

CATO

Performance incentives for competitively appointed transmission owners

Office of Gas and Electricity Markets (OFGEM)

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EXECUTIVE SUMMARY

The findings from Ofgem's Integrated Transmission Planning & Regulation Project (ITPR) confirmed the potential benefits to consumers of extending the use of competitive tenders for the provision of onshore transmission infrastructure, specifically transmission assets that are new, separable and of a high value. So, on 19 October 2015, Ofgem published an industry consultation on the potential arrangements for competitively appointed owners (CATOs) of such transmission assets. ^[1]

As with TOs under RIIO-T1, ^[2] as well as with offshore transmission owners (OFTOs), Ofgem considers there is a need for CATO performance incentives to ensure that CATOs operate and maintain reliable assets in cooperation with other system stakeholders and at an economic and efficient cost. Ofgem has thus appointed DNV GL to develop an operational performance incentive structure for CATOs that could deliver on these objectives.

We approached the task of proposing CATO operational performance incentives by considering what assets a CATO comprises, understanding stakeholder requirements from CATOs, reviewing the options for incentives and proposing a CATO-focussed incentive set, outlining also the supporting arrangements that would be required. However, whilst we have, on occasion, used numbers to illustrate the principles of the incentive set, we have not recommended any technology specific incentive levels, neither have we proposed any specific incentive strengths, since we believe that these should be considered as a next step once the principles proposed here have been accepted. (Absolute and relative revenue at risk is discussed at Section 5.4.2.)

CATOs are expected to have a variety of roles on the UK National Electricity Transmission System (NETS) but, broadly, these may be allocated between three categories: highly integrated with the Main Interconnected Transmission System (MITS), point to point connections, or radial connections.

We believe that CATOs should adopt, and be incentivised to adhere to, the following key behaviours:

- high annual asset availability (available for service for a high proportion of the year);
- high asset reliability (available for service when required and operating correctly when in service);
- prompt, flexible, cooperation with the SO throughout the revenue term; and
- effective, long-term asset management.

The incentives - a summary

The incentives proposed here comprise a 3-part package:

Part 1 – An underpinning set of obligations and arrangements to manage CATO operational performance and interactions with other parties:

Ofgem, Extending competition in electricity transmission: arrangements to introduce onshore tenders, 19 October 2015, available at: https://www.ofgem.gov.uk/sites/default/files/docs/2015/10/ecit_consultation_v6_final_for_publication_0.pdf.

² RIIO-T1 – The UK RIIO-T1 Electricity Transmission Price Control, effective for the years 2013 – 2021

1. Rules and arrangements contained in **licences, codes, standards**, policies and other documentation to direct, facilitate and support the required CATO behaviours. These are largely already in place and working to manage the existing SO-TO arrangements, though some need adjusting to also accommodate CATOs.

Part 2 – A ‘core’ financial incentive framework based on CATO asset availability but designed to ensure CATO’s assets are not only available for use but also available when they are needed:

2. **This availability and reliability framework** is a symmetric incentive structure whose ‘bonus’ rate for beating the annual target is less than its penalty rate for failing to meet target, in order to promote reliability; annual bonus earned is subject to a natural cap by virtue of the natural limit to annual availability, whilst annual penalty is limited to mitigate investor risk; however residual penalty may be spread over several years.

Part 3 – Additional mechanisms that would refine or supplement the ‘core’ financial incentive. All these incentives are optional for any CATO application, and most are applied through the ‘core’ financial incentive framework. They would sharpen the incentives on CATO behaviours relating to specific areas of performance, so may be appropriate to consider for some or all CATO projects:

3. A **long-term asset health** incentive is used to counter any incentive that the CATO may have to allow a drop in asset care, particularly towards the end of the revenue term. This incentive is based upon penalty payments from a performance bond, these payments being tied to asset condition & functional capability, assessed by inspection / audit as the end of the revenue term approaches – see Section 6.3.1.
4. A **standard unplanned unavailability incentive** is used to discourage unplanned unavailability during normal operations. It operates through the mechanism of the availability and reliability framework to reduce annual revenue in proportion to the duration of unplanned outages and is set for the duration of the revenue term – see Section 6.3.2.
5. **Cyclical period incentives** are used to encourage the CATO to plan unavailability during periods best suited to their transmission role. They are set for the duration of the revenue term and apply to planned and unplanned outages – see Section 6.3.3.
6. A **premium unplanned unavailability period incentive** is used to discourage unplanned unavailability during specific periods of anticipated high system stress. It operates through the mechanism of the availability and reliability framework to reduce annual revenue in proportion to the duration of unplanned outages and is set for the duration of the revenue term – see Section 6.3.3.
7. **Planned maintenance / prompt return-to-service** incentives are used to encourage They operate through the mechanism of the availability and reliability framework to modify annual revenue and are set for the duration of the revenue term:
 - o An incentive to plan outages more than a year ahead – see Section 6.3.4; and
 - o An incentive to return to service promptly following a planned outage – see Section 6.3.4.
8. A **flexible timings** incentive is used to encourage the CATO to remain as flexible in the timing of its outages as possible in order that the SO can retain some control of any disruptions to outage plans – see Section 6.3.5.
9. **Emergency return-to-service (ERTS)** incentives are used to encourage the CATO to promptly cooperate with ERTS instructions from the SO – see Section 6.3.6.
10. **Depleted capability** incentives are used to encourage the CATO, so far as possible commensurate with health, safety and environmental considerations, to retain its circuit in service for the benefit of system operations even when its transfer or control capabilities are partially depleted, whilst repairs are being arranged. The two incentives operate through the mechanism of the availability and reliability framework to reduce annual revenue to reflect the degree of capability loss and are set for the duration of the revenue term – see Section 6.3.7.

1 INTRODUCTION

The Office of Gas and Electricity Markets (Ofgem) protects “the interests of existing and future electricity and gas consumers,”^[3] amongst others by:

- promoting value for money;
- promoting security of supply and sustainability, for present and future generations of consumers, domestic and industrial users;
- the supervision and development of markets and competition; and
- regulation and the delivery of government schemes.

The main interconnected electricity transmission system (MITS) of Great Britain (GB) is presently planned, constructed, owned and operated by three^[4] incumbent transmission owners (TO) who, between them, hold monopoly positions over the onshore transmission infrastructure within their territory. The TOs are regulated by Ofgem through the RIIO price control framework.^[5]

In 2009, Ofgem established a regulatory regime for offshore transmission infrastructure. Under this regime, offshore transmission licences (for connections between the MITS and offshore wind farms) are granted through a competitive tender process, through which Ofgem aims to “ensure offshore renewable generation projects are economically and efficiently connected to Britain’s electricity grid.”^[6] The winners in this competitive tender process (offshore transmission owners, or OFTOs) acquire the right to own offshore transmission infrastructure to connect the new wind farm and to recover the cost of this investment, including a reasonable return, over the course of a 20-year revenue term.

In 2012, Ofgem set up the Integrated Transmission Planning and Regulation (ITPR) project to review, in consultation with industry stakeholders, the existing arrangements for planning and delivering electricity transmission infrastructure on the National Electricity Transmission System (NETS),^[7] to meet two key objectives:^[8]

- **That the network is planned in an economic, efficient and coordinated way.** To achieve this, parties that have the best incentives and information to plan the network efficiently should have responsibility to do so, and roles and responsibilities must be clearly defined.
- **That asset delivery is efficient, and consumers are protected from undue costs and risks.** To achieve this, competition should be used to deliver transmission assets where it benefits consumers. There also needs to be a clear, predictable and fair regulatory framework for infrastructure development.

³ <https://www.ofgem.gov.uk/about-us/who-we-are>

⁴ National Grid Electricity Transmission (NGET), Scottish Power Transmission Limited (SPTL), and Scottish Hydro Electric Transmission (SHE Transmission).

⁵ RIIO: Revenue = Incentives + Innovation + Outputs, see: <https://www.ofgem.gov.uk/network-regulation-riio-model/riio-t1-price-control>

⁶ <https://www.ofgem.gov.uk/electricity/transmission-networks/offshore-transmission> and <https://www.ofgem.gov.uk/electricity/transmission-networks/offshore-transmission/our-role-offshore-transmission>

⁷ THE national electricity transmission system (NETS) comprises the main interconnected electricity transmission system (MITS) plus the radial transmission connections to generators and/or consumer grid supply points at the periphery of the system.

⁸ Ofgem, Integrated Transmission Planning and Regulation (ITPR) project: final conclusions, 17 March 2015, p5, available at: https://www.ofgem.gov.uk/sites/default/files/docs/2015/03/itpr_final_conclusions_decision_statement_publication_final.pdf

The findings from Ofgem's ITPR confirmed the potential benefits to consumers of extending the use of competitive tenders for the provision of onshore transmission infrastructure, specifically transmission assets that are new, separable and of a high value. So, on 19 October 2015, Ofgem published an industry consultation on the potential arrangements for competitively appointed transmission owners (CATOs) of such assets. ^[9]

As with TOs under RIIO, as well as with OFTOs, Ofgem considers there is a need for CATO performance incentives to ensure that CATOs operate and maintain reliable assets in cooperation with other system stakeholders and at an economic and efficient cost. Ofgem has thus appointed DNV GL to develop an operational performance incentive structure for CATOs that could deliver on these objectives.

Ofgem, Extending competition in electricity transmission: arrangements to introduce onshore tenders, 19 October 2015, available at: https://www.ofgem.gov.uk/sites/default/files/docs/2015/10/ecit_consultation_v6_final_for_publication_0.pdf.

2 WHAT IS A CATO?

2.1 CATO assets - role in the transmission system

In practical terms, a CATO will be a party that has won an auction to construct a tranche of onshore transmission infrastructure and act as steward of that infrastructure for the first 25 years of its physical life. (Ofgem's current position is that the revenue term will be 25 years, although this is still subject to consultation.) As the owner of this infrastructure, a CATO will be required to:

- Make its transmission assets available to the system operator (SO) for use as part of the overall network;
- Facilitate the safe, economic, co-ordinated and efficient operation of the CATO assets within the wider network; and
- Act in accordance with the relevant laws, licences and codes.

We consider that any operational performance incentive for CATOs must reflect the role and position of the relevant infrastructure within the wider transmission system, as well as recognise the requirements of asset ownership.

2.2 Types of assets - criteria for tendering

To be eligible for competitive tendering, transmission infrastructure developments must fit the following criteria set by Ofgem: ^[10]

1. *New, meaning that*

- the infrastructure is built to fulfil a role that no infrastructure is presently providing (green-field); or that
- the development involves a complete replacement of an existing asset. The existing asset need not already be owned by the CATO designate.

2. *Separable, meaning that*

- the demarcation of asset ownership is clear; and that
- it is not necessary for the CATO assets to be contiguous or electrically separable. ^[11]

3. *High value, meaning*

- capital expenditure in excess of £100M. ^[12]

¹⁰ Section 1.12 of Ofgem's Integrated Transmission Planning and Regulation (ITPR) project: final conclusions, Decision statement, dated 17 March 2015

¹¹ Ofgem, Extending competition in electricity transmission: arrangements to introduce onshore tenders, 19 October 2015, Section 2.9, p13.

¹² https://www.ofgem.gov.uk/sites/default/files/docs/2015/05/criteria_open_letter_0.pdf

2.3 SWW projects in RIIO-T1

Ofgem has indicated ^[13] that, during the RIIO-T1 period (that is, until 2021) only SWW projects, those whose construction funding it has not already approved, could be subject to competitive tendering.

We have thus assumed that the potential SWW projects will provide further insight into the types of projects that CATOs will own, and the roles that CATOs will have to fulfil. Although this probably doesn't constitute the full potential scope of CATOs over the long term we consider this to be a logical starting point. Table 2-1 below reproduces some of the details from a non-exhaustive list of SWW projects published by Ofgem in November 2013. ^[14] Note, however, that we have not applied the CATO definition criteria to any of these projects; our analysis here is presented simply to build up a picture of the potential types of assets that may be owned by CATOs.

Between them, these SWW projects use a wide range of technologies (including HVAC, HVDC, overhead line - lattice or T-pylon, underground cable and subsea cable). We note that, in addition to the 'headline' connections being proposed, a number of them incorporate new substations, distribution connections and / or new generation connections, as well as reactive compensation. Not all of them are connected to brand new substation bays, either; the technique of utilising the stubs ^[15] of diverted overhead line routes to connect the new assets is also proposed.

From the Table 2-1 list of prospective SWW projects it is clear that CATOs may utilise any, or all, current transmission technologies, including overhead lines, underground cable, HVAC and HVDC. In addition, SWW projects are not limited to MITS infrastructure, but can also include:

- Distribution and or generation connections;
- Reactive compensation; and
- Substation and / or mid-circuit boundaries.

However, despite the initial impression that these projects cover a great range of roles on the transmission network, every single one of the projects listed in Table 2-1 above is triggered by the connection of new generation ^[16] so, at a high level, they may be divided into just three categories, as follows:

1. Reinforcement of the existing MITS (for example, for augmentation of boundary transfer capability, stability alleviation) with a highly integrated addition to the existing AC network;
2. Bulk reinforcement of the existing MITS (for example, augmentation of transfer capability over several boundaries) with an AC or HVDC addition to the existing AC network; and
3. Extension to the existing MITS (for example, connection of new generation and / or load) with an AC or HVDC addition to the existing AC network;

¹³ Paragraph 3.4 of Ofgem's Integrated Transmission Planning and Regulation (ITPR) project: final conclusions, Decision statement, dated 17 March 2015

¹⁴ Ofgem, Strategic Wider Works Factsheet 125, November 2013, Table 1, available at https://www.ofgem.gov.uk/sites/default/files/docs/2013/12/strategic_wider_works_factsheet_0.pdf

¹⁵ When an overhead line circuit between two substations is cut and the circuit is re-directed on to another route, the 'stub' is the (usually short) section of line that remains connected to the substation and that may be re-used to connect a new circuit.

¹⁶ Although all these projects are triggered by generation connections, this does not, of itself, preclude the inclusion of other aspects in the SWW projects, such as new grid supply points for distribution network owners.

Table 2-1: Prospective Strategic Wider Works projects as at November 2013

Transmission Owner	Proposed project ^[17]	Key driver for investment
NGET	Hinkley-Seabank	Proposed new nuclear generation at Hinkley Point
NGET; SHE Transmission; SPTL	Eastern subsea HVDC link	Increase in the north-south transfer capacity; new offshore generation in Firth of Forth
SHE Transmission	Caithness-Moray	Onshore and offshore renewable generation
SHE Transmission	400kV East Coast	Increase capability to export renewable energy to central Scotland and North England
SHE Transmission	Kintyre-Hunterston	Renewable generation around Kintyre, Argyll and Bute area
SHE Transmission	Western Isles link and onshore works	New generation on Lewis
SHE Transmission	Shetland HVDC link	Generation on Shetland
SHE Transmission	Orkney Isles link	Renewable generation around the Orkney Isles and Pentland Firth
SHE Transmission	Beaully-Mossford overhead line	Renewable generation projects in the Strathconon and Mossford areas
SHE Transmission	Second East Coast subsea HVDC link	Wind generation including Moray Firth and marine generation from Pentland Firth and the Orkney Waters
SPTL	Dumfries and Galloway	To facilitate renewables in SW Scotland and to provide a secure link to the Moyle interconnector
SPTL	East Coast (Kincardine – Harburn) 400kV	Enables increased levels of renewable energy to be transferred from SHETL to SPTL network areas.

¹⁷ Though this list indicates what CATOs could 'look like', it should not be construed as a list of future CATOs because Ofgem indicates that any SWW projects whose funding has already been agreed will not be proposed as CATO candidates.

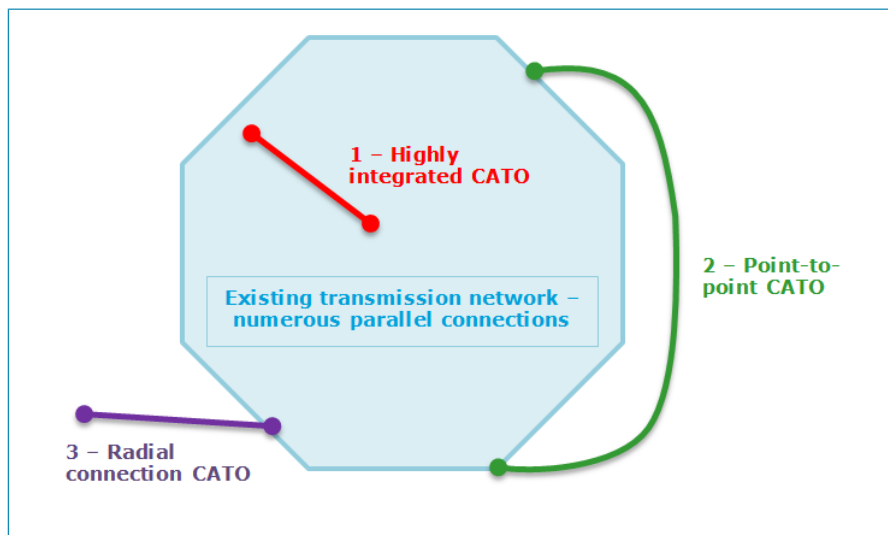
Table 2-2 maps the foregoing list of SWW projects against these categories.

Table 2-2: The fit of SWW projects into the three CATO categories

1 - Reinforcement of existing MITS – highly integrated with existing AC system	2 - Reinforcement of existing MITS – bulk point-to-point transmission	3 - Extension to existing MITS – less integration, mainly radial connections
<ul style="list-style-type: none"> • NGET - Hinkley-Seabank • SHE Transmission - Caithness-Moray ^[18] • SHE Transmission - Beaulieu-Mossford overhead line • SPTL - Dumfries and Galloway • SPTL - East Coast (Kincardine – Harburn) 	<ul style="list-style-type: none"> • Joint - Eastern subsea HVDC link • SHE Transmission - Caithness-Moray ^[18] • SHE Transmission - 400kV East Coast • SHE Transmission - Second East Coast subsea HVDC link 	<ul style="list-style-type: none"> • SHE Transmission – Kintyre-Hunterston • SHE Transmission – Western Isles link and onshore works • SHE Transmission – Shetland HVDC link • SHE Transmission - Orkney Isles link
NGET – National Grid (Electricity Transmission) SHE – Scottish Hydro Electric Transmission plc SPTL – Scottish Power		

We consider that these three categories cover the full range of potential CATO projects for the foreseeable future. Figure 2-1 illustrates the three categories:

Figure 2-1: Illustration of the three identified CATO project categories



Understanding these SWW project types helps to inform our understanding of the range of CATO stakeholders and their interactions with CATOs. To establish appropriate performance incentives, therefore, our next step is to identify the potential stakeholders for these three categories of CATO and the range of CATO behaviours that they require.

