This is a draft chapter. The final version is available in “Electricity Network Regulation in the EU. The Challenges Ahead for Transmission and Distribution”, edited by Leonardo Meeus and Jean-Michel Glachant, published in 2018, Edward Elgar Publishing Ltd.

DOI: https://doi.org/10.4337/9781786436092.00011

ISBN: 978 1 78643 608 5

For more information about the book, please look at https://www.e-elgar.com/shop/gbp/electricity-network-regulation-in-the-eu-9781786436085.html

Chapter 1: The British reference model

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In the field of regulatory practice, the regulation of the energy sector and in particular of the electricity network sector in Britain represents a crucial reference. There are five reasons for this. First, Britain was a pioneer in the concrete application of the RPI-X incentive regulation to the energy sector. Second, and because of this, it is a very instructive illustration of the application of the theoretical principle of incentive regulation, and an interesting case study for the assessment of the efficiency-improving prediction of incentive regulation. From this point of view, third, since the very beginning of its application and the liberalization process, incentive regulation has achieved great success in the electricity network sector, in terms of cost and tariff reduction, increase in quality of service for network users and in investment by network companies. Fourth, this application has also shown that the very theoretical principles must be adapted in practice because theory is based on a simplified and stylised view of reality. These adaptations were designed in a pragmatic way as difficulties emerged, not necessarily through investigating back the overall architecture of regulation. However, and fifth, after twenty years of application of the RPI-X regulatory principles, the British regulator, the so-called Office of Gas and Electricity Markets (Ofgem), felt it necessary to reconsider the overall picture of its regulatory practice in order to reset the regulatory principles. Some practitioners may have interpreted this as the dawn of a real revolution in the industry, even if many of the components of the historical application of the RPI-X regulation remain.

After a short presentation of the industry landscape in Britain (section 1), the chapter describes the overall evolution of the British application of incentive regulation, from the very beginning of the RPI-X regulation (section 2) to the renewal brought by the new RIIO (Revenue = Incentives + Innovation + Outputs) regulation (section 3). It shows the difficulties in applying concretely the theoretical principle of incentive regulation, the need to complement it with safeguards and even incentives to provide specified outputs and innovation, and the interaction and inefficient interferences that can emerge as regulation results from a set of regulatory schemes. Interesting too, the need felt by Ofgem to reset its overall regulatory practice questions again the theory on the goal of incentive regulation. Cost-killing is not a regulatory holy grail, if the network value for network users is missed. It shows too that theoretical work is still needed to define a cost function of electricity network activities as it could help go beyond the seminal theoretical design of incentive regulation in the power sector.

1.1. The TSO and DSO landscape in Britain

Until 1989, the Central Electricity Generating Board (CEGB) had a monopoly over the generation and transmission of electricity in England and Wales. Moreover, 12 Area Boards were acting as regional electricity distribution and supply monopolies. In Scotland, two companies integrated over the whole supply chain (generation, transmission, distribution and supply) had a monopoly on their supply areas. In practice, their price was set on a cost-of-service basis.[i]

During the late 1970s and 1980s these companies were said to be inefficient for four main reasons. First, they had a bad record of controlling capital investment costs. Second, they built uneconomic nuclear power stations. Third, they paid excessive prices for British coal under a nationalistic decision to support the domestic mining sector. Finally, in the absence of competitive information sources, the CEGB appeared to greatly underestimate the future costs of decommissioning nuclear power stations at the end of their useful life. Nevertheless, in terms of short-run operating efficiency, the CEGB's performance appears to have been reasonably good, except (as is now more apparent) for over-staffing.

Considering these inefficiencies, the British government decided after several years of discussions to restructure the power sector and to privatize it (Electricity Act, 1989). After numerous subsequent reforms and divestments, the industry is now organized with:

1) several firms freely competing for the generation and supply of electricity to consumers;
2) a transmission system operator, National Grid,[ii] which operates the whole British system and owns the transmission network in England and Wales;[iii]
3) two transmission and distribution network owners in Scotland (Scottish Power Energy Networks in the south and Scottish Hydro in the north);
4) twelve other electric distribution companies in England and Wales, several of which are under common ownership (see Figure 1.1);
5) an independent regulatory authority, Ofgem, in charge of regulating the newly privatized industry.[iv]

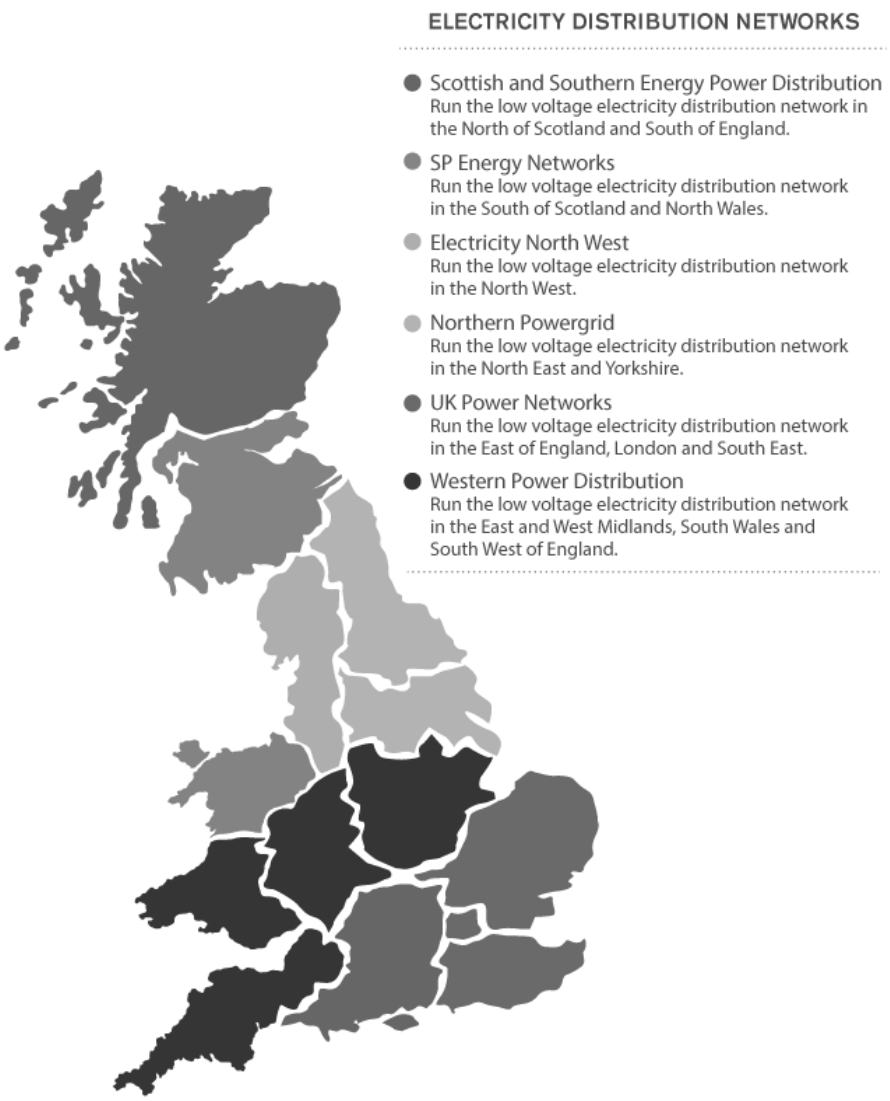

Figure 1.1 – Map of the 14 electricity distribution networks existing in Great Britain. Source: Ofgem.

