RPI-X@20: Output measures in the future regulatory framework

A REPORT PREPARED FOR OFGEM

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Executive Summary

Background

At the RPI-X@20 review, Ofgem is currently assessing the regulatory frameworks applied to the gas and electricity transmission and distribution businesses. Ofgem has stated that regulation of networks should promote two objectives:

- facilitating delivery of a sustainable energy sector; and
- delivering value for money in the long term for existing and future customers.

Ofgem has also identified six output categories that are intended to translate these two objectives into meaningful areas of performance in which the networks must ensure delivery. These output categories are:

- reliability (of network services and the wider system);
- safety;
- environmental targets, particularly the delivery of low carbon energy services;
- conditions for connection to network services;
- customer satisfaction; and
- network related social obligations.

Our remit

We have been asked to address the following questions[1]:

- Are the output categories appropriate in that they provide complete coverage of network activities that are valued by stakeholders (covered in section 2)?
- What principles should apply when developing the set of outcomes and outputs (covered in section 3)?

1 In doing so, we have been asked to ignore the present legal restrictions that prevent Ofgem and/or the operators from discriminating in favour of low carbon generation.

- What are the high-level outcomes in each category, and what are the types of outputs that should be used to drive behaviour towards achieving the desired outcomes (covered in section 3)?
- Can that set of outputs be put together in a coherent regulatory package of incentives that can be expected to be effective in driving the desired behaviour (covered in sections 3 and 4)?

It should be noted that it is beyond the scope of this report to provide detailed advice on how measures would be calculated (or explicitly defined in the case of more qualitative outputs), what information would be needed or what targets are appropriate.

Our conclusions

Output-based incentive regulation is a highly effective way of promoting efficiency whilst enabling delivery to customers and other relevant stakeholders of valued outputs. It requires the regulator to define output targets, and provide profit incentives on operators to achieve those targets. If the regime is well designed, this approach should encourage operators to achieve these outputs (for example, a high level of supply continuity) at lowest cost to customers. A key feature of an output-based regime is that once the parameters of the regime have been set, the regulator should not intervene again until a pre-determined trigger enables it to do so (e.g. a periodic price control review). This feature creates a stable commercial framework, with well understood rules to allow the operator to make efficient and sustainable commercial decisions.

This approach is preferable to an input based approach, in which regulators intervene to prescribe how the operators should achieve the desired outcomes. For example, a regulator might not only specify the high level of supply continuity as the output, but the regulatory rules would also have the effect or intent of specifying the scale, location and type of investments required to achieve that output. Or, the regulator may develop a reputation for *ad hoc* intervention in an output-based regime, which undermines the stability of the commercial framework and causes the operator to distort its behaviour through second guessing the regulator rather than operating efficiently. This input-based approach has particularly poor incentive effects, culminating in inefficiency, lack of innovation, micro-management, and blurred lines of responsibility between the regulator and operators, with the associated breakdown of accountability.

However, the implementation of an output-based regime is not straightforward. Firstly, a large number of outputs and outcomes are likely to be valued by a wide group of stakeholders, and this makes the regulatory task complicated. Not only that, but the challenges that the regulatory regime will need to address in future - bringing about an energy system that encourages substantial carbon emission reductions in a timescale consistent with the government's targets – are arguably far more complex than the regulatory challenges Ofgem has had to face to date.

Secondly, many of the outputs cannot be easily incentivised by performance regimes, and this means that a pure output-based incentive regime is unlikely to be achievable, leaving the regulator with little option but to intervene directly, at the cost of weaker efficiency and innovation. In our view, in order to preserve the benefits of output-based regulation, any application of input-based regulation needs to be prescribed, and credibly so, to avoid the whole regime collapsing into opportunistic input based regulation. The absence of a credible and well-understood boundary between delegated autonomy to the operator and intervention by the regulator is the greatest risk to an output-based incentive regime. In the absence of such a boundary, it will be easy for the regulator to slip into detailed micro-management at a significant cost to efficiency, innovation and longer term customer benefits. Creating the boundary depends as much (if not more so) on the regulatory culture and values within the regulatory agency as on the development of a set of rules (which can never hope to capture all possible eventualities).

High-level outcomes

With this overview in mind, we conclude that the six output categories Ofgem has defined are the right ones, and we have defined a set of high-level outcomes that reflect a reasonable set of aspirations we might have of a good network operator, which are set out in Table 1 below.

Absent the specific focus on low carbon generation - these generic outcomes are probably very similar to those that would have been identified by a similar study at any time over the past 50 years, reflecting the fact that the aspirations of what can be expected from a network operator, both now and in the future, should be reasonably constant over time. In general, however, the means of achieving those aspirations will inevitably change over time and these are best handled through the specific outputs and regulatory instruments which we discuss below.

It is clear from the table that some output categories tend to *draw from* other categories, and others tend to *feed in* to other output categories. The table shows the extent to which the satisfaction of any individual high-level outcome tends to depend on outputs in other categories, the only exception relating to conditions for connection. It is clear that the environment, reliability and customer connections categories are the key building blocks of Ofgem's two high-level objectives of value for money and sustainability, and these are the main focus of our report.

Table 1. High-level outcomes, and the inter-relationships across the output categories

Output category	High-level outcomes	Mainly achieved via outputs in:
Environment	Minimise the 'narrow' environmental impact of the operator's activities	Environment
	Facilitate improved energy efficiency	Environment
	Maximise the volume of low-carbon flows on the network (electricity only[2])	Reliability, Connections
Reliability	Maintain operational performance of the network at acceptable levels	Reliability (electricity) Safety (gas)
	Ensure networks adapt to the consequences of climate change	Reliability
	Anticipate new patterns of energy injection and offtake to accommodate the decarbonisation of the energy sector on the network in its planning and investment decisions	Reliability
Conditions for Connection	Fair, accurate, and non-discriminatory access terms	Connections
	Minimise the time taken to connect	Connections
	Minimise the time taken to connect low carbon generation (electricity only)	Connections
Customer Satisfaction	Maintain levels of customer satisfaction at high levels and improve where possible	Customer Satisfaction, Reliability, Safety, Connections
Safety	Operate a safe network	Safety
Social Obligations	Fulfil the social obligations imposed upon it	Social Obligations, Reliability, Safety, Connections

Source: Frontier Economics

2 In future, it might be expected that the restriction to electricity could be widened to gas if there is a clearly agreed policy goal to promote biogas, with the appetite to support such a high-level outcome with primary outputs and incentive mechanisms.

The introduction of an environmental objective creates a heightened degree of interplay between the reliability, environmental and connection output categories. Two concerns have been identified to us around particular obstacles to achieving the roll-out of low carbon generation:

- delays in connecting low carbon generation to the grid; and
- investment strategies that do not adequately anticipate future generation (and to a lesser extent the increased load that could result from, for example, a greater volume of electric cars).

Consequently, the achievement of environmental objectives will materially depend on establishing an effective regulatory package around reliability and connections.

Primary outputs

A summary of the primary outputs we have developed that sit within each category is provided in Table 2. It should be noted that the primary outputs are the ones that will make a material contribution to the outcomes, which contrast to what we have described as "secondary outputs" which have an important role in the regulatory regime, but which are not sufficiently material to represent the primary mechanisms to achieving Ofgem's objectives. In addition, Ofgem will need to rely on supporting indicators to build up some of the output measures we propose in this report.

Also reported in Table 2 are the proposed incentive mechanisms for each output, given the characteristics of the output in question. Outputs can be incentivised in a number of different ways depending on the characteristics of the output in question:

- through marginal incentives;
- through guaranteed standards; and
- through *ex post* evaluation of output performance that can affect the share of out-performance benefits that can be retained (which in turn requires the specification and monitoring of outputs).

As the tables show, some outputs are sufficiently controllable and capable of being measured to a good degree of accuracy to lend themselves to direct incentivisation through a set of marginal incentives or guaranteed standards. These include the number of customers who are connected within a period of time, and the flow of low carbon power over electricity networks, for example. Other outputs such as the network's engagement with other industry participants to promote energy efficiency are much less capable of measurement, and therefore any outputs should be monitored rather than incentivised.

The overlap between output-based and input-based regulation

Table 2 also reveals that the incentive mechanism of *ex post* evaluation of output performance plays a crucial role in facilitating outcomes, particularly the reliability outcomes. A theme that runs through this category of outputs is that it is not always easy to apply output-based regulation to ensure that the desired outcomes are realised. These cases would generally fall into three types:

- the available output measures may provide little insight into current performance, allowing operators to diminish provision in the short-term in order to meet financial targets, with no penalty for doing so;
- the desired output cannot be well controlled by the operator (or measured by the regulator), so that a high-powered incentive could expose the operator to too much risk; and
- the desired output could largely resemble an input (e.g. the roll out of an electric car charging network is essentially the extension of the present system by a certain number of kilometres of cable with connection points).

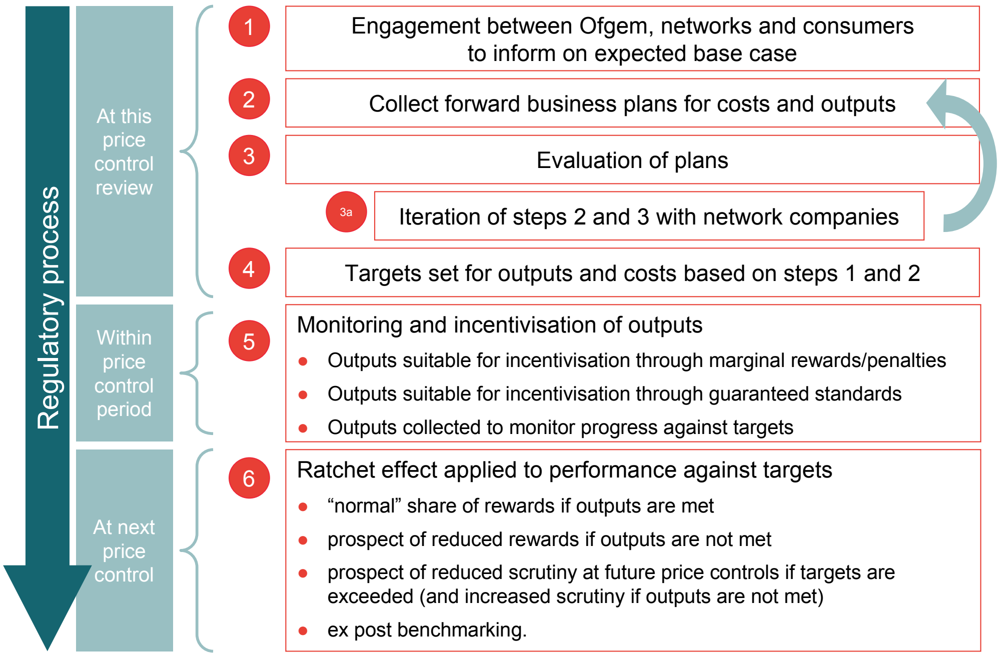
These cases mean that there will be some reliance on assessing performance by reference to performance against inputs rather than outputs. But this does not mean that the regime needs to collapse into a highly interventionist, micro-management style of regulation. In this report we provide discussions of each of these types of cases to illustrate that incentive-based solutions are feasible. But, in each of these cases it would be very easy for the regulator to fall into an interventionist regulatory model, and to avoid this Ofgem would need to clearly limit the scope of its interventions. In doing so, it would not be sufficient for Ofgem to merely to assert its intent to not intervene beyond its announced scope; it also requires it to establish regulatory arrangements that have that effect.

A proposed approach to limiting and focusing the scope for direct regulatory intervention

A useful way of considering how to limit the "creep" into input based regulation is to understand how the inputs and outputs fit into a typical regulatory cycle. A stylised characterisation is set out in Figure 1 and it reveals that outputs can be used to condition the cost allowances of the operators at the time the price control is set; they can be monitored throughout the course of the price control period; and they can be used in a performance regime. The rewards or penalties on those outputs can be applied both throughout the price control period, and at the end, as part of an overall assessment of whether the operators delivered on the regulatory "bargain" struck at the time the price control was set.

How these outputs are used, and at what stage in the cycle, have significant economic effects, and it is this insight that enables the regulator to limit the use of inputs to those parts of the regulatory process where they have greatest value, and avoid putting them in other parts of the regulatory cycle, where they could be value-destroying.

Figure 1. The use of outputs over the regulatory cycle



Source: Frontier Economics

Target-setting

It is important to recognise that inputs are a crucial input into determining cost allowances that feed into price controls (steps 2 and 3 of the process described in Figure 1. A good sense of the work that operators will need to do to their networks over the next 5 years is needed to set credible and robust price controls.

It is also important to recognise that in most cases operators are likely to be best placed to know what is required on their networks to maintain performance (or improve it, if that is what stakeholders would value), and so the principal regulatory task at the target-setting stage is largely to establish whether those plans that the operators put forward represent adequate value for money.

However, in some cases, operators will be increasingly required to make investments in anticipation of large and uncertain future events and the choices they make will need to be legitimatised, in order to avoid either gold-plating, or inadequate provision. This legitimisation process will involve the regulator but should maintain a clear distinction between management and regulation.

It is therefore necessary to define when the need for this heightened degree of intervention will be required. This should be based on a test of proportionality where the likely cost to customers associated with the regulator not engaging in this way is compared to likely cost of doing so, under a variety of scenarios. Starting from a cultural pre-disposition not to intervene directly into the affairs of the operators, this would only reveal clear-cut areas for intervention where the regulator needs to take a strategic lead to will the means as well as the ends (e.g. more direct regulatory engagement and involvement to reduce the costs of constraints rather than continuing to rely on the System Operator [SO] incentive).

Having defined the area for intervention in the target-setting process, this legitimisation process should maintain a clear distinction between management and regulation.

- The operator, who has best sight of the technical issues, should present "investment ahead of need" scenarios as part of the business planning process at each price control review. These scenarios would take account of any impact on the base case, in order that the net costs of the investment can be identified, and highlight the future risks if anticipated events do not materialise.
- The regulator evaluates those scenarios both in isolation and in comparison with other relevant information received.
- The regulator agrees to a plan and associated expenditure, which is then monitored for delivery.

During the price control period

Having agreed the target levels of performance (whether on an output or input basis), the agreed financial sharing parameters, and the penalties for failing to deliver on the output or input commitments, the regulator should step away until the pre-determined triggers for re-engagement with the operator (such as a price control review or a re-opener) are pulled. This enables the operators to work within a stable commercial framework free from regulatory interference.

However, during this time, the regulator should monitor performance against what was expected at the time the price control was set in a Reliability Report. This will enable it to apply penalties and rewards for delivery against what was expected in certain circumstances.

After the price control period has ended

At the end of the price control period, as well as settling up the share of over-or-under financial performance that the operator should bear, it will be necessary to compare the performance of the operators in respect of any “input-based” outputs. In this report, we have identified two of these types of “input-outputs”:

- those that were developed in order to set a credible and realistic cost allowance associated with the maintenance of a particular level of operational risk on the network at the time the price control was last set; and
- those that were developed as part of the heightened degree of intervention that was needed to guide the strategic priorities of the operator towards delivering particular outcomes.

Great care will be needed in using the metrics that fall under the first category (such as the tier 2 measures developed by Ofgem at DPCR5) to set penalties and rewards for performance. This is because, in our view, it is impossible to objectively measure the underlying health of the system, and the impact of interventions in respect of each asset type, where these interventions could vary from asset replacement, refurbishment, reinforcement, and load transfers to contracts for demand-side response, as well as other more system-wide interventions, whilst also taking into account any material changes of circumstance. Our view is that these calculations can never be so definitive as to enable a mechanistic revenue penalty to be applied for marginal variations in performance. Consequently, penalties should be applied for clear and material non-delivery that has unambiguously raised the operational risk of the network relative to what was expected at the last price control review.

The dangers of applying financial penalties for minor diminutions of performance against the imperfect measure(s) that would be used to judge performance are highly significant. The effect (if not the original intent) of these arrangements would be greater regulatory involvement and sign off on any interventions (or absence of them) that the operators might be inclined to make. This is because there are usually options associated with how network risk should be managed, and operators will naturally want to be assured that their choice won’t get penalised, and will seek assurances from the regulator that its course of action is acceptable.

This increased regulatory involvement would take one of two forms: either the regulator will need to become increasingly precise in its definitions of unreliability for the purpose of developing *ex ante* rules, which will imply an ever-lengthening rulebook; or the regulator will become increasingly drawn into the real-time management of the system in order to judge whether the actions of the operator have been or will be acceptable - which it can then communicate to the operator in an ever increasing number of letters of comfort. In both cases, the networks will, over time, reflect the preferences of the regulator, rather than the optimal decisions of an innovative operator.

Over the longer term, the dynamic efficiency cost could be very great as the industry settles on an established way of doing things rather than exploring the full potential of smarter networks and the possibility of using of innovative technologies that would be incentivised under a less prescriptive approach.

The pressure for the regulator to be drawn into the operations of the networks is likely to stem less from a concern that outputs have been diminished, and more around protecting customers from "over-paying" for assets. However, in our view, this risk is better handled through a robust process of target setting (for which these indicators of asset health and performance can play a major role), effective incentives for truth-telling, and incentive arrangements for out-performance. Even with these arrangements in place, customers may still pay more than they would in a world of perfect information and foresight, but to try and eliminate this risk entirely draws the regulator inexorably into input based regulation with far greater customer detriments. In other words, application of input-based regulation is not a proportionate response to the concern.

These same considerations also apply in respect of the second category of input "outputs" that may be developed to guide the strategic priorities of the operator at the target setting stage. In practice, the penalties would need to be agreed up-front on a case-by-case basis. In the simple case, where the input "output" was clear and unambiguous, it is fairly clear if it hasn't been delivered and an appropriately simple penalty system would apply. In more complex cases, it may only be possible to penalise clear and material non-delivery, in order to avoid the kind of regulatory creep into the management of the network described above.

In summary, the use of inputs in regulatory processes is unavoidable, but their use needs to be confined to the parts of the regulatory cycle where they are of greatest value. This discussion has illustrated the choices the regulator needs to make in order to set a boundary between delegated authority to the operator, and intervention by the regulator, in order to preserve the benefits of incentive-based regulation.

Table 2. Summary of recommended primary outputs

Output Category	Electricity Distribution		Electricity Transmission		Gas Distribution		Gas Transmission	
	Primary outputs	Incentive Mechanism	Primary outputs	Incentive Mechanism	Primary outputs	Incentive Mechanism	Primary outputs	Incentive Mechanism
Environment Minimise the 'narrow' environmental impact of the operator's activities;	Business carbon footprint Losses Other network emissions Visual impacts	Marginal incentives (when this becomes appropriate) Relatively weak guaranteed standards and marginal incentives Inform ex post assessment against expectations Planning regime	Business carbon footprint Losses Other network emissions Visual impacts	Marginal incentives (when this becomes appropriate) Relatively weak guaranteed standards and marginal incentives Inform ex post assessment against expectations Planning regime	Business carbon footprint Shrinkage Other network emissions Visual Impacts	Marginal incentives (when this becomes appropriate) Marginal incentives and/or guaranteed standards Inform ex post assessment against expectations Planning regime	Business carbon footprint Shrinkage Other network emissions Visual Impacts	Marginal incentives (when this becomes appropriate) Marginal incentives Inform ex post assessment against expectations Planning regime
Facilitate improved energy efficiency; and	Measure of engagement	Monitoring	N/A	N/A	Measure of engagement	Monitoring	N/A	N/A
Maximise the volume of low-carbon flows on the network	MWh of low carbon generation	MWh of low carbon generation or % of available low carbon generation transmitted	MWh of low carbon generation or % of available low carbon generation transmitted	Payment per MWh or "availability" payment	N/A	N/A	N/A	N/A

Output Category	Electricity Distribution		Electricity Transmission		Gas Distribution		Gas Transmission	
	Primary outputs	Incentive Mechanism	Primary outputs	Incentive Mechanism	Primary outputs	Incentive Mechanism	Primary outputs	Incentive Mechanism
Reliability Maintain operational performance of the network at acceptable levels;	CI	Guaranteed standards and marginal incentives	ENS	Incentive scheme	Restoration of supply after an interruption	Guaranteed standards	Interruptions lasting longer than 15 days	Marginal incentive
Ensure networks adapt to the consequences of climate change; and	ENS or CML	Guaranteed standards and marginal incentives			CML or ENS	Safety regulations determine performance, but CML/ENS can be monitored by Ofgem.		Safety regulations determine performance, but reliability report can be monitored by Ofgem
	Various metrics in the business plans/ reliability report (e.g. asset health)	Ex ante target setting and ex post monitoring, with financial penalties for clear and material non-delivery	Various metrics in the business plans/ reliability report (e.g. asset health)	Ex ante target setting and ex post monitoring, with financial penalties for clear and material non-delivery	Various metrics in the business plans/ reliability report (e.g. asset health)	Ex ante target setting and ex post monitoring.	Various metrics in the business plans/ reliability report (e.g. asset health)	Ex ante target setting and ex post monitoring.
Anticipate new patterns of energy injection and offtake to accommodate the decarbonisation of the energy sector on the network in its planning and investment decisions.	Various metrics in the business plans/ reliability report	Ex ante target setting and ex post monitoring, with financial penalties for clear and material non-delivery	Various metrics in the business plans/ reliability report	Ex ante target setting and ex post monitoring, with financial penalties for clear and material non-delivery	Various metrics in the business plans/ reliability report	Safety regulations determine performance, but reliability report can be monitored by Ofgem.	Various metrics in the business plans/ reliability report	Safety regulations determine performance, but reliability report can be monitored by Ofgem.
			Congestion costs	Harmonisation of SO incentive with TO PCR target setting				

Output Category	Electricity Distribution		Electricity Transmission		Gas Distribution		Gas Transmission	
	Primary outputs	Incentive Mechanism	Primary outputs	Incentive Mechanism	Primary outputs	Incentive Mechanism	Primary outputs	Incentive Mechanism
Conditions for Connection								
Fair, accurate, and non-discriminatory access terms	Defined in licence	Licence condition	Defined in licence	Licence condition	Defined in licence	Licence condition	Defined in licence	Licence condition
Minimise the time taken to connect; and	Time taken to connect a request for a generation node	Guaranteed standards and/or marginal incentives	Time taken to connect a request for a generation node	Guaranteed standards and/or marginal incentives	Time taken to complete a connection request	Guaranteed standards and/or marginal incentives	Time taken to complete a connection request	Guaranteed standards and/or marginal incentives
	…for a demand node	Guaranteed standards and/or marginal incentives	… for a demand node	Guaranteed standards and/or marginal incentives				
Minimise the time taken to connect low carbon generation	…for a low carbon generation node	Guaranteed standards and/or marginal incentives	…for a low carbon generation node	Guaranteed standards and/or marginal incentives	N/A	N/A	N/A	N/A
Safety Operate a safe network	Comply with minimum legal safety requirements	Outside the regulatory regime	Comply with minimum legal safety requirements	Outside the regulatory regime	Comply with minimum legal safety requirements	Outside the regulatory regime	Comply with minimum legal safety requirements	Outside the regulatory regime

Output Category	Electricity Distribution		Electricity Transmission		Gas Distribution		Gas Transmission	
	Primary outputs	Incentive Mechanism	Primary outputs	Incentive Mechanism	Primary outputs	Incentive Mechanism	Primary outputs	Incentive Mechanism
Customer Satisfaction Maintain levels of customer satisfaction at high levels and improve where possible	Broad measure of customer satisfaction Measures captured under other categories: CI, CML, time to connect, narrow environment measure	Inform an ex post assessment. Some elements of the broad measure may be subject to guaranteed standards. See incentive mechanisms for primary outputs under other output categories.	Broad measure of customer satisfaction Measures captured under other categories: CI, ENS, time to connect, narrow environment measure	Inform an ex post assessment. Some elements of the broad measure may be subject to guaranteed standards. See incentive mechanisms for indicators under other output categories.	Broad measure of customer satisfaction Measures captured under other categories: safety, time to connect, narrow environment measure	Inform an ex post assessment. Some elements of the broad measure may be subject to guaranteed standards. See incentive mechanisms for indicators under other output categories.	Broad measure of customer satisfaction Measures captured under other categories: safety, time to connect, narrow environment measure	Inform an ex post assessment. Some elements of the broad measure may be subject to guaranteed standards. See incentive mechanisms for indicators under other output categories.
Social Obligations Fulfil the social obligations imposed upon it	Targets for worst-served & vulnerable customers Measures captured under other categories	Guaranteed standards See incentive mechanisms for primary outputs under other output categories.	Measures captured under other categories	See incentive mechanisms for primary outputs under other output categories.	Targets for worst-served and vulnerable customers Measures captured under other categories	Guaranteed standards See incentive mechanisms for primary outputs under other output categories.	Measures captured under other categories	See incentive mechanisms for primary outputs under other output categories.

