Incentives for investments: Comparing EU electricity TSO regulatory regimes[1]

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Executive summary

There are considerable needs for electricity infrastructure investments in the European Union. The achievement of the EU internal market calls for a free movement of trade across the countries' borders. Decarbonisation of the generation mix requires reaching areas with large amounts of renewable energy sources located far from load centres. Network capacity is also essential to cope with the challenges of system stability under extended to massive intermittency. The European Network of Transmission System Operators for electricity (ENTSO-E) hence identified in the Ten Year Network Development Plan (TYNDP 2012) that €104 billion investments are required in the next ten years on projects of pan-European significance. These investments require of course massive debt or equity raising (Roland Berger, 2011). They also require that the Transmission and System Operators (TSOs) be able to finance these investments at a low cost of capital, that is to say that they receive sufficient cash flow to cover their CAPEX and payments to shareholders and debt holders (otherwise experiencing financeability issues) (Henriot 2013). It is therefore crucial that their regulatory frame allows them enough revenue and ensures their long term financeability.

In the context of the Third Package and the Infrastructure Package implementation, the national regulatory regimes for TSOs got a central position in the management of EU massive needs of network investments. As a consequence, comparing and understanding the existing TSO national regulatory regimes is key to check whether the EU TSOs can both individually and all together ensure that these investments might be financed from now on up to 2020 or 2030 (see the last Green Paper from European Commission issued in March 2013). It is therefore fundamental to analyse the potential consequences of the various national regulatory choices for investments which already have an increasing impact on the functioning of the EU regional markets. The development of the network is also taking a European scale through the industrial structures of the TSOs. Cross-border TSOs have recently appeared with the acquisitions of respectively the German TSO 50Hertz by the Belgian TSO ELIA, and another German TSO Transpower by the Dutch TSO Tennet. Even if the day-to-day regulation is still decided at the national level, these cross-border TSOs make these national frames interacting. Non-coordinated interaction might suppress degrees of liberty in the building of the EU internal market by restricting too much the scope of interactions between the various national regulatory paths.

The objective of this paper is therefore to study the potential consequences of national regulatory choices with regard to network investments influencing the development of the European market in the North Western region. To reach our objective, we first build an analytical framework to study the different properties of the national regulatory regimes. We consequently define criteria to compare the economic properties for investment of any regulatory regime. We establish a set of theoretical and empirical principles to identify the key economic properties of the main regulatory characteristics and the main design options, summing it up in a graphical analysis. In a second step, we study selected countries in our analytical framework. Our high level analysis focuses on five European countries that are connected in a regional market and cover more than half of the EU electricity production. These countries are namely Belgium, France, Germany, Great Britain and the Netherlands. We address the existing regulatory incentives for investments in this area, relying on theoretical and applied economic literature as well as an analysis of each country regulatory regime. The frame is then used to compare the economic properties of these various national regulatory regimes. Third, after discussion of the potential reasons of national choices, we analyse the potential outcomes of these regulatory regimes when being put together in the context of regional market integration. Finally, we discuss the need of some harmonisation and the key harmonisation targets.

Analytical framework

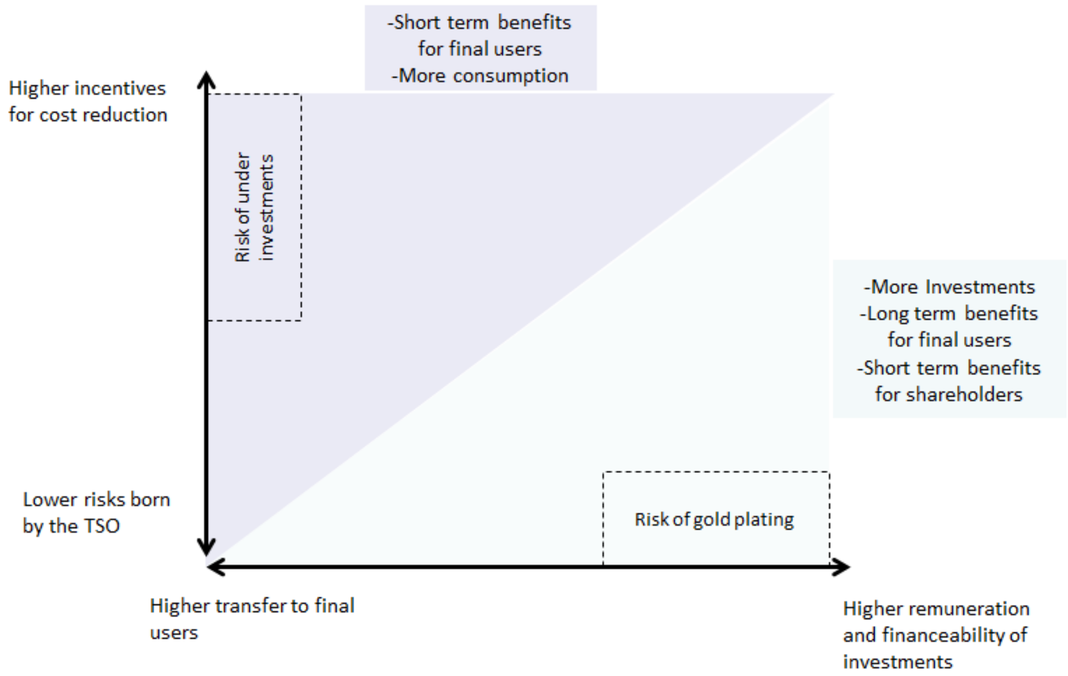
The analytical framework to perform the study of national regulatory regimes is built in section 1. Based on economic theory, four main economic properties of regulatory regimes are defined: a) the capability to sufficiently remunerate TSO investments and to ensure their financeability, b) the capability to reduce the risk born by the TSO, c) the capability to incentivise TSO cost reduction and d) the capability to transfer efficiency gains and redistribution to final users.

The main design characteristics of regulatory regimes are then established by defining design options and by analysing their economic properties. Any regulatory regime can be described as a periodic revenue cap scheme where the main design characteristics are: the length of the regulatory period, the scope of the revenue cap (TOTEX versus building blocks), the tools to define allowances and efficiency targets (benchmarking versus cost and efficiency audit), the practical setting of the capital remuneration and the adjustment mechanisms. A theoretical and empirical set of principles is then used to identify economic properties of regulatory designs options. These principles are grounded on how different design options combine economic properties of theoretical incentives instruments (from the less to the more powered ones, cost plus regulation, revenue/price cap, performance regulation, menu of contracts and yardstick competition) and on how theoretical instruments are implemented in practice.

Beside the potential implementation errors of regulatory designs (whose correction may improve the score in several properties at the same time), one important conclusion from the theoretical and applied analysis is that there are strong tensions or trade-offs between economic properties when selecting a design option. In other words, no regulatory design will “score” high in all the economic properties (i.e., the four criteria). For instance, there is a balance to be done between the incentives for achievable cost reduction of a regulatory design and the risks born by the TSO. Similarly, a too high transfer to end-users may reduce the TSO remuneration and contribute to financeability problems. The regulatory designs and their trade-offs can hence be easily analysed in a graphical manner summarising the tensions in two axes, the horizontal axis for the transfer to final user versus remuneration and financeability and the vertical axis for incentives for cost reduction and risks for the TSO (figure 1).

Two areas are then distinguished. The upper-left corner area corresponds to a situation of high incentives for cost reduction (and high risk born by the TSO) plus low remuneration and financeability of the TSO (with high transfer to final users). Given this combination of economic properties, a regulatory design located in this area will result in lower tariffs (in the short term) and likely more consumption (according to the short term elasticity of users). However, this design will also deliver weak incentives for investments and favour today’s under-investment resulting in potential higher costs in the future (if investment is needed and quality is weakened). The lower-right corner area corresponds to a high remuneration and financeability (with lower transfer to final users) as well as lower risks for the TSO (and lower incentives for cost reduction). Given this combination of economic properties, a regulatory design located in this area will result in more incentives for today’s investments and potential lower costs in the future. However, this regulatory design might also imply higher tariffs in the short term and a possibility of over-investment (“gold plating”).

Figure 1. Simplified graph and regulatory designs areas



Given the imperfections of all the instruments and their necessary trade-offs, it should be noticed that the economic properties of actual regulatory designs should be analysed only when considering the context where the regulation is applied. When the context is one of a huge level of TSO inefficiency and investment is not a priority, regulatory designs with high incentives for cost reduction on controllable items and a high transfer to final users will fit best. Indeed, the risk of under-investment is not there a big issue because investments are not needed. Inversely, these regulatory designs do not fit in a context where investment needs are high and investment itself is risky. It might even be socially costly because it calls for under-investment (lowering future network quality or missing the infrastructure objectives – e.g., energy transition or internal market building). On the top, it induces a higher cost of capital because the network operators experience more risk and a weaker financeability. In a context where investment needs are high and investment itself is risky (during an innovation wave for instance), designs favouring a low risk born by the TSO and an appropriate remuneration and financeability fit better. The cost of capital might be reduced and the new infrastructure objectives (as innovation, sustainability or achievement of the internal market) are favoured by this regulatory design. Such a regime can then be socially beneficial as it exceeds its weaker performances in terms of incentives for cost reduction and the lowering of tariffs in the short term.

Comparing the national regulatory regimes and assessing economic properties

Section 2 is dedicated to a high level case study analysis of the five selected countries: Belgium (regulatory period from 2012 to 2015), France (regulatory period from 2013 to 2016), Germany (regulatory period from 2014 to 2018), Great Britain (regulatory period from 2013 to 2021) and the Netherlands (regulatory period from 2014 to 2016, based on draft proposal).

Relying on our analytical framework, the characteristics of each national regulatory regime are described with their main design options. We find there are three main types of regulatory regimes.

Belgium and France use a "building blocks" approach. They mainly exclude investments from the revenue cap and lower the strength of incentives to reduce this type of costs. The building blocks approaches are complemented by efficiency audits of the investment budgets (*ex ante* approval of investments and potential control of investments *ex post*). Once the investments are made and accounted in the Regulated Asset Base, they are subject to a straight-line depreciation and they are remunerated with an allowed cost of capital (WACC). This approach can be considered as bearing low-risk on the TSOs since the main part of the costs is treated as pass-through items (including SO costs). In parallel, this approach provides modest incentives on cost reduction because it does not optimise the trade-offs between OPEX and CAPEX, resulting in a modest transfer of efficiency gains in this respect.

Germany and the Netherlands use a "TOTEX" approach with a strong reliance on yardstick/benchmarking techniques. They include most investments in the revenue cap scope. Each regulatory regime defines its own classification of costs and the impact of efficiency targets on each cost, while globally most of the investments are included in the revenue cap envelop. Both regulatory regimes are favouring benchmarking as the key tool to define the required efficiency levels. These regulatory regimes are by nature bringing more incentives on cost reduction than the building blocks regimes, even to an extreme level since efficiency targets also apply to old investments (in the RAB), while their costs are sunk and cannot be influenced anymore. These regulatory regimes are also bringing more risks for the TSO than the building blocks regimes. Because of the difficulties to control exactly for the different environments where the TSOs operate, applying benchmarking on transmission network still leads to fragile results that are not fully reliable. If the German and Dutch approaches are based on the same technique, they distinguish however on two obvious differences. The first difference is grounded on the use of comparable companies to perform the benchmark. The Dutch regime must ground its scoring on international benchmark (as there is only one TSO in the Netherlands) whereas the German regime combines international with national benchmarking (based on the four TSOs operating in Germany). This difference is consequential as long as any benchmarking assumes that both the transmission regulatory environment and the "doing business" environment are sufficiently similar for all the scored companies to not interfere with the scoring results. In this respect, the German approach can only be more robust, for it is based on four national companies sharing the same transmission and "doing business" environments (rules of law, of administrative behaviour, of social and industrial relationships, etc.), even if some degree of heterogeneity may remain (e.g., East versus West). As a result, the related regulatory risks incurred by the benchmarked TSO can only be higher in the Dutch regime than in the German regime. The second difference is grounded on the scope of costs that escape temporarily from the TOTEX efficiency targets. To our understanding, the system of Investment budget (IB) applied in Germany lowers the risks born by the TSOs because these investments are excluded for one or two regulatory periods from the efficiency targets.

In these circumstances, the regulation applied in Great Britain represents an intermediary level between these two types of regulatory regimes. First, the already long regulatory past of the British system can only increase risks and incentives to get further deep cost reduction. Second, the British regime did move to a TOTEX "approach". This second factor should strengthen the risk and incentives born after twenty years of sustained efficiency gains. However, it is not the case because of a key difference when defining the efficiency targets. We have seen that Germany and the Netherlands use benchmarking as the main efficiency target tool, while the British regime combines different tools, where benchmarking is only one part of a global evaluation and not used directly for the calculation of the efficiency targets. Moreover, these efficiency targets only apply to OPEX and the new CAPEX (during the regulatory period) and do not touch upon the assets already integrated in the RAB. Finally, the British regime uses a "menu of contracts" where the TSO (NGET, SPT or SHET) chooses its preferred combination of incentives and risks according to its manageable business trajectory. Besides, several adjustment mechanisms are implemented in order to link the actual network revenues to defined driver changes (like generation and load connection, network constraints, etc.).

Concerning the allowed cost of capital, three main levels are observed. The British regime applies the highest level[5]. The Dutch draft proposal[6] and the Belgian regime[7] currently offer the lowest levels of remuneration of capital. Finally, the French[8] and German[9] regimes are in a medium range.

By comparing the regulatory regimes, it is then possible to contrast their economic properties. Table 1 sums them up and the stylised regulatory regimes can be located on figure 2 in our graphical taxonomy.

[5] Allowed cost of capital in Great Britain (NGET) (nominal post tax values): RoE = 9.0% and vanilla WACC = 6.6%. We have converted the British rates expressed in real values only by the OFGEM into nominal values since the other regulators express these rates in nominal values most of the time.

[6] Allowed cost of capital in the Netherlands (nominal post tax values): RoE = 5.6% – with a notional gearing decided at 50% meaning that the RoE with a hypothetical 60% gearing is up to 6.2% – and vanilla WACC = 4.7%.

[7] Allowed cost of capital in Belgium (nominal post tax values): RoE = 4.3% – with a notional gearing decided at 67% - meaning that the RoE with a hypothetical 60% gearing is down to 4.1% – and vanilla WACC = 4.3%.

[8] Allowed cost of capital in France (nominal post tax values): RoE = 7.3% and vanilla WACC = 5.7%.

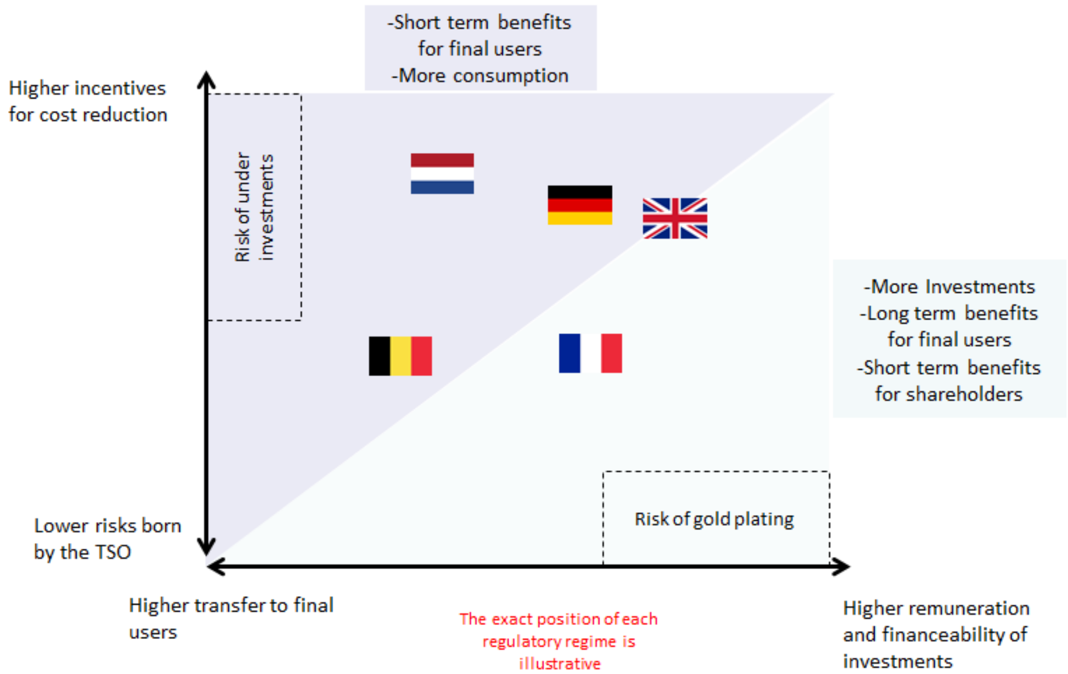
[9] Allowed cost of capital in Germany (nominal post tax values): RoE = 7.4% and vanilla WACC = 5.5%.

Table 1. Economic properties of stylised EU regulatory regimes

Criteria	BELGIUM	FRANCE	GERMANY	GREAT BRITAIN	NETHERLANDS
Remuneration and financeability for TSO investments	Very low remuneration/ financeability	Medium/high remuneration/ financeability	Medium/high remuneration/ financeability	High remuneration/ financeability	Low remuneration/ financeability
Minimising risks born by the TSO	Low TSO risks	Low TSO risks	Medium/high TSO risks	Medium/high TSO risks	High TSO risks
Incentives for cost reduction	Modest incentives on cost reduction	Modest incentives on cost reduction	High incentives on cost reduction	Medium/High incentives on cost reduction	High incentives on cost reduction
Transfer of efficiency gains and redistribution to final users	Modest/high transfer to final users	Modest transfer to final users	Medium/high transfer to final users	Medium/High transfer to final users	High transfer to final users

These stylised national regulatory regimes show a significant heterogeneity of economic properties, expressing several tensions in the design of regulatory regimes. These tensions are coming from underlying trade-offs that can be observed using the simplified graph of economic properties (see figure 2). For instance, the French regulatory regime is located in the investment friendly area, combining economic properties of higher remuneration and financeability with lower risks born by the TSO, while lowering the incentives for cost reduction and the transfer to end-users in the short term. The Dutch regulatory regime is located in the short term end-users greater benefits area, combining economic properties of a higher transfer to end-users and higher incentives for cost reduction with lower remuneration and financeability of investments and higher risks born by the TSO.

Figure 2. Economic properties of stylised national regulatory designs



Section 3 aims at discussing the potential consequences of national heterogeneity. Before analysing this at a regional level of the EU (section 3.2), we have explored the national specificities. It could bring some light concerning the reasons of such heterogeneity and the economic properties of each regulatory design having been chosen (section 3.1).

The regulatory regimes in a national context

Four aspects have been analysed at the national level: investment needs, the cost of capital, the potential efficiency gains and the impact of transmission tariff on the electricity final tariffs.

Investments needs

The investment needs are a key point when analysing the alignment of the various regulatory choices with national specificities. Indeed, the financeability of the investments and the risks born by the TSO depend on the ambition of the investment plans. If the investment plan is modest and the risks on investments are low (like replacement assets using a mature technology), the resulting risks born by the TSO will be smaller and financeability will be higher. On the contrary, if the investment plan is ambitious and the investments are riskier, the financeability and the risk touch or outpace some limits. The more ambitious and the riskier the investment plan is, the more sensitive a regulatory regime should be to its capability of ensuring financeability and minimising risks. In this respect, it can be observed that all these countries have a significant investment plan. Some of these plans are riskier (Germany, Netherlands, Great Britain) and some are relatively more important with respect to the current asset base (Netherlands, Great Britain). Besides, the countries are at different stages of this investment trend. France, Germany or Great Britain have already seen their investment level increased for several years while the investment level is just beginning to increase for Belgium and the Netherlands.

Cost of capital

The second point to consider when analysing the alignment of regulatory choices with national specificities is the cost of capital experienced by the TSOs on the financial markets. When setting the regulated value, the regulator has to balance the tension between two economic properties. If the cost of capital is structurally low, the financeability and risks issues will be less important. On the contrary, if the cost of capital is high, the financeability and risks issues should be keys in the understanding of the regulatory choices. From a theoretical point of view, the cost of capital is expected to be modestly lower for good looking state-owned companies (France, Netherlands) and higher for regulatory regimes that allocate more risks on the TSO (relying on a benchmarked TOTEX – in the Netherlands, Germany, Great Britain) and those that do not have the healthiest financial situation (50Hertz 60% owned by ELIA in Germany and SPT in Great Britain). Besides, the regulator may also influence the cost of capital when expressing its preferences, and arbitraging between two objectives: facilitating investments (and increasing tariffs in the short term) or lowering network tariffs in the short term (and depressing investments). When the regulatory preferences are not aligned with the investment needs, the cost of capital could increase and hamper the long term financial trajectory if a growing amount of investment is needed.

Efficiency level of the TSOs

The third point to be considered is the TSO potential efficiency gains from cost reduction. If there is a huge potential of efficiency gains to materialise, the incentives for cost reduction will be more important than the direct effect on the financeability. Financing constraints might even be relaxed given the potential cash liquidities that the TSO could gain by becoming more efficient (provided that the regulator does not define too ambitious efficiency targets). On the contrary, if there is a too small potential of efficiency gains on the TSO side (i.e., the TSO is already reasonably efficient), the incentives for cost reduction will be less relevant. It is difficult to assign the potential efficiencies that can still be realised at the national scale by each TSO. The regulator may have different views regarding the remaining inefficiencies and the amount of time for the TSO to achieve the efficiency gains. What can be said here is that if these potential efficiencies exist, they will take time to materialise. And the cash liquidities expected from these efficiencies (i.e., reducing actual cost lower than efficiency targets and earning the associated monopoly rent) will not help the TSO financeability in the short and medium term.

Tariff impact

The fourth point to be noticed is the impact of these regulatory choices on the electricity final bill. Indeed, the higher the impact of transmission tariff on the end-user bill is, the more essential it is that the regulatory regime considers incentives for cost reduction and transfer of efficiency gains to final users. Here, depending on national specificities, the regulatory preferences can vary. In practice, despite a generally low impact of transmission tariffs on the end-user bill, there might be different appetites for lower transmission network tariffs, going from politically sensitive tariff changes for household users to a focus on the national industrial structure or industrial strategies.

We have already found reasons for the existing heterogeneity and others factors may complete them. The heterogeneity of regulatory regimes may express national preferences for short term efficiency vis-à-vis long term investment adequacy. For instance, in Great Britain, France or even Germany, several economic properties of the existing regulatory regimes (remuneration of capital and financeability) are rather in line with ambitious investment plans. Reciprocally with situation of lower investment requirement in the past, other regulatory regimes retain lower remuneration (in Belgium and the Netherlands) and more pressure related to cost reduction (in the Netherlands or in Germany and in Great Britain to a smaller extent). However such regulatory regimes do not present a combination of economic properties aligned to the new context of ambitious investment plans and technology innovation. Investment ambition, risk and remuneration seem to us better aligned in France and Great Britain, while we fear seeing a misalignment in Belgium (very low level of remuneration), in the Netherlands (low/medium remuneration but risky regulation and investments) and to a smaller extent in Germany (medium level of remuneration but risky regulation and investments).

