Annex NGET_A14.04_ITOMS December 2019

As a part of the NGET Business Plan Submission

nationalgrid

RIIO-T2

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Electricity Transmission

NGET_A14.04_ITOMS

Value For Money
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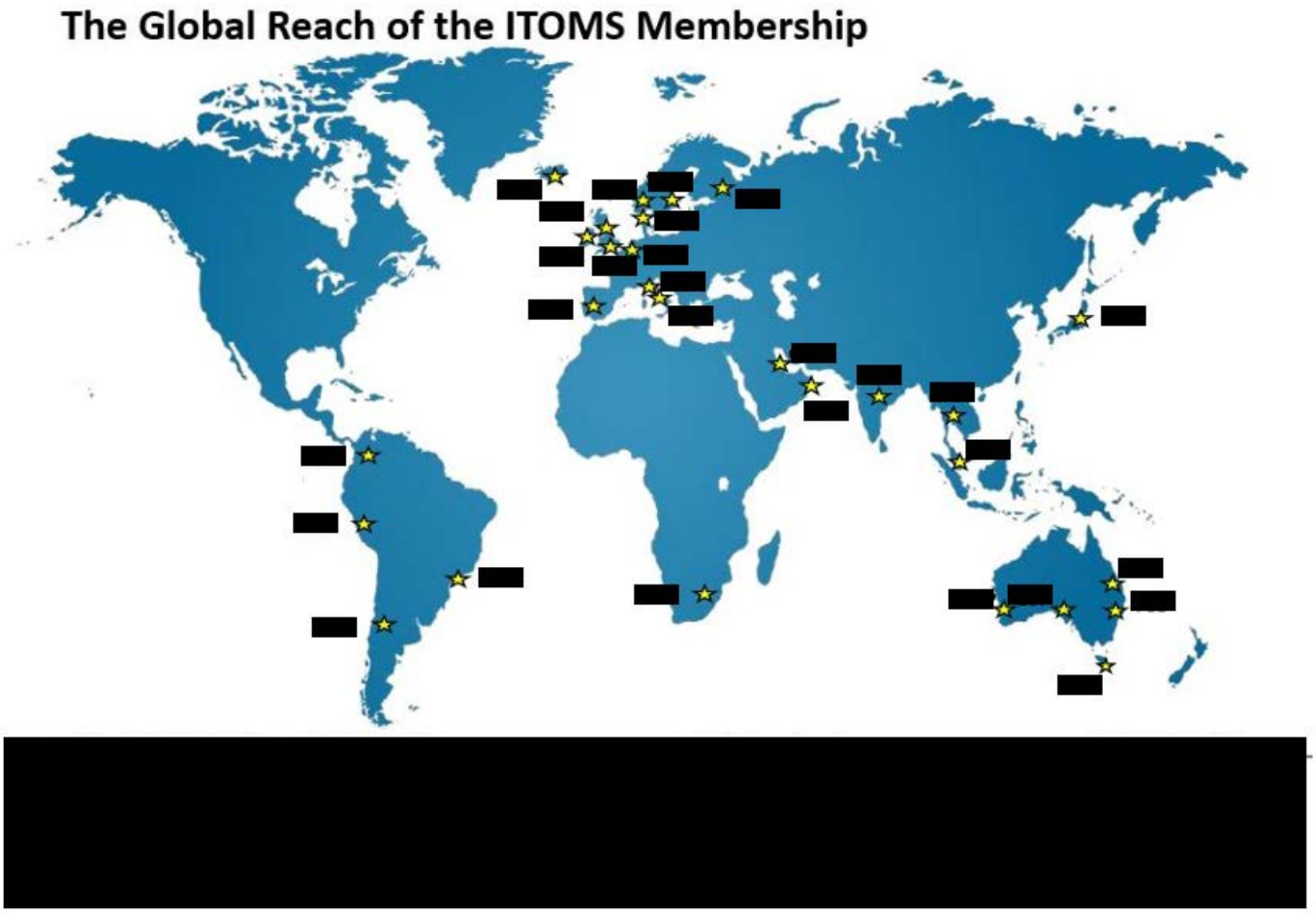
A Summary of ITOMs Benchmarking

Since 1994, we have been engaging in benchmarking activities comparing our costs and maintenance activities with organizations across the globe. Benchmarking is a licence obligation and the use of benchmarking to support continuous improvements is a feature in ISO 55000.