Source: Frontier Economics

1 Context and remit

Through the RPI-X@20 review, Ofgem is currently assessing the regulatory frameworks applied to the gas and electricity transmission and distribution businesses. Even if the challenges faced by these businesses were the same as those in the past it would still be necessary to address the issue of output-based regulation because the regimes that have applied historically have not always sent clear signals to operators. Now that the networks are expected to evolve to meet new challenges, particularly in relation to decarbonisation, regulation needs to evolve with them to continue to promote efficient delivery of outputs and ensure that public policy objectives are met. Outputs therefore need to be properly defined and specified, and the regulatory framework within which they sit needs to be clearer.

In this section we review in more detail the context and motivation for this study. We describe the underlying rationale for the use of outputs in a regulatory context, Ofgem's initial thinking and our remit.

1.1 The evolving use of outputs in regulation

Output-based incentive regulation is the practical expression of the separation of powers and responsibilities that was created at privatisation. At that time, it was seen as appropriate that policy-makers define the over-arching structural, regulatory and commercial framework; the regulator implements that framework by defining the regulatory rules that operators must abide by; network operators make planning, investment, price and service decisions within those rules; and the shareholders of the operators ensure that they make those decisions in the most profitable way.

Output-based incentive regulation is a highly effective way of promoting efficiency whilst enabling delivery to customers and other relevant stakeholders of valued outputs. It requires the regulator to define output targets, and provide incentives on operators to achieve those targets. If the regime is well designed, an output-based incentive regime should encourage operators to achieve these outputs (for example, a high level of supply continuity) at lowest cost to customers. A key feature of an output-based regime is that once the parameters of the regime have been set, the regulator should not intervene again until a pre-determined trigger enables it to do so (e.g. a periodic price control review). This feature creates a stable commercial framework, with well understood rules to allow the operator to make efficient and sustainable commercial decisions.

This approach is preferable to an input based approach, in which regulators intervene to prescribe how the operators should achieve the desired outcomes. For example, a regulator might not only specify the high level of supply continuity as the output, but the regulatory rules would have the intent or effect of also specifying the scale, location and type of investments required to achieve that output. Or, the regulator may develop a reputation for *ad hoc* intervention in an output-based regime, which undermines the stability of the commercial framework and causes the operator to distort its behaviour through second guessing the regulator rather than operating efficiently. This input-based approach has particularly poor incentive effects, culminating in inefficiency, lack of innovation, micro-management, and blurred lines of responsibility between the regulator and operators, with the associated breakdown of accountability.

The incentive-based regime that was implemented in the early post-privatisation period, could be characterised as *meet customer demands for defined quality at minimum necessary cost (including a reasonable risk-adjusted return for investors)*.[3] This was a very simple output-based regime that was implemented through a cap on prices and a set of quality standards that would only be reviewed at infrequent intervals (every 4 or 5 years), and subject to meeting these targets, the operators were delegated considerable commercial freedom. Operators took advantage of this freedom by making enormous changes in working practices and new asset management and replacement strategies. This led to a significant increase in efficiency, and ultimately to much lower prices for customers.

Although the output-based incentive regime implicitly focused on price and quality outcomes, many other outcomes resulted from the commercial freedom given to the operators. Some of those outcomes have caused concern for a variety of stakeholders, for example:

- redundancies, as part of an efficiency drive;
- high profits earned by operators, particularly in the first 10 years after vesting;
- the time taken in connecting renewable generation, which is perceived as too long;
- the perceived inability of operators to invest ahead of need;
- the concern that some operators may increase the operational risk on their networks in the short to medium term in order to meet cost reduction targets; and
- the concern that the wrong choices are being made, for example between investment and operating expenditure, and between investment and congestion management.

3 In addition to the objectives that Ofgem communicated to operators via the regulatory framework, the operators were also required to meet a set of outputs defined by other, non-economic, regulatory agencies such as the Health and Safety Executive (HSE).

This illustrates that unintended consequences can flow from delegating commercial freedom to operators, and that these outcomes may not be universally welcomed. Furthermore, if these other outcomes do matter for stakeholders, then it is important to evaluate whether they can be given legitimate expression in the regulatory framework.

If the regulator does decide to intervene to promote a wider set of outcomes, then the regime will become much more complex. The regulator can choose to intervene by prescribing (in intent or effect) how the outcome is to be realised (i.e. input based regulation, such as profit caps or directions to make particular investments) or by setting targets and incentives to promote the outcomes being achieved. In either case, the relatively simple regime that originally existed has become considerably more complex. In practice, Ofgem has probably chosen to intervene in both ways over the years, and has done so in a rather incremental way.

The challenges that the regulatory regime will need to address in future – particularly bringing about an energy system that encourages substantial carbon emission reductions in a timescale consistent with the government's targets – are arguably far more complex than the regulatory challenges Ofgem has had to face to date. If regulation continues to evolve in an incremental way, there is a serious danger that it will become unnecessarily complex, creating weak, conflicting or perverse signals to all stakeholders and operators, and resulting in inefficiency and under-provision of desirable outcomes.

In taking a fresh, over-arching view of regulation, the RPI-X@20 project itself is a response to these lessons. In its *Emerging Thinking*[4], Ofgem has reasserted its strong commitment to outputs-based regulation because of its extremely good incentives to improve efficiency and innovation and so drive greater value for money. Moreover, Ofgem anticipates at the outset that it will need to promote a much larger set of regulatory outcomes than simply price and service quality. Ofgem has identified that the regulatory regime should satisfy two key objectives - networks should:

- play a full role in facilitating delivery of a sustainable energy sector; and
- deliver value for money in the long term for existing and future customers.

Ofgem has also identified 6 output categories that are intended to translate these two objectives into meaningful areas of performance in which the networks must ensure delivery. These output categories are:

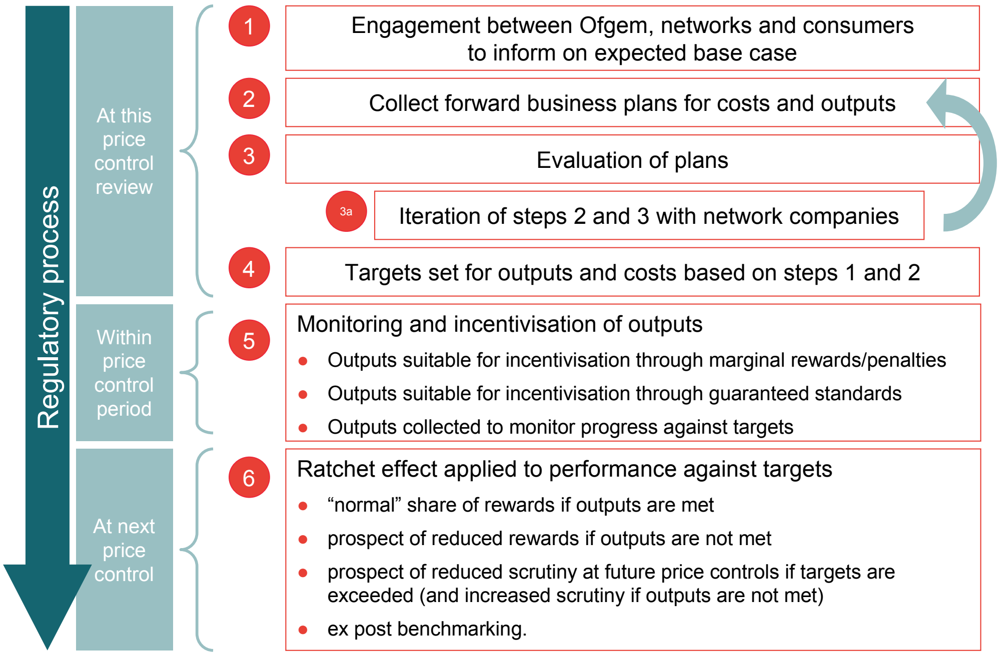
- reliability (of network services and the wider system);

4 "Regulating energy networks for the future: RPI-X@20 Incentivising efficient long-term delivery of desired outcomes", January 2010, page 8.

- safety;
- environmental targets, particularly the delivery of low carbon energy services;
- conditions for connection to network services;
- customer satisfaction; and
- network related social obligations.

Incentives for delivery of outputs under these categories can be applied at different points in the regulatory cycle, as demonstrated in Figure 2 below.

Figure 2. The use of outputs over the regulatory cycle



Source: Frontier Economics

Figure 2 illustrates that output provision can be incentivised not just through incentive schemes or guaranteed standards, but also through a comparison of output delivery against what was expected at the time the price control was set, which can then impact on the share of out-performance an operator is permitted to retain at the end of the price control period.

This suggests that how outputs are used, and at what stage in the cycle, have significant economic effects, and it is this insight that would enable the regulator to apply output based regulation appropriately, and limit the use of inputs to those parts of the regulatory process where they have greatest value, and avoid putting them in other parts of the regulatory cycle, where they could be value-destroying.

Context and remit

1.2 Summary and our remit

The key questions that will be addressed in this report are[5]:

- Are the output categories appropriate in that they provide complete coverage of network activities that are valued by stakeholders (covered in section 2)?
- What principles should apply when developing the set of outcomes and outputs (covered in section 3)?
- What are the high-level outcomes in each category, and what are the types of outputs that should be used to drive behaviour towards achieving the desired outcomes (covered in section 3)?
- Can that set of outputs be put together in a coherent regulatory package of incentives that can be expected to be effective in driving the desired behaviour (covered in sections 3 and 4)[6]?

In fulfilling this remit, it should be acknowledged that it may not always be possible to apply "pure" output based regulation. An output based regime requires the regulator to specify a target level of output and a set of penalties and rewards associated with over-or-under performance against that target. In some situations this approach may not be capable of being applied. In these cases, the regulator may need to intervene to direct the operators to the outcomes it wishes to observe. If this is the case – and we find some significant examples of this problem in this report – then in order to preserve the benefits of output-based regulation, any application of input-based regulation needs to be prescribed, and credibly so, to avoid the whole regime collapsing into opportunistic input based regulation.

The absence of a credible and well-understood boundary between delegated autonomy to the operator and intervention by the regulator is the greatest risk to an output-based incentive regime. In the absence of such a boundary, it will be easy for the regulator to slip into detailed micro-management at a significant cost to efficiency and longer term customer benefits. Creating the boundary depends as much (if not more so) on regulatory culture and values within the regulatory agency as on the development of a set of rules (which can never hope to capture all possible eventualities).

5 In answering these questions, we have been asked to ignore the present legal restrictions that prevent Ofgem and/or the operators from discriminating in favour of low carbon generation

6 It should be noted that it is beyond the scope of this report to provide detailed advice on how measures would be calculated (or explicitly defined in the case of more qualitative outputs), what information would be needed or what targets are appropriate.

2 Are the proposed output categories the right ones?

We have been asked to consider whether the proposed set of six output categories identified in Ofgem's *Emerging Thinking* is fit for purpose:

- reliability (of network services and the wider system);
- safety;
- environmental targets, particularly the delivery of low carbon energy services;
- conditions for connection to network services;
- customer satisfaction; and
- network related social obligations.

In order to establish whether this list represents the full set of categories we first develop an exhaustive long list of potential outputs that stakeholders might value. The candidate outputs are then 'mapped' to Ofgem's six categories, in order to answer two questions.

- Are there any network activities we have identified which don't naturally fall under one of the six output categories, which would suggest that more categories are required?
- Are there any output categories under which we are unable to place any network activities whatsoever, and which are therefore irrelevant?

Second, we also ensure that Ofgem's statutory duties and its guidance received by DECC[7] match up to the six output categories.

It should be noted that we do not in this section make firm recommendations about which outputs will sit in which category. Our objective is simply to verify that the output categories provide a complete coverage of valued network activities and that the output categories are the 'right' ones.

Our task in the subsequent chapters will be to define more precisely which primary outputs fit in which categories, and to put together a coherent and effective package of outputs.

7 Specifically, the Social and Environmental Guidance to the Gas and Electricity Markets Authority provided by DECC

2.1 Outputs and interactions with stakeholders

In order to determine an exhaustive set of outputs, which is then mapped back to the output categories, it is important to have a clear view of:

- the stakeholder – i.e. who values network activities; and
- the characteristics of the activity – i.e. what is valued.

In terms of the *stakeholders*, final customers in general are the most obvious first choice. However, it will also be important to consider the potential for output measures in relation to other stakeholders, for example:

- specific groups of final customers (especially vulnerable customers);
- intermediate customers, such as generators, shippers and suppliers;
- government, most importantly in relation to the role played by the network operator's service in relation to environmental policy; and
- society, in relation to any broader societal objectives (for example, security of supply may be a further relevant consideration)[8].

In defining the relevant characteristics of the activities, it is useful to consider the broad areas in which networks interact with these stakeholders. We identified three relevant areas:

- **Activities falling with the boundary of present activity**: networks undertake a wide range of activities that impact directly on stakeholders, e.g. in ensuring network availability/reliability, in connecting new users etc. Within this area, the characteristics of the output that are particularly relevant to stakeholders are:
  - the quality of the product being delivered; and
  - the quality of the interaction with customers in the delivery of that output.
- **Engagement with stakeholders on related activities**: in addition to core activities directly within their control, networks interact with other parties within the energy supply value chain and elsewhere. The characteristics of

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8 For the purposes of this exercise, we do not consider the stakeholders associated with the inputs to network operators such as providers of finance (bondholders, shareholders) and employees, since the focus here is on establishing whether network users (whether individual users or society as a whole) value particular network activities. The views of these "input" stakeholders are of course relevant in other contexts, for example, at price control reviews when the regulator needs to ensure that revenues it allows operators to earn are sufficient to remunerate the inputs used to provide the outputs.

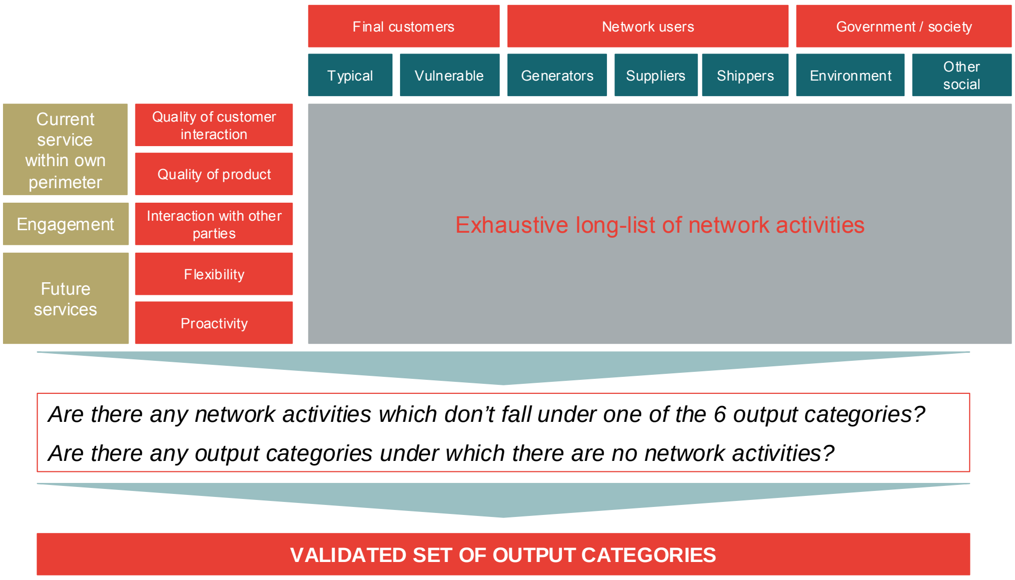
Are the proposed output categories the right ones?

the relevant activities essentially reduce to the extent to which networks engage effectively and proactively on these issues and bring about fruitful interactions that deliver good outcomes.

- **Potential future services**: finally, we also considered the potential additional activities that networks might be asked to undertake in the future, for example in support of the drive to develop a low carbon economy. Within this area, the characteristics that are particularly relevant to stakeholders are:
  - the flexibility of service elements; and
  - proactivity in considering new service offerings.

Across these two dimensions we identify the set of possible activities that stakeholders might find valuable, across the set of characteristics, or attributes, that each possible product might possess. This approach is summarised in Figure 3 below.

Figure 3. Evaluation of Ofgem's 6 output categories



Source: Frontier Economics

Populating this matrix for each of the four networks has generated a comprehensive set of network activities that are valued by customers. Any of these activities is a potential candidate as an output measure.

In Annexe 1, we present the 'long-list' of potential output measures that we derived. These candidate outputs have been generated through a combination of technical input from Consentec, a review of existing output measures, and further input from Ofgem and ourselves. So, for example, we have identified "continuity of supply" as a relevant quality of product issue that is highly valued by final customers. Continuity of supply can be measured using a number of metrics, including, for example, customer interruptions (CI) or customer minutes lost (CML). CI and CML are therefore presented as candidate output measures in annexe 1, and mapped to the reliability output category.

Having generated a complete set of candidate outputs in this way, we found that we were able to map all of them to at least one of the six output categories identified by Ofgem. We therefore conclude that it will not be necessary to create an additional output category. The coverage of the proposed six output categories appears complete.

Furthermore, we were able to place candidate outputs under all of the six output categories, for each of the four networks. It can therefore be concluded preliminarily that none of the six categories are redundant.

Finally, we have also concluded that the proposed set of six output categories can be considered to be sufficiently small for regulatory purposes, i.e. there is no obvious merit in reducing the number of categories or merging categories together. However, we have identified that many of the potential outputs could fall into more than one output category. For example, CI/CML could be a measure of both reliability and customer satisfaction.

In general, we have found that some output categories tend to *draw from* other categories, and can therefore be said to have a higher place in the output hierarchy than those output categories that tend to *feed in* to other output categories. This implies that properly defining the output categories and understanding linkages, overlaps and trade-offs will be crucial if we are to generate a coherent set of outputs. Only through appropriate definitions of the categories will we be able to draw a clear link between the package as a whole and Ofgem's high level objectives. Again, we will return to this discussion in more detail later in the report.

2.2 Consistency with Ofgem's statutory obligations

As a final check of the six categories, we have cross-referenced them to Ofgem's statutory duties and to its guidance received by DECC. Ofgem is governed by the Gas and Electricity Markets Authority (GEMA). The Authority's principal objective, as set out in legislation[9], is to protect the interests of existing and future consumers. Wherever appropriate, this objective is to be achieved by promoting effective competition between relevant energy sector stakeholders.

9 Relevant legislation includes the Gas Act 1986, the Electricity Act 1989, the Utilities Act 2000, the Competition Act 1998, the Enterprise Act 2002 and the Energy Act 2004, as well as arising from directly effective European Community legislation. The 2010 Energy Act requires the Authority to consider carbon abatement and security of gas supply as amongst consumers' interests.

Ofgem's statutory obligations include a number of secondary objectives that contribute towards protecting consumer interests. These secondary objectives include (but are not limited to):

- ensuring that all reasonable demands for supply of gas and electricity are met;
- contribution to the achievement of sustainable development;
- protecting the interests of individuals who are disabled or chronically sick, of pensionable age, with low incomes, or residing in rural areas (i.e. 'vulnerable customers');
- ensuring public safety;
- securing a diverse and viable long-term energy supply; and
- the effect on the environment of energy network activities.

