# ANNEX 15: THE POTENTIAL FOR FRONTIER SHIFT IN ELECTRICITY DISTRIBUTION

Electricity North West Limited
Registered Office:
304 Bridgewater Place,
Birchwood Park,
Warrington,
Cheshire.
WA3 6XG.
Registered no: 2366949 (England)

Oxera

# The potential for frontier shift in electricity distribution

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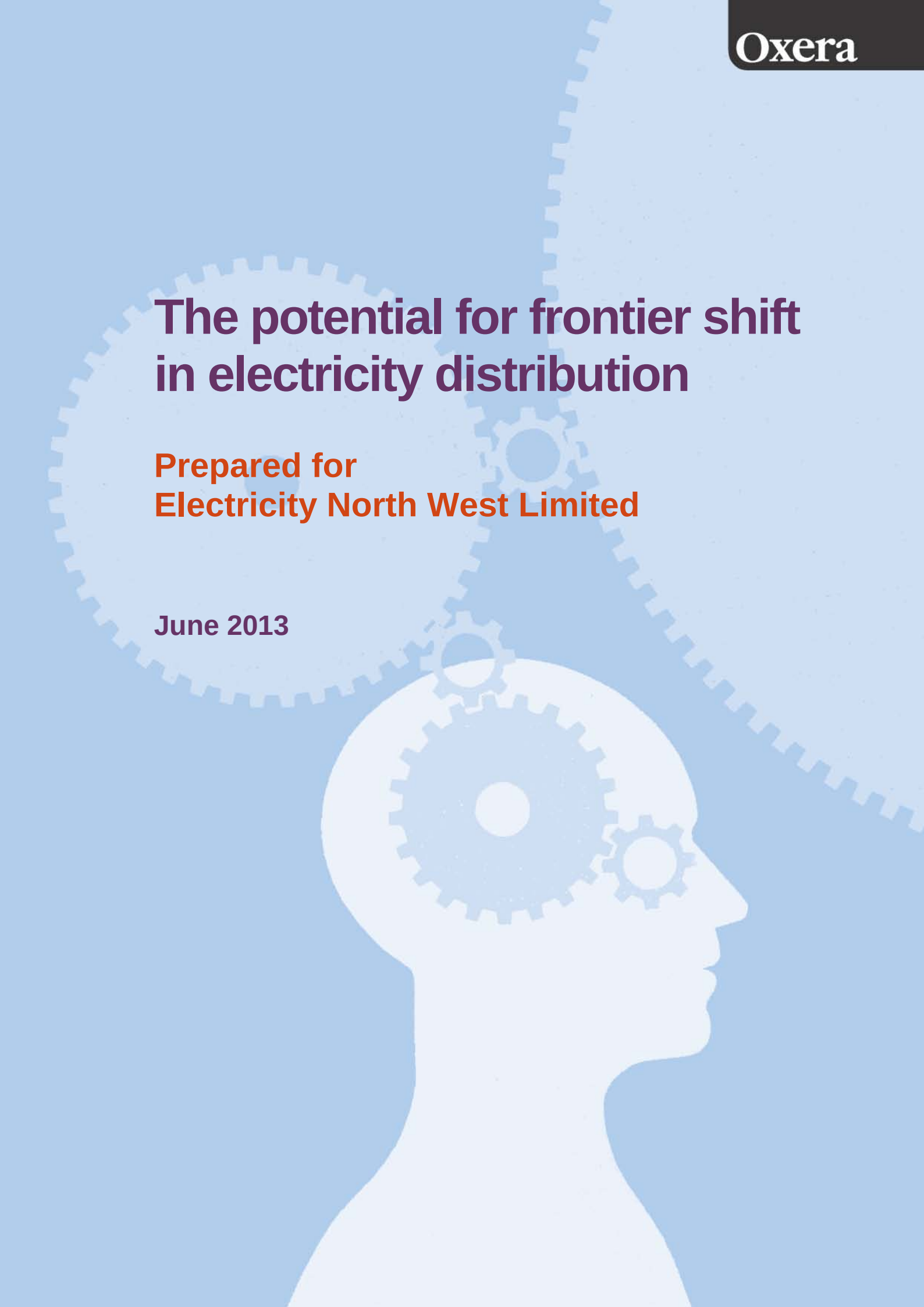

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# Executive summary

In this report, Oxera examines the potential for electricity distribution network operators (DNOs) to improve their efficiency over the RIIO-ED1 period through ongoing efficiency improvements or frontier shift (ie, technological change or new working practices). Two approaches were used for this assessment:

– direct evidence—looking at what DNOs have achieved in terms of net frontier shift in the recent past (ie, the impact of technological change net of input price inflation);

– indirect evidence—looking at what other sectors have achieved in terms of frontier shift in the recent past before any impact of input price inflation is accounted for (the approach used by Ofgem in RIIO-T1 and RIIO-GD1).[1]

The assumption behind both approaches is that the past rate of technological progress is a good indicator of the potential future rate. In addition, the second approach assumes that the rate of technological progress in the benchmark sectors is a good indicator of the rate of technological progress in electricity distribution. Owing to the nature of these indirect comparisons, the robustness of this latter approach is likely to be significantly reduced relative to the former approach. However:

– the indirect comparisons are examined in this report in order to provide a cross-check;

– the direct evidence is currently preliminary as the data and models to be used for RIIO-ED1 have yet to be finalised.

Overall:

– the direct evidence shows a stable frontier (ie, no technological change net of input price inflation);

– the indirect total factor productivity evidence shows a frontier shift of around 0.4–1% per year, with a midpoint of 0.7% (before any impact of input price inflation is accounted for).