¹⁸ Note: This project fits two categories

3 CATO STAKEHOLDERS AND PERFORMANCE REQUIREMENTS

As we set out in section 2.1, a CATO is responsible for ensuring its assets are available and can be efficiently operated in co-ordination with the wider transmission network. Across the three categories of CATO identified in section 2, CATO assets will interact with a variety of different stakeholders through both tangible (physical) and intangible interfaces; and these stakeholders will have different requirements in terms of those assets' performances. This section identifies the key CATO interfaces, the stakeholders at these interfaces, and their requirements, to drive out CATO assets' core operational performance requirements.

3.1 Stakeholder goals

3.1.1 Tangible interfaces

As a starting point, we have mapped out the stakeholders with whom the CATO may share physical or on-site asset interfaces. Table 3-1 lists their objectives or requirements, and the effects of poor CATO performance on their asset(s) or interests.

Table 3-1: CATO impact on physical interfaces (during operations and maintenance)

Stakeholder	Stakeholder Goals	Potential impact of poor CATO performance
TO owner of a substation shared with a CATO	Efficient substation equipment maintenance with minimum delay. Reliable transmission equipment operation.	<ul style="list-style-type: none"> TO asset unavailability and unnecessary delay in return-to-service; TO breach of SQSS requirements; Damage to TO-owned equipment.
TO tenant who shares a CATO-owned substation		
TO part-owner of a circuit that is also part-owned by the CATO	Efficient circuit asset maintenance with minimum delay. Reliable transmission equipment operation.	<ul style="list-style-type: none"> Damage to landowner interests or property.
Landowner - grantor of easement or access	Sympathetic use of land by the CATO, without significant permanent damage.	
CATO and/or TO staff, general public ^[19]	Compliance with rules for health & safety and for the environment.	<ul style="list-style-type: none"> Danger to individuals and/or the environment.

Table 3-1 indicates that TOs who share a physical interface with a CATO asset want to avoid unavailability of their assets as a result of poor CATO performance, both to ensure ongoing compliance with SQSS requirements (and avoiding potential penalties for non-compliance) as well as to avoid damage to their assets. In terms of CATO performance, this broadly requires a planned, competent and efficient completion of maintenance activities along with minimum restoration times. Tenancy agreements of shared assets will normally include arrangements for the risk of 2nd party damage, however, such agreements may (need to) be informed by more detailed arrangements setting out

¹⁹ Referring to members of the public who may be, or whose property may be, physically or visually affected by CATO infrastructure.

stakeholder responsibilities and actions in case of shared tenancy or co-ownership of physical assets, for instance in Site Responsibility Schedules (SRS) and Network Access Policy (NAP) documents.

We would expect the performance requirements from landowners, staff, and the public to be covered in contractual arrangements and relevant legislation. Since we have assumed that CATOs will comply with legal and contractual obligations we do not consider these particular performance requirements further for incentivisation.

3.1.2 Intangible interfaces

Table 3-2 outlines the intangible (non-physical) interfaces with CATO stakeholders, again identifying the stakeholders' objectives and the potential effects on their interests of CATO performance. We provide further detail of the existing incentives on these stakeholders, which has informed this table, in Appendix 2.

Table 3-2: CATO impact on intangible interfaces

Stakeholder	Stakeholder Goals	Potential impact of poor CATO performance
SO	Network constraints – The SO is incentivised, through the Balancing Services Incentive Scheme (BSIS) ^[20] , to minimise system balancing costs. Balancing performance can impact the SO's revenue by around +/- £30M each year.	Unreliable or unavailable CATO assets could increase the SO's balancing mechanism costs and potentially lead to SO balancing performance penalties.
SO	SQSS compliance – The SO seeks to apply the SQSS in the face of the prevailing outage pattern. The SO can be fined in the event that it fails to operate the system in accordance with SQSS requirements.	Unplanned CATO unavailability will not necessarily contravene the SQSS, but will force the SO to take action to re-secure the system. Unnecessarily long CATO outage periods or ERTS ^[21] times would increase the burden upon the SO of re-securing the system in the event of failure of adjacent equipment.
SO	Transmission losses – As with incumbent TOs, the SO is subject to a reputational incentive to minimise transmission network losses.	Unavailability of CATO circuits could increase overall system losses, which could affect the SO's reputation on system losses.
SO	System reinforcement & investment planning	The SO needs to be able formulate efficient reinforcement options that may require input and innovation from the CATO.

²⁰ <http://www2.nationalgrid.com/UK/Industry-information/Electricity-system-operator-incentives/bsis/>

²¹ ERTS = Emergency return to service

Table 3-2: CATO impact on intangible interfaces

Stakeholder	Stakeholder Goals	Potential impact of poor CATO performance
SO	Real Time System Management – Promote a secure transmission system that optimises CML, energy not supplied (ENS), system balancing costs and voltage profile.	A CATO could, through poor switching or control practice: <ul style="list-style-type: none"> • Worsen the local voltage profile; • Increase the amount of reactive power spend; • Reduce quality of supply; • Impact ENS; <p>In events where crucial operational information is not shared, or SO instructions are not completed in a timely manner, the CATO could put the system security at risk.</p>
Adjacent TOs	Energy not supplied (ENS) performance – ENS payments (levied on TOs) are currently £16,000 per MWh, collared at 3% of TO allowed revenues. [22] For further consideration of ENS, see Box 1, p13.	Unplanned unavailability of CATO circuits could increase the likelihood of ENS, particularly where CATO circuits supply a DNO grid supply point or a directly connected customer. [23]
Adjacent TOs	Efficient isolation and site switching	Poor engagement from a CATO can: <ul style="list-style-type: none"> • Lengthen outage durations; and • Waste field staff resource within counterparties.
SO, adjoining generators / OFTOs, adjoining DNOs	Security of supply – The SO, generators/OFTOs and DNOs require connection security in order to minimise constraint costs, to maximise generation revenues and to avoid CML and CI incentive penalties, respectively.	CATO unavailability can increase the likelihood of: <ul style="list-style-type: none"> • Higher constraint costs for the SO; • The SO incurring BSIS penalties; • Generators losing revenue; • Consumers losing supply; and • The DNO incurring CML and CI penalties.
SO, Adjacent TOs, Adjoining DNOs	Co-ordinated outage planning – The SO has a reputational incentive to plan outages effectively, in co-ordination with asset owners and connected parties, so that their impact on the system is minimal. Rules and responsibilities regarding outage planning are set out in TOs' Network Access Policies (NAPs). Co-ordinated planning against well-defined NAPs enables good performance in the BSIS and helps other TOs and DNOs to conduct maintenance in an efficient manner.	CATO failure to plan outages through effective co-ordination with other stakeholders can <ul style="list-style-type: none"> • Reduce available outage slots for other network users; • Waste SO effort; • Waste effort of adjacent TOs; • Worsen the BSIS performance; • Require greater risks to be taken or increase inefficiency at the outage planning stage.

²² RIIO-T1 Final Proposals for SPT and SHETL: pp12, pp15 - https://www.ofgem.gov.uk/sites/default/files/docs/2012/04/sptshetlfpssupport_0.pdf
NGET Electricity Transmission Licence Special Conditions: VOLL, pp102 – <https://epr.ofgem.gov.uk/Content/Documents/National%20Grid%20Electricity%20Transmission%20Plc%20-%20Special%20Conditions%20-%20Current%20Version.pdf>

²³ For example, In 2014/15, 57 loss-of-supply incidents caused an estimated 375 MWh of energy not supplied – see National Electricity Transmission System Performance Report 2014-2015, <http://www2.nationalgrid.com/UK/Industry-information/Electricity-transmission-operational-data/Report-explorer/Performance-Reports/>

Table 3-2: CATO impact on intangible interfaces

Stakeholder	Stakeholder Goals	Potential impact of poor CATO performance
Consumers	Asset management – Efficient investment in asset health management	Inefficient investment in asset health management can adversely impact the CATO assets' reliability ^[24] and thus reduce the value and remaining operational life of the CATO assets upon expiration of the revenue term. (To the extent that inadequate asset management increases the risk of equipment failure this could also impact business interruption and event insurance premiums, which will in turn impact investor value.)
Consumers	Security of supply (including consistently good CATO performance against incentives). Efficient, low-cost and reliable transmission service (including high residual technical asset life).	Poor or inconsistent CATO performance undermines the efficient operation and management of the transmission system and risks reductions to security of supply. This can unnecessarily increase the costs of the overall transmission service to consumers.
Investors	Financial goals – Consistently good CATO performance against incentives.	Poor or inconsistent CATO performance (on almost any requirement) undermines the stability of cash flows, and possibly lowers the return on investment. Poor or inconsistent CATO performance can also adversely affect investors' reputation. This can affect investors' ability to win potential future CATO licences (or undertake similar investments).

The terms 'unavailability' and 'reliability' have been used in this table and will come up again frequently in the incentive proposals that follow; Box 1 therefore defines the terms for this discussion.

²⁴ See Box 1: Availability and reliability

Box 1: Availability and reliability

Availability of a CATO is defined as the percentage of each year that it is available to the SO for normal operations. The CATO should be capable of transmitting energy at its full design specification and its supporting systems (controls, communications and protection) should be fully operational. The definition of availability is discussed further in Appendix 3.

If the timing and duration of a CATO's period of unavailability has already been planned and agreed with the SO, then the outage is considered to be **planned unavailability**. However, if the outage is unexpected by the SO then the outage is considered to be **unplanned unavailability**.



Reliability of a CATO is defined as the absence of unplanned unavailability. For the SO, high transmission circuit reliability can be as important as high availability because, for example:

- The arrangements to re-secure the network following an unplanned circuit outage are normally much more costly to the consumer than when an outage is planned ahead;
- An unplanned outage on one circuit can cause emergency return to service (ERTS) costs on other neighbouring circuits; and
- The risk of ENS is much higher following an unplanned outage than during a planned outage.

Regarding ENS, although this is currently used as an incentive metric for incumbent TOs, it is important to recognise that ENS is not an appropriate metric for CATO operational performance. For the incumbent TOs, unreliability and energy not supplied (ENS) are synonymous, however, ENS would not work as a CATO's performance metric because the CATO, comprising just a small part of the overall NETS, cannot reasonably manage the risk of ENS (except, perhaps, in the very particular case where the CATO owns a whole grid supply point). Because managing the risk of ENS with a CATO performance incentive would be impractical, reliability and unreliability of CATOs will need to be measured without referencing ENS.

Notwithstanding the above argument, we note that a CATO's poor performance could still increase the risk of ENS and that, conversely, good CATO reliability (by the definition in this box) should reduce the risk of ENS.

In the long-term, as more CATOs are added to the transmission network over the years and the incumbent TOs comprise ever smaller proportions of the overall network, we consider that it may become increasingly unreasonable that the incumbent TOs be held accountable for ENS, since the efficient management of ENS can only occur at the system level. We thus recommend that, at some appropriate point – perhaps for the RIIO-T2 review – Ofgem should consider whether the ENS incentive should be re-formulated or, alternatively, reassigned.

3.2 Summary of CATO performance requirements


Table 3-3 below summarises the combined requirements for each type of CATO stakeholder. The majority of requirements in Table 3-3 apply broadly equally to each of the three CATO project categories identified in section 2.2 and illustrated in Figure 2-1 although, arguably, in comparison with CATO project types 1 and 2, CATO project type 3 (radial connections) may have comparatively little interaction with OFTOs and comparatively more interaction with connected generators, DNOs, and other load customers.

Table 3-3: Required CATO behaviours

CATO stakeholders	Need from CATO
SO (identifier of the CATO Needs Case)	High availability, High reliability during key periods, Good cooperation on the NAP, Good cooperation on maximum asset capability & real-time flexibility, Good cooperation on further investment / connections in future.
All neighbouring incumbent TOs	Clear boundaries & responsibilities, Good cooperation on the NAP.
Neighbouring OFTOs	Clear boundaries & responsibilities, Good cooperation on the NAP, Continuity of supply.
Outage coordinator (SO)	Achievable, coordinated, effective and stable outage plan for the whole of the national transmission network through the NAP
Directly connected generators	Continuity of supply
DNOs	Continuity of supply
Investors	Predictable cash flows and predictable licence-expiry asset value
Staff & the local public	Safe working
Land owners, the environment and the wider public	Long-term sustainable operation
Consumers	Efficient, low cost, reliable transmission

For stakeholders in the transmission system (the SO, incumbent TOs, OFTOs, DNOs, generators, and load customers), the key performance requirement is for CATO assets to be available, to ensure continuity of the transmission service, to avoid placing technical risk (and costs) on other asset owners, and to facilitate the SO's efficient operation of the system.

The SO has a particularly strong requirement for CATOs to be available during periods when the network is under stress; during such periods, CATO circuit unreliability may have major technical and economic consequences for the transmission system, its stakeholders, and consumers (as mentioned in Box 1, page 13). In terms of CATO asset performance requirements, we therefore consider that CATO availability and reliability, with full functionality (that is to say, with all the supporting systems – communications, control and protection – fully operational), to be the principal performance elements to encourage with CATOs.



A CATO project that meets the requirements of transmission system stakeholders and investors will thus also deliver the requirements of consumers; that is, an efficient, low cost, reliable transmission system that supports security of electricity supply.

4 RELEVANT PRECEDENTS AND INDUSTRY VIEWS

Having identified the key performance requirements for CATOs, this section discusses research we have undertaken to inform the development of a suitable operational performance incentive, covering:

- 1) Relevant precedents of transmission performance incentives in the UK and elsewhere;
- 2) Stakeholder responses to Ofgem's consultation on the planned arrangements for CATO infrastructure; and
- 3) Discussion with the SO on its current requirements.

Our approach to these three aspects is as follows:

1) Relevant precedents

Of immediate relevance are the regulatory frameworks for incumbent TOs of the NETS (RIIO) and the incentive mechanism for OFTOs. Alignment with the arrangements for TOs and OFTOs is one consideration in the development of a CATO performance incentive, to create a level playing field between owners of each type of asset, taking account of the relative risk of each type of asset. Section 4.1.1 below summarises the arrangements for TOs and OFTOs, as well as those for interconnectors with the NETS, where Ofgem has approved an optional cap-and-floor revenue protection mechanism along with an OFTO-like availability incentive.

Section 4.1.2 describes the arrangements in Victoria, Australia, for the independent ownership, construction and operation of groups of the assets that comprise the overall Declared Shared Network (DSN). As with CATOs, ownership and construction is awarded through competitive tender, and availability incentives are in place for the subsequent operation of the assets.

2) Stakeholder consultation responses

On 19 October 2015 Ofgem published a consultation on the planned arrangements for competitive tenders of onshore transmission infrastructure projects ("the consultation").^[25] Ofgem received the responses to this consultation on 11 January 2016, and has asked DNV GL to review all non-confidential responses for industry viewpoints relevant to the development of the CATO operational performance incentive.

Of the questions raised in the consultation, we consider of primary relevance the questions directly pertaining to the performance incentive itself. Section 4.2 provides a comprehensive overview of the relevant stakeholder responses and draws out their main findings.

3) Discussion with National Grid SO

On 31 March 2016 we took part in a telephone conference between National Grid (the SO), Ofgem and DNV GL, to ensure that our understanding of the SO's requirements from CATOs is current and that the

²⁵ Ofgem, "Extending competition in electricity transmission: arrangements to introduce onshore tenders", 19 October 2015. https://www.ofgem.gov.uk/sites/default/files/docs/2015/10/ecit_consultation_v6_final_for_publication_0.pdf

performance incentives we propose are properly focused. Section 4.3 outlines the insights obtained in that discussion.

4.1 Relevant precedents on transmission performance incentives

4.1.1 The UK

4.1.1.1 RIIO – the incumbent TOs

Both reliability and availability are among the output categories for incumbent TOs under RIIO-T1. Depending on a TO's performance in delivering the requirements in each category, it may face financial and/or reputational consequences.

The primary *Reliability* metric is Energy not Supplied (ENS). ENS is set as an annual target level (in MWh) specific to each TO. For RIIO-T1, the incentive rate is set at £16,000/MWh (in real terms), based on an estimate of the Value of Lost Load (VOLL). The incentive is symmetric, so that TOs are rewarded if they outperform their target (subject to a natural cap at 0 MWh of ENS) and penalised if they fall short (limited to 3% of annual revenues).^[26]

As regards *Availability*, all TOs are required to prepare and maintain a Network Access Policy (NAP) document. The NAP facilitates the efficient co-ordination between the TO and the SO (National Grid) on the short- and long-term planning, operation and management of the MITS, to minimise the overall costs of the transmission system to consumers, as well as to co-ordinate on matters where actions by one party affect (the costs or performance of) the other.^[27] There is no immediate financial consequence (penalty or reward) tied to failure to prepare or adhere the NAP. Rather, preparing a NAP is a TO licence requirement, and adherence to the NAP affects the TOs reputation and relationship with investors and the SO. Failure to prepare and maintain a NAP therefore potentially has long-term financial consequences, and in the extreme, could lead to loss of the transmission licence and associated financial sanctions.

We provide further consideration of the NAP in Section 6.1.5.

4.1.1.2 OFTOs

Availability (rather than ENS) is the key OFTO performance measure. Through this measure OFTOs are incentivised to promptly restore wind farm connections to the MITS following (planned or unplanned) outage. The nature of the incentive is a symmetric adjustment to an OFTO's annual Base Transmission Revenue in the event that its annual availability exceeds or falls below its licenced target availability

²⁶ Ofgem, *RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Grid Gas*, 17/12/2012, §2.6, p11; and: Ofgem, *RIIO-T1: Final Proposals for SP Transmission Ltd and Scottish Hydro Electric Transmission Ltd*, 23/04/2012, Table 1 (p15) and Table 5 (p20).

²⁷ Ofgem, *RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Grid Gas*, 17/12/2012, p15-16.

which, in the case of most OFTOs to date, stands at 98%. The rate of the incentive is a linear 2½% adjustment to revenue for every 1% change in recorded annual availability. ^[28]

The incentive is not designed to compensate connected generators for lost generation, since such impacts on OFTOs would be disproportionately large relative to their revenues. Rather, the levels of revenue at risk are designed to incentivise OFTOs to maintain high levels of availability across the 20 year term of their base revenue stream, but without putting them in danger of default on lending agreements in the event of lengthy outages. We note that this incentive is powerfully reinforced since, although the penalty on the OFTOs' annual revenues are collared at 10% pa, the penalty for a very serious drop in annual availability would be an overall loss of up to 50% of annual revenue, levied in 10% tranches over a five year period.

This single performance incentive thus has the potential to affect a much higher proportion of the OFTO's revenue than does the ENS incentive of the incumbent TOs (just 3% of their annual revenue is at stake for ENS performance). The much stronger incentive on the OFTO is desirable because the key OFTO behaviour being incentivised is its availability, whereas the incumbent TOs are being incentivised over a broad range of performance measures, just one of which is ENS.

The OFTO availability performance incentives can therefore be summarised as follows (more detail is provided in Appendix 4):

- Availability:
 - Linear slope with revenue break-even at the availability target of 98%;
 - Seasonal availability weighting, typically chosen by the wind generator;
 - Exponential available capacity weighting of the outage duration, with 'a' & 'b' chosen by Ofgem;
 - Cap of +5% of base annual revenue for 2% above availability target; and collar of -10% for 4% below target.