The national regulatory regimes in the EU and regional context

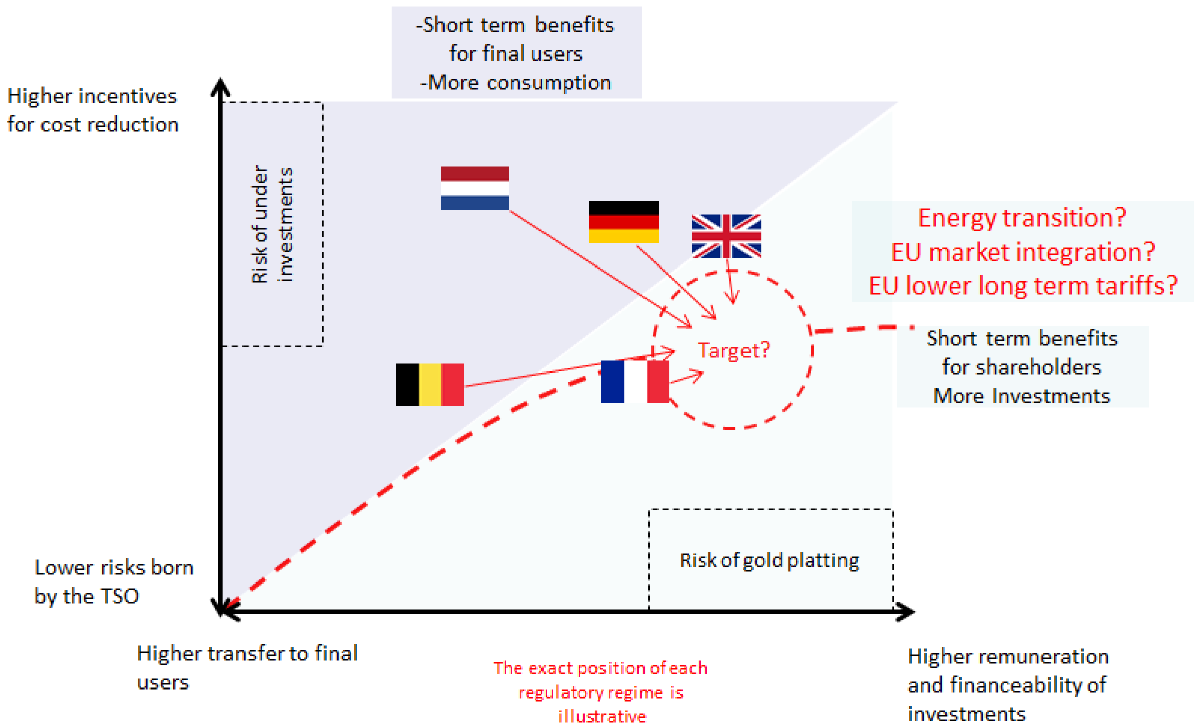
The heterogeneity of the existing national regulatory regimes can be understood as having mainly developed in an isolated manner, but with the European pulse to prompt for wider liberalisation through a sharper network unbundling and a more independent regulation. Meanwhile, this relative isolation of national regulations and their misalignment without substantial consequences will be more and more a past state of nature. It is what the Third Package and the Infrastructure Package aim at deeply changing for a real common EU regulatory frame. Furthermore, all the power transmission networks in the North/Central Western region are now undertaken in a common regional market and are facing similar challenges regarding the amount and risk of investment, and its financeability.

The alignment/harmonisation of regulation in the North/Central Western Europe is now needed for two reasons. First, a more common and friendly scheme for investors in regulated utilities could help to minimise their cost of capital. Indeed, improving the confidence and the stability of regulatory regimes helps to reduce the premium asked by investors to inject their money in regulated utilities. ACER could here play an active role in formulating “good practice guidelines” regarding the regulation of transmission. It could thus promote sound regulatory practices that try to minimise the risks for investors and to share good/bad practices. Second, regulatory regimes with different economic properties could actually hamper adequate cross-border investments, because grid might be expanded where an investor gets a more favourable return instead of where it would be optimal from a social welfare perspective.

This needed alignment/harmonisation target of the national regulatory regimes in North/Central Western Europe can be characterised as follows in our analysis framework. The current national and European situation is that the national networks and the corresponding European network need considerable investments as well as the development of new innovative technologies. In these circumstances, the cost of capital and the financeability issues are keys for the EU as a whole and individually for each TSO (Henriot, 2013, Beckers et al., 2013, Brunekreeft 2013). Besides, if an absolute priority to cost reduction was an excellent idea in a period of low investment or low technology innovation, it is less of a unique priority in times of massive investment and innovation. The social cost of not having enough investment or innovation could be much higher than the cost of remaining OPEX inefficiencies/monopoly rents. In advanced countries like Great Britain, after several decades of "lower OPEX" (decreasing by more than 50% between 1990 and 2005 in real terms) and lower tariffs (decreasing by 40% in real terms while the investment level has been on average twice higher than its pre-liberalisation level during the same period), the general level of efficiency seems today quite fair (low cost enough TSOs in Great Britain) and the impact of further efficiency effort on the transmission tariff will be smaller.

As a result, we think that the target for the harmonisation of regulation at the regional level should be in a zone more favourable for investments. Figure 3 shows where this target could be. Note that the area of the target is large enough to accommodate national specificities and possibly others differences.

Figure 3. Regional harmonisation target



Our analysis leads to the following conclusions. There are misalignments between the economic properties of existing national regulatory regimes and what would be a coherent enough regional EU target. Some adjustments might be undertaken by the national regulatory regimes to align better their properties, in particular to tackle two issues related to investments (remuneration and financeability and risk born by TSOs). The following table sums up what the potential modifications might be in order to align the national regulatory regimes with the existing investment ambitions and EU objectives. If no harmonisation target is ever reached, we might end up with under-investment (lowering the future network quality or missing the infrastructure objectives – e.g., energy transition or internal market building) and a high cost of capital for network investment. The network operators might bear too much risk and face financeability issues to eventually further increase the network tariffs.

Table 2. Fine-tuning regulatory regimes to reach an investment-friendly regional EU target

Fine-tuning	BELGIUM	FRANCE	GERMANY	GREAT BRITAIN	NETHERLANDS
Horizontal fine-tuning (financeability versus short term transfer to final users)	Improve significantly remuneration and integrate financeability in its determination	Integrate financeability in the determination of remuneration	Integrate financeability in its determination of remuneration Limit the application of efficiency targets to new investments only	No change	Improve remuneration and integrate financeability in its determination e.g. Increase WACC / or reduce X targets / or limit the application to new investments only
Vertical fine-tuning (minimising risks for TSO versus incentives for cost reduction)	Keep risk acceptable	Keep risk acceptable	Reduce risk born by the TSOs e.g. limit the risk of benchmarking techniques using it as an informative tool e.g. focus incentives on controllable costs (while regularly checking non controllability) e.g. fine tuning uncertainty mechanisms	Reduce risk born by the TSOs e.g. keep fine tuning uncertainty mechanisms	Reduce risk born by the TSO e.g. limit the risk of benchmarking using it as an informative tool e.g. focus incentives on controllable costs (while regularly checking non controllability) e.g. fine tuning uncertainty and adjustment mechanisms

Introduction

There are considerable needs for electricity infrastructure investments in the European Union. The achievement of the EU internal market calls for a free movement of trade across the countries' borders. Decarbonisation of the generation mix requires reaching areas with large amounts of renewable energy sources located far from load centres. Network capacity is also essential to cope with the challenges of system stability under extended to massive intermittency.

For, The European Network of Transmission System Operators for electricity (ENTSO-E) hence identified in the Ten Year Network Development Plan (TYNDP 2012) that 80% of the hundreds of bottlenecks in the EU transmission network are related to the integration of renewable energy sources. Besides, European networks are getting old. The IEA estimated that 44% of the European networks must be replaced until 2035 for a total cost of € 76 billion for the ENTSO-E area (IEA, 2011 and Henriot, 2013). These investments require of course massive debt or equity raising (Roland Berger, 2011). They also require that the Transmission and System Operators (TSOs) be able to finance these investments at a low cost of capital, that is to say that they receive sufficient cash flow to cover their CAPEX and payments to shareholders and debt holders (otherwise experiencing financeability issues) (Henriot 2013). It is therefore crucial that their regulatory frame allows them enough revenue and ensures their long term financeability.

In the aftermath of the Third Package and the Infrastructure Package, in the new network regulatory frame being set up by ENTSO-E and ACER, the European energy policy goals for 2020 and beyond have a legitimacy of their own and call for a more substantial harmonisation of actions undertaken at the country level. ENTSO-E identified that € 104 billion investments are required in the next ten years on projects of pan-European significance. Indeed, the electricity EU internal market building is pushing for network development. For instance, the strong regional market integration process with market coupling within the Central Western Europe and more broadly the North Western Europe region is increasing the cross-border exchanged volumes. Several bottlenecks have been identified in the region. Not only cross-border investments but also internal investments are then expected to relieve these congestions (ENTSO-E, 2012). The development of the network is also taking a European scale through the industrial structures of the TSOs. Cross-border TSOs have recently appeared by acquisition of respectively the German TSO 50 Hertz by the Belgian TSO ELIA, and another German TSO Transpower by the Dutch TSO Tennet. Even if the day-to-day regulation is still decided at the national level, these cross-border TSOs make these national frames interacting. Non-coordinated interaction might suppress degrees of liberty in the building of the EU internal market by restricting too much the scope of interactions between the various national regulatory paths.

In this context, the national regulatory regimes for TSOs got a central position in the management of EU massive needs of network investments. As a consequence, comparing and understanding the existing TSO national regulatory regimes is key to check whether the EU TSOs can as individually as all together ensure that these investments might be financed from now on up to 2020 or 2030 (see the last Green Paper from European Commission issued in March 2013, EC 2013). It is therefore fundamental to analyse the potential consequences of the various national regulatory choices for investments which already have an increasing impact on the functioning of the EU regional markets.

Until now, little research did look in that direction. For instance, to complete classical incentive regulation literature (Laffont and Tirole, 1993 and Shleifer 1985), Guthrie (2006) offered a detailed review on the definition of an adequate regulatory framework and required incentives to ensure that the needed investments will be delivered by the regulated monopolies. Nevertheless, the cross-border aspects were absent of his analysis.

Otherwise, applied research has mainly focused on the reasons why the different European countries have made different regulatory choices. Several reasons can explain that. *Florence School of Regulation*, among other research institutes, has been working on this topic for several years. First of all, the national goals and the national trends within the European Union have been for a long time significantly and legitimately different. Even during the early liberalisation period and the introduction of incentive regulation for network operators in the 1990s, the quest for more efficient regulated companies with reduced cost (while maintaining or even increasing outputs such as quality and stability) has followed different paces and different orientations in the different European countries (Lévêque et al. 2009, Microeconomix 2007 and 2009, Ruester et al. 2012, Saguan et al. 2011). However, from the 2000's, the European regulatory paradigm progressively changed to market integration and later on to energy transition. Several changes consequently appeared in network regulation, alongside new national peculiarities. It has already been underlined at *Florence School* that the EU network regulation had to move from the absolute priority of OPEX reduction to the other priority of investment (controllable CAPEX) fine tuning. It also implies going from only national to EU compatible objectives (Meeus et al. 2010, Glachant et al. 2012)[10]. It was shown that the existing various regulatory paths could be explained by different regulatory resources and capabilities as set by national governments and legislators (Glachant et al. 2012). This also covers different (national) internal conditions with regard to TSO ownership (Lévêque et al. 2009), the level of investment needs (ENTSO-E 2012, Meeus et al. 2012) and the TSOs financial strength (IHS CERA 2013, Henriot 2013). While some literature has looked at regulatory harmonisation and related investment issues (see for instance, ENTSO-E 2013, Meeus et al. 2012 and Ruester et al. 2012), they have not focused on analysing the existing regulatory regimes heterogeneity within highly connected regional markets.

The paper is organised as follows. First, we build an analytical framework to study the different properties of the national regulatory regimes. We consequently define criteria to compare the economic properties of any regulatory regime for investment. We establish a set of theoretical and empirical principles to identify the key economic properties of the main regulatory characteristics and the main design options, summing it up in a graphical analysis. Second, we study the five selected countries in our analytical framework. Then, we compare the economic properties of these various national regulatory regimes. Third, we discuss the other potential outcomes of these regulatory regimes when being put together in the context of regional market integration. Finally, we discuss the need of some harmonisation and the key harmonisation targets. Then we conclude.

[10] Another literature also exists on Cost Benefit Analysis applied to electricity transmission (see for instance Pérez-Arriaga 2013 or Meeus et al. 2013).

1 Analytical framework

There are several regulatory designs that can be applied to a Transmission System Operator (TSO). These designs have different economic properties, which can be analysed through a common analytical framework. The present section describes such a framework to be used in our study. It starts with the definition of the criteria used to compare the economic properties of the regulatory designs (2.1). It is followed by the presentation of the main design principles derived from theoretical and applied economic literature (2.2). We then apply this framework to the economic properties of the main regulatory designs, to conclude with a simple graphical analysis underlying the fundamental trade-offs faced by of the economic properties of regulatory regimes (2.3).

1.1 Definition of criteria: economic properties of regulatory regimes

Joskow (2008) states that: "*the primary goal of regulation in the public interest is to stimulate the regulated firm to produce output efficiently from cost and quality (including reliability) perspectives, to price the associated services efficiently, and to achieve these goals consistent with satisfying a break-even or budget-balance constraint for the regulated firm that allows the firm to covered its costs of providing service while restraining its ability to exercise its market power to exploit consumers by charging excessive prices*".

To achieve these goals, monopoly regulation basically deals with different issues. First, the theory of incentive regulation is founded on the idea that there is an information asymmetry between the regulator (the principal) and the TSO (the agent). The regulator knows well neither the cost function of the TSO (this is called the adverse selection problem) nor the level of effort that the TSO could make to reduce its costs (this is called the moral hazard problem – Laffont & Tirole, 1993). The theory of incentive regulation has also examined the impact of the (exogenous, management/efficiency or regulatory) risk level on the properties of the different theoretical regulatory instruments (Armstrong and Sappington, 2003; Schmalensee, 1989). Finally, the remuneration of a TSO depends on the relationship between its revenues and its actual costs, which are both affected by the regulatory instruments used (Guthrie, 2006).

To analyse the TSO's investment behaviour in a frame of incentive regulation, we first need to define what the key economic properties are at stake. The key economic properties of a TSO regulatory regime for investment are fourfold: a) the capability to sufficiently remunerate the TSO investments and to ensure their financeability, b) the capability to reduce the risk born by the TSO (hence the cost of capital), c) the capability to incentivise the TSO cost reduction, d) the capability to transfer efficiency gains and redistribution to final users. In what follows, these criteria and their properties are defined. Once these properties are established, we will be able to analyse, for each main design characteristic, which option is the most suitable to each economic property.

Criterion 1: the capability to remunerate the TSO's investments and to ensure their financeability

The first criterion concerns as much the capability to sufficiently remunerate the TSO's investments as to ensure their financeability. The TSO activities are capital intensive, i.e., they are largely based on infrastructures, and building these infrastructures requires a lot of capital raising. The capital for investment in an asset is normally raised when the investment is realised but the remuneration is only received progressively during the whole lifetime of the asset or its depreciation period. In order to engage in long-live and large investments, the TSO needs to be sufficiently remunerated for them. Namely, its remuneration must cover the cost of the investments and a sufficient remuneration of the capital engaged. The remuneration should therefore take into account two factors. Firstly, it should take into account the (actual) cost of capital of the TSO, which depends on the risk incurred by the TSO (including the risk attached to its regulatory regime). Second, the remuneration of investments should take into account the financeability of the TSO, i.e., the ability of the TSO to raise a sufficient amount of capital over time to realise and finance its required investments. Without such a sufficient remuneration, the TSO will not be able to invest and there will be a risk of under-investment and / or a decrease in the quality supplied to the end-user).

Criterion 2: the capability to reduce the risks born by the TSO

The second criterion addresses the capability of a regulatory regime to reduce the risks born by the TSO. Different kinds of risks exist: the exogenous risks (being shocks on input costs or users demands), the internal risks (from the management and own company efficiency hazards) or the regulatory risks (born from the own regulatory hazards). Different regulatory regimes have different ways of dealing with the size of these risks and their allocation. For instance, the size of regulatory risks can be reduced by using robust methods to define allowance or efficiency targets. The exogenous TSO's risks can be reduced by passing through non-controllable risks and costs to final users (e.g., the volume or demand risk to compute tariff from the allowed revenues, purchase of energy and power for ancillary services).

Criterion 3: the capability to incentivise the TSO to cost reduction

The third criterion is the capability of the regulatory regime to give incentives to cost reduction, including notably the minimisation of the investment realisation costs (given defined outputs: capacity, quality, etc.) and the optimal trade-off between investments (CAPEX) and operational expenditures (OPEX)[11]. It should be noted that a regulatory regime that finds the optimal trade-off between CAPEX and OPEX will minimise at the same time the risk of over-investment, also called gold plating (too much CAPEX, too little OPEX).

Criterion 4: the capability to transfer efficiency gains and redistribution to final users

The last criterion first includes the capability of the regulatory regime to transfer efficiency gains realised by the TSO to final users and to avoid excessive monopoly rents[12]. This criterion also includes the capability of the regulatory regime to ensure lower tariffs, at least in the short term. Lower tariffs in the short term, can be achieved by transferring a high level of effective efficiency gains so

[11] Note that we do not consider in this criterion the financial cost of CAPEX, clearly related to the cost of capital. We only consider here CAPEX realisation cost. Financial and capital costs are analysed later when considering the context where regulatory designs are applied (see section 3).

[12] We will see later that the economic literature indeed shows that there is a trade-off in monopoly regulation between cost efficiency and the transfer of efficiency gains: the higher the transfer of efficiency gains to end-users is, the lower the efficiency incentive to the monopoly is. Thus, a portion of the monopoly rent should be maintained in order to better incentivise cost reduction.

minimising the monopoly rent or by redistributing the normal rent of the regulated company (for instance, by defining efficiency targets higher than achievable or by defining a low allowed cost of capital).

To keep our analysis simple enough, we do not consider in this paper the proper "effectiveness" of the investments. We suppose that the regulatory regimes include other mechanisms (not studied here) to ensure that the benefits of investments are sufficiently higher than their costs (e.g., Costs – Benefits Analysis, quality constraints or incentives, user consultations, etc.)[13]. So, the term "efficiency" in this paper should be interpreted (if the contrary is not explicit) as the minimisation of cost of inputs to achieve a given output.

1.2 Theoretical and applied analysis of TSO regulatory regime design

The theoretical and applied economic literature provides very useful conceptual elements to understand the economic properties of different regulatory designs. The different designs are the result of the application of theory and applied research to TSO regulation. In order to present the main design principles, a three-step rationale is followed. First, the most popular theoretical regulatory instruments are presented and analysed. Second, regulation is analysed in the presence of long-life and irreversible investments. Third, the practical implementation of regulatory regimes is studied identifying their main characteristics and options. Finally we conclude by summarising main design options with their corresponding economic properties.

1.2.1 The theory of incentive regulation and its five regulatory instruments

Several regulatory instruments have been proposed by the regulation theory to price a regulated service. The most popular theoretical instruments are cost-plus mechanism, price or revenue cap, performance-based regulation, menu of contracts, and yardstick competition. Most of them have been studied in a context of incentive regulation and information asymmetry (Armstrong & Sappington 2003, Laffont and Tirole 1993, Agrell 2010, Glachant et al. 2012).

In order to later ease the description of actual regulatory regimes, we first describe these five different incentive regulation instruments in a purely theoretical way, before detailing their own economic properties (Joskow, 2008, Vogelsang 2002, Laffont and Tirole, 1993, Shleifer, 1985).

- **Cost-plus**: With cost-plus regulation, the regulator allows the network operator to basically recover its expenses as well as an authorised margin corresponding to a return on investment[14]. In this case, the network operator is incentivised to declare its actual costs,

[13] See for instance Pérez-Arriaga 2013 or Meeus et al. 2013.

[14] The cost-plus (theoretical) mechanism differs from the rate-of-return regulation applied in particular to the integrated utilities in the USA before the liberalisation of network industries. The rate-of-return regulation was rather a revenue or price cap regulation whose regulatory period ended when either the company or the regulator asked for a price revision (Joskow, 2006). During the regulatory period, the company hence had incentives to improve efficiency because it could keep its monopoly rents earned during that time period. Inversely, (theoretical) cost-plus regulation consists in a pass-through of any change in the costs of the company.

reducing the risk of monopoly rent (or the adverse selection problem). However, it does not incite the operator to optimise its processes. Therefore, the remuneration of the network operator only covers its costs, avoiding a monopoly rent, and risk is mostly transferred to final users.

- **Forever price/revenue cap**: In price/revenue cap (theoretical) regulation, the regulator sets *ex ante* a fixed (forever) price for the service provided by the network operator, which is then incentivised to optimise its processes since it will be able to make a profit by reducing costs. While this instrument solves the problem of moral hazard, it does not provide any cost revelation of the network operator.

- **Performance-based or sliding-scale regulation**: The regulator can implement an instrument which defines a rule for sharing of efficiency gains, which are assessed by comparing actual incurred costs with expected/budgeted costs. This scheme balances the properties of the cost-plus mechanism with the properties of the forever price cap at a level that depends on the applied sharing rule.

- **Menu of contracts**: Rather than proposing a unique performance target, the regulator can propose a menu of contracts with different levels of incentives corresponding to different level of costs for the network operator. The network operator can then self-select the most appropriate regulatory scheme from its own point of view. The trade-off is then between the cost revelation of the network operator and the level of incentives given by the selected contract.

- **Yardstick competition**: At last, the regulator can use yardstick competition when it regulates several comparable monopolies operating in similar franchised businesses. It is able to compare the costs and the level of efficiency of each monopoly to the performances of the others and to fix the company's revenues based on the average or best practice sector performances. Each monopoly can increase its profit if it is more efficient than the average level, which incentivises most – if not all – of them to improve their processes.

The analysis of these five theoretical regulatory instruments provides interesting insights related to the economic properties of each one of these theoretical regulatory instruments and the tensions existing between them.

The regulatory instruments that disconnect revenues from costs (e.g., forever price cap) are those which give the most incentives for cost reduction. Naturally, the regulatory instruments that base revenues on cost observation (i.e., cost-plus mechanism or mechanisms that base revenues on intrusive and detailed efficiency bottom-up audit) are those that give fewer incentives to cost reduction.

At the same time, the regulatory instruments that disconnect revenues from costs (e.g., forever price cap) are most likely to create/allocate more risks to the network operator. Indeed, the revenues are not linked to uncertainties impacting the cost of the network operator. This is described by Guthrie (2006) as "price inflexibility", as the network operator cannot transfer cost evolutions to final users. Obviously, the risks imposed to the network operator are reduced with regulatory instruments that base revenues on actual costs (i.e., cost-plus mechanism).

The design of a regulatory regime with regard to incentive regulation is therefore ensured to raise tensions between the different economic properties. The first tension is clear: the theoretical instruments which give more incentive for cost reduction (e.g., forever price cap) are most likely to create more risks for the network operator.

Another example is the tension between the incentives for cost reduction and the transfer of efficiency gains to final users. Thus, the theoretical instruments which give more incentive for cost reduction (e.g., forever price cap) are most likely to have limited transfer of efficiency gains to final users. In contrast, the theoretical instruments giving less incentives for cost reduction (e.g., cost-plus) allow a maximal transfer of efficiency gains to final users because the tariffs are defined near the actual cost level while they give no incentive to cost reduction.

Sliding scale or performance regulation can then be applied to trade-off between these two extreme options to balance the risk for the network operator, the incentives for cost reduction and the transfer of efficiency gains to final users.

Yardstick regulation and menu of contracts can also conciliate some of these tensions. For instance, yardstick competition bases the setting of revenue on exogenous information about the efficient level of cost. In theory, the mechanism will therefore ensure or make compatible the incentive objective and the objective related to the improvement of the transfer of efficiency gains to the final users. However, as yardstick competition completely disconnects the revenue of a company from its costs, it implies a considerable risk for the regulated company, mainly when yardstick competition cannot control the natural heterogeneity of different benchmarked companies (different "doing business" environments, history, pre-liberalisation legacy, geographical conditions, population density, NIMBY problem intensity, natural areas to avoid, effects of the regulatory regimes on the TSO's behaviour, …). In this case, the less comparable companies are, the riskier yardstick regulation is.

The menu of contract provides another way of conciliating tensions between incentives for cost reduction and the transfer of efficiency gains to final users. In fact, if the network operator anticipates that it can make large efficiency gains, it will select a contract with high incentives (i.e., a contract where most part of the efficiency gains is kept by the network operator). As the contracts with more incentives are those with the lowest starting allowed revenue, there is a cost revelation mechanism. This instrument provides a second best considering the information asymmetry situation because there is a trade-off between how much information the network operator is ready to share in exchange of potential future rents (from efficiency gains).