These two findings are likely to be broadly consistent—ie, suggesting a net frontier shift of around 0% per year—once input price inflation is overlaid on the latter. Similarly, ignoring the potential impact of real price effects (ie, input price inflation), the analysis indicates that it would be appropriate for a DNO to assume an overall efficiency frontier movement of around 0.7% per annum in its business plan.

[1] Ofgem (2012), 'RIIO-T1/GD1: Initial Proposals – Real price effects and ongoing efficiency appendix. Consultation – appendix', July; and (2012) 'RIIO-T1/GD1: Real price effects and ongoing efficiency appendix. Final decision – appendix', December.

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# 1 Introduction

ENWL commissioned Oxera to examine the potential for electricity distribution companies to improve their efficiency through ongoing efficiency improvements or frontier shift (ie, technological change or new working practices). The basis for such an assessment was to examine:

– direct evidence—looking at what DNOs have achieved in terms of frontier shift in the recent past;

– indirect evidence—looking at evidence from other sectors (the approach used by Ofgem in RIIO-T1 and RIIO-GD1).[2]

## 1.1 Structure of report

The report is structured as follows:

– section 2 provides some background information on the two main methodologies used in the report;

– section 3 examines direct comparators, assessing the productivity potential of the electricity distribution industry;

– section 4 examines indirect comparators;

– section 5 concludes.

[2] Ofgem (2012), 'RIIO-T1/GD1: Initial Proposals – Real price effects and ongoing efficiency appendix. Consultation – appendix', July; and (2012), 'RIIO-T1/GD1: Real price effects and ongoing efficiency appendix. Final decision – appendix', December.

# 2 Approaches to estimating the potential for frontier shift in electricity distribution

There are two elements to efficiency improvements:

– **catch-up**, or efficiency change, which includes all improvements in performance required to achieve best practice in an industry—ie, to catch up to the best-performing peers;

– **frontier shift**, or ongoing efficiency change, which relates to changes in the performance of best practice in the industry, through technological change or new working practices.

This report focuses on the latter element.

There are two main approaches to establishing a benchmark rate for the future potential for frontier shift in electricity distribution:

– **direct comparisons**—using data across DNOs and over time, it is possible to estimate the historical rate of frontier shift that DNOs have achieved. On the assumption that the past rate of technological progress is a good indicator of the potential future rate, this approach provides the most direct and relevant evidence for establishing a benchmark for the future potential for frontier shift in electricity distribution;

– **indirect comparisons**—based on data on other regulated companies or sectors in the economy, it is possible to estimate the historical rate of frontier shift that other regulated companies or sectors have achieved. On the assumption that the past rate of technological progress is a good indicator of the potential future rate *and* that the rate of technological progress in these sectors is a good indicator of the rate of technological progress in electricity distribution, this approach also provides useful evidence for establishing a benchmark for the future potential for frontier shift in electricity distribution.

These two approaches are discussed briefly below.

## 2.1 Direct comparators: frontier-based benchmarks

Frontier-based benchmarks involve analysing data on the DNOs over recent years, using techniques similar to those used to estimate relative efficiency across the DNOs. By modelling data across DNOs and over time, it is possible to estimate both the efficiency frontier and the rate of change in that frontier over the period examined. This historical rate of change in the efficiency frontier then provides a benchmark for the future potential for frontier shift in electricity distribution.

One of the key advantages of the direct comparators approach is that it relies on examining historical rates of change that have been achieved by the companies in the industry being considered. As such, conceptually, the only issue is whether one believes that the past rate of technological progress can continue in future.

This approach to identifying a rate of frontier shift has been used by regulators in instances where data across companies and over time has been examined.[3] The approach is examined further in section 3.

## 2.2 Indirect comparators: composite benchmarks

At a high level, UK regulators' ongoing efficiency targets tend to be based on a framework that has previously been used across a number of sectors, although its implementation varies. In summary, the framework reaches a conclusion on the potential for productivity improvement in the assessed industry through the use of indirect comparisons, such as estimates of (total factor) productivity (TFP) change achieved in whole sectors of the economy.[4]

The framework is made up of several components, and important decisions need to be taken for the assessment, including:

– the productivity measure(s) to be used. In this report TFP, as used by Ofgem, is examined;[5]

– the type and number of external comparators that will inform the benchmarks;

– the link between overall productivity improvement, frontier shift and catch-up to best practice;

– the period over which historical performance will be examined;

– the impact of growth on estimated productivity.

These are examined in section 4.

[3] See, for example, Nera (2008), 'The comparative efficiency of BT Openreach', a report to Ofcom, March; and (2005), 'The comparative efficiency of BT Openreach in 2003', a report to Ofcom, March.

[4] Such estimates are based on information from the National Accounts. See EU KLEMS Growth and Productivity Accounts, available at: http://www.euklems.net/index.html (accessed May 9th 2013).

[5] Ofgem (2012), 'RIIO-T1/GD1: Initial Proposals – Real price effects and ongoing efficiency appendix. Consultation – appendix', July; and (2012), 'RIIO-T1/GD1: Real price effects and ongoing efficiency appendix. Final decision – appendix', December.

# 3 Direct evidence

## 3.1 Background

One of the main disadvantages of Ofgem's approach in RIIO-T1 and GD1 is that it relies on composite benchmarks from other sectors of the economy. Therefore, the companies in the comparator group do not undertake the same activities as the distribution and transmission companies, but are from sectors of the economy that are deemed by Ofgem to carry out similar activities. Owing to the nature of these indirect comparisons, the approach is likely to be less robust than evidence based on direct comparators (eg, what the electricity DNOs have achieved historically).