Our existing direct opex benchmarking is based on ITOMs (International Transmission Operational Maintenance Study). The study covers inspections, maintenance and repair activities; it is beginning to capture asset replacement activities and trialled overhead lines capital investments in the 2017 submission as a development module.

The ITOMS program is a closed confidential forum where more than 31 companies representing 25% of electricity transmitted across the globe share information, practices, policies, processes and plans to compare efficiency, system performance and operational costs.



The participants operate in diverse environments - regulatory, economic, environmental and otherwise. This diversity serves to benefit the group, as different companies bring very different ideas and practices to the table, which can often be beneficial to all.

Data is normalised for cost of labour, currency, categorisation of equipment, and any other variables to ensure valid “like-for-like” comparisons. Intercompany communication and two-way sharing is supported and actively encouraged.

The ITOMS benchmarking exercise takes place every two years and is managed by a consultancy group called the UMS group, on behalf of the consortium under the direction of the ITOMS Steering Group. UMS Group is a consultancy whose expertise lies in performance measurement of the electric utility industry. Data collection is scheduled over a five- to seven-month period. Historically, this has allowed participants sufficient time to collect data and, if they preferred, to use the most relevant financial year (as opposed to a strict calendar year). Data validation is directed across all participants by the UMS group.

Overall, we benefit from benchmarking. The examples included below will highlight how comparing and measuring performance with other TSOs enables us to:

- Stimulate cost and performance improvements
- Discover better practices and asset-related strategies which appear to hold the most promise
- Demonstrate our current performance and business context to ourselves and our regulator
- Observe emerging industry problems and trends
- Test potential changes in our asset strategies

NGET Performance analysis

The benchmarking results show that we consistently have higher than average reliability and better than average safety performance. The benchmarking places much of our plant and substation performance in the upper half of the benchmarking study, with one of the best in the study with respect to MWhr not served.

We deliver an overall maintenance programme at a slightly higher than average study cost. The study indicates that NGET has one of the oldest asset bases in the study and, in the case of circuit-breakers, retains air-blast and oil technologies which most other utilities have already replaced. This type of decision is based on achieving whole life value and it should be noted that the ITOMS focus on opex does not give a full picture of how we may balance opex and capex to deliver the best whole life value.

We have specific practices identified in the study which may impact the way costs are reflected against us in the study including:

System Design Philosophy. NGET designs, operates, and maintains a transmission system to the National Electricity System (NETS) Security and Quality of Supply Standards (SQSS), which embodies an N-2 security standard. This means that we have redundancy in the design of our network, which enables us to tolerate higher levels of unavailability of plant or assets than other networks because this would not affect the service seen by customers and consumers. In the study, 77% of the peer group report that all or a significant proportion of their system is N-1. This results in NGET having a larger asset base to meet the same system peak load compared to much of the peer group. While this approach results in higher end-customer reliability (see Figure 1), it also means that NGET, with more assets, has a higher overall maintenance work load per MWhr transmitted. While the maintenance normalization will adjust for this (as the comparison is based on an adjusted cost per equivalent asset), there will be a modelling impact for NGET where non-plant assets such as site care are likely to come out at a higher cost.

