replacement requirements for RP5 and RP6. In particular there is a need to replace the conductors on the 275kV double circuit that connects Coolkeeragh substation in Londonderry to the main interconnected 275kV network at Magherafelt. In addition there is a need for a programme of work on certain sections of the 275kV and 110kV targeted at the refurbishment and replacement of the asset components listed above.

Distribution 33kV Towerlines

Whilst the majority of over three hundred 33kV overhead circuits are wood pole line construction a total of 28 were constructed with steel tower supporting structures which allow for longer span lengths and greater conductor heights where required. Six of these circuits, although operating at 33kV, were built to 110kV construction to allow for future upgrading and are considered within the transmission element of our capex plan. The remaining 22 circuits have structures of 69kV construction, the prevailing standard at the time of construction. The oldest of the tower lines was constructed in 1930 by the Antrim Light and Power Company and the youngest in 1972.

As with transmission towerlines (as previously discussed) each of the various component categories deteriorate in different timeframes and from different effects. A detailed asset condition assessment of the entire distribution tower line network was carried out during 2009/10. There are a number of conductors and earth wires showing visible signs of corrosion. The insulator condition combined with the level of wear on shackles necessitates a replacement programme. Tower steelwork is of particular concern with heavy levels of surface corrosion identified on a significant amount of the tower network and with some towers now requiring complete replacement.

During RP3 & RP4 a number of towerlines have been refurbished and given the current age and poor condition of the steel tower lines, it is essential that the programme of refurbishment of the distribution tower lines should continue during RP5 & RP6. This will address the known defects and ensure the continued serviceability of the distribution tower lines. In total it is proposed that 18 circuits will be addressed in RP5.

Distribution 33kV and 11kV Overhead Lines

The 33 kV, 11 kV and 6.6 kV overhead networks comprise of approximately 23,910km of wood pole construction overhead line of which 3110 km are 33 kV and approximately 20,800 km are 11 kV and 6.6 kV. The 11kV network is made up of main lines that form the “backbone” of the network and spur lines that radiate to the extremities of a very extensive rural distribution system. The 33kV network is less reticulated than the 11kV network in that it is generally configured as radial or ring circuits with very few spur lines.

As a consequence of the gradual and continuous development of the distribution overhead network, poles, conductors, steelwork and fittings of widely varying ages are broadly distributed throughout the system. As a result, generally overhead lines should not be subject to wholesale like-for-like replacement at a point in time. They should instead undergo 15 year cyclic refurbishment driven by condition monitoring of the individual line components. This is best practice as generally adopted by the industry in GB. In addition, a “lighter” more frequent targeted asset replacement (TAR) programme is needed to focus mainly on tree interference and urgent defects, with decayed pole and other major component replacement being referred to the overhead line refurbishment teams which are equipped to carry out the work more efficiently.

To date, only a small amount of conductor has been replaced. It is now clear that the current refurbishment programme with a specification that results in a low volume of conductor replacement will not adequately prevent network deterioration in the medium and longer term. Reconductoring and associated redesign, described by NIE as re-engineering, is now required particularly on those circuits that are showing signs of extensive conductor deterioration. There is also recent experience, based on the ice storm that affected the 11kV network in March 2010, that the replacement of 25mm^2 conductor must be addressed and NIE is considering this specific issue at present.

Distribution LV Overhead Lines

NIE's low voltage (LV) mains network is approximately 14,500km long comprising overhead line, undereaves and underground cable. Approximately 780,000 customers are connected to the LV network in our cities as well as almost 300 towns, villages and hamlets throughout NI. Approximately 5,400km of this network is overhead line construction. A substantial proportion of this network was constructed between the late 1950s and the mid 1970s to facilitate rural electrification. The general practice of extending the LV overhead network ceased during the early 1990s when the use of underground cable in rural areas became the NIE standard construction.