To address this issue, in this section Oxera examines the dataset that Frontier Economics used on behalf of Ofgem to assess the total expenditure (TOTEX) efficiency levels of the electricity DNOs.[6]

## 3.2 Approach

Frontier Economics' preferred model in Phase 1 of its work uses data over five years (2006/07–2010/11), with TOTEX as the cost measure, and number of customers, peak capacity, population density and national wage index as explanatory variables.[7] A time trend was included in its Phase 1 model to control for movement in costs over time, as a proxy to measure the technological change in the industry over the period. Based on the estimate for the time trend in the model, Frontier Economics argued that there has been an apparent technological regression of the industry. In Phase 2, Frontier Economics subsequently dropped the time trend owing to collinearity.[8] Both of these results would seem to indicate that little technological progress is possible in this sector.

However, there are some issues that need to be resolved when assessing the frontier shift:

– Frontier Economics' Phase 1 model included both the trend variable and the wage index with a view to capturing movement in costs over time. This results in an identification conflation issue, as acknowledged by Frontier Economics;[9]

– the time trend in the model captures the productivity change over the period, which also includes an estimate of efficiency change over the period.

To mitigate the first issue, Oxera modelled TOTEX in real terms (ie, deflating the TOTEX measure using the retail price index) prior to estimation and without the wage index in the model. When the wage index is excluded from the model specification, the trend variable provides an estimate of *net* ongoing efficiency (ie, ongoing efficiency *less* real price effects).

To mitigate the second issue, Oxera used stochastic frontier analysis to separately identify and estimate the frontier shift and efficiency change of the DNOs.

[6] ENWL provided the dataset to Oxera.

[7] The material used as the input to this report was limited to the presentation slides from Frontier Economics and the dataset used by Frontier Economics in its Phase 1 analysis. Both were provided to Oxera by ENWL.

[8] Frontier Economics (2013), 'Total cost benchmarking at RIIO-ED1 – Phase 2 report – Volume 1', June, p. 38.

[9] Ibid.

In addition, given that Frontier Economics has highlighted that there are inconsistencies in the first two years of the data, Oxera used year dummies to separate these data concerns from the actual technological shift.

Finally, it should be noted that the form of the models to be used for RIIO-ED1 has yet to be decided. For example, it could be considered that the modern equivalent asset value (MEAV) provides a more appropriate cost driver than those used in Frontier Economics' model, in that it captures, to an extent, the size and complexity of a DNO's asset base.[10] As such, two alternative models are used here: one based on Frontier Economics' model and one using MEAV.

## 3.3 Results from the direct evidence using DNO data

The *net* ongoing efficiency estimates using Frontier Economics' specification, and an alternative specification with MEAV as the scale driver, are presented in Table 3.1. Note that a negative value indicates an improvement—ie, costs are decreasing by the percentage value per annum.

**Table 3.1 Direct evidence of potential *net* ongoing efficiency using Frontier Economics' data**

| | Frontier Economics' model (peak capacity, number of customers) (%)[1] | MEAV and population density (%)[1] | Is the *net* ongoing efficiency significantly differently from 0?[2] |
|---|---|---|---|
| **How the *net* ongoing efficiency is estimated** | | | |
| using time trend only | 2.2 | 1.2 | No |
| using year dummies and time trend | 0 | –2.4 | No |
| **If efficiency is assumed to be time-varying** | | | |
| using time trend only | –0.3 | 0.2 | No |
| using year dummies and time trend | –4.1 | –3.7 | No |

Note: [1] The cost variable is TOTEX in constant prices. [2] At the 10% level of significance.
Source: Oxera analysis, using Frontier Economics data.

Hence, preliminary analysis indicates that, regardless of the model specification, the net ongoing efficiency achieved by DNOs in recent years does not appear to be statistically significant in the models, indicating that the technology (net of any input price inflationary effects) has been largely stationary.[11]

Since this is direct evidence on what the DNOs have actually achieved, it should be seen as being more robust in informing the future potential for net frontier shift, especially when the data has been further developed.[12]

[10] However, this measure has yet to be collated such that, within the current dataset, it is constant over time.

[11] This would need further examination when the data is more robust.

[12] As an alternative approach, Oxera normalised costs for wages as an approximation for removing the impact of real price effects (in so far as real price effects are captured by wages). Again, preliminary analysis indicates that, regardless of the model specification, the ongoing efficiency achieved by the DNOs in recent years does not appear to be statistically significant in the models. This would need further examination when the data is more robust—ie, by using a wage index that captures regional differences in wages rather than a national index.

## 3.4 Summary

The analysis undertaken in section 3.3 estimates the *net* ongoing efficiency achieved by DNOs over the period 2006/07–2010/11. That is, the figures in Table 3.1 are equivalent to Ofgem's 'net impact of RPE and ongoing productivity'.

**Oxera's preliminary analysis indicates that the *net* ongoing efficiency achieved by the DNOs in recent years has not been statistically significant, indicating that the technology (net of any input price inflationary effects) has been largely constant.**

While these findings would require further examination when the data is more robust, this is more direct and robust evidence on what has actually been achieved in recent years and, by implication, what is potentially achievable by the DNOs in future.[13]

[13] This direct measure assumes that historical performance is a good indicator of future performance, as does Ofgem's indirect approach.

# 4 Indirect comparisons: growth accounting-based TFP

## 4.1 Background to growth accounting and TFP

Growth accounting-based TFP is the method most widely used for measuring productivity growth in economic aggregates—eg, the whole economy or sectors of the economy. A major factor in the widespread adoption of TFP in this setting is that estimates can be (relatively) easily produced using country- or sector-specific National Accounts data, without having to rely on information from outside the country or the sector examined. Growth accounting, however, requires the adoption of a number of simplistic assumptions, most notably that markets are perfectly competitive, which could lead to unreliable estimates.