On top of this incentive, the OFTO licence requires that the licensee procures a financial security of at least 50% of its base transmission revenue to cover future financial liabilities until the end of the revenue term. ^[29] This security ensures that the OFTO can be penalised for poor incentive performance over the full course of the revenue term, and provides a direct financial incentive for the OFTO to undertake efficient long-term asset management.

4.1.1.3 Interconnectors

Interconnectors that serve GB currently have two business model options; ^[30] they may opt either for the unconstrained business model, known as the 'merchant-exempt route' or they may choose the cap

²⁸ The description of the OFTO performance incentive scheme in this section is derived from the following documents:

- Ofgem's letter "Changes to the Offshore Transmission Owner (OFTO) availability incentive", dated 28 March 2011;
- Ofgem's letter "The generic offshore transmission owner (OFTO) licence for Tender Round 3", dated 7 March 2014; and
- Ofgem's "Generic Offshore Transmission Owner (OFTO) Licence", dated March 2014.

²⁹ Ofgem, Generic Offshore Transmission Owner (OFTO) Licence (Version 1.5), August 2013, Supplementary provisions 14-15, p58, available at: https://www.ofgem.gov.uk/sites/default/files/docs/2013/09/generic_ofto_licence_v1_5_changes.pdf. To come into effect by year 16 after licence award and designed to cover financial liabilities through the availability incentive mechanism in the last 5 years of the OFTO revenue term.

³⁰ This description for the incentive schemes of UK interconnectors is derived from the following documents:

- The Secretary of State's statutory instrument regulations document "The Electricity Capacity (Amendment) Regulations 2015", dated 23 March 2015, available at: http://www.legislation.gov.uk/ukxi/2015/875/pdfs/ukxi_20150875_en.pdf

and floor regulated route, where their profits are capped and their losses are collared. Compared to the 'merchant-exempt route', the cap and floor regulatory incentive mechanism aims to open up more interconnector construction finance options through this risk reduction for investors.

To maintain the incentive to offer high levels of availability Ofgem proposes to put in place availability incentives; the amounts may vary from project to project, but for the NEMO interconnector the incentive in high revenue years is expected to be an adjustment of +/-2% of cap revenue against a target availability of 97%.

Ofgem is currently consulting on the possible introduction of an interconnector availability incentive in the electricity interconnector standard licence conditions.³¹

4.1.2 International practice - Victoria, Australia

Within Victoria, Australia, contestable augmentations to the DSN^[32] are extensions or upgrades to the existing electricity transmission network whose construction and operation are open to a competitive tender process. For each tendered network augmentation, the successful transmission network service provider (TNSP) wins the right to construct and to operate, for 30 years, the augmentation which, upon commissioning, becomes part of the DSN.

These augmentations are regulated by the Australian Energy Regulator (AER), who operates a Service Target Performance Incentive Scheme (STPIS) to encourage TNSPs to achieve, amongst other things, high levels of availability. The incentives take the form of 'rebates' (penalties) on the monthly Transmission Charges that the independent SO pays to the TNSP.^[33]

The Heywood Terminal Station Upgrade example (see further details in Appendix 5), which comprises a fifth 'supergrid transformer' being added to an existing set of four, shows that the SO's valuation of availability / reliability of the Heywood plant varies by a factor of around 60 over the course of the day, which has the combined effect of discouraging outages at peak times of the day whilst encouraging planned outages to be short – just a few hours each if they are during the peak season.

The other significant factor noted from our review of this utility was that, where a TNSP's actions are shown to cause a neighbouring TNSP to incur availability penalties, the TNSP causing the issue pays the neighbour's penalties too.

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- Ofgem's IEA electricity security advisory panel presentation "The role of interconnectors in GB adequacy planning", dated 28 September 2014, available at: <https://www.iea.org/media/workshops/2015/esapworkshopvi/Becker.pdf>;
 - Ofgem's letter "Interconnector developers and other interested parties", dated 27 November 2015, available at: https://www.ofgem.gov.uk/sites/default/files/docs/decision_to_open_a_second_cap_and_floor_application_window_for_electricity_interconnectors_in_2016.pdf; and

³¹ Ofgem, "Consultation on proposed changes to the standard conditions of the electricity interconnector licence, the electricity interconnector licences held by Nemo Link and NGIL and the electricity transmission licence held by NGET to implement the cap and floor regime and use of revenues compliance", 04 February 2016, p6-7, available at: https://www.ofgem.gov.uk/system/files/docs/2016/02/consultation_on_licence_modifications_to_implement_the_cap_and_floor_regime_and_use_of_revenues_compliance.pdf

³² The Declared Shared Network (DSN) is equivalent to the UK's MITS.

³³ In this case the SO is AEMO - the Australian Energy Market Operator.

4.2 Review of stakeholder consultation responses

4.2.1 Stakeholder views on performance incentives

Stakeholders' views on the structure of performance incentives for CATOs were solicited through the following Ofgem consultation question:

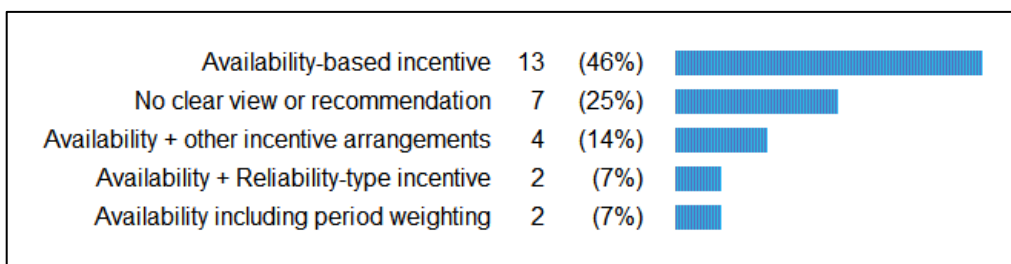
"What are your views on our proposed package of financial incentives for CATOs? Do you have any views on how we could structure an availability-based incentive to ensure CATOs operate their assets with a 'whole network' view?" ^[34]

Section 4.2.2 summarises the twenty-eight responses received to this question. As the chart in Figure 4-1 shows, the majority (21) of respondents agreed in principle with the introduction of an availability-based incentive, although seven respondents in this group specifically proposed additional or modified arrangements:

- Two respondents advocated an availability incentive in conjunction with a reliability incentive, such as energy-not-supplied (ENS) under RII0;
- Four respondents argued that an availability incentive would have to be supported by further arrangements, such as an asset-management incentive (1), differentiation between planned and unplanned availability (1), a requirement for the CATO to be bound by the STC and the NAP, as well as subject to NOMs (1), and additional measures of network capability and operation (1); and
- Two further respondents endorsed monthly or peak-period weighting, reflecting the previous arrangements for OFTOs, to capture differences in the opportunity costs of unavailability at different times.

The remaining seven respondents did not provide a clear endorsement of an availability-based incentive or of any other specific incentive measure.

Figure 4-1: Stakeholder support for availability-based incentive



The two respondents arguing the need for a reliability incentive alongside an availability-based incentive cite "whole network" type considerations, including, respectively, the need to co-ordinate planned

³⁴ Question 7, p16.

outages with the SO, and the need to consider the criticality of CATO assets, where they involve generation circuits, demand circuits, and circuits with and without constraint implications.

The four respondents who advocated additional measures alongside an availability incentive offered the following considerations:

- One respondent argued that an availability-based performance incentive must be supported by an asset-management incentive, to ensure the CATO licence holder is incentivised to invest in asset maintenance for the asset's physical life, not just for the revenue term. The respondent reasoned that this would avoid a potential perverse incentive to maximise short-term availability requirements in lieu of maintenance and inspection to increase long-term availability.
- A second respondent suggested additional incentives differentiating between planned and unplanned outages, where planned outages up to an industry-accepted limit do not incur penalties, and unplanned outages always incur a penalty. Moreover, this respondent suggested that the penalty for unplanned outages should always be higher than the penalty for planned outages.
- A third respondent suggested that CATOs be bound to the STC and NAP, to underline the role of a CATO as part of the wider ("whole") network, as well as subject to NOMs, to incentivise CATOs to manage the health and condition of its assets;
- The fourth respondent in this group suggested incentives for a range of technical performance measures, such as MVAR capability (rather than just MW), Short-term overload capability, harmonic performance, Ramp rates (for HVDC equipment), black start ability start, and Frequency Response (for HVDC equipment).

Various respondents offered additional considerations for the implementation of a performance incentive:

- Around half of the 28 respondents to question 7 highlighted the importance of a performance incentive, availability-based or otherwise, to reflect the position of CATOs within the integrated onshore transmission network, requiring a "whole network approach" to considering (the regulation of) CATO performance requirements, taking account of (the costs of, or value to) different stakeholders affected by CATOs, as well as different interfaces CATO infrastructure may have with the MITS.
 - One respondent in this group, who agreed with an availability-based incentive mechanism, noted that the need for an incentive to reflect (the costs of) different stakeholders may require the incentive parameters to be tailored to individual CATO projects;
 - Another respondent suggested that an availability incentive could be tailored to reflect the added value of reduced downtime in some circumstances, for instance in meeting shortfalls in the relevant network area, based upon forward reviews of asset lifecycle and maintenance plans.

4.2.2 Summary of stakeholder responses

The strongest, most often-repeated message to emerge from the responses on the subject of performance incentives was the need, one way or another, for CATOs to 'fit in' with existing practices and standards of the current transmission industry, in terms of (i) operational reliability and availability, (ii) cooperation (and flexibility) around maintenance outage planning and (iii) whole-of-life asset management.

Regarding how these objectives are to be achieved, whilst a majority of respondents endorse the principle of an availability-based incentive mechanism, a number of respondents consider that other aspects of CATO performance may also need to be regulated. These other aspects include:

- Availability at key times to obviate, or to mitigate, network stress (reliability);
- Cooperation with the SO and incumbent TO over efficient, stable, and yet flexible outage plans;
- Compliance with the STC, the Grid Code, and appropriate Standards;
- Cooperation with the SO on real-time asset capability in order to efficiently manage system potential stress;
- Management of the CATO assets for the whole-of-asset-life (indicated by one respondent as 45 years) rather than just for the revenue term; and
- Facilitation of further transmission connections to the CATO assets during its lifetime, as the need is identified by the SO.

The reflection, in its incentives, of a CATO's value / costs to different stakeholders also finds broad support, as does the complementary view that any incentive should take account of a CATO's position in, and interaction with, the wider transmission network.

4.3 Discussion with the SO

The following brief note summarise the discussion between National Grid (the SO), Ofgem and DNV GL which DNV GL requested in order to ensure that its understanding of the SO requirements for CATOs was current. The key messages were as follows:

- **Planning**
 - It is important that the CATO is available during key periods of network operation, but even more relevant is that the CATO plans its unavailability well ahead (in line with the multi-year ahead outage planning approach embodied in the UK NAPs);
 - Adherence to planned outage times is paramount – prompt outage starts and finishes are vital;
 - Agreed emergency restoration times must be achievable;
 - Unplanned unavailability can cause severe disruption to the system, causing the SO constraint costs, other TOs outage rearrangement costs, and the consumer the risk of ENS;
 - It was agreed that reliability, in the context of a CATO, is the avoidance of unplanned unavailability rather than the avoidance of ENS; and

- In answer to a question about short notice changes to circuit availability requirements, the SO indicated that a CATO's flexibility in adjusting outage timings at short notice, for example, in response to weather conditions that disrupt the established national outage plan, would be of value.
- **Operations**
 - CATOs must clear faults successfully, within required timescales, and with good protection discrimination;
 - For expected single circuit risks, anticipated severe weather, onset of winter, etc., although the SO might not expect to see a specific incentive associated with these events it would expect the responses of the CATO to be those of a responsible TO, safeguarding its reliability particularly during critical periods;
 - Winter availability used to be key for the SO; however availability requirements during the summer and the seasonal loading shoulders are now starting to match those of the winter;
 - Short-term ratings and post-fault ratings are a significant current requirement, as is the TO's amenability to the retro-fitting of automatic switching and intertrip schemes (we note that this not so much a performance issue but reflects the need to make provisions in the CATO asset designs and in its licence conditions);
- **Other points made by the SO**
 - The tension between the SO and CATO on outage duration preferences were noted; There will be a tendency for the SO to seek short outages which, in some circumstances, may not align with the CATO's natural preferences for managing maintenance outages. The SO raised the concepts of charging CATOs for access rights to the equipment and of the SO paying a 'facilitation fee' to the CATO for decreasing an outage's duration; and
 - Aside from single circuit risks, it is difficult to identify, ahead of time, 'premium periods' of network stress that might benefit from special measures by the CATO to enhance its reliability during these periods.

Except for charging the CATO for access rights to maintain its own equipment and paying the CATO facilitation fees for reducing outage durations compared with planned durations, we have endeavoured to accommodate these points within the incentive proposals of this document.

4.4 Summary of precedents

The regulatory frameworks for incumbent TOs and OFTOs in the UK incentivise the owners to ensure their assets are available for operations. For OFTOs, changes in the rate of asset availability lead to changes in annual allowed revenues and therefore carry a specific financial consequence. For incumbent TOs, asset availability is incentivised through a licence requirement to prepare and maintain a Network Access Policy (NAP). Currently, there is no direct financial consequence to TOs for failing to maintain or adhere to the NAP, however failure to do so may have a negative impact on the TOs reputation in the eyes of investors, the SO, and other industry stakeholders. Owners of interconnectors in the UK are not currently subject to an availability incentive, although Ofgem is currently consulting on the possible

introduction of a financial availability incentive for interconnectors that choose the cap and floor regulated regime. ³⁵

In addition to availability, incumbent TOs under RIIO are incentivised to deliver high reliability of consumer supplies by penalising interruptions of electricity flows to consumers. This incentive changes TOs' allowed revenues depending on their performance against a target quantity of energy not supplied (ENS); the penalty is collared at $\pm 3\%$ of annual allowed revenues. In comparison to asset availability, ENS carries a comparatively low risk since under normal circumstances unavailability of a single circuit on the UK NETS only rarely results in ENS.

The need to incentivise both the availability and reliability of transmission infrastructure is reflected in the regulations for UK OFTOs as well as in the rules for contestable augmentations in Victoria, Australia. Both regulatory frameworks regulate asset availability in first instance, and both include periodic (monthly, peak - off peak) weightings that reflect a higher value placed on asset reliability at specific times. (Note: 'reliability' as defined in Box 1, p13.)

On the basis of this research, we consider availability and reliability as the primary CATO behaviours to be incentivised, and have found this view confirmed in stakeholder responses to Ofgem's recent consultation on regulatory arrangements for CATOs. Moreover, a number of respondents have advocated the need for CATO incentives to facilitate co-ordination with the wider transmission network (the 'whole network approach') as well as to encourage efficient long-term asset management. The latter comments reflect current arrangements under RIIO, where incumbent TOs co-ordinate outages via NAPs, and long-term asset health is monitored through NOMs reporting. We consider similar arrangements are appropriate for CATOs, as we explain in the next section.

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https://www.ofgem.gov.uk/system/files/docs/2016/02/consultation_on_licence_modifications_to_implement_the_cap_and_floor_regime_and_use_of_revenues_compliance.pdf

5 CATO PERFORMANCE REQUIREMENTS

In Section 3, we identified likely key CATO stakeholders, the relationships and interfaces that CATOs would have with each stakeholder, and the requirements that each stakeholder would have of any CATO. In Section 4, we reviewed performance incentives faced by TOs, OFTOs and UK interconnectors, as well as relevant regulatory precedent in Australia and the views expressed by stakeholders in Ofgem's recent consultation. From these three sources we have drawn the clear message that there is a small set of critical behaviours that, together, will characterise desirable CATO performance. In this Section 5, we explain these performance requirements.

5.1 Summary of CATO performance requirements

Table 5-1 summarises the key performance requirements we have identified for CATOs. In addition to noting the operational requirements of availability and reliability, this list reflects the significant importance of cooperating at a high level with the other transmission and distribution stakeholders as well as with the SO. We discuss these requirements further in the remainder of this chapter.

Table 5-1: Key CATO behaviours

Desired CATO Behaviour	Interested stakeholders	Performance notes
1 High annual availability (defined in Box 1, p13)	SO, TOs, consumers	<ul style="list-style-type: none"> A CATO's circuit performance target takes into account asset or technical characteristics alongside network requirements; Where a CATO operates more than one circuit, these may play different roles in the transmission system and may have different availability targets.
2 High reliability (defined in Box 1, p13)	SO, TOs, consumers, investors	<ul style="list-style-type: none"> CATOs to avoid unplanned unavailability, which is likely to have a greater impact on system operation than planned unavailability; There may be certain times when CATO reliability is more critical to system operation than others.
3 Cooperation on outage planning	SO, neighbouring TOs, consumers	<ul style="list-style-type: none"> CATOs to plan routine maintenance in advance with the SO and stick to agreed outage windows; CATOs to offer timing flexibility to accommodate system needs at short notice, where it is economic and efficient to do so.
4 Effective asset management for consumer's benefit	SO, consumers, investors	<ul style="list-style-type: none"> CATOs to adopt asset management policies / strategies over the duration of the revenue term that achieve economic lifetimes.

5.2 Description of CATO performance requirements

5.2.1 High annual availability

High CATO asset availability delivers the utility intended of the CATO assets. High CATO asset availability simplifies NETS operation, increases the opportunities for planned outages on the network (maintenance, new connections and transmission reinforcement) and lowers the costs of transmission losses. It also promotes higher overall network reliability – that is, it reduces the risk of ENS.

We have provided and explained a definition of CATO asset availability at Box 1, p.13. On this definition, which may be summarised as the percentage of each year that a CATO circuit is available to the SO for normal operations, CATO circuit availability is straight-forward to measure, record, and analyse. We expect there to be a range of high annual availabilities that would be acceptable from a CATO asset, whilst below this range the utility of the asset to the SO, and thus the satisfaction of all stakeholders, would quickly start to fall.

5.2.1.1 Performance Target

This requirement for high availability from the CATO may be characterised by the application of a ‘target’ annual availability that would be set by the SO to suit the CATO assets’ role on the network (for example, MITS circuits, DNO supply, generation connections) and, in the case of a late-build CATO, to take reasonable account of the capabilities of the CATO’s transmission topology and technologies (for example, overhead line, underground cable, HVDC) too. ^[36]

The reason that the network role for the CATO can be relevant to the setting of the availability target relates to the type of service required from the CATO. In a MITS role, for example, CATO reliability may take priority over its availability – the key message being that the durations of planned outages are not critical; the important thing is to be reliable at times of system stress. In this case a circuit outage on a MITS overhead line with parallel-running circuits would be unlikely to impact ENS except during times of system stress so the availability target may not need to be set very high. However, the same outage on a DNO supply or a generation connection could have a much greater impact on network users. In this case, high availability could thus take a higher priority than reliability – the key message being that a few brief trips are acceptable so long as the circuit is returned to service very quickly. Here, then, the availability target may be set higher than for the MITS role.