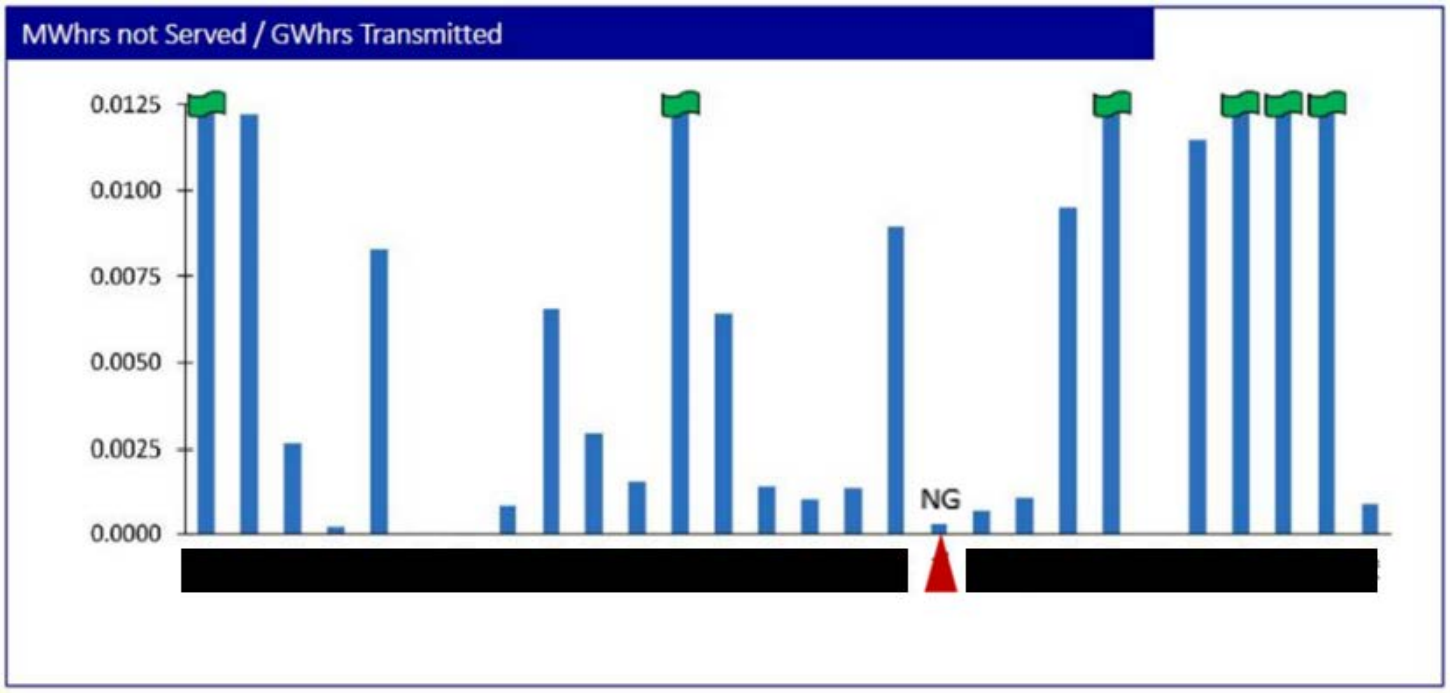


Figure 1: NGET Energy not served

Safety and Wellbeing. Our safety and wellbeing philosophy incurs more cost associated with work delivery as we make work areas safe. NGET is required by UK legislation to provide facilities in substations but this is not a requirement for most of the peer group, namely: -

- Kitchens complete with cooking facilities
- Toilet, eating & changing facilities complete with wastewater facilities
- Water storage facilities for potable water and firefighting facilities
- Oil containment civils
- Emergency diesels for back up emergency station power when both the primary and alternate station power supplies fail

Rights of Way. We have wayleave agreements to retain and operate overhead lines on third-party land for over 60% of the network, whereas 90% of the peer group secure permanent easements. The impact of this is discussed later.

[redacted]

All utilities within the study group have areas of leading performance and areas for improvement but this overview demonstrates that, at the highest level, we continue to progress in line with global industry performance norms. NGET is a leading performer compared to the other European companies (note that the definition of Europe used for ITOMS excludes the Scandinavian companies).