TFP analysis has often been used in a regulatory setting to derive an estimate of the performance improvements that are likely to be available in the future (usually until the next price control review). This analysis typically examines the productivity growth of a number of sectors of the *economy* that are deemed comparable to the assessed *companies*, referred to in this report as the 'comparator set'. The analysis uses this information to form a view on the potential for frontier shift, or 'ongoing efficiency' improvements, as Ofgem describes it. In essence, the comparator set forms the comparator group used to benchmark the regulated company.

## 4.2 Comparison of Oxera's approach and Ofgem's approach in RIIO-GD1

Based on this general framework (indirect TFP comparisons), this section provides Oxera's initial analysis of the scope for future productivity improvements. However, some adjustments have been made here to the framework adopted by Ofgem in RIIO-GD1:

– the final TFP estimate has been adjusted so that it reflects productivity improvements that are driven solely by ongoing improvements in best practice. The definition of frontier shift closely matches the definition of Ofgem's ongoing efficiency measure;[14]

– the analysis has been extended by constructing a 'composite' benchmark based on typical DNO activities. This can be used either as a cross-check or as the main source of productivity estimates.

In addition, slightly different choices relative to Ofgem's TFP analysis for RIIO-GD1 have been made, to reflect more closely the assessed industry and to strengthen the robustness of the final estimates.

– Oxera's comparator set includes industries that undertake activities similar to those undertaken in electricity distribution. Clearly, the selection of the comparator set requires a degree of judgement, and so ideally sensitivity analysis should be undertaken to check how the final estimates change with respect to the selection of the comparator set.

– The analysis focuses on a more recent timeframe. Ofgem examined productivity performance over a longer period, from 1970–2007, but there are issues with both the accuracy of the productivity estimates from the earlier periods and their relevance.

[14] Ofgem states that: 'The ongoing efficiency assumption is the expected productivity improvement that an efficient company should be able to make over the price control.' See Ofgem (2012), 'RIIO-GD1: Initial Proposals – Overview', July.

– The analysis examines only multi-factor productivity measures. Ofgem also looked at partial productivity indicators, but as these were constructed in a non-standard way, any conclusions drawn from them should be treated with caution.

## 4.3 Strengths and weaknesses of TFP analysis

The major advantage of TFP analysis of indirect comparators is that it can be implemented when there are no direct comparators, or when it is deemed that the data is not of sufficient quality to rely on direct comparisons. Although the TFP approach described above requires consistent data on inputs, outputs and their relative prices for the sectors of the economy that form the comparator set, this information is easily sourced from pan-European productivity databases (such as EU KLEMS) or national statistical agencies (such as the Office of National Statistics, ONS).

The main disadvantage of such analysis is that the comparator set is not made up of companies that undertake the same activities as the assessed company, but rather sectors of the economy that are deemed to carry out similar activities. Owing to the nature of these indirect comparisons, the robustness of this approach is likely to be significantly reduced relative to the frontier-based approaches discussed in section 2. Nevertheless, they are examined here since they can provide a cross-check on the results presented in section 2.

The other main disadvantage of TFP analysis is that the approach measures overall productivity growth, which includes elements of both catch-up efficiency and frontier shift. As such, it is unclear what proportion of productivity gains is attributable to each element. For this analysis, Oxera has used evidence from external sources to assess the possible composition of the estimated productivity measure (see section 4.2.4 for more details). Note that direct decomposition of the productivity estimate is possible when using direct comparisons (as in section 2) or where the TFP analysis uses frontier-based approaches.

## 4.4 Methodology

### 4.4.1 Productivity measures considered

For RIIO-GD1, Ofgem calculated productivity measures based on *two* available output measures: value-added (VA) and gross output (GO).[15] The choice of output measure on which to base the productivity estimates is very important because *VA-based TFP measures will always display larger productivity growth than GO-based TFP measures*,[16] and the differences can be quite significant. However, deciding which output measure is more appropriate is difficult and requires some judgement.

Both of these types of TFP measure are theoretically valid means of measuring productivity. The main advantage of using GO-based TFP measures is that gross output is the appropriate output concept since it includes the contribution of intermediate inputs to production. However, measuring GO at the aggregate level (as in EU KLEMS) is difficult and might lead to measurement errors.[17] As VA-based TFP measures are immune to these measurement issues, they are more robust to measurement error. The final decision on which TFP measure to rely on should be made according to whether these measurement issues are expected to have a material influence on the TFP estimates.

This issue cannot be addressed without further research; therefore, both measures are considered here.

[15] Ofgem (2012), 'RIIO-T1/GD1: Initial Proposals – Real price effects and ongoing efficiency appendix', July, sections 3 and 4.

[16] When the productivity analysis is based on growth accounting (the methodology adopted by both Ofgem and EU KLEMS).

[17] Further discussion on why this is the case is provided in Balk, B.M. (2009), 'On the relation between Gross Output- and Value Added-based productivity measures: The importance of the Domar Factor', *Macroeconomic Dynamics*, **13**, pp. 241–67.

Although GO-based TFP measures are not reported in the latest release by EU KLEMS, the primary data required for their estimation is available and has been used by Oxera to estimate GO-based TFP values for the selected comparator set.

### 4.4.2 Comparator sectors

During DPCR5 and RIIO-T1/GD1, Ofgem selected the following industries for its comparator set:

- Construction;
- Financial Intermediation;
- Manufacture of Chemicals & Chemical Products;
- Sale, Maintenance & Repair of Motor Vehicles/Motorcycles; Retail Sale of Fuel;
- Manufacture of Electrical & Optical Equipment;
- Manufacture of Transport Equipment;
- Transport & Storage.

Some of these sectors undertake activities similar to those undertaken by a typical DNO, but for others it is not clear why they have been included.