Ofgem must also have regard to statutory guidance on social and environmental matters that is periodically issued by the Secretary of State[10]. The guidance as it relates to networks can be summarised as emphasising the importance of removing boundaries to the development of low carbon generation technologies, through:

- improved access and connection arrangements;
- networks investing in advance of need;
- effective network charging arrangements;
- provision of incentives to connect distributed energy; and
- promotion of R&D.

The output categories defined by Ofgem appear consistent with Ofgem's duties, and the guidance received from government. Indeed, the duties and the guidance can inform the primary outputs discussed later in the report.

2.3 Summary

The six output categories identified by Ofgem are appropriate and provide sufficiently complete coverage. We have not identified any network activity that cannot be mapped to one of these six output categories and there is no obvious need to propose an alternative categorisation for any of the four network sectors.

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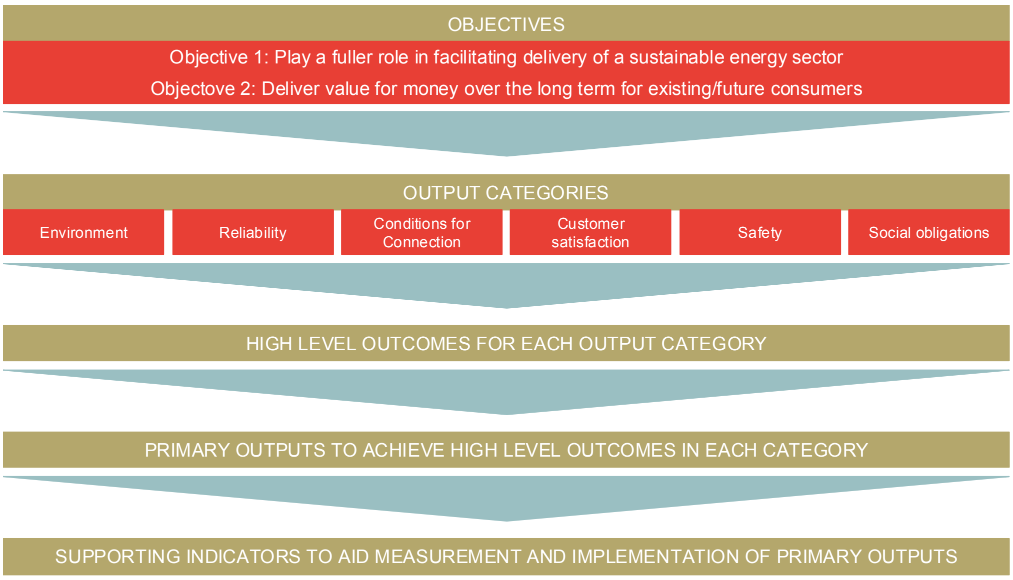
10 Social and environmental guidance to the gas and Electricity Markets Authority, Department of Energy and Climate Change (DECC), 18th January 2010.

3 The package of high-level outcomes and primary outputs

3.1 Approach to defining the high-level outcomes

Having confirmed that the output categories are complete and appropriate, we can proceed to define the **high level outcomes** that are associated with each category. Ofgem has given us guidance that the high-level outcomes should jointly represent the reasonable aspirations of what can be expected from a network operator, both now and in the future. We will therefore identify the appropriate high-level outcomes by asking the question "what will be required of the networks over the coming decade(s)?" Ofgem has also asked us to keep the list of high-level outcomes as short as possible, with more detail cascading down to the primary outputs[11] and supporting indicators, as Figure 4 below illustrates.

Figure 4. Cascade of high-level outcomes, primary outputs and supporting indicators



Source: Frontier Economics

11 It is worth noting that the regulatory regime will also include a variety of secondary outputs that could be incentivised in a number of ways. These outputs have an important role in the regulatory regime, but are not sufficiently material to represent the primary mechanisms to achieving Ofgem's objectives.

The choice of high-level outcomes should therefore be durable, since these aspirations of what can reasonably be expected of a network operator should not be subject to frequent change. The same also applies, although to a lesser extent to the primary outputs, although these are more likely to be subjected to regulatory revision.

The importance of these high-level outcomes is that they will frame the choice of primary outputs under each output category. This emphasises the importance of correctly and coherently specifying the high-level outcomes, especially given the fact that there are a number of potential areas of overlap and interplay across the output categories. If the high-level outcomes are poorly specified, then the outputs that sit in each output category, which will be used as regulatory instruments, may not be fit for purpose, leading to a regulatory framework that is misaligned with the interests Ofgem seeks to promote. The discipline imposed by ensuring the output categories include well-defined high-level outcomes which feed directly through to primary outputs will therefore help us ensure that the final package is meaningful. Our approach to defining the high-level outcomes has been one of trial and error, iterating with each other and with the primary outputs, before arriving at the most complete and coherent set.

Current legal and policy requirements dictate that Ofgem must not discriminate between types of generator through the regulatory framework. However, there is potential for these legal obligations to evolve. In particular, Ofgem's policy stance related to its duties on the environment and the deployment of low carbon technologies may change. The clarification to Ofgem's duties under the Electricity Act 2010 set out that the Authority should consider carbon abatement as amongst consumers' interests, lending perhaps more weight in this area. In addition, the Renewables Directive 2009, set out that Member States should provide priority or guaranteed access to renewable generators. This has yet to be transposed in the UK. If the legal/policy positions were to change, it may provide for, or even require Ofgem to apply differential treatment to low carbon generators. Ofgem has therefore asked us to design the outputs package on the assumption that the non-discrimination requirements that presently prevail are relaxed. As such, the outputs package may provide explicit, preferential treatment of low carbon technologies, if we consider that such outputs would be beneficial. Where necessary, we will identify where an output might conflict with the current legal/policy requirements, and may therefore need to be re-considered were those requirements to remain.

3.2 Approach to defining the primary outputs

The primary outputs should fully and consistently match up with the high level outcomes defined in the previous section, such that with appropriate incentivisation, the outcomes have a reasonable chance of being realised. As our discussion in section 1 showed, outputs can be incentivised in a number of different ways depending on the characteristics of the output in question:

- through marginal incentives;
- through guaranteed standards; and
- through *ex post* evaluation of output performance that can affect the share of out-performance benefits that can be retained (which in turn requires the specification and monitoring of outputs).

We have identified (in annexe 1) a long list of candidate primary outputs on the basis of:

- a review of current arrangements; and
- technical input from Consentec.

In order to narrow down this long list into a set of primary outputs and associated incentives, we have developed a set of criteria that we have applied for the purposes of this report, and which we recommend Ofgem applies in defining the full set of outputs.

Criteria for identifying primary outputs and type of incentive

An outcome of this exercise should be that the proposed output set and supporting regulatory mechanisms are genuinely effective in delivering the desired outcomes. In other words, the high level outcomes must not be "cheap talk" but must be backed by a meaningful set of outputs, where meaningful is defined as being capable of being applied in regulatory proceedings.

In general, for any given metric to be effective in realising desired outcomes and applicable in regulatory proceedings, it must broadly satisfy a number of criteria.

- **Materiality**: do the indicators match up to, and make a significant contribution toward, the outcomes that Ofgem seeks to promote?
- **Controllability**: are the indicators physically under the control (even partially) of the operator?
- **Measurability**: can the indicators be meaningfully measured, taking account of:
  - any trade-offs with other indicators;
  - any trade-offs between short run and long run output delivery;
  - the trade-off between greater accuracy or detail, and the usefulness of that accuracy; and
  - the degree of definitional ambiguity that might exist.

- **Comparability:** can the indicator be measured consistently across the operators to facilitate meaningful comparisons and ensure equitable treatment across operators if this is valued[12]?

Having identified a candidate output, we can evaluate it against these criteria. This allows us to understand the outputs' regulatory applicability, and will also determine the type of incentives we are likely to attach. For example:

  - if the output makes a material contribution to the delivery of the high-level outcome, it should be a primary output, otherwise a secondary output[13];
  - if the output cannot be accurately measured, then it may be appropriate to apply a weak incentive to avoid rewarding or penalising outcomes that have arisen by measurement error rather than performance;
  - if the output is only partly under the control of the operator, then it may be appropriate to apply a weak incentive to avoid rewarding or penalising outcomes that have arisen because of external factors rather than performance;
  - if the output is a pass: fail output type, then it may be appropriate to regulate this through licence enforcement measures, or "traffic light" type arrangements. In contrast, if the output is of the type where performance can get progressively better or worse, then a marginal incentive rate could be applied;
  - if the output is sufficiently comparable across operators, then this may enable application of comparative regulation; and
  - if performance on a particular output has an immediate impact (e.g. safety outputs; CML, CI), then both the assessment and regulatory response should take place within a reasonable period after the effect has been observed. For intermediate outputs (e.g. leading indicators of future quality) then the assessment period may be longer.

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12 This criterion therefore requires the regulator to determine whether comparability is valuable, which can vary on a case-by-case basis. Consequently, this criterion is less binding than the others in our choice of outputs.

13 These secondary outputs tend to fall under the "customer satisfaction" or "social obligations" categories, and are often regulated as guaranteed standards. It is beyond the remit of this project to define the full set of secondary outputs that can sit alongside the primary outputs.

Depending on the outcomes of this exercise, it will be possible to answer the question *"can the indicators be applied in a revenue determination process or to set penalties and rewards, and if so, how?"* This will require us to check whether the package as a whole is coherent. This does not necessarily mean that the package is simple, but it should mean that it is clear, and gives well-understood signals for future behaviour.

3.2.1 The consequences of failing to identify an output (or group of outputs) that fully pass the criteria

It is possible that we could fail to identify an output, or group of outputs, that pass the criteria. There are a number of reasons why this might occur.

The first is that some outputs that could make a material contribution to an outcome cannot be measured, but others can. By incentivising the outputs that can be measured, Ofgem could be in danger of undermining innovation and efficiency by effectively directing operators to perform well on the sub-group of outputs. This missing output problem needs to be acknowledged and remedied, either by understanding the qualitative information that would need to be gathered to complete the picture and/or by adjusting the incentive regime applied to the outputs that can be measured. We indicate where these problems are likely to be most acute, and offer some remedies.

Second, some outputs cannot be achieved solely through output-based incentive arrangements, because the combination of targets and payment rates that would achieve the "right" level of output provision is either unknown or their application would impose a significant cost (or risk) onto either operators or customers. In these situations, it may become necessary for the regulator to become involved in the funding and monitoring of inputs that might be expected to achieve the desired outcomes. It is useful to think of a hierarchy of network activities within any given output category that spans the following range:

- the provision of **information** by the network operator to enable stakeholders to make the right decisions;
- **engagement** by the network operator with relevant stakeholders to improve information flow and identify better outcomes;
- **actions** by the operator that directly contribute towards achieving outcomes; and
- final **realisations** of desired outcomes, such as a reduction in the time taken to connect.

Ideally, primary outputs should be associated with the realisations we observe. If the final realisations that are valued are capable of being meaningfully targeted and incentivised, then there should be no compelling need to set targets and incentives for performance against actions, engagement or information provision.

An approach that is focused purely on realisations would be most consistent with light touch regulation. If, however, final realisations can neither be measured accurately, or are not completely under the control of network operators, then it may be necessary to judge and incentivise performance on the basis of their actions, and so on down the hierarchy.

This needs to be done with great care, in order for the output-based regime to avoid slipping into opportunistic input based regulation. Consequently, in order to preserve the benefits of output-based regulation, any application of input-based regulation needs to be prescribed, and credibly so, to avoid this risk. We indicate the areas where this problem is likely to occur, and offer some remedies.

3.3 The high-level outcomes associated with each of the output categories

Table 3 below sets out the high level outcomes associated with each category. There are a number of general observations to make from this table.

First, the individual definitions are both clear in terms of what a network operator is expected to do, but vague in terms of how each outcome will be evaluated. This is because the aspirations of what can be expected from a network operator, both now and in the future, should be reasonably constant over time. Indeed, absent the specific focus on low carbon generation - these generic outcomes are probably very similar to those that would have been identified by a similar study at any time over the past 50 years.

On the other hand, the means of achieving those aspirations, will inevitably change over time and these are best handled through the specific regulatory instruments. This applies to very simple primary outputs (such as time taken to connect, which could be updated over time), and even more so to more complex output categories such as reliability, where a number of primary outputs, each appropriately parameterised, will need to be applied. It also applies to customer satisfaction – it must surely be an aspiration to maintain customer satisfaction levels at high levels, but it can be expected that the outputs that customers value will change over time.

Second, the final column of the table clearly demonstrates that some output categories tend to *draw from* other categories, and others tend to *feed in* to other output categories. Table 3 shows the extent to which the satisfaction of any individual high-level outcome tends to depend on outputs in other categories, the only exception relating to conditions for connection. It is clear that the environment, reliability and customer connections categories are the key building blocks of Ofgem's two high-level objectives of value for money and sustainability.

Table 3. High-level outcomes, and the inter-relationships across the output categories

Output category	High-level outcomes	Mainly achieved via outputs in:
Environment	Minimise the 'narrow' environmental impact of the operator's activities	Environment
	Facilitate improved energy efficiency	Environment
	Maximise the volume of low-carbon flows on the network (electricity only[14])	Reliability, Connections
Reliability	Maintain operational performance of the network at acceptable levels	Reliability (electricity) Safety (gas)
	Adapt to the consequences of climate change	Reliability
	Anticipate new patterns of energy injection and offtake to accommodate the decarbonisation of the energy sector on the network in its planning and investment decisions	Reliability
Conditions for Connection	Fair, accurate, and non-discriminatory access terms	Connections
	Minimise the time taken to connect	Connections
	Minimise the time taken to connect low carbon generation (electricity only)	Connections
Conditions for Connection	Minimise the time taken to connect	Connections
	Minimise the time taken to connect low carbon generation (electricity only)	Connections
Customer Satisfaction	Maintain levels of customer satisfaction at high levels and improve where possible	Customer Satisfaction, Reliability, Safety, Connections
Safety	Operate a safe network	Safety
Social Obligations	Fulfil the social obligations imposed upon it	Social Obligations, Reliability, Safety, Connections

Source: Frontier Economics

14 In future, it might be expected that the restriction to electricity could be widened to gas if there is a clearly agreed policy goal to promote biogas, with the appetite to support such a high-level outcome with primary outputs and incentive mechanisms.

The package of high-level outcomes and primary outputs

Following on from this point, the third point to make is that the introduction of an environmental objective creates a heightened degree of interplay between the reliability, environmental and connection output categories. Two concerns have been identified to us around particular obstacles to achieving the roll-out of low carbon generation:

- delays in connecting low carbon generation to the grid; and
- investment strategies that do not adequately anticipate future generation (and to a lesser extent the increased load that could result from, for example, a greater volume of electric cars);

If these concerns are valid, then quite clearly one or more of the environment, reliability and connections outcomes will not be achieved. The outputs framework enables these trade-offs to be explicitly treated in order to establish a regulatory package of targets and incentives that efficiently shares risks between operators and users.

The fourth point to make is that the high level outcomes are able to be controlled or influenced by the operator. The extent to which operators can control these outcomes may vary by category and by sectors, which will impact upon the risk exposure that the operators should be reasonably expected to bear – but it is clear that the operators can significantly affect these outcomes by their actions.

Finally, the output category definitions relate to outcomes that are valued by stakeholders, not the means by which these outcomes are realised. There are many ways an operator can run a reliable network as that is defined in the table. It can anticipate new patterns of demand and supply by investing to alleviate constraints, by offering contracts, by incurring congestion or O&M costs and so forth. It is not the purpose of the high-level outcomes to prescribe how an operator should meet these outcomes, although the regulatory instruments may have an element of prescription.

3.4 Summary of the primary outputs in each sector

In this section we provide a summary table which lists the proposed primary outputs that could be used for each network under each output category. In section 4 we discuss the (mainly) generic elements of the proposed package in more detail and in section 5 we focus particularly on the specific challenges associated with implementing the package, which largely reduce to developing a clear incentive regime to promote the reliability outcomes.

Table 4. Electricity Distribution - primary outputs

Output Category	Primary Outputs	Potential incentive mechanisms
Environment Minimise the 'narrow' environmental impact of the operator's activities;	Business carbon footprint Losses Other network emissions Visual impacts	Marginal incentives (when this becomes appropriate) Relatively weak guaranteed standards and marginal incentives Inform ex post assessment against expectations Planning regime
Facilitate improved energy efficiency; and	Measure of engagement	Monitoring
Maximise the volume of low-carbon flows on the network	MWh of low carbon generation	Payment per MWh or "availability" payment
Reliability Maintain operational performance of the network at acceptable levels; Adapt to the consequences of climate change	CI ENS or CML Various metrics in the business plans/ reliability report (e.g. asset health)	Guaranteed standards and marginal incentives Guaranteed standards and marginal incentives Ex ante target setting and ex post monitoring, with financial penalties for clear and material non-delivery
Anticipate new patterns of energy injection and offtake to accommodate the decarbonisation of the energy sector on the network in its planning and investment decisions.	Various metrics in the business plans/ reliability report	Ex ante target setting and ex post monitoring, with financial penalties for clear and material non-delivery
Conditions for Connection Fair, accurate, and non-discriminatory access terms	Defined in licence	Licence condition
Minimise the time taken to connect; and	Time taken to connect a request for a generation node …for a demand node	Guaranteed standards and/or marginal incentives Guaranteed standards and/or marginal incentives
Minimise the time taken to connect low carbon generation	…for a low carbon generation node	Guaranteed standards and/or marginal incentives
Customer Satisfaction Maintain levels of customer satisfaction at high levels and improve where possible	Broad measure of customer satisfaction Measures captured under other categories: CI, CML, time to connect, narrow environment measure	Inform an ex post assessment. Some elements of the broad measure may be subject to guaranteed standards. See incentive mechanisms for primary outputs under other output categories.
Safety Operate a safe network	Comply with minimum legal safety requirements	Outside the regulatory regime
Social Obligations Fulfil the social obligations imposed upon it	Targets for worst-served and vulnerable customers Measures captured under other categories	Guaranteed standards See incentive mechanisms for primary outputs under other output categories.

Source: Frontier Economics

Table 5. Gas distribution - primary outputs

Output Category	Primary Outputs	Potential incentive mechanisms
Environment Minimise the 'narrow' environmental impact of the operator's activities; and	Business carbon footprint Shrinkage Other network emissions Visual Impacts	Marginal incentives (when this becomes appropriate) Marginal incentives and/or guaranteed standards Inform ex post assessment against expectations Planning regime
Facilitate improved energy efficiency.	Measure of engagement	Monitoring
Reliability Maintain operational performance of the network at acceptable levels; Adapt to the consequences of climate change; and	Restoration of supply after an interruption CML or ENS Various metrics in the business plans/ reliability report (e.g. asset health)	Guaranteed standards Safety regulations determine performance, but CML/ENS can be monitored by Ofgem. Ex ante target setting and ex post monitoring
Anticipate new patterns of energy injection and offtake to accommodate the decarbonisation of the energy sector on the network in its planning and investment decisions.	Various metrics in the business plans/ reliability report	Safety regulations determine performance, but reliability report can be monitored by Ofgem.
Conditions for Connection Fair, accurate, and non-discriminatory access terms	Defined in licence	Licence condition
Minimise the time taken to connect	Time taken to complete a connection request	Guaranteed standards and/or marginal incentives
Customer Satisfaction Maintain levels of customer satisfaction at high levels and improve where possible	Broad measure of customer satisfaction Measures captured under other categories: safety, time to connect, narrow environment measure	Inform an ex post assessment. Some elements of the broad measure may be subject to guaranteed standards. See incentive mechanisms for indicators under other output categories.
Safety Operate a safe network	Comply with minimum legal safety requirements	Outside the regulatory regime
Social Obligations Fulfil the social obligations imposed upon it	Targets for worst-served and vulnerable customers Measures captured under other categories	Guaranteed standards See incentive mechanisms for primary outputs under other output categories.

Source: Frontier Economics

The package of high-level outcomes and primary outputs

Table 6. Electricity transmission - primary outputs

Output Category	Primary Outputs	Potential incentive mechanisms
Environment Minimise the 'narrow' environmental impact of the operator's activities; and	Business carbon footprint Losses Other network emissions Visual impacts	Marginal incentives (when this becomes appropriate) Relatively weak guaranteed standards and marginal incentives Inform ex post assessment against expectations Planning regime
Maximise the volume of low-carbon flows on the network.	MWh of low carbon generation or % of available low carbon generation transmitted	Payment per MWh or "availability" payment
Reliability Maintain operational performance of the network at acceptable levels;	ENS Various metrics in the business plans/ reliability report (e.g. asset health)	Incentive scheme Ex ante target setting and ex post monitoring, with financial penalties for clear and material non-delivery
Adapt to the consequences of climate change; and Anticipate new patterns of energy injection and offtake to accommodate the decarbonisation of the energy sector on the network in its planning and investment decisions.	Various metrics in the business plans/ reliability report Congestion costs	Ex ante target setting and ex post monitoring, with financial penalties for clear and material non-delivery Harmonisation of SO incentive with TO PCR target setting
Conditions for Connection Fair, accurate, and non-discriminatory access terms	Defined in licence	Licence condition
Minimise the time taken to connect; and	Time taken to connect a request for a generation node …for a demand node	Guaranteed standards and/or marginal incentives Guaranteed standards and/or marginal incentives
Minimise the time taken to connect low carbon generation	…for a low carbon generation node	Guaranteed standards and/or marginal incentives
Customer Satisfaction Maintain levels of customer satisfaction at high levels and improve where possible.	Broad measure of customer satisfaction Measures captured under other categories: CI, ENS, time to connect, narrow environment measure	Inform an ex post assessment. Some elements of the broad measure may be subject to guaranteed standards. See incentive mechanisms for indicators under other output categories.
Safety Operate a safe network.	Comply with minimum legal safety requirements	Outside the regulatory regime
Social Obligations Fulfil the social obligations imposed upon it.	Measures captured under other categories	See incentive mechanisms for primary outputs under other output categories.