In order to improve efficiency, electricity generators and suppliers are obliged to compete in the market, whereas network companies are subject to monopoly regulation. The goal of regulation is then to supervise competition on the open markets of generation and supply, considering these markets are frequently oligopolistic or subject to other types of market failures. Moreover, for network monopoly companies, the role of regulation is to mimic competition so that companies are more cost-efficient and provide better services to customers (so-called value for money). Ofgem also has

the mandate to promote security of supply and sustainability, for present and future generations of consumers.

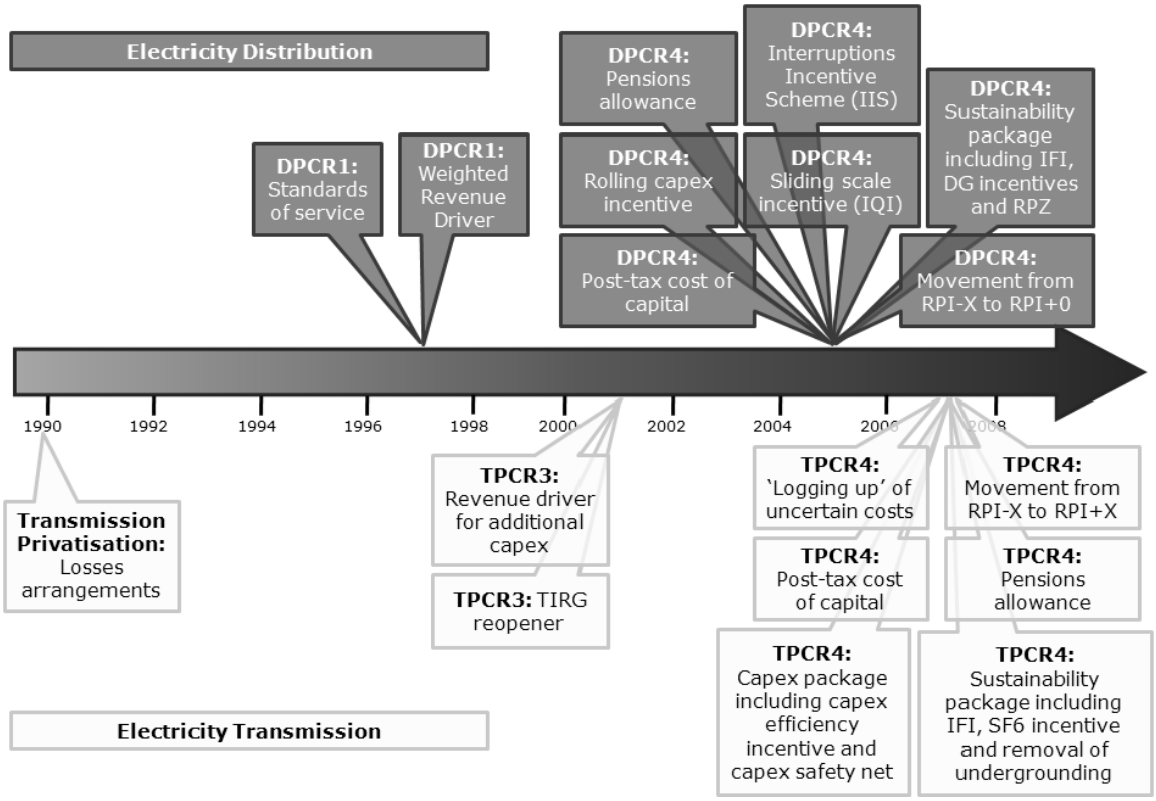

Figure 1.2 – Major milestones in the regulation of electricity transmission and distribution grids. Source: Ofgem (2009), *Regulating Energy Networks for the Future: RPI-X@20. History of Energy Networks Regulation,* p.2.[v]

Focusing on the regulation of network monopoly companies, Ofgem has gradually scrutinized and extended its regulatory tools. Hence, a learning process took place as follows (see Figure 1.2). First, Ofgem wanted to control only some inputs and types of costs of monopolies, while ignoring the others. Network companies soon learned how to play with these partial controls, moving expenditures from one type of input to another, neglecting the increase of some inputs or even decreasing some of the outputs – such as the level of service quality provided to network users. Ofgem noticed these secondary effects and progressively improved its regulatory control to avoid this undesirable edge effect. As implied by the chronology above, over time Ofgem has expanded its regulatory control from maintenance and energy losses (as soon as transmission was privatized), to quality of service (for the transmission sector with an interruption incentive scheme in 2003 following a blackout in London, and for the

distribution sector with standards of service in 1997 and an interruption incentive scheme in 2005), congestion costs (from 1993 in the transmission sector), investment (with specifically dedicated regulatory schemes for transmission in 2001 and 2007 and for distribution in 2005) and innovation (during the late 2000s). This whole movement of regulation in Britain between 1990 and 2010 was encapsulated under the term of RPI-X regulation. Even if the RPI-X regulation was at the centre of Ofgem control of the network companies during this period, in reality more and more subtle regulatory tools have been implemented in order to overcome the difficulties encountered by the sole use of RPI-X regulation.

1.2. The rise of RPI-X

At the centre of the regulatory framework established for the British electricity industry in the 1990s, there is an ex ante definition, provided by the regulator, of the price dynamics that network firms must respect when charging their customers. The underlying idea is to exert a pressure on network firms to reduce costs and progressively share any achieved cost reduction with network users. The framework apparently worked: network firms were usually able to significantly outperform their baseline and record increased profits, especially during the first regulatory periods; meanwhile, network users benefited from an important price reduction between the subsequent regulatory periods. However, some critical positions clearly emerged over the 20 years of RPI-X regulation and some problems required pragmatic intervention by the regulator.