- Construction (F)—this appears to be an appropriate comparator since DNOs undertake a host of civic, electrical and mechanical engineering activities.

- Financial Intermediation (J)—this might be a useful comparator, although its applicability is limited since the financing activities undertaken by DNOs are likely to represent only a very small proportion of their total activities.

- Manufacture of Chemicals & Chemical Products (24)—this might be an appropriate comparator for gas distribution and transmission, but not for electricity distribution.

- Sale, Maintenance & Repair of Motor Vehicles/Motorcycles; Retail Sale of Fuel (50)—it is not clear why this sub-sector is an appropriate comparator. The sale of vehicles/ motorcycles and fuel is unlikely to be similar to activities undertaken by DNOs. It is also not clear how electricity distribution activities are similar to the maintenance and repair of motor vehicles/motorcycles.

- Manufacture of Electrical & Optical Equipment (30–33)—this is likely to be an appropriate comparator for electricity distribution, given that the industry undertakes a range of activities relating to the installation, operation and maintenance of assets that the ONS classes as ‘Electrical & Optical Equipment’.

- Manufacture of Transport Equipment (34–35)—it is not clear why this would be a suitable comparator for electricity distribution.

- Transport & Storage (60–63)—this is likely to be an appropriate comparator for DNOs, especially the sub-sector of ‘Inland Transport (60)’.

Other possible comparators from EU KLEMS include:

- Renting of Machinery and Equipment (71)—this appears relevant since leasing agreements are likely to be prevalent in the distribution and transmission sector.

- Computer and Related Activities (72)—this appears relevant due to the heavy adoption of automation in the electricity distribution and transmission sector.

- Other Business Activities (74)—this covers legal, technical, advertising and general administration activities, so it would probably be a good benchmark for distribution and transmission headquarter activities.

– Post and Telecommunications (64)—this may be relevant (but for a relatively small proportion of a DNO's cost base) owing to the adoption of IT and specialist communication systems for monitoring the distribution and transmission networks. Note, however, that the telecommunications sector has experienced rapid technological growth over the last 20 years, which translates to high productivity growth estimates. Indeed, according to EU KLEMS, this sector displays the highest productivity growth in the whole of the UK economy and might therefore not be a suitable comparator. As such, Oxera provides a sensitivity below (ie, with and without the sector), as well as presenting a weighted average based on the relevant proportion of the cost base.

As stated above, the selection of the comparator set is a decision based mostly on qualitative analysis and, as such, requires a degree of judgement. This mapping was, however, also discussed and confirmed with ENWL.

EU KLEMS does not include all the necessary information to derive TFP estimates for all lower-level aggregates, such as Computer and Related Activities (72). In such cases, the analysis presented here uses the TFP estimates of the higher-level aggregates that include the relevant sectors. Specifically, the final comparator set includes:

– Electrical and Optical Equipment;[18]
– Transport Equipment—using only a small set of DNO activities relating to 'Vehicles & Transport';
– Electricity, Gas and Water Supply;
– Construction;
– Transport and Storage;
– Post and Telecommunications—used mainly for the construction of the composite benchmark;
– Renting of Machinery and Equipment and Other Business Activities—this includes the relevant sub-sectors of Renting of Machinery and Equipment (71), Computer and Related Activities (72), and Post and Telecommunications (64).

#### 4.4.3 Timeframe to consider

The timeframe over which productivity performance is measured in the comparator set is important for these types of indirect comparison, mainly because productivity tends to be influenced by the business cycle.[19] Compared with the long-run trend, TFP growth tends to be lower during recessionary periods (eg, since companies typically do not shed labour immediately, in order to maintain capacity at the expense of reductions in productivity) and higher during growth periods as this excess capacity is used. Thus, TFP growth comparisons are made over a complete business cycle to avoid misrepresenting the impact of recessionary or growth periods.

Examining UK VA output suggests the following potential business cycles over which TFP can be examined:[20]

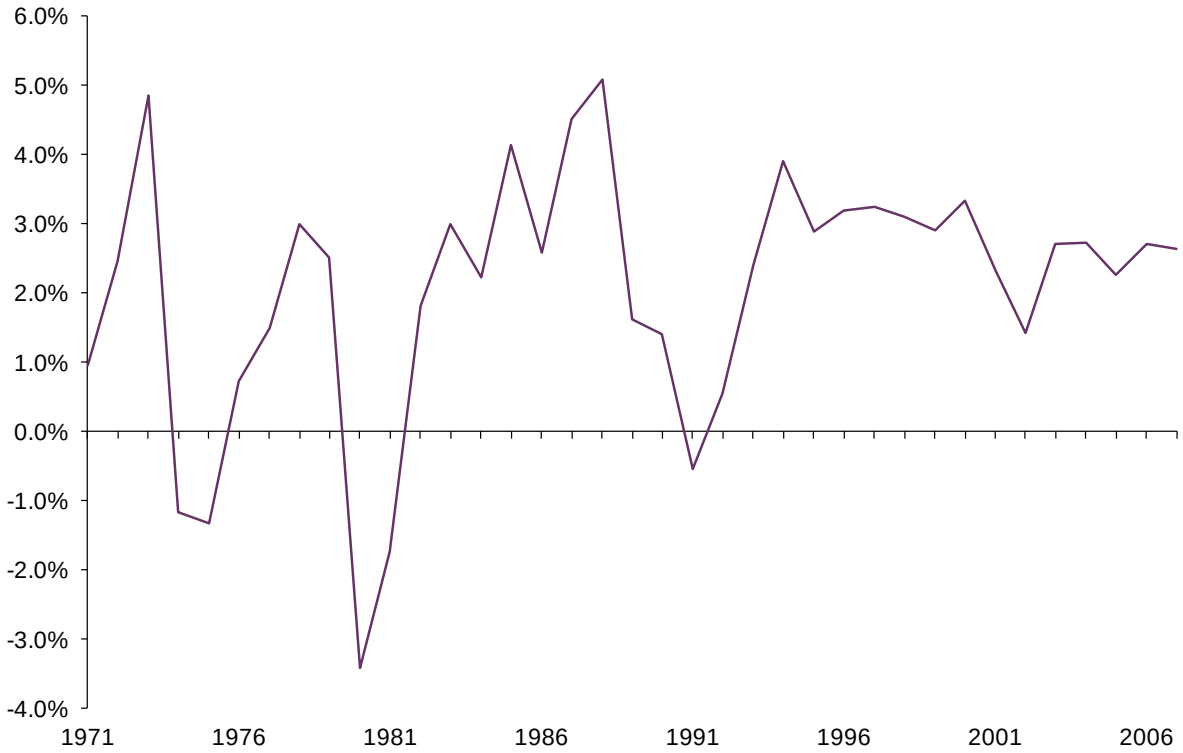
– there was significant volatility in the 1970–80 period—however, there is tentative evidence of two possible business cycles, one from 1970 to 1974 and a second from 1975 to 1981;
– one full business cycle from 1982 to 1991;
– a final business cycle from 1992 to 2008.