In conclusion, the theoretical regulatory instruments provide different incentives to cost reduction and transfer of efficiency gains, different levels of risks for the regulated companied and differently conciliate the tensions between these economic properties. Cost-plus mechanism is good at limiting monopoly rent and the risks born by the regulated company but provides no incentive to cost reduction. Inversely, forever price cap provides powerful incentives to cost reduction but it is highly risky and there is no transfer of efficiency gains to end-users. Performance-based regulation or a menu of contracts provide a trade-off between these two extreme options to balance the risks for the network operator, the incentives for cost efficiency and the transfer of efficiency gains to final users. Yardstick regulation also provides a trade-off between the incentives for cost efficiency and the transfer of efficiency gains to final users but it remains risky for network companies. We see now how economic properties of the theoretical regulatory instruments are modified by the long-life and sunk nature of investments in electricity networks.

1.2.2 The application of incentive regulation to long-life and sunk investments

General literature on incentive regulation has rarely considered specific industries with large long-life and sunk investments. A new wave of literature studies the regulatory issues related to this kind of investments, and in particular those related to power networks (see for instance Guthrie 2006, Vogelsang 2006, Brunekreeft and McDaniel 2005, Brunekreeft and Meyer 2011, Petrov et al. 2010, Stern 2006, Alexander 2006, Perner et al. 2007, Stoft 2007, von Hirschhausen 2008, Brunekreeft 2013). This literature provides insights to better understand the properties of the regulatory regimes in a context of large investment needs. Three key issues come out from this specific literature: i) the importance of the level of risks and their allocation, ii) the importance of the remuneration of capital and financeability, and iii) the difficulties for measuring cost efficiency of investments.

First, long-life and irreversible investments make the regulatory regime much more sensitive to risks (Guthrie 2006). Risks are higher when the investment lifetime is longer, simply because uncertainties increase with time[15]. Besides, given the investment irreversibility, there is a clear differentiation between *ex ante* (i.e., before the investment is made) and *ex post* (i.e., once the investment has been made) situations. Indeed, after the investment, the value of assets for alternative uses is low or zero and they are then called stranded or sunk costs. This effect puts the regulated company in a situation of weakness with respect to the regulator: Once the investment has been made, the regulator is tempted to lower the revenue that has been set *ex ante*[16]. This is known as the hold-up problem. It intensifies the impact of any risks on the investment decisions, whether they are exogenous or regulatory ones. In conclusion, the long-life and sunk nature of investment in electricity networks increases the sensibility of any regulatory regime to risks, which can have a negative impact on incentives for investments.

Secondly, energy network investments need to raise a lot of capital in order to be made. This implies that the remuneration, as well as the financeability of this capital, has to be specifically analysed over the regulatory regime (Petrov et al 2010, Henriot 2013, OXERA 2010a, 2010b). Given the capital-intensive nature of electricity networks, the remuneration of capital accounts for a significant share of the allowed revenue. As relatively small changes to the rate of return can have a significant impact on the total revenue requirement and the investment behaviour of the companies, it is essential that the regulator sets the rate of return at a level that reflects an adequate commercial return for the regulated companies. Regulated companies compete for financing with companies operating in competitive markets and thus rely on the same financial market conditions. Equity and debt financing will only be available to utilities (whether they are private or public ones) who agree to the credit conditions set to firms that operate in competitive industries and have a comparable credit ranking. Equity financing will only be available if the profitability of the company is high enough to cover the risk-free rate of interest and an individual equity risk premium based on the market premium. In conclusion, the decision of investments is extremely sensitive to how the regulatory regime considers the remuneration of capital and its financeability.

Thirdly, the (cost) efficiency of investments is quite difficult to measure given that it is problematic to have a clear reference of "efficient cost" (i.e., the minimal cost for a given level of outputs). In other words, it is very difficult to differentiate a reduction in CAPEX given by a cost efficiency gain from a

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[15] In addition, in presence of exogenous uncertainty, the regulated company is unable to fully exploit economies of scale provided by network investments.

[16] In fact, the regulator is tempted to set the price to variable/avoidable cost given that the regulated company will continue to provide the service if its variable/avoidable cost is paid (Vogelsang 2010a).

reduction in CAPEX that does not have any impact on short term objectives of the company but that would have an impact in the long term (the typical example for this is the cost of R&D – Bauknecht, 2010, Müller 2011– or the impact on the “quality” stocks of the assets – Ajodhia and Hakvoort, 2006). There is in fact a problem of time inconsistency with long-life assets. Indeed, the benefits of investment are generally perceived long after capital expenditure, beyond the few years of the regulatory period when efficiency assessment is performed. The combination of all these aspects implies that, from the point of view of the regulator, information asymmetries are stronger on investments whose evaluation in terms of costs (and benefits) is very complicated and uncertain (Brunekreeft & McDaniel, 2005; Stoft, 2007). In brief, as the effects of not having the necessary investment are difficult to detect (for the regulator), imposing too much incentives on (CAPEX) cost reduction is likely to create negative impacts on investment decisions (and at the end of the day on the long term welfare).

In conclusion, it is difficult to regulate long-life and sunk investments for three reasons. First, they are very sensitive to risks in particular to the regulatory ones, which may hamper their development. Second, they are capital-intensive and the financeability of the regulated company is consequently essential to the associated equity and debt raising in the most efficient and least costly possible way. Third, imposing the regulated company possibly stringent cost efficiency targets on CAPEX may incentivise it to limit its investments and decrease network quality in the long term because it is difficult to measure cost efficiency of investments in the long term (i.e., the minimal cost for a given level of outputs). We see now that incentive regulation in practice differs from the pure theoretical instruments and other characteristics of regulatory regimes so that these difficulties in regulating long-life and sunk investments can be tackled to some extent.

1.2.3 The regulatory regimes and the incentive regulation in practice: main design characteristics and options

A periodic revenue cap as a central mechanism of TSO regulatory regime

The details of the construction of a regulatory regime for electricity transmission are much more complex than the simple theoretical descriptions. The actual regulatory regimes cannot be detailed by using a simple theoretical instrument alone. Each regime presents its own specificities, depending in particular on the inherent objectives of the regulation. Still, one regulatory instrument emerges as the heart of the incentives applied to electricity transmission: this is the periodic revenue cap (Joskow 2006, 2008). Thus, the revenue cap mechanisms actually applied often combine to different extents the characteristics of the five theoretical instruments. The final properties of the regulatory regime then depend on how the different theoretical instruments are used to define the periodic revenue cap and on what design options have been taken.

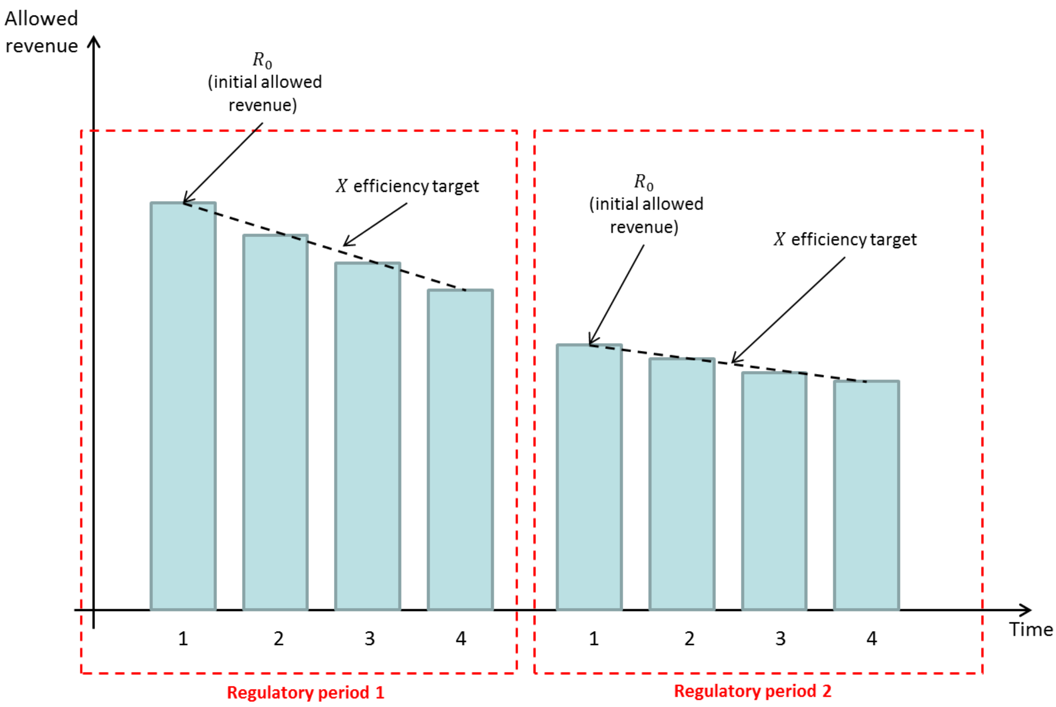
In what follows, we present the main structure of a periodic revenue cap. It should be first noted that there are different possible versions of the periodic revenue cap. The simplest version is however to fix the allowed revenue for the regulated services provided by the network operator as follows (see also Figure 4):

- The regulator defines the length of the regulatory period (during this period the parameters of the revenue cap will not be revised).

- At the beginning of the regulatory period (at t = 0), the regulator sets an initial revenue R_0 and an efficiency target X. R_0 is calculated from the historical costs of the regulated firm or the forecasted future costs.

- The revenue of year t is adjusted according to the following formula:
$$R_t = R_{t-1} * (1 + RPI - X) + Z_t$$
where *RPI* is an index of change in consumer prices (inflation) and Z_t is a term for the integration of the elements or costs that are not included in revenue cap mechanisms (pass-through items, volume adjustment terms).
- The above formula is valid for the whole regulatory period. At the end of the regulatory period, new values of R_0 and X are determined.

Figure 4. Periodic revenue cap (focus on two regulatory periods)



Even if the same general structure of the revenue cap apply to the different regulatory regimes, the final economic properties of the regimes might differ according to the design options chosen in each case. Mainly, the periodic revenue cap can be defined based on five design characteristics:

- the length of the regulatory period and the resetting rules,

- the scope of the revenue cap (TOTEX vs. building blocks, pass-through items),

- the tools to define allowances and efficiency targets (benchmarking vs. efficiency audit),

- the practical setting of the capital remuneration,

- and the adjustment mechanisms.

In what follows we present the main design options for each of these characteristics as well as the theoretical and empirical insights concerning their economic properties.

Design characteristic 1: the length of the regulatory period and the resetting rules

Joskow (2008) shows that a periodic price or revenue cap works as a sliding-scale or performance mechanism, sharing the efficiency gains between the network operator and the final users. The frequency of price revision and the length of the regulatory period combined with the rules of sharing (R_0 and X) can help balance the level of incentives, the level of risks and the level of transfer of efficiency gains to final users.

- *Length and incentives for cost reduction:* The theoretical principle is that, thanks to more stability of the revenue a long period of regulation gives more incentives for perennial cost restructuring. The longer the regulatory period is, the higher the incentive to cost reduction given by the revenue cap is. A very long regulatory period makes the periodic revenue cap closer to the theoretical (forever) revenue cap instrument (hence maximising the incentives for cost reduction – see figure 5). In contrast, a very short regulatory period makes the periodic revenue cap closer to cost-plus mechanism (because revenue is more frequently revised and aligned with observed cost hence minimising the incentives for cost reduction)[17]. Of course, this theoretical principle only applies on mechanisms where the resetting rules depend to some extent on the observation of actual costs (in pure yardstick regulation the length of the period will have less impact because the allowed revenue is not linked to actual costs).

- *Length and the sharing of efficiency gains:* The shorter the regulatory period is, the more important the transfer of efficiency gains to final users is, as the regulated company is not able to develop a long term monopoly rent.

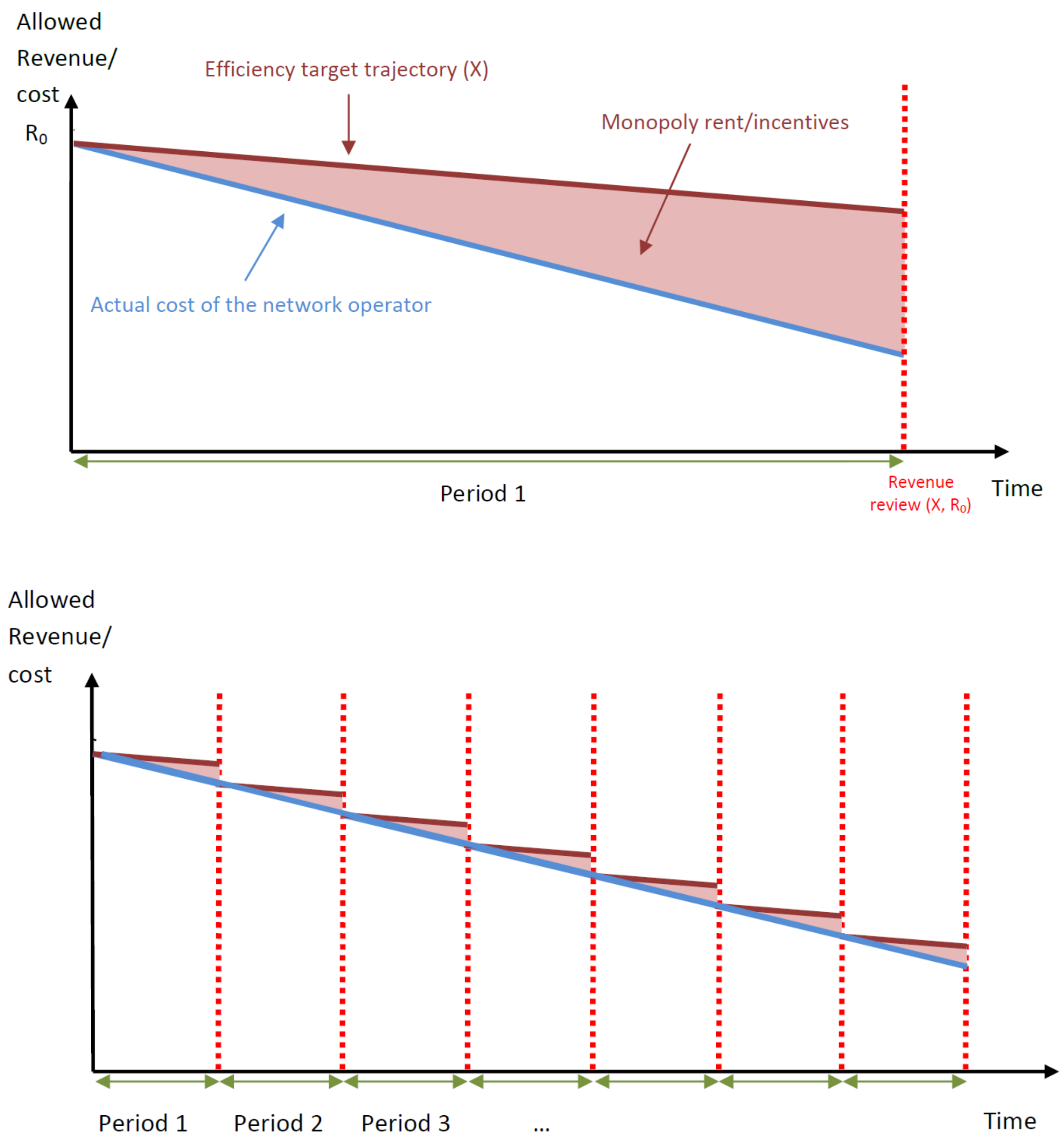
- *Length and uncertainty or (exogenous) risks*: One of the explanations for the periodic nature of the revenue cap is the presence of uncertainty in addition to information asymmetry. Indeed, the revenue cap is then set based on preliminary incomplete information about the next regulatory period. A longer regulatory period will then provide more *ex ante* uncertainty, and therefore further risk of errors in the level of the revenue cap (Brunekreeft-McDaniel 2005; Schmalensee 1989).

- *Length and regulatory risks*: The length of the regulatory period also affects the level of commitment of the regulator, as the risk that the regulator reviews the revenue cap during the period increases with duration, particularly if the level of revenue originally allowed leaves a large monopoly rent to the network operator (Baron-Besanko 1988, Brunekreeft-McDaniel 2005, Gilbert-Newbery 1994). The problem related to the credibility of the regulator directly affects the incentives provided to the regulated company. If it is not able to keep some of the benefits of its efforts, the regulated firm will have less incentive to make these efforts. The credibility of the regulator is a particularly important issue for investments,

[17] Compared to forever revenue cap, the periodic revenue cap provides less incentive to improve cost efficiency. The regulated company no longer enjoys its efforts on an infinite time but only on the regulatory period. For example, Williamson (1997, 2001) calculates that if the regulatory period is five years, the regulated firm receives only 29% of the earnings she would have received over an infinite period.

in particular long-life and irreversible ones. Faced with a non-credible regulator, the regulated firm will tend to invest less in order to reduce the risk of hold-up by the regulator (Vogelsang, 2004)[18]. It may also favour technologies with little stranded costs, even if these are less effective than other technologies with higher stranded costs.

Figure 5. Incentives and the length of the regulatory period



[18] Note that short regulatory period can also be a source of risk for the TSO because the rules of the regulatory regime can be more frequently changed. This depends on the credibility and the commitment of the regulator.

The rules used for the resetting of the revenue cap, notably the definition of R_0 and X at the beginning of the regulatory period are also important in balancing economic properties of the revenue cap. It can be said that the more this parameters are based on observed cost values, the less the revenue cap incentivises to cost reduction, the more it transfers efficiency gains to final users and the less risky it is. We will analyse in detail the definition of these parameters later.

Design characteristic 2: the scope of the revenue cap (TOTEX vs. building blocks, pass through items)

The scope of the revenue cap is an important design characteristic for the definition of the economic properties of the regulatory regime. It represents how the different types of costs are integrated in the revenue cap mechanism (i.e., the costs concerned by a fixed allowed revenue and the direct application of efficiency targets), are treated separately through other specific efficiency specifications, or are not incentivised at all as is the case of pass-through or cost-plus items.

The scope of the revenue cap can vary from two extremes:

- the "TOTEX" approach : the revenue cap adopts the widest scope including all the costs/tasks of the TSO (e.g., OPEX, capital expenses, SO costs, etc.) in the revenue cap,
- and the "building blocks" approach: the revenue cap adopts a small scope, including only one part of operating expenditure (e.g., controllable OPEX) in the revenue cap, as the other cost elements are remunerated through a cost-plus (or pass-through) mechanism.

Between these two extremes, a large continuum of possible cases exists, depending on what costs are included in the revenue cap and what other efficiency incentives whose related costs are excluded from the cap are (e.g., efficiency audit for investments or sliding scale scheme for SO costs, definition of controllable or not controllable costs, etc.).

In what follows, we describe what economic literature provides as insights in the TOTEX vs. building blocks scope discussion.

Incentives on cost reduction and uncertainties

From a pure theoretical point of view, the incentive mechanism should cover as much as possible all costs incurred by the network operator, i.e., operating costs, SO costs, capital costs and costs related to quality of service (Joskow 2006, Stoft 2007). The economic rationale for this recommendation is simple: when the incentive scheme covers all costs, the regulated firm can achieve the optimal trade-off between the different types of costs and how to reduce them globally (i.e., productive efficiency in the selection of inputs). For example, to keep a level of quality at minimal cost, the regulated firm can find a balance between the maintenance costs on its network (i.e., OPEX) and replacement of assets (i.e., CAPEX). Indeed, the regulated firm is the best placed (and informed) to know and to do these trade-offs. Thus, following this theoretical principle, the "TOTEX" scope would give more incentive for cost reduction than other scopes because cost reduction incentives are aligned between the different types of costs (e.g., Ajodhia et al. 2006, Cuningham 2012). In contrast, the "building blocks" approach can suffer from incentive distortions. Indeed, if the different types of costs are regulated with different mechanisms (with different incentive levels for each mechanism), the revenue cap is likely to generate cost inefficiencies[19].

However it should be noted that this pure theoretical point of view should be adjusted in the presence of exogenous cost uncertainties. In this context, the network operator cannot completely control cost level because it depends on external shocks (e.g., the network losses in interconnected transmission systems depend strongly on the non-controllable cross-border flows) with unpredictable consequences. Thus, the scope of the revenue cap should be based on an assessment and a balance between the controllability and predictability of each type of cost (Glachant et al, 2012). Indeed, putting incentives on costs that are not controllable will not result in efficiency gains if these costs actually turn out to be unpredictable and uncertain. The risk for the TSO to control its cost reduction effort with regard to incentives will then be increased without any potential benefit. As a consequence, a common "rule of thumb" principle applied in regulatory designs is that only controllable costs should be covered by the revenue cap incentive scheme. The costs on which the regulated firm has no or little control should then be excluded from the revenue cap and be compensated through a cost-plus mechanism[20].

Providing services in a real life transmission network implies to make different types of tasks and to incur different type of costs. Each of these tasks/costs can have a different level of controllability and predictability. When defining the scope of the revenue cap, these different tasks/costs could be included or not. In this context, if the scope of the revenue cap is larger (i.e., closer to TOTEX) it is likely that the incentives for cost reduction increase (because there is more opportunities for trade-off between costs). However, it is also likely that the risks imposed on the TSO increase because the revenue cap scope may include some costs/tasks where the lack of predictability effect will be higher than their controllability.

Issues when applying incentives on capital costs (CAPEX and existent assets)

Regardless of the controllability and the predictability of the different costs incurred by the transmission operator, the theoretical principle for giving incentives for cost reduction promotes the idea of the "TOTEX" scope for the revenue cap. However, this does not go without raising additional issues, in particular regarding the inclusion of capital expenses, and CAPEX in particular, in the scope of the revenue cap. Indeed, it is difficult to associate CAPEX to network outputs and therefore to measure the risk/cost of under-investment generated by the incentive mechanism. For instance, it is very difficult to assess the correlation between a decrease in reliability in a transmission network and the level of under-investment. Transmission networks are designed to provide very high levels of quality and reliability (e.g., only few minutes cuts per year in average) and it is likely that the effects of under-investment on reliability do not materialise or become observable very late. Thus, it is very difficult to implement incentives targeting quality by allowing greater freedom (and incentives) in investment plans[21]. Then, the inclusion of investments within the revenue cap in the transport of

[19] The typical example of this is the case of Averch-Johnson (1962) effects, where the regulated company is incentivised to over invest on CAPEX.
[20] Schmalensee (1989) studied the influence of uncertainty on the regulatory mechanisms such as the price cap and the cost of service. It concludes that the consumer surplus is all the higher with a cost plus mechanism rather than with a price cap mechanism that uncertainty is greater.
[21] Cost reduction incentive on investments without a well-defined output target as a safeguard would lead to a risk of under-investment (Spence, 1975).

electricity without consideration of the (future) output level that the network should produce is likely to lead to under-investment by the regulated companies (Rees and Vickers 1995).

Therefore, in the case that network outputs are difficult to define and measure, the better way to consider investment costs in the period revenue cap is to partially or completely exclude them from the incentive mechanism, so as to reduce the risk of under-investment. This is in line with the prudency rule considering that the cost of under-investment (i.e., increasing the frequency of partial or total black-out) is in general higher than the cost of over investment. The investment costs can then be controlled through a cost-plus type mechanism and this has inspired the building blocks approach. This regulatory mechanism should however be framed by complementary measures in order to limit the risk of over-investment incentive. Indeed, if the investments are paid on the basis of a pure cost-plus mechanism and investment decisions are entirely left to the regulated company, it will be incited to increase its capital expenditures in an inefficient manner, or to pass certain operating expenses in investment spending. In practice, the control of capital expenditure thus combines the cost-plus mechanism and other efficiency tools (*ex ante* consultations and approval and efficiency audits) as we will see in the next paragraph.

Note finally, that the concept of RAB disappears in an extreme application of (yardstick)-TOTEX. Indeed, the allowed revenue is defined in a completely exogenous way, without any reference to the actual assets of the regulated firm. The dilution of the concept of RAB in extreme TOTEX approaches implies that the risk born by the TSOs is extremely high given that there is not a mechanism that materialises the commitment of the regulator to remunerate investments once they are sunk (Helm, 2010). This of course comes with the corresponding increase of cost of capital. In practice, purely theoretical (yardstick)-TOTEX are not frequent. To minimise the effect of RAB dilution and too much increase on cost of capital, TOTEX approaches often apply a hybrid model where RAB is maintained. If it allows to decrease the cost of capital, this simplification however has a cost in terms of incentives for cost reduction: the company has still different incentives to use CAPEX or OPEX, inheriting to some extent inefficiencies from the building blocks approach.