In this section, we start by presenting the overall principle of RPI-X regulation and the way it was pragmatically implemented by Ofgem. Then, we narrow the focus on two critical aspects of this form of incentive regulation, namely service quality and innovation. Finally, we provide a brief assessment of the RPI-X regulatory experience and a list of drawbacks that justified the move to a new regulatory framework around 2010.

1.2.1. RPI-X principle

The overall principle of RPI-X regulation is that the allowed revenue of a (network) monopoly company or the price it is allowed to charge its customers are subject to a cap linked to the Retail Price Index (RPI), a common measure for price inflation, and to an efficiency factor called the X-factor, representing the expected efficiency gains of the industry compared to those of the rest of the economy. With a revenue or price dynamics set in advance, the monopoly firm is incentivized to reduce its costs below the expected efficient cost level, because it will retain any difference between the cap and its actual costs as a profit. Figure 1.3 graphically explains this mechanism. The dark grey

sloping line represents the price cap over time, as defined by the initial price level P_0, the productivity objective X set by the regulator at the beginning of the regulatory period and price inflation as measured by RPI. The regulated firm can charge a price up to the level defined by this line. The light grey sloping line represents the real unit costs borne by the firm. The difference between the two lines, i.e. the shaded areas, is the profit the firm can earn (if the light grey line lies above, and not below, the dark grey one, then the firm records a loss and not a profit).

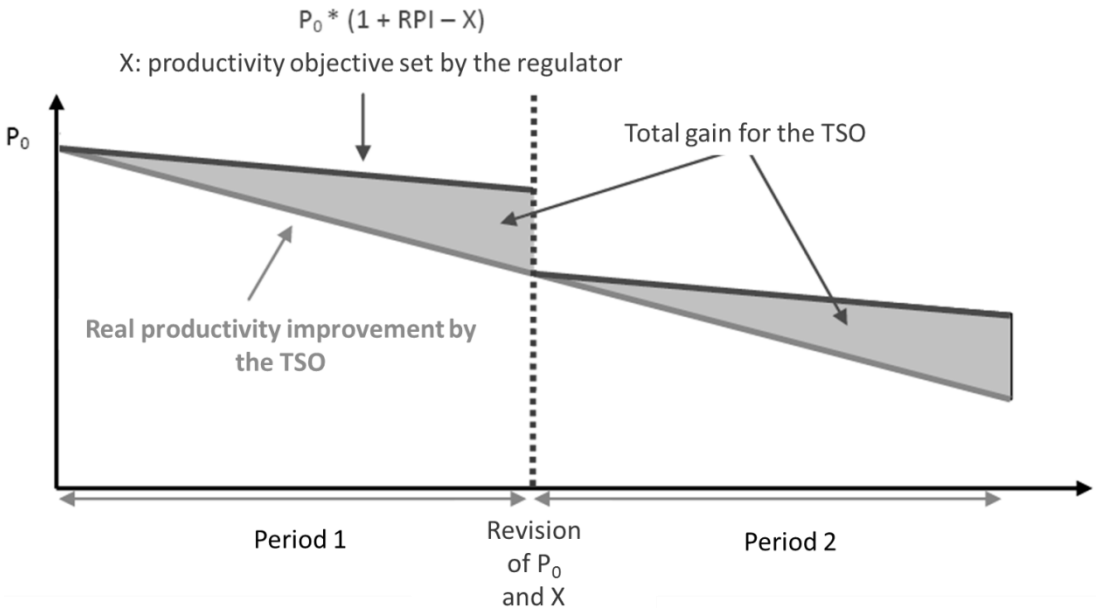

Figure 1.3 – Graphical representation of how RPI-X regulation works. Source: the authors.

Ideally, the firm is incentivized to be most efficient if the price dynamics are set for a long period of time. However, in practice regulators fix the cap only for a limited number of years, usually from three to five, because the uncertainties surrounding the activity of the monopoly company grow quickly over time and unforeseen implementation issues can emerge.[vi] In the early 1990s the British regulator adopted a regulatory period of four years for transmission (Transmission Price Control Review, TPCR) and of five years for distribution (Distribution Price Control Review, DPCR). Based on the experience gained in the first rounds of price controls and as a consequence of the integration of the electricity and gas transmission grids in one single company, in the mid-2000s Ofgem decided to implement a single regulatory period for electricity and gas transmission. Its length was extended to five years, as in the case of distribution (see Table 1.1 and 1.2).

Year	England & Wales	Scotland
April 1990 – March 1995	Post privatization price control	Post privatization price control
April 1995 – March 1996	DPCR1	DPCR1
April 1996 – March 2000	DPCR2 after Offer reopened in 1995 the price review	
April 2000 – March 2005	DPCR3 after merger of the regulatory process for all British distribution companies	
April 2005 – March 2010	DPCR4	
April 2010 – March 2015	DPCR5	
April 2015 – March 2023	RIIO-ED1	

Table 1.1 – Chronology of the regulatory periods for electricity distribution in Great Britain. Source: the authors based on Simmonds (2002), Ofgem (2009) and Ofgem website.

Year	England & Wales	Scotland
April 1990 – March 1993	Post privatization price control	Post privatization price control
April 1993 – March 1994	TPCR1	
April 1994 – March 1997		SCOTCO1
April 1997 – March 1999	TPCR2	
April 1999 – March 2000		SCOTCO1 one year roll-over
April 2000 – March 2001		SCOTCO2
April 2001 – March 2005	TCPR3	
April 2005 – March 2006		SCOTCO2 two years roll-over
April 2006 – March 2007	TPCR3 one year extension	

April 2007 – March 2012	TPCR4 after merger of the regulatory process for gas and electricity transmission companies over the whole GB
April 2012 – March 2013	TPCR4 one year roll-over
April 2013 – March 2021	RIIO-T1

Table 1.2 – Chronology of the regulatory periods for electricity transmission in Great Britain. Source: the authors based on Simmonds (2002), Ofgem (2009) and Ofgem website.

Electricity distribution and transmission tariffs are determined at the beginning of each regulatory period by using a building block approach, where operating expenditure, depreciation and the return on regulatory asset base (RAB) are estimated separately and then added together in order to define the maximal allowed revenue for the firm and the efficient and fair value for the various network tariffs. Originally, the RPI-X approach was applied only to a part of operating expenditure. Its extension to capital expenditure occurred later.