[18] Includes: Office, Accounting and Computing Machinery; Electrical Machinery and Apparatus; Radio, Television and Communication Equipment; Medical, Precision and Optical Instruments.

[19] Business cycles are periodic swings in an economy's pace of demand and production activity, characterised by alternating phases of growth and recession.

[20] The same business cycles can be seen when examining UK output expressed in GDP terms. See Bank of England (2010), 'The UK recession in context — what do three centuries of data tell us?', Quarterly Bulletin 2010 Q4, available at: http://www.bankofengland.co.uk/publications/Documents/quarterlybulletin/qb100403.pdf.

**Figure 4.1 Annual change in VA, UK (whole economy)**




Source: Oxera analysis based on EU KLEMS data.

### 4.4.4 Converting the TFP figure to an estimate of frontier shift

Ofgem's analysis of the potential for ongoing efficiency improvements relies on the use of productivity indicators, which include an element of efficiency change. This is described in the EU KLEMS methodology paper:[21]

> Under strict neo-classical assumptions, MFP [multifactor productivity] growth measures disembodied technological change. In practice, MFP is derived as a residual and includes a host of effects such as improvements in allocative and technical efficiency, changes in returns to scale and mark-ups as well as technological change proper. All these effects can be broadly summarized as 'improvements in efficiency', as they improve the productivity with which inputs are being used in the production process. In addition, being a residual measure MFP growth also includes measurement errors and the effects from unmeasured output and inputs.

As a reminder, the most common decomposition of productivity change in the academic literature is:

productivity change = efficiency change (catch-up) x technological change (frontier shift) x scale efficiency change

where:

– efficiency change measures how performance has changed from one period to the next, with reference to a peer set;
– frontier shift measures how best practice (optimal performance) has changed from one period to the next;
– scale efficiency change measures improvements in efficiency due to a company moving closer to the most productive scale size.

[21] Timmer, M., O'Mahony, M. and Van Ark, B. (2007), 'EU KLEMS Growth and Productivity Accounts: Overview', November, available at: http://www.euklems.net/data/overview_07ii.pdf (accessed July 10th 2009).

Ofgem assesses the potential for efficiency improvements (ie, catch-up) over the next price control period using a separate methodology and combines this with its estimate for ongoing efficiency improvements (or frontier shift). As such, the current analysis focuses on providing an estimate for the potential of the frontier shift of the electricity distribution industry only.

The issue is that the productivity measurement approach adopted by EU KLEMS (and, by extension, by Ofgem) does not allow the decomposition of the productivity estimate into its component parts. As such, to derive an estimate of frontier shift from the available TFP estimates, one has to rely on external evidence. The available studies that could be used for this purpose are few and all focus on assessing the productivity performance of whole economies, rather than industry sectors. Of these, the most notable is a study by Färe et al. (1994), which found that, on average, 75% of the economy-wide TFP growth, including the contribution from non-market sectors, was due to frontier shift. [22] This study was used in Oxera (2008),[23] and this particular split had previously been adopted by the Office of Rail Regulation and the Competition Commission.[24]

A more recent study by Giraleas (2009),[25] based on the EU KLEMS dataset, found that for the whole of the UK economy, the contribution of frontier shift to overall productivity change was approximately:

– 81–84% during the 1970–2007 period;
– 72–78% during the 1992–2007 period.

Given that the focus of the current analysis is 1992–2007 (see section 4.2.3), the latter estimate is the more relevant. The midpoint of this range (ie, 75%) is consistent with the estimate in Färe et al. (1994) and is therefore used below.

### 4.4.5 Additional issues

Additional issues to consider, if relevant, include:

– the effects of scale change on estimated productivity for the comparators;
– the impact of growth on estimated productivity.

Table 4.1 below summarises the per-year growth rate in terms of customer numbers, units distributed and peak demand.

**Table 4.1 ENWL's actual and projected volume growth (% per year, by period)**

| Output measure | DPCR5 | RIIO-ED1 |
|---|---|---|
| Number of customers | 0.1 | 0.1 |
| Units distributed | –0.4 | 0.7 |
| Network-wide peak demand | 0.4 | 0.7 |

Source: ENWL.

The volume growth is relatively low and thus any adjustment to account for the impact of volume growth is likely to be small.