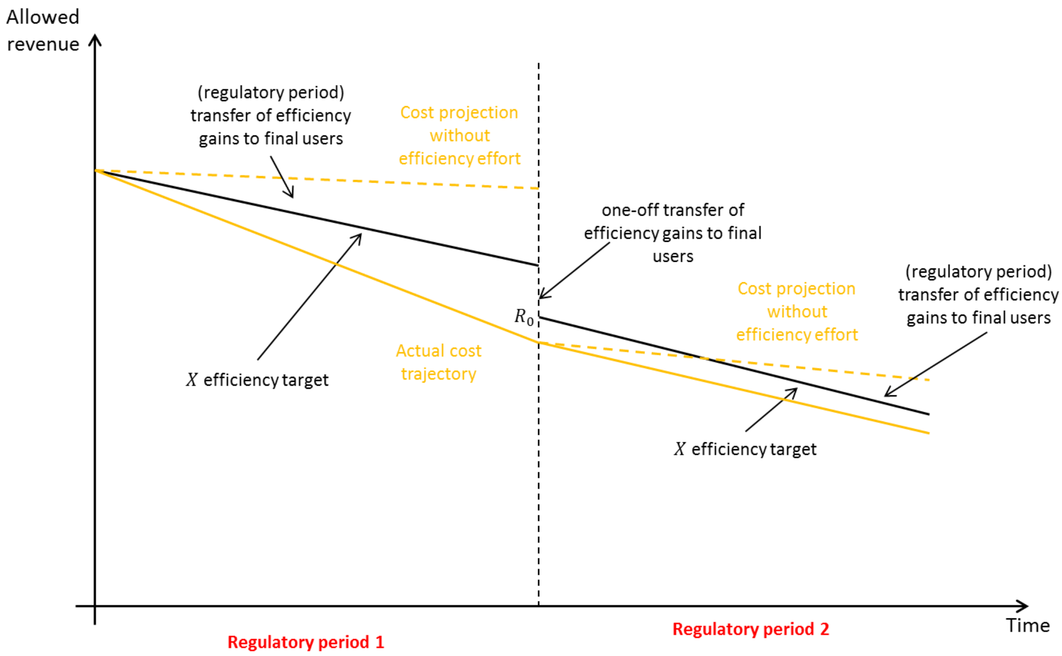
In conclusion, defining the scope of the revenue cap mainly balances two economic properties: the incentives for cost reduction and the risks imposed to the TSO. TOTEX performs better for the first property while the building blocks approach performs better for the second one.

Design characteristic 3: efficiency targets and tools

The construction of the revenue cap requires the definition of the allowed initial level of revenues (R_0) and the cost reduction trajectory (X-factor) applied to this initial level (i.e., how the allowed revenue varies during the regulatory period). In order to ensure a maximal transfer of efficiency gains to final users, these parameters should be defined so that the revenue allowance is as close as possible to the efficient level of cost. If the efficiency targets are too ambitious (i.e., they go further potential efficiency gains), they will produce a redistribution of normal rent. If the efficiency targets are too light, they will leave too much monopoly rent to the network operator.

In particular, the R_0 and X parameters of the periodic revenue cap help determine how efficiency gains are shared and redistribution is done between the regulated company and the final users (Figure 6). There are different ways/tools to determine this sharing level. However, their use impacts different economic properties of the resulting regulatory regime (remuneration and financeability, risks, incentives for cost reduction, transfer of efficiency gains and redistribution to final users) (Petrov et al., 2006, Jacobzone 2010).

Figure 6. Periodic revenue cap resetting rules and efficiency gains sharing rules



In what follows, we describe the main options from economic literature to set allowances and efficiency targets and insights on their economic properties.

The main options to determine allowance/efficiency targets are inspired by the theoretical instruments: i) efficiency audit (inspired from the historical observation of cost variation trends and/or expectations from expert analyses), ii) menu of contracts and iii) benchmarking (inspired by yardstick competition)[22]. The actual regulatory regimes often use a combination of these instruments.

Efficiency audit

Efficiency audit is based on a detailed analysis on the (observed/historical or projected) costs of the TSO. As this option is based on the cost-plus theoretical instruments, it shares with it the same properties. On the hand, this instrument facilitates the transfer of efficiency gains to final users by allowing a high correlation between the revenue allowance and the costs of the TSO, so that its risks are minimised and a fair remuneration is ensured. On the other hand, its incentive power in terms of

[22] Rather than benchmarking comparing the relative efficiency of companies, it is also possible to compare efficiency of each company to a reference model. The regulator then relies on an investment and operation model to simulate the efficient network development and operation and sets the allowed revenue accordingly (see Griffel-Tatjé et al., 2003 or Saplacan, 2008 for an analysis of this regulation implemented in Norway or Spain for power distribution networks or Frontier-Consetec 2012 for an analysis of this method for a transmission network).

cost reduction is low. Indeed, the regulated firm integrates the fact that a detailed analysis will be performed on its costs and that efficiency gains will be transferred to final users, which decreases the incentive to reduce its costs to an efficient level. The more intrusive the efficiency audits are, the lower the incentive power for cost reduction is (e.g., Weitzman 1980, Stern 2006, Agrell 2010).

For the specific case of CAPEX, efficiency audit can be used *ex ante* (to validate or approve an investment plan) and/or or *ex post* (to assess cost efficiency and to share difference with respect to the *ex ante* approved costs) (Brunekreeft and Meyer 2011, Petrov et al. 2010). As *ex post* efficiency audit introduces risk on the TSO, this is often combined with *ex ante* investment approval. Thus, a certain level of investment planning is made *ex ante*, so that investment decisions are subject to consultations and discussions between the regulated company and the regulator (and sometime users). At the end of the discussions, a certain volume of investments is approved *ex ante*. Complementary rules may also be established to review the cost efficiency of *ex ante* approved investments. For example, a "used and useful" rule could provide for additional investments after approval. The application of such a rule is very simple: it provides an *ex post* review of investments which were not approved nor expected *ex ante*, and an additional remuneration procedure for the cost efficiency of investments that were approved *ex ante*. Note that this option is often used in combination with a building blocks approach, to decide if the incurred investment costs should be partially or totally included in the RAB. Note however that once the costs are included in the RAB, they are no more affected by cost efficiency reviews[23].

Menu of contracts

This tool is directly inspired from the theoretical instrument (Laffont and Tirole 1993, Crouch 2006, Joskow 2008). The regulator proposes to the network operator a menu of contracts with different levels of incentives and corresponding to different level of allowed revenues for the network operator. When the menu is well designed, the contracts with the lowest allowed revenues are also those providing more incentives (with a higher additional income/penalty and a higher of efficiency gains with regard to the efficiency target kept by the monopoly). The network operator can then self-select the most appropriate regulatory scheme from its own point of view, considering the trade-off between the cost revelation and the potential future (monopoly) rents if the efficiency target included in the selected contract can be outperformed.

This tool has the clear advantage that there is a self-selection of the network operator and this implies a reduction of risk of the TSO. In theory, a TSO will never select an infeasible or too risky contract (i.e., a contract with a too ambitious efficiency target that would dramatically increase the management and the efficiency risk of the regulated company). The level of sharing of efficiency gains with final users is then defined by the selected contract. It will be in general a relatively medium value because each contract balances incentives for efficiency gains with their transfer to final users.

The level of incentives for cost reduction will be defined too by the selection of the network operator. However, the incentives choices will be constrained by the specific implementation of the

[23] This common sense rule has also the benefits of keeping the cost of capital low because the value of past investments (that have become uncontrollable once they have been entered into operation) is preserved. This also benefits to the end-users.

menu of contract. For instance, the different contracts can be limited in terms of incentives (e.g., in Great Britain, the proposed contracts go from 40% to 50% sharing of efficiency gains and a +/-2.5% additional income reward/penalty). Besides, the methods used to build the menu of contracts may have an impact on the general level of incentives. The menu of contracts is often built using a combination of different efficiency tools (from benchmarking to efficiency audits). As in the case of efficiency audit, it is likely that the more intrusive the construction of a menu of contracts is, the lower the incentive power for cost reduction could be (e.g., Stern 2006).

Yardstick/benchmarking

The efficiency targets can be also defined using a set of benchmarking methods which aim at assessing the efficient level of cost of the analysed company/process/unit. As this option is based on yardstick competition, it shares the same economic properties: by allowing a complete disconnection between the revenue allowance trajectory and the actual costs of the regulated company, this tool provides a very high level of incentives power for the company (Shleifer 1985, Agrell 2010). However, this approach increases the risk for the TSO because its revenue is disconnected from its actual cost. The level of remuneration recognised by these approaches depends on the level of efficiency of the regulated firm relatively to the benchmark level of efficiency (if the firm is more efficient than the average then the remuneration will be higher).

Benchmarking techniques are often based on the determination of the « efficiency frontier », from sample of companies. When efficiency frontiers are dynamically estimated (from a time series rather than from a panel), two types of efficiency targets can be assessed: the static efficiency (or catch up) and the dynamic efficiency (or frontier shift)[24].

When looking at the construction of the benchmarking applied to a regulated company, the most important condition that needs to be checked is the comparability of peers (Lowry and Getachew 2009). This comparability requirement must integrate two dimensions: the structural comparability and the temporal comparability.

The structural comparability dimension dictates that the benchmarked companies should be similar in terms of inputs and outputs. For instance, comparing gas and electricity transmission networks will not provide very useful information given the significant difference between the two network industries. As perfectly comparable companies do not exist, the use of econometric analysis (or other methods) allows a control of differences and an adaptation of the benchmarking to the lack of comparability (Frontier 2010, OXERA 2012). Nonetheless, this implies that extensive database should exist and that the use of control variables will be needed to eliminate almost all the heterogeneity between the firms (Haney and Pollitt 2012, Brunekreeft 2013, Lawrence 2003). In the case of transmission networks, this point is crucial, since there is in general only one TSO (or few ones in the best cases) managing the high voltage network in each country. The choice of an international comparison will then raise many questions concerning the comparability of the TSOs and the availability of coherent database (example with accountant rules). Consequently, international

[24] Different methods have been proposed to realise benchmarking: econometric methods (OLS, stochastic frontiers), non-parametric methods (DEA, data envelopment analysis), productivity analysis (for more detail on this see for instance Jamasb and Pollitt 2001, OXERA 2012, CEPA 2013).

benchmarking is not currently fully robust for TSO regulation (see for instance Brunekreeft, 2013; Haney and Pollitt, 2012; see box 1).

Box 1. Problems and lack of robustness of international benchmarking of TSOs

Any international benchmarking of TSOs relies on relatively few observations on the one hand and large structural differences on the other hand. For these reasons, the reliability of international benchmarking result is still weak (even if promising) and thus increases the efficiency risk (Brunekreeft 2013; Haney and Pollitt, 2012). Besides, methodological problems also come from a general criticism on TOTEX benchmarking, including so CAPEX in incentive regulation. Network investments are irreversible and therefore led to sunk capital costs. Including these CAPEX into the benchmarking approach means to apply an *ex post* efficiency test for investments already made that cannot consequently be adjusted *ex post*. Of course, *ex post* TOTEX benchmarking may have discipline effect *ex ante*. The question is whether this advantage of efficiency pressure outweighs the disadvantage of higher inefficiency risk (Brunekreeft & Meyer, 2011).

The temporal comparability dimension dictates that a certain level of stability of the sector is necessary to enable a relevant comparison between past and future information on efficiency and costs (Frontier 2010). In a context of high innovation or when output changes are quite significant (e.g., energy transition), the temporal comparability should not be ensured. Incentives might be useful only for repetitive similar investments and under certain conditions (Weber & Schober, 2006; Ajodhia et al. 2006). Indeed, repetitive investments offer enough points of comparison so that benchmarking techniques can be robustly applied. Not only companies can be easily compared but also it is then possible to track efficiency gains over time for a given company. Inversely, in presence of innovative investment, the companies are very likely to choose very different investment strategies with different expositions to risks (technology risks and exogenous risks). Besides, establishing frontier shift then becomes very uncertain because companies are less comparable and past trends of efficiency gains say nothing about future ones in a period of innovative and risky investments. Considering that the future investments in the power transmission network are unprecedented and innovative, it is unlikely that benchmarking be fully reliable in this case.

Beside the potential incentives properties of yardstick/benchmarking tools, the problem of comparability may lead to too risky outcomes for the TSO. For instance, if the benchmarking outcome is not perfectly robust (or with an extremely large bandwidth)[25], the risk of error of the regulator to fix ambitious efficiency targets considerably increases. To reduce this risk, the yardstick/benchmarking tools are often used in combination with other tools (e.g., efficiency audit, menu of contracts, direct negotiation between the regulator and the network operator) and intervene only partially on the definition of efficiency targets[26]. Moreover, if the outcome is

[25] For instance, for the benchmark study for TenneT in 2009, the results indicate that the efficiency score of TenneT was between 0.2 and 1 depending on the method used (see Dutch 6th regulatory period May 2013 proposal, https://www.acm.nl/nl/publicaties/publicatie/11228/Ontwerp-methodebesluiten-TenneT-2014-2016/).

[26] For instance, OFGEM's view on 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*

supposed to be not perfectly robust, some rules can be implemented to minimise the risk for the TSO (for instance, in Germany, the "best of four" methods applied for DSOs or a relative reference network analysis applied for TSOs).

Independently from its inherent issues, the benchmarking/yardstick instrument can be applied at the different levels of costs included in the incentivised revenue cap, going from Top down to bottom up approaches: TOTEX, OPEX, CAPEX, process or unit costs (Frontier 2010, OXERA 2012). The choice made can enhance or lower the level of relevance of benchmarking. For example, one possible problem for the application of the benchmarking in a separate OPEX-CAPEX split is that the outcome can result in impossible targets (e.g., the minimum level of OPEX is not compatible with the minimum level of CAPEX). A larger scope would on the contrary take into account every possible trade-off made by TSOs between the different costs. However, the problem of comparability increases when the scope of the benchmarking is larger.

Design characteristic 4: The practical setting of the capital remuneration

Given the capital-intensive nature of electricity networks, the remuneration of capital accounts for a significant share of the allowed revenue. This remuneration normally includes a rate-of-return on the Regulatory Asset Base (RAB) and an allowance for depreciation. The RAB reflects the net value of the investments undertaken by the company and it is yearly adjusted to take into consideration new investments as well as depreciation.

In what follows, we analyse the design options and the economic properties of the following parameters: the allowed rate of return, financeability and the treatment of old and new investments

Allowed Rate-of-return

Weighted Average Cost of Capital (WACC) formula is a commonly used method for determining a return on an asset base. It is generally set equal to the sum of the cost of each individual component of the capital structure weighted by its share, i.e., the allowed Return on Equity (RoE), the allowed cost of debt (CoD), a gearing and other complementary terms (inflation rate, etc.). These parameters are fundamental as the risk in the estimation of the cost of capital is listed as one of the major risks for network companies and their lenders (see Bakovic et al. 2003 for the case of distribution companies).

A typical method to set the level of the allowed RoE is the Capital Asset Pricing Model (CAPM) (Gözen 2011). The formula used in the model is $RoE = Rf + \beta a \times (Rm - Rf)$, where Rf is the risk-free interest rate, βa is beta asset, i.e. the correlation between asset return and market return and Rm is the market return. The use of this method, common in competitive markets is natural. The idea is that equity financing will only be available if the profitability of the company is high enough to cover the risk-free rate of interest and an individual risk premium based on the market premium.

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".

The remuneration of capital, in particular for new investments, should be defined considering the level of risk and the type of investments (Helm 1995a, Alexander et al. 2000). For example, Evans and Guthrie (2006) show that in a context of sunk costs the remuneration of the capital should be higher. Different types of regulation should apply different risk-adjusted rate of return on capital to reflect the appropriate cost of capital of the investment (Grout & Zalewska 2003, Grout & Zalewska 2006). For instance, Wright et al. (2003) argue that (theoretical) price cap regulation needs a higher cost of capital than unregulated firm. This is linked to the idea that in competitive markets, the firm has some possibility of pass-through the input shocks on prices whereas in the (theoretical) price cap does not allow to a pass-through. Helm (1995b) shows too in practice that the cost of capital for utilities was higher in the UK under the beginning of the RPI-X price cap era than in a number of other developed countries. Complementary adders can also complete the remuneration of investments taking into account their specific risks (ENTSO-E, 2013; the infrastructure package proposes this kind of adders for projects of European significance).

The use of the CAPM approach to set the revenue allowance relies on the implicit idea that a significant part of any regulatory regime must be set according to an exogenous cost of capital. Meanwhile a literature shows too that other parameters of the regulation impact the cost of capital (Helm 2009, 2010). This is also true for credit rating where different characteristics of the regulatory regimes are considered to set the credit rating. As a consequence, the cost of capital is an endogenous variable of the regulatory regimes that may be impacted by a wide set of parameters (Weber and Schaeffler, 2012).

Another important aspect is the *ex ante* or *ex post* characteristics of the methods to define the allowed RoE and cost of debt. For instance, two different ways to remunerate the cost of debt may be implemented (OXERA 2013b):

- The cost of debt allowance can be set to cover the actual cost paid by a company on its borrowings. This is often referred to as the “embedded debt” approach.
- The allowance can be set according to market rates –i.e., the expected cost of debt as evidenced by market yields on bonds issued by other corporations that are similar in terms of sector or credit rating.

The properties of these two options can be explained by assimilating them to two theoretical instruments: cost plus (*ex post* cost of debt setting) and price cap (*ex ante* cost of debt setting). The first one (embedded debt) is similar to a cost-plus mechanism. This option can be associated to weaker incentives (to optimise the debt management) but also to weaker risks for the TSO. On the contrary, the second option provides better incentives to the optimisation of the cost of debt but implies more risks for the TSOs. Note that intermediate options also exist as is the case of indexing the level of allowed revenues with some market indicator.

Indexation can also be applied to the allowed RoE (see the case of Belgium). This allows to better adjust the allowed RoE to the theoretical short term value of raising capital (and to maximise the transfer of increase or decrease of the RoE to the final users). This however can introduce too much risk on the TSO, mainly when the value of the RoE decreases considerably. To limit the risk of this indexation, and in general the use of model as CAPM whose inputs can considerably vary over the time, the use of bandwidths or range can help to create a more investor friendly regulatory regime (e.g., the case of Great Britain).

All in all, while it is critical to protect final-users from the pricing behaviour of natural monopoly, the energy regulator has also the duty to ensure that the utility can finance its operations and remain in business. In other words, the regulator must balance the transfer and redistribution to final users with the needs of investors to obtain fair returns on investment.

Financeability

In a period of massive investment (for instance the one that Europe is expected to experience in the coming 20 years), the allowed revenue of network companies must take this particularity into account to ensure the company's financeability. Financeability refers to the ability of TSOs to raise finance from capital markets in order to meet their investment program (Henriot, 2013; OXERA 2010a, 2010b). This means that it is necessary to maintain the profile of revenue of network companies to a high enough level so that they remain able to keep a good credit rating and to attract debt and equity at low cost in spite of massive investment doubling or tripling their asset base in a decade. Their investment programs may be otherwise unachievable (even if it has been proven used and useful) and the credit rating of the network company will decrease (Moody's 2009). Consequently, the network quality will decrease and the network company's financing cost will increase, hence increasing the tariff paid by the end-users and the cost of supply (because of poorer quality and experience of very costly unsupplied energy). Even if integrating financeability in tariff setting means that the network tariff increases in the short term, it is very likely that the long term payoff is positive, as it ensures that the required investments are actually developed (Henriot, 2013).

The impact of efficiency targets on the investments distinguishing old and new investments

It is legitimate to incentivise efficient new investments within a regulatory period (e.g. via a menu of regulation for capital expenditure) and, potentially, to disallow the addition of some CAPEX to the RAB (e.g., via an *ex post* efficiency audit). Incentive regulation might produce efficiency gains on new investments incentivising the company to find ways either to reduce cost or increased output from investments. Disallowance also incentivises the company to invest in a prudent manner. Inversely, imposing efficiency targets on past (non-controllable) investments would result in a redistribution of a part of normal returns on investments that were defined before the investment itself (Haney and Pollitt, 2012). Indeed, the cost of these assets cannot be influenced anymore. If the integration of an asset in the RAB (and its cost) is accepted during a past regulatory period, this decision should be kept until the full depreciation of the considered asset, even if it happens that investments are found less efficient than expected because unexpected events during planning occur in reality. As such, the current RAB may reflect past involuntary inefficiencies. Consequently, it is important that the regulator distinguishes between the efficient level of costs of new controllable investments, the efficient cost of capital applied to remunerate RAB, and an efficient RAB (which relies on a network built from scratch, ignoring historical regulatory decisions and uncertainty arising during network planning).

Design characteristic 5: The adjustment mechanisms

The introduction of a revenue cap requires a number of *ex ante* estimates to determine the revenue/tariff trajectory during the regulatory period. The adjustment mechanisms (Z factors) are put in place to manage the differences between the estimated *ex ante* and the values actually observed (i.e., *ex post*).

Electricity demand uncertainty is one of the most important factors to adjust. In revenue cap schemes, the transformation between allowed revenues to the network tariff needs an *ex ante* estimation of electricity demand. Thus, if observed demand is different from the *ex ante* estimation, the adjustment mechanism should adjust the level of tariff in order to ensure a proper remuneration for the TSO (i.e., corresponding with the allowed revenues).

Non controllable cost is another factor to adjust the allowed revenue. The principle of adjustment mechanisms is an *ex post* correction for the revenue differences between the estimated *ex ante* and *ex post* observed values of parameters on which the network operator has no control.

Adjustment mechanism can also include controllable costs whose level depends on some exogenous non controllable variables. For instance, the cost of losses or the cost of ancillary services depends on the price of energy. Or the needed investments depend on the level of RES integration. In such cases, the revenue can be automatically adjusted with revenue drivers, linking the observed value to external variable (price of energy, RES integration, etc.) with a unit revenue value. This kind of mechanism allows to keep some incentives for cost reduction (the revenue is not linked to observed costs) and at the same time diminished the risk allocated to the TSO (because exogenous risks are transferred to final users).

The adjustment can be made each year during the regulatory period or at the beginning of the following period. Note that the frequency of adjustments is a priori not related to the duration of the regulatory period. It is possible to set a time control during the whole regulatory period with an annual adjustment. In contrast, the frequency of adjustments determines the rate changes. If adjustments are made each year, the rates will be changed each year.

1.2.4 Economic properties of the main regulatory design options

Applying the economic criteria described in section 1.1 to the different characteristics of regulatory designs defined and analysed over this section, it is now possible to assess the main design options of each characteristics according to their economic properties. Table 3 summarises the link between design options and economic properties.