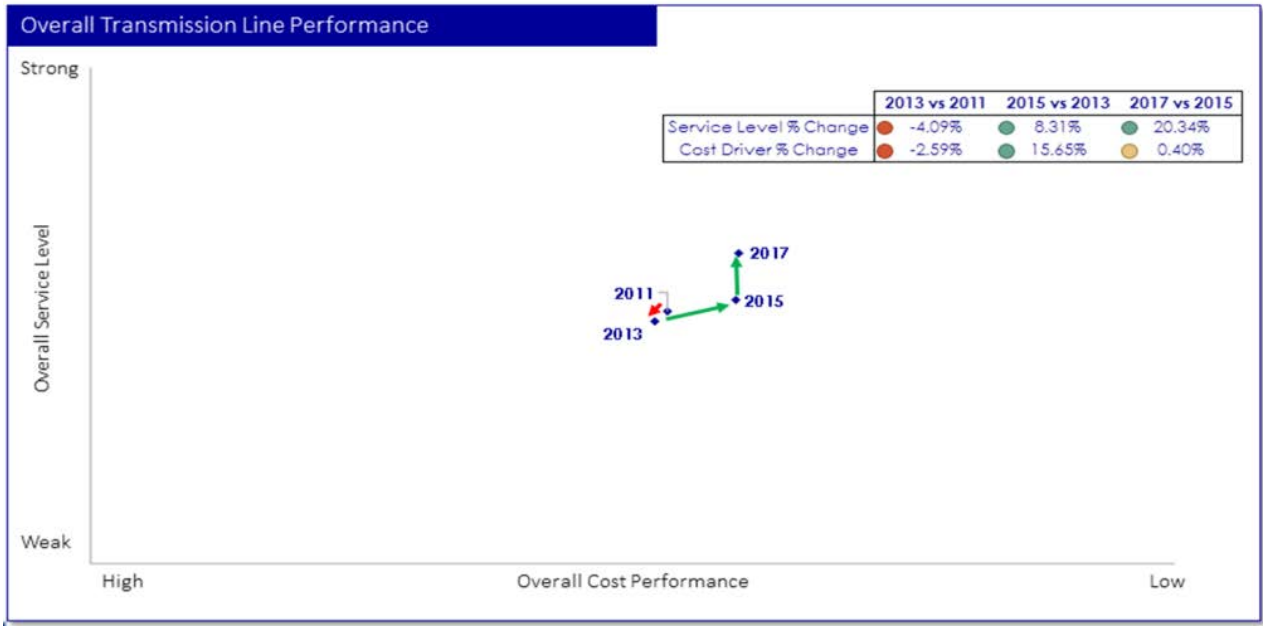


Figure 2: NGET Overall Transmission Line Performance, 2011-2017

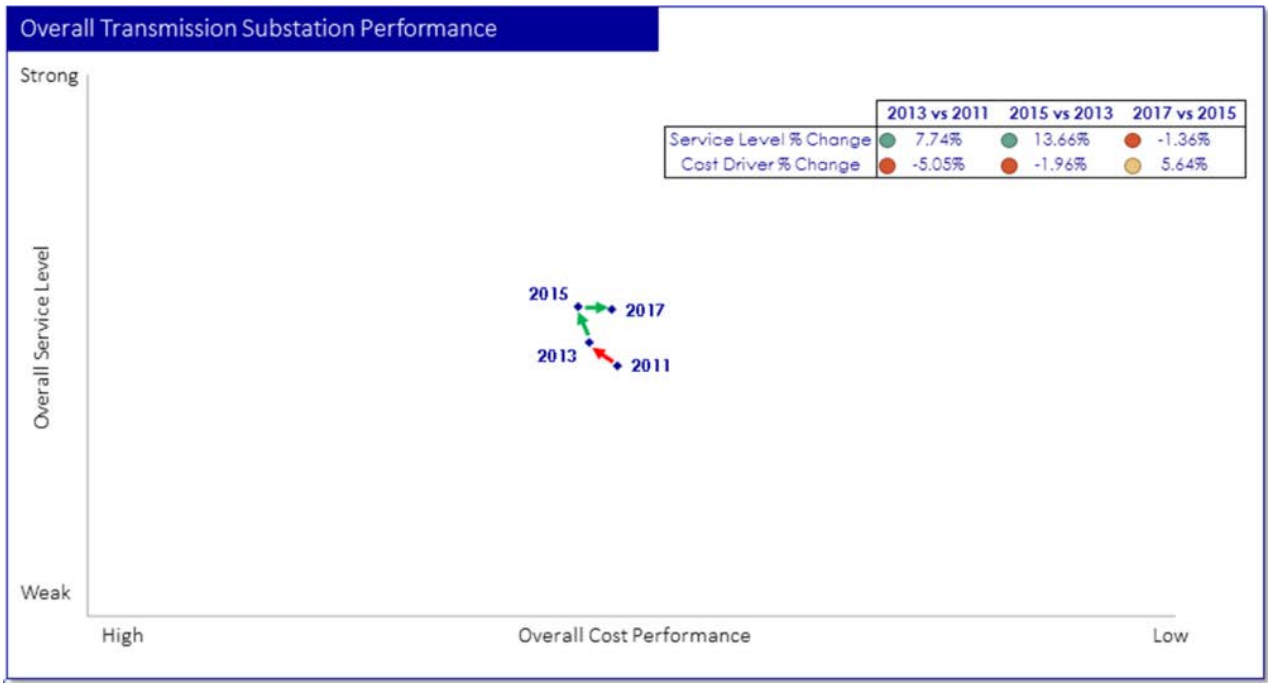


Figure 3: NGET Overall Transmission Substation Performance, 2011-2017

NGETs composite performance relative to other 2017 ITOMS members in specific asset and activity categories is shown in Figure 4 which demonstrates generally high levels of performance with a wide spread of costs.

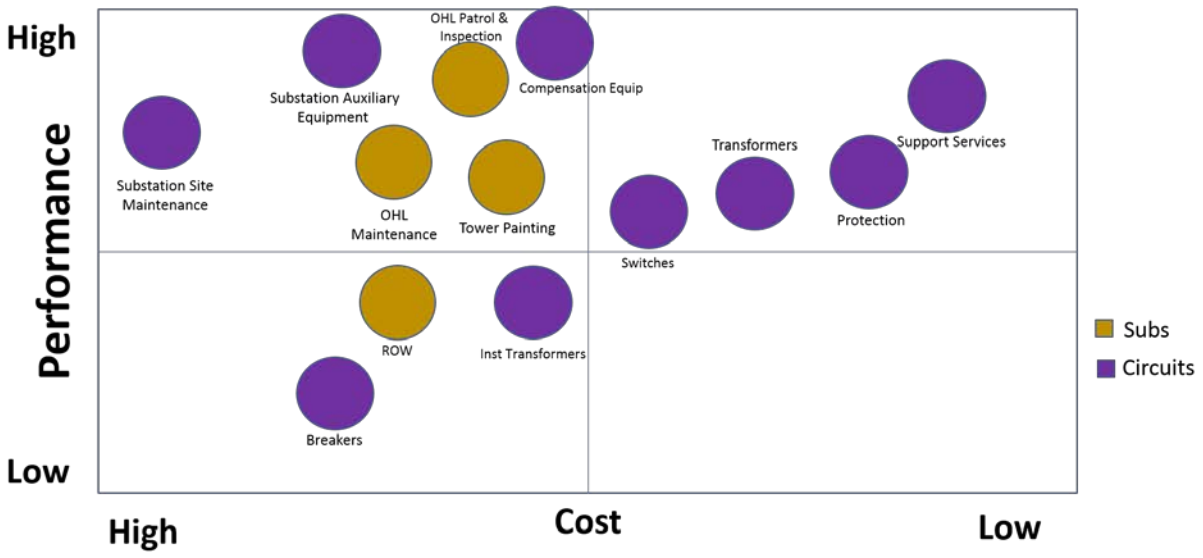


Figure 4: NGET Overall Performance by Asset and Activity Classes

We have been consistent high performance, low cost performers for transformers, switches (disconnectors and switches) and protection since the 2011 benchmarking cycle.

For all transmission assets except circuit breakers and instrument transformers, we are in the high-performance category. Substation site care (maintenance) has consistently been a high cost, high performance item. Our ROW (Right of Way) maintenance has consistently been a relatively high cost.

The following sections provide additional information around specific key aspects of our recent ITOMS performance.

Transformers, Protection, Switches, Support Services (low cost, high performance)

In order to maintain our position of low cost, high performance in respect of transformers, protection, switches and support services, we have continued to innovate and adopt best practices. Transformers is an example where our results show costs lower than the average European performance. In line with the best performers, we carry out routine transformer oil monitoring, off-line and on-line condition monitoring and dissolved gas in oil checks.

Where fitted, the tap-changer is checked for performance at 3-yearly intervals or number of tap-changer operations; the 3-yearly period is more frequent than the 6-year international practice. An intrusive maintenance is planned at 6 or 9 years driven by tap-changer duty or other condition triggers. Again the 9-year interval is more frequent than the international 11-year average internal practice. Should a transformer unit become a

cause for concern, on-line condition monitoring equipment is fitted to determine the cause of the problem or ultimately aid the decision to replace the unit.