[22] Färe, R., Grosskopf, S., Norris, M. and Zhang, Z. (1994), 'Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries', *The American Economic Review*, **84**:1, March, pp. 66–83—specifically, Table 4: Decomposition with scale effects, p. 78.
[23] Oxera (2008), 'What is Network Rail's likely scope for frontier shift in enhancement expenditure over CP4?', report prepared for the Office of Rail Regulation.
[24] Ibid., p. 25; and Competition Commission (2010), 'Bristol Water plc: A reference under section 12(3)(a) of the Water Industry Act 1991', Appendix K, para 51 (which refers to Oxera (2008), op. cit.), para 109 (which makes a net adjustment, implying at least a 10% adjustment for catch-up) and para 112.
[25] Giraleas, D. (2009), 'Productivity growth in the EU: Comparisons between growth accounting and frontier-based approaches', European Workshop on Efficiency and Productivity Analysis.

## 4.5 Results

Table 4.2 presents the average values of the yearly VA-based TFP change estimates for the comparator set, sourced directly from EU KLEMS.

**Table 4.2 VA-based TFP estimates (% per year, by period)**

| Activity | Code | 1970–74 | 1975–81 | 1982–91 | 1992–2007 | 1970–2007 |
|---|---|---|---|---|---|---|
| Electrical and Optical Equipment | 30t33 | 5.4 | –1.4 | 6.4 | **4.8** | 4.1 |
| Transport Equipment | 34t35 | –0.4 | –0.6 | 6.0 | **2.1** | 2.3 |
| Electricity, Gas and Water Supply | E | 5.5 | 3.4 | 2.2 | **0.8** | 2.2 |
| Construction | F | –3.3 | –0.3 | 3.1 | **0.7** | 0.7 |
| Transport and Storage | 60t63 | 3.9 | 1.0 | 2.6 | **1.9** | 2.1 |
| Post and Telecommunications | 64 | 0.3 | 1.3 | 0.4 | **5.6** | 2.7 |
| Renting of Machinery and Equipment and Other Business Activities | 71t74 | 1.9 | –2.6 | –0.6 | **0.7** | –0.2 |

Source: Oxera analysis, based on EU KLEMS.

As noted above, the TFP estimates from the early periods (ie, the 1970s) are of limited value for two main reasons. First, they are likely to be less accurate owing to both the lack of modern data-handling techniques available at the time, and the subsequent evolution of the National Accounting Standards, which govern how the primary data is collated. Second, there is the issue of relevance: how likely is it that productivity performance from the 1970s and 1980s can offer a reasonable guide for the potential of productivity growth some 30–40 years in the future?

The most relevant estimates are likely to come from the later period considered—ie, 1992–2007. TFP estimates from that period range between 5.6% and 0.7% per year, with an average of 2.4%. The high end of the range is from the Post and Telecommunications sector, which is to be expected, given the rapid technological growth of the IT industry. Although DNOs are highly likely to benefit from advances in IT in order to increase their productivity, their main activities involve larger-scale engineering projects and, as such, the impact of advances in IT is likely to be less pronounced. Excluding the Post and Telecommunications sector, the range of TFP change becomes 0.7–4.8% per year, with an average of 1.8%.

The Electrical and Optical Equipment sector has the second-largest TFP change estimate, which is also likely to be because of general advances in IT and electronics. This sector is also relevant to DNOs. Again, however, it is unlikely that they will be able to reap the full benefits from advances in manufacturing automation and miniaturisation, which appear to be some of the main sources of productivity growth in this sector. Excluding the Post and Telecommunications, and the Electrical and Optical Equipment sectors, the range of TFP change becomes 0.7–2.1% per year, with an average of 1.2%.

Table 4.3 presents the GO-based average values of the yearly TFP change estimates for the comparator set.[26]

[26] The primary data is from EU KLEMS, but the estimation has been undertaken by Oxera.

**Table 4.3 GO-based TFP estimates (% per year, by period)**

| Activity | Code | 1970–74 | 1975–81 | 1982–91 | 1992–2007 | 1970–2007 |
|---|---|---|---|---|---|---|
| Electrical and Optical Equipment | 30t33 | 2.0 | –0.8 | 2.8 | **1.8** | 1.6 |
| Transport Equipment | 34t35 | –0.4 | –0.2 | 3.3 | **0.6** | 1.1 |
| Electricity, Gas and Water supply | E | 3.4 | 1.8 | 1.1 | **0.2** | 1.1 |
| Construction | F | –1.5 | –0.2 | 1.3 | **0.2** | 0.2 |
| Transport and Storage | 60t63 | 1.8 | –1.2 | 1.6 | **0.8** | 0.7 |
| Post and Telecommunications | 64 | 0.2 | 2.0 | 0.1 | **3.2** | 1.8 |
| Renting of Machinery and Equipment and Other Business Activities | 71t74 | –0.1 | –3.7 | –0.4 | **0.4** | –0.6 |

Source: Oxera analysis, based on EU KLEMS.

The GO-based productivity estimates are significantly smaller than their VA-based counterparts: for the 1992–2007 period, the estimates now range from 0.2% to 3.2% per year, with a midpoint of 1%. Excluding Post and Telecommunications, the range becomes 1.8% to 0.2% per year, with a midpoint of 0.7%. Also excluding Electrical and Optical Equipment produces a range of 0.8% to 0.2% per year, with a midpoint of 0.5%.

Table 4.4 summarises all the above results.

**Table 4.4 GO-based TFP estimates (% per year, by period)**

| | VA-based TFP | | GO-based TFP | |
|---|---|---|---|---|
| | Range | Midpoint | Range | Midpoint |
| All sectors | 5.6–0.7 | **2.4** | 3.2–0.2 | **1.0** |
| Excluding Post and Telecommunications | 4.8–0.7 | **1.8** | 1.8–0.2 | **0.7** |
| Excluding Post and Telecommunications, and Electrical and Optical Equipment | 2.1–0.7 | **1.2** | 0.8–0.2 | **0.5** |

Source: Oxera analysis, based on EU KLEMS.