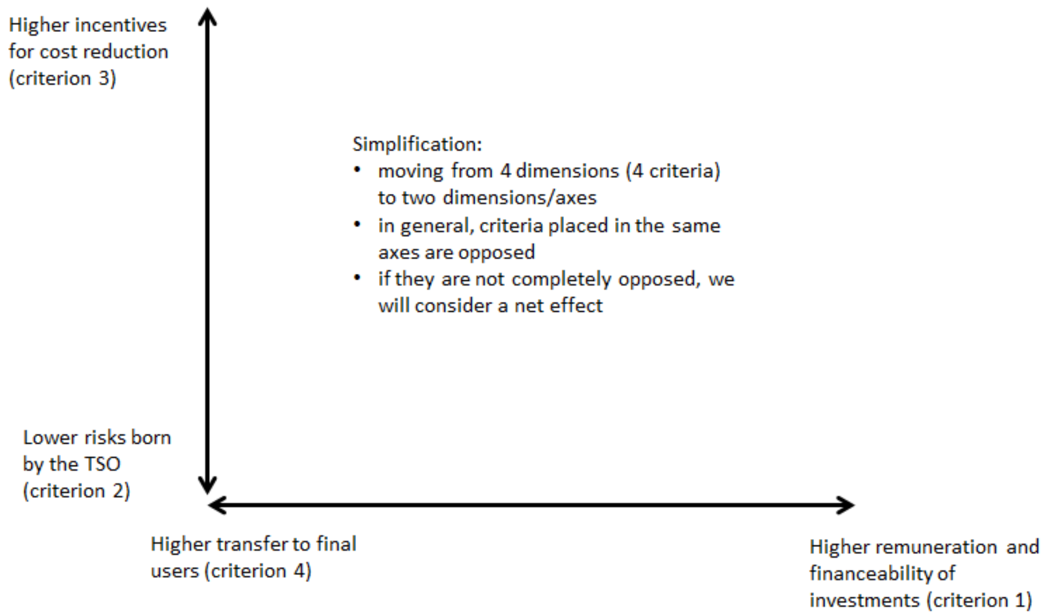
Table 3. Characteristics, options and economic properties (criteria)

Design characteristics	Criterion 1 (remuneration and financeability of investments)	Criterion 2 (minimising TSO risks)	Criterion 3 (incentives for cost reduction)	Criterion 4 (transfer of efficiency gains and redistribution to final users)
Length of the regulatory period	(its impact depends on sharing rules)	☺ Shorter regulatory period	☺ Longer period	(its impact depends on sharing rules)
Scope of revenue cap	☺ Building blocks (connect remuneration to actual costs) ☹ TOTEX (risk of lower remuneration if efficiency targets applied to past investments)	☺ Building blocks + pass-through items (lower risks born by the TSO) ☹ TOTEX (higher risk born by the TSO, mostly when applied to non-controllable costs)	☹ Building blocks (lower incentives for cost reduction) ☺ TOTEX (higher incentives for cost reduction; trade-off + CAPEX)	☺ TOTEX (high redistribution if efficiency targets applied to past investments)
Efficiency targets and tools	(its impact depends on the relative efficiency of the company) ☹ Ambitious X targets applied on investments imply less financeability	☹ Yardstick /benchmarking (higher risks born by the TSO - risk increase when comparability is low) ☺ Efficiency audit (lower risks born by the TSO)	☺ Yardstick/benchmarking (higher incentives for cost reduction) ☹ Efficiency audit (lower cost reduction incentives – intrusive) 😐 Menu of contracts	😐 Yardstick (the transfer depends on the comparability) 😐 Menu (the transfer depends on contracts chosen by the TSO) ☺ Ambitious X targets applied on investments imply more transfer to final users
Remuneration of capital and treatment of investments	☺ Higher WACC and adders ☺ Cash flow matching mechanism ☺ Financeability test ☹ Ambitious X targets applied on all investments imply less financeability	☺ Embedded (actual) cost of debt allows to transfer cost of debt risk to final users ☺ Bandwidth WACC/sharing rule	☺ Ex *ante* cost of debt and notional gearing (gives incentives for optimising financial structure)	☺ Lower WACC ☺ Differentiated WACC for old and new investments ☺ Ambitious X targets applied on investments imply more transfer to final users
Adjustment mechanisms		☺ Revenue/expansion drivers (help to transfer exogenous risk to final users) ☺ Pass-through items (help to transfer non-controllable cost risk to final users)		

1.3 Trade-offs of the regulatory designs and their graphical representation

A key conclusion drawn from the analysis of the economic properties of regulatory design is the existence of unavoidable tensions[27] between the different economic properties. These tensions can be analysed using a simple graphical representation. The idea is to give the four criteria structuring the economic properties in a two-dimension figure. To do so, the second criterion (minimising the risks born by the TSO) is combined with the third one (incentives for cost reduction) in the vertical axis. This illustrates a primary level of tension inherent to the regulatory design: the more stringent are the incentives for cost reduction designed by the regulatory regime, the more risks the TSO bears. Then, the first criterion (ensuring remuneration and financeability) is combined with the fourth (higher transfer of efficiency gains and redistribution to final users) in the horizontal axis. This illustrates a secondary level of tension inherent to the regulatory design: the more the efficiency gains are transferred to the final users and the more redistribution, the less the TSO will easily finance its investments. Figure 7 shows the construction of this graph.

Figure 7. Construction of the simplified graph to analyse regulatory designs



Once these main levels of tension are placed on the different axis, the graph can easily be divided into two contrasted areas (figure 8).

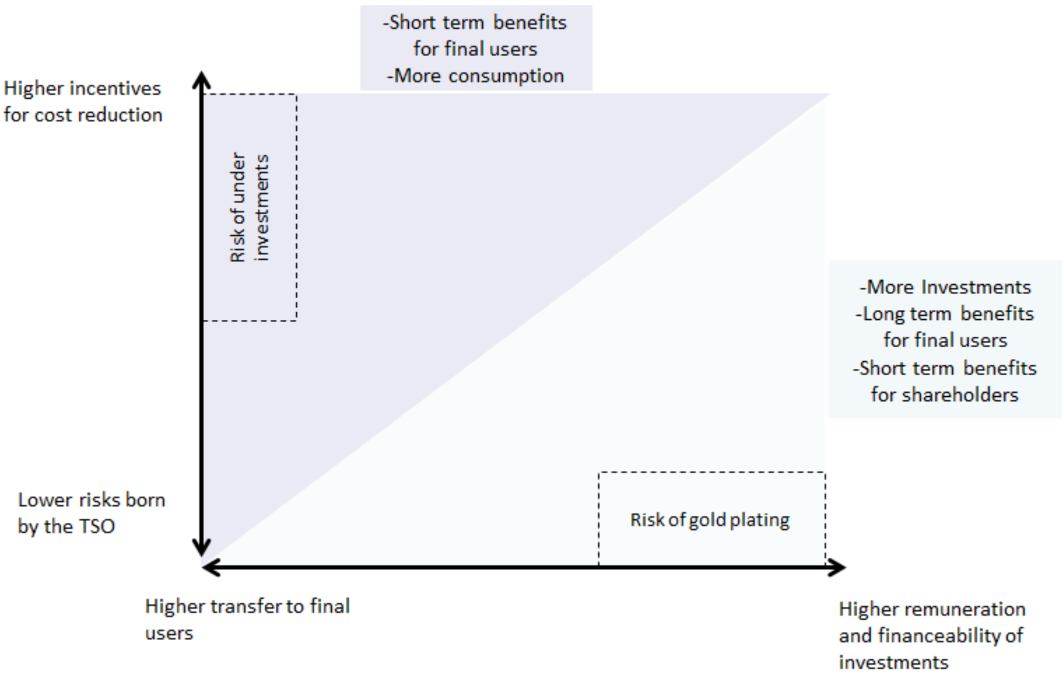
- The upper-left corner area corresponds to a situation of high incentives for cost reduction (and high risks born by the TSO) plus a low remuneration and financeability (with a high transfer and redistribution to final users). Given this combination of economic properties, a regulatory design located in this area will result in lower tariffs (in the short term) and likely more consumption (according to the short term elasticity of users). However, this design will

[27] Note that if regulatory designs are not well-implemented (i.e., they include design or implementation errors), their correction might not suffer from these tensions. Indeed, the correction of the design may improve the score in several properties at the same time.

also deliver weak incentives for investments and favour today's under-investment and financeability issues with potential higher costs in the future.

- The lower-right corner area corresponds to a high remuneration and financeability (with a lower transfer and redistribution to final users) as well as lower risks for the TSO (and lower incentives for cost reduction). Given this combination of economic properties, a regulatory design located in this area will result in more incentives for today's investments and potential lower costs in the future. However, this regulatory design also implies higher tariffs in the short term and a likelihood of over-investment ("gold plating").

Figure 8. Simplified graph and regulatory designs areas



To illustrate how this graph works, we now introduce two extreme regulatory designs. The first extreme design (1) called "gold plating" is characterised by a building blocks approach, a very high allowed WACC and no *ex ante* or *ex post* efficiency audit of investments (i.e., investment cost are purely passed through). The second extreme design (2) called "under-investment" is characterised by a TOTEX approach, a very low allowed WACC, ambitious efficiency targets (fixed exclusively from exogenous yardstick information and applied to TOTEX) and weak constraints for quality. Table 4 summarises the design options of each regulatory design and the corresponding economic properties.

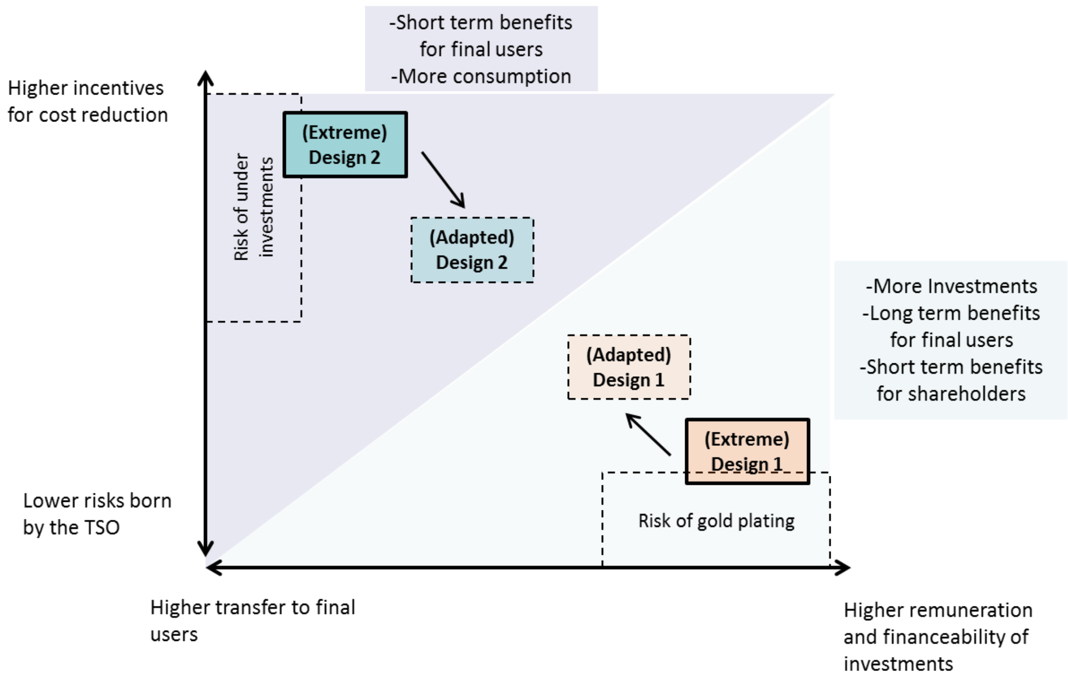
As the first design implies that the TSO bears very few risks (no *ex ante*/*ex post* efficiency test, pass-through) and high remuneration and financeability (very high allowed WACC, no X applied on investments), this design gives high incentives for investments. However, this design provides little incentives for cost reduction (no *ex ante*/*ex post* efficiency test, pass-through) and little transfer of efficiency gains and redistribution to final users (no X and very high allowed WACC). As the second design implies high incentives for cost reduction (fixed TOTEX allowance without any relationship with actual cost) and high transfer to final users (ambitious X, very low allowed WACC), this design ensures short term benefits for final users (i.e., low network tariff at short term). However, the high risk born by the TSO (no pass-through, ambitious and exogenous X applied on TOTEX) and a low remuneration and financeability for investments (very low allowed WACC and ambitious X) imply little incentives for investments. The two (extreme) hypothetical regulatory designs are located in figure 9.

Table 4. Extreme hypothetical designs

Regulatory designs		**Regulatory design 1 ("gold plating")**	**Regulatory design 2 ("under-investment")**
Characteristics		-Building blocks with very high allowed WACC -No *ex ante* or *ex post* efficiency audit of investments -Pass-through items covering large perimeter of different types of costs	-TOTEX approach with very low allowed WACC -Ambitious (exogenous/yardstick) X applied to TOTEX (OPEX, CAPEX and old investments) -No pass-through items -Weak constraints for quality
Criteria/ Properties	**Investment remuneration and financeability**	High financeability for investments (very high allowed WACC, no X applied on investments)	Low financeability for investments (Very low allowed WACC, ambitious X applied on investments)
	Minimising risks born by the TSO	Low risk for the TSO (Pass-through items, no *ex ante*/ *ex post* efficiency test of investments)	High risk for the TSO (no pass-through items, ambitious X applied on investments)
	Incentives for cost reduction	Low incentives for cost reduction (Pass-through items, no *ex ante* / *ex post* efficiency test of investments)	High incentives for cost reduction (no pass-through items, TOTEX incentives)
	Transfer of efficiency gains and redistribution to final users	Low transfer of efficiency gains and redistribution to final users (no X and very high allowed WACC)	High transfer of efficiency gains and redistribution to final users (ambitious X applied on investments, very low allowed WACC)

It is worth noting that in real life, pure versions of these two extreme examples are not frequent. They are normally adapted to avoid extreme economic properties and thus, finding a balance. For instance, in building blocks approaches an *ex post* efficiency test ("used and useful" test) is often included. The TSO consequently has some incentives to reduce the cost and limits the risk of gold-plating (the incentives to reduce cost materialise *ex ante* because the TSO knows the existence of the *ex post* efficiency test). This however introduces some risks for the TSO as it is not sure that the incurred cost will be completely recovered. This, combined with an intermediate level of WACC (ideally close to the cost of capital), allow a better transfer and redistribution to final users. TOTEX/yardstick approaches in real life do not exclusively rely on exogenous (yardstick/benchmarking) information to define the allowed revenue of the TSO. Indeed, the actual (observed) cost is somehow considered in the definition of allowances. This could be done for instance by excluding from the TOTEX scope some non-controllable (or semi-controllable) costs, notably the historical asset base, introducing pass-through mechanisms or, by ensuring a proper level of remuneration for the realised investments (i.e., fixing an intermediate allowed WACC). These modifications imply that the risks born by the TSO decreases and that the financeability increases, resulting in a reduced risk of under investments. This however implies losing some incentives for cost reduction and moderating the transfer of efficiency gains and redistribution to final users.

Figure 9. Simplified graph and hypothetical designs



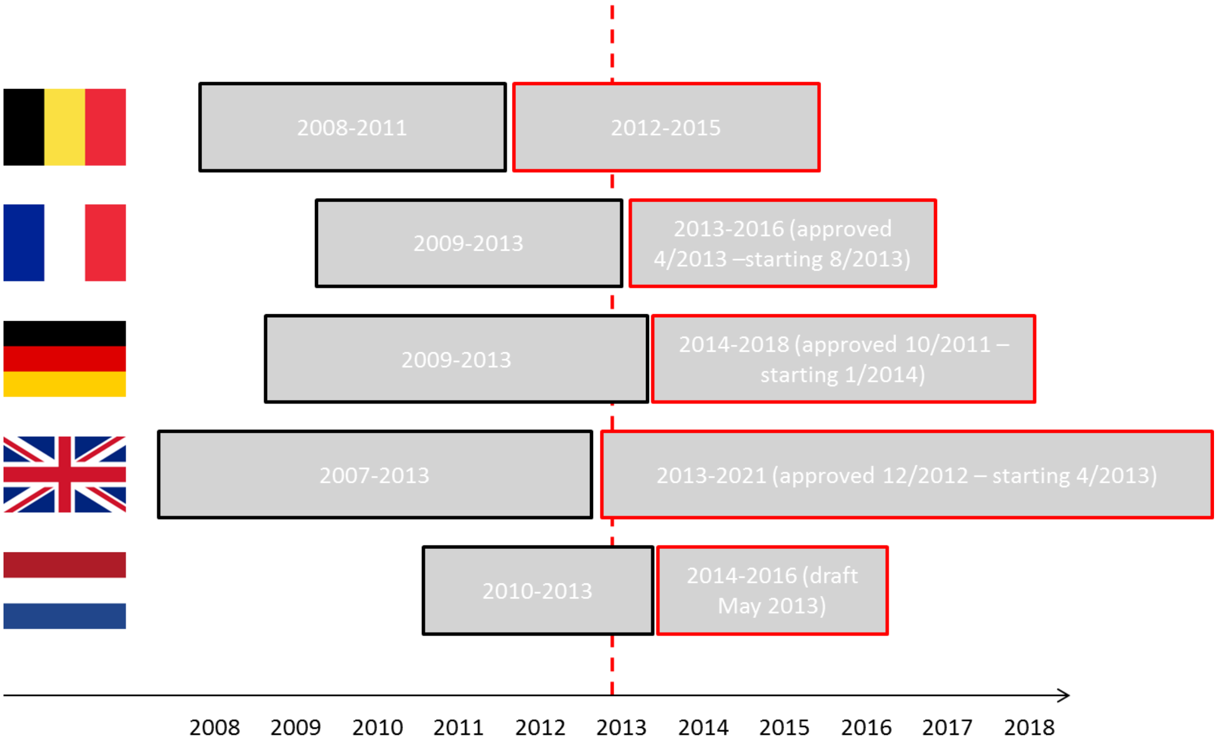
It should eventually be noticed that economic properties of regulatory designs should be analysed considering the context where the regulation is applied. In a context where there is a huge level of inefficiency and where investments are not a priority, designs with high incentives for cost reduction and a high transfer and redistribution to final users will fit best (under the strict condition that there is a firmly reliable comparability of benchmarked companies). Indeed, the risk of under-investment is not a big issue because they are not needed before long. Inversely, if such designs are implemented in a context where investment needs are huge and risky, they are not fitted and may be costly because they result in under-investment (lowering future network quality or missing the infrastructure objectives – e.g., energy transition or internal market building) and the very high cost of capital when the network operators experience too much risk and financeability issues. In a context where investment needs are huge and risky, designs having the properties of low risk born by the TSO and high remuneration and financeability fit better. Indeed, the cost of capital could be reduced by these designs and exceed the losses in terms of incentives for cost reduction and the tariff impacts in the short term. These aspects will be discussed in a more detailed manner in section 3.

2 Comparing EU regulatory regimes

This section aims at comparing the TSO regulatory regimes of different EU countries. We focus the study on five countries that are highly connected in a regional market and cover more than half of the whole European market: Belgium, France, Germany, Great Britain, and the Netherlands.

Following our analytical framework, we analyse national regulatory regimes by their main design characteristics and options having an impact on investment. We focus on design options and parameters of regulatory periods that will have an impact on future investments. Figure 10 shows (in red) the studied regulatory periods. It is important to notice that all the regulatory designs and parameters have not been already approved. It is notably the case of Dutch regime, whose design and parameters studied are based on the draft proposal (May 2013). Thus, the results of comparison could change if the proposed design and parameters are finally changed.

Figure 10. The studied regulatory periods



The description of the five regulatory regimes can be found in appendix A. This description is based on available public information and results in stylised regulatory regimes. Note that some discrepancies between the stylised regulatory regimes and the reality may appear because of their more flexible or stricter application by the regulator. This section presents the main insights coming from the study of these five regulatory regimes. The section starts with a presentation of the main design options of each regulatory design (3.1). The section then analyses the economic properties of each regulatory regime based in their main options (3.2). Finally the section concludes (3.3).

2.1 National regulatory designs

2.1.1 Main design options

Table 5 shows the main design options used by the five regulatory regimes. We find there are three main types of regulatory regimes.

Belgium and France use a "building blocks" approach. They mainly exclude investments from the revenue cap and reduce the incentives for this type of costs. The building blocks approaches are complemented by efficiency audits of the investment budgets (an *ex ante* approval of investments and an *ex post* potential control of investments). Once the investments are made and accounted in the Regulated Asset Base, they are subject to a straight-line depreciation and they are remunerated with an allowed cost of capital (WACC). This does not include any extra efficiency requirement. This approach can be considered as bearing low risks on the TSOs since the main part of the costs is treated as pass-through items (including SO costs).

Germany and the Netherlands use a "TOTEX" approach with a strong reliance on yardstick/benchmarking techniques. They include most investments in the revenue cap scope. Each regulatory regime defines its own classification of costs and the impact of efficiency targets on each cost, while globally most of the investments are included in the revenue cap envelop. Both regulatory regimes are favouring benchmarking as the key tool to define the required efficiency levels. These regulatory regimes are by nature bringing more incentives on cost reduction than the building blocks regimes, even to a far too extreme level since efficiency targets apply to old investments (in the RAB), while their costs cannot be influenced anymore. These regulatory regimes are also bringing more risks for the TSO than the building blocks regimes. Because of the difficulties to control for the different business environments where the TSOs operate, applying benchmarking on transmission network still leads to results that are not fully reliable. There are however two noticeable differences between the Dutch and the German regimes. The first difference is grounded on the use of comparable companies to perform the benchmark. The Dutch regime grounds its regulation exclusively on international benchmark (as there is only one TSO in the Netherlands) whereas the German regime combines international with national benchmarking (based on the four TSOs operating in Germany). This difference is consequential as long as benchmarking the TSOs has to assume that both the transmission regulatory environment and the "doing business" environment are sufficiently similar for all the scored companies to not interfere with the scoring results. In this respect, the German approach can only be more robust, for it I based on four national companies sharing the same transmission and "doing business" environments (history, geographical conditions, etc.), even if some problematic heterogeneity may remain. As a result, the associated regulatory risks should be expected as higher in the Dutch regime than in the German regime. The second difference is grounded on the scope of costs that escape temporarily from the TOTEX efficiency targets. To our understanding, the system of Investment budget (IB)[28] applied in Germany lowers the risks born by the TSOs because these investments are excluded for one or two regulatory period from the efficiency targets.

[28] The IB category includes costs incurred for specific "investment measures", *i.e.* the investments projects approved by BNetzA for the expansion and restructuring of transmission systems, as well as for the expansion of the offshore network.

In these circumstances Great Britain represents an intermediary level between these two types of regulatory regimes. First, the already long regulatory past of the British system increases risks and incentives for further deep cost reduction. Second, the British regime is now based on a "TOTEX" approach. However, there is a key difference when it comes to the method used to define the efficiency targets. While Germany and the Netherlands use benchmarking as the main efficiency target tool, the British regime combines different tools, where benchmarking is only part of a global evaluation and not a calculation of the efficiency targets. Moreover, the efficiency targets only applies to OPEX and new CAPEX (during the regulatory period) and does not concern the assets already integrated in the RAB. At last, the British regime uses a "menu of contracts" instrument where the TSO (NGET, SPT or SHET) chooses its preferred combination of incentives and risks according to its manageable business trajectory. Besides, several adjustment mechanisms are implemented which link the network revenues to defined driver changes (like generation and load connection, network constraints, etc.).

Table 5. Main options of regulatory design

Regulatory regime characteristic	BELGIUM	FRANCE	GERMANY	GREAT BRITAIN	NETHERLANDS
Length of the regulatory period	4 years	4 years	5 years	8 years (with a possible 4 year revision)	3 years
Revenue cap	Building blocks Approval of investments and possible ex posts audits Pass-through items (SO costs, and non-controllable OPEX)	Building blocks Approval of investments and possible ex posts audits Pass-through items (SO costs, and non-controllable OPEX)	TOTEX (excluding SO costs and IB costs) SO cost (sliding scale scheme)	TOTEX (excluding non controllable OPEX) SO cost (sliding scale scheme)	TOTEX (excluding SO costs) SO cost (sliding scale scheme)
Tools to define allowances (R0 and X)	Audit and expert analysis	Audit and expert analysis	National and international benchmarking (OPEX and TOTEX) Productivity analysis	Menu of contracts, audit and expert analysis, benchmarking & consultation process	International benchmarking (OPEX and TOTEX) Productivity analysis
Application of the efficiency targets	Controllable OPEX (in the revenue cap) CAPEX *ex ante* approval (and potential *ex post* control)	Controllable OPEX (in the revenue cap) CAPEX *ex ante* approval (and potential *ex post* control)	Controllable cost (OPEX + CAPEX including historical RAB except IB CAPEX) IB CAPEX *ex ante* approval (and potential *ex post* control)	TOTEX (excluding non controllable OPEX and historical RAB) + several (adjustment) mechanisms to adjust the cost and revenue allowances to drivers changes	TOTEX (including historical RAB, excluding SO costs)
Comments			IB costs (RES and SoS CAPEX + offshore OPEX)		

2.1.2 Remuneration of capital and adjustment mechanisms

Tables 6, 7 and 8 and figures 11 and 12 show the design options concerning the remuneration of capital, the treatment of investment and the adjustment mechanisms for the different regulatory regimes.