For the same reason as explained above in respect of the 33kV and 11kV network LV overhead lines should not be subject to wholesale like-for-like replacement at a point in time. They should instead undergo cyclic refurbishment driven by condition monitoring of the individual line components. The most significant condition issue associated with LV overhead lines is the extent of poles that are heavily decayed. Presently NIE is concentrating its refurbishment efforts on a proportion of the 2,400kms of LV overhead network that exists within the urban areas of NI. This reflects the heightened concerns over failures of the LV network in such areas and particularly the risk to safety resulting from the failure of wood poles. It is proposed in RP5 to carry out a level of refurbishment on the outstanding proportion of the urban network that will mean that further refurbishment will not be required for a further 15 years. As with the HV network, refurbishment programme needs to be supported by a much less intensive network-wide targeted asset replacement programme and tree cutting programme (TAR), carried out on a five yearly cycle.

In addition to the above programmes of refurbishment and TAR it will be necessary to replace certain sections of the overhead network with underground cables in situations where poles may be landlocked and inaccessible, where there is a very high degree of pole decay or where the conductor is in poor condition and no longer serviceable.

Undereaves Conductors

In some situations LV circuits and services are attached to the surface of the eaves of customers' premises by clips. These circuits were installed up to the 1970s and much of this equipment is now in poor condition. There are approximately 58,000 premises in the province supplied in this way, the majority in suburban locations or in rural towns and villages. In addition to the undereaves mains & services discussed above, it is estimated that there are a further 8000 premises supplied from an overhead line connection via a single undereaves service.

These undereaves conductors have traditionally been painted by the property owner when the eaves of the property were being painted and many are now brittle and the insulation has cracked with ageing. Such undereaves wiring that is in poor condition or has been damaged presents a risk of personal injury through inadvertent physical contact with exposed live conductors and there have been over 100 such incidents reported over the 5 years to December 2009, an average of almost 2 incidents per month. In addition, there is a risk from fire as a result of faulty insulation. During the 5 years from February 2005 to January 2010 there were also a total of 936 faults on the undereaves network. A review of these faults has concluded that 788 can be attributed to the poor condition of the undereaves network.

During RP4 the programme to replace 16,000 undereaves will be exceeded with the intention to now complete 18,000 undereaves in the period. This reflects the safety and reliability risks associated with this category of asset. There are no options available other than to continue this work and maintaining the target established during RP4 will result in the replacement of a further 16,000 properties served by undereaves wiring being addressed during RP5. This will leave 3,880 properties supplied from PBJ undereaves by the end of RP5.

Cutouts

NIE has approximately 760,000 domestic customers and 54,000 small to medium enterprise (SME) customers. The majority of domestic and SME LV service cables supplying these premises are terminated in a service cutout with fuse. The purpose of the fuse is to provide backup fault protection to the customer’s installation and to protect the service cable from excessive overload.

Cutouts have an estimated life expectancy of 40 years but levels of failure would indicate that certain types are prone to premature failure as a result of deterioration and overloading. The main risk associated with cutouts are risk of electrocution as a result of the exposure of live connection and overloading which can cause overheating and may result in fire. Failure modes have included leakage of compound, overheating and fires, flickering lights and deterioration of fuses resulting in loss of supply. Cutout replacement during RP3 and RP4 has been based on a combination of programmed and reactive asset replacement. A total of 8,500 cut outs were replaced during RP3. It is estimated that a further 8,800 units approximately will be replaced during RP4. A total of 8,000 replacements is planned for RP5.

Underground Cables

Underground cables are used at all voltages on the NIE network from 275kV to 230V. They are utilised predominately within urban areas where for example, safety, practical or aesthetic considerations preclude the use of overhead lines. It is estimated that there is approximately 14,000km of underground cable.

At 275kV the cabling is used within Coolkeeragh, Kilroot and Ballylumford substations only, connecting transformers to switchgear and switchgear to overhead tower lines. At 110kV their use is more widespread as they connect Grid substations to Main substations. As a result the majority of 110kV cables are located in public footways and roadways. The transmission cables on the NIE system are in the region of 30 to 55 years old.

Distribution underground cables are used at all voltages on the NIE network. At 33kV (640km approx) they are used extensively to connect Main substations to Primary substations and then to 33/11kV transformers. The majority of 33kV cables are in the Belfast and Londonderry areas but more recently its use has become more widespread with installation of 33kV cable in most of NI's major towns. The age of the 33 kV cables on the NIE system range from present day to 75 years old, with the oldest cables being installed in the greater Belfast area. 11kV & 6.6kV (3,340km approx) and LV (9,400km approx) cables are used extensively in urban areas throughout the country. Currently NIE specify XLPE cable, however the vast majority of the network consists of PILCSWA cable. The age of these cable networks range from 90 years old to present day.