To help narrow the range of the TFP estimates, a composite benchmark has been created based on the functions undertaken by DNOs. A number of different sectors were assigned to each function according to the similarity of the activities undertaken in these sectors relative to the different DNO functions. These functions were then given weights based on the TOTEX recorded for them in the 2010–13 period (which in turn was based on the TOTEX across all DNOs). For functions that were mapped to multiple sectors, the TFP performance of these sectors was given equal weight. The time period used to measure productivity change in the comparator set was 1992–2007. The mappings and relevant weights are presented in Table 4.5.

**Table 4.5 Mapping of DNO functions to sectors of the economy**

| Activity | Weighting (%) | Comparators | | |
|---|---|---|---|---|
| Load Related New Connections & Reinforcement | 23 | EGW | C | TS |
| Non-load Non-fault New & Replacement Assets | 34 | EGW | C | TS |
| Non-operational New Assets & Replacement | 3 | C | TS | |
| Faults | 8 | EGW | C | |
| Inspectns & Maint. (excl. Tree Cutting) | 4 | EGW | | |
| Tree Cutting | 4 | C | | |
| Network Policy (incl. R&D) | 0 | BA | EGW | EOQ |
| Network Design & Engineering | 2 | BA | EGW | EOQ |
| Project Management | 2 | BA | EGW | EOQ |
| Engineering Mgt & Clerical Support | 6 | BA | EGW | EOQ |
| Control Centre | 1 | BA | COMMS | |
| System Mapping - Cartographical | 0 | BA | COMMS | |
| Customer Call Centre (incl. compensation claims) | 1 | BA | | |
| Stores & Procurement | 1 | TS | | |
| Vehicles & Transport | 2 | TrE | | |
| IT & Telecoms | 3 | COMMS | | |
| Property Mgt | 2 | BA | | |
| HR & Non-operational Training | 1 | BA | | |
| Health & Safety & Operational Training | 1 | BA | | |
| Finance & Regulation | 2 | BA | | |
| CEO & Group Mgt/Legal & Co Secty/Community Awareness | 1 | BA | | |

Note: EGW, Electricity, Gas and Water Supply; C, Construction; TS, Transport and Storage; BA, Renting of Machinery and Equipment and Other Business Activities; EOQ, Electrical and Optical Equipment; COMMS, Post and Telecommunications; TrE, Transport Equipment.
Source: Oxera analysis, based on DPCR5 FBPQ submissions, provided by ENWL.

The productivity performance of this composite benchmark was found to be:

– 1.3% per year, using the VA-based TFP estimates;
– 0.5% per year, using the GO-based TFP estimates.

Given the above analysis, the potential for annual productivity improvement in the comparator set is likely to be between 1.3% and 0.5% per year.

Applying the 75%/25% frontier shift/catch-up split (as suggested by Färe et al. 1994 and Giraleas 2009), **the range for the potential frontier shift (before any impact of input price inflation is accounted for) becomes 1–0.4% per year, with a midpoint of 0.7%.**

## 4.6 Summary/conclusion

Given the issues discussed with regard to using TFP-based benchmarks to establish a possible range for the potential frontier shift, Oxera considers that such an approach can provide only a cross-check on the more direct measures (as undertaken in section 3), where these are available.

**Based on TFP benchmarks, the range for the potential frontier shift is 1–0.4% per year. This is not directly comparable to technological progress in cost-efficiency terms (as estimated in section 3) as it excludes, among other things, the impact of real input price inflation. Once real input price inflation is included, it appears that the TFP-based benchmark is likely to be broadly consistent with a stable frontier.**

# 5 Conclusions

In this report, the potential rate of future frontier shift, or ongoing efficiency change, has been estimated using two different approaches:

– **direct comparisons**—based on data across DNOs and over time, Oxera estimated the historical rate of net frontier shift that DNOs have achieved (ie, the impact of technological change net of input price inflation);

– **indirect comparisons**—based on data on other regulated companies or sectors in the economy, Oxera estimated the historical rate of frontier shift achieved by other sectors in the economy (before any impact of input price inflation is accounted for).

Both approaches assume that the past rate of technological progress can continue and is a good indicator of the potential future rate of technological progress. In addition, the indirect comparisons assume that the rate of technological progress in the comparator sectors is a good indicator of the rate of technological progress in electricity distribution.

Overall, the direct evidence shows a stable net frontier (ie, any technological progress is more or less equally offset by increases in input price inflation), while the indirect evidence shows a frontier shift of around 0.4–1% per year (excluding the impact of input price inflation).

Once input price inflation is overlaid on the indirect evidence, both approaches are broadly consistent. That is, both approaches suggest that a 0% net frontier shift could be a reasonable target for DNOs to achieve over the RIIO-ED1 period. Similarly, ignoring the potential impact of input price inflation, the analysis indicates that it would be appropriate for a DNO to assume an overall efficiency frontier movement of around 0.7% per annum in its business plan.

Park Central
40/41 Park End Street
Oxford OX1 1JD
United Kingdom

Tel: +44 (0) 1865 253 000
Fax: +44 (0) 1865 251 172

Stephanie Square Centre
Avenue Louise 65, Box 11
1050 Brussels
Belgium

Tel: +32 (0) 2 535 7878
Fax: +32 (0) 2 535 7770

200 Aldersgate
14th Floor
London EC1A 4HD
United Kingdom

Tel: +44 (0) 20 7776 6600
Fax: +44 (0) 20 7776 6601

www.oxera.com