Concerning the remuneration of capital and the treatment of investment, five main differences are observed when comparing these regulatory regimes:

The first difference concerns the level of the allowed cost of capital which directly impacts the remuneration of investments (RoE and WACC). Table 6 and figure 11 present allowed RoE whereas table 7 and figure 12 present allowed WACC. From these tables and figures, it can be observed that there are three main levels of remuneration of capital. The British regime applies the highest level of remuneration for investments, while the Dutch (draft proposal) and the Belgian regimes currently offer the lowest levels of remuneration of capital. The French and German regimes are in a medium range.

Table 6. Comparison of allowed or regulated Returns on Equity[29]

Country	Nominal pre-tax RoE	Nominal post-tax RoE	Nominal post-tax RoE (g=60%)
Belgium	6.6 %*	4.3 %*	4.1 %*
France	**11.2 %**	7.3 %*	7.3 %*
Germany	10.6 %*	**7.4 %**	7.4 %*
Great Britain	11.7 %*	9.0 %*	9.0 %*
Netherlands	7.4 %*	**5.6 %**	6.2 %*
Average value	*9.5 %**	*6.7 %**	*6.8 %**

*Two types of values are presented in table 6. The values given by the regulators are indicated as bold. And we have computed the values identified with a star * the bold values and other assumptions provided by the regulated documents. Besides, as the notional gearing is not the same in the different regulatory regimes, we used, for the case of RoE, an adjusted value corrected for an equal notional gearing of 60% (this value will only be different for the regulatory regimes using a gearing different from 60%, i.e., the Dutch and the Belgium regimes). This allows to have a better comparability between the regulatory regimes. Note that WACC is computed considering the notional gearing decided by the regulation (which may vary from one country to another). These different values (RoE and WACC) are computed in details in the appendix B.*

[29] The calculations of RoE are based on the following assumptions: an inflation rate of 2% for all the countries and the corporate tax rates are as follows: Belgium 33.99%; France 34.4%; Germany 30.0%; Great Britain 23.0%; the Netherlands 25.0%). See appendix B for more details.

Figure 11. Comparison of allowed or regulated Returns on Equity

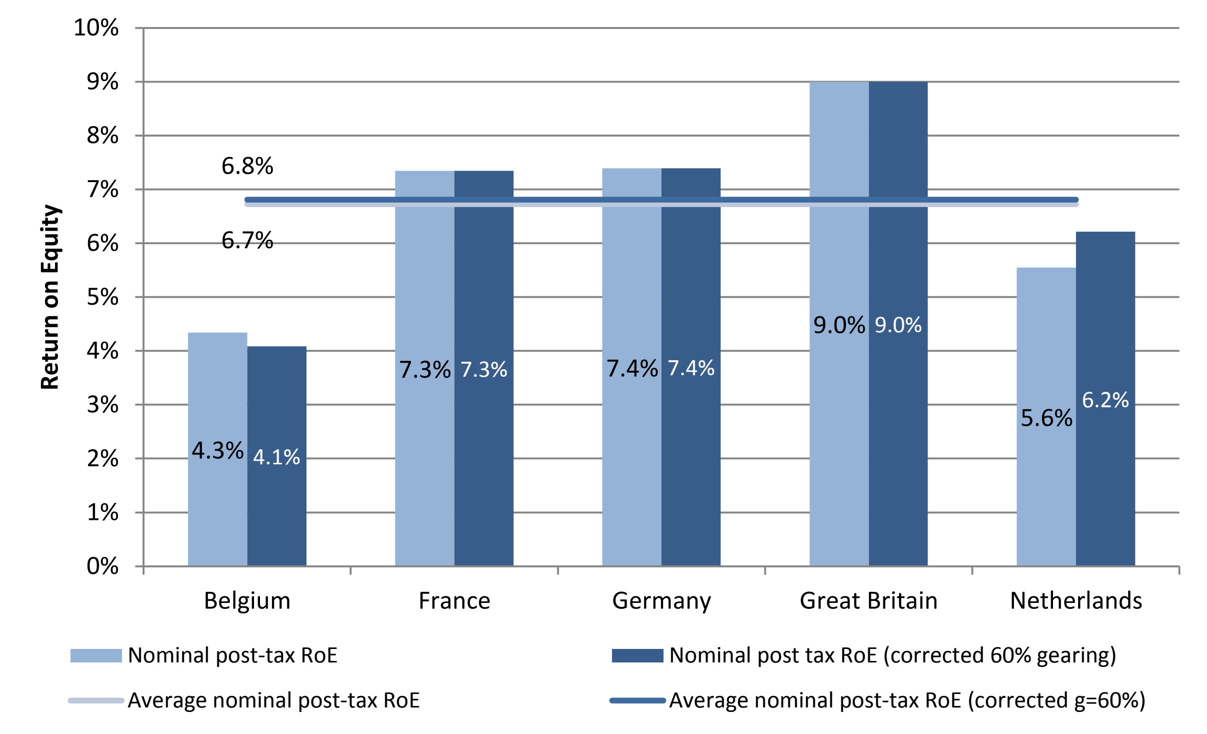


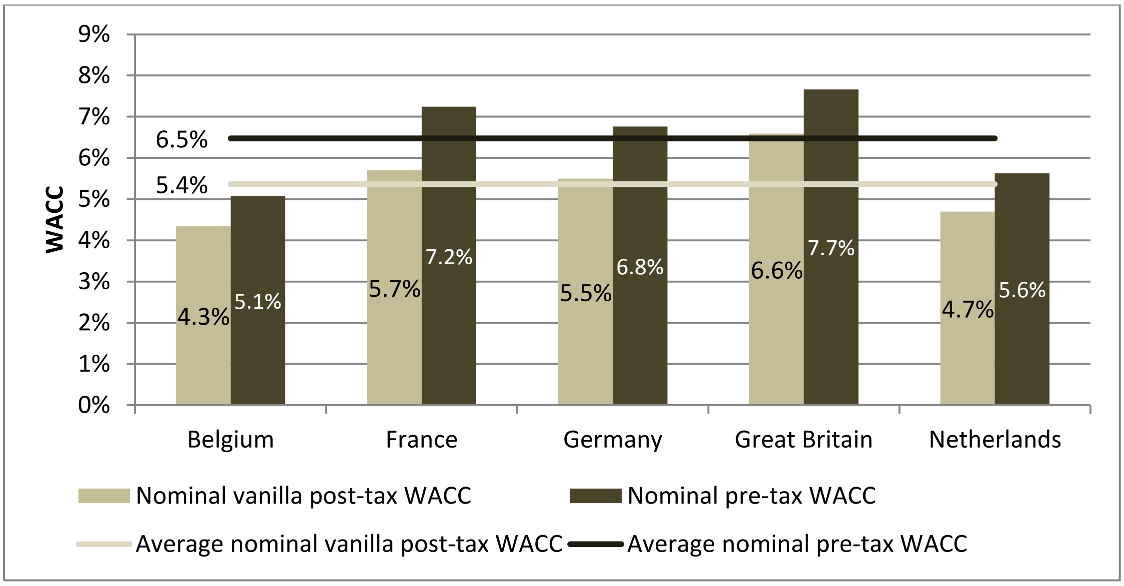
Table 7. Comparison of (allowed or regulated) Weighted Average Costs of Capital[30]

	Nominal WACC	
Country	**Pre-tax**	**Vanilla Post-tax**
Belgium	5.1 %*	4.3 %*
France	**7.2 %**	5.7 %*
Germany	6.8 %*	5.5 %*
Great Britain	7.7 %*	6.6 %*
Netherlands	**5.6 %**	4.7 %*
Average value	*6.5 %**	*5.4 %**

All the values in table 7 are computed by our own (see assumptions and formulas used in appendix B).

[30] The calculations of WACC are based on the following assumptions: an inflation rate of 2% for all the countries and the corporate tax rates are as follows: Belgium 33.99%; France 34.4%; Germany 30.0 %; Great Britain 23.0%; the Netherlands 25.0%). See appendix B for more details.

Figure 12. Comparison of (allowed or regulated) Weighted Average Costs of Capital



The second difference applies to the use of WACC adders for certain investments. Belgian and French regimes consider an adder to incentivise specific investments (in Belgium, the replacement CAPEX and in France investments related to interconnections). The other countries do not apply WACC adders.

The third difference concerns the *ex ante* or *ex post* definition of key parameters of WACC, in particular the cost of debt. Three different design options can be distinguished. The embedded (or pass-through) debt design, used in Germany and in Belgium, implies less risk for the TSO but less incentive to optimise the financial structure. The *ex ante* allowed cost of debt design, used in the Netherlands and in France, implies more incentive to optimise the financial structure but more risks born by the TSO. The British design is an intermediate case because the allowed cost of debt is indexed to market values.

The fourth difference applies to the use of financeability check to ensure that the investment programs are financially feasible, given allowed WACC parameters. To our knowledge, the British regulatory design is the only one that includes a financeability check.

The fifth difference relates to the use of efficiency targets for regulated investments (either CAPEX or old assets). In principle, in a TOTEX approach an efficiency target (X) is applied on the whole RAB (including CAPEX as well as the "old" investments). This means that the remuneration of a new investment (CAPEX) itself integrates this efficiency expectation. If the TSO outperforms its efficiency target on the whole RAB (while it could only act on its on-going CAPEX and not that much on the historically sunk investments), it will earn a higher return than the *ex ante* defined WACC. Conversely, if the TSO underperforms its efficiency target for the whole RAB, it will earn a lower return than the pre-agreed WACC. If we now turn to the building blocks approach, it might happen that the *ex ante*/*ex post* efficiency test of CAPEX introduces some efficiency downgrades when investments are integrated into the RAB. However this is not normally the case given that investments are approved *ex ante*.

These regulatory regimes also differ with regard to their use of matching mechanisms aligning the timing of investment and the timing of revenues. This is important when allowances do not include an investment plan forecast or when important unexpected investments are necessary far before the end of the current regulatory period and the beginning of another one. The German and the Dutch cases both consider this type of mechanism. In Germany, since 2012 the matching between costs and revenue is annually done for any investment budget (i.e., work in progress). In the Netherlands, the adjustment is done two years later once the investment is completed, which is more constraining for the TSO's financeability[31]. In France, any change in the capital expenses is integrated in a "buffering" regulatory account (CRCP) and integrated in the tariff the next year. In Belgium, the main part of the investments has to be anticipated at the beginning of the regulatory period and the other investments may only be integrated at the beginning of the next regulatory period. Note that all the national regulatory regimes have implemented *ex post* volume correction.

[31] Note however that this rule only applies for a limited number of significant investments.

Table 8. Remuneration of capital and adjustment mechanisms

Regulatory regime characteristic		BELGIUM	FRANCE	GERMANY	GREAT BRITAIN	NETHERLANDS
Remuneration of capital and treatments of investment	WACC	RoE *ex post* (CAPM) CoD embedded Adder for replacement CAPEX (a €5 million fund per year, standing for up to 35 bp)	RoE *ex ante* (CAPM) CoD *ex ante* (CAPM) (future) adder for interconnection investments (undefined yet)	RoE *ex ante* (CAPM) CoD embedded	RoE *ex ante* (CAPM) Bandwidth CoD indexed Financeability test	RoE *ex ante* (CAPM) CoD *ex ante*
	Impact of efficiency targets on all assets (new and old ones)	No	No	Yes (except IB CAPEX)	No	Yes
Adjustment mechanisms	Matching/cash flow	*Ex ante* budget based on forecast and *ex post* correction	*Ex ante* budget based on forecast and *ex post* correction	Matching y+0 with work in progress included (before 2012: y+2)	*Ex ante* budget based on forecast	*Ex ante* budget based on historical CAPEX Matching 2 years after asset completed
	Volume	*Ex post* volume correction	*Ex post* volume correction	*Ex ante* revenue drivers (expansion factors) *Ex post* volume correction (yearly if more than 10%)	*Ex ante* revenue drivers (expansion factors) *Ex post* volume correction	*Ex post* volume correction

2.2 Economic properties of the stylised national regulatory designs

Once the main designs options of the national regulatory designs have been identified, their economic properties can be assessed using the analytical framework developed in section 1. It is important to notice that this is a relative assessment of the properties, i.e., all things being equals. This first applies for the design characteristics, i.e., as if the designs characteristics that are not studied here are similar in all regimes (e.g., quality restriction or incentives). This also applies for other national specificities (e.g., investment needs, cost of capital, potential inefficiencies, etc.). This last point will be discussed in section 3.

Table 9 provides a detailed assessment of different design options concerning the four criteria/economic properties defined in section 1. Starting from this detailed analysis, we then summarise the general characteristic of the stylised regulatory designs. In what follows, we present how the general assessment is made.

2.2.1 Belgium

The Belgian regulatory regime might be characterised as giving a very <u>low remuneration and financeability of investments</u>, a <u>low level of risk</u> born by the TSO, <u>modest incentives</u> for cost reduction and a <u>modest/high transfer</u> of efficiency gains and redistribution to final users.

The very low level of remuneration and financeability for investments is a direct consequence of the formula used to calculate the allowed RoE. It directly depends on the risk-free interest (OLO), whose current level is very low[32]. This impact of the RoE can however be partially balanced by the use of an "adder" for replacement CAPEX (with €5 million fund per year, standing for up to 35 base points), improving modestly the remuneration and the financeability of this type of investments.

The low risk for the TSO is due to the building blocks approach as well as the adjustment mechanisms related to the demand volume and to the non-controllable costs of the TSO. The investment costs are risk-free enough, as they are mostly considered as pass-through as well as the system operation costs and the costs of debt. Still, risks remain with regard to a possible negative *ex post* evaluation of the investments and their incomplete incorporation into the RAB. However, this risk is limited because the investment plans are approved *ex ante* by the regulator.

The modest score in terms of incentives for cost reduction have two reasons. First, the use of building blocks approach increases the risk of distortion between CAPEX and OPEX. Second, the method used to analyse CAPEX efficiency (efficiency audit by cost observation and analysis) only provides a modest level of incentives for cost reduction.

The modest/high score for transfer of efficiency gains and redistribution to final users is mainly due to the pass-through-item allowing a direct transfer of the actual cost to final users, ensuring that no monopoly rent is kept by the TSO, and to the current very low WACC providing lower network tariffs to final users. Some elements however limit the transfer of efficiency gains and redistribution to final users. These elements include the use of the building blocks approach that limits the scope of

[32] The OLO felt from 4.94 % in 2011 to 2.98% in 2012.

incentivised costs and where efficiency targets are applied (efficiency targets are only applied for controllable costs).

2.2.2 France

The French regulatory regime is characterised by a medium to high degree of remuneration and financeability for investments, a low level of risk put on the TSO, modest incentives for cost reduction and a modest transfer of efficiency gains and redistribution to final users.

The medium/high score considering remuneration and financeability is mainly due to the fact that the French TSO benefits from a medium/high allowed level of WACC, and the possibility to include adders for certain investments (interconnections).

The low risk for the TSO is mainly due to the building blocks approach used in this regulatory regime and on the adjustment mechanisms used to limit the non-controllable risks of the TSO. There are so few risks on investment costs, as they are mostly considered as pass-through. Still, a degree of risk remains with regard to the possible (negative) *ex post* evaluation of the investments and their partial incorporation in the RAB. However, this risk is very limited considering that investment plans are approved *ex ante* by the regulator.

The modest score in terms of incentives for cost reduction are due to two reasons. First, the use of building blocks approach increases the risk of distortion between CAPEX and OPEX. Second, the method used to analyse CAPEX efficiency (efficiency audit by cost observation and analysis) only provides a modest level of incentives for cost reduction.

The modest score for transfer of efficiency gains and redistribution to final users is due to the balance between different factors. On the one hand, some elements limit the transfer of efficiency gains and redistribution to final users. These elements include the use of the building blocks approach that limits the scope of incentivised costs and where efficiency targets are applied (efficiency targets are only applied for controllable costs) and the medium/high WACC. On the other hand, pass-through-item allows the direct transfer of the actual cost to final users, ensuring that no monopoly rent is kept by the TSO.

Table 9. (detailed) economic properties of the national regulatory regimes

Criteria	BELGIUM	FRANCE	GERMANY	GREAT BRITAIN	NETHERLANDS
Remuneration for TSO investment and financeability	☹ Very low WACC ☺ RoE adder for replacement CAPEX	☺ Medium/high WACC ☺ Adder for interconnection CAPEX	☺ Medium/High WACC ☺ Matching mechanism (work in progress, y+0) ☹ X applied to all investments (TOTEX, except IB for 1 or 2 periods)	☺ High WACC ☺ Financeability test 😐 X applied to investments	☹ Low WACC ☹ X applied to all investments (TOTEX) 😐 Matching mechanism (y+2 after assets completion)
Minimising risks for the TSO	😐 *Ex post* efficiency audit of investments (but *ex ante* approval) ☺ Pass-through items (cost of debt, SO costs, etc.) ☺ Volume revenue adjustment mechanism	😐 *Ex post* efficiency audit of investments (but *ex ante* approval) ☺ Pass-through items (cost of debt, SO costs, etc.) ☺ Volume revenue adjustment mechanism	☹ Risks from TOTEX incentives 😐 Benchmarking risks (computation of X) ☹ Risks from SO incentives ☺ Pass-through items (cost of debt, etc.) ☺ Expansion factor and volume revenue adjustment mechanism	☹ Risks from TOTEX incentives ☹ Long regulatory period ☹ Risks from SO incentives ☺ Menu of contract and WACC bandwidth ☺ Revenue drivers and volume revenue adjustment mechanism	☹ Risks from TOTEX incentives ☹ Benchmarking risks (computation of X without national peers) ☹ Risks from SO incentives ☺ Volume revenue adjustment mechanism
Incentives for cost reduction	😐 Cost reduction on CAPEX modestly incentivised (*ex ante*/*ex post* efficiency audit)	😐 Cost reduction on CAPEX modestly incentivised (*ex ante*/*ex post* efficiency audit)	☺ TOTEX (OPEX-CAPEX trade-off; incentives on CAPEX) ☺ SO incentives	☺ TOTEX (OPEX-CAPEX trade-off; incentives on CAPEX) ☺ SO incentives ☺ Long regulatory period 😐 Menu of contracts	☺ TOTEX (OPEX-CAPEX trade-off; incentives on CAPEX) ☺ SO incentives
Transfer of efficiency gains and redistribution to final users	☺ Very low WACC 😐 *Ex post* efficiency audit and *ex ante* approval of investments 😐 Modest efficiency targets	😐 *Ex post* efficiency audit and *ex ante* of investments 😐 Modest Efficiency targets 😐 Medium/high WACC	☺ Ambitious X high sharing with consumers/users ☺ X applied to all investments (except IB for 1 or 2 periods) 😐 Medium/high WACC	😐 Menu of contracts (Depend on the contract chosen by the enterprise) 😐 X applied on investments ☹ High WACC	☺ Ambitious X (theta and FS) high sharing with consumers/users ☺ X applied to all investments ☺ Low WACC

2.2.3 Germany

The German regulatory regime is characterised by a medium to high degree of remuneration and financeability for investments, a medium to high level of risk put on the TSO, high incentives for cost reduction and a medium/high transfer of efficiency gains and redistribution to final users.

The medium/high score considering remuneration and financeability is due to the fact that the German TSOs benefit from medium/high values of RoE and WACC and from the existence of a matching mechanism allowing them to rapidly adjust revenues when investment volumes for certain projects do not correspond to historical/projected levels. These elements are moderated by the fact that the efficiency targets (X) are applied on most of the investments, potentially reducing the effective WACC and the financeability.

The medium/high risk born by the TSO is due to the TOTEX and benchmarking approach used in this regulatory regime, which apply to most of the OPEX, part of CAPEX and historical RAB. There is also an additional risk introduced by the SO sliding scale scheme. The global risk is partially reduced by several elements: the use of expansion factors and volume adjustment mechanism to adjust revenue and limit uncertainty, and the pass-through remuneration of certain categories of costs (e.g., the cost of debt).

The high score in terms of incentives for cost reduction are due to two reasons. First, the use of TOTEX approach partially aligns incentives between CAPEX and OPEX[33]. Second, the (partial) disconnection between the remuneration of CAPEX and the actual cost of investments strongly incentivise the TSO for CAPEX cost reduction and CAPEX efficiency.

The medium/high score for transferring efficiency gains and redistribution is mainly due to the ambitious efficiency targets (X) applied on the totality of costs (TOTEX), allowing a direct transfer to the final users. This factor is moderated by a medium/high level of allowed WACC.

2.2.4 Great Britain

The British regulatory regime is characterised by a high degree of remuneration and financeability for investments, a medium to high level of risk put on the TSO, medium to high incentives for cost reduction and a medium to high transfer of efficiency gains and redistribution to final users.

The high score considering remuneration and financeability is due to two factors: the relatively high values of RoE and the WACC and the use of a financeability test to ensure that the investment programs are feasible. These elements are moderated by the fact that efficiency targets (X) are applied on new investments only (not the historical asset base), potentially reducing the effective RoE of CAPEX.

The medium/high risk for the TSO is due to the TOTEX approach, the long regulatory period (8 years) and some additional risks introduced by the SO sliding scale scheme. The risk is reduced through several regulatory components: the limited use of international benchmarking in the process of

[33] Nevertheless, the company has more incentives to increase CAPEX than OPEX because it earns the WACC on CAPEX while it is only paid the cost on OPEX.

defining efficiency targets, the use of a menu of contracts, the use of revenue drivers and volume adjustment mechanisms and the use of a bandwidth for key parameters (e.g., incentive power in the menu of contracts, WACC, etc.).

The medium/high score in terms of incentives of cost reduction is due to three reasons: the use of the TOTEX approach aligns incentives between CAPEX and OPEX[34], the partial disconnection between the remuneration of CAPEX and the actual cost of investments that incentivises the TSO to CAPEX cost reduction and CAPEX efficiency and the longer length of the regulatory period. These incentives are moderated by the use of a menu of contracts.

The medium/high score for transferring efficiency gains and redistribution is mainly due to the fact that efficiency targets (X) applied on new investments, allowing a direct transfer to the final users. Note that the old sunk assets are excluded from the application of the efficiency targets. The use of a menu of contracts also leads to a higher transfer of efficiency gains and redistribution to final users. These factors are moderated by a high level of allowed WACC.

2.2.5 The Netherlands

The Dutch regulatory regime is characterised by a low degree of remuneration and financeability for investments, a high level of risk imputed on the TSO, high incentives for cost reduction and a high transfer of efficiency gains and redistribution to final users.

The low score considering remuneration and financeability is due to two elements. First, the RoE and the WACC present low values, and are negatively impacted by the application of efficiency targets (X) to all the investments (including old sunk assets). Besides, a matching mechanism adjusts revenues two years after the completion of significant assets.

The high risk for the TSO is due to the TOTEX and benchmarking approach used by the regulatory regime. The benchmark approach is riskier than in the German case given the absence of national comparable peers. There are some additional risks introduced by the SO sliding scale scheme. The risk is reduced by a volume adjustment to adjust revenue and limit uncertainty.

The high score in terms of incentives for cost reduction is due to two reasons. First, the use of the TOTEX approach aligns incentives between CAPEX and OPEX[35]. Second, the partial disconnection between the remuneration of CAPEX and the actual costs of investments, strongly incentivises the TSO to CAPEX cost reduction and CAPEX efficiency.

The high score for transferring efficiency gains and redistribution is due to the ambitious efficiency targets (X) applied on the totality of costs (TOTEX), allowing a direct transfer to the final users. In addition, the high transfer and redistribution to final users is reinforced by a low level of allowed WACC.

[34] Nevertheless, the company has more incentives to increase CAPEX than OPEX because it earns the WACC on CAPEX while it is only paid the cost on OPEX.
[35] Nevertheless, the company has more incentives to increase CAPEX than OPEX because it earns the WACC on CAPEX while it is only paid the cost on OPEX.

Table 10 summarises the high level assessment in terms of economic properties of the stylised national regulatory regimes.