Source: Frontier Economics

Table 7. Gas transmission - primary outputs

Output Category	Primary Outputs	Potential incentive mechanisms
Environment Minimise the 'narrow' environmental impact of the operator's activities	Business carbon footprint Shrinkage Other network emissions Visual Impacts	Marginal incentives (when this becomes appropriate) Marginal incentives Inform ex post assessment against expectations Planning regime
Reliability Maintain operational performance of the network at acceptable levels; Adapt to the consequences of climate change; and	Interruptions lasting longer than 15 days Various metrics in the business plans/ reliability report (e.g. asset health)	Marginal incentive Safety regulations determine performance, but reliability report can be monitored by Ofgem.
Anticipate new patterns of energy injection and offtake to accommodate the decarbonisation of the energy sector on the network in its planning and investment decisions.	Various metrics in the business plans/ reliability report	Ex ante target setting and ex post monitoring Safety regulations determine performance, but reliability report can be monitored by Ofgem.
Conditions for Connection Fair, accurate, and non-discriminatory access terms	Defined in licence	Licence condition
Minimise the time taken to connect	Time taken to complete a connection request	Guaranteed standards and/or marginal incentives
Customer Satisfaction Maintain levels of customer satisfaction at high levels and improve where possible	Broad measure of customer satisfaction Measures captured under other categories: safety, time to connect, narrow environment measure	Inform an ex post assessment. Some elements of the broad measure may be subject to guaranteed standards. See incentive mechanisms for indicators under other output categories.
Safety Operate a safe network	Comply with minimum legal safety requirements	Outside the regulatory regime
Social Obligations Fulfil the social obligations imposed upon it	Measures captured under other categories	See incentive mechanisms for primary outputs under other output categories.

Source: Frontier Economics

The package of high-level outcomes and primary outputs

4 Generic features of the package

In this section we review the features of the package, by category, that are largely generic, or where sector specific considerations can be dealt with relatively briefly – these areas relate to five of the six output categories: environment, conditions for connection, customer satisfaction, safety and network-related social obligations. We discuss reliability briefly in this section, and more fully in section 5.

4.1 Environmental outputs

In future, it is reasonable to expect that more will be required of the energy networks in respect of supporting and effecting environmental policy, in particular in the drive towards decarbonisation of the UK energy sector. The environmental activities of networks can be grouped under two broad categories.

- **Direct/Narrow impact:** Network companies have a direct impact on the environment through emissions associated with network activities.

- **Indirect/Wider impact:** Networks will play a central role in facilitating the deployment of renewable or low carbon technologies. This is particularly relevant for electricity networks, but also for gas networks in the future who are likely to play a supporting role, in particular supplying small scale reserve electricity generation plant to balance intermittent wind, and who may have a wider impact if biogas becomes a viable alternative to natural gas, or if existing assets can be put to alternative uses (such as transporting carbon away from CCS plants). Networks must strategically plan over the long term to ensure that there is sufficient capacity. This can be achieved by encouraging efficient consumption of energy, and facilitating demand-side response as well as investing in new kit to upgrade the network.

Of these two sets of activities, the second will, if managed correctly, lead to far greater environmental benefits than the first. The table below sets out a suite of environmental activities may be expected of a 'good' network.

Table 8. Environmental activities that may be expected of a 'good' network

Type of Activity	Narrow Impact	Wide Impact
Information	N/A	Quality and accuracy of information provided to distributed generation (DG) and low carbon generation to aid connection (e.g. budget estimates, quotations, price accuracy, scheduling of work, and agreed timescales for completion)
Engagement	Consultation in planning phase (e.g. on visual impacts)	Consultation of generators (e.g. on investment plans) Energy efficiency (i.e. co-ordination with different parts of value chain on end-user efficiency)
Actions	Losses/Shrinkage Carbon Footprint (e.g. emissions from vehicle fleet/buildings, SF6, NOx) Other network emissions (e.g. noise, dust etc.) Visual impacts	Number of low carbon generation/ESCo connections Time taken to connect (possibly at different intervals e.g. request to response, response to connection) Size of the 'queue' (e.g. no. connections as % of requests) Reduction of system constraints and bottlenecks Provision of appropriate access terms (i.e. standardised, efficient, timely, accurate, transparent, non-discriminatory) Energy efficiency (i.e. efficient network management, smart grids) R&D/trialling new technologies Investment to adapt to climate change (i.e. improved resilience to extreme weather)
Realisations	Decreased network business related GHG emissions	MWh of low carbon flows through network Improved energy efficiency amongst end users

Source: Frontier Economics

Generic features of the package

4.1.1 High-level outcomes

We recommend that the high-level environmental outcomes should:

- encourage all network operators to minimise their narrow environmental impact
- emphasise the operator's role in facilitating and promoting energy efficiency; and
- encourage electricity operators to maximise low carbon flows on their networks.

It should be understood that the primary means by which the wider outcome in electricity is achieved will depend almost wholly on the outputs that fall within the reliability and connections categories. This is because operators will be required to ensure that the networks are reinforced and/or operated in a way that accommodates a wider transition to low carbon technologies (e.g. the adoption of electric space and water heating). The delivery of wider environmental outcome of high volumes of low carbon power flows, will be largely facilitated through ensuring:

- the timely connection of both generation and potentially new demand nodes; and
- that the networks are able to cope with the resulting flows, either through the provision of sufficient capacity or through the efficient management of constraints.

Both of these activities should be monitored and incentivised under other output categories – reliability and connections. For this reason, the impact of the present legislation that prohibits discrimination in favour of particular technologies is largely presentational since – as we shall argue in more detail in section 5 - the same effect could be largely achieved without having to specify the maximisation of low carbon flows as a high-level outcome for electricity. Therefore, in the event that Ofgem has to work within the present legal framework, this high-level outcome must be removed, but the intent of that outcome can still be achieved through other output categories.

However, quite clearly, including the reduction of carbon emissions as a high-level outcome that networks should aspire to would send a much stronger signal to operators and stakeholders.

4.1.2 Primary outputs

In this section we discuss the primary outputs associated with these outcomes.

Narrow environmental outcome

All networks will be required to minimise the 'narrow' environmental impact of the network in respect of:

- the business carbon footprint;
- other network emissions; and
- visual impacts of the network.

Each of these outputs are material and controllable, but currently suffer from measurability problems which, in our view, limit the extent to which high-powered incentives can be applied to these outputs at present.

The business carbon footprint captures the networks' direct GHG emissions (arising, for example, from their vehicle fleet). In electricity distribution, standards have been devised for business carbon footprint reporting and Ofgem is publishing an annual league table of emissions reductions. We recommend that similar standards be developed in the other three network sectors.

The CRC Energy Efficiency Scheme (formerly known as the Carbon Reduction Commitment) is a new regulatory incentive to improve energy efficiency in large public and private sector organisations. The CRC is effectively a cap and trade scheme on emissions, which applies to companies that use electricity above a certain threshold level. In developing the business carbon footprint measure for electricity distribution, Ofgem has considered whether the CRC Scheme alone would be sufficient. However, some of the distribution network operators (DNOs) are below the threshold for CRC, and other DNOs will be reporting CRC as part of their parent company. Since not all DNOs will be part of the CRC scheme, it was determined that the business carbon footprint can be used instead, so as to ensure a common reporting regime across all the DNOs. If the business carbon footprint is rolled out for the other networks, the sector-specific implications of the CRC scheme will have to be considered when designing the incentives that are attached.

Other network emissions include, for example, noise and dust emissions. These types of emission are difficult to measure, are likely to remain so, and we are currently unaware of any standardised procedures for attempting to do so. As such it will be difficult to apply marginal incentives to other network emissions. We propose that Ofgem undertake a qualitative assessment of these emissions, which will inform an ex post assessment of performance.

The visual impacts of a network's investments are also a direct impact on the surrounding environment. Networks must engage with appropriate local governing bodies as part of the planning regime when undertaking new investments. Since these impacts are governed by the planning process, performance is determined externally to the outputs regime. Ofgem will therefore not need to apply direct incentives to visual impacts.

Generic features of the package

In addition to these generic outputs, there are a number of sector-specific outputs that should be included amongst the narrow environmental outputs.

For electricity distribution and transmission, we include network losses as a primary output whose minimisation should be encouraged by the regulatory regime. Losses are a significant narrow impact of electricity networks, representing approximately 1.5% of total GB GHG emissions. However, we include losses here with two caveats: first, there are a number of problems with the existing losses incentives, because the pure technical losses (which drive the environmental cost) cannot be easily separated from theft, measurement error and other reporting problems on the distribution systems. Until smart meters improve measurability, a losses incentive would need to be applied with care. Second, electrical losses are due to the configuration of the network, and if it is the case that this configuration is to be driven in future by the imperative to connect unpredictable generation plant that is located large distances away from load centres then losses will increase – but presumably for good reason. Consequently, a powerful losses incentive may encourage networks to delay or even prevent the connection of these remote sources of generation. Furthermore, as the embodied carbon content of electricity falls, the environmental justification for a losses incentive becomes less relevant.

This issue is even more pertinent in transmission, where the volumes and voltages are higher, and the distances travelled much greater. The transmission networks will be required to connect a large amount of remote renewable generation capacity, particularly wind power, over the coming two decades. These effects should be borne in mind when setting losses incentives at future reviews, so the losses incentive will not lead to these perverse outcomes. In addition electricity transmission networks should also retain an incentive for reducing SF_6 leakages.

In gas networks, the narrow environmental outputs should include shrinkage, but it is worth noting that the issues raised in the context of losses may also be relevant in the context of gas transmission. Gas distribution networks do not have an equivalent issue of connecting generators in locations that might be significant distances from load centres, there is less risk that a shrinkage incentive will run counter to some desired outcomes elsewhere in the regime. Furthermore, gas leaks will always represent a GHG emission (whereas in a decarbonised sector, electricity losses do not have an environmental impact). As such, it will be important to reduce gas shrinkage from both the environmental and the efficiency perspectives. Since shrinkage is measurable and largely controllable, it will be suitable to apply strong marginal incentives to shrinkage. In addition, gas transmission networks currently have incentives relating to methane emissions and these should be retained.

Both transmission losses and shrinkage are currently incentivised through the System Operator (SO) control. Therefore, it is necessary to consider how these incentives will interact with any proposed incentive for the network operators. For the transmission networks, this issue was considered at TPCR4. For electricity, the Transmission Operator (TO) incentive was based around the price of wholesale electricity, which in turn reflects the value of carbon as revealed through EU ETS. For the gas transmission network, it was noted that, since it is a high pressure network, there are very low levels of leakage anyway. Direct emissions were therefore left to be covered as part of the SO incentive.

In general, it is sensible to leave incentives with one or other of the SO or TO, however, it may not be practically possible to design effective incentives in this way. If incentives placed solely on the SO are found to be ineffective in ensuring appropriate TO behaviour, and changes to the SO incentive cannot improve the pass-through of the cost signal to the TO, then Ofgem will have to consider incentivising both SO and TO behaviour. Therefore, although we have included shrinkage and losses as primary outputs for the TOs, Ofgem should consider whether a consolidated SO incentive is in fact effective at reducing shrinkage and losses. In section 5.3.1, we discuss another area where TO and SO incentives might overlap - in the efficient management of network constraints. Further principles on the design of TO incentives that are considered in that section are also relevant for this discussion of losses and shrinkage.

Energy efficiency

Network operators are limited in what they are able to do to promote energy efficiency. The legal requirements for vertical unbundling, which will be reinforced under the EU's 3rd Package regulations, prevent networks' from having direct involvement in other areas of the value chain. This precludes the possibility of networks playing a more active role in, for example, low-carbon electricity generation, or energy efficiency schemes for end-users. Outputs that would require networks to undertake activities that would breach these legal obligations and must therefore be excluded.

Nevertheless, we envisage two areas where networks may be able to play a role that is consistent with the legal framework. The first results from the enduring relationship that a distributor has with a customer's premises (in contrast to the shorter relationship that a customer may have with an individual supplier). Since energy efficiency measures are likely to have benefits that are long-lasting – and are likely to relate to the property rather than the customer - there may be a role for distributors to play in facilitating these long term investments. How this facilitation and engagement is measured is beyond the scope of this report, and we recommend that some indicator of engagement is developed to assess the extent to which network operators are facilitating energy efficiency initiatives that is consistent with the role that policymakers and Ofgem want the operators to play. The second is in relation to network operators charging policies, where operators may be able to use the tariff structure to effect a meaningful demand side response. Again, this would need to be made clear in the objectives of any charging regime in order to promote this outcome.

The role of the wider environmental output in electricity networks

Finally, we have considered the effect of an output that rewarded the volume of low carbon flows on the network, either through a reward per MWh of low carbon power carried on the network, or an incentive on the network operator to enable all low carbon generating plant to be able to run when they are available to do so up to a certain number of hours in the year (or some other measurement period). As our discussion on constraints in section 5.3 note, it is likely that low-carbon generation will be 'must run' in any case so it is unlikely that arrangements of this type will have a material bearing on the flows of low carbon power. However, one could envisage situations where low carbon power might be constrained off at the margin, so an incentive that encourages network operators to consider alternatives would be desirable from an environmental perspective. It therefore remains the case that the connections incentives and the regulatory arrangements to encourage network operators to anticipate future patterns of injection and load on the system will have a more significant bearing on environmental outcomes than this incentive.

However, because these flows (or availability) are measurable, the greater value in an incentive arrangement of this type is that it provides an extra degree of freedom for the regulator to remunerate the operator. If low carbon generation is likely to require investment in the networks, then introducing a revenue driver that is related to low carbon generation would enable some proportion of revenue to be conditional on the outcome of low carbon power flowing across the system. Properly calibrated, this could promote efficient risk and cost sharing between the operator and customer. In addition, if low carbon generation causes networks to incur higher costs than carbon generation, then a low carbon incentive can provide an incentive to favour low carbon generation over carbon generation at the margin.

4.2 Conditions for connection

There are existing arrangements in place to ensure that those wishing to connect to the network are able to do so in a timely manner. In addition, licence conditions guarantee that the networks offer fair, accurate, and non-discriminatory access terms.

However, the timeliness of connections will be an increasingly important area of network performance in the future, largely in order to promote the wider environmental outcomes. For example, large scale nuclear and renewable generation is envisaged on the electricity transmission system, and smaller scale generation on the electricity distribution system. Networks will also be required in future to connect Energy Services Companies (ESCos) to their networks, which offer a range of services, from simple energy efficiency advice to provision of actual energy usage benefits such as comfort, refrigeration or industrial scale heating. All these different types of operator can potentially contribute towards achieving Ofgem's two priority outcomes of a sustainable energy sector and value for money for consumers.

These operators require access to electricity networks and potentially gas networks (particularly at the distribution level). Delayed or uncertain connection to these networks may act as a barrier to the deployment of low carbon generation, particularly where these operators have unusual or 'bespoke' connection requests that might be considered too complicated for networks to complete. Consequently, it will be important that all forms of generation are able to connect to the networks quickly.

For these reasons, DECC are currently proposing a change to the enduring grid access regime from the current "Invest then Connect" to "Connect and Manage". Such a change would allow renewables to connect within a fixed period of time irrespective of the availability of transmission capacity. In addition, National Grid is reviewing the Security and Quality of Supply Standards which set out the transmission network requirements associated with individual connections, and Ofgem and the transmission operators are continuing to work on "enhanced incentive" arrangements to facilitate some degree of anticipation of the potential for future generation connections.

Should the legal environment allow, it may also be possible for Ofgem to focus even sharper incentives on the timely connection of low carbon generation, so that access to networks does not impact investment decisions or form a barrier to the deployment of this generation.

Finally, in addition to generation connections, it will continue to be desirable, as it has been in the past, to also connect demand nodes in a timely manner. For gas networks, the environmental motivation for ensuring timely connections will largely result from the use of biogas in future; but even at present timely connections are still relevant from the point of view of customer satisfaction.

4.2.1 High-level outcome

We therefore propose "minimising the time taken to connect" as a relevant outcome for all types of connections on all four energy networks. The distinction between the timeliness of connections in general, and that for low carbon generation in particular, gives Ofgem the option of discriminating in favour of the latter, should it be legally possible.

4.2.2 Primary outputs

The primary output we propose for all sectors is to place a target on the "time to connect" for all operators. Clearly, the target that is set, and the incentive rate applied to performance around that target will be sector-specific.

This output is directly measurable. To an extent, it is also within the control of the operator, although we note that planning restrictions and other external factors can frequently be relevant. Consequently, it is likely to be desirable to break down the connection process into separate segments (e.g. time between connection requests and network response, time between network response and completion of connection), in order to incentivise those parts of the connections process that are more closely under the control of the operator, leaving separate those parts of the process that could be held up for reasons outside the control of the operators, such as delays caused by the planning regime. For the purposes of this report, therefore, the "time to connect" output is shorthand for the time to connect over the relevant parts of the connection process over which the operator can exercise control.

Given these output characteristics, it is unnecessary to include any other primary outputs to further encourage the satisfaction of the high-level outcome.

The output target and the incentive rate (whether symmetric or asymmetric[15]) applied to performance will vary by sector. Where the need for connection is particularly pressing, minimum standards could be supported by financial incentives for outperformance (i.e. the operator is required to connect within a given timeframe or it will face a fine, but might be rewarded further for connecting faster). The pay-off associated with deviations from the target would, in principle, relate to the social costs of delay, which would be expected to vary across sectors. The distinction between the timeliness of connections in general, and that for low carbon generation in particular, gives Ofgem the option of adjusting the payoffs and targets for the latter, should it be legally possible. The target should be based on what can feasibly be achieved by a well-run operator, and again may vary by sector and type of connection.

What will universally be the case is that if a meaningful target and incentive is applied, then this increases the risk exposure of the operators. Other things being equal, constraints on electricity networks will increase, which will be costly to alleviate. This means that the incentivisation of this output should be seen as part of a package with reliability and environmental outputs. In gas, better performance on connection times also increases risk exposure, which will need to be handled within the incentive package as a whole.

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15 An incentive scheme that is symmetric rewards operators equally for out-performance and penalises them under-performance. An asymmetric scheme, such as a guaranteed standard, only penalises operators for underperformance. Caps and collars can be applied to limit financial exposure.

Electricity

It will continue to be important that electricity network connections are completed in a timely manner. Both load and generation connections are equally important, and we have therefore proposed separate primary outputs for each of these types of connection.

Connection times for low-carbon generation are particularly significant in the context of the UK's environmental objectives, and Ofgem's obligations to encourage the development of a low-carbon energy sector. Swift connection to the electricity transmission network is crucial for the deployment of large scale low-carbon generation. Since lengthy connection processes could represent a barrier to investment in these technologies, it will be important to place a strong incentive on the time taken to connect generation nodes in electricity transmission. Equally, for DNOs it will be important to connect distributed generators and ESCos swiftly to meet these environmental targets. We have therefore included a specific primary output for monitoring the connection of low carbon generation.

We note that this output may have to be removed if Ofgem's legal requirements for non-discrimination remain in place. However, should these outputs be removed, it is still likely that the more general connection time incentive will be effective in delivering wider environmental objectives, particularly if other policies that support the deployment of low carbon generation (e.g. the Renewables Obligation, Feed-in Tariffs, and the EU Emissions Trading Scheme) are effective in encouraging investment in low carbon generation as opposed to more conventional technologies.

Gas

The connections performance of gas transmission and distribution networks is less relevant for achieving wider environmental objectives at present (but not in future if biogas is used), but speedy connection is still an outcome that customers would value.

Although some distributed generation, such as micro-CHP, may make use of the distribution network, connecting a unit such as this is equivalent to connecting a standard boiler (i.e. micro-CHP is still an offtake demand for GDNs). We have therefore not separated the types of connection out for the gas networks. Rather, we propose a single primary output that simply measures the time taken to connect any request, including requests from ESCos which may wish to use the network.

4.3 Reliability

The reliability output is the key building block to the achievement of Ofgem's objectives since if the networks are unreliable it is unlikely that they will facilitate the environmental, customer satisfaction or social objectives. The high-level outcomes and associated outputs need to be carefully defined and then properly calibrated at regulatory reviews. In this section we discuss the high-level outcomes, but reserve discussion on the primary outputs to section 5, where they can be dealt with more fully.

4.3.1 High level outcomes

We propose that a reliable network should both:

- maintain operational performance of network assets at acceptable levels;
- adapt to the consequences of climate change; and
- anticipate new patterns of energy injection and offtake to accommodate the decarbonisation of the energy sector on the network in its planning and investment decisions.

The first outcome is a continuation of the reliability performance that has been implicitly or explicitly expected and required of network companies historically. This outcome essentially relates to effective stewardship of assets, such that the operational performance of the network can be maintained at an appropriate standard. In the gas sector, although there a number of metrics that be used for the purposes of monitoring the operational performance of gas network assets, they are likely to be rendered redundant by the stringency of statutory safety obligations. Safety concerns are so material for the gas industry and gas networks are planned and operated with this in mind. Given that safety obligations are monitored and enforced by the HSE, there is likely to be only be a limited role for Ofgem in defining, monitoring and incentivising reliability performance here, and that therefore this reliability outcome for gas is likely to be primarily achieved within the safety category, although we still envisage a role for Ofgem monitoring reliability. In electricity, there is a greater discretion over the level of reliability and regulatory incentive arrangements have been in place for some time. We discuss the primary outputs to facilitate these outcomes in section 5.

The second outcome relates to the adaptation to climate change that networks must consider. In general, networks will need to consider the risks and consequences associated with potential climate change. Most familiarly, this relates to the ability of the gas networks to handle high-levels of demand associated with extremely cold winters. Currently, GDNs have a licence obligation to develop and maintain their pipeline system to meet gas demand on a 1 in 20 demand day. However, if the frequency of these extreme events increases in the future, then the networks will need to be planned to reflect this if the same level of resilience is to be maintained. Climate change also implies an increased risk of extreme weather events such as flooding, storm and ice damage, for example, and networks will need to maintain resilience in the face of these more likely events. Finally, there are other potential effects of climate change to which networks will need to adapt, such as the potential for changes in average temperatures to impact on the performance of electricity networks. Network operators will have to demonstrate that they have taken the consequences of climate change into account and have sufficient plans for adaptation. In our view, the relevant primary outputs that will deliver this outcome are contained within those that promote the other two outcomes in this category.