However, for late-build CATOs, the availability target set by the SO needs to take into account, to some degree, the CATO technology and topology (and even the geographic location), all of which can have some bearing on circuit availability due to weather patterns, maintenance requirements and failure repair times. Conversely, for early-build CATOs, circuit design and overall CATO topology would need to take into account the availability targets specified by the SO.

As the target annual availability metric so simply characterises the desired CATO behaviour of delivering high circuit availability it is relevant to link it with degrees of annual reward and/or penalty for performance above and below this level.

³⁶ For early-build CATOs, the target availability required by the SO would be a factor in the choice of transmission technologies employed within the CATO assets.

This is not a new approach. The mechanism is already familiar to UK stakeholders through the OFTO incentive regime, and both the OFTO and Victoria Australia realisations of the mechanism successfully use annual revenue to effectively incentivise behaviours that promote high availability. For all of these reasons, we propose that CATO availability is incentivised using a direct link to annual revenue.

The choice of the target availability mechanism to incentivise CATO availability is further endorsed by the fact that another of the CATO required behaviours – reliability – can also be incentivised through the same basic mechanism – see Section 5.2.2.

Having said that it is straight-forward to establish this metric, it is worth considering the situation where a CATO can only transfer a proportion of its declared capacity, or some of its specified control functions are unavailable or restricted. There is more than one way of assessing the functional depletion of a CATO circuit for incentive purposes. One approach would be to simply say that, if the circuit capacity or functionality is partially reduced, the circuit would be counted as 100% unavailable and should be penalised as such in order to incentivise a speedy repair. An alternative approach, however, would be to apply a lower penalty than this, that reflects just the missing capability (or an approximation to it).

Our concern with the first approach is that the CATO may decide that, since it is not being rewarded for partial availability, it will have no incentive to maintain any availability at all until a repair is effected, thus risking the loss of the benefits to the transmission system that the CATO circuit might still be able to offer. We consider that an approach that rewards the CATO for delivering its partial in-service capability until a repair can be arranged, but that still incentivises a repair as quickly as practicable, would best serve the interests of consumers and would thus be the most appropriate. Further details of our proposal for such an approach are outlined in 6.3.7.

5.2.1.2 Multiple circuits

On the face of it, the simplest approach to incentivising CATO performance would be to set a single set of parameters for the whole CATO. However, depending upon the complexity of a CATO's assets and the manner of their connection into the NETS, it is quite possible that some of the CATO's circuits will perform different functions to others and it is very likely that its circuits will not perform identically to each other over their lives. From the SO's viewpoint, too, it will want to control and plan outages for each of the CATO's circuits on an individual basis, rather than as a group. Given both that a CATO's circuits may have a variety of performance requirements and that the SO will, in any event, need to manage their outages on an individual basis, monitoring and incentivising the performance of a CATO as a single technical entity would be likely to be confusingly simplistic (if 'fiddle factors' have to be used to 'tune' the incentive), and possibly perverse and counterproductive (if a broad-brush incentive over- or under-rewards CATO performance).

For this reason, our recommendation is that the performance incentives described here, and the monitoring and analysis associated with them, are applied to each CATO primary circuit separately so that, for a CATO that owns, for example, four transmission circuits, the performance of each of the four would be separately managed against their relevant performance incentives.

5.2.2 High asset reliability

High asset reliability benefits all stakeholders. By minimising unexpected outages on the transmission network, high CATO asset reliability promotes lower risk of ENS and lower network constraint costs. It also tends to improve the quality of supply (less unplanned switching, so fewer associated voltage steps) and tends to lower the risk to performance incentive payments for incumbent TOs and the SO. There is reputational benefit for all transmission stakeholders, too. It follows, therefore that poor reliability in transmission assets is costly, and to be discouraged.

Reliability, on the face of it, is a more complex metric to establish and incentivise, since it can involve consumer impact, asset unavailability, and outage timing and frequency issues. Amongst our early considerations of this performance aspect was whether the established RIIO-T1 approach to measuring unreliability – namely measuring ENS – could also be used for CATOs. However, we quickly rejected this approach since it would be impractical for the CATO to have any meaningful control over reducing ENS in its area of the NETS and frequently it would also be very complex to fairly apportion blame to a CATO for local increases in ENS. Box 1, p.13 provides further discussion on why ENS is an inappropriate performance metric for CATOs.

There is an argument that any unreliability metric should take account of the number and/or frequency of unplanned transmission interruptions and the duration of these interruptions; however, in the context of the UK transmission network, where there is a degree of circuit redundancy that renders the NETS already robust against transient circuit interruptions (especially to accommodate lightning strikes), our view is that, for most connection topologies, CATO stakeholders (including the SO) are less likely to be concerned about transient circuit trips than about prolonged unplanned outages. Our proposal, therefore, is that a reliability incentive should concentrate upon the duration of unplanned outages rather than upon their frequency.

Of course, very frequent transient circuit trips and reinstatements would carry a more serious difficulty for the network than the occasional trip; however, our view is that any CATO that owns its own boundary circuit breakers is already incentivised to avoid frequent trips by avoiding the additional wear that its breakers would suffer. (Where the CATO equipment is protected by another stakeholder's circuit breakers this approach may not apply, in which case a separate incentive to avoid frequent tripping may need to be applied.)

Given the above stakeholder requirements, we consider that, by adopting our definition of unreliability stated in Box 1, p.13, it is possible to effectively measure unreliability with the same mechanism as unavailability, simply by excluding planned unavailability from the metric. Taking this approach, annual unreliability (percent) would be measured as unplanned unavailability (percent).

Since circuit reliability is normally enhanced by appropriate asset maintenance, which requires service outages from time to time, the requirement for reliability is, in some ways, perverse to the requirement for availability. However, one way of resolving this perversity is to decide, from the outset, the ideal balance of availability and planned maintenance outages for the CATO circuit and to set this as its annual availability target. If the incremental reward rate for availability above target is lower than for availability below target whilst, at the same time, the penalties for unplanned unavailability are strengthened, the CATO will be encouraged to take appropriate planned outages to improve the health of its assets. (See the Note in Appendix 7.) This is the essence of the argument for a target availability of less than 100%.

We have considered the possibility of an incentive mechanism whereby annual circuit availabilities above target could actually lower the annual availability reward. However, we have rejected this approach because some equipment does not need to be maintained every year so, in the years when availability is genuinely able to exceed the target without adversely affecting asset health, it is important to maintain the incentive for high availability. To properly accommodate the technical realities of multi-year maintenance intervals for some plant types we propose the use of rolling annual performance averages.

5.2.3 Cooperation on outage planning and management

Cooperative and flexible outage planning and timing, through a coordinating mechanism such as is embodied by the existing NAPs, maximises the opportunities for planned outages and identifies options for the SO in situations of unexpected system stress. Through these benefits, cooperation lowers consumer costs.

Cooperation with the SO on outage planning involves several associated behaviours. Key amongst these is the submission of planned outage requests more than year-ahead wherever possible. Coupled with this, it is of great importance to the SO that agreed outage windows are adhered to in real time. This is because there can be times when the implications of overrunning a planned outage period has a similar gravity to unplanned unavailability.

In addition to these normal outage planning behaviours, TOs that can offer flexibility on their agreed outage windows can help the SO to re-optimize the efficiency of the national outage plan when it becomes disrupted – a situation that can occur for a number of reasons, but particularly due to severe weather.

Incentives for these behaviours could, to a certain extent, be purely deterministic, imposed, for example, through licence conditions and conditions within a CATO NAP – and indeed we propose that these CATO behaviours are specified in this way. However, such rules do not encourage a CATO to ‘strive to cooperate’ in a manner that would be most helpful to the SO, who needs to be able to request TOs to flex their outage plans when the system is already under some duress. We therefore consider that further measures, which encourage the CATO to accommodate the SO’s needs with alacrity, would be useful options for the SO; especially where the CATO performance heavily impacts the MITS’ overall performance. The further measures we propose are explained in Section 6.3.5.

5.2.4 Effective asset management

Effective, well managed asset management offers the revenue term benefits of promoting CATO reliability and safety and predictable cash flows for investors and the long-term (after expiry of the revenue term) benefit of leaving the assets in a robust state to continue operation for a further significant period.

All transmission assets’ capabilities and health degrade with time and/or operation and equipment economic lives can range from as little as around 15 years (for example, some control and communications equipment) to well over 50 years (for example, some underground cables). We anticipate, therefore that the majority of a CATO’s assets should be able to offer many years of reliable

operation beyond the CATO the end of the revenue term, if they and their environments are properly maintained.

However, if the availability incentive proposals discussed in Section 5.2.1 are adopted, the CATO could be incentivised to achieve a high availability of its assets at the expense of appropriate maintenance to sustain asset health and reliability. This practice would be counter to consumer's interests in the long term since it runs against the whole-of-life cost optimisation principles of good asset management in favour of short-term CATO gain, resulting in increased risk of poor technical performance in the later years of the revenue term and beyond.

In the early years of the CATO revenue term, the requirements of good asset health and high availability, broadly do not conflict – the future requirements for good availability, and certainly for good reliability, are likely to encourage the CATO to perform some maintenance. As the end of the revenue term approaches, however, the CATO's priority on long-term future performance could lessen so it may increasingly be inclined, at that stage, to sweat the assets to levels that are inappropriate to achieve their optimal technical lives.

These conflicts of interest are brought about by the different timescales over which the CATO and the consumer view the assets. On the one hand, the CATO's time horizon is limited to the duration of the revenue term, whilst on the other, the consumer is interested in longer term value-for-money from the assets. One way to resolve these timescales could be to allow the CATO a longer term or an 'in-perpetuity' option on its revenue term. However, if these timescale differences cannot be resolved, other measures to protect asset health and, through that, reliability and consumer value-for-money may be required.

For this purpose we have identified two complementary methodologies and consider that both could be employed together. Firstly, as just mentioned, good asset health is a pre-requisite for reliable operation, so we propose that the operational reliability incentives already discussed in Section 5.2.2 are made strong enough to encourage the CATO to adequately maintain its assets for the early and middle years of the revenue term.

Secondly, however, to appropriately protect asset health towards the end of the revenue term, we propose independent assessments of the CATO asset condition that would lead to estimates of residual technical asset lives and to judgements of quality of asset management. One of these assessments would take place at the end of the revenue term and at least one other would take place at an agreed period before that. Further details of the proposed incentives are provided in Section 6.3.1.

5.3 Considerations in incentivising owners of regulated assets

By definition, a principal objective of commercial undertakings is to maximise profits. However, the ability of an undertaking to achieve this objective, as well as the way it pursues the objective, is influenced by the financial, legal, and reputational incentives acting upon the undertaking. Typically, a regulated undertaking faces a combination of all these natural ^[37] incentives plus the rewards and penalties imposed by the Regulator to influence its behaviour towards its short- and long-term performance obligations.

³⁷ Natural incentives are those that impact an organisation even before any regulatory incentives have been applied. These might include the need to make a profit, or the need to maintain a good reputation.

This is certainly the case for all the TOs and OFTOs in the UK, whose natural reputational, legal and financial incentives are supplemented by the Regulator's financial incentives linked to transmission performance requirements. This direct linkage between transmission performance and profits has proved a powerful incentive mechanism for existing TOs and OFTOs and we consider that a similar mechanism could successfully be applied to CATOs. We present next some further considerations of each of the main incentive elements.

5.3.1 Reputation

The attractiveness of regulated network businesses to investors is that they provide stable, long-term investments with comparatively low risk. Key to the network businesses' ability to obtain financing is that they maintain the reputation of offering this stability and risk profile to investors, since failure to maintain a "good" reputation with investors may jeopardise their ability to obtain future financing or lead to an increase in financing costs that reduces their future earnings. For this reason, network businesses have a strong incentive not to undertake any action that undermines the stability of regulated returns, or otherwise increases the risk to investors.

5.3.2 Industry Framework

An owner of an electricity transmission asset derives its entitlement to transmit electricity and to charge for this service through holding a transmission licence, whose authority is granted by Ofgem under the Electricity Act 1989. The transmission licence places conditions on the revenue entitlement for the licensee; it stipulates minimum performance requirements and obliges the licensee to comply with relevant laws and industry codes and regulations as well as to make available certain information (reporting requirements). The electricity industry codes themselves underpin the provisions of the licence by articulating the rules and processes that a licensee must follow in order that the market can operate effectively and efficiently. Licensees are therefore required to maintain, become party to, or comply with the industry codes in accordance with the conditions of their licence.

Failure to comply with licence conditions can result in measures (including fines) against the licensee or, in extreme cases, can lead to loss of the licence.

5.3.3 Explicit financial incentives

Compliance with licence conditions and the need to maintain reputation provide long-term incentives for network companies to avoid repeated or sustained poor performance over a longer period of time. However, these incentives are less effective in encouraging desired behaviours in the short-term, where some TO managers may make decisions to meet short-term business targets to the detriment of day-to-day transmission service levels and longer term issues, such as asset condition. To encourage a CATO to properly manage these less tangible or longer term issues throughout its revenue term, suitably applied financial incentives – both rewards and penalties – can sharpen a CATO's resolve to meet its obligations effectively.

A further benefit of financial incentives is that they may be targeted very specifically to drive the desired behaviours rather than relying upon the CATO to make the appropriate connection between its broad,

non-financial incentives and the behaviours that are in the interests of consumers. For example, inadequate asset maintenance on the part of the CATO could, in the long term, trigger constraint costs or ENS penalties for other stakeholders, but the CATO may not see this as an undesirable behaviour since the effects don't impact its own balance sheet. However, such behaviours as carrying out adequate asset maintenance can be encouraged through incentives that carry a direct and more immediate financial consequence for the licensee, such as penalties or rewards applied to the licensee's regulated revenues. In one way or another, all the incentives we propose in Section 6 use this approach.

To be effective in encouraging the desired performance, though, the designs of such incentives must balance the behavioural benefit with the need to ensure that investment in the regulated network business is financeable. We provide further notes on incentives design in Section 5.4, and on potential conflicts at Appendix 6.

5.4 Managing investor risk

5.4.1 Controllability of performance requirements

In order for the CATO business to be attractive to investors their risks need to be measurable and manageable by the CATO. An effective regulatory incentive must therefore pertain to performance factors and behaviours within the control of the business.

The four key behaviours that stakeholders would require from CATOs and their assets are identified in Section 5.1; in brief they are:

- High availability (low planned unavailability);
- High reliability (low unplanned unavailability);
- Good cooperation on outage planning; and
- Effective asset management for the consumer benefit.

All of these four are measurable and are within the control of the CATO, so they are all eligible for regulatory incentivisation.

5.4.2 Revenue at risk

5.4.2.1 Absolute risk

Section 5.3.3 noted that effectiveness and financeability are potentially conflicting requirements for a financial incentive and we have sought to mitigate this conflict in arriving at the proposals in Section 6. An example from each side of this conflict is provided here:

- Regarding the effectiveness of the incentive: The SO generally finds that unplanned unavailability (unreliability) is far more costly to the consumer and causes far higher risks to network security than planned unavailability, so we propose to incentivise the CATO to avoid unreliability by

reflecting the cost impact on the transmission system of unreliability through premium penalties on unplanned CATO outages; and

- Regarding the financeability of the incentive: Investors perceive reliable revenue streams to be low risk, and uncertain revenue streams to be higher risk so, to mitigate the perceived risk of investment in CATOs, we propose that the CATO revenue at risk in any year is limited to a fixed percentage of the annual target revenue. Where, due to exceptionally poor performance, the CATO incurs a penalty in excess of this annual limit then the excess would become due over, say, the next four years (consistent, in principle, with the approach already in place for OFTOs).

5.4.2.2 Relative risk


Both of these elements relate to the absolute level of investors' revenue that is at risk. However, another factor relevant to the revenue at risk is the relative weighting of the incentives on each of the CATO's key behaviours. We propose that all four of the key CATO behaviours listed in Section 5.4.1 should be incentivised since, without an appropriate balance of all four, the CATO would not be able to deliver a full transmission service to the SO and yet still exhibit value for money to the consumer.

Availability and reliability and, to a large extent, cooperation on the national outage plan, characterise the CATO's in-service performance – its immediate transmission service deliverables, whilst effective asset management and, to some extent, cooperation on the national outage plan characterise its out-of-service performance – its long-term transmission service deliverables.

The precise circumstances that would pertain at the end of the CATO revenue term have yet to be finalised, so it is difficult to be categorical about the power of incentive needed to ensure that the CATO's asset management allows its assets to reach their economic lifetimes. We recommend that Ofgem considers further the relative weighting applied to the incentivisation of CATO asset management once the intentions for the CATO assets at the expiry of the revenue term are better known.

Regarding the immediate requirements of availability, reliability and cooperation on outage plans, however, these are relatively well understood and are, to a very great extent, linked with each other, as explained in Section 5.2.2. Availability and reliability performance elements could already be monitored with a single basic metric – availability – as explained in Box 1, so this places them on the same measurement 'scale' as each other. Although the day-to-day balancing of these parameters is complex, in our view the management of this balance may be left to the CATO, and need not be separately incentivised, since planned and unplanned availability are so closely linked technically. We thus propose applying a single financial incentive to the CATO's combined performance on availability and reliability and we propose, in Section 6, some relative weightings for the availability and reliability performance elements.

With availability and reliability incentivised together in this way, the key behaviour not yet addressed here is cooperation on outage planning. There are two main factors that would assist the SO in managing the national outage plan; requesting outage bookings well ahead of real time, and being flexible with the bookings at short notice. To maintain the CATO's focus on availability, to simplify the incentive metrics, and to keep the revenue at risk transparent to investors (potential and actual), we propose, in Section 6, mechanisms to reward good planning cooperation that, like availability and reliability, result in adjustments to the CATO's availability metric. In this way, all three performance elements (availability, reliability and planning cooperation) are placed on the same measurement scale



as each other and, again, weightings for the planning cooperation relative to the availability and reliability elements are proposed in Section 6.

6 PROPOSED INCENTIVES

Having established what we think are the main CATO performance requirements, we next consider the range of ways that a CATO could be made to perform as required against these. We propose that Ofgem consider an incentive structure using:

- A set of legal obligations that provide the context for a ‘core’ financial incentive;
- A ‘core’ financial incentive framework based on CATO asset availability; the mechanism on which all the financial incentives are based; and
- optional ‘bolt-ons’ to the financial incentive for fine-tuning as required.