Ofgem experienced six kinds of difficulties in setting the parameters of the RPI-X regulation.[vii] First of all, Ofgem had difficulties in setting the perimeter of RPI-X. Initially, the cap was not applied to the overall operating expenditure, because part of it was wrongly or rightly supposed to be uncontrollable by the regulated firm. Congestion costs, for instance, were not subject to an incentive scheme but were simply passed-through to the network users, since they were supposed to depend not only on network constraints but also on the costs of the generators activated to relieve congestion, a variable upon which the network operator does not have any control. However, during the first regulatory period congestion costs multiplied by five in just four years (from £50 million to £250 million) because generators exerted their local market power and the transmission and system operator, National Grid, was not made financially responsible for congestions and the associated costs resulting from its maintenance activity. Indeed, as soon as a cap was applied to congestion costs, these costs began to decrease and returned to their 1990 level within four years. They further shrank by a factor of five in the following four years, reaching an overall level of some £10 million. This drastic cost decrease resulted from two changes in the behaviour of National Grid. First of all, the regulated scheme incentivized it to enter into a long-term contract under the scrutiny of the regulator with generators located in load pockets that were essential for network reliability and able to exert significant market power. Moreover, the regulated scheme incentivized National Grid to plan its maintenance programme in a way that would minimize network constraints and costs.

A second difficulty for Ofgem was the interference between the various incentive schemes. In the case of electricity distribution, for instance, Ofgem first set the efficiency target on operational expenditure (OPEX). In a later distribution regulatory review, it introduced it on capital expenditure (CAPEX) too. The problem recognized at the fifth distribution regulatory review in 2010 was that having different levels of reward to go beyond the respective OPEX and CAPEX targets prompted the network companies to choose CAPEX over OPEX. Besides, a return on investment adds up to CAPEX once integrated into the RAB, while OPEX is, at best, only covered without any additional revenue. These two effects taken together incentivized companies to choose CAPEX over OPEX, which is likely to be inefficient since both are needed to provide least-cost network services.

Third, Ofgem had difficulties in setting the X efficiency factor. This problem was particularly visible in the distribution sector. In the run-up to the 1990 privatization and before the first distribution price control review was held by the regulator in 1994, bundled distribution and supply tariffs were increased significantly. During the post-privatization regulatory period between April 1990 and March 1995, distribution companies were allowed to increase network charges by RPI+1 per cent on average. At that time there was limited knowledge of distribution costs and how to assess the efficiency factor. Significant capital expenditure programmes and a limited growth in the amount of distributed electricity were also expected. In the end, actual costs were lower and excessive rent was left to the distribution companies. As a consequence, distribution firms earned remarkable profits, as confirmed by their high stock value. The British regulator then decided to revise down tariffs in 1995, between 11 per cent and 17 per cent, with further cuts in 1996 between 10 per cent and 13 per cent. An RPI-3 per cent formula was imposed upon the companies over the following three years.

Fourth, Ofgem had difficulties in displaying transparently the methods used to set the X efficiency factor for regulated companies, in particular through benchmarking. The benchmarking model of distribution companies, for instance, was only disclosed from the second regulatory review onwards, despite the fact such a model had already been used in the first regulatory review. Statistical benchmarking methods have been applied by the regulator, especially in the distribution sector, to determine the relative efficiency of the individual firms' operating costs and service quality, compared to their peers. The information obtained from these methods can be used as an input for setting the values of P_0 and X, in a way to incentivize the firms far from the efficiency frontier to move closer to it and to reward the most efficient firms so that they are induced to stay on the efficiency frontier (see Chapter 2.3.1 for more information on benchmarking and yardstick competition). A range of empirical methods have been applied to identify the operating cost efficiency frontier and to measure how far from it an individual company is positioned. Their results are obviously not identical and this has created a problem of transparency for Ofgem. Indeed, depending on the benchmarking technique chosen and

the associated results, a distribution company will score closer to or further away from the efficiency frontier and hence will receive a tougher or less tough cost target for the next regulatory period. Understanding the impact of the benchmarking technique on their cost target is then of higher importance for network companies. Although the inclusion of quality of service considerations have further complicated the issue, transparency has increased through the following regulatory reviews, with Ofgem progressively publishing benchmarking methods, data and variables used.

However, transparency revealed a fifth difficulty for the British energy regulator: a lack of consistency and justification for changes in the benchmarking methods adopted over time. For instance, the weight applied to the different variables in the benchmarking during the second and third distribution regulatory reviews in 1999 and 2004 was different, without Ofgem giving any explanation for such change.

A last problem recognized only at the third distribution regulatory review was data gathering for benchmarking. Ofgem noticed that costs were accounted for in quite different ways across the industry. Several problems were identified. The main one was the so-called capitalization of OPEX: some distribution companies accounted part of OPEX as CAPEX; they then benefitted from the return on this fictitious 'investment' and reached more easily the efficiency target on OPEX. Other problems of data collection also concerned the accounting treatment of exceptional costs, intra-company margins or expenditure required to repair the grid after major faults. Data gathering and a uniform accounting system are essential for developing sound efficiency analysis through benchmarking on an equal footing.

1.2.2. Output regulation as a safeguard for services to network users

A major drawback of RPI-X regulation is that, on a stand-alone basis, it incentivizes companies to decrease the quality of the provided service. Indeed, it is far easier to cut costs by disregarding quality of service. Mechanisms providing output-related incentives have hence been developed by the energy regulator on a case-by-case basis to compensate for the failure of RPI-X regulation to ensure an adequate level of service quality for network users (see Box 1.1 and also Chapter 2.3.1).

Output regulation can apply to a variety of specific activities. Basically, any time-specific outputs can be defined, monitored, subject to targets and rewarded or penalized. For instance, outputs can encompass environmental policy goals (e.g. minimising power losses from transits through modification of the network topology and of voltage control) or social policy objectives (e.g. the Customer Service Reward Scheme to reward actions by distribution licensees to help vulnerable customers on affordability, or, in the gas sector, gas safety and awareness of the dangers of carbon monoxide). However, the main reason output regulation has been introduced is that cost reduction prompted by RPI-X regulation could jeopardize quality of service in the longer term, with more

frequent and deeper disconnections and poorer voltage quality (harmonics, voltage drops, voltage overload, etc.).

BOX 1.1: From RPI-X regulation to output regulation

Output regulation generalizes the principle of RPI-X regulation to outputs, instead of inputs. A target is set and the regulated company is assumed to at least reach it. Then, if she outperforms the target, she will receive a reward. Otherwise, a financial penalty will be inflicted on her. A deadband, where the company is neither penalized nor rewarded, can also be introduced around the target. Deadbands, rewards and penalties may be defined in a symmetrical manner or not. Rewards and penalties may be respectively subject to a cap or a floor to avoid windfall profits or losses for the regulated company. The relationship between the performance of the company and the remuneration related to this regulation scheme balances the risk of the company and its reward or penalty. By doing that, it and drives the share of profits and losses between the network company and network users.