The main evolution for reliability requirements arises from the expectation of significant changes in the level and direction of energy flows expected on the gas and electricity networks. Outputs and incentives therefore need to be developed to encourage operators to anticipate future injection and load developments, enact plans to efficiently accommodate them, and to efficiently maintain network reliability in the face of these new demands.

4.4 Customer Satisfaction

4.4.1 High level outcomes

Ofgem's primary duty is to protect the interests of customers. It is therefore important to evaluate performance against the services that customers require of networks. In this context, there are different types of customers. The "primary" customers, whose interests Ofgem are required to protect, are those who are the final consumers of energy. However, there are a number of intermediate customers such as generators connected to the distribution and transmission grids, shippers and suppliers. The interests of these users need to be protected, and consequently it is important that they are satisfied with the services they receive from the network operator, not only in their own right, but also because their preferences may (but not always) mirror those of their customers further along the supply chain. However, their interests are subordinate to the interests of final customers since to give their interests equal weighting to final customers is to elevate (some) producer interests to customer interests. An extreme example should serve to make the point: suppose a thermal generator is "dissatisfied" because it is nearly always constrained off. If the network operator has constrained off the generator because that is the least cost choice to make, then any attempt to remedy the generator's dissatisfaction will harm the final customer. Consequently, in devising measures of customer satisfaction, these should be focused primarily on the final customer, with a focus on intermediate customers limited to those areas where intermediate customer satisfaction would not conflict with the interests of final customers.

The emerging thinking on the RPI-X@20 project noted that the existing regulatory framework had encouraged networks to focus on satisfying Ofgem's needs, rather than trying to determine what their customers wanted. By directly incentivising customer satisfaction outputs, an output-based framework has the potential to shift the focus of networks' attention on to the consumer. The aim of customer satisfaction outputs is therefore to ensure that networks are engaging with customers to discover what areas of network service can be improved, and that customers are satisfied with the service they receive.

We propose that the high-level outcome is to maintain customer satisfaction and improve it where possible.

4.4.2 Primary outputs

We envisage the customer satisfaction primary output measures being drawn from two sources. The first is from the other output categories such as the reliability metrics, the time taken to connect, safety performance and the narrow environmental impact, which are all relevant for customer satisfaction. If networks perform well on these indicators, customer satisfaction is likely to be maintained at a high level. For each type of network, the weights associated with these outputs will change - for electricity networks, reliability and the time taken to connect will be particularly important, whereas for the gas networks, the safety performance would be a more meaningful indicator of customer satisfaction.

Second, Ofgem should attempt to measure the networks' performance on their direct interactions with customers. To this end, an important development on customer satisfaction incentives at DPCR5 was the inclusion of the 'broad measure of customer satisfaction'. The intended function of the metric is to capture and measure customer experiences of contact with their DNO across a range of services and activities. There are three key components of the broad measure of customer satisfaction, which constitute a set of supporting indicators:

- a customer satisfaction survey, focusing on DNO performance on interruptions, connections and general enquiries;
- a complaints metric, focusing on unresolved and repeated complaints; and
- a stakeholder engagement metric, focusing on all stakeholder views of the DNO approach to engagement and outcomes from this.

In principle, the broad measure of customer satisfaction that has been developed for electricity distribution companies at DPCR5 can be applied across all four network sectors, although they are of greatest relevance to the distribution operators. The specific form will need to be adapted for each sector, reflecting the different types of customer associated with each sector and the need to ensure that customer satisfaction measures developed for intermediate customers do not conflict with final customer benefits.

Although it is clear what the broad measure is intending to capture, it is not yet clear whether the outcome will be a metric that is measurable and comparable across networks. It may be the case that some elements of the broad measure might be suitable for guaranteed standards or marginal incentives, while others are more suitable for a qualitative assessment. At the very least, the measure could be published in a league table, without attaching a revenue risk to it.

We propose that this broad measure of customer satisfaction, in addition to the relevant outputs from other categories, should act as the primary outputs for the customer satisfaction category. It should be stressed that any incentives or rewards provided under the customer satisfaction category must relate only to those areas that are not covered in other output categories, so as to avoid double counting.

Given that this output category depends so heavily on the outputs in other categories, and it is beyond the scope of this report to define the customer satisfaction metric, we give no further consideration to this output category in this report.

4.5 Safety

The outputs framework has very limited role for designing and incentivising safety performance. Instead, performance in this area is determined by legislation and is monitored and enforced by a different regulatory body (the HSE). As such, this output category exists to ensure that those minimum safety requirements are recognised formally within the regulatory framework. We do not propose to design any specific incentives that will be applied in the outputs regime.

For electricity networks, the relevant safety legislation is contained primarily in the Electricity Safety, Quality and Continuity Regulations 2002. For gas networks, where statutory safety requirements are very strong, the Gas Safety (Management) Regulation, the Control of Major Accident Hazard (COMAH) Regulations and Pipeline Safety Regulations are all relevant. The HSE also monitors gas network safety performance through its emergency testing programme and Safety Performance Indicators (SPIs). The legal safety requirements imposed on gas networks determine that they operate at very high levels of reliability, with very few interruptions or failures, and therefore safety outputs dictate the reliability requirements for gas networks. We will discuss this further in the section on reliability for gas networks, but with this exception we give no further consideration to safety outputs in this report.

4.6 Network-related social obligations

4.6.1 High-level outcome

All energy consumers rely on networks to deliver gas and electricity to meet their demands. As the physical link between producers, suppliers and consumers of energy, networks play a crucial role in providing consumers with some of their most basic needs. As a result, there are a number of network-related social obligations placed upon network companies, and we simply propose a high-level outcome that requires that these obligations are satisfied.

4.6.2 Primary outputs

The list below represents a set of relevant social obligations for the energy networks. In our view, all of the obligations listed below are covered under another output category (indicated in parentheses):

- ensuring security of supply (reliability);
- ensuring safe operation of the network for consumers and employees (safety);
- protecting the environment (environment);
- facilitating a move to a low-carbon energy sector (environment, connections and reliability);
- facilitating competition amongst network users (connections); and

Given this significant degree of overlap, it should be stressed that any incentives or rewards provided under the social obligations category in the future must relate only to those areas that are not covered in other output categories, so as to avoid double counting.

In addition to these social obligations, there are likely to be further obligations imposed on networks through guaranteed standards and licence conditions. For example, the gas and electricity distribution networks are currently required to have consideration for the needs of vulnerable customers and worst served customers. Since these obligations do not appear to be covered by another output category, we have included primary outputs relating to these obligations.

Vulnerable customers are those who are highly dependent on energy services, or whose interests may easily be ignored. This includes customers who are disabled or chronically sick, the elderly, customers with low incomes and rural customers[16]. In electricity distribution, a worst served customer is one that experiences, on average, at least 5 HV interruptions per year over a 3 year period, with at least 3 interruptions per year, and output measures are in place to incentivise DNOs to improve performance in this area. Gas network operators have additional social obligations to extend their networks to reach off-grid customers, and outputs are in place to encourage this. These outputs (or variants of them) are measurable, controllable and material.

[16] These are the customer types listed in the Utilities Act 2000. Ofgem has at times included other customer types in the definition of vulnerable customers.

We note that these specific outputs are liable to change. Ofgem will review the types of social obligations it wishes to place on the networks, and will look to ensure consistency with their duties and public policy objectives. For example, the third package may also introduce 'public service obligation' PSOs that may enter into this output category. As such, we include the vulnerable and worst served customer obligations as currently relevant social obligations, and note that they are indicative of the type of primary output that might feature here in the future, although the specific requirements may change.

In summary, as with customer satisfaction output measures discussed above, we see the relevant outputs for the social obligations category being drawn from two sources. The first is from the other output categories – for example reliability, safety record, carbon footprint, low carbon power flows (for electricity), and timely connection. The second is from outputs associated with Ofgem's duties and other public policy objectives. Currently, this includes worst served and vulnerable customers for electricity and gas distribution. Given that this output category depends so heavily on the outputs in other categories, we give no further consideration to this output category in this report.

5 Primary outputs to promote the high-level reliability outcomes

In this section, we discuss the reliability outputs by sector. We begin by addressing the outputs required to meet the first outcome relating to the ongoing operational performance of the networks, before addressing, on a sector-by-sector basis, the challenges faced by networks in anticipating new patterns of energy injection and load, and the role outputs can play in facilitating that outcome. We regard the third high-level outcome, relating to ensuring the networks adapt to the consequences of climate change as resulting from the outputs discussed in the context of promoting the first two outcomes.

A theme that runs through this section is that for this category of outputs in particular it is not always easy to apply output-based regulation to ensure that the desired outcomes are realised. These cases would generally fall into three types:

- the available output measures may provide little insight into current performance, allowing operators to diminish provision in the short-term in order to meet financial targets, with no penalty for doing so;
- the desired output cannot be well controlled by the operator (or measured by the regulator), so that a high-powered incentive could expose the operator to too much risk; and
- the desired output could largely resemble an input (e.g. the roll out of an electric car charging network is essentially the extension of the present system by a certain number of kilometres of cable with connection points).

These cases mean that there will be some reliance on assessing performance by reference to performance against inputs rather than outputs. But this does not mean that the regime needs to collapse into a highly interventionist style of regulation. In this section we provide discussions of each of these types of cases to illustrate that incentive-based solutions are feasible[17]. But, in each of these cases it would be very easy for the regulator to fall into an interventionist regulatory model, and to avoid this Ofgem would need to clearly limit the scope of its interventions. In doing so, it would not be sufficient for Ofgem to merely to assert its intent to not intervene beyond its announced scope; it also requires it to establish regulatory arrangements that have that effect.

17 We have obviously not produced an exhaustive regulatory treatment of all the regulatory issues faced in each sector. The case studies contained here are intended to give a flavour of the choices Ofgem will need to make if it wishes to adopt an output-based regulatory model.

In the course of these discussions it will be clear that, in our view, it may be proportionate for Ofgem to be less interventionist in some areas of network regulation, but more interventionist in others. This judgement is essentially based on the likely distortion caused by interventionist regulation compared to the benefit that the intervention would realise for customers.

5.1 Maintain operational performance of the network at acceptable levels

Reliability outputs that relate to this outcome fall into two types – contemporaneous measures of reliability, and leading indicators of future reliability.

Contemporaneous measures of reliability

The contemporaneous measures of reliability have been a familiar feature of network performance regimes for some time. These are CI/CML for electricity distribution, unplanned interruptions in gas, and unsupplied energy in electricity transmission. As discussed in the context of each sector, we propose that measures such as these should continue to be used as regulatory targets and have incentive rates applied in the case of electricity distribution and transmission, but the incentivisation of gas output reliability is largely subsumed by safety requirements.

The problem of unobservable output diminution, and the role of leading indicators of reliability

There has been a growing concern, primarily in the electricity distribution sector, that operators can temporarily ramp down on their investment and maintenance expenditure without this usually affecting their performance on the contemporaneous measures of reliability but which, nonetheless, reduces the resilience of the network. Consequently, customers are not getting the network resilience that is implicit in the price control settlement, and in the event that some unexpected event was to occur, they could face greater disruption than would otherwise be the case. To put the issue differently, the concern is that in the absence of some leading indicators of reliability, operators are able to transfer the risk of financial under-performance to customers who, unknowingly, would then face greater risk of network failure. Even if the risk does not materialise, customers would still not have had the network they paid for, for a period of time, which undermines value for money.

Ex ante target setting and ongoing monitoring

To remedy this problem, we propose that Ofgem should develop leading indicators of reliability such as the asset health measures developed by Ofgem at DPCR5. The expected plans associated with these assets can be used to set the future capital expenditure allowances more robustly than in the past, and which give a sense of the underlying level of network health that the operator is required to maintain. During the price control period, the network operator should produce an annual "Reliability Report" in which it would present a wide range of evidence on network performance, areas of concern and, consequently, priority areas for the forthcoming period. The report would track performance on the same asset health measures that were used at the time the price control was set, plus any other qualitative and quantitative information that would be relevant for assessing whether the operator has maintained the resilience of the network as it was required to do at the time the price control was set. Where the company had followed a different course of action to that anticipated at the previous review, it would need to provide evidence in support of that alternative approach, identifying why it was preferred and how it had delivered the same outcome (or better) in terms of network reliability. The status of this Reliability Report might be assured by requiring it to be signed off by a company director or a compliance officer, representing that it provided a "fair and reasonable" description of the condition of the network. The recent Consultation Document produced by Ofgem[18] contains a reporting framework that is consistent with this approach.

<u>Criteria for penalties for non-delivery</u>

If the Report were to indicate that there is a strong possibility that the operator has not maintained reliability at the required level, then this would provide a trigger for the regulator to investigate this concern in further detail. If those further investigations allow the regulator to satisfy itself that the network has become less reliable than required, then penalties would be appropriate, although as discussed in the sector-specific commentaries below, this is likely to only be appropriate for the electricity networks. Although a full discussion of the basis for the penalties is beyond the scope of this report, the most obvious approach is to deny the operator the full out-performance payment for beating its costs target that it would have received at the end of the price control period (or equivalently further penalise an operator for over-spending its target). The exact sum of money would be based on an estimate of the investment that the operator should have made to maintain reliability at the required level, with some additional penalty attached to render the strategy as a whole NPV negative.

It is worthwhile emphasising that the default option is that the operators would earn their normal outperformance payments, with these penalties only invoked if there is clear evidence that a material diminution in the health of the system has been allowed to occur. If there is a general expectation that these penalties could be applied on a frequent basis for rather minor diminutions of network resilience,

18 Electricity Distribution Price Control Network Asset Data and Performance Reporting - Regulatory Instructions and Guidance (Draft). 31st March 2010.

then this will place an evidential burden on the Reliability Report that it would be unlikely to be able to bear. This is because, as we discuss in the sections below, but particularly in relation to electricity distribution, it is impossible to objectively measure the underlying health of the system, and the impact of interventions in respect of each asset type, where these interventions could vary from asset replacement, refurbishment, reinforcement, and load transfers to contracts for demand-side response, as well as other more system-wide interventions, whilst also taking into account any material changes of circumstance. Our view is that these calculations can never be so definitive as to enable such a mechanistic revenue penalty to be applied. Or, to put it another way, if these calculations can be so definitive as to capture all possible eventualities and innovations, then the regulator should be running the networks.

The risk of slipping into input-based regulation

The dangers of applying financial penalties on the basis of minor diminutions of performance against the imperfect measure(s) that would be used to judge performance are highly significant. The effect (if not the original intent) of these arrangements would be greater regulatory involvement and sign off on any interventions (or absence of them) that the operators might be inclined to make. This is because there are usually options associated with how network risk should be managed, and operators will naturally want to be assured that their choice won't get penalised, and will seek assurances from the regulator that its course of action is acceptable. It would be disingenuous for the regulator not to give guidance by using the argument that "these choices are for the operator to make", because it will be making a very definitive judgement on those choices after the fact.

This increased regulatory involvement would take one of two forms: either the regulator will need to become increasingly precise in its definitions of unreliability for the purpose of developing *ex ante* rules, which will imply an ever-lengthening rulebook; or the regulator will become increasingly drawn into the real-time management of the system in order to judge whether the actions of the operator have been or will be acceptable - which it can then communicate to the operator in an ever increasing number of letters of comfort . In both cases, the networks will, over time, reflect the preferences of the regulator, rather than the optimal decisions of an innovative operator.

Over the longer term, the dynamic efficiency cost could be very great as the industry settles on an established way of doing things rather than exploring the full potential of smarter networks and the possibility of using of innovative technologies that would be incentivised under an output, rather than input based approach.

Primary outputs to promote the high-level reliability outcomes

The pressure for the regulator to be drawn into the operations of the operators is likely to stem less from a concern that outputs have been diminished[19], and more around protecting customers from "over-paying" for assets. However, in our view, this risk is better handled through a robust process of target setting (for which these indicators of asset health and performance can play a major role), effective incentives for truth-telling, and incentive arrangements for out-performance. Even with these arrangements in place, customers may still pay more than they would in a world of perfect information and foresight, but to try and eliminate this risk entirely draws the regulator inexorably into input based regulation with far greater customer detriments. In other words, application of input-based regulation is not a proportionate response to the concern.

We now discuss this issue in the context of each sector.

5.1.2 Electricity distribution

Contemporaneous measures of reliability

Traditionally, the measurement of reliability for electricity DNOs has focused on outputs that measure the number and duration of interruptions of supply at the connection points of network customers within a given period (typically 1 year). These are material indicators of reliability, which lie within the control of the operator. Internationally, a number of different indicators, such as SAIDI[20], CAIDI[21], and SAIFI[22], are used to reflect the different dimensions of network reliability. From the network users' perspective, three dimensions are most important:

- the number of interruptions at their connection point;
- the average duration of interruptions or their cumulated duration within a specific period; and
- the volume of energy that cannot be supplied due to interruptions.

The first two of these dimensions are covered by the indicators CI (customer interruptions) and CML (customer minutes lost) on which the existing Interruptions Incentive Scheme is based. Although CML (the cumulated duration of interruptions within 1 year) reflects the number and duration of interruptions at the same time, CI is used in addition because it makes a difference to customers if a certain level of CML is caused by many short or by few long interruptions.

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19 Which in any case has not be proven to have occurred, and even if it has had, it has not been proven to have had any material effect on the quality of supply that customers receive.

20 System Average Interruption Duration Index.

21 Customer Average Interruption Duration Index.

22 System Average Interruption Frequency Index.

An indicator that reflects the volume of Energy Not Supplied (ENS) due to interruptions is not currently used in the UK, although it is used elsewhere (for example in Norway). An output such as ENS potentially allows a better differentiation of interruptions in terms of their consequences. If ENS were to be used as a primary output, it might not be necessary to use CML at the same time, because these measures are clearly strongly correlated to each other.

ENS is, however, more difficult to measure than CI and CML because network operators – particularly on the lower voltage levels – typically do not have any measurement data of the level of load at the time when an interruption occurs. The calculation of ENS would require agreement on which data and/or assumptions (like standardised load profiles) are to be used, although these measurement difficulties will reduce once smart meters are rolled out.

Our proposal is that the choice of ENS or CML is worth considering within the context of the outputs debate that Ofgem wishes to have.

As well as these outputs, the network-related social obligations output category should continue to include outputs and incentives in respect of worst served customers.

Leading indicators of reliability

The concerns that we described above that operators can temporarily ramp down on their investment and maintenance expenditure and raise operational risk for customers led Ofgem, at DPCR5, to develop 'tier 2' reliability metrics. These measures of potential network deterioration processes were introduced in DPCR5 to reflect the development of asset health condition. These indicators, the Health Index (HI) and the Fault Rates, are measured separately for a number of asset categories.

These indicators are material and controllable, and can therefore contribute to understanding the development of asset health condition in the networks. As far as we understand, the HI is based on an evaluation of asset health, with each asset being allocated to one of 5 health categories. This evaluation can for example take account of asset age as well as to the results of continuous observation of the assets. In contrast, Fault Rates are a more objective indicator that is particularly relevant for assets whose health condition cannot be monitored directly, such as underground cables.

Due to their high level of granularity, it is inappropriate to use these tier 2 measures as an output against which financial incentives can be directly applied, since they only provide an estimate of the health of the asset (and implied probability of asset failure), rather than network risk. In the absence of a "tier 1" network risk measure, then it will be necessary to estimate the trade-offs between tier 2 measures (and other actions that are not measured) to come to a view on network risk. These trade-offs will be, to some extent, subjective and qualitative and therefore not capable of being objectively measured.

Primary outputs to promote the high-level reliability outcomes

Ofgem has indicated that a tier 1 measure of network risk should be some aggregate measure of the tier 2 metrics. The method of aggregation is not yet established, but this exercise is also likely to require some assumptions or subjective judgement to be made, rather than relying wholly on objective fact. For example, it could be calculated as the tier 2 measure of probability of an asset failure multiplied by the consequence of that failure, summed across all assets. It is unlikely that the estimation of the consequences of failure would be wholly objective, and therefore this measure would be unlikely to be amenable to finely calibrated financial incentives.

Further, the measured metric is an important indicator of future reliability, but not a complete one. A DNO whose network assets get into a worse health condition over time does not necessarily neglect their duty to provide a highly reliable network. Rather, the operator might have identified ways to improve reliability more efficiently by increasing the redundancy of network topology (i.e. by building additional network branches and/or increasing the switching possibilities) or by increasing the degree of network automation. Such measures would aim at reducing the number of customers that are affected by an interruption of supply and/or at reducing the duration of the interruption, which is ultimately what customers value. In other words, it is possible that asset health indicators could show a deteriorating reliability performance, but the network has not actually exposed consumers to increased operational risk, either contemporaneously or in the longer term, and consequently, although the indicators are measurable, they do not fully measure the outcome that is being sought. Consequently, direct incentives applied to asset health outputs (or aggregate combinations thereof) can encourage operators to ignore other non-asset specific approaches to assuring reliability.

Ofgem envisages that it will be able to objectively measure the impact of interventions in respect of each asset type, where these interventions could vary from asset replacement, refurbishment, reinforcement, and load transfers to contracts for demand-side response, and clearly it would seem appropriate to measure other interventions such as of the type discussed in the previous paragraph. Ofgem also envisages that it will be able to objectively take account of material changes of circumstance (such as changes to input data, calculation and assessment technique, changes in external factors or changes to the DNO's asset management strategy and approach).

Our view is that these calculations can never be so definitive as to enable a mechanistic revenue penalty to be applied in respect of performance against this measure. Moreover, if operators were penalised for modest "under-performance" against this measure it would lead inexorably into growing regulatory creep into the operational decisions that properly belong with the operator, with the associated efficiency and accountability problems that we discussed above.