Table 10. Economic properties of EU regulatory regimes (final score)

Criteria	BELGIUM	FRANCE	GERMANY	GREAT BRITAIN	NETHERLANDS
Remuneration and financeability for TSO investments	Very low remuneration/ financeability	Medium/high remuneration/ financeability	Medium/high remuneration/ financeability	High remuneration/ financeability	Low remuneration/ financeability
Minimising risks born by	Low TSO risks	Low TSO risks	Medium/high TSO risks	Medium/high TSO risks	High TSO risks
Incentives for cost reduction	Modest incentives on cost reduction	Modest incentives on cost reduction	High incentives on cost reduction	Medium/High incentives on cost reduction	High incentives on cost reduction
Transfer of efficiency gains and redistribution to final users	Modest/high transfer of efficiency gains	Modest transfer of efficiency gains	Medium/high transfer of efficiency gains	Medium/High transfer of efficiency gains	High transfer of efficiency gains

2.3 Conclusion: comparing economic properties of the stylised national designs

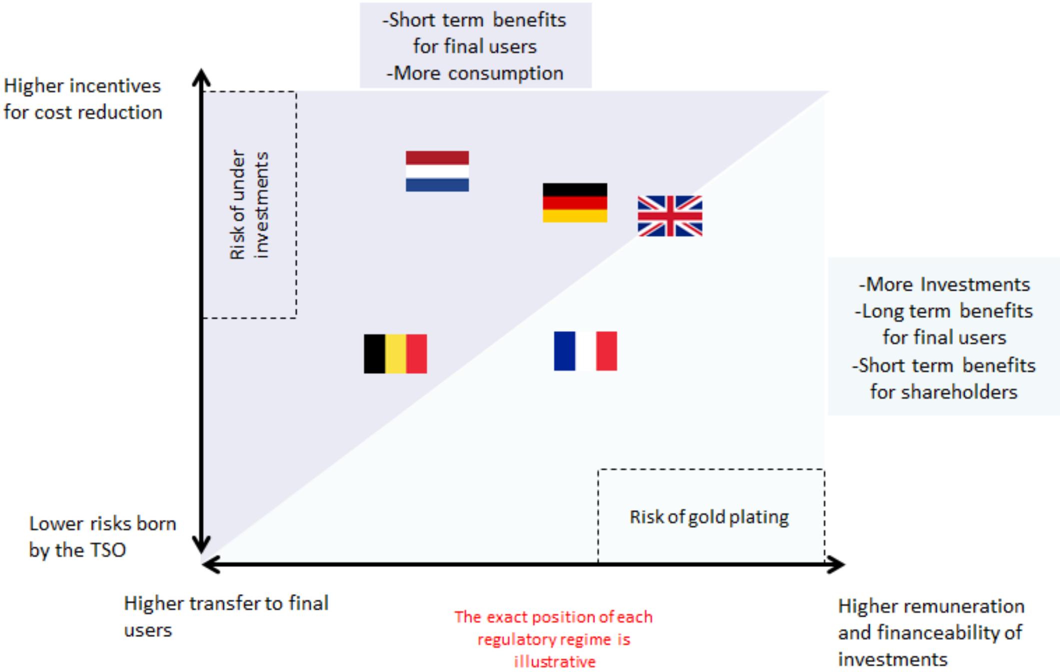
The economic properties of the national stylised regulatory regimes can be presented in a simplified graph (see section 1.3). Figure 13 illustrates these economic properties. From this figure we see a quite high heterogeneity of the regulatory regimes economic properties. The presence of tensions or trade-offs in the design of regulatory regimes is also visible in this figure.

Some of these regimes are more focused on investments and on potential long term benefits for final users, using regimes with lower risks for the TSO and higher financeability (e.g., France). However, these regimes only provide modest incentives for cost reduction and transfer of efficiency gains and redistribution to final users in the short term.

Some regimes are more focused on short term benefits for final users, using regimes with higher transfer of efficiency gains and redistribution to final users and strong incentives for cost reduction (e.g., the Netherlands). However these regimes are often linked to higher risks and lower financeability for TSO.

This heterogeneity may have unforeseen consequences when combining all the various regimes in a common regional market as we will do in section 3.2. However, before analysing the possible consequences of investment regulatory heterogeneity in a European context, the next section explores more of the rationale for heterogeneity, by analysing some elements of the national regulatory regimes.

Figure 13. Economic properties of the national regulatory designs



3 Discussion

3.1 The regulatory regimes in their national context

There are several legitimate reasons that can explain different national regulatory choices and their respective economic properties. Regulatory regimes are the result of an intricate process and interaction of various factors including political willingness, given institutional and governance framework, influence of interest groups, national priorities and historical paths (Brousseau and Glachant, 2011; Glachant et al., 2012).

Regulators are key players vis-à-vis the design of the regulatory regime. However regulators also have to comply with the regulatory constraints given by national and EU energy laws while being assigned the powers and resources they can use to perform their duty (Glachant et al., 2012, Haney and Pollitt 2010). For instance, the regulator's mission might have been defined as protecting the national welfare or preferably the welfare of the final consumers. Maximising consumer surplus is a consequential objective in theoretical terms, and substantially differs from maximising social welfare. Besides, all existing regulatory regimes are built piece by piece in a long period of time and are regularly confronted by emerging new priorities of national or EU energy policy. That broader policy frame might evolve faster than the intricate process of law and regulatory changes (Brousseau and Glachant, 2011; Crouch, 2012). Moreover, as theory and empirical results on the regulatory design do not give "turn-key" adapted solution to each specific case, various alternative regulatory instruments are simultaneously implemented and constantly adapted (Brousseau and Glachant, 2011; Glachant et al. 2012).

The existing designs of the regulatory regimes are then evolving under these constraints. Given their endowments and the policy context, regulators select tools within their national regulatory regimes according to moving circumstances.

This section aims at analysing some specificities that could explain the existing heterogeneity. This section also aims at identifying any alignment between the economic properties of each regulatory regime and its specificities. Of course we focus here on the specificities related to investments. We therefore address four aspects that would be important in terms of regulatory choices. The first one is national ambition in terms of transmission investments (volume and riskiness). The second one is the cost of capital for TSOs. The third one is the efficiency gains asked to TSOs. The fourth and last is the impact of regulatory choices vis-à-vis the resulting transmission tariff transferred to the final consumer bill. For sure these regulatory dimensions echo our former four criteria of analysis (1° TSO remuneration and financeability; 2° risk minimisation; 3° incentives for cost reduction; and 4° transfer of efficiency gains and redistribution to final users). This will help us to infer what criteria ranking was de facto embedded into the national tariff setting.

The following table summarises information related to the national specificities considering these four aspects.

Table 11. National specificities

National/TSO internal situation	BELGIUM	FRANCE	GERMANY	GREAT BRITAIN	NETHERLANDS
Investment ambition/needs and types	Low 2012-2015 net RAB growth forecast around 6% (to compare with 3-4% in the two previous regulatory periods)	Medium/high 2013-2016 net RAB growth forecast around 13 % per annum (to compare with 8 and 11% in the two previous regulatory periods)	High and risky (RES + offshore)	High and risky (energy transition) 2013-2021 net RAV growth forecast around 13 % for NGET, beyond 15% for SPT and up to 25% for SHET per annum (compared to 13% on average in the previous regulatory period)	High and risky (reinforcement, high voltage cable technology, etc.) More than double RAB in ten years (around 20% per annum investment to RAB ratio in the ten coming years)
Cost of capital (Access to capital, risks born by TSOs, ownership & Financial situation of the TSO)	Listed company (partially owned by municipalities)	Considered as a public company but integrated by a listed company (partially state-owned)	Listed companies (except TenneT)	Listed company	100 % state-owned and not listed company (but currently thinking to open the capital)
	Credit rating (S&P): A- for ELIA group	Credit rating (S&P): A+	Credit rating: German part of ELIA (Moody's): Baa1 Amprion (Moody's/Fitch/): A3/A- Tennet (Moody's): A3 TransnetBW: A3/A-/A-	Credit rating NGET (Moody's/S&P/Fitch): A3 / A- / A (National grid group much lower rating) SPT (Moody's/S&P): Baa1/BBB SHET (Moody's/S&P): A3/A-	Credit rating (Moody's): A3 (Moody's)
	Low risks born by TSO (building blocks)	Low risks born by TSO (building blocks)	Medium/high risks born by TSO (TOTEX)	Medium/High risks born by TSO (TOTEX/menu)	High risks born by TSO (TOTEX)
Potential efficiency gains	Difficult to estimate the potential efficiency gains still available for each TSO Efficiency gains realised from the beginning of application of incentive regulation approaches (mainly on OPEX but also on CAPEX)				
Impact on final tariff	In general low (but can impact energy intensive industrial consumers)	In general low (but can impact energy intensive industrial consumers)	In general low (but can impact on energy intensive industrial consumers)	In general low (but can impact energy intensive industrial consumers)	In general very low (but can impact energy intensive industrial consumers)

3.1.1 Investment needs (volume and riskiness)

The investment needs are a key point when analysing the alignment of the regulatory choices with national specificities. Indeed, the financeability of the investments and the risks born by the TSO depend on the ambition of the investment plans. If the investment plan is modest and the risks on investments are low (like replacement using a mature technology), the resulting risks will be smaller and financeability will be easier. On the contrary, if the investment plan is ambitious and the investments riskier, the financeability and the risk touch or outpace some limits. The more ambitious and the riskier the investment plan is, the more sensitive a regulatory regime should be to its capability of ensuring financeability and minimising risks.

When looking at the investments of the TSOs, we see that all investment plans are up for all the regulatory regimes. There is a general increase of investment with respect to the past (Roland Berger, 2011; ENTSO-E, 2013). This is due to three reasons: hosting renewable, replacing old assets and achieving the EU internal market. However these new investment ambitions have more impact on certain TSOs. It is certainly the case if the new investment plan represents a bigger proportion of the current asset base (i.e., the existing stock of investment). Indeed, the (negative) cash flows needed for investments plans become considerable higher that the allowed (positive) cash-flows from the depreciation of existent assets. In this regard, some TSOs have very ambitious investment plans. For instance RTE, the French TSO is going to double its RAB in a decade more or less as are the British TSOs NGET and SPT. Beyond this, Tennet and the British SHET are more than doubling up to tripling their RAB in the coming ten years. It is an enormous wave of investments and of financing. It is like creating in a decade one or two new companies as big as the existing ones.

The riskiness of these new investments is therefore a crucial issue. These new development plans also assume the deployment of new technologies (being off-shore HVDC, extra high voltage cables, etc.). New risks occur with these technologies. First of all, the real availability and degree of maturity are particularly uncertain. Today's decisions will also face in the future some technological path dependency. A today's choice favouring one technology may force to go along with the evolution of this technology and induce incompatibility or major cost for changing this technology. The costs are themselves uncertain since the TSOs do not benefit from a long experience or from any experience at all (Meeus et al., 2011). The regulatory regime should account for the level of risk and innovation that investments require (Vogelsang 2010a, Müller 2010).

To conclude, all five countries have significant and risky investments plans. It means that investment financeability and risk put to the TSOs should become the key factors to consider at the national level. Their importance increases as the investment plans represent a higher part of the existing asset base (e.g., in the Netherlands, in France or for British TOs) or when the targeted technologies are riskier (e.g., in the Netherlands with the use of extra high voltage cables and Germany with the development of offshore links for offshore wind farms). Besides, the countries are at different stages of this investment trend. France, Germany or Great Britain have already seen their investment level increased for several years while the investment level is just beginning to increase for Belgium and the Netherlands. Note that this wave of innovative investment with different paths makes the TSOs more difficult to compare, in particular in a benchmarking process.

3.1.2 The cost of capital[36]

The second point to consider when analysing the alignment of regulatory choices and national specificities is the effective cost of capital. If the cost of capital is low, the financeability and risks issues will be less important. On the contrary, if the cost of capital is high, the financeability and risks issues will be overwhelming in the understanding of the regulatory choices.

At the beginning of every regulatory period, the regulator aims to set the allowed or regulated WACC as close as possible to the actual cost of capital of the TSO. However this is a very complicate task because in general the actual cost of capital is unobservable. In addition, it should be defined *ex ante* and thus forecasted. Economic studies aiming to assess the actual cost of capital of a TSO (*ex ante*) give a range of possible values. It is up to the regulator to decide if the regulated value should be closer to the lowest range values or to the highest range values. When setting the regulated value, the tension between two economic properties reappear. If the value is set close to the highest range of values, the remuneration of investment will be higher and the financeability would be easier. If the value is set close to the lowest range of values, the risk of monopoly rents as well as the network tariff will be lower (in the short term).

The cost of capital depends on several national characteristics, including the risk-free rate, the market/regulatory risks premium, the TSO access to the equity market (e.g., being a listed company or not), its credit rating, and its ownership structure (state-owned or not). Our goal is not to define with an extreme precision the cost of capital in each country (it is up to regulators and TSOs to consider all the national specificities when discussing about the allowed WACC). It is to study major elements that could explain the heterogeneity of regulatory regimes.

In terms of methodology, a main difference in setting the risk-free rate in a post-crisis context is the use of “spot” values instead of “moving average” values of fixed long term loan rates (OXERA 2013a). With the financial crisis and the monetary measures to reactivate the economy the “spot” value of the (fixed long term loan) risk-free rate has considerably decreased vis-à-vis the “longer term” trends. In some cases, the market references are negative[37]. At the same time, the equity risk premium has increased. Given the long term investment horizon of a typical regulated transmission entity, some regulators have been prudent. They did not translate the significant reduction in government bond yields in an equivalent reduction of the allowed returns (what could have the same effect is to increase market premium and beta)[38]. Other regulators have preferred to transfer to final users the lower values of the cost of capital.

The market / regulatory risk is indeed intrinsically specific to each country and each national industry (Brunekreeft 2013, Helm 2009). For a given European regulated transmission company, this depends on the national regulatory regime and its genuine level of risk. We have seen that regulatory regimes do not put the same amount of risk on the TSO because they have different mixes of regulatory aims. This implies that countries with a preference for more TSO risks also candidate for a higher

[36] Note that we refer here to the effective cost of capital of the TSO, i.e., the actual cost that TSO should pay to investors (equity and debt) to raise the necessary capital and not the allowed or regulated one. In theory, the allowed cost of capital should be defined near the actual cost of capital.
[37] For instance, since the start of 2012, real yields of several government bonds have remained near zero or negative for all maturities up to 20 years (e.g., Germany, Great Britain, etc.).
[38] By construction, the sum of the risk free-rate and the equity risk premium equals the expected return on the overall equity market. Several regulators consider the overall market return either as an input to the WACC determination or as a cross-check (OXERA 2013a).

cost of capital. On the contrary, countries with a preference for allocating less risk to the TSOs are candidate for a lower cost of capital.

Another factor that can impact the cost of capital is the company ownership structure. State-owned companies owned by good-looking states might be seen as deserving a lower cost of capital because they bear a lower market/regulatory risk. First, state-owned companies may belong to a large asset portfolio and their owner hence has wider investment diversification. Second, with state-owned companies, the intervention/regulatory risks are borne with the owner (they are internalised) and this reduces its absolute size (see Helm 2010). As a main risk for capital-intensive network industries is the public intervention risk, this risk is limited when the decision right is allocated to those that can control it[39]. Third, the state-owned company can borrow cheaper when it has the warranty of a good-looking state. However these arguments seem to be of limited application for the case of electricity transmission and in particular for the studied countries. The argument based on diversification depends on the size and on the effective diversification of the asset portfolio. The argument based on the regulatory risk internalisation of state-owned firms is weak because the regulatory risk mainly depends on the regulator, which is an independent entity from other state institutions (including those that are in charge of the state-owned company, e.g., the industry or economy minister). The cheaper debt argument is weak too. The implicit warranty given by the state to the state-owned company has an opportunity cost (e.g., the risk of bankruptcy of the state increases if too many implicit warranties are given). This other opportunity cost has to be considered when analysing the actual cost of capital. In conclusion, the impact of state-ownership of some TSOs (e.g., in France or in the Netherlands) seems to have modest impact on the cost of capital.

The last element to be discussed is now the current financial situation of the TSOs. This includes the easiness to raise equities (e.g., listed companies or not) and the credit rating. Except for TenneT, all the other TSOs are belonging to companies that are listed. This might imply more ease to raise capital through equity. When considering the credit rating, most of these TSOs actually have a good rating (A, A+) (Roland Berger 2011). However, the past financial preference for debt and the current high needs of investments start introducing tensions. For instance, ELIA for its German network and SPT in Great Britain are both Baa1 rating. Besides, TenneT might have to open its capital to face its huge investment plan because debt emission touches some limits[40].

In conclusion, several factors can impact the cost of capital of a TSO and the alignment of regulatory choices with these specificities. We will retain three elements from this investigation: 1° a modest lowering of capital cost for "good looking" state-owned companies, 2° a higher cost of capital for regulatory regimes that put more risks on the TSO and for those TSOs that have not the healthiest financial situation and 3° a preference revelation of the regulator arbitraging among two objectives: easing investments or lowering network tariffs at short term.

[39] Helm (2010) argues that: "*Credibility is a political and regulatory risk, not a business problem. Hence, the allocation of that risk to the private sector is, in effect, the allocation of exogenous risk to private investors. Since it is exogenous – investors cannot manage it – the relative cost is likely to be high, and higher than if it remains in the public sector, where in principle that risk is endogenous.*"

[40] See for instance: http://www.reuters.com/article/2013/03/13/tennet-ipo-idUSL6N0C52PW20130313

3.1.3 The potential TSO efficiency gains

The third point to be considered is the TSO potential efficiency gains from cost reduction. If there is a huge potential of efficiency gains to be done, the incentives for cost reduction will be more important than those related to financeability. Financing constraints might be relaxed given the potential cash liquidities that the TSO could gain by becoming more efficient (provided that the regulator does not define too ambitious efficiency targets). On the contrary, if there is no or a too small potential of efficiency gains on the TSO side (i.e., the TSO has been rather efficient since long), the incentives for cost reduction will be less relevant.

Yet, determining the potential for further efficiency of each TSO is not an easy task... TSOs always argue that they are already efficient enough. Regulators always argue that TSOs are not. Benchmarking techniques always promise to better evaluate the TSOs relative efficiency but are not robust enough yet in the transmission sector to provide very accurate results (Brunekreeft 2013, Haney and Pollitt, 2012).

Despite the difficulties when assessing potential efficiency gains, several arguments can be discussed. First, the current situation of TSOs can be different. Most TSOs having been privatised after being national monopolies their present efficiency depends on how they have been managed before privatisation. Moreover, after this early liberalisation and privatisation process, the cost efficiency paradigm has been the most important. It has been translated in the national regulatory regimes with different levels of strength. From this period, noticeable efficiency gains have already been realised in some countries (see for instance Joskow, 2006 or Dale 2013 for efficiency gains of NGET and Rious 2007 for efficiency gains of RTE). It is then not sure that the trend of efficiency gains could be maintained *ad infinitum*. Third, producing efficiency gains takes time as changes in internal management and process have to be implemented. Predicting efficiency in an industry with long-life sunk investment and significant uncertainties is a difficult task. Even if the past decisions have been taken in an optimal way (i.e., following a stochastic optimisation under uncertainty), they can negatively impact the actual efficiency *ex post* once the uncertainty prevailing while they were planned has disappeared.

In conclusion, it is difficult to evaluate the remaining efficiencies gains to be realised by each national TSO. The regulator can have different views (justified or not) concerning the remaining inefficiencies and the necessary time for the TSO to materialise the efficiency gains (e.g., Mulder 2012). What it can be said is that in cases where the cost efficiency paradigm has been strongly applied in the past, it is likely that new efficiencies will take time to be extracted. As a result, in these cases it could be expected that the cash liquidities to be gained from reducing these inefficiencies (i.e., reducing costs under the efficiency targets to increase the TSO gross margin) will not significantly help the TSO financeability in the short or medium term.

3.1.4 The impact on final electricity bill

The fourth point to be analysed is the effective impact of regulatory choices on the final electricity bill. Indeed, the higher the impact of transmission tariff on the end-user bill is, the more essential it is that the regulatory regime considers incentives for cost reduction and a transfer of efficiency gains to final users. Here, depending on national specificities, the regulatory preferences can vary too.

The final electricity bill is composed of several terms, being: generation, transmission, distribution, supply, public services (RES subsidies), tax, etc. In general, the impact of transmission cost on the electricity end-user bill is quite low in average for all types of consumers. Table 12 illustrates this point using data from Eurostat and ENTSO-E.

Table 12. Share of transmission network tariffs in the final electricity price

Countries	Electricity price (without taxes – €/MWh) - Eurostat 2012		Transmission tariff (200-150 kV – €/MWh) ENTSO-E 2012	Share of transmission network tariffs in the final electricity price (without taxes)	
	Industrial consumers	Household consumers		Industrial consumers	Household consumers
Belgium	95.0	159.0	5.1	5.4%	3.2%
Germany	89.5	144.1	6.2	6.9%	4.3%
France	80.9	98.6	5.7	7.0%	5.8%
Netherlands	80.5	131.7	6.8	8.4%	5.2%
United-Kingdom	109.7	160.3	7.8	7.1%	4.9%

In the case of residential or small business consumers, the impact is low as transmission only accounts for less than 5% of the total bill (without taxes) on average. This type of consumers is often characterised by a low demand elasticity. We might expect weak effects on consumption to appear here while this does not mean that consumers are not sensitive to change in their bill: when demand elasticity is low all price increase really hurts (e.g., gasoline price increase). Thus, tariff increase is politically sensitive. Moreover, increases in transmission network tariffs are "competing" with other potential drivers of tariffs increase (generation, RES, distribution tariff, etc.).

When it comes to industrial consumers, the impact of transmission tariff changes might be higher as transmission tariff accounts for 7% of the final bill on average and the demand reaction can be significantly higher. The most important impact would appear with energy-intensive industrials because the transmission tariff would represent a higher share and the consumer elasticity is higher. However, it already exists tariff structures which can allocate less transmission cost to this type of consumers (given their flatter consumption profile). The extreme is to be seen in Germany where the industry is protected from the increase of network costs borne by the public renewable push.

In conclusion, despite a generally low impact of transmission tariffs on the end-user bill, there might be different reasons among the regulators concerning the appetite for lower transmission network tariffs, going from politically sensitive tariff changes for household users to a focus on the national industrial structure or industrial strategies.

3.1.5 Conclusions

In this section, we analysed reasons explaining the economic heterogeneity of existing regulatory regimes. Four economic aspects have been retained: the need for investments, the cost of capital, the potential efficiency gains and the impact of transmission tariff on the electricity final bill.

- **Size of investments**: all countries have significant investment plans. Some of these plans are riskier (Germany, Netherlands, Great Britain) and some an even bigger importance vis-à-vis the current asset base (Netherlands, Great Britain)

- **Cost of capital**: the cost of capital depends on national specificities. It is presumably modestly lower for “good looking” state-owned companies (France, Netherlands) and higher for regulatory regimes that put more risks on the TSO (Netherlands, Germany, Great Britain) or those that do not have the same healthy financial situation (50Hertz 60% owned by ELIA in Germany and SPT in Great Britain). Different perceptions on the level of the cost of capital in the post-crisis situation might leave some room to the regulators to express preferences among different objectives of the regulatory regime (lower tariff versus higher financeability).

- **Efficiency**: it is difficult to conclude on the potential efficiencies to be realised by each TSO. National situations could be different. What can be said is that if significant potential efficiencies exist, they will take time to be extracted. Consequently, it cannot be guaranteed that cash liquidities expected from these efficiency gains (i.e., reducing actual cost lower than efficiency targets and earning the associated monopoly rent) could help the TSO financeability in the short and medium term.

- **Tariff**: in general the level of the transmission tariff has a low impact. However it could have a more significant impact on energy-intensive industries. There could exist different reasons among the regulators concerning the appetite for lower transmission network tariffs, going from political sensitive tariff changes for household users to a focus on the national industrial structure or industrial strategies.

We have already found reasons for the existing heterogeneity and others factors may complete them. The heterogeneity of regulatory regimes may express national preferences for short term efficiency vis-à-vis long term investment adequacy. For instance, in Great Britain, France or even Germany several economic properties of the existing regulatory regimes (remuneration of capital and financeability) are rather in line with ambitious investment plans. And relying on situation with lower investment requirement in the recent past, other regulatory regimes remains with lower remuneration (in Belgium and the Netherlands) and more pressure to cost reduction (in the Netherlands or in Germany and in Great Britain to a smaller extent). All the regulatory regimes do not present a combination of economic properties adapted to the new context of ambitious investment plans and technology innovation. With this regard, investment ambition, risk and remuneration are better aligned in France and Great Britain, while there seems to be a misalignment in Belgium (very low level of remuneration), in the Netherlands (low/medium remuneration but risky regulation and investments) and to a smaller extent in Germany (medium level of remuneration but risky regulation and investments).