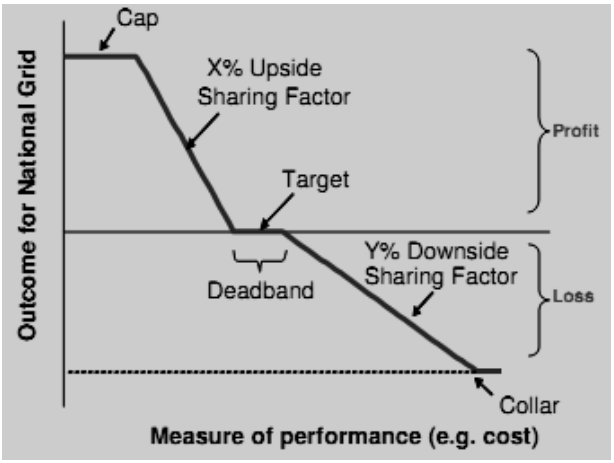

Figure 1.4 – Relationship between the measure of a network output and the financial outcome for the network company under output regulation. Source: Ofgem.

1.2.3. Three mechanisms for one goal: innovation

Even with a quality safeguard, the RPI-X regulation still holds a major drawback in the long run. Indeed, it incentivizes regulated companies to cut Research, Development and Demonstration (RD&D) costs, mainly for two reasons. First, those costs can be easily cut overnight. Second, cutting those costs does not immediately endanger quality of service, thereby avoiding any immediate penalty for a network firm subject to output regulation as well. On the contrary, the firm can reach more easily its RPI-X target and

earn extra-profit. However, although a cut in RD&D costs may be beneficial in the short run for the individual firm, in the long run it is detrimental from a social welfare point of view because of the public good aspect of RD&D. Thanks to spill-over effects, RD&D activities provide benefits not only to the investing company but also to other companies in the field and more generally to society as a whole. Without RD&D, little innovation can emerge, a development that is particularly negative in a period of deep technical, economic and organizational transformation for the entire energy industry.

Following the liberalization and privatization of the British electricity industry, a collapse in energy RD&D was noticed. By 2004, the amount of money spent by British network companies on RD&D was very small – less than £4 million per year or less than 0.1 per cent of their total revenues. Three regulatory schemes dedicated to innovation were hence designed towards the end of the RPI-X era: the Innovation Funding Incentive, the Registered Power Zones, and the Low Carbon Network Fund.

The Innovation Funding Incentive (IFI) was the first one created in 2004 to allow distribution companies to invest in RD&D, even when project costs and benefits span beyond the price control's five-year horizon. IFI, extended to transmission in 2007, allowed, up to its replacement in 2015, network companies to spend up to 0.5 per cent of their yearly distribution/transmission activity revenues on eligible IFI projects. The amount of money effectively spent under the mechanism is small, in total about £25 million per year for both transmission and distribution, but still much higher than the investments recorded before its establishment. Indeed, companies could recover 80 per cent of their eligible project expenditure under the licence condition, with a 25 per cent cap on their internal costs such as salaries. Eligible projects had to meet the criteria set out in an IFI Good Practice Guide and, as a minimum, align with at least one of Ofgem's five sustainable development themes: i) managing the transition to a low carbon economy; ii) eradicating fuel poverty and protecting vulnerable customers; iii) promoting energy saving; iv) ensuring a secure and reliable gas and electricity supply; and v) supporting improvement in all aspects of the environment.

Three Registered Power Zones (RPZs) were created in 2005 to encourage electricity distribution companies to develop new and more cost effective technologies for connecting and operating renewable generation. The three zones were Skegness & Fens (Central Networks), the Orkney Isles (Scottish Hydro Electric Power Distribution) and Martham Primary (EDF Energy). Allowed revenues for the companies were then increased if renewable generation capacity connected to the respective network turned out to be higher than the baseline.[viii] The RPZ incentive scheme ceased to apply to any new generation connecting onto the RPZs in March 2012.

Lastly, the Low Carbon Network (LCN) Fund was part of the electricity distribution price control arrangements that ran from 1 April 2010 to 31 March 2015 (DPCR5). The Fund allocated up to £500 million for support to projects sponsored by distribution

companies to try out new technology, operating and commercial arrangements that would be needed to deliver smart grids capable of supporting the growth of electric vehicles or locally-based generation. There were two tiers of funding under the LCN Fund. A first tier was designed to enable distribution companies to recover a proportion of expenditures incurred on small-scale projects, whereas under the second tier Ofgem promoted an annual competition for the allocation of up to £64 million to help fund a small number of flagship projects.

The combination of these three innovation mechanisms may have been enough to appreciably improve the rate of technical progress in British networks at a time when capital expenditure was increasing significantly due to the necessity to replace old assets and prepare the system for the challenges associated with the transition to a low carbon economy. It was assessed that the benefits of some of these mechanisms in terms of social welfare were more than six times higher than the associated expenses.[ix] However, one can conclude from the short overview provided above that they were not harmonized. On the one hand, different mechanisms had the same target, for instance for electricity distribution network companies that were eligible to all the mechanisms. On the other hand, they were incomplete for two reasons. First, transmission was not fully able to participate in these mechanisms before 2007. Second, non-network players were not able to participate as well, hence preventing the opening to competition in the (still monopolistic) network activities.

1.2.4. Benefits for companies

A consumer association, Citizens Advice, blamed the RPI-X regulation and its application by Ofgem for providing excessive remuneration to the regulated companies, as proved by their ability to significantly outperform the baseline set by the regulator.[x] During the last RPI-X regulatory periods, ending respectively in 2013 for transmission and 2015 for distribution, while the allowed return on equity was set close to 6 per cent, its effective value was generally closer to 9 or to 10 per cent, once the rewards and penalties stemming from the various incentive regulation schemes were considered. It happened only once to two distribution companies to get an effective return on equity below the normal rate. Indeed, a network company had the possibility, by cumulating the rewards or the penalties of the different incentive regulatory schemes, to increase its remuneration or be penalized by 400 base points over or below the allowed return on equity.

Nevertheless, it is undeniable that RPI-X regulation in the electricity sector was able to achieve great success. Prices decreased over the RPI-X regulation periods by 30 to 50 per cent (transmission to distribution). Quality of service improved significantly with a reduction of power cuts by more than 10 per cent in number of events and 30 per cent in duration, a drastic increase in the level of investments (almost multiplied by two

compared to the pre-privatization period), and a transformed use of the power networks by CCGT first and renewables then.

These achievements could happen because a temporary rent was left to network companies. Despite the temptation to reduce allowed revenues and regulatory rewards to better off consumers or return efficiency gains to consumers more quickly, the theory of incentive regulation shows that doing so would destroy any incentive for companies to improve their efficiency level over time. Meanwhile, an upgrade of regulation itself is always welfare improving because it may either lower costs or provide higher value and quality of service for the network users or both simultaneously. The continued improvement of regulation under the RPI-X era was in that vein and was the real purpose of refunding it with the RIIO regulation.