Another tier 2 measure that was introduced in DPCR5 is the Load Index (LI) against which clearly defined and agreed sums of money were allowed at DPCR5. In this sense, there is a clear link between the output (the degree of utilisation of the existing network capacity, particularly the transformer capacity of substations) and the cost permitted, which essentially related to reinforcement expenditure. This may be a useful regulatory device to ensure that funds hypothecated to reinforce particular assets are spent on that purpose, and therefore may make a contribution to achieving value for money. However, it has no direct relation to network reliability except in very extreme situations.

Against this background, it is very clear that these indices are highly informative in setting targets for operators, and can enable far more effective cost target setting than Ofgem has been able to manage in the past. Moreover, these measures, combined with other information, should be able to reveal where there has been a clear and material breach of the regulatory bargain struck at the price control review against which penalties can be applied. However, if there is too close a link from these measures to revenue, then this would create severe inefficiencies with no great benefit in terms of the ultimate output that customers value – the number and duration of interruptions.

5.1.3 Electricity transmission

Reliability indicators like CI, CML and ENS can in principle also be used for electricity transmission networks. However, measuring these outputs is more difficult than in the distribution sector, because TNOs typically do not know how many final customers are fed from a specific substation of their network. ENS is easier to measure in transmission than the customer-related indices CI and CML, and is the more relevant measure of contemporaneous reliability, as far as transmission users are concerned.

In addition to this practical issue, such indicators are typically less meaningful in transmission because events that lead to the interruption of final customers are very rare. Consequently, whilst outputs of these types are material and controllable, there are some measurability issues.

Up to and including the last transmission price control review, NGET was set a target for the volume of unsupplied energy, with associated upside and downside revenue risks. SPTL and SHETL were set targets for the number of events which result in unsupplied energy, with similar incentive arrangements, and arrangements such as these (or similar) could continue to be applied and as such we have included ENS as a primary output measure for electricity transmission.

Subsequent to the last TPCR, the transmission networks have been undertaking a review of the network output measures used to measure reliability and Ofgem recently accepted their proposals to use a new measure of Average Circuit Unreliability, and a number of leading indicators of reliability relating to Asset Health and Fault/Failure Rates, which Ofgem has accepted.

Primary outputs to promote the high-level reliability outcomes

We consider it reasonable to use these output measures as a means to monitor these indicators in the Reliability Report against the requirements that were established at the time of the price control review. We would also recommend that the reliability performance summary given in the report compared to that required at the time of the price control is used to inform financial penalties, in the event of a clear and material diminution of network health relative to what was expected at the time of the price control review.

The TNOs have proposed some different indicators of network capacity utilisation including "boundary utilisation" and "substation utilisation". The volume of "temporary disconnection compensation" paid to generators for disconnection due to network unreliability can also be considered a measure of network utilisation, or an indirect measure of system reliability. Unlike in electricity distribution systems, which are usually designed to meet 100% of demand, transmission networks are typically not designed to this standard, and nor are they designed to enable all generators to operate at their declared level of availability. For this reason, we defer the discussion on capacity utilisation indicators to the section that deals with the "anticipation of future demand and injection on the system" in section 5.3 since this bears heavily on incentives to configure the network.

5.1.4 Gas transmission and distribution

Contemporaneous reliability indicators relating to the number and duration of interruptions can, in principle, be determined in gas networks just as for electricity networks. We note, however, that reliability measures are less meaningful in the gas sector, for two reasons.

First, compliance with safety legislation ensures much lower levels of unreliability in gas networks than in electricity networks. After an interruption of gas supply, network operators have to make sure that all the customers' appliances are in a safe state, and that the lines do not contain a mix of gas and air. This requires the operator to visit each customer affected by the interruption before supply can be restored which is very costly.

Second, due to the low level of unreliability, reliability indicators for gas networks can be expected to be very volatile which makes it more difficult to use them as a basis for financial incentives.

Consequently, maintaining the operational performance of network assets at acceptable levels is better determined by safety laws than by regulatory targeting and incentivisation, but we would regard it as reasonable to report and to monitor the number and duration of unplanned events in a Reliability Report.

However, incentives can be applied that encourage operators to reinstate supply in the event of an interruption. In gas distribution there are a number of guaranteed standards, of one stands out as a primary output – the restoration of gas supply within 24 hours of an unplanned interruption. Whilst this may be a less important driver of maintaining reliability than the safety legislation, it provides a marginal incentive, and is also relevant in the context of customer satisfaction which places a significantly greater cost on unplanned interruptions than planned interruptions.

Currently, National Grid Gas (NGG) transmission has to pay a charge where it interrupts a supply point for longer than 15 days. We would propose that the 15 day interruptions incentive be continued, and have therefore included this as a primary output. In addition, NGG has been working to develop a set of outputs to be used in monitoring reliability under the Gas Transmission Special Licence Condition C13. Our proposed reliability report would include, for the purposes of monitoring, those measures that have been developed and conditionally accepted by Ofgem. These include a set of reports regarding network asset condition, network risk, network performance and network capability.

More generally, we envisage the development of the Reliability Report for both transmission and distribution that would include leading indicators of future network reliability

Unlike for electricity distribution, we envisage no financial penalty associated with under-performance being applied in the case of gas networks; with any sanctions for under-performance resulting from the operator being in breach of safety legislation.

5.2 Anticipating new patterns of energy injection and offtake on the energy networks

The second desired high-level reliability outcome is for networks to anticipate - through their planning and investment decisions - new patterns of energy injection and offtake to primarily to accommodate the decarbonisation of the energy sector, but also as a consequence of other major changes.

For example, the changes to gas networks over the coming decades will be profound as a consequence of developments outside of the network sector:

- gas from the UKCS will diminish and GB will become increasingly dependent on imported gas;
- decarbonisation will lead to significantly reduced levels of load as usages such as space heating become increasingly electrified; and
- gas-fired generators will be increasingly required to balance electricity systems given the increased amount of intermittent renewable generation on the system, so load will become more volatile.

The possible outcomes for gas networks are numerous, ranging from a managed decline in networks; through to maintained utilisation via the development of biogas; and to the use of the networks as part of a Carbon Capture and Storage (CCS) infrastructure.

Electricity networks will change in (at least) three significant ways in future:

- there will be a significant increase in the amount of renewable generation on the systems;
- the amount of load on the system will increase as customers switch from gas, and electric cars are more commonplace;
- the networks will become "smarter", including the roll-out of smart meters.

Transmission systems will change, and as the long term electricity network scenarios (LENS) work showed[23], distribution networks could evolve in any number of ways in response to these changes.

The volume of generation and load that will materialise on the system is likely to be very large, but there is considerable uncertainty over what will be required of the network operators to facilitate decarbonisation. It is not, at present, clear what actions will be required or what costs might be incurred in the process.

Given this uncertainty both gas and electricity operators will need to be provided with an incentive framework that encourages innovation and decisive action in dealing with the challenges in their respective sectors. Operators might seek to reduce their risk exposure by waiting for more information to emerge, but more rapid progress is likely to be needed (particularly in order to meet wider environmental targets).

Notwithstanding the uncertainty over what activity might be required, there is likely to be a need for a substantial increase in expenditure over the coming years, especially in the electricity networks. Given the likely scale of that expenditure, strong incentives to seek efficiencies are likely to be a key element of future arrangements in order to ensure that money is well spent. Much of this spend may be capex (supporting the view that capex assessment will be increasingly important) but there is also likely to be scope for capex to be replaced by other types of expenditure (e.g. interruptible contracts)[24]. In all cases where increased expenditure is needed to meet decarbonisation objectives, it will be important

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23 Long term electricity network scenarios for Great Britain in 2050. Final Report for Ofgem's LENS project, Ault *et al*, November 2008

24 For example, there already exists a "Capacity outputs incentive" that incentivises GDNs to strike the right balance between providing network capacity and contracting interruptible capacity with network users in order to optimise network capacity, which should be continued to be applied.

that operators are incentivised to deliver the best value solution (be that opex or capex).

The threat of *ex post* cost disallowance – either through benchmarking or some other regulatory instrument – could have the effect of undermining incentives to invest, innovate and incur cost in transforming networks to meet the carbon challenge – this risk is particularly significant in the electricity sector.

However, if *ex post* cost disallowance is to be de-emphasised in the regulatory package, then this would remove a primary route that Ofgem has historically used to transfer benefits from operators to customers. In order to continue to ensure value for money for customers, there should continue to be a strong emphasis on the benchmarking and evaluation of future plans, assessing the extent to which they represent value for money for customers.

This is not without its challenges. As well as raising measurement implications (which we discuss in our benchmarking report[25]), the uncertainties associated with future spending and future output provision, and the likely increased requirement on operators to anticipate future events, rather than react to events as they occur, implies a need for a changed engagement between Ofgem and the operators. Specifically, investing ahead of need needs to be legitimatised, in order to avoid either gold-plating, unnecessary asset standing, or inadequate provision of capacity. This legitimisation process should maintain a clear distinction between management and regulation.

- The operator, who has best sight of the technical issues, should present "investment ahead of need" scenarios as part of the business planning process at each price control review. These scenarios would take account of any impact on the base case, in order that the net costs of the investment can be identified, and highlight the future utilisation risk if anticipated connections do not materialise;

- The regulator evaluates those scenarios both in isolation and in comparison with information received from other operators in the same process (comparison would therefore mainly concern distribution);

- The regulator agrees to a plan and associated expenditure, which is then monitored in a similar way to the reliability outputs.

In the absence of a clear process for engagement, where the roles are clear, the outputs defined, and costs estimated, the risk properties of the regime are undermined, leading to sub-optimal levels of investment, with corresponding public policy implications.

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25 The future role of benchmarking in regulatory reviews – a report for Ofgem, Frontier Economics, May 2010

Primary outputs to promote the high-level reliability outcomes

This is a significant challenge and one where in our view Ofgem can be pro-active. As discussed in section 5.1 above, a significant amount of the regulator's resources have been, or are envisaged to be, spent checking the detailed operational actions of operators, and then developing metrics for the purpose of penalising the operators if those operational actions fall short of what was expected at the time the price control was set. On the other hand, the regulatory framework within which to handle the key strategic questions of network scope, scale, reach, and configuration with their implications for risk sharing and investment incentives is not yet so well determined. Yet it is likely that the costs to customers and society associated with the wrong decisions made in respect of these questions are of an order of magnitude greater than the cost to customers and society associated with operators possibly not quite doing what was expected of them at the time of last price control review.

We now discuss the specific example of electricity transmission as an example where there should be greater harmonisation of SO and TO incentives, and a greater involvement by the regulator to achieve better long term outcomes.

5.3 Incentivising an efficient level of constraints in electricity transmission

The issue of constraints has been a live one in the transmission sector for some time, but will also be increasingly relevant for distribution networks as more distributed generation enters the system.

There are two key challenges associated with promoting this outcome:

- if operators have incentives to connect generation quickly (whether that is low carbon or conventional generation), what outputs are required to incentivise the operators to manage the resulting constraints efficiently?; and
- if constraints are likely to increase as a result of the connections incentive, is there a danger that low carbon generators could be constrained off without another output that incentivises the network operator to ensure that the low carbon power actually flows?

Clearly, if low carbon plant was constrained off, particularly if the plant that replaces that generation is carbon emitting, then this would defeat the environmental purpose of the renewable plant. In reality, we think it highly unlikely that renewable generation will be constrained off to any significant extent, since renewable generation will usually be considered 'must run'[26]. Instead, thermal plant is likely to be constrained off in the presence of system

[26] Directive 2009/28EC on the promotion of the use of energy from renewable sources

constraints. However, in order to minimise the risk of low carbon generation becoming constrained off, as discussed in section 4.1 we propose a separate output under the environmental category which incentivises network operators to maximise the low carbon power flows on their system.

What is likely to be more significant is that if our proposed connections output is properly incentivised so that operators connect a large amount of new capacity (be it low carbon or otherwise) in shorter timeframes, then the constraints on the system are likely to increase, and the costs of managing those constraints will rise considerably from levels that have already grown enormously over the past few years. Put another way, the introduction of the connections incentive effectively causes a transfer of cost and risk from those seeking connections to the operators and to customers.

Consequently, the key focus of the output and incentive package should be on encouraging efficient constraint management to promote value for money – one of Ofgem's two primary objectives, and one Ofgem has asked us to consider in this report.

5.3.1 How can an efficient level of constraints be incentivised?

The cost of constraints manifests itself as the balancing costs incurred by the SO because generating plant located 'behind a constraint' cannot generate (i.e. the plant is "constrained off") or because plant located on the other side of a constraint is forced generate in order to meet demand (i.e. it is "constrained on").

To achieve an efficient level of constraints, the network operator must be incentivised, broadly speaking, to alleviate constraints where the expenditure required to do so is lower than NPV of the expected reduction in congestion costs resulting from alleviating the constraint. The cost of alleviating a constraint might either be capex (i.e. expanding network capacity) or costs associated with alternative congestion management measures (such as interruptible contracts and demand side management). Ideally, networks would be incentivised to seek the most cost-efficient ways of reducing constraints to the efficient level. The challenge is to ensure that congestion costs somehow factor into network investment decisions.

In an ideal world, incentives on the SO (who bears the cost of managing constraints) would result in the TO (responsible for investing to relieve constraints) investing at an optimal level. In other words, SO risks must be signalled to TOs, and in effect passed through to TOs in a way that stimulates the appropriate investment. If the SO bore the cost of managing congestion over a long period (e.g. the lifetime of a transmission asset, 40 years), and the TO and SO were under common ownership, then such an outcome might be conceivable. With this framework, the common owner would trade off the investment required to reduce congestion (increased TO cost) against the NPV of the reduced cost of congestion over the asset life (decreased SO cost). Where the SO and TO are not under common ownership, it should be possible to design the contracts between SO and TO such that the SO incentive is passed through effectively.

Present arrangements

Under the present arrangements, the SO and TO are legally separated. National Grid is the SO for the entire GB network, and is also the TO for the England and Wales network. Thus, the common ownership that is required for SO risks to be passed through to the TO is in place for the England and Wales networks. In Scotland, there are two different transmission network owners (Scottish Power and Scottish Hydro-Electric). However, it is conceivable that a contractual agreement between National Grid and the Scottish TOs would allow the SO to pass through some element of the cost of failure to invest (although this is not currently a feature of the arrangements).

Current arrangements, however, are ineffective at signalling risk to the TOs for three reasons.

First, the SO control currently lasts only 1 year, which means that SO allowances effectively increase in line with expected increases in congestion costs before any signal of those costs can be passed through to the TO. The trade-off between long-term congestion costs and investment in relieving constraints does not occur, since SO allowances are frequently re-aligned with expected congestion costs. Given the volatility of system operation costs, and the limited extent to which the SO can manage such volatility, a very lengthy multi-year year SO control is unlikely to be implemented. Thus signals passed through to TOs are weak.

A second limitation on the strength of signals passed from SO risks to TOs is the nature of SO settlements. In order to remain consistent with National Grid's (NG's) WACC, the returns agreed at the SO control often remain constant within a 'deadband' range of outturn costs with respect to allowed revenue. There is some risk-sharing if outturn costs move outside of this range, but these risks (and associated returns) are capped and collared if outturn congestion costs prove to be significantly lower or higher than anticipated at the control. Thus, the risk-sharing agreement between the SO and customers limits the extent to which the SO is exposed to congestion risk, and consequently limits the extent to which such risks can be passed through to the TO. Again, these arrangements are unlikely to change, and therefore the incentives passed through from SO to TO will remain weak.

Finally, the TO control at present is settled for a 5 year period. This is shorter than the time taken to undertake major transmission upgrades. Even if the SO control were agreed over a longer period, TO investment horizons would currently not be sufficiently forward-looking to achieve the optimal level of system constraint.

These weaknesses result from the fact that although constraint costs are within the control of the TO in the longer term, they are not so much within the control of the SO/TO in the shorter term, when events outside the control of the operator can impact significantly on constraint costs. This creates a time inconsistency problem, which is that the very incentives that would stimulate the operator to choose the right level of constraints in the long term would impart enormous risk in the short term. This problem, unless addressed, will be manifested in even greater cost to customers if the connection time incentive is meaningful.

Possible remedies

There are a number of potential outputs that might be used to deliver an efficient level of constraints.

- Directly incentivise constraints through a more high-powered SO control
- Directly specify a particular level of constraints, such as:
  - an "operate at an efficient level of network constraints" output;
  - a "reduce network constraints" output;
  - a "minimum network constraints" output; and
  - "maximum availability" output that requires all generating plant to be able to run when they are available to do so up to a certain number of hours in the year (or some other measurement period);
- Harmonisation of SO incentive with the target setting and investment allowances at the TO price control review

The first of these options maintains the de-centralised approach to constraints that have prevailed to date, but would strengthen of the SO incentive regime to enable a stronger signal to be sent from the SO to the TO, who would then alleviate some constraints in response to the sharper price signal. However, the cost to customers for the realisation of this new level of constraints could be extremely high, since the operator would naturally seek to insure itself against as much downside risk as possible by requiring either a generous target level to be set, or a higher WACC. This downside risk is highly material, and is largely outside of the control of the TOs since it arises from wholesale electricity price movements, generators' connection decisions, planning delays associated with transmission build, and so forth.

Primary outputs to promote the high-level reliability outcomes

Under these uncertain conditions, the danger with applying this approach in isolation is precisely that we identified in section 1, namely that the actual level of constraints that the operator would choose as commercially optimal is both unknowable, and may still be someway short of what stakeholders might regard as the socially optimal level.

The second group of options would involve the regulator directly specifying an output around the level of constraints that the operator should achieve. In principle, this output would represent a direct intervention by Ofgem that might fully replace the development of the SO control for the purposes of incentivising efficient constraints.

However, we think there are a number of significant problems with this type of output. Firstly, in order for the output to be meaningful, Ofgem would be required to define what an 'efficient' level of constraints is (since the TOs do not take congestion costs into account automatically). Second, it would then need to fund this level of output, either through an incentive regime or through the price control. In the first case, the same problems as those that currently exist with the SO control would manifest themselves, and in the second, the regulator would need to ensure that the huge sums made available to invest in alleviating constraints are being spent for that purpose, which would draw it inevitably into the micro-management of plans and input based regulation.

A hybrid of input-based and output-based regimes

So, if neither output-based, nor input based regulation appears to be an attractive way of promoting value for money, then what would be? In our view, the answer is a hybrid of the two, through the formal harmonisation of the SO and TO regimes. If stakeholders, through the regulator, wish to reduce constraints on the network then an approach that could be characterised as follows could be adopted:

- Ofgem sets a long-term (say, 10 year) aspiration for the target and profile for congestion costs that is consistent with the views of stakeholders.

- The operator and Ofgem agree a (say, 5 year) TO price control that is expected to be sufficient to cover the investment costs required to fund transmission build, generation connections, etc. to meet the congestion cost target profile up to that point. The settlement would also include agreements on the appropriate sharing factors to apply for financial over-or-under performance, and material under-performance on delivery of the plan.

- Ofgem set an SO control on the basis of the same profile too, but with sharing factors and duration set to ensure that the SO risk is consistent with the overall WACC - the RORE framework developed at DPCR5 could be used for the purpose of assessing the combined risk characteristics of the

SO and TO. For the reasons described above, this will probably imply a shorter SO control (say 3 years) than the TO control.

- The TO control updates within the price control period in line with factors that may have changed from the initial assumptions. The regime should also include a limited re-opener to harmonise the TO control with any information that is used in the re-setting of the SO control (given that the SO and TO regulatory periods are not synchronous). This will enable changes of plan to be agreed in response to new information and the ongoing monitoring of the investment plan and associated asset developments.

- At the appropriate break-points and/or at the next price control review, the regulator would be able to take a view on two things:

  - whether the congestion cost profile needs to be adjusted in the light of new information; and

  - whether the operators have made their best efforts to meet the congestion cost profile and to penalise them if they have not done so.

Compared to present arrangements, this approach has an explicit 'target' for costs, monitoring, verification against that target throughout the TO control period (including penalties for non-delivery if appropriate), and a somewhat longer SO control.

This approach seems to combine the most advantageous aspects of output-based and input-based regulation. First, the regulator specifies the outcome it wishes to see, and then uses the instruments of the TO price control and the SO incentive to set the conditions within which the operator can optimise constraints from a commercial perspective. This would not only require the parameters of the regime to be set, it would also require active engagement around the forward-looking plans for constraint management at the price control review, with different levels of constraint levels and costs set out. Consequently, we see the business plans as a crucial part of the output regime.

Second, in its "pure form" this approach could avoid the need to monitor progress against the constraint-minimisation and investment plans implicit in the TO price control settlement, by simply exposing the operator to the risk that if the investments are not made, its penalties under the SO regime would be significant. This is likely to be ambitious, however. In practice, it is likely that the SO control would be of shorter duration than the TO control (say 3 years), and that the incentive power of the regime would continue to remain quite weak for the reasons described above. In practice, therefore, Ofgem would probably need to monitor the investment and constraint management initiatives and compare them to what was expected at the time of the price control review in a separate section of the Reliability Report. However, if it were to do so, then the terms on which the regulator could intervene on the basis of the information contained in the Reliability report would need to be well-defined.

Third, this regime can be updated with new information at each price control review (or other break point), which allows the regulator to evaluate value for money at periodic intervals.

In summary, the incentivisation of efficient constraint management is not straightforward. Pure output-based regulation is unlikely to be workable, whilst input based regulation will not be efficient. We have proposed that Ofgem reforms the SO control (work which we understand is already underway) and ensure that it interacts with the TO price control appropriately. This approach gives Ofgem better control over outcomes, but delegates responsibility for delivering the outcomes to the operator who must optimise within the integrated SO/TO incentive package. The TO element of the package will involve the regulator in assessing plans for the purpose of setting the price control but this role is, and should be, limited in order to avoid drifting into opportunistic intervention[27].