NIE's replacement strategy to date, as for the other UK DNOs, has primarily been a reactive one with intervention only after a failure or incident has occurred. Whilst cables have one of the longest lives of all asset categories they are not an infinite asset, and faced with an overall asset base of almost 14,000km, there is significant risk in ignoring the potential for an unmanageable escalation of failures. NIE therefore proposes a modest but proactive investment in targeted cable replacement and refurbishment in RP5. The programme would seek to replace or refurbish cable that is deemed to be highest risk. To support a more proactive approach to cable management it is also proposed to invest in increased cable condition monitoring.

2 Load Related Requirements

Transmission Load Related

The transmission system includes a complex meshed network of 275kV single and double circuits constructed on steel lattice towers connecting three power stations and seven 275/110kV grid supply points. There is a 500MW DC Link to Great Britain (Moyle Interconnector) and a 600MVA 275kV double circuit connection to the Republic of Ireland (RoI). The transmission network also includes an inner 110kV meshed system based around Lough Neagh with an extension to the west and north of the province. The 110kV network connects to 110/33kV substations mostly through double or two single circuit radials. The 110kV network also includes two connections to the RoI, one from Enniskillen to Gortgonnis and the second from Strabane to Letterkenny.

NIE is responsible for the planning and development of the transmission system in accordance with its Licence and the obligations set out in the Transmission Interface Agreement which defines the cooperation and coordination that is required with SONI. The assessment of the transmission load related investment is based primarily on (i) NIE's forecast of system demand and its forecast of demand on 110/33kV substations and (ii) a set of transmission assumptions provided by SONI which defines the relevant generation dispatch scenarios.

Based on an initial assessment of need a total of 19 projects have been identified. The projects will seek to address:

- Risk of voltage collapse in 110kV networks in the east and west of the province (2 separate projects)
- Replacement of switchgear and cabling due to fault level exceeding rating (3 separate projects)
- Establishment of four new 110/33kV substations to provide reinforcement to the 33kV network and address associated transmission issues
- Installation of an additional 275/110kV transformer and an additional 275kV bus coupler to address deficiencies in network security
- Uprating of eight 110kV circuits to address thermal overload
- Construction of an additional 110kV circuit to secure an existing 110/33kV substation
- Replacement of strategic generator cables at Ballylumford
- Installation of sequence switching schemes at two 275/110kV substations to improve performance under storm conditions

This initial plan has been challenged robustly particularly in terms of need and risk. As a result five of the 19 projects contained in the initial plan were modified or deferred, allowing a 29% reduction in the cost of the submission plan. The reduction results in 16 projects and does however result in increased risk that will have to be managed by NIE and SONI over the course of the period.

Distribution Load Related Investment

The extent of required distribution network load related investment has been assessed by separate but coordinated assessments of the 33kV, 11kV and LV networks.

33kV Load Related Investment

The 33kV network comprises some 3,700kms of overhead line and underground cable circuits and operates as a sub-transmission network supplying power from the transmission network to more than 200 33/11kV and 33/6.6kV substations for local distribution. The assessment of load related investment requirements of the 33kV network is based on the following analysis:

- Forecast of demand until end of RP5, 2016/17
- Extensive contingency analysis based on forecast load flows in 2016/17
- Identification of overload, under voltage or excessive fault level conditions
- Costed options
- Choice of optimised solutions

The investment requirements for RP5 have been assessed by means of a two stage process which has considered scope to minimise investment requirements through deferral, derogation and application of Smart solutions against an initial assessment of investment need. This optimisation enabled a reduction of 12 of the 31 33kV circuit sections identified as forecast to become overloaded during RP5. The remaining 19 identified overloaded sections of 33kV network will need to be addressed through 10 separate projects. Three further projects are required to address deficiencies in the 11kV network through the development of new 33kV infrastructure and two projects are linked to the development of 33kV infrastructure associated with new 110kV development proposals. In terms of investment in the uprating of transformers at 33/11kV substations or demand transfer, the requirement for investment in a total of 18 sites has been identified.