1.2.5. Success and required improvements

For twenty years RPI-X regulation in Britain was able to achieve great success with major price decrease and increase in quality of service while triggering a new investment cycle and accompanying the power sector in several transformations.

The RPI-X regulation applied in practice in Britain was built with pragmatism, correcting incentive mechanisms or developing new ones when it was considered needed. However, the RPI-X regulation had four main drawbacks. First, it resulted in a patchwork of mechanisms whose interactions were neither fully identified nor understood. Second, it had also a short-run bias with a focus on cost saving through a sweating asset regulation. Third, correction patches on outputs and innovations were introduced but they incentivized the regulated companies to focus on the regulator's expectations rather than on investigating the network users' expectations. With this regard, since networks are essential for the integration of renewable energy sources and the transition to a low-carbon energy sector, a realignment of regulation with climate policy objectives is needed. Fourth and lastly, regulation became a rather intrusive process with detailed audit and benchmarking reviews, leading to regulatory costs, possibly unaligned with the network users' expectations.

1.3. The evolution towards RIIO

In 2009, Ofgem decided to revise the overall principle of the RPI-X regulation in order to overcome the difficulties identified since its early implementation in the 1990s. The review resulted in the so-called RIIO regulation where RIIO stands for 'Revenue = Incentives + Innovation + Outputs', meaning that the revenues of regulated companies shall be set to deliver strong incentives, innovation and outputs for network users. The RIIO regulation is built keeping in mind that the goal of regulation is to mimic competitive pressure on monopoly firms. The activity of the regulated company should

hence be consumer-oriented. Namely, it should focus on a) outputs to improve services to network users, b) incentives for cost reduction and c) innovation in order to provide new services and cost reduction in the long run to the benefit of network users.

Meanwhile, what was announced as a revolution, in fact, became an evolution. All the elements of the RPI-X regulation are still present (the RPI-X theoretical approach, output-based regulatory schemes and innovation-promoting mechanisms). The RIIO regulation has nevertheless the advantage of overhauling the entire regulatory process with the goal of overcoming the problems identified in the RPI-X regulation. Reorienting regulation towards outputs has then shifted the focus on network users' expectations. Besides, the objective of considering total expenditure (TOTEX, i.e. the sum of OPEX and CAPEX) as well as OPEX and CAPEX individually was also to consider the overall service provided and not different types of costs that are of no immediate relevance for network users. The RIIO regulation also has the characteristics to allow companies to choose their incentive scheme on TOTEX from a so-called menu of contracts, with more or less incentives and subsequent potential risks and rewards. Lastly, innovation was fully integrated into the regulatory process and was no longer addressed through disparate mechanisms.

In this section, we start by showing how the RIIO framework is supposed to reflect better the expectations and needs of network users through the regulation of network outputs. Then, we move to consider how a menu of contracts for TOTEX can incentivize efficient behaviour by network companies. Finally, we illustrate how the promotion of innovation has been deeply embedded in the regulatory process.

1.3.1. Output regulation reflecting network users' expectations

RIIO is a performance-based model for setting the network companies' price controls for a period of eight years. Contrary to RPI-X, the RIIO regulatory framework has been built with outputs as the core element: while RPI-X regulation prescribed a set of inputs whose level had to be kept under control by the regulated company, RIIO regulation defines first a set of outputs to be delivered to network users and, only later, seeks to deliver them at the cheapest cost.[xi]

Six key output categories have been identified to frame the activity of network regulated companies: customer satisfaction, safety, reliability, availability, conditions for connection, environmental impact and social obligations. Consumers and stakeholders have participated in the definition of both specific outputs for each category and the expected targets to be achieved by companies. Beside the regulator, the network company may consult them too while realizing its business plan, proposing additional or alternative outputs and incentivize arrangements where these address the specific needs of the stakeholders. Considered in the overall RIIO regulatory process, it provides

powerful incentives for companies to innovate and seek least cost ways to provide network services.

To enable regulator, network companies and stakeholders to have a clear understanding of what is delivered throughout the regulatory periods, outputs have hence been defined. They were designed in such a way to be material, controllable, measurable, comparable, applicable, compatible with the promotion of competition and legally compliant.

Output categories that differ from legal requirements or do not benefit from reputational incentives are subject to an adequate incentive scheme. Basically, incentives for safety and connections mainly rely on the general enforcement of legislation. Reputational incentives apply on availability, environmental impact of losses and business carbon footprint publication and visual amenity. In contrast, incentive mechanisms apply to the other categories, namely reliability, customer satisfaction and environmental impact of SF_6, a gas with a major greenhouse effect (several thousand times higher than CO_2) that is used in transformers for electrical insulation. Output regulation also partly applies on safety for network replacement and visual amenity.

The base revenue estimate, including investment requirements, will be based on the assessment of efficient costs for delivering the agreed outputs. Performance on outputs subject to regulatory incentive mechanisms then impacts the return on equity earned by the regulated company and can add up and down to the allowed return until 100 base points, hence a remuneration at risk close to 15 per cent of its base level (in the first RIIO regulatory period for transmission (RIIO-T1) and distribution (RIIO-ED1), the return on regulated equity without reward and penalty from incentive schemes was set at 6.7 per cent for distribution companies and close to 7 per cent for transmission companies).

Even if the first regulatory period of RIIO is still ongoing, its mid-term review and the letter by Ofgem beginning the discussion on the RIIO-2 framework have shown that some questions on the definition and proper delivery of outputs remain open. One of the main questions is that key performance indicators (KPIs) are sometimes closely related to the realization of one specific investment (examples are shunts or HVDC lines). Regulatory schemes associated to these KPIs and specific investments are then extremely similar to classic RPI-X regulation, simply capping the cost of these investments. But unexpected events have occurred. For instance, the regulated companies were able to provide some expected outputs with technical solutions different to those planned at the beginning of the regulatory period for a far lower cost. The regulator is hence considering decreasing the cost cap initially designed for this output/investment. Another example also stems from unplanned external factors impacting the need for new investments in order to ensure the delivery of some outputs that have materialized, which then leads to questions about the definition of the associated outputs and their associated baseline level of costs. These questions are

classical ones for regulatory-like concession contracts. Regular renegotiations are then needed because of the incompleteness faced with unexpected events. Let us see how Ofgem will cope with that at the end of RIIO-1 and in the design of RIIO-2.