This discussion provides a useful example of the limits of output-based regulation, but it also illustrates that the alternative is not to apply a highly interventionist style of regulation. Instead, it relies on the usual sharing mechanisms for financial out-performance, a well-understood agreed plan of deliverables (which may need to be tied to specific items of work or investment), ongoing monitoring against the plan, and agreed breakpoints to monitor progress and if necessary adjust the plan. Such a scheme would, however, collapse into input based regulation if:

- the financial sharing mechanisms were over-rode because the operator out-performed against the financial targets; or
- if the breakpoints for penalising under-performance against the output plans were not observed; or
- if output performance (or under-performance) against plan was too tightly defined.

The first of these would undermine the risk properties of the deal, and would set the precedent for future similar arrangements which could now be reasonably expected to be asymmetric in nature. A sensible operator would seek to avoid

27 It should be noted that DNOs could face similar issues with respect to constraints as more distributed generation enters the system. However, these issues will be resolved structurally (i.e. whether there is a DSO, or whether constraint costs are dealt with directly in future DPCRs) is still to be resolved, but this discussion has shown that there is a need for clear incentives that ensure the efficient trade-offs are made between congestion cost management and investment.

this outcome, and would either require higher returns, or better insurance against financial under-performance. Both would be costly and inefficient. The second and third would inevitably push the regulator too close to ongoing real-time management decisions and undermine innovation.

Implications for output (or high-level outcome) definition

It should be clear from the discussion above that the regulation of constraint costs is primarily a value for money problem that needs to be resolved using available information at periodic price control reviews. For these reasons, it would be inappropriate to require operators to "minimise constraints", or achieve a "target (or minimum) level of constraints" or a "maximum level of availability" as a high-level outcome of the reliability category. Such a high-level outcome both prejudges the efficient outcome for constraints, and hard-wires that pre-judgement into the regime.

These considerations also apply to the use of these metrics as primary outputs in the regime as it would be applied at each price control review. The eventual choice of target that is agreed in the framework we described above is an outcome of the regulatory engagement that balances the expected congestion costs with the investment costs that would be needed to alleviate the constrains that give rise to those congestion costs. In the presence of considerable uncertainty, it makes little sense to pre-define a target that will make customers worse off.

The one caveat to this conclusion (which we have been asked to consider) is if constraints were regarded as a measure of unreliability borne by generators in the same way that interruptions are regarded as an indicator of unreliability for customers. If a generator-specific reliability metric were appropriate, then this could be manifested as a "maximum availability" output that requires the network operator to enable all generating plant to be able to run when they are available to do so up to a certain number of hours in the year (or some other measurement period). In our view, such an approach confuses producer interests with consumer interests, and would be equivalent to compelling customers to take power from producers, even when it would be cheaper to take it from others. Such an output measure would run counter to Ofgem's high level objectives.

However, this does not preclude TNOs paying "temporary disconnection compensation" to generators for disconnection due to network unreliability that has arisen, which is independent of the constraint issue.

Primary outputs to promote the high-level reliability outcomes

5.4 Summary

The discussion in this section has not only covered particular outputs and metrics, but it has also identified the key areas where the use of inputs as outputs can be applied in the regulatory process.

This discussion has revealed that inputs can play a highly valuable role in determining cost allowances that feed into price controls. A good sense of the work that operators will need to do to their networks over the next 5 years is needed to set credible and robust price controls. In most cases operators are likely to be best placed to know what is required on their networks to maintain performance (or improve it, if that is what stakeholders would value), and so the principal regulatory task at the target-setting stage is largely to establish whether those plans that the operators put forward represent adequate value for money.

However, in some cases, operators will be increasingly required to make investments in anticipation of large and uncertain future events and the choices they make will need to be legitimatised through greater engagement with the regulator, in order to avoid either gold-plating, or inadequate provision. It will be necessary to define when the need for this heightened degree of regulatory intervention will be required. This should be based on a test of proportionality where the likely cost to customers associated with the regulator not engaging in this way is compared to likely cost of doing so, under a variety of scenarios. Starting from a cultural pre-disposition not to intervene directly into the affairs of the operators, this would only reveal clear-cut areas for intervention where the regulator needs to take a strategic lead to will the means as well as the ends (e.g. more direct regulatory engagement and involvement to reduce the costs of constraints rather than continuing to rely on the SO incentive). Once this test is passed, the legitimisation process will involve the regulator but should maintain a clear distinction between management and regulation as we discussed in section 5.2.

Having agreed the target levels of performance (whether on an output or input basis), the agreed financial sharing parameters, and the penalties for failing to deliver on the output or input commitments, the regulator should step away until the pre-determined triggers for re-engagement with the operator (such as a price control review or a re-opener) are pulled. This enables the operators to work within a stable commercial framework free from regulatory interference.

However, during this time, the regulator should monitor performance against what was expected at the time the price control was set in a Reliability Report. This will enable it to apply penalties and rewards for delivery against what was expected in certain circumstances.

At the end of the price control period, as well as settling up the share of over-or-under financial performance that the operator should bear, it will be necessary to compare the performance of the operators in respect of any "input-based" outputs. In this section, we have identified two of these types of "input-outputs":

- those that were developed in order to set a credible and realistic cost allowance associated with the maintenance of a particular level of operational risk on the network at the time the price control was last set; and
- those that were developed as part of the heightened degree of intervention that was needed to guide the strategic priorities of the operator towards delivering particular outcomes.

Great care will be needed in using the metrics that fall under the first category (such as the tier 2 measures developed by Ofgem at DPCR5) to set penalties and rewards for performance for the reasons we described in section 5.1. It may not be the intent of the regulator to micro-manage the networks, but the rules that could end up being applied could have that effect, with serious consequences for efficiency, innovation and accountability.

These same considerations also apply in respect of the second category of "input-outputs" that may be developed to guide the strategic priorities of the operator at the target setting stage. In practice, the penalties would need to be agreed up-front on a case-by-case basis. In the simple case, where the "input-output" was clear and unambiguous, it is fairly clear if it hasn't been delivered and an appropriately simple penalty system would apply. In more complex cases, it may only be possible to penalise clear and material non-delivery, in order to avoid the kind of regulatory creep into the management of the network described above.

In summary, the use of inputs in regulatory processes is unavoidable, but their use needs to be confined to the parts of the regulatory cycle where they are of greatest value, and the regulator should avoid putting them in other parts of the regulatory cycle, where they could be value-destroying.

This discussion has illustrated the choices the regulator needs to make in order to set a boundary between delegated authority to the operator, and intervention by the regulator, in order to preserve the benefits of incentive-based regulation.

Annexe 1: The long-list of candidate outputs

In section 2 we set out the process through which we tested the validity of Ofgem's proposed six output categories. That process generated a 'long-list' of candidate output measures, which were mapped to the six output categories for each of the four networks. In this annexe we present this long list of potential outputs for each network. The motivation for selecting any given output relates to an activity identified by populating the matrix in Figure 3. The tables therefore demonstrate how the activities and candidate outputs map to the six output categories for each network.

We also make some preliminary categorisations of the candidate output measures. We identify the 'type' of indicator that each potential output represents, in terms of whether it measures contemporaneous behaviour or is a leading indicator, and its place on the hierarchy of network activities developed in section 3 (i.e. the information/engagement/action/realisation categorisation). Finally, the tables demonstrate an initial understanding of the overlaps between output categories. The tables are not intended to completely represent all areas of overlap, but rather demonstrate an initial understanding of how output categories draw from and feed into each other. The links between output categories are developed more fully in the main body of the report.

Reliability

Table 9. Reliability, Electricity Distribution

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
REL.ed.1	**Customer interruptions**	Contemporaneous, Realisation	Reliability measure focusing on the frequency of interruptions.	Links to customer satisfaction and social obligations
REL.ed.2	**Customer minutes lost**	Contemporaneous, Realisation	Reliability measure integrating both frequency and duration of interruptions.	Links to customer satisfaction and social obligations
REL.ed.3	**Energy not supplied**	Contemporaneous, Realisation	Reliability measure taking account of the frequency and duration of interruptions and of the volume of load interrupted.	Links to customer satisfaction and social obligations
REL.ed.4	**Maximum frequency or duration of interruptions per customer**	Contemporaneous, Realisation	Reliability measure indicating the level of quality of supply for the worst-served customers (in terms of reliability).	Links to customer satisfaction and social obligations
REL.ed.5	**Asset Health Index (HI)**	Leading, Action	Tier 2 measure indicating potential for future reliability issues.	Links to social obligations
REL.ed.6	**Fault rates**	Leading, Action	Tier 2 measure indicating asset health condition where this cannot be observed directly.	Links to social obligations
REL.ed.7	**Load index (LI)**	Leading, Realisation	Tier 2 indicator of future demand for network reinforcement.	Links to social obligations

Table 10. Reliability, Gas Distribution

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
REL.gd.1	**Customer interruptions**	Contemporaneous, Realisation	Reliability measure focusing on the frequency of interruptions	Links to customer satisfaction
REL.gd.2	**Customer minutes lost**	Contemporaneous, Realisation	Reliability measure integrating both frequency and duration of interruptions	Links to customer satisfaction
REL.gd.3	**Energy not supplied**	Contemporaneous, Realisation	Reliability measure taking account of the frequency and duration of interruptions and of the volume of load interrupted	Links to customer satisfaction
REL.gd.4	**Maximum frequency or duration of interruptions per customer**	Contemporaneous, Realisation	Reliability measure indicating the level of quality of supply for the worst-served customers (in terms of reliability).	Links to customer satisfaction
REL.gd.5	**Asset Health Index (HI)**	Leading, Action	Tier 2 measure indicating potential for future reliability issues. For gas networks, HI can be used as a "risk indicator" for network reliability since direct measures like CML can be highly volatile.	
REL.gd.6	**Disturbance rates**	Leading, Action	Tier 2 measure indicating asset health condition where this cannot be observed directly. As for HI, disturbance rates can be used as a "risk indicator" for network reliability since direct measures for gas network reliability can be highly volatile.	

Table 11. Reliability, Electricity Transmission

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
REL.et.1	**Reliability measures like CI, CML and ENS**	Contemporaneous, Realisation	Reliability measures focusing on different aspects like frequency and duration of interruptions and volume of load interrupted. Can in principle be measured in the same way as for distribution networks.	Links to customer satisfaction
REL.et.2	**Average circuit unreliability**	Contemporaneous, Action	Measure for the risk of supply interruptions due to unavailability of circuits.	
REL.et.3	**Asset Health Index (HI)**	Leading, Action	Tier 2 measure indicating potential for future reliability issues.	
REL.et.4	**Fault/failure rates**	Leading, Action	Tier 2 measure indicating asset health condition where this cannot be observed directly.	
REL.et.5	**Temporary disconnection compensation**	Contemporaneous, Action	The volume of compensation paid to generators for disconnection due to transmission system unavailability can be used as an indirect measure of system reliability.	Links to customer satisfaction
REL.et.6	**Network capability and utilisation indicators (e.g. boundary or substation utilisation)**	Contemporaneous/ Leading, Realisation	Utilisation of network capability is a contemporaneous measure for existing network restrictions as well as a leading measure for potential future restrictions.	Links to customer satisfaction

Table 12. Reliability, Gas Transmission

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
REL.gt.1	**Reliability measures like CI, CML and ENS**	Contemporaneous, Realisation	Reliability measure focusing on different aspects like frequency and duration of interruptions and volume of load interrupted. Can in principle be measured in the same way as for distribution networks.	Links to customer satisfaction
REL.gt.2	**Asset condition indicators**	Leading, Action	Tier 2 measure indicating potential for future reliability issues.	
REL.gt.3	**Network risk**	Contemporaneous, Action	Indicator calculated by NGG to quantify the risk that supply is interrupted or does not satisfy capability requirements due to asset unreliability.	
REL.gt.4	**Unplanned events (restrictions to operating pressure or entry/exit flows)**	Contemporaneous, Action	Measure indicating the extent of operational restrictions to transmission system users caused by unplanned events on the transmission system.	
REL.gt.5	**Network capability and utilisation indicators**	Contemporaneous/ Leading, Realisation	Utilisation of network capability is a contemporaneous measure for existing network restrictions as well as a leading measure for potential future restrictions.	Links to customer satisfaction

Environment

Table 13. Environment, Electricity Distribution

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
ENV.ed.1	**Number of low carbon generation connections (below 5MW capacity)**	Action, Contemporaneous.	Quantitative measure of success in connecting small-scale low carbon generation	
ENV.ed.2	**Number of low carbon generation connections (above 5MW capacity)**	Action, Contemporaneous.	Quantitative measure of success in connecting larger low carbon generation	
ENV.ed.3	**MWh of low carbon electricity flowing through network**	Realisation, Contemporaneous.	Quantitative measure of success in facilitating low carbon generation	
ENV.ed.4	**Conditions for connection – including CON.ed.1-7,13 and 14**	See Conditions for Connection.	Collectively measure the extent to which a DNO is acting as a barrier to deployment of distributed generation.	Links from conditions for connection
ENV.ed.5	**Losses**	Realisation, Contemporaneous.	Quantitative measure of DNO performance on reducing losses	
ENV.ed.6	**Carbon footprint**	Realisation, Contemporaneous.	Quantitative assessment of DNO's direct environmental impact in terms of carbon emissions.	
ENV.ed.7	**Other network emissions (e.g. noise and dust)**	Realisation, Contemporaneous.	Measures environmental impacts other than greenhouse gas emissions.	
ENV.ed.8	**Adopting best practice energy efficiency measures**	Action/ Engagement, Contemporaneous.	Qualitative assessment of efforts to improve energy efficiency. This includes efficient management of the network, but also efforts to co-ordinate with different parts of the value chain to improve efficiency for the end user.	
ENV.ed.9	**Work carried out to adapt to/prepare for climate change**	Action, Contemporaneous.	Qualitative assessment of improvements to network resilience to prepare for climate change.	Links to reliability
ENV.ed.10	**Research and development, demonstration, and trialling of new technologies**	Information/ Engagement/ Action, Contemporaneous.	Qualitative assessment of efforts to develop new approaches to managing networks that deliver carbon emissions reductions (e.g. through increasing efficiency, facilitating growth in low carbon generation and demand reduction technologies, or encouraging desired behaviour changes in customers and other network users).	

Table 14. Environment, Gas Distribution

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
ENV.gd.1	**Carbon footprint**	Realisation, Contemporaneous.	Quantitative assessment of GDN direct environmental impact in terms of carbon emissions.	
ENV.gd.2	**Shrinkage**	Realisation, Contemporaneous.	Quantitative assessment of GDN direct environmental impact relating specifically to shrinkage.	
ENV.gd.3	**Other environmental emissions**	Realisation, Contemporaneous.	Quantitative assessment of GDN direct environmental impact in terms of gas leaks.	
ENV.gd.4	**Other network non-GHG emissions (e.g. noise and dust)**	Realisation, Contemporaneous.	Measures environmental impacts other than greenhouse gas emissions.	
ENV.gd.5	**Connection of new small-scale plant to act as back-up for intermittent renewable generation**	Action, Contemporaneous.	Quantitative measure of connections to provide reserve generation capacity for intermittent wind	
ENV.gd.6	**Work carried out to adapt to/prepare for climate change**	Action, Contemporaneous.	Qualitative assessment of improvements to network resilience to prepare for climate change.	Links to reliability
ENV.gd.7	**Research and development, demonstration, and trialling of new technologies**	Information/ Engagement/ Action, Contemporaneous.	Qualitative assessment of efforts to develop new approaches to managing networks that deliver carbon emissions reductions (e.g. through increasing efficiency, facilitating growth in low carbon generation and demand reduction technologies, or encouraging desired behaviour changes in customers and other network users).	

Table 15. Environment, Electricity Transmission

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
ENV.et.1	**Number of low carbon generation connections**	Action, Contemporaneous.	Quantitative assessment of effort to connect low carbon generation	
ENV.et.2	**MWh of low carbon electricity flowing through network**	Realisation, Contemporaneous.	Quantitative measure of success in facilitating low carbon generation	
ENV.et.3	**Conditions for connection outputs, including CON.et.1-6 and 12.**	See Conditions for Connection.	Collectively measure the extent to which a TO is acting as a barrier to deployment of distributed generation.	Links from conditions for connection
ENV.et.4	**Carbon footprint**	Action, Contemporaneous.	Measures TO efforts to reduce direct impact on the environment through greenhouse gas emissions.	
ENV.et.5	**Losses**	Realisation, Contemporaneous.	Quantitative measure of TO performance on reducing losses	
ENV.et.6	**SF_6 emissions**	Realisation, Contemporaneous.	Quantitative measure of TO performance on reducing SF_6 emissions	
ENV.et.7	**Other network emissions (e.g. noise and dust)**	Realisation, Contemporaneous.	Measures environmental impacts other than greenhouse gas emissions.	
ENV.et.8	**Adopting best practice energy efficiency measures**	Action/ Engagement, Contemporaneous.	Qualitative assessment of efforts to improve energy efficiency. This includes efficient management of the network, but also efforts to co-ordinate with different parts of the value chain to improve efficiency for the end user.	
ENV.et.9	**Work carried out to adapt to/prepare for climate change**	Action, Contemporaneous.	Qualitative assessment of improvements to network resilience to prepare for climate change.	Links to reliability
ENV.et.10	**Research and development, demonstration, and trialling of new technologies**	Information/ Engagement/ Action, Contemporaneous.	Qualitative assessment of efforts to develop new approaches to managing networks that deliver carbon emissions reductions (e.g. through increasing efficiency, facilitating growth in low carbon generation and demand reduction technologies, or encouraging desired behaviour changes in customers and other network users).	

Table 16. Environment, Gas Transmission

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
ENV.gt.1	**Carbon footprint**	Realisation, Contemporaneous.	Quantitative assessment of NGG direct environmental impact in terms of carbon emissions.	
ENV.gt.2	**NO_X emissions**	Realisation, Contemporaneous.	Quantitative assessment of NGG direct environmental impact in terms of NO_X emissions.	
ENV.gt.3	**Other network emissions (e.g. noise and dust)**	Realisation, Contemporaneous.	Measures environmental impacts other than greenhouse gas emissions.	
ENV.gt.4	**Work carried out to adapt to/prepare for climate change**	Action, Contemporaneous.	Qualitative assessment of improvements to network resilience to prepare for climate change.	Links to reliability
ENV.gt.5	**Research and development, demonstration, and trialling of new technologies**	Information/ Engagement/ Action, Contemporaneous.	Qualitative assessment of efforts to develop new approaches to managing networks that deliver carbon emissions reductions (e.g. through increasing efficiency, facilitating growth in low carbon generation (e.g. CCS) and demand reduction technologies, or encouraging desired behaviour changes in customers and other network users).	

Customer satisfaction

Table 17. Customer Satisfaction, Electricity Distribution

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
CS.ed.1	**Guaranteed standards of performance**	Action/ Engagement/ Information, Contemporaneous.	Quantitative and qualitative assessment of whether DNOs meet minimum service standards for a variety of activities.	
CS.ed.2	**Customer satisfaction survey**	Action/ Engagement/ Information, Contemporaneous.	Broad measure of customer perception of DNO performance. Forms part of the 'broad measure of customer satisfaction'.	
CS.ed.3	**Complaints metric focusing on unresolved or repeated complaints**	Action, Contemporaneous.	Quantitative measure of DNO performance in resolving disputes. Forms part of the 'broad measure of customer satisfaction'	
CS.ed.4	**Stakeholder engagement metric focusing on all stakeholder views of the DNO approach to engagement**	Engagement, Contemporaneous.	Measure of DNO efforts to understand needs of consumers. Forms part of the 'broad measure of customer satisfaction'	
CS.ed.5	**Telephony performance**	Engagement, Contemporaneous.	Quantitative measure of ease of customer communication with network, and satisfaction with that communication.	
CS.ed.6	**Activities captured under the Customer service reward scheme**	Information/Action, Contemporaneous.	Scheme is focused on wider communications strategies, priority customer care initiatives and corporate social responsibility, with emphasis on communication with worst served customers and approach to understanding customer needs and responding to these.	
CS.ed.7	**Voltage metric**	Action, Contemporaneous.	Measure of quality of product supplied.	
CS.ed.8	**Site work (e.g. including response time, advance warning given, level of disruption and disturbance)**	Action, Contemporaneous.	Qualitative assessment of inconvenience caused to customers as a result of site works and quality of communication regarding site works.	
CS.ed.9	**Proactivity in piloting new service offerings, including provision of information and support**	Engagement, Contemporaneous,	Qualitative measure of responsiveness to consumer demand for new services (e.g. facilitating deployment of smart meters/electric cars/distributed generation).	
CS.ed.10	**Reliability measures including REI.ed.1-4**	See reliability	Collectively measure the impact on customers of network reliability.	Links from reliability
CS.ed.11	**Conditions for connection measures including CON.ed.1, 2, 8-12, and 14.**	See conditions for connection	Collectively measure the impact of connections on customer satisfaction	Links from conditions for connection

Table 18. Customer Satisfaction, Gas Distribution

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
CS.gd.1	**Guaranteed standards of performance**	Action, Contemporaneous.	Assessment of whether GDNs are complying with licence obligations for minimum customer standards on a range of activities.	
CS.gd.2	**Customer satisfaction survey results**	Action, Contemporaneous.	Broad measure of customer satisfaction with GDN performance.	
CS.gd.3	**Stakeholder engagement**	Engagement, Contemporaneous.	Qualitative assessment of DNO efforts to understand needs of consumers.	
CS.gd.4	**% of complaints responded to within prescribed timescales**	Action, Contemporaneous.	Measure of ease and quality of customer communications	
CS.gd.5	**% of reinstatement jobs completed within prescribed timescales**	Action, Contemporaneous.	Measure of ease of, and satisfaction with, reinstatement jobs.	
CS.gd.6	**Site work metric (level of disruption and disturbance, advance warning given etc.)**	Action, Contemporaneous.	Measure of inconvenience caused to customers as a result of site works and quality of communication with customer regarding planned interruptions.	
CS.gd.7	**Response times to phone calls**	Action, Contemporaneous,	Measure of ease of customer communications.	
CS.gd.8	**Gas specification/ composition**	Action, Contemporaneous,	Measure of quality of product	
CS.gd.9	**Proactivity in piloting new service offerings, including provision of information and support**	Action/ Engagement, Contemporaneous.	Measure of responsiveness to consumer demand for new services (e.g. facilitating deployment of smart meters).	
CS.gd.10	**Reliability measures including REl.gd.1-4**	See reliability	Collectively measure the impact on customers of network reliability.	Links from reliability
CS.gd.11	**Conditions for connection measures including CON.gd.1-7**	See conditions for connection	Collectively measure the impact of connections on customer satisfaction	Links from conditions for connection

Table 19. Customer Satisfaction, Electricity Transmission

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
CS.et.1	**Conditions for connection outputs, including CON.et.1-12**	See conditions for connection.	Collectively monitor those aspects of TO performance that network users care about.	Links from conditions for connection
CS.et.1	**Reliability outputs, including REL.et.1, 5 and 6**	See reliability.	Collectively monitor those aspects of TO performance that network users care about.	Links from reliability

Table 20. Customer Satisfaction, Gas Transmission

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
CS.gt.1	**Conditions for connection outputs, including CON.gt.1-2**	See conditions for connection.	Collectively monitor those aspects of NGG performance that network users care about.	Links from conditions for connection
CS.gt.2	**Reliability outputs, including REL.gt.1 and 5**	See reliability.	Collectively monitor those aspects of NGG performance that network users care about.	Links from reliability

Safety

Table 21. Safety, Electricity Distribution

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
SAF.ed.1	**Comply with health and safety legislation**	Action, Contemporaneous.	High-level check on whether safety obligations are being met. DNOs must be compliant with minimum health and safety standards as set out in legislation and regulations, including the Electricity Safety, Quality and Continuity Regulations 2002.	Links to network-related social obligations.
SAF.ed.2	**Number of infringement proceedings**	Action, Leading.	In order to assess whether safety performance might be compromised in the near future, Ofgem might monitor over time the number of infringement proceedings that are brought against a network. Were this to increase significantly, it might indicate that safety performance is slipping.	Links to network-related social obligations.