We have developed a transformer strategic spares holding per family based on a risk and cost optimisation analysis. At an average of just under 3 transformers per 100 in service, the number held is low compared to the study average of over 5. Given the average age of its transformer population, NGET's maintenance approach is viewed as efficient and effective.

Tower Painting (high cost, high service)

We conduct rigorous value assessments to review our maintenance policies. An example of this is tower painting. Most companies in the study do not need to carry out this activity. The reasons for this vary. Some of the companies utilise predominately wood or concrete structures and only use steel on special dead-end or corner structures. Others utilise self-supporting steel with special coatings which protect the structure from rusting issues. Other companies are not in an environment that is prone to deteriorating the structure, whereas we operate on a temperate island; 'time of wetness' is a key driver of corrosion, as is proximity to coastal (saline) pollution. In almost all cases, companies plan to replace the structures in thirty to fifty years. We have a policy of maintaining the structure for an 80-year life. This requires that additional maintenance on the structures be performed throughout the life of the structure to ensure that the planned life is achieved.

We have undertaken two studies to review, challenge and justify our tower painting policy which have concluded that the optimum economic period to paint towers is between 15 to 20 years in England and Wales. We presented our findings at the ITOMS conference and some utilities have engaged directly to learn from our painting policy and practices. It is expected this trend will continue internationally as asset bases age.

Instrument Transformers (low performance, high cost)

Prior to and during T1, end-of-life management of our instrument transformer fleet has been fundamentally reactive, evidenced by a relatively high number of short-notice, emergency replacements. With unplanned outages as the key performance indicator within ITOMS, this approach results directly in a low performance score for this asset family. Further, managing a fleet of older assets approaching their predicted end-of-life with known deterioration issues incurs higher costs in terms of more frequent maintenance, condition assessment and, in some cases, hazard management. These costs have materialised in the T1 period. During T2, we will develop our asset management philosophy for these assets to move away from a predominantly reactive approach to a more proactive method. As described in the justification reports for instrument transformers and condition monitoring, we plan to improve our condition monitoring, forensic and diagnostic capabilities to provide better end-of-life prediction capability, reduce costs and improve performance. More accurate predictive capability of the onset and evolution of deterioration for these assets will allows us to better plan interventions and, potentially, further develop our monetised risk approach.

Circuit-breakers (low performance, high cost)

Circuit-breaker performance has reduced over recent benchmarking cycles and reported costs have increased.

High circuit-breaker costs can be attributed to two key factors: cost allocation and higher costs of care for older designs of circuit-breaker. (NB. The operating costs reported into the 2017 ITOMS benchmarking included an element of capital intervention expenditure. Whilst this has been correctly attributed in all financial and regulatory contexts, the ITOMS submission remains out of step with these.)

ITOMS indicates that our circuit breaker maintenance philosophy is in line with other leading utilities, using condition and operational information in addition to diagnostic tools, operational checks and intrusive techniques to optimise planned preventative maintenance. This approach has enabled us to extend maintenance frequencies to longer durations than the study average in all technology types. A risk management approach is taken when planned maintenance cannot be completed according to policy due to other constraints on the network; this is considered good industry practice.

However, we operate circuit breakers over a life of typically 60 years, and strive for an optimal whole lifecycle cost. Newer circuit breakers are replaced on a shorter lifecycle due to their technology design and operational practices. This has resulted in a diverse NGET circuit breaker asset base which covers a range of circuit breaker technology (oil, air, gas). NGET's circuit-breaker fleet has the highest overall percentage of old oil and air-blast circuit-breakers of any ITOMS participant and it is well known that these designs require greater maintenance and intervention than modern SF_6 designs. Whilst there is some attempt within ITOMS to compensate for this using the concept of "equivalent circuit-breakers", this does not fully address the issues associated with aspects such as pressure vessel inspections which are legally mandated.

Asset support requires competencies, skills, knowledge, spares and specialist consumables which should be maintained either by combination of the utility and/or manufacturer. Other companies in the study have a shorter asset life (35 to 40 years) and therefore invest less in maintaining their equipment (opex), but the result is higher capex due to the shorter replacement cycle. Going forwards, we are adopting similar approaches to leading performers in the study by adopting on-line monitoring as standard. We are looking at increasing the deployment of operational breaker timing, SF_6 on-line trending and sensors for other key detectable failure modes. This information may also inform future equipment procurement decisions, strengthening the tie between maintenance experience and procurement activities.