1.3.2. A menu of contracts for TOTEX efficiency incentives

Besides being oriented toward output regulation, the current British regulatory design is based on a periodic revenue cap mechanism (with an eight-year period rather than the five-year period under the previous RPI-X regulation). The costs budgeted by the companies for regulated activities (operation and investments) in their business plan are taken into account to define revenue allowances for the regulatory period. The revenue cap mechanism applies to budget costs following a TOTEX design. TOTEX is defined as the sum of CAPEX (i.e., only new investments that are considered completely controllable, but not the historical asset base) and controllable OPEX.[xii]

A major change from the first RIIO regulatory period is the definition of the Regulated Asset Value (RAV).[xiii] In the RPI-X regulation, the RAV was classically defined as the non-depreciated network assets (namely power lines and substations). Other short life assets such as IT facilities were included in the OPEX and so did not generate any return on investment. Consequently, there was an incentive for the company to prefer CAPEX over OPEX since CAPEX was generating a return on investment, whereas OPEX was only paid at cost (except when specific incentive mechanisms applied). The network companies were also allowed to retain more efficiency gains on CAPEX than OPEX, amplifying their interest in CAPEX.

To avoid this pitfall, Ofgem decided to change the way the RAV is defined. Now, the RAV is not only made of CAPEX. A fixed part of total expenditures, whether CAPEX or OPEX, is included each year in the RAV. The TOTEX capitalization rate then defines the part of TOTEX (so-called slow money) that is included in the RAV. A TOTEX capitalization rate of between 85 per cent and 90 per cent has been set for network companies (based on historical shares between OPEX and CAPEX). The non-capitalized part of TOTEX and non-controllable costs taken together form the so-called fast money and are funded in the year of expenditure. The RAV is then depreciated assuming that the new capitalized TOTEX is depreciated in a straight-line manner during 45 years on average[xiv, xv].

The revenue cap is applied on network companies' TOTEX with a menu of contracts mechanism (see Chapter 2.3.1 for further information on the menu of contracts tool). This scheme is known as the Information Quality Incentive (IQI). The regulator targets two purposes with this menu of contracts. The first idea is to decrease information asymmetry as the network companies select the incentive scheme they think is more appropriate to their situation, hence revealing their target cost. Second, this incentive scheme defines the sharing factor applied to the gains or losses the network company

may incur compared to the target cost. For instance, the proposed contracts go from a 40 per cent to a 50 per cent sharing of efficiency gains above the target and a +/-2.5 per cent additional income reward/penalty.

BOX 1.2: Adjustment of TOTEX, RAV and revenue to external factors and revenue formula

The TOTEX and consequently the Regulated Asset Value (*RAV*) can be adjusted because of changes in drivers of expenditures (generation or demand connections, relieving internal network constraints, etc.). A baseline for a part of TOTEX (so-called Load Related Expenditures) is hence defined for the whole regulatory period based on some assumptions of drivers of the network companies activities. Changes in these drivers lead to additional TOTEX allowances. These drivers are the volume of new generation connections, new demand connections, additional transfer capability to relieve internal network constraints, integration of cost of mitigation measures to gain consent for reduction in visual amenity and funding for delivering outputs in RIIO-T2. The *RAV* is also updated by inflation level. It is remunerated at the weighted average cost of capital (*WACC*) value. Besides, a two years lag is introduced to make the tariff predictable enough. The authorized revenue R_N for year N is hence determined as follows:

$$R_N = FastMoney_{N-2} + D_N + WACC * RAV_N + A_{N-2} + I_{N-2}$$

With D_N depreciation of the RAV for year N,

A_{N-2} adjustment from the year N-2,

and I_{N-2} financial incentive from the year N-2.

The TOTEX allowances and efficiency targets are computed based on a combination of several methods (disaggregated analysis of CAPEX and OPEX, efficiency audits, consultation process, benchmarking). International benchmarking is only used to inform the overall Ofgem assessment of the companies' forecasts. No mechanic application of benchmarking as incentive scheme is implemented. Rather, it is used in the stakeholder consultation process for the regulator to assess the cost of the network companies' business plan and set the TOTEX allowances, but not to set the maximal allowed revenue itself.[xvi]

Incentive on TOTEX may increase or decrease the return on regulated equity by 300 base points (compared to a base level fixed at 6.7 per cent for distribution companies and around 7 per cent for transmission companies). This means that the remuneration of a network company in Great Britain can be increased by more than 40 per cent, if it

reaches all the efficiency and output objectives set in the RIIO regulation. The TOTEX incentive accounts for more than 75 per cent of the whole level of incentives.

1.3.3. Full integration of innovation in the regulatory process

The RIIO regulation encourages technical and commercial innovation through the core incentives of price control, innovation stimulus package and competition with the option of giving responsibility for delivery to third parties.

The core incentives of the RIIO regulation stimulate innovation with the price control framework. First, firms are incentivised to innovate and deliver the outputs asked by consumers and beyond through associated schemes of output regulation. Second, firms which innovate are rewarded through the normal mechanism of retaining part of the efficiency savings they achieve. Indeed, their incentive to innovate is higher in the RIIO regulation than in the RPI-X regulation because they retain efficiency gains over a longer regulatory period (eight versus five years). Lastly, companies can propose, in their business plans, the roll-out of innovative technologies, techniques or commercial strategies which may pose higher cost in the price control period than the business-as-usual approach, but that are justified by the longer-term delivery of outputs at lower cost to customers.

However, innovation also requires other mechanisms outside the price control framework. Indeed, where the commercial benefit of innovation is not clear, network companies may not have a strong motivation to pursue innovation in a timely way. It then requires the development of further specific schemes in order to encourage innovation (see Chapter 2.3.3 for additional thoughts on the regulation of innovation).

An innovation stimulus package was then built as a starter to supplement incentives inherent to the RIIO price control framework. It provides partial financing for innovative projects intended to meet environmental objectives, not just those related to the low carbon agenda. It relies on two processes, first on innovation allowance and second on the network innovation competition.

Innovation allowances provides directly for small scale innovation projects, with companies having the possibility to self-certify against set criteria. The allowance is between 0.5 per cent and 1 per cent of total allowed revenues, depending on the quality of the supporting innovation strategy. In principle, it is similar to the previous IFI and to the First Tier funding available under the LCN Fund.