11kV and 6.6kV Load Related Investment

The 11kV and 6.6kV networks take supply from 33/11kV or 33/6.6kV substations and distribute power via overhead lines and underground cables to distribution substations or directly to the intake terminals of larger customers' networks. The network has more than 20,000km of overhead line and 3500km of underground cable and comprises approximately 409 rural and 825 urban circuits (450 urban circuits outside Belfast). These circuits are supplied from 212 33/11kV and 33/6.6kV substations.

The electrical capacity of the 11kV network is assessed on an ongoing basis to take account of increasing demand which increases power flows and voltage drop on distribution circuits and leaves less spare capacity available for resupply purposes or for the connection of new customers. Loading above design limits would compromise quality and reliability of supply and may also give rise to public safety issues and reinforcement must be provided in time to prevent such occurrences. Extensive load monitoring is carried out on the 11kV network using the Supervisory Control & Data Acquisition (SCADA) system. A network risk register has also been developed and is populated with information provided by staff who plan, operate and control the network on a day-to-day basis. The identified network risks and associated solutions have undergone considerable assessment and prioritisation to ensure that only high priority schemes are included for investment during RP5.

Some 17 network reinforcement schemes have been prioritised for investment to address problematic areas currently identified in the 11kV network risk register. Some provision is also required to address reactive hot spot network reinforcement requirements. From experience gained during RP3 and RP4, opportunities will exist to reduce expenditure through risk management by network monitoring and reconfiguration and by taking opportunities to carry out works in conjunction with the connection of new large customers or in conjunction with third party schemes. It will also be possible to defer some works that will arise towards the end of RP5. On this basis we consider that the total estimated investment requirement could be reduced by a nominal 20% which, while challenging is considered to be manageable. The investment proposed is broadly in line with the expenditure levels in RP3 & RP4.

LV Load Related Investment

NIE's low voltage (LV) network comprises some 14,500km of underground cabling, overhead line and undereave cabling. The network delivers power from distribution transformers to customers intake metering positions. The network also supplies unmetered supplies to street lighting connections and road signs. In each of the last 5 years, between 10,000 and 16,000 new customers have been connected to the network. While the majority of individual LV connections can be accommodated without network reinforcement the cumulative effects can cause voltage complaints or network overload. Also endemic growth occurs as customers will often increase demand without reference to NIE.

Additional demand causes overloading of LV circuits and transformers and can lead to multiple loss of supplies if fuses rupture due to overload. The limited ability to monitor demand on the LV network, coupled with the sporadic and circuit specific nature of the growth in demand will limit the opportunity of detecting potential overloads. In addition extra demand increases voltage drop on LV circuits leading to voltage complaints and can leave less capacity for resupply purposes which is required for substation maintenance and in the event of a fault.

Prior to RP4, load related issues on the LV network were managed by a combination of reconfiguration and reactive investment. This required operating parts of the LV network abnormally to maintain adequate voltage levels and to cater for load growth. On a number of occasions interconnections failed catastrophically under fault conditions causing undereaves wiring and underground cable to overheat and burn out. In addition, widespread fuse operations were occurring for simple faults causing greater loss of supply and adding significant complexity and time to the fault location process.

In light of the above, and with the significant town centre development during the period prior to RP4, a more focused approach to address known LV load related network issues was introduced. A load related LV risk register was established based on information provided by the staff that operate the network on a day-to-day basis, combined with network performance data and the limited demand monitoring information that is available. This database is now used for the prioritisation of investment needs and when applications for new or additional demand are being appraised. The LV risk register presently identifies approximately 140 load related risks on the network that are yet to be addressed. Based on the prioritised investment needs of the risk register, investment in the LV network is now being carried out in both large and small towns throughout the province.

Clearly, it is not possible to predict the explicit LV network reinforcements that will be required for the duration of RP5. However based upon the volume and scope of risks presently within our risk register it is anticipated that expenditure in RP5 will be required to continue at a level that is similar to RP4 with investment targeting:

- Overloaded town centre network;
- Overloading on ground mounted transformers; and
- Voltage complaints.