During T1, we have moved away from further refurbishment of the more costly/complex air-blast designs which we expect to reduce the ongoing costs of ownership of our circuit-breaker fleet. This remains an area of focus and initiatives are already underway to critically review maintenance activities for alignment with the recently introduced Failure Mode and Effects Analysis (FMEA) approach and to optimise work delivery to ensure maintenance tasks are relevant, timely and effective.

SF_6 (poor performance, no cost benchmark)

The environmental issues associated with leakage to atmosphere of SF_6 are extensively reported and discussed. ITOMS results [redacted] confirm NGET as a below study average performer in this respect which can be linked to our being an early adopter of gas insulated switchgear technology and having significant populations of such equipment exceeding 25 years old. The ITOMS benchmark, in conjunction with other indicators and drivers, supports initiatives and innovations to reduce the environmental impact of our activities. We already

have substation replacement projects, leak repair initiatives and world-leading technology pilots/early adoptions of SF_6-free equipment aimed at improving our performance in this arena and accelerating widespread adoption of new technologies. We are participating widely in international initiatives and fora to ensure we are the forefront of developments in this field and will continue to use benchmarking to drive improvements in our performance.

Rights of Way (low performance, high cost)

In respect of Rights of Way (ROW)**,** NGET is different to many of the ITOMS cohort due to historical practice established prior to privatisation. We have wayleave agreements to retain and operate overhead lines on third-party land for over 60% of the network, whereas 90% of the peer group secure permanent easements. Since circa 2010, all new NGET overhead lines are secured through easements. The result is higher opex for annual wayleave payments to grantors, than seen by other companies in the peer group. However, these other companies will incur higher capex associated with purchasing land rights. We have 22,000 grantors. When the opportunity arises on the existing network and it is cost-effective to do so, we convert these wayleaves to easements for one-off capex payments.

Vegetation management around overhead lines is also associated with this activity area. We use foot and helicopter patrol data to provide information for the ROW team, both for preventative (planned) and reactive vegetation cutting where this proves necessary. Landowners can demand customised tree trimming regimes, which can be time consuming but is worthwhile to maintain good relationships. Environmentally-friendly techniques are employed, such as the use of approved herbicides and selective forestry techniques. All contractors are professionally qualified arborists and must comply with our safety instructions. These factors make us high cost. However, we adopted industry best practice of using a digital vegetation database since its inception in 2003. This enables us to target inspection activities more efficiently and, together with more-sophisticated growth prediction software, has improved planning of our future vegetation management programme. We are currently developing new Geographic Information Software (GIS) software which further enhance the prediction of vegetation growth and automatically optimise site-cutting visits.

Sharing best practice

We have a great record for innovation and sharing practice with the benchmarking community and have fed back experience as first adopters of the following technologies:

- Operational use of a non-SF_6 gas as insulator for 400kV Gas Insulated Busbar at Sellindge;
- 400kV synthetic ester, heat recovery transformers;
- Insulator installation to allow increased height of power lines over Tyne Crossing;
- Portable ballistic screens to manage hazard zones; and
- Portable earthing devices to increase site safety and deliver operational efficiencies.

During the T1 period, we have hosted best practice benchmarking visits and teleconferences from TSOs from all around the world, including Australia, Brazil, Belgium, Columbia, Croatia, Peru, Spain, Ireland, Netherlands, France, and the USA.

During the 2017 ITOMS conference, we shared the following details with the benchmarking community during the main conference.

Oil Filled & XLPE Cables	Our asset management approach towards the management of Cables addressing faults and corrosion of Cables. The 30 other TSOs will now include more cable-related data in future benchmarks.
Condition Monitoring Portable Trailer	The development and deployment of a tactical maintenance condition monitoring tool portable trailer.
Maintenance Resourcing Model	Our workforce management and planning approach, which ensures we have trained and authorised resource in place to achieve all our maintenance requirements.
Best Practice R&D	Our Innovation Strategy was shared and we presented details of our new high voltage innovation centre at Deeside Substation.

Future Participation

We have agreed to participate in the 2019 ITOMs study and would expect to receive results in 2020.