In this section we describe these concepts further, relating them to the CATO performance requirements. Table 6-1 summarises our proposal:

Table 6-1: Proposed CATO performance incentive structure

Part 1: Underpinning obligations	Part 2: Proposed ‘core’ financial incentive framework	Part 3: Potential additional incentive ‘bolt-ons’
<ul style="list-style-type: none"> • Framework of the CATO licence, STC, & other codes, that, together, underpin the financial incentives; • CATOs to develop / contribute to a Network Access Policy. 	<ul style="list-style-type: none"> • Annual availability target for individual circuits, with financial penalty / reward proportional to availability up to target; • Symmetric incentive structure but ‘bonus’ rate for beating annual target less than penalty rate for failing to meet target, to promote reliability; • Annual penalty limited to mitigate investor risk – residual penalty may be spread over several years. 	<ul style="list-style-type: none"> • long-term asset health incentive – penalties will be tied to unreasonably poor asset health or functional capability, assessed by inspection / audit at end of revenue term. • Higher penalties for unplanned unavailability, including late returns to service following planned outages • Cyclical / seasonal weightings; • Premium periods when penalty for unplanned unavailability are more severe; • Incentives for planning outages a year ahead or more and for remaining flexible to help cover times of system stress; • Incentives to quickly restore to full functionality any asset with a depleted capability.

Different CATOs will be required to fulfil different technical roles on the network so the CATO behaviours desired by the SO may thus not be quite the same in every case. The CATO performance incentives that are proposed here therefore follow three general principles:

1. The design of the incentives outlined in Table 6-1 is generalised in nature; the parameters used to set the incentive values are presented as the elements of a template, with opportunities for adjusting them to suit different CATO applications on the network.
2. Furthermore, the design of these incentives is in the form of a framework (a core that is required) on to which a number of “bolt-on” additions (optional) may be attached, as appropriate. As the need for a CATO is established by the SO, Ofgem or the SO’s network planners could choose as few or as many of the incentive elements from the template’s bolt-ons as are required. ^[38]
3. These incentives relate specifically to the CATO assets’ operational performance, not to the performance of the GB network as a whole. This is because, at least for the foreseeable future, a CATO is unlikely to have the overall network control enjoyed by the incumbent TOs and will thus not be in a position to manage the operational performance of the overall NETS. The best way that CATOs will be able to serve the overall network will be to provide their (fully functional) availability, their reliability, and their flexible cooperation in response to the SO’s operational needs. These behaviours are what the following incentives aim to promote.

It is also important to note that no incentive mechanism will be effective unless the cost to the CATO (whether financial or non-financial) of not behaving as desired is greater than the cost of behaving in the required manner.

6.1 Part 1 – Underpinning obligations: Context for the core financial incentive mechanism

Part 1 of the incentive system template is a collection of rules and arrangements that, together, direct, facilitate and support the behaviours required of CATOs in respect of their operations and maintenance and their interactions with CATO stakeholders. These rules and arrangements need to consider not only the CATO’s interactions with other TOs and the SO, but also the management of its own assets.

An important component of CATO behaviour as part of the wider transmission system pertains to co-ordination (principally in the planning of outages) with other stakeholders and the need to define, and agree upon, asset boundary responsibilities. Traditionally these arrangements have been made between incumbent TOs and the SO on the basis that all parties are aiming to achieve a common goal, with loss of reputation being a major incentive on them to make their responsibilities fit and their outage plans work together. However, given the dependence of the integrity of the overall transmission system on the many transmission assets that it comprises, we consider that the entry into the GB transmission market of multiple new asset owners without the long-standing traditions of mutual support and common goals enjoyed by the incumbent TOs constitutes a potential risk to the NETS’ operational security.

To manage this future risk, detailed rules would be required to govern the interactions of transmission asset owners with each other as well as with the system operator. We recommend that Ofgem makes separate provision to review and amend the governance of these interactions in a way that

³⁸ A number of times during the following description of proposed incentives reference is made to the decisions of system planners or to decisions made during production of the needs case. The reason these references occur is that we consider that these particular decisions are best made by those who are establishing the needs case and who can thus best judge what incentives will be appropriate for the CATO role under consideration. In addition, it will be to the benefit of consumers that these decisions are declared to potential CATO bidders ahead of the tender process so that tenderers can best assess the risks and avoid unnecessarily raising their bid prices to cover unknown risk.

accommodates increasing numbers of transmission owners on the GB network, since we consider that these risks could not efficiently be covered by performance incentives alone.

The many ways in which the SO and the present transmission owners interact are formalised in electricity industry codes, standards, policies and licences. This section identifies some key documents that are likely to have a bearing on CATO performance or are likely to need review in order to accommodate the arrival of CATOs on the network, but first it considers the long-term management of its own assets.

6.1.1 The System Operator – Transmission Owner Code (STC) ^[39]

This section outlines the main points within the STC that would be need to be reviewed and/or adjusted to accommodate CATOs on the transmission system.

The STC defines the relationship between transmission asset owners and the System Operator and covers both transmission planning and operations functions. Key points with respect to the arrival of CATOs include:

- Under Transmission Services and Operations, Section C, the STC requires TOs to provide transmission services by, amongst other things, making their transmission assets available to the SO up to their capabilities and subject to any technical or safety limitations. ^[40]
- The same Section C also makes provision for Transmission Interface Agreements and Embedded Transmission Interface Sites. ^[41] We anticipate that the majority of CATO-specific interfaces with the incumbent TOs of the NETS will be established through this provision.
- Under Planning and Co-ordination, Section D, ^[42] the STC discusses ‘Transmission Interface Site’ specifications but makes no prescription as to the standard configuration of transmission interfaces. Furthermore, it discusses ^[43] the extent of ‘Planning Boundaries’ with respect to connections to the transmission system, however it specifically disassociates planning boundaries from plant ownership. ^[44]
- However, under Transmission Services and Operations, Section C, the STC also requires that TOs provide, to the SO, coordinated outage proposals that include required outage durations and provisions for reinstatement; and it requires the SO to establish a national outage plan from this information. ^[45]

We anticipate that exactly the same information as is required from the existing SOs would be required from CATOs in order that the SO can continue to properly constitute the national outage plan. However, as already discussed in Section 6.3.6, we consider that CATOs should be fully reimbursed for their additional costs incurred due to any emergency return to service (ERTS) instruction so we propose that,

³⁹ STC – National Grid’s System Operator -Transmission Owner Code <http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/STC/The-STC/>

⁴⁰ STC Section C, Part 1.

⁴¹ STC Section C, Part 3.

⁴² STC Section D, Part 1, sub-paragraph 2.7 “Transmission Interface Site Specification”.

⁴³ STC Section D, Part 1, sub-paragraph 3 “Default Planning Boundary”.

⁴⁴ STC Section D, Part 1, sub-paragraph 3.3.

⁴⁵ STC Section C, Part 2.

at the time that its outages are booked, ^[46] the CATO should also be required to provide its estimated costs for early reinstatement, in order that the SO can take this cost into account in decisions to instruct an ERTS.

Given the above, we recommend that Ofgem reviews and amends the STC to allow for the introduction of multiple new transmission owners, in particular allowing for the concept of costs and compensation for ERTS that may be raised by the introduction of CATOs.

6.1.2 Site Responsibility Schedule (SRS)

SRSs are established through a provision of the STC ^[47] to 'inform site operational staff of agreed responsibilities for Plant and/or Apparatus at an operational interface'. These schedules must be agreed and in place prior to construction completion and we anticipate that all CATO interfaces with incumbent TOs would be subject to these schedules, along with associated safety arrangements.

6.1.3 The Connection and Use of System Code (CUSC) ^[48]

The CUSC establishes the typical ownership boundaries employed within the GB electricity supply industry and generally anticipates that user infrastructure will be self-sufficient in terms of operational switching and fault clearance. ^[49] However, the CUSC only deals with metered ownership boundaries that are between the transmission system on the one hand and power stations, DNOs and non-embedded customers on the other. ^[50]

Since the CUSC was written with metered ownership boundaries in mind, and since it is likely that some CATO boundaries may not be at substations, we recommend that Ofgem considers whether the CUSC's definition of transmission boundaries needs to be generalised to the extent necessary to accommodate, for example, ownership boundaries mid-circuit, where metering would be inappropriate.

6.1.4 The CATO Licence

The CATO transmission licence will bestow upon a CATO the right to operate its transmission assets. It will contain a number of conditions that will variously define and limit the business operations of the CATO and it is this document that we anticipate will hold the finally adopted performance incentives against which CATO candidates will tender for the revenue term.

We anticipate that the CATO licence will detail the mechanics of the incentive mechanisms, including a definition of circumstances in which a CATO is exempt from penalties, as well as the criteria for the SO to set "premium" availability periods.

⁴⁶ STC Section C, Part 3, sub-paragraph 3.7.

⁴⁷ STC Section D, Part 2, sub-paragraph 15.

⁴⁸ CUSC – National Grid's Connection and Use of System Code <http://www2.nationalgrid.com/Corporate/Search/?q=cusc>

⁴⁹ There may be justifications for CATO assets not to be contiguous or terminated by full switchgear bays. DNV GL foresees that there could sometimes be economies where CATO assets are terminated somewhere along a circuit rather than being terminated by a full switchgear bay.

⁵⁰ The CUSC, Section 2.12.

6.1.5 Network Access Policy (NAP)

NAPs formalise the mutual cooperation between TOs and the SO to minimise the overall costs of running the network – in particular relating to outage planning, whether for construction, planned maintenance or emergency purposes. NAPs are relatively recent additions to the regulatory governance of electricity transmission in Great Britain ^[51] since, in past times, outage planning was performed with a mutual trust and understanding between the SO and incumbent TOs and by the common reputational goal of ‘keeping the lights on’. However, the need for increased transparency of the delivery of the consumer benefits brought about by good outage planning and the associated securing of the system has necessitated the development of NAPs.

The arrival of CATOs means an increase in the number of transmission owners whose assets are active on the transmission system and, as a result, an increasing interdependency of asset owner outage agreements. This interdependency raises still further the importance of formalising the system of co-operation between the SO and TOs, including CATOs, to ensure that asset owners’ behaviour is co-ordinated and transparent, and that responsibility can be determined in cases where the actions of one owner affect the performance of another.

Therefore, although Ofgem also noted, in letters to incumbent TOs ^[52], that “approach to financial incentives is unlikely to be resolved in the near term”, we consider that, with the formation of the first CATOs, the need for well-defined NAPs and for financial incentives to adhere to their provisions is likely to be reinforced.

6.1.6 Administration of the CATO / SO interfaces

Since the need for the CATO has been identified by the SO, and the SO will be the principal receiver of CATO services, we envisage that the SO or its agents will have a larger operational role (more transmission owners with whom to liaise) in administering the CATO. Likely activities include:

- Recording CATO availability, and administering the CATO’s annual revenue;
- Including CATOs in the outage planning process; and
- Reviewing CATO periodic capability test results (and arranging tests, if required);
- Reporting to Ofgem on CATO performance, as required.

During production of the tender specification for the CATO, the SO will also have to establish the performance parameters against which the CATO will be built and tested.

⁵¹ The transmission licences granted by Ofgem now require (since RIIO-T1 came into force in 2013) that TOs have NAPs to formalise the cooperation needed between TO and SO to reduce overall costs of outages to consumers.

⁵² Ofgem letters of 24 June 2015 headed “Electricity Transmission: Network Access Policy (NAP)”, <https://www.ofgem.gov.uk/publications-and-updates/authority-decision-approve-network-access-policy-nap>

6.2 Part 2 – Core financial incentive framework

6.2.1 Availability – actual and declared

Part 2 of the incentive system template is a ‘framework’, acting as the basis for all the CATO financial performance incentives and comprising a set of linear relationships between a CATO’s asset availability and its annual revenue. Figure 6-1 depicts the basic straight-line relationship of this framework.

Figure 6-1: CATO incentive framework – revenue v. availability



As with OFTOs, this linear relationship is the fundamental mechanism by which the CATO would be remunerated throughout its revenue term, with higher annual availability tending to result in higher annual revenue being earned by the CATO. We say ‘tending to’ because we propose that the ‘declared’ annual percentage availability (which would be used to calculate annual revenue) would be calculated by adjusting the ‘actual’ recorded annual percentage availability to encourage specific desired CATO behaviours, as described in Part 3 of the incentive template.

Regarding terminology, we often abbreviate here references to the ‘actual recorded percentage annual availability’ (or unavailability) of the CATO to the ‘actual (un)availability’.^[53] Conversely, the annual availability figure that results from applying the various bonus and penalty mechanisms to the actual availability is termed here the ‘declared availability’.

6.2.2 Availability framework

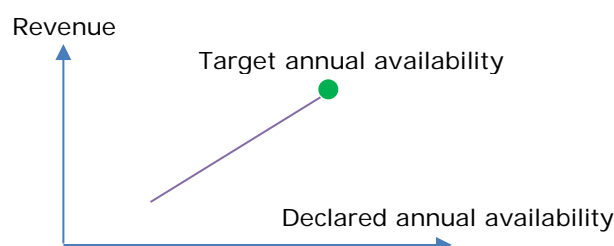
We recognise that the SO requires that the CATO books its planned maintenance outages well ahead; that these are as short as practicable; that return to service times are to plan; and that the CATO can offer speedy ERTS times. All of these behaviours contribute to the SO’s role of protecting security of supply and reducing cost to customers. CATOs, however, will look to maximise returns for their owners, and may take a different view of the most economic and efficient way of delivering maintenance activities, which may not necessarily involve minimising the duration of individual outages. For instance, CATOs may want to bundle a greater number of maintenance tasks into a single outage, or remediate unexpected findings during the visit, to lower the costs of its maintenance activities, even though individual outages might thus take longer.

⁵³ Frequently we refer here to the CATO’s ‘unavailability’ rather than to its ‘availability’. These two terms are linked as follows: percentage unavailability = 100 - percentage availability.

Hence, the SO's interests and a CATO's interests may not always be aligned, and for this reason we propose to incentivise CATOs to manage their outages to match the SO's needs as follows:

- to encourage high annual circuit availability the CATO's annual revenue would be varied in direct proportion to the declared availability of the circuit, up to a target availability, as shown in Figure 6-2.

Figure 6-2: Target annual availability



Further details of the proposals for this availability incentive, including annual and overall limitations to the downside for the CATO that are provided to spread and limit a CATO's commercial risk, are provided in Appendix 3.

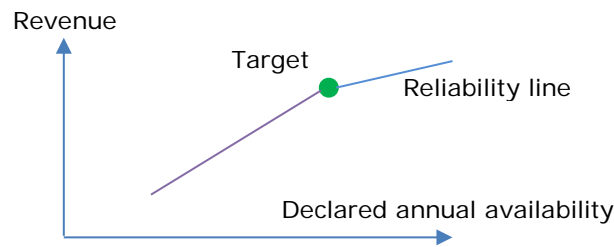
6.2.3 Reliability framework

Unplanned unavailability of a transmission circuit is normally far more of an imposition on the network operations and is far more costly than planned unavailability (see Box 1, p13). For this reason we propose incentives that minimise these extra costs by promoting reliability in addition to availability.

Good asset health and asset reliability requires appropriate maintenance outages, which may be seen, in the short term, as a perverse requirement to high availability. For this reason the provision of high reliability needs the power of the availability incentive to be reduced in favour of an incentive to perform appropriate maintenance. To reduce the power of the availability incentive for CATO circuits above the target availability we thus propose that annual availabilities would attract further revenues, but at a lower rate. This rate may be chosen differently for each CATO and is depicted in Figure 6-3 as the 'reliability line', above the green target availability point.

We recognise that the availability / reliability balance point – the target availability – may need to be different for different CATO roles on the network and need to be commensurate with the choice of asset configuration and technology adopted by the CATO. In practice, therefore, we propose that the target availability and the slope of the reliability line will be set during the production of the CATO needs case to reflect the balance of requirements from a particular CATO's assets.

Figure 6-3: Reliability line added above target annual availability



The reliability line of Figure 6-3 extends up to 100% declared annual availability and is an integral part of the availability framework already described. Further detail of the reliability incentive framework is provided in Appendix 7.

The lower value slope of the reliability line (above target) in comparison to the availability incentive slope (below target) is a 'permissive' provision, in that it allows CATOs to arrange planned unavailability without losing much availability incentive. However it does not, of itself, encourage the CATO to work to increase the reliability of its assets so, since unreliable operation of transmission assets is far more costly to the consumer than reliable operation, we next propose further sharper incentives for reliability. Since they are all optional extras to the core incentive framework we term them 'bolt-ons'.

6.3 Part 3 - Financial incentive 'bolt-ons'

Part 3 of the CATO performance incentives template comprises mechanisms that refine the CATO behaviour incentives to more closely meet stakeholder requirements. These mechanisms may be chosen (or not) for a particular CATO application to adjust the actual unavailability of a CATO circuit to arrive at a declared availability. This declared availability will then act with the framework to impact, positively or negatively, the CATO's annual revenue, depending upon the nature of the behaviour being incentivised.

Since the declared availability would determine the CATO's revenue, appropriate adjustments during its calculation would encourage specific desired CATO behaviours over and above straight-forward maximisation of annual availability.

We propose that each of these incentives is treated as an option for Ofgem to add to the incentive framework for individual CATO projects. However, Ofgem may also wish to consider whether any of these would be appropriate to add to the 'core' incentive consistently, for all CATOs, or whether different CATO project types (as outlined in Chapter 2) could use customised packages of these 'bolt ons' to create appropriate incentive structures.

6.3.1 Long-term asset health incentive

We propose that the CATO would be subject to a long-term asset health incentive, whereby penalties would apply to the CATO in the event that unreasonably poor levels of asset health or functional capability pertain at the expiry of the revenue term. One effective way of achieving this incentive would be to require the CATO to purchase a long-term asset health performance bond, part or all of whose value would be forfeit dependent upon CATO asset condition at the end of the revenue term (see discussion in Section 5.2.4).

Regarding assessing the adequacy of the assets' condition, we propose that, firstly, hand-back requirements are established prior to financial close, and then an independent asset inspection is used to assess asset condition at revenue term expiry. However, in order to minimise surprise and risk at that time for both Ofgem (risk of poor condition assets) and for the CATO (risk of significant call on the performance bond value) we propose that, in addition to the final inspection, at least one asset condition audit, with results disclosed to both Ofgem and the CATO, is carried out long enough before revenue term expiry to allow the CATO the opportunity to adjust the condition of its assets prior to the final inspection, if necessary. The in-service audits and end-of-revenue-term inspection are outlined next; further detail may be found at Appendix 9.

Regarding purchase of the performance bond, we propose that the CATO contributes to this over the final 10 or 15 years of the revenue term, for example by setting aside a pre-determined percentage of its annual allowed revenue.

6.3.1.1 In-service asset condition audit

The purpose of one or more in-service maintenance audits is to establish whether the CATO's assets' condition is commensurate with age and operation and to communicate this to both Ofgem and the CATO. The value of this information before expiry of the revenue term is threefold:

- Firstly, it avoids nasty surprises for Ofgem at revenue term expiry;
- Secondly, it allows the CATO adequate time to manage the recovery of any sub-standard asset condition prior to the end of the revenue term; and
- Thirdly, the assessment process has been practiced and witnessed, so that refinements to reduce ambiguity or contention can be made before the end-of-revenue-term inspection.