Table 22. Safety, Gas Distribution

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
SAF.gd.1	**Compliance with health and safety legislation**	Action, Contemporaneous.	High-level check on whether safety obligations are being met. Under the Gas Safety (Management) Regulation, gas conveyors are required to produce a Safety Case which describes arrangements for managing the safety of the gas networks[28]. This includes plans for iron mains replacement[29], and targets for response times for emergencies. Other relevant safety obligations are included in the Control of Major Accident Hazard (COMAH) Regulations and Pipeline Safety Regulations.	Links to network-related social obligations.
SAF.gd.2	**Performance against HSEs "Major Hazards Safety Performance Indicators (SPIs)"**	Action, Leading.	Qualitative leading indicator of safety performance. Major incidents in the UK gas and pipelines industry occur infrequently and as such do not provide sufficient data with which to monitor the sector's safety performance. SPIs are used to monitor trends, and provide assurance that the arrangements to minimise the risk of a major incident are effective. SPIs can be chosen from near-miss data such as low-level incidents or from precursors which might, in combination, give rise to a major incident.	Links to network-related social obligations.
SAF.gd.3	**Emergency testing**	Action, Leading.	HSE oversees industry emergency exercises aimed at testing arrangements for dealing with a potential or actual supply emergency. Potentially, these tests could indicate where a GDN is not sufficiently prepared to deal with emergencies.	Links to network-related social obligations.

28 http://www.hse.gov.uk/gas/supply/emergencies.htm

29 http://www.hse.gov.uk/gas/supply/mainsreplacement/irongasmain.htm

Annexe 1: The long-list of candidate outputs

Table 23. Safety, Electricity Transmission

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
SAF.et.1	**Comply with health and safety legislation**	Action, Contemporaneous.	TOs must be compliant with minimum health and safety standards as set out in legislation and regulations, including the Electricity Safety, Quality and Continuity Regulations 2002.	Links to network-related social obligations.
SAF.et.2	**Number of infringement proceedings**	Action, Leading.	In order to assess whether safety performance might be compromised in the near future, Ofgem might monitor over time the number of infringement proceedings that are brought against a network. Were this to increase significantly, it might indicate that safety performance is slipping.	Links to network-related social obligations.

Table 24. Safety, Gas Transmission

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
SAF.gt.1	**Compliance with legal safety requirements**	Action, Contemporaneous.	High-level check on whether safety obligations are being met. Under the Gas Safety (Management) Regulation, NGG is required to produce a Safety Case which describes arrangements for managing the safety of the gas networks. This includes plans for iron mains replacement, and targets for response times for emergencies. The Safety Case is accepted and subjected to routine inspection by the HSE. NGG also provide HSE, SEPA and EA with a risk assessment in accordance with the Gas Safety (Management) Regulations, Control of Major Accident Hazard (COMAH) Regulations and Pipeline Safety Regulations. The risk assessment is qualitative for the network as a whole, but quantitative for specific sites/locations where required.[30]	Links to network-related social obligations.
SAF.gt.2	**Performance against HSEs "Major Hazards Safety Performance Indicators (SPIs)"**	Action, Leading.	Major incidents in the UK gas and pipelines industry occur infrequently and as such do not provide sufficient data with which to monitor the sector's safety performance. SPIs are used to monitor trends, and provide assurance that the arrangements to minimise the risk of a major incident are effective. SPIs can be chosen from near-miss data such as low-level incidents or from precursors which might, in combination, give rise to a major incident.	Links to network-related social obligations.
SAF.gt.3	**Emergency testing**	Action, Leading.	HSE oversees industry emergency exercises aimed at testing arrangements for dealing with a potential or actual supply emergency.	Links to network-related social obligations.

30 Source: NG, "Gas Transmission – The Development and Maintenance of a Methodology for Network Output Measures".

Conditions for Connection

Table 25. Conditions for connection, Electricity Distribution

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
CON.ed.1	**Guaranteed standards of performance for connections (the 'New Connections Standards')**	Action, Contemporaneous.	A broad range of activities are covered by the minimum standards for the connections process. Includes standards for provision of budget estimates, quotations, price accuracy, scheduling of work, and agreed timescales for completion.	Feeds into environmental, social obligations, and customer satisfaction outputs.
CON.ed.2	**Appropriate access terms (i.e. standardised, efficient, effective, timely, accurate, transparent and non-discriminatory)**	Action/ Information, Contemporaneous.	Access terms should be appropriate for providing easy access.	Feeds into environmental, social obligations, and customer satisfaction outputs.
CON.ed.3	**Number of DG connections as % of connection requests**	Action, Contemporaneous.	Quantitative measure of DNO performance on completing connections on the supply side.	Feeds into environmental outputs.
CON.ed.4	**Average speed of response to DG connections requests**	Action, Contemporaneous.	Quantitative measure of speed of response to connection requests	Feeds into environmental outputs.
CON.ed.5	**Average time taken between DG connection request and completion of connection**	Action, Contemporaneous.	Quantitative measure of efforts to reduce delays to connecting DG	Feeds into environmental outputs.
CON.ed.6	**Engagement and consultation of distributed generators (e.g. consultation on investment plans)**	Engagement, Contemporaneous.	Qualitative assessment of DNO efforts to engage generators in relation to connections	Feeds into environmental outputs.
CON.ed.7	**Availability of simple, accessible and reliable information for connecting DG (e.g. the DG connections guide)**	Information, Contemporaneous.	Qualitative assessment of DNO efforts to facilitate connection of DG, particularly given that some microgen customers are likely to have very different levels of knowledge and experience than normal generator connections.	Feeds into environmental outputs.
CON.ed.8	**Number of customer connections as % of connection requests**	Action, Contemporaneous.	Quantitative measure of DNO performance on completing connections on the demand side.	Feeds into customer satisfaction.
CON.ed.9	**Average speed of response to customer connections requests**	Action, Contemporaneous.	Quantitative measure of speed of response to connection requests	Feeds into customer satisfaction.
CON.ed.10	**Average time taken between customer connection request and completion of connection**	Action, Contemporaneous.	Quantitative measure of efforts to reduce delays to connecting customers	Feeds into customer satisfaction.
CON.ed.11	**Engagement and consultation of customers (e.g. consultation on investment plans)**	Engagement, Contemporaneous.	Qualitative assessment of DNO efforts to engage customers in relation to connections	Feeds into customer satisfaction.
CON.ed.12	**Availability of simple, accessible and reliable information for connecting customers**	Information, Contemporaneous.	Qualitative assessment of DNO efforts to make connections easy and simple for consumers.	Feeds into customer satisfaction.
CON.ed.13	**No. ESCos connected to network**	Action, Contemporaneous.	Assessment of whether network company is a barrier to ESCos	Feeds into environmental outputs.

CON.ed.14	**Support in changing regulatory framework for access terms and connections, to facilitate new business models (e.g. innovative tariff structures, efficient use of smart grid)**	Engagement, Contemporaneous.	Qualitative assessment of support for new business models and deployment of smart grid technologies.	Feeds into environmental and social obligations outputs.

Table 26. Conditions for connection, Gas Distribution

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
CON.gd.1	**Compliance with connection conditions in licence**	Action, Contemporaneous.	Licence conditions contain a number of activities with minimum standards for connection process. Standards include response times to request for a quotation, completion of connections within agreed timescales, response times to land enquiries and time taken to complete connection work.	Feeds into customer satisfaction and social obligations
CON.gd.2	**Appropriate access terms (i.e. standardised, efficient, effective, timely, accurate, transparent and non-discriminatory)**	Action/ Information, Contemporaneous.	Access terms should be appropriate for providing easy access.	Feeds into customer satisfaction and social obligations
CON.gd.3	**Number of connections as % of connection requests**	Action, Contemporaneous.	Quantitative measure of DNO performance on completing connections.	Feeds into customer satisfaction
CON.gd.4	**Average speed of response to connection requests**	Action, Contemporaneous.	Quantitative measure of ease of connecting for customers.	Feeds into customer satisfaction
CON.gd.5	**Average time taken between connection request and completion of connection**	Action, Contemporaneous.	Quantitative measure of efforts to reduce delays to connecting customers	Feeds into customer satisfaction.
CON.gd.6	**Availability of simple, accessible and reliable information regarding connections**	Information, Contemporaneous.	Qualitative assessment of GDN information provision, in order to engage customers and facilitate connections.	Feeds into customer satisfaction
CON.gd.7	**Support in changing regulatory framework for access terms and connections, to facilitate new business models**	Engagement, Contemporaneous.	Qualitative assessment of support for new business models and deployment of smart technologies.	Feeds into customer satisfaction and social obligations

Table 27. Conditions for connection, Electricity Transmission

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
CON.et.1	**Appropriate access terms (i.e. standardised, efficient, effective, timely, accurate, transparent and non-discriminatory)**	Action/ Information, Contemporaneous.	Qualitative assessment of access terms to ensure that they are appropriate for providing easy access.	Feeds into environment, customer satisfaction and social obligations
CON.et.2	**Number of generation connections as % of connection requests**	Action, Contemporaneous.	Quantitative measure of completion of generation connections.	Feeds into environment and customer satisfaction
CON.et.3	**Average speed of response to generator connection requests**	Action, Contemporaneous.	Quantitative measure of speed of response to connection requests	Feeds into environment and customer satisfaction
CON.et.4	**Average time taken between generator connection request and completion of connection**	Action, Contemporaneous.	Quantitative measure of efforts to reduce delays to connecting generation	Feeds into environment and customer satisfaction
CON.et.5	**Engagement and consultation of generators (e.g. consultation on investment plans)**	Engagement, Contemporaneous.	Qualitative assessment of TO engagement efforts with generators, in particular to ensure investment decisions can be made with clear knowledge of current and future network capability	Feeds into environment and customer satisfaction
CON.et.6	**Availability of simple, accessible and reliable information for connecting generators**	Information, Contemporaneous.	Qualitative assessment of TO efforts to facilitate connection of generation.	Feeds into environment and customer satisfaction
CON.et.7	**Number of load connections as % of connection requests**	Action, Contemporaneous.	Quantitative measure of TO performance on completing connections on the demand side.	Feeds into customer satisfaction
CON.et.8	**Average speed of response to load connections requests**	Action, Contemporaneous.	Quantitative measure of speed of response to connection requests	Feeds into customer satisfaction
CON.et.9	**Average time taken between load connection request and completion of connection**	Action, Contemporaneous.	Quantitative measure of efforts to reduce delays to connecting load	Feeds into customer satisfaction
CON.et.10	**Engagement and consultation of load centres (e.g. consultation on investment plans)**	Engagement, Contemporaneous.	Qualitative assessment of TO efforts to engage load centres in relation to connections	Feeds into customer satisfaction
CON.et.11	**Availability of simple, accessible and reliable information for connecting load**	Information, Contemporaneous.	Qualitative assessment of TO efforts to make connections easy and simple for consumers.	Feeds into customer satisfaction
CON.et.12	**Support in changing regulatory framework for access terms and connections, to facilitate new business models (e.g. innovative tariff structures, efficient use of smart grid)**	Engagement, Contemporaneous.	Qualitative assessment of support for new business models and deployment of smart grid technologies.	Feeds into environment, customer satisfaction and social obligations

Table 28. Conditions for connection, Gas Transmission

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
CON.gt.1	**Compliance with licence conditions regarding connections**	Action, Contemporaneous	A variety of licence conditions determine that access terms should be fair and other conditions for connection	Feeds into customer satisfaction
CON.gt.2	**Availability of simple, accessible and reliable information regarding connections**	Information, Contemporaneous.	Qualitative assessment of NGG NTS information provision, in order to engage network users and facilitate connections.	Feeds into customer satisfaction and social obligations

Network related social obligations

Table 29. Social obligations, Electricity Distribution

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
SOC.ed.1	**Provision of services for vulnerable domestic customer groups**	Action, Contemporaneous.	Qualitative assessment of services provided for vulnerable customers. This includes, for example, repositioning of meters for elderly, disabled or sick customers, provision of services that allow blind or deaf consumers to complain/ask about their service, using passwords when visiting vulnerable customers etc.	
SOC.ed.2	**Engagement of vulnerable customers**	Engagement, Contemporaneous.	Qualitative assessment of DNO programmes to understand which customers are vulnerable and how service for them might be improved.	
SOC.ed.3	**Provision of replacement facilities to vulnerable customers in the event of interruptions.**	Action, Contemporaneous.	In order to understand whether DNOs are able to protect vulnerable customers that might rely on electricity supply (e.g. elderly with electric heating, those that might need equipment for a medical condition etc.)	
SOC.ed.4	**Number of 'worst-served' customers**	Action, Contemporaneous.	Quantitative measure to be used to measure DNO efforts over time to reduce the number of worst-served customers.	Links to reliability and customer satisfaction
SOC.ed.5	**Speed of provision of meter registration data for change of supplier**	Information, Contemporaneous.	Quantitative measure of DNO efforts to facilitate easy switching.	
SOC.ed.6	**Accuracy of data provided to alternative suppliers**	Information, Contemporaneous.	Quantitative measure of DNO efforts to facilitate easy switching.	
SOC.ed.7	**Speed and accuracy of provision of data to support settlement**	Information, Contemporaneous.	Quantitative measure of efforts to facilitate efficient functioning of settlement	
SOC.ed.8	**Response to civil emergencies or defence crises**	Action, Contemporaneous.	Qualitative assessment of DNO performance in the event of, for example, severe floods, terrorist attack, or other situations of force majeure.	
SOC.ed.9	**Environmental outputs including ENV.ed.1-3, and 5-10**	See environmental	Collectively measure DNO performance on social obligations towards the environment and facilitating move to low-carbon energy sector.	Links from environmental outputs
SOC.ed.10	**Conditions for connection outputs including CON.ed.1-14**	See conditions for connection	Contribute towards assessing DNO performance on social obligations to facilitate competition and to facilitate move to low-carbon energy sector.	Links from conditions for connection outputs
SOC.ed.11	**Reliability outputs including REL.ed.1-7**	See reliability	Collectively measure DNO efforts to ensure security of supply.	Links from reliability outputs
SOC.ed.12	**Safety outputs including SAF.ed.1**	See safety	Collectively measure DNO performance on safety	Links from safety outputs

Table 30. Social obligations, Gas Distribution

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
SOC.gd.1	**Provision of services for vulnerable domestic customer groups**	Action, Contemporaneous.	Potentially quantitative assessment of responsibilities towards vulnerable customers. For example repositioning of meters for elderly, disabled or sick customers, provision of services that allow blind or deaf consumers to complain/ask about their service, using passwords when visiting vulnerable customers.	
SOC.gd.2	**Engagement of vulnerable customers**	Information/ Engagement, Contemporaneous.	Qualitative assessment of GDN programmes to understand which customers are vulnerable and how service for them might be improved.	
SOC.gd.3	**Provision of replacement facilities to vulnerable customers in the event of interruptions.**	Action, Contemporaneous.	Assessment of whether GDNs are able to protect vulnerable customers that might rely on gas supply (e.g. elderly with gas heating)	
SOC.gd.4	**Number of 'worst-served' customers**	Realisation, Contemporaneous.	Quantitative measure to be used to measure GDN efforts over time to reduce the number of worst-served customers.	
SOC.gd.5	**Gas network extensions to fuel-poor communities**	Action, Contemporaneous.	Quantitative measure of extensions of gas network to alleviate fuel poverty for vulnerable rural customers.	
SOC.gd.6	**Speed of provision of meter registration data for change of supplier**	Action, Contemporaneous.	Quantitative measure of GDN efforts to facilitate easy switching.	
SOC.gd.7	**Accuracy of data provided to alternative suppliers**	Information, Contemporaneous.	Quantitative measure of GDN efforts to facilitate easy switching.	
SOC.gd.8	**Speed and accuracy of provision of data to support settlement**	Information, Contemporaneous.	Quantitative measure of efforts to facilitate efficient functioning of settlement	
SOC.gd.9	**Response to civil emergencies or defence crises**	Action, Contemporaneous.	Qualitative assessment of GDN performance in the event of, for example, severe floods, terrorist attack, or other situations of force majeure.	
SOC.gd.10	**Environmental outputs including ENV.gd.1-7**	See environmental	Collectively measure GDN performance on social obligations towards the environment and facilitating move to low-carbon energy sector.	Links from environmental outputs
SOC.gd.11	**Conditions for connection outputs including CON.gd.1-7**	See conditions for connection	Contribute towards assessing GDN performance on social obligations to facilitate competition and to facilitate move to low-carbon energy sector.	Links from conditions for connection outputs
SOC.gd.12	**Reliability outputs including REL.gd.1-6**	See reliability	Collectively measure GDN efforts to ensure security of supply.	Links from reliability outputs
SOC.gd.13	**Safety outputs including SAF.gd.1-3**	See safety	Collectively measure GDN performance on safety	Links from safety outputs

Table 31. Social obligations, Electricity Transmission

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
SOC.et.1	**Speed of provision and accuracy of data to support settlement**	Information, Contemporaneous.	Quantitative measure of TO efforts to facilitate efficient functioning of settlement and competition in the wholesale market.	
SOC.et.2	**Provision of long-term demand forecasts**	Information, Leading.	Ensures that TOs are planning sufficiently in advance to ensure that security of supply is maintained.	
SOC.et.3	**Response to civil emergencies or defence crises**	Action, Contemporaneous.	Qualitative assessment of TO performance in the event of, for example, severe floods, terrorist attack, or other situations of force majeure.	
SOC.et.4	**Environmental outputs including ENV.et.1-10**	See environmental	Collectively measure TO performance on social obligations towards the environment and facilitating move to low-carbon energy sector.	Links from environmental outputs
SOC.et.5	**Conditions for connection outputs including CON.et.1-12**	See conditions for connection	Contribute towards assessing TO performance on social obligations to facilitate competition and to facilitate move to low-carbon energy sector.	Links from conditions for connection outputs
SOC.et.6	**Reliability outputs including REL.et.1-6**	See reliability	Collectively measure TO efforts to ensure security of supply.	Links from reliability outputs
SOC.et.7	**Safety outputs including SAF.et.1**	See safety	Collectively measure TO performance on safety	Links from safety outputs

Table 32. Social obligations, Gas Transmission

Reference No.	Output	Type of indicator	Motivation	Overlaps with other output categories
SOC.gt.1	**Speed of provision and accuracy of data to support settlement**	Information, Contemporaneous.	Quantitative measure of NGG efforts to facilitate efficient functioning of, and competition in, the wholesale market.	
SOC.gt.2	**Provision of long-term demand forecasts**	Information, Leading.	Ensures that NGG is planning sufficiently in advance to ensure that security of supply is maintained.	
SOC.gt.3	**Response to civil emergencies or defence crises**	Action, Contemporaneous.	Qualitative assessment of NGG performance in the event of, for example, severe floods, terrorist attack, or other situations of force majeure.	
SOC.gt.4	**Environmental outputs including ENV.gt.1-5**	See environmental	Collectively measure NGG performance on social obligations towards the environment and facilitating move to low-carbon energy sector.	Links from environmental outputs
SOC.gt.5	**Conditions for connection outputs including CON.gt.1-2**	See conditions for connection	Contribute towards assessing NGG performance on social obligations to facilitate competition and to facilitate move to low-carbon energy sector.	Links from conditions for connection outputs
SOC.gt.6	**Reliability outputs Reliability outputs including REL.gt.1-5**	See reliability	Collectively measure NGG efforts to ensure security of supply.	Links from reliability outputs
SOC.gt.7	**Safety outputs including SAF.gt.1-3**	See safety	Collectively measure NGG performance on safety.	Links from safety outputs

FRONTIER ECONOMICS EUROPE
BRUSSELS | COLOGNE | LONDON | MADRID

Frontier Economics Ltd 71 High Holborn London WC1V 6DA
Tel. +44 (0)20 7031 7000 Fax. +44 (0)20 7031 7001 www.frontier-economics.com