Besides, partial funding can be awarded through the Electricity Network Innovation Competition (NIC) scheme**.** An independent panel is appointed to evaluate the bids submitted. Ofgem then takes the final decisions on the awarding of funding based on the panel assessment. Contrary to all the other innovation mechanisms previously

mentioned (under the umbrella of the RPI-X regulation or the RIIO regulation), network and non-network parties are eligible to apply for funding to help progress projects at any stage of innovation, from early research activities to trials and pilot schemes. The amount of funding available for electricity networks was initially £95 million per year, including £30 million per year for transmission. It is now closer to £45 million per year for electricity networks. Funding can reach up to 90 per cent of the project costs, with the rest to be financed through network tariffs. Non-network parties are eligible to participate and compete in the innovation stimulus package if they satisfy a set of criteria. They must hold an 'innovation licence', demonstrate that they are well placed to undertake innovation related to network services, notably showing an ability to understand network operation, have qualified specialists, have previous experience on relevant projects and a fully worked up proposal for an innovative project. They should also have a facilitated access to the network. Indeed, if the innovation project proposed by a non-network company involves trialling on a network, the non-network company should seek to arrange for this access in advance of making the bid for innovation stimulus funding. If it is unable to secure agreement from a network company, the governance panel of the innovation stimulus package will decide in these cases whether to recommend Ofgem consider taking action to require a network company to facilitate access.

1.3.4. A major evolution, not a revolution

The RIIO regulation is a major evolution of the RPI-X regulation. It allows for a less intrusive regulatory process if business plans proposed by the companies are satisfactory for network users, stakeholders and the regulator. Hence, it is based on a consultation process and focuses on network users' needs. Through the definition of appropriate outputs, RIIO regulation mimics competition pressure and fosters the emergence of services needed by network users and the proposal of innovative solutions to them. Besides, under RIIO the regulatory schemes are harmonized if not merged to avoid inefficient arbitrages by the companies. Nevertheless, the RIIO regulation remains grounded on the same theoretical principle that underpins RPI-X regulation.

1.4. Conclusion

The application of the RPI-X regulation in Britain has been an example if not a source of inspiration for many regulators in Europe and worldwide, showing the possibility to apply concretely the RPI-X principle, its pitfalls, the improvements needed to adapt it to real situations or unexpected and unintended observed effects. The RIIO regulation is also viewed with much interest by regulators and network operators since it shows, on

the one hand, new regulatory forms and, on the other hand, new opportunities and risks for regulated companies.

From a theoretical and practical point of view, the change from the RPI-X regulation to the RIIO regulation shows that before wanting to cut costs, it is necessary to identify what users expect from the network service and possible alternatives. Otherwise, regulation incentivizes companies to decrease outputs in order to reduce costs, at the expense of network value for users. This concretely stems from a lack of a proper mathematical definition of network cost function. If it was available, more modelling of regulation would have been possible, and deeper economic understanding of wanted and unwanted consequences of the different regulatory schemes applied or proposed would also have been possible. It explains too why it is difficult to assess efficiency factors whatever the benchmarking methods applied, because it is difficult to compare the performance of a given company over time and circumstances and with peers. With such a mathematical definition of a network cost function, it would have been possible to have more parametric econometric analyses, better grounded on the physical and organizational principles of network activity. A network cost function could also be very valuable to enrich the seminal works on incentive regulation and to help it evolve.

Despite the undeniable great improvements of regulation there have been, since the outset, persisting difficulties with assessing efficiency factors, defining network outputs and fostering innovation in a regulated environment. There is still work for practitioners and theoreticians in this regard. The recent and dense letter by Ofgem opening the consultation on the RIIO-2 framework shows that it wants to keep improving the current framework in all its dimensions: better definition of outputs and associated delivery, improvements in the process of setting incentives for cost reduction and innovation. One can expect that Great Britain will remain at the forefront of this field for some time.

1.5. References

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[i] In this chapter we focus on Great Britain. Other parts of the UK like Northern Ireland are not considered here.

[ii] National Grid has changed its name several times since its unbundling and privatization in 1990. For the sake of simplicity and generality, we use its most common denomination.

[iii] National Grid also owns and operates the high pressure gas pipelines in the whole of Great Britain. Additionally, the company has a minority stake in some British gas distribution networks and investments in electricity and gas grids in North America.

[iv] Ofgem was formed in 1999 by the merger of the Office of Electricity Regulation (Offer) and the Office of Gas Supply (Ofgas) – the two sector-specific regulators were initially created by the British government with the Gas Act of 1986 and the Electricity Act of 1989.

[v] Under the incentive regulation framework established in the 1990s, the acronyms DPCR and TPCR denoted, respectively, a Distribution Price Control Review and a Transmission Price Control Review. For a chronology of the price control reviews see tables 1.1 and 1.2.

[vi] One of the largest uncertainties concerns the level of electricity demand, which in turn affects the estimation of the efficient average cost for the network firm.

[vii] To be precise, the British regulator of the electricity sector was, until 2000, Offer. However, for the sake of simplicity, we refer here generically to its heir Ofgem.

[viii] Defined in this way, the RPZ incentive scheme can be considered as a form of innovation output regulation. Conversely, the IFI can be seen as a form of innovation input regulation.

[ix] In a report for Ofgem the consultancies Mott MacDonald and BPI estimated a net benefit for customers of £92 million due to the RPZ mechanism and of £386 million due to IFI. Costs for customers were respectively estimated at about 29 and 57 million.

[x] See Moore, Simon (2015), *Many happy returns? The Consumer Impact of Price Controls in Regulated Networks*, UK: Citizens Advice.

[xi] As we have seen in the previous section, a focus on outputs was present also within the RPI-X regulation. Nevertheless, in that case the focus aimed merely to avoid that cost reduction by network firms was realized at the expense of service quality.

[xii] Non controllable OPEX are outside TOTEX and incentive regulation. They are directly passed through to the network users. They mainly include the licence fees, the business rates (a tax on the occupation of non-domestic property in England and Wales), pensions and pensions schemes administration, and the costs related to the Inter-TSOs compensation mechanism.

[xiii] The definition of RAV is very close to that of RAB. They are sometimes used as synonyms.

[xiv] The assets of the network companies that were already in place before the introduction of RIIO regulation will continue to be depreciated over 20 years.

[xv] The work in progress is integrated in the TOTEX and so in the RAV, under the condition that the considered asset eventually provides the required output.

[xvi] Ofgem's view on international benchmarking in the RIIO regulation is as follows: '*Under the RIIO regulatory framework, international benchmarking is a key element of the cost assessment toolkit, and we will continue developing our international dataset and TOTEX benchmarking methods during this price control. We will also ask the TOs to put forward more international benchmarking analysis themselves at both an aggregate and disaggregated level. However, having considered the emerging issues such as availability and maturity of the data for international comparators and stakeholders' concern on the robustness of international benchmarking, we intend to rebalance the role of TOTEX benchmarking in RIIO-T1. Although we will take the results of TOTEX benchmarking into consideration when we assess cost efficiencies of network companies, we will focus more on disaggregated cost assessment approaches.'*