Such an audit would be commissioned at a pre-set period (say, between five and eight years) before the end of the revenue term, in order that the CATO would have time to restore the health of any plant in an untoward condition. A poor outcome of this audit, or poor CATO in-service performance at any time, could trigger further audits to assist in managing the situation to a satisfactory conclusion for all parties..

In-service maintenance audits would assess CATO assets' health to assess and draw conclusions on what reasonable refurbishment should be performed, by the CATO, before the end of the revenue term to allow assets to reach their optimised asset life potential (which may be beyond the expiry of the current revenue term).

6.3.1.2 End of revenue term inspection

The end of revenue term inspection would be very similar to the in-service maintenance audit, but with a greater sample of inspected equipment in order to assess, with greater confidence, whether the health of the CATO's assets is commensurate with their ages. Any trends in maintenance levels, asset condition and asset performance between audits should be explained by the CATO.

In the event of excessive degradation, Ofgem would have the option to penalise the CATO (through the asset health performance bond mechanism) to reflect the cost of restoring the assets to the condition expected in the light of the service duty actually seen by the assets. ^[54]

Since the aims of the audits and inspection are to encourage the CATO to provide a consistent high-quality and reliable service throughout the revenue term and to leave the assets in reasonable condition as that term expires, these interventions should not only reduce the risk to Ofgem but also reduce commercial risk to the CATO and encourage value-for-money to the consumer by providing:

- the CATO with an incentive to maintain consistent asset health;
- the CATO with a reasonable view of Ofgem's expectations before the end of the revenue term; and
- Ofgem with ongoing assurance that major repairs or refurbishment will not be unexpectedly required as the CATO's revenue term expires.

6.3.2 Unplanned unavailability incentive (penalty)

In Section 5.2.2, we outlined why poor reliability is costly to the transmission system and is to be discouraged in CATO assets. To incentivise high reliability and to reflect the relatively higher impact of unplanned downtime on the performance of the whole system we propose that unplanned CATO asset unavailability is penalised more heavily than planned unavailability. The mechanism we propose for this purpose is the application, whenever unplanned unavailability occurs, of a greater-than-unity 'Standard Unplanned Unavailability Factor' (StUUF) that inflates the CATO asset's declared unavailability as follows:

$$\text{Declared unavailability} = \text{StUUF} \times \text{Actual unplanned unavailability}$$

Because it has been inflated by the StUUF, this declared unavailability, when applied to the core incentive framework of Section 6.2, results in a lowering of the annual revenue for the CATO that is dependent upon the outage duration; this risk of revenue reduction thus acts as an incentive to achieve high reliability – see examples of use of the factor at Appendix A8.2.

6.3.3 Period incentives for reliability

Period incentives allow the SO to designate periods of time for which reliability is particularly important and are intended to act in conjunction with the availability framework described in Section 6.1 to allow the SO to provide a particular emphasis on the importance of CATO in-service reliability at certain 'peak' times and to encourage CATOs to plan for maintenance outages during 'non-peak' times. However, unlike the availability incentive framework and the reliability line discussed there, which are both essential parts of the performance incentive framework, the period incentives that follow may be applied, or not, as additional 'bolt-on' incentive elements, at the time the CATO needs case is being developed.

We propose two types of period incentive:

⁵⁴ The lump sum payment would reflect the cost to restore the assessed remaining technical asset lives. Such assessments are subject to interpretation so the results would potentially require independent verification and an arbitration route.

- **Cyclical period incentives** (for example, OFTO seasonal weighting type availability incentives) are used to encourage the CATO to plan unavailability during periods best suited to their transmission role. They are set for the duration of the revenue term to reflect the CATO role and comprise multiplication factors close to, and either side of, unity, balanced to limit investor risk. Cyclical period incentives apply to planned and unplanned outages; and
- An **Unplanned unavailability period incentive** is used to encourage reliability and to discourage unplanned CATO unavailability. This could be particularly relevant to, for example, known upcoming single circuit risk. The incentive comprises a multiplication factor above unity that operates in conjunction with the StUUF and any cyclic period factors. The unplanned unavailability period incentive applies only to unplanned outages during periods that have been previously notified to the CATO by the SO.

In both of these cases, the period incentives comprise multiplication ‘factors’ that are used to derive declared outage durations from any actual recorded unplanned outage durations, in order to adjust the CATO’s annual revenue. These two types of period incentive factors are outlined in turn, next, whilst further description may be found at Appendix 8.

6.3.3.1 Cyclical period incentives

As explained in Appendix 8, cyclical period incentive factors would typically attempt to incentivise CATOs to perform their planned maintenance in the less critical parts of the year by allocating, for example, a factor less than unity (say, 0.8) to the summer months and a factor greater than unity (say, 1.3) to the winter months. In this example case, the declared percentage unavailability for a 36.5 day outage (10% of the year) in winter would be calculated as follows:

$$\text{Percentage declared unavailability in winter} = \frac{100}{365} \times 36.5 \text{ days} \times 1.3 = 13\% ,$$

whilst, for the same 36.5 day outage in summer, the percentage declared unavailability would be calculated as:

$$\text{Percentage declared unavailability in summer} = \frac{100}{365} \times 36.5 \text{ days} \times 0.8 = 8\% .$$

Accordingly, by performing maintenance during non-peak periods the CATO can both reduce its revenue lost during the maintenance outage and increase its probability of avoiding (expensive) unplanned outages during peak periods.

6.3.3.2 Premium unplanned unavailability period incentive

In addition to the normalised cyclical period incentives described above that would be set for the duration of the revenue term, we anticipate that the SO will sometimes value the flexibility of being able to declare ahead of time additional periods during which a CATO’s in-service reliability is particularly important to system security or to the minimisation of consumer costs.

This premium unplanned unavailability period incentive is thus designed to sharpen the CATO’s resolve to avoid unplanned outages during particularly critical operating periods anticipated by the SO. The SO’s option of declaring a period of premium cover would be exercised by the SO notifying the CATO more than a given period ahead, say, three months. CATO asset unplanned unavailability during these

premium periods would then be penalised more heavily than at other in-service times to reflect the higher importance of availability that the SO places on these known periods at risk of higher system stress.

This incentive would be applied through the application of a Premium Unplanned Unavailability Factor (PrUUF) which, like the (StUUF), would inflate the CATO asset's declared unavailability and result in a lowering of the annual revenue for the CATO that is dependent upon the duration of the unplanned outage; this risk of revenue reduction thus acts as an incentive to achieve high reliability – see examples of use of the factor at Appendix A8.2.

6.3.4 Planned maintenance & prompt return to service

We recognise that it is very important to the SO that, in the spirit of the NAP, the CATO (i) plans its outages well ahead and (ii) adheres to the agreed outage windows. It would be possible to leave these behaviours to be incentivised by the provisions of the NAP and the associated long-term reputational pressure on the CATO, however, these may not be adequate to incentivise these very specific short-term behaviours.

We thus propose, two optional 'bolt-on' incentives, specifically to encourage this behaviour; firstly a 'carrot' to request its planned unavailability periods more than a year ahead, and secondly a 'stick' to encourage the CATO to return to service within an outage window that is agreed within the plan. These two incentives are as follows:

- For planned outages taken by the CATO that were initially requested more than year-ahead, the declared outage duration will equal the actual outage duration (up to the planned return-to-service time) multiplied by a 'NAP factor'. We propose that a NAP factor, for example 0.95 p.u., is fixed during the production of the CATO tender specification.
- We propose that, whatever time a planned outage is started, should the return-to-service time pass the planned return-to-service time for any reason except a direct SO request, the declared outage duration beyond the return-to-service time would be counted as unplanned unavailability, and be penalised at same level as other standard unplanned outages through the application of the StUUF (see Section 6.3.2).

6.3.5 Flexible timings for short notice outages

From our discussion on CATO behaviours with the SO we recognise that, despite the best efforts of all parties to plan outages well ahead of real time, factors such as the weather can significantly disrupt long-term plans in the hours and days before an outage slot starts. In order to minimise the knock-on effects of these situations, the SO typically attempts to re-optimize the efficiency of the national outage plan, which sometimes involves bringing planned outages forward – particularly where a short planned outage will efficiently fill a near-term outage opportunity. For this reason the SO sees value in TOs' near real-time flexibility in accepting outage slots whose timings differ from the agreed plan.

To continue to exploit such re-optimisation opportunities into the future it would be important to the SO that CATOs exhibit this same flexibility with their outage plans as do the incumbent TOs, where practicable. Therefore, where a CATO can accept the SO's offer of an alternative outage slot at short

notice, we propose that the declared CATO outage duration will equal the actual outage duration (up to the planned return-to-service time) multiplied (reduced) by the 'NAP factor' described in Section 6.3.4.

We recommend that, if Ofgem takes this proposal forward, it should consider further how to define "short notice"; this definition might best be linked to the detailed outage planning processes that the SO carries out.

6.3.6 Emergency return to service (ERTS)

The SO indicated in its discussion with us ^[55] that there may be occasions when, despite the best planning efforts and mutual cooperation between the SO and TOs, the SO requires a CATO, at short notice, to curtail a planned maintenance outage for system security reasons, or even – though this is not strictly an ERTS issue – to cancel a planned outage altogether. Historically this has not happened frequently however, should it occur, the potential benefits to the SO of an ERTS are much greater if the CATO has put in place contingency plans beforehand. We anticipate, therefore, that the current provisions of the System Operator – Transmission Owner Code (STC) ^[56] would be extended to require CATO outage plans to include a statement of the time required to return the CATO circuit to service following an ERTS request.

However, if the SO instructed an ERTS, the CATO might reasonably incur additional costs. We propose, therefore, that the CATO includes in its outage planning discussions with the SO the following information:

- Estimated range of ERTS times (these times could reasonably vary depending upon the stage that the maintenance work has reached); and
- Estimated range of costs that could reasonably be incurred by the CATO in returning to service ahead of schedule, including the later completion of the works and the administration costs.

To incentivise the CATO to accommodate an actual ERTS instruction we propose, as an optional 'bolt-on' incentive, that, to obviate any reason why the CATO might be disinclined to react quickly on request, the CATO would always receive:

1. Its reasonable estimate of time necessary to restart and complete the planned work deducted from his total annual declared unavailability;
2. Its reasonable estimate of extra costs incurred due to the interruption of the work (guided by the estimate provided during the planning phase); and
3. A Call-back fee: a fixed period, for example, six hours, deducted from its total annual declared unavailability.

⁵⁵ The SO – see 4.3 – and the STC – see 6.3.2 – requires emergency return to service times to be furnished to the SO when outages are booked.

⁵⁶ STC – see 6.3.2.

6.3.7 Functional testing and depleted capability

A transmission asset that is unable to deliver its full set of specified capabilities and functions to the SO could be threatening system security and failing to provide value for money to the consumer. For this reason it is important that any material defect or depletion in capability of a CATO's assets is quickly and efficiently resolved.

Functional testing

Depleted capability of a CATO asset may be immediately obvious if the asset fails to deliver some facility or service demanded by the SO, however some facilities are demanded only rarely and possibly only under times of system stress. To determine the ongoing availability of the assets' capabilities, therefore, we propose that tests demonstrating the CATO's functional capability be carried out at circuit commissioning and at predetermined maximum intervals ^[57] thereafter throughout the revenue term, including a final set of due diligence tests prior to the end of the revenue term.

Where, either through maintenance activities or in-service conditions, the availabilities of these capabilities have already been confirmed more recently than the predetermined maximum test intervals require, the relevant capability tests for that period may be omitted. Where, however, a particular capability has not been demonstrated in the last period due to a lack of appropriate operational conditions or relevant maintenance, we recommend that the scheduled tests go ahead.

Depleted capability


If, through tests or through normal operations, the CATO asset is shown to be incapable of meeting some requirement of its functional specification, whether this manifests itself as a reduction in transfer capacity or as a defect in the protection, control or communication systems, we propose that a depleted capability penalty would immediately apply in order that the CATO places a high priority on restoring this capability. However, sometimes faulted assets are able to continue to run in 'depleted mode' – that is, with less than their full capabilities being available to the SO for operational service – until a repair is effected. Such a capability depletion might amount to a reduction in the transmission transfer capacity or a defect in one of the protection or control facilities (for example, the delayed auto reclose control).

In this kind of situation, and if the health and safety situation allows it, the SO frequently prefers the asset to continue to operate in its depleted state until the problem can be rectified, rather than that it is completely removed from service whilst awaiting repair, so we propose that the CATO is incentivised to facilitate the former approach to its operations. However, it would be inappropriate to continue to reward the CATO with the full revenue stream whilst its assets are in a depleted capability state since there would be little incentive to reinstate full capability. Instead, and in order to incentivise the CATO to remain in service (where possible and safe to do so) whilst at the same time retaining an incentive to rectify the fault promptly, we propose that the circuit be declared unavailable for the duration of the depletion, but with the following factors applied to the duration:

- Secondary equipment depletion factor: ^[58] with a value of, say, 0.1 p.u., to be decided during the production of the CATO needs case. For example, in the case of a 0.1 p.u. secondary equipment

⁵⁷ Different intervals may be chosen for each of the specified critical parameters, as appropriate to the technology and the CATO role.

⁵⁸ 'Secondary equipment' refers to all protection, controls and communication systems.



depletion factor the expected CATO revenue would be reduced by 10% for the duration of the capability depletion; and

- Transfer capacity depletion factor: equal to the above secondary equipment depletion factor, or the proportion of the actual transfer capacity depletion, where this is greater. For example, where the defect causes a transfer capacity depletion of 40%, the expected CATO revenue would be reduced by 40% for the duration of the capability depletion.

These factors would then be applied to the actual period of depleted capability to arrive at a declared unavailability that would be processed in the normal way through the availability framework described in Section 6.2.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

We approached the task of proposing CATO operational performance incentives by considering what assets a CATO comprises, understanding stakeholder requirements from CATOs, reviewing the options for incentives and proposing a CATO-focussed incentive set. At the start of this process, our review of Ofgem's recent documents on extending competition in electricity transmission and of its Strategic Wider Works factsheet concluded that:

- CATOs would have a variety of roles on the UK NETS but that, broadly, they may be allocated between three categories: highly integrated with the MITS, point to point connections, or radial connections; and that
- regardless of role, the key requirements of CATOs would be that they optimise availability and reliability and provide prompt, flexible cooperation with the SO with assets whose health at the end of the revenue term is commensurate with duty seen and appropriate asset management during that period.

Our review of stakeholder performance requirements for CATOs included a review of stakeholder responses to Ofgem's consultation of 19 October 2015 and a discussion with the NGET SO in order to check our various expectations of the SO's current requirements for CATO performance. These reviews confirmed that CATOs must support the SO in its efforts to provide consumer value-for-money from the transmission network by exhibiting the following key behaviours:

- high annual availability;
- high reliability;
- good cooperation on outage planning and adherence to agreed outage slots; and
- effective, long-term asset management.

Our review of other performance incentive precedents included the UK's RIIO-T1 and OFTO regimes and the contestable transmission augmentations regime of Victoria, Australia. We found that:

- RIIO and OFTO regimes both have performance incentive elements that are relevant to CATOs, but that neither has a mix of incentives that is completely appropriate to CATOs;
- Victoria, Australia uses performance incentives linked to time-of-day as well as to the season;
- Stakeholder responses to the Ofgem 19 October 2015 consultation strengthened our original perception of the importance of CATO reliability; and
- The SO discussion on 31 March 2016 confirmed our expectations but refined some of our emphasis on required behaviours – particularly on returning to service from planned outages promptly and on being able to achieve the agreed ERTS times if called upon to return early from planned outages.

Recognising that CATOs will have a variety of topologies and roles on the transmission network, we concluded that this package of CATO performance incentives should be adaptable enough to span these ranges and yet present a stable, recognisable structure for all CATOs. Accordingly, we concluded that a three-part CATO performance incentive package with variable parameter settings and optional additional

incentive elements would allow the SO adequate flexibility to encourage CATO behaviours appropriate to the role that each project is to fulfil. The three parts are as follows:

- Part 1 - A set of legal obligations that provide the context for a 'core' financial incentive. This is a collection of rules and arrangements (licences, standards and codes) that, together, direct, facilitate and support the behaviours required of CATOs in respect of their operations and maintenance and their interactions with CATO stakeholders.
- Part 2 - A core financial incentive framework based on CATO asset availability; the mechanism on which all the financial incentives are based; and
- Part 3 - Adjustments to 'actual' measured availabilities to develop 'declared' availabilities that aim to encourage specific CATO behaviours associated with reliability, cooperation on outage planning, and long-term asset management.

7.2 Incentives summary

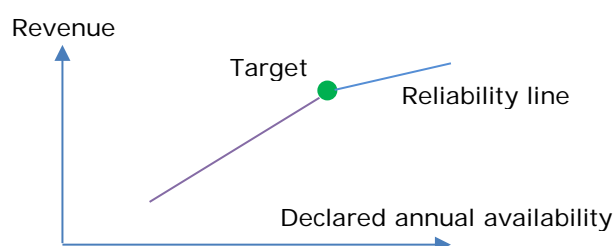
The three parts of the incentives package described in Section 6 are summarised next – firstly the availability framework on which all the incentives rely, then the optional mechanisms that refine the CATO behaviour incentives to more closely meet stakeholder requirements.

Part 1 – A set of legal obligations that provide the context for a 'core' financial incentive:

1. Rules and arrangements contained in **licences, codes, standards**, policies and other documentation that direct, facilitate and support the required CATO behaviours. The rules and arrangements they contain would be mandatory for any CATO and, in general, would form the constraints within which the incentives of Parts 2 and 3 could operate effectively.

Part 2 – The core financial incentive framework based on CATO asset availability, on which almost all the financial incentives are based:

2. **The availability and reliability framework** is a straight-line relationship between *declared* availability and annual revenue. The slope of the line above target availability and 100% availability may be less than the slope below the target, as shown here:



Part 3 – Mechanisms to refine the CATO behaviour incentives:

All these incentives are optional for any CATO application, and most are applied through the financial framework of Part 2. They sharpen the incentives on CATO behaviours relating to specific areas of performance – see Section 6.3. We recommend that Ofgem consider whether these mechanisms could all be appropriate to all CATOs, or whether some are only relevant to certain types of CATO projects.

3. A **long-term asset health** incentive is used to counter any incentive that the CATO may have to allow a drop in asset care, particularly towards the end of the revenue term. This incentive


is based upon penalty payments from a performance bond, these payments being tied to asset condition & functional capability, assessed by inspection / audit as the end of the revenue term approaches – see Section 6.3.1.

4. A **standard unplanned unavailability incentive** is used to discourage unplanned unavailability during normal operations. It operates through the mechanism of the availability and reliability framework to reduce annual revenue in proportion to the duration of unplanned outages and is set for the duration of the revenue term – see Section 6.3.2.
5. **Cyclical period incentives** are used to encourage the CATO to plan unavailability during periods best suited to their transmission role. They are set for the duration of the revenue term and apply to planned and unplanned outages – see Section 6.3.3.
6. A **premium unplanned unavailability period incentive** is used to discourage unplanned unavailability during specific periods of anticipated high system stress. It operates through the mechanism of the availability and reliability framework to reduce annual revenue in proportion to the duration of unplanned outages and is set for the duration of the revenue term – see Section 6.3.3.
7. **Planned maintenance / prompt return-to-service** incentives are used to encourage They operate through the mechanism of the availability and reliability framework to modify annual revenue and are set for the duration of the revenue term:
 - o An incentive to plan outages more than a year ahead – see Section 6.3.4; and
 - o An incentive to return to service promptly following a planned outage – see Section 6.3.4.
8. A **flexible timings** incentive is used to encourage the CATO to remain as flexible in the timing of its outages as possible in order that the SO can retain some control of any disruptions to outage plans – see Section 6.3.5.
9. **Emergency return-to-service (ERTS)** incentives are used to encourage the CATO to promptly cooperate with ERTS instructions from the SO – see Section 6.3.6.
10. **Depleted capability** incentives are used to encourage the CATO, so far as possible commensurate with health, safety and environmental considerations, to retain its circuit in service for the benefit of system operations even when its transfer or control capabilities are partially depleted, whilst repairs are being arranged. The two incentives operate through the mechanism of the availability and reliability framework to reduce annual revenue to reflect the degree of capability loss and are set for the duration of the revenue term – see Section 6.3.7.

7.3 Further recommendations

We recommend that:

- The current STC is amended to incorporate CATOs as well as OFTOs and the incumbent TOs in its requirements for cooperation over the production and operation of the SO's national outage plan;
- The CUSC is reviewed and adapted to accommodate, for example, the more flexible definitions of ownership boundaries that could be required by CATOs;
- Ofgem considers the impact of the introduction of CATOs on the efficacy of the current incentive on TOs to reduce ENS and considers whether, in due course, the ENS incentive should be reformulated or reassigned;
- Ofgem considers further the relative weighting applied to the incentivisation of CATO asset management once the intentions for the CATO assets at the expiry of the revenue term are better known; and

- 
- Ofgem considers reviewing and amending the STC to allow for the introduction of multiple new transmission owners. If the incentives relating to the concept of costs and compensation for CATO ERTS that are proposed in this document are taken forward, to include in that review consideration of whether such CATO costs and compensation should be provided for by the STC.

APPENDIX 1 ACRONYMS

BSIS	National Grid's Balancing Services Incentive Scheme
CATO	Competitively Appointed Transmission Owner (onshore)
CI	Customer Interruptions
CML	Customer Minutes Lost
CUSC	National Grid's Connection and Use of System Code
DNO	Distribution Network Operator
DSN	Declared shared network (Australian term for the network equivalent to the NETS)
ENS	Energy Not Supplied
ERTS	Emergency Return To Service
GB	Great Britain - the territories of England, Scotland and Wales that are served by the National Electricity Transmission System (NETS)
ITPR	Ofgem's Integrated Transmission Planning & Regulation Project, within which the concept of CATOs was initially developed
ITT	Invitation to Tender (to qualified bidders to tender for the CATO)
MITS	Main Interconnected Transmission System
MWh	Megawatt hours
NAP	Network Access Policy – required by transmission licences.
NETS	National Electricity Transmission System
NOMs	Network Output Measures
Ofgem	Office of Gas and Electricity Markets, the energy regulator for GB
OFTO	Offshore transmission owner
p.u.	Per Unit
PrUUF	Premium unplanned unavailability factor
RIIO-T1	UK RIIO-T1 Electricity Transmission Price Control, effective for the years 2013 – 2021
SO	System Operator
SQSS	National Grid's NETS Security and Quality of Supply Standards
SRS	Site Responsibility Schedule – a document provided for each transmission site where ownership is shared. Required by the STC.
STC	The System Operator–Transmission Owner Code – transmission owners must sign up to this code before being allowed access to the network.
StUUF	Standard unplanned unavailability factor
SWW	Strategic Wider Works
TO	Transmission Owner
TRS	Tender Revenue Stream

APPENDIX 2 STAKEHOLDER EXISTING INCENTIVES

The following table provides some further detail on stakeholder incentives. These details were used to inform the Table 3-2 list of CATO stakeholders and their requirements.

Table A 2-1: CATO stakeholders & relevant current incentives

CATO stakeholders	Existing Incentives
SO (identifier of the CATO Needs Case)	<ul style="list-style-type: none"> Balancing Services incentive scheme – financial incentive where national grid can earn extra profit or make greater loss on the basis of the outturn system balancing costs] Wind Forecasting incentive scheme – financial incentive to improve the accuracy of wind production forecasting] Transmission losses – reputational incentive scheme to track reduction in system losses] SO Innovation Roll Out Mechanism –funding stream to encourage innovation in the SO function.
All neighbouring incumbent TOs	<p>Financial:</p> <ul style="list-style-type: none"> Reliability – Managed via a direct incentive scheme to minimise energy not supplied - £16,000 per MWh with a collar and with different ENS targets per TO; Customer Satisfaction – +/-1% revenue influence] Connections [direct financial penalty – Up to 0.5% of revenue in some cases; <p>Non-financial:</p> <ul style="list-style-type: none"> Safety – Managed via Network Output Measures relating to asset health, reliability and Availability; Network Access/Availability – intended to improve interaction between SO and TO. Mostly a reputational incentive - implementation via Network Access plans; SF6 – National reporting scheme, direct targets, non-financial; Transmission Losses – Direct Incentive scheme in place for SO, reputational for TOs; Business Carbon impact – reputational reporting; Visual amenity – funds available for selective undergrounding of new assets; Broader environmental impact; Wider System works – focus upon SWW completion date and costs, direct financial incentives.
Neighbouring OFTOs	<ul style="list-style-type: none"> Availability – financial elements are: <ul style="list-style-type: none"> - Linear slope with break-even target ~ 98%; - Seasonal weighting chosen by wind farm; and - Exponential capacity weighting, 'a' & 'b' chosen by Ofgem. SF6 – National reporting scheme, non-financial.
Outage coordinator (SO)	<ul style="list-style-type: none"> Stable outage plans – reputational incentive between existing parties.
Directly connected generators	<ul style="list-style-type: none"> Revenue – per MWh supplied;
DNOs	<ul style="list-style-type: none"> ENS – CIs and CMLs have a direct financial impact; Other customer-centric and innovation encouraging incentives.
Investors	<ul style="list-style-type: none"> Profit – maximise; Stability – maximise; Risk – minimise.
Staff & the local public	<ul style="list-style-type: none"> Continuing good health, stable employment
Land owners, the environment and the wider public	<ul style="list-style-type: none"> None
Consumers	<ul style="list-style-type: none"> None

APPENDIX 3 AVAILABILITY PERFORMANCE INCENTIVE

This appendix contains further details of the proposals associated with the availability performance incentive that represents the basis for the CATO incentive system. It should be read with Section 6.2.2, which provides the context.

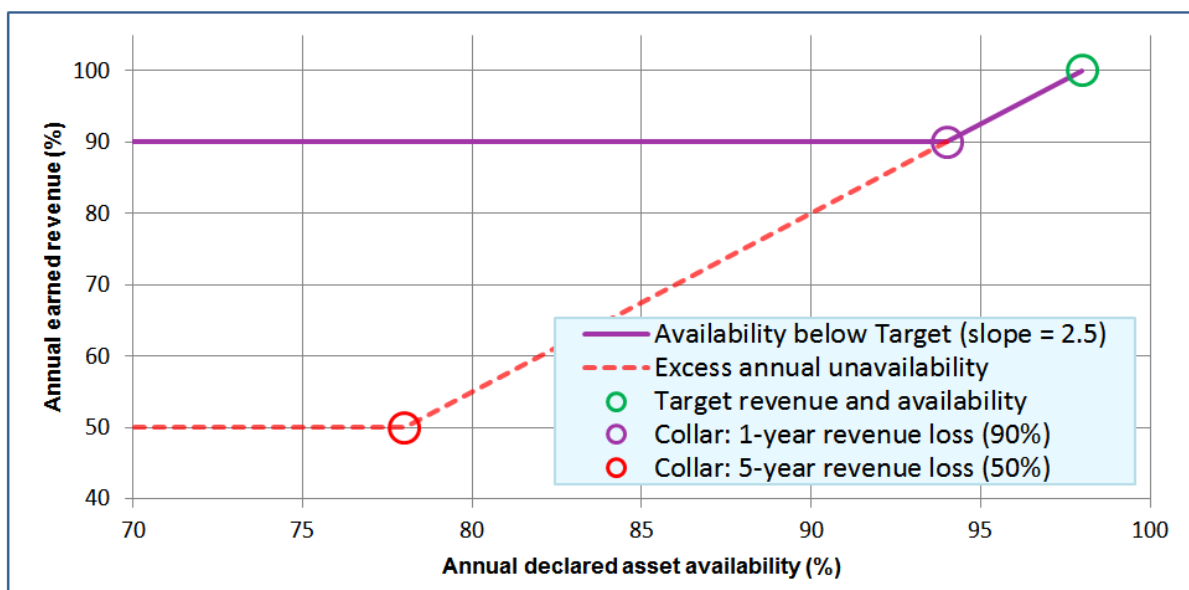
We propose that:

- The availability of a CATO's asset is defined as the percentage of qualifying time each year that the asset is available to the SO for operational service. By qualifying time we mean:
 - a year;
 - less the durations of any outages that were requested by the SO to accommodate actions that were not caused or requested by the CATO; for example, transmission construction, new connections, or safety related actions triggered by third parties;
 - less any complete and correct automatic switching sequences designed to minimise danger to personnel or equipment or to avoid overload; An example of such a sequence is the delayed auto-reclose following lightning strikes.
- Each CATO circuit be counted 'available' when it's actual in-service capacity is at least 100% of specified pre-fault transfer capacity and all specified operational/control capabilities are available to the SO;
- Where a defective CATO circuit is able to provide a significant partial capacity or capability a partial declared availability may apply until the circuit is repaired. We make further proposals relating to the declared availability of defective CATO circuits at Section 6.3.7 and Appendix 7;
- For annual declared availability performance below target, the CATO's annual revenue will be reduced in direct proportion. This proportion will be chosen (through financial modelling or otherwise) in order to apply the appropriate availability incentive power for the particular CATO role being identified. In the example shown in the graph of Figure A 3-1, this proportion has a slope of 2.5 (that is, a 1% reduction in availability causes a 2.5% reduction in annual revenue);
- Annual revenue will reduce in proportion to annual declared availability down to an annual collar limit of target annual revenue to limit investor risk. (For the OFTO regime, this is currently set at 90%, but for the CATO regime this value would need to be chosen in order to set an appropriate level of financial risk.) The purple circle in Figure A 3-1 indicates the point at which the relationship changes from proportional to collar-limited;
- To increase the power of the availability incentive, as with OFTOs, further reductions in annual declared availability continue to incur further reductions in revenue due; however, penalties in excess of the annual collar limit (indicated by the horizontal purple line in Figure A 3-1) would become due in tranches over the successive years (up to, say, 5 years in total). An overall collar (which, for this example, this has been set to 50% of annual revenue for the present OFTO regime and is indicated by the horizontal red dotted line in Figure A 3-1) would apply to poor performance relating to any one year. Again, the purpose of this collar is to limit investor risk, so for CATOs it would need to be chosen to appropriately control their financial risk. The red circle in the same graph indicates the point at which the relationship changes from proportional to collar-limited; and

- To avoid any irrelevant biasing of return-to-service (RTS) durations that would be created by, for example, measuring outage durations to the nearest whole hour or day, such deadlines be removed by recording outage durations to the nearest minute or better. ^[59] In addition, we propose that all calculations to derive the declared unavailability from the actual recorded unavailability are performed to preserve this precision.

An example of the proposed straight-line relationship between annual declared availability and annual revenue below the target annual availability is shown in Figure A 3-1.

Figure A 3-1: Availability incentive framework



⁵⁹ This biasing occurs when the incentive bonus or penalty has significant step changes at specific times. Such quasi-deadlines apply inappropriate variations in pressure on repair teams and can also be unfair on either the CATO or the consumer. The intention of this accuracy in recording unavailability and in calculating declared unavailability is simply to remove the biasing altogether.

APPENDIX 4 OFTO PERFORMANCE INCENTIVE DETAILS

Section 4.1.1.2 outlines the OFTO incentive mechanism. This appendix provides a little more detail on the elements used to capture the impact of an outage on the annual OFTO revenue:

- Inputs:
 - The OFTO transmission capacity, 'C', in megawatts (MW) lost during the outage;
 - The duration of the OFTO outage, 'D', in hours;
 - Capacity reduction weighting elements 'a' and 'b' (Ofgem has chosen the current factor and exponential values as 1 and 1.3 respectively); and
 - Monthly seasonal weighting terms, 'W', in % (chosen by the wind farm).

- Calculations for annual unavailability percentage, in order:

- Outage weighted capacity reduction, in %:

$$WCR = a.(C)^b$$

- Weighted energy outage, in megawatt hours (MWh):

$$\text{Each WEO} = WCR \times D \times \text{max capability}$$

- Total monthly, seasonally weighted, unavailability, in MWh:

$$MWU = \sum (WEO) \times W$$

- Annual weighted unavailability, in MWh:

$$WU = \sum_{i=1}^{12} MWU$$

- Annual total unavailability, in %:

$$TU = \frac{WU}{\text{Max seasonally weighted annual availability (MWh)}}$$

The annual total unavailability percentage thus derived is then converted to a financial reward or penalty to reflect the annual availability performance of the OFTO.

OFTOs are also required to report their performance on losses of sulphur hexafluoride gas (SF₆), since it is a powerful 'greenhouse gas' with negative effects on the environment. However, there are currently no SF₆ performance-related financial implications for the OFTO.

The OFTO unweighted availability incentive is depicted in Figure A 4-1, whilst typical capacity weighting is shown in Figure A 4-2.

Figure A 4-1: Typical OFTO availability incentive

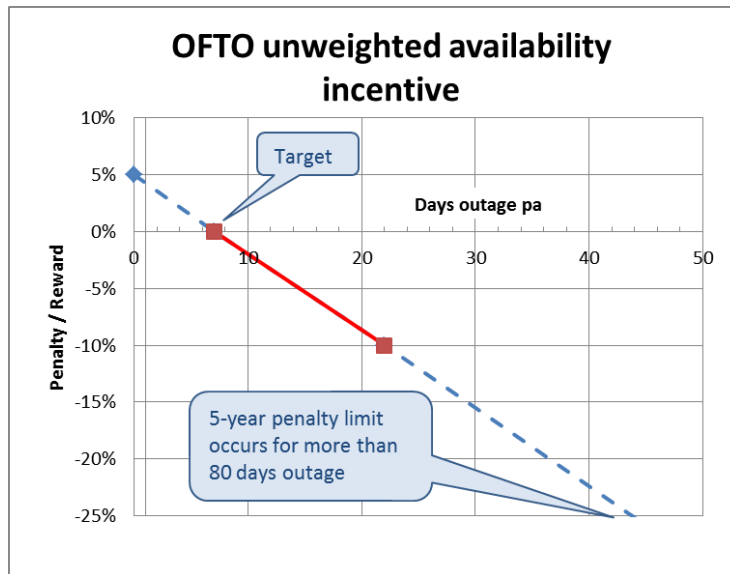
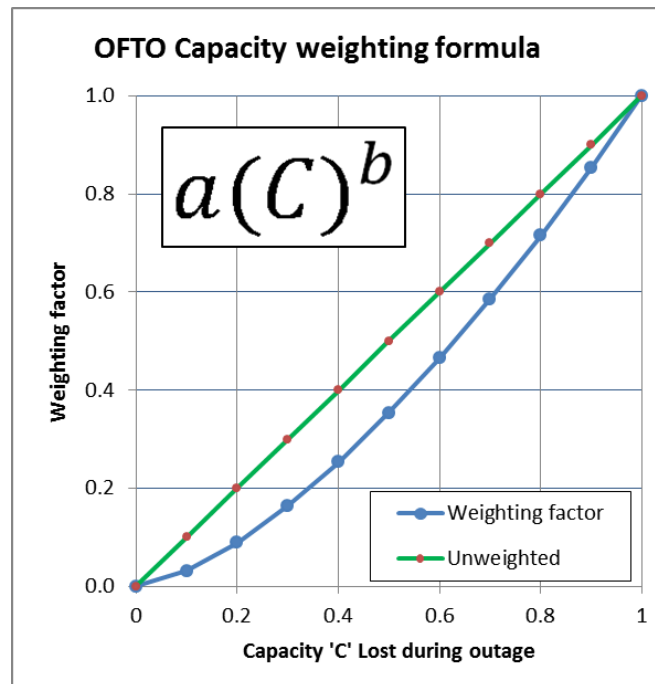


Figure A 4-2: Typical OFTO performance incentive capacity weighting



APPENDIX 5 VICTORIA (AUS) PERFORMANCE INCENTIVE

The Victoria, Australia, **availability incentives** encourage transmission network service providers (TNSP) to maximise network capability (availability) and minimise the market impact of their outages. These incentives are outlined in Section 4.1.2 and this appendix explains how the incentives are applied:

$$\text{Payment to TNSP} = \text{Monthly transmission charge} - \text{Base Rebate} - \text{Network Rebate}$$

Where:

Base Rebate is calculated as the augmentation service outage period (in hours) multiplied by the defined rate per hour, but capped by the monthly Transmission Charge. As an example, the Base Rebate (the availability incentive) for an outage of the Heywood Terminal Station Upgrade ^[60] is calculated on one of three different rates depending upon the season and time of day:

- o Peak - \$2,895 per hour - Weekdays, November-March, 1100-2100hrs, excluding public holidays and 2-weeks at Christmas;
- o Intermediate - \$1,418 per hour - Weekdays, June-August, 0700-2200hrs; and
- o Off-peak - \$50 per hour - All times other than Peak or Intermediate periods.

Network Rebate is calculated as the sum of the outage liabilities (incentive penalties) suffered by specific named neighbouring elements of the shared network as a result of any outage caused to them by the TNSP. The Network Rebate is capped by the monthly Transmission Charge payable by the SO to the TNSP.

Total Availability Rebate: The sum of the Base Rebate and the Network Rebate is capped by the monthly Transmission Charge payable by the SO to the TNSP.

All these incentive rebates are subject to an annual inflation escalator.

⁶⁰ The Heywood Terminal Station Upgrade comprises a 500/275 kV transformer plus HV and LV substation bays, all at a single site.

APPENDIX 6 NOTES ON INCENTIVE DESIGN

To be effective in encouraging a particular behaviour, the designs of regulatory incentives must balance the desired behavioural benefit with the need to ensure that investment in the network business being regulated is financeable. We outline these design requirements at Section 5.4 and define them as follows:

1. **Incentive effectiveness** in encouraging the desired performance requires that:
 - a. the performance requirement pertains to actions or behaviour within the licensee's control; and that
 - b. the potential penalty (financial and reputational) for underperformance is at least equal to the cost of efficient asset operations and maintenance;
2. **Incentive financeability** means that the incentive must not render the investment unattractive to investors, which requires that:
 - a. investors are able to understand and manage the risks associated with the investment and its incentives; and that
 - b. in the case of poor performance against an incentive, the financial impact on the licensee would not affect its cash-flows so severely that the continuity of its licence is jeopardised.

The requirement (1a), that the performance incentive pertains only to factors controllable by the licensee, facilitates, and is mutually compatible with, the manageability of investment risk (2a) so long as the performance incentive, and the rules and principles to support it, are properly defined and explained. Section 5.4.1 provides our specific considerations in this regard for CATOs.

However, the requirement (1b), the level that a potential penalty (revenue at risk) needs to be in order that the incentive is effective, and the requirement (2b), the limit on financial impact, are potentially conflicted. Depending upon the circumstances of the particular CATO in question, one or other or both of these incentive requirements may need to be compromised, which could reduce the effectiveness of the incentive.

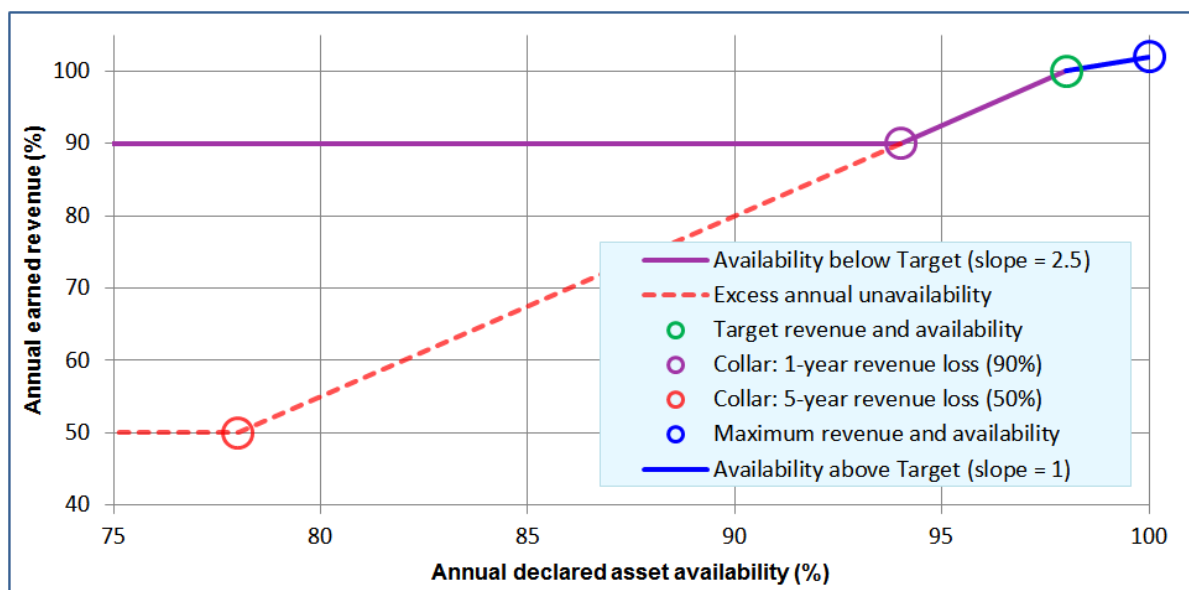
APPENDIX 7 RELIABILITY

A reliability framework is proposed in Section 6.2.3. This appendix provides some further detail on that proposal.

To encourage reliable CATO assets we propose that annual availabilities above the target availability would attract some further revenues but at a lower rate. In the example that follows (see Figure A 7-1), a slope of 1 (1% increase in availability above target attracts a 1.0% increase in annual revenue) is proposed which, with a target availability of 98%, gives an annual revenue limit of 102% of target; this occurs at 100% availability. The reason that we propose the value of this slope to be lower than the availability incentive slope is that, whilst it still rewards very high availabilities (which may be practicable in some years), the incentive to achieve these maximum availabilities is reduced in favour of taking appropriate maintenance outages and performing other actions that improve the CATO's probability of high reliability in future (see the note below).


The straight-line relationship between annual declared availability and annual revenue above the target annual availability is shown in blue in Figure A 7-1. (Other elements of this graph are explained in Appendix 3.)

Figure A 7-1: Reliability added to availability incentive framework



Note: Behaviours to maximise reliability might include, for example, extra checking of oil and SF₆ levels and running temperatures, noting whether any ongoing equipment defects are being adequately managed and ensuring that perimeter fences are fully intact to deny unauthorised entry that might trigger discontinuity of service. ^[61] In addition to such preparations, during periods of operation when reliability is particularly important, it is possible that substations would be manned by staff capable of enacting contingency plans to minimise the impact of any unplanned events that do occur. It would also

⁶¹ Such actions may well come under the general description of 'winter preparedness', although the UK network is increasingly seeing system stress at other times of the year, too.



be important to ensure that any staff who are involved with CATO equipment or controls at these times are fully trained and able to avoid unintended interventions to in-service equipment.

APPENDIX 8 PERIOD INCENTIVES

In Section 6.3.1 we propose two types of period incentives:

- Cyclical period incentives; and
- An unplanned unavailability period incentive.

Application of each of these is detailed next.

A8.1 Cyclical period incentives

We describe here just two examples of cyclical period incentives, each of which is characterised by a series of 12 monthly per unit (p.u.) factors. In practice, any relevant period incentive may be devised that serves the system and transmission user requirements and that is understandable and achievable by the CATO and its assets. We propose that cyclical period incentives be set during production of the CATO needs case.

Firstly, for the Consumer Load cyclical period incentive (see example in 2nd column of Table A 8-1), the SO would select a set of 12 monthly factors to best match the loading requirements anticipated for the CATO assets over the revenue term. Secondly, for the Wind Capacity cyclical period incentive (see example in 3rd column of Table A 8-1), the SO may decide these factors in conjunction with the generation developers.

Other cyclical period incentive sets besides these two are quite possible; for example, should a new transmission connection serve largely new PV generation, then the shape of its p.u. factor graph might approximate to an inverted version of the wind capacity factor graph, placing the emphasis for reliable connection on the summer sun rather than the winter winds. Alternatively, a lunar calendar version could be most appropriate for future radial connections to significant sized tidal generation parks.

For any given CATO, a cyclical period incentive could be used alone, or several could be used together. Either way, the resulting factors are, in every case, used to multiply the duration of any 'actual' outage to develop a 'declared' outage duration. The declared outage durations are then summed over the course of the year and applied to the performance incentive framework to determine the revenue paid to the CATO in any year.

Figure A 8-1 provides an example of the combination of the factors of Table A 8-1 ^[62] and shows how the highs and lows of combined factors will be emphasised where they provide emphasis on reliability at similar times of year. Note, however, that where period factors are combined, the overall period factor (the red plotted line) is adjusted so that its average over the period remains equal to unity in order that the CATO sees a consistent average level of risk regardless of values chosen for the period factors.

In the example of the factors shown in Table A 8-1, if just the consumer load factors were in use, then 10 day outages in December and June would be declared as 13.0 days and 8 days respectively whilst, if

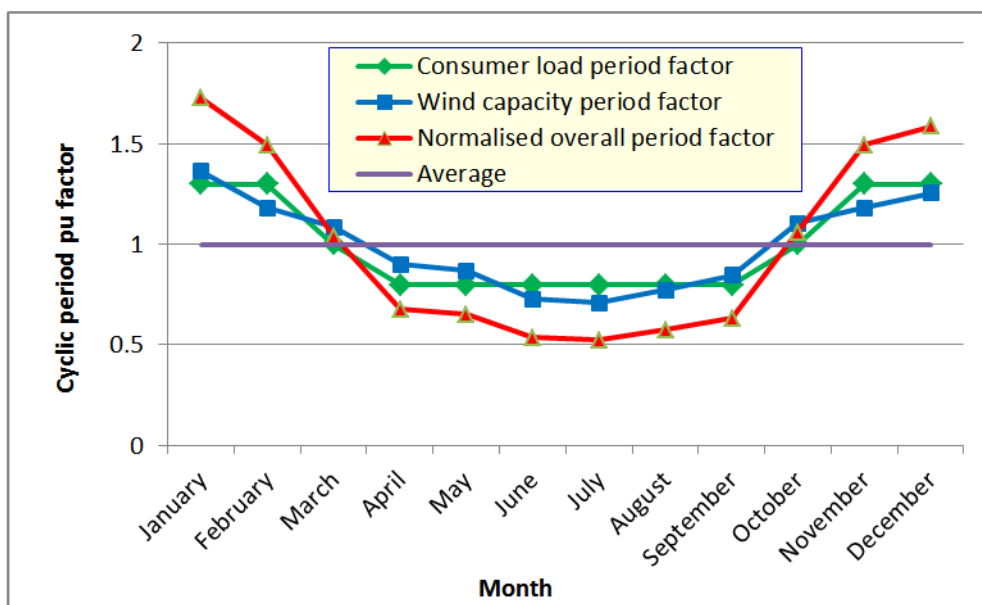
⁶² In this case the combination is achieved through multiplying the pairs of monthly factors together to provide an overall set of 12 monthly factors, all of which are adjusted by subtracting 0.044 to return their overall average to unity. Other methods are possible.

both calendar month and wind capacity factors were in play, the same 10 day outages would be declared as 15.87 days and only 5.37 days duration, respectively.

Table A 8-1: Example cyclical period incentive factors

Calendar Month	Period p.u. factors for Consumer Load	Period p.u. factors for Wind Capacity	Normalised overall period p.u. factors
January	1.3	1.363	1.728
February	1.3	1.183	1.494
March	1	1.087	1.043
April	0.8	0.901	0.677
May	0.8	0.870	0.652
June	0.8	0.726	0.537
July	0.8	0.708	0.522
August	0.8	0.774	0.575
September	0.8	0.846	0.633
October	1	1.105	1.061
November	1.3	1.183	1.494
December	1.3	1.255	1.587
Average	1.0	1.000	1.000

Figure A 8-1: Combined cyclic period incentive p.u. factors



A8.2 Unplanned unavailability period incentive

The premium period unplanned unavailability factor (PrUUF) would operate in conjunction with the StUUF and any cyclical period incentives to heighten the CATO's incentive to maintain good asset management practices and encourage high in-service reliability particularly during periods when the SO anticipates higher than normal risk of system stress. The PrUUF would apply for short periods of the year that are chosen by the SO from time to time, to provide the additional incentive for high reliability during these periods.

The StUUF and the PrUUF would, together, have the effect of increasing the CATO's annual declared unavailability (and thus decreasing annual revenue) should the CATO suffer unplanned unavailability over the course of any year. The incentive factor may be summarised as:

$$\text{Total reliability incentive factor} = \text{Cyclical incentive factor} \times (\text{StUUF} + \text{PrUUF})$$

This factor would then be applied to the availability framework incentive calculation as follows:

$$\text{Declared unavailability} = \text{Total reliability incentive factor} \times \text{Actual unplanned unavailability}$$

For most periods of the year, however, when the SO's requirement for CATO reliability is not at a premium, the PrUUF factor would be set to zero. Operation of the StUUF and the PrUUF are described next, in turn.

A8.2.1 Standard unplanned unavailability factor (StUUF)

As explained in Section 6.2.3, unplanned unavailability of a transmission circuit is normally far more of an imposition on the SO's operations than planned unavailability. We thus propose the principle that, in addition to any cyclical period incentive, any unplanned unavailability during normal operations is associated with a StUUF that produces declared unavailability durations in excess of the outage durations actually measured. The StUUF would be set at the time of the production of the CATO needs case.

For example, if the value of the StUUF was chosen to be equal to 3.0 and the cyclical period incentive at that time equalled 1.2, then the overall period incentive factor would be 3.6. An unplanned unavailability of one day duration during this period would thus be declared as 3.6 days unavailability. An unplanned outage at that time would therefore result in significant lowering of the CATO's annual revenue, thus incentivising the CATO to check, during maintenance and during operations, the health of its assets, to optimise the probability of reliable in-service operations.

Note that the needs case specification and use of the StUUF for any CATO is not mandatory – it does not form part of the performance incentives framework, but is an 'optional bolt-on'.

A8.2.2 Premium period unplanned unavailability factor (PrUUF)

In addition to any standard priority that the SO places on a CATO's reliability through the StUUF, there may sometimes be additional periods during which it will be particularly important for the SO that the CATO assets remain reliably in service. These requirements might be triggered by, for example, pre-published public events, or by temporary network pinch-points due to established outage plans.

For these types of event, in order that the SO could emphasise its requirement for reliability during these 'premium' periods, we propose the option of an additional period factor, the 'premium unplanned unavailability factor' (PrUUF).

To provide flexibility to the SO in instructing the CATO to provide premium reliability cover whilst at the same time limiting the level of risk to CATO investors at the time of tender assessment, we propose that use of the PrUUF would be subject to an annual maximum quota. The quota system described here uses example values; actual values could be different for each CATO to reflect the specific network role and geographic location.

PrUUF quota system:

- The annual use quota for which the PrUUF may be demanded by the SO is set at a certain number of 'premium factor days equivalent quota' (pfdeq). that would be decided during the production of the CATO needs case. A pfdeq of 30 per annum, for example, would mean that the SO could choose any 30 days in the year during which the PrUUF would equal unity; ^[63]
- Although the annual quota (pfdeq) for the PrUUF will be known, the number of days that the SO calls for this cover will not be known for certain until the end of the year. The value of the PrUUF for the year would thus be established at year-end; pfdeq would simply be divided by the total number of days in the year that the SO actually calls for the PrUUF premium cover to establish the value of the PrUUF for the year just completed;
- The pfdeq allocation would be specified during the production of the CATO needs case, to limit and clarify investor risk; and
- With this quota system, if the SO uses the PrUUF only rarely in any year, then its value could rise very high, presenting an unreasonable risk to the investor. Therefore, to limit and clarify investor risk, a maximum value for PrUUF regardless of the level use – for example, 5 – would also be specified during the production of the CATO needs case.

Table A 8-2 presents the above example PrUUF quotas along with examples of the number of premium days cover declared by the SO for a given year and the resultant variable period factors that, in the event of unplanned unavailability, would be added to the StUUF during these declared days. Note that, in one of the example cases, the actual PrUUF is less than that calculated because the overall factor limit of 5 comes into play. Of course, if the CATO asset remains reliably in service, then none of these factors will apply; and therefore neither will there be any revenue penalty on the CATO.

⁶³ Alternatively, with a pfdeq of 30 per annum, the SO could choose any 15 days of the year during which the PrUUF would equal 2, or any 10 days when the PrUUF would equal 3, and so on.

Table A 8-2: Examples of PrUUF calculations

Example annual quotas for PrUUF	Example days of cover declared by the SO in a year	Example PrUUF values (to be added to StUUF)
pfdeq = 30 PrUUF limit = 5	Example 1: 15	2
	Example 2: 12	2.5
pfdeq = 60 PrUUF limit = 5	Example 1: 21	2.86
	Example 2: 5	5 ^{††}
^{††} Note: In the example described here, 5 = overall factor limit for any period, so in this case the calculation of PrUUF is overridden by that limit		

A necessary consequence of this quota approach is that the CATO’s final declared availability can only be evaluated at year-end because, until that time, it will not be known whether the CATO suffers any unplanned outages, neither will it be known for certain what premium reliability requests the SO will make within the year. However, in this way the SO can manage some of the uncertainties of system security throughout the revenue term whilst, at the same time, the CATO can see a limit to (the costs of) the operational requirements that can be demanded by the SO. Thus, CATO bids do not have to factor in unnecessary risk throughout the duration of the revenue term, so consumers can benefit from lower tendered revenue streams.

Note: to achieve this saving for the consumer at the time of CATO tender (in other words, to avoid CATO bids factoring in unnecessary risk) it would be important for the SO to consider whether the PrUUF option is required at all for the CATO in question, and to rule it out before the tendering process starts if it is not required.

Summarising these unplanned unavailability incentives, the CATO will always be in one of three types of period through the year:

1. Standard, non-premium operation – periods of normal running conditions, when the CATO assets should be operating normally– no planned outages. Unplanned unavailability incurs declared unavailability at the rate of any cyclical period factors multiplied by the StUUF:

$$\text{Declared unplanned unavailability} = \text{Actual unavailability time} \times \text{cyclical period factor} \times \text{StUUF}$$

2. Notified premium reliability operation – periods that have been notified to the CATO in advance by the SO as being periods where reliability will be at a premium. Unplanned outages incur declared unavailability at the rate of any cyclical period factors multiplied by the (StUUF + PrUUF):

$$\text{Declared unplanned unavailability} = \text{Actual unavailability time} \times \text{cyclical period factor} \times (\text{StUUF} + \text{PrUUF})$$

and

3. Planned CATO outage periods. Planned outages incur declared unavailability at the rate of any cyclical period factors;

$$\text{Declared planned unavailability} = \text{Actual unavailability time} \times \text{cyclical period factor}$$

Note that, with the above proposals, all of the periods of premium reliability are notified ahead of real-time by the SO to the CATO in an ongoing manner throughout the revenue term, so do not need to be set during the production of the CATO needs case. Only the following need to be set during production of the needs case:

- StUUF;
- pfdeq; and
- PrUUF limit.

This allows an operationally flexible arrangement whereby the SO can identify and communicate its premium reliability requirements of the CATO during any part of the planning cycle, yet the CATO's investment risk level remains contained.

APPENDIX 9 A NOTE ON ASSET HEALTH AUDITS

We describe, at Section 6.3.1, asset health assessments that would contribute to the incentives for CATOs to maintain good asset management practices throughout their revenue terms. This Appendix lists some of the factors that could contribute to those assessments.

In-service audits:

- Maintenance standards and maintenance planning;
- Actual maintenance performed in comparison to these plans;
- Asset health – condition assessment of plant, equipment and buildings in the context of the service, network criticality and environmental conditions seen by the assets – a suite of measures equivalent to the incumbents' RIIO-T1 network output measures (NOMS) but targeted at CATOs;
- Unreliability history – faults, failures, safety issues; any SO complaints of poor CATO performance;
- Any relevant derogations that the CATO has sought from Ofgem;
- History of early (pro-active) defect detection;
- Asset condition and maintenance record-keeping; and
- An assessment of whether asset health is commensurate with age and operation.

End-of-revenue term inspection:

- The same basic factors would be considered as for in-service audits, but with a greater sample of inspected equipment;
- In addition to reviewing maintenance and performance history, trends in comparison with the previous audit data should be reviewed and explained;
- Ofgem should give consideration as to how and whether any asset condition that is not commensurate with age and duty is to be reinstated by the CATO (or whether the CATO is to be financially penalised).



ABOUT DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.