3.2 The national regulatory regimes in the EU and regional context

The heterogeneity of the existing national regulatory regimes can be understood as having mainly developed in an isolated manner, but with the European pulse to prompt for wider liberalisation through sharper network unbundling and more independent regulation. Meanwhile, this relative isolation of national regulations and their misalignment without substantial consequences will be more and more a past state of nature. It is what the Third Package and the Infrastructure Package aim at deeply changing for a real common EU regulatory frame. Furthermore, all the power transmission networks in the Central Western region are now undertaken in a common regional market and are facing similar challenges regarding the amount and risk of investments, and its financeability.

We now can ask if some level of alignment/harmonisation of regulation in the North/Central Western Europe is now needed (section 3.2.1). We will then detail what this targeted common regulation could be (section 3.2.2) and how it could be reached (section 3.2.3).

3.2.1 Is regulatory harmonisation necessary at the regional level?

Ruester et al. 2012 analysed for DG Energy at the European Commission the question of gas and electricity tariff harmonisation (revenue/instruments/structure) in the EU context. They conclude that a complete EU-wide harmonisation (on the level of revenue and regulatory instruments) is not needed. However, they establish different criteria to determine a rationale and efficient harmonisation at different geographical levels. These criteria include the impact of heterogeneity on the general investment climate, the impact on cross-border investments and the impact on cross-border competition. In what follows, we will revise these criteria because we address the more particular context of a strongly connected regional market with the presence of several cross-border TSOs.

The impact on the general investment climate

First of all, having national regulatory regimes with significantly heterogeneous economic properties makes it more difficult to attract funds from external investors, in spite of the financing needs we have in the EU for the coming decades. It creates a barrier to financing investment because of the absence of a level playing field vis-à-vis the EU regulatory regimes risks and promises. This fractioning decreases the whole equity and debt liquidity that the whole TSOs can reach, and consequently increases their average cost of capital (Ruester et al., 2012).

A more common and friendly scheme for investors in regulated utilities could help to minimise their cost of capital. Indeed, improving the confidence and the stability of regulatory regimes helps to reduce the premium asked by investors to inject their money in regulated utilities. ACER might here play an active role by formulating “good practice guidelines” regarding the regulation of transmission. It could thus promote sound regulatory practices that try to minimise the risks for investors and to share the knowledge accumulated by best/bad practices.

Avoiding national regulation that generates cross-border regional effects

Regarding projects that have a regional (hence cross-border) impact, regulatory regimes with heterogeneous economic properties could actually hamper adequate investments. Given that we face an increasing need to build long-distance transmission lines, alternative possible transit projects might be partially substitutable (it is explicitly envisaged by the Infrastructure Package implementation: see Meeus et al. 2013). This substitutability between corridors (and thus between TSOs from different Member States) can imply that the grid might be preferably expanded where an investor gets a more favourable return instead of where it would have been optimal from a social welfare perspective. Besides, it is also artificial to completely separate internal and cross border investments in electricity network. It is because cross border capacities also need investments inside the national networks. Consequently, a certain level of coordination and alignment of incentives is necessary to ensure a good coordination between the different investments. A typical example of the problem of misalignment is the case where one TSO is highly incentivised to push the cost of internal congestion at the border (hence on the cross-border flows) while discouraging the cross-border investments (Glachant & Pignon 2005, Ruester at al., 2012).

The problem of competition in regional markets (downstream markets)

At last, the difference in national regulatory regimes also raises a problem in terms of competition distortions. The regulatory choices can induce the network tariff to be higher or lower. Consequently, the network users may have higher or lower transmission tariffs other things equal depending on the countries where they connect. This infringes the spirit and the logic on the EU internal market. This implies potential distortions on the downstream markets (energy wholesale and retail markets). Given the limited impact of the transmission network tariff on the final electricity price for most of the consumers, competition distortion will mainly impact energy-intensive network users and the generators in some countries. This is because the transmission tariff may have a considerable impact on the network users' business plan[41].

In conclusion, a certain alignment on the economic properties of the existing regulatory regimes is necessary in the context of a common regional market. This does not imply that all the regulatory design options, parameters or revenue components should be exactly the same but that the regulatory preferences and the economic properties influencing the network investments should be aligned to a certain extent[42].

3.2.2 Which regional harmonisation target?

Once the necessity of some degree of harmonisation is established, the following question is what the harmonisation target would be. And therefore who should adapt, even by going away from the former national choice.

The current national and European situation is that the national networks and the corresponding European network need considerable investments (as well as the development of new innovative technologies). In these circumstances, the cost of capital and the financeability issues are keys for the EU as a whole and individually for each TSO (Henriot, 2013, Brunekreeft 2013). Besides, if an absolute priority to cost reduction was an excellent idea in a period of low investment or low technology innovation, it is less a unique priority in a period of massive investment and innovation. The social cost of having not enough investment or not enough innovation could be much higher than the cost of remaining OPEX inefficiencies/monopoly rents. In advanced countries like Great

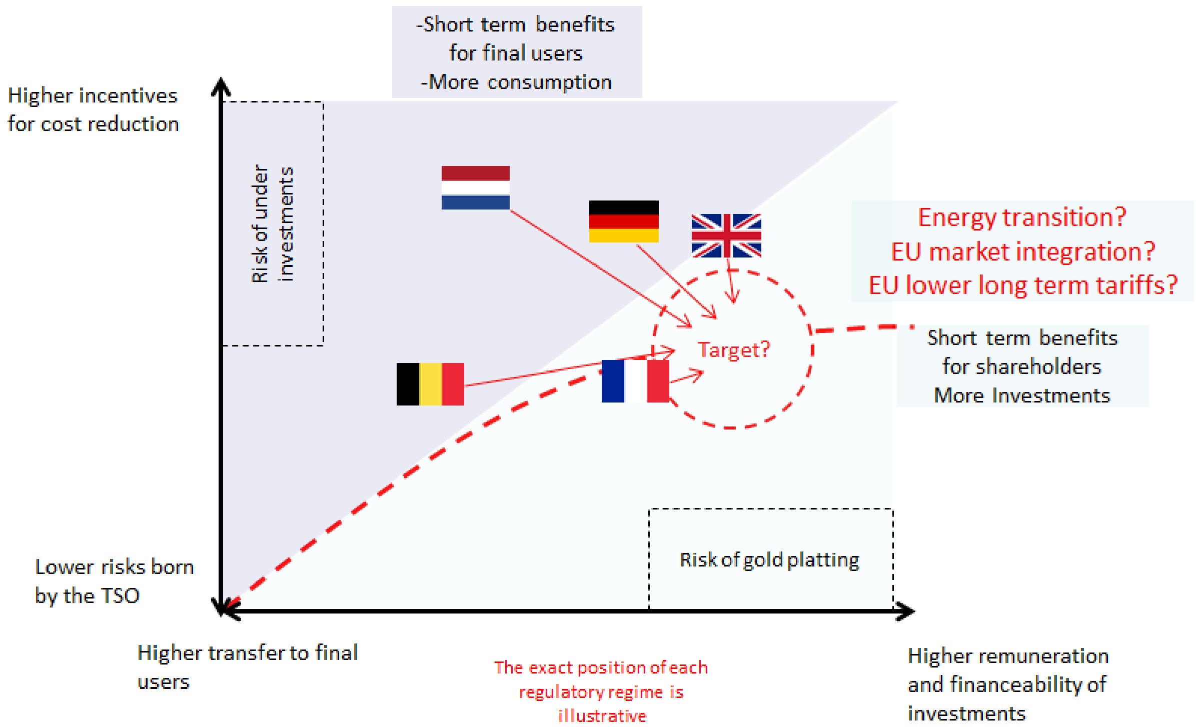
[41] Note that this problem of competition distortion can also be perceived as a state aid issue when the concerned network company is state-owned.

[42] Note that some diversity in regulatory practices can provide valuable insights into functioning models and might allow to discover best (and bad) practice for specific situations (Ruester et al. 2012).

Britain, after several decades of "lower OPEX" incentive regulation (decreasing by more than 50% between 1990 and 2005 in real terms) and lower tariffs (decreasing by 40% in real terms while the investment level has been on average twice higher than its pre-liberalisation level during the same period), the general level of efficiency seems quite fair (with low cost enough TSOs, for instance in Great Britain) and the impact of further efficiency effort on the transmission tariff will be smaller (Dale, 2013).

As a result, the target for more harmonisation of regulation regimes at the regional level should be to push the entire zone to a more favourable environment for investments (Vogelsang 2010b, Brunekreeft 2013). Figure 14 shows where this target could be. Note that the size of the target is quite large to accommodate national specificities and possibly others differences.

Figure 14. A regional harmonisation target



Since the main regulatory goal is going to reduce the cost of capital and to ensure the favourable financial structures (Henriot 2013, Beckers et al. 2013, Brunekreeft 2013), a new balance between TSO investment risks and TSO incentive for cost efficiency must be found (see the vertical fine-tuning in figure 14). Since higher risks increase the cost of capital and have a major impact on future network costs, the actual economic properties of existing regulatory regimes should be modified in order to decrease the risks born by the TSO.

Besides, a new balance should be established between the remuneration given for the TSO investments and the sharing of its efficiency with final users (see the horizontal fine-tuning in figure 14). In general terms, investments should be better remunerated, as to ensure a better financeability. Without this horizontal adjustment the needed investment might not take place or arrive too late. It should be kept in mind that in a period of massive investment, too low network tariffs today could induce a far steeper increase of cost for consumers later on. Moreover, if too many investments must be rapidly developed later on (because they have not been done in a good timing) the network company's credit rating might decrease too much, damaging its financial costs and the further tariffs. Indeed, in cases where a new investment plan represents a high proportion of the current asset base (i.e., the existing stock of investment), the problem of financeability could be higher and this has an impact on the cost of capital (OXERA 2010). Indeed, in these situations the (negative) cash flows needed for financing the investments plan become considerably higher that the allowed (positive) cash-flows from the depreciation of existent assets and the need of external financing sources increases. Thus, the risk born by the TSO also increases because there is a higher probability that the TSO will not be able to raise enough capital to complete its investment programs (cash-flow risk). More risk born by the TSOs implies a more expensive cost of capital. Note that if the volume of investments is not realised on time (for instance the TSO postpones them because it cannot raise enough capital), the problem is pushed to the future and worsened. Indeed, the difference between the needed cash-flows and the allowed cash-flows increases since the amount of yearly needed investments increases and the revenue decreases because the RAB decreases (from deprecation). The financial situation of the company is so downgraded, and the later the investments arrive, the higher the increase of cost of capital will be.

This harmonisation process is needed to respond to other EU coordination tools for investments (TYNDP, Infrastructure Package, etc.) (Meeus et al. 2013, Buijs 2011). Notably the Infrastructure Package positively contributes to investment, but it cannot mitigate by itself the risk issue open by the heterogeneity of existing regulatory regimes.

3.2.3 How could the alignment target be reached?

Our high level analysis brings us to the following conclusions. First there are several problems of alignment between the economic properties of regulatory regimes, in a national and an EU context. Some adjustments should be undertaken by the existing national regulatory regimes in order to align their properties and significantly improve at the regional level the issues of investment financeability and risks born by TSOs. Table 13 suggests what could be the move to align the national regulatory regimes with regional markets investment ambitions and the main EU objectives.

As a whole, more converging methodologies regulating TSOs revenues (definition of RAB, computation of WACC, etc.) would help to easily evaluate the individual TSO performances. It would indeed help investors, regulators and TSOs management to refer to a performance level playing field. Besides, for investment of regional or European significance, a decision at the appropriate governance level (the EU or regional one) would allow to align remuneration whoever (which TSO) is consequently investing, which would also allow to promote more favourable WACC to high risk projects.

The reduction of risks should be pursued in order to offer the lowest possible cost of capital (vertical fine-tuning with regard figure 14). This means first reducing the risks born by the TSO. In particular, to limit the risk of benchmarking analysis with limited data, this analysis should be combined with other efficiency tools and should be used more as an informative and a negotiation tool. Besides, incentives should be focused on demonstrated controllable costs, while checking non controllability to keep searching and finding types of costs with achievable efficiency gains. With regard to exogenous risks, incentive regulation should continue being accompanied by uncertainty mechanisms and a continuing process of improvement of these mechanisms should be engaged, including among other things trigger events to revise regulatory schemes.

A good equilibrium should also be found between (short term) profit sharing and the allowed WACC to maintain the network companies' financeability in the future (horizontal fine-tuning with regard figure 14). This requires balancing effects of investment on tariffs in the short run and in the long run. While it would be tempting to ignore financeability to maintain tariffs low for current users, this may be to the expense of future users that may then have to pay for deteriorated network companies' credit rating or lower network quality because of a lack of investment. This means that in some cases remuneration of capital for investments (WACC) shall be increased, efficiency targets moderated, and that the scope of incentive regulation should be reduced avoiding past already incurred investment.

If the harmonisation target is not reached, it might be expected under-investment (lowering future network quality or missing the infrastructure objectives – e.g., energy transition or internal market building) and a high cost of capital for network investment when the network operators experience too much risk and financeability issues increasing the future network tariffs.

Table 13. Fine-tuning regulatory regimes to reach an investment-friendly regional EU target

Fine-tuning	BELGIUM	FRANCE	GERMANY	GREAT BRITAIN	NETHERLANDS
Horizontal fine-tuning (financeability versus short term transfer and redistribution to final users)	Improve significantly remuneration and integrate financeability in its determination	Integrate financeability in the determination of remuneration	Integrate financeability in its determination of remuneration Limit the application of efficiency targets to new investments only	No change	Improve remuneration and integrate financeability in its determination e.g. Increase WACC / or reduce X targets / or limit the application to new investments only
Vertical fine-tuning (minimising risks for TSO versus incentives for cost reduction)	Keep risk acceptable	Keep risk acceptable	Reduce risk born by the TSOs e.g. limit the risk of benchmarking techniques using it as an informative tool e.g. focus incentives on controllable costs (while regularly checking non controllability) e.g. fine tuning uncertainty mechanisms	Reduce risk born by the TSOs e.g. keep fine tuning uncertainty mechanisms	Reduce risk born by the TSO e.g. limit the risk of benchmarking using it as an informative tool e.g. focus incentives on controllable costs (while regularly checking non controllability) e.g. fine tuning uncertainty and adjustment mechanisms

4 Conclusion

The TSO regulatory regimes are in a central position to achieve European objectives in terms of internal market, security of supply and the energy transition. These objectives imply considerable needs of investments on electricity infrastructure and important technological innovation. Given this situation, the “incentive regulation” paradigm, focused on the reduction of costs, is moving to a more investment friendly paradigm. Because of the considerable amount of needed investments, the cost of capital will be an important driver of the total cost of infrastructure. Considering that easy/fast gains of efficiency might have already been realised in the past, and with regard to the high cost for the society of not having needed infrastructure on time, the new regulation paradigm should be more investment friendly. Investment friendly regulation should find a new balance between the incentives for cost reduction and the risks born by the TSO on the one hand, and the remuneration of investments and the transfer to final users on the other. Regulatory regimes adapted to a new context of very high and riskier investment should combine properties of low risk transmitted to the TSO with higher remuneration and financeability of investment. This alignment might be realised to some extent at the national level and at the European level, in particular in case of highly connected regional markets and in presence of cross-border TSOs.

This paper has analysed the TSO regulatory regime in five North/Central Europe countries (Belgium, France, Germany, Great Britain and the Netherlands). Using a theoretical analytical framework and a stylised/high level description of each regulatory regime, it has assessed their actual economic properties. Given the heterogeneity of these properties, the paper has studied the potential consequences of not having a fair level of harmonisation and what the harmonisation target could look like. This target has been defined as corresponding to a new paradigm of regulation in a context of high and riskier investments. Finally, recommendations have been provided to better align the existing TSO regulatory regimes with the identified target.

The theoretical analysis of regulatory regimes undertaken in this paper calls for further research. First, the actual TSO regulatory regimes are more complex and their final economic properties depend on the very interactions among all the design elements. A more detailed analysis of regulatory designs and options (e.g., RAB and depreciation rules, details on tariff resetting and efficiency targets, output regulation, etc.) is needed to complete our understanding of their economic properties. Second, a quantitative analysis would be useful to challenge the qualitative analysis by assessing the relative weight of each design option vis-à-vis the economic properties.

5 Appendix A: description of EU regulatory regimes

This appendix presents a description of the TSO regulatory regimes in five countries: Belgium, France, Germany, Great Britain, and the Netherlands. For each regulatory regime, we provide a general description of the national context, the regulatory design currently applied (or likely to be applied in the next regulatory period). We focus our description on the main characteristics and design options defined in section 1. The idea here is to be able to characterise national regulatory regimes as a stylised design, composed by a selected set of design options. Note that the description made here is based exclusively on available public information.

5.1 The regulatory regime applied by CREG in Belgium

5.1.1 General context

The whole Belgian federal transmission system is operated by ELIA System Operator, which was designated in 2002 as the sole TSO after the beginning of the liberalisation process in 1999 with the Electricity Act. The license is 20-year long and renewable. ELIA is partially owned by a cooperative of municipal entities, while 52.1% of its shares are publicly listed on Euronext. Since 2010, ELIA owns 60% of 50Hertz, one of the four TSOs operating in Germany.

As a legal monopoly in Belgium, a part of its activities (transmission and system operation mostly) are regulated by the Belgian gas and electricity regulatory commission CREG. ELIA is thus remunerated through the application of regulated access tariffs approved by CREG. For every regulatory period, after proposal by ELIA, CREG defines the tariffs to be applied to electricity network users for the period. Concretely, CREG decides the allowed revenue to ELIA and the global volume of costs to be passed to consumers for the regulatory period. It decides also the level of tariff for each service and each category of users (tariff structure).

The regulatory principles for both decisions are defined in the CREG decree[43] dated 11.24.2011 and setting out provisional calculation methods and tariffs conditions for connection and access to transmission grids. The methods are then applied for each regulatory period on the basis of the tariff proposal made by ELIA and agreed by CREG. As of 01.01.2008, the regulatory regime sets tariffs values for four-year periods, barring specific circumstances. The tariffs are set with regard to the current and future challenges of the Belgian network, in particular the necessary investments in accordance with the Federal Investment Plan[44]. Accordingly, ELIA's capital expenditure is about to face some significant tensions, drawn by the needs of decentralised generation integration, the development of the EU regional market, the network expansion as well as the replacement requirements[45].

The regulatory regime is structured in 4-year periods. The current regulatory period runs from 2012 to 2015. Originally based on the tariff proposal dated 06.30.2011, it now applies the elements decided according to the "Rectified Tariff Proposal" dated 04.02.2013 and approved by CREG on 05.16.2013[46]. The new proposal applies to the whole 2012-2015 regulatory period as an *ex post* correction. We focus on design and parameters that are applied in the remaining regulatory period (2013 to 2015)[47].

[43] CREG, 2011. Arrêté (Z) 111124-CDC-1109/1

[44] A development plan is agreed every four years between the regulator and the TSO. The last agreed plan covers the 2010-2020 period. It articulates around four axes: development of interconnections, integration of RES units, integration of new centralised units, and network reinforcement. In 2012, the plan focused mainly on replacement investments (42%), followed by investments to cover internal consumption (32%) and RES (10%) (Source: definitive version September 2011 http://www.elia.be/fr/grid-data/grid-development/plansd-investissements/~/media/files/ELIA/publications-2/investment-plans/federal/plan-dedeveloppement-federal-2010-2020_FR.pdf)

[45] ELIA 2012 annual report

[46] This change in tariff setting results from the decision by the Brussels court against the tariff proposal dated 06.30.2011 after a claim by generators for paying ancillary services tariffs and injection tariffs.

[47] CREG (2013). Décision (B)130516-CDC-658E/26 relative à « la proposition tarifaire rectifiée de ELIA SYSTEM OPERATOR S.A. du 2 avril 2013 pour la période régulatoire 2012- 2015» http://www.creg.info/pdf/Decisions/B658E-26FR.pdf

It is important to note that the investment trend (around 6% investment to RAB ratio) considered in the regulatory period is double compared to the trend of the two previous regulatory periods (around 3-4% investment to RAB ratio) while remaining relatively modest. Investments are mainly oriented to replacements and internal consumption (~75%) whereas offshore investments only stand for 6 % of investments[48].

5.1.2 Regulatory design

Length and scope of the revenue cap

The Belgian regulatory design is based on a periodic revenue cap mechanism (applied for 4 years). The budgeted costs supported by the TSO for regulated activities (operation and investments), as well as the net expected income from non-regulated services, are taken into account to define revenue allowances for the regulatory period. The revenue cap mechanism corresponds to a “building blocks” approach. The revenue cap thus makes a distinction between two types of costs. The non-controllable costs include in particular the capital expenditure (*i.e.*, the financial costs, the remuneration of equity investors, and the depreciation of the regulated asset base). They are basically passed through in tariffs following a cost-plus style mechanism. The controllable costs are limited to the operational expenditure (OPEX), with the exception of costs for the provision of ancillary services, the usage fees to other operators, and the pension costs. These controllable costs are subject to the application of efficiency and productivity targets (X-factor incentive for cost reduction), and their remuneration level is capped through an effective revenue-cap mechanism.

Definition and application of the efficiency and productivity targets

A revenue cap allowance is applied to controllable costs (OPEX, with the exception of ancillary services, usage fees and pension costs) through the application of an X-factor to an *ex ante* defined value of controllable costs. The CREG fixes the base value for controllable costs *ex ante* grounded on the tariff proposal made by ELIA. The “X” incentive mechanism combines two efforts demanded to the TSO. The first one consists in increasing its static “incumbent efficiency” in comparison with an “efficient and structurally comparable network”, defined through a regulatory audit and benchmarking. The second consists in increasing its dynamic productivity in line with the electricity transmission sector (“frontier shift”). The combined X-factor is defined *ex ante* based on the cost reduction considered achievable by the regulator and the original base cost. The current level of targeted cost reduction is thus €25 million for the 2012-2015 regulatory period. This represents 0.8% of total allowed revenue and 2.3% of controllable part (total allowed revenue for the whole period around €3,185 million and controllable €1,110 millions).

The outperformance or underperformance relatively to the efficiency and productivity targets is 100% born by the TSOs and is not reflected in the tariffs for final consumers for the duration of the regulatory period. This ensures a higher incentive for cost reduction. If actual costs are higher than budgeted costs, the revenue of the regulated company is further negatively impacted. If they are

[48] ELIA 2012 annual report

lower, the revenue is positively impacted. This is described as the Y1-incentive in the Belgian regulation. For the first regulatory period, the absolute value of the Y1-incentive is capped at €25 M.

Beside the efficiency target applied on controllable costs, other complementary efficiency tools are applied to control to some extent the cost efficiency of other cost elements of the revenue (notably CAPEX). In this respect, there is an *ex ante* approval process of investments where the projected level proposed by ELIA is challenged and finally approved. CREG has also the possibility to realise *ex post* efficiency test and adjustment in the RAB if major divergences between budgeted and actual costs appear. Once the investment enters in the RAB, no efficiency target is applied.

Remuneration of capital and investments

The cost of capital is considered as non-controllable in the Belgian regulation and is directly reflected in tariffs through a cost-plus style mechanism (with *ex ante* approval and *ex post* efficiency check). This includes the remuneration of capital and the depreciation.

The remuneration of capital is differentiated between the remuneration of equity and the remuneration of debt.

The authorised remuneration of equity is defined in accordance with a “fair remuneration for equity investors”, as defined in the regulation. It is calculated as the product of the Regulated Asset Base (RAB) and the allowed rate of return on equity (RoE), which is based on the Capital Asset Pricing Model according to the following formula:

$$RoE_t = OLO_t + \min(\beta_t \times Rp_t, 70bp)$$

- RoE_t is the allowed return on equity on year t of the regulatory period
- OLO_t is the risk-free rate. It corresponds to the interest rate of the Belgian 10-year linear bonds for the year t. It is estimated *ex ante* by calculating the average value of the four calendar years preceding the approved tariff proposal. The estimated value for 2012-2015 was fixed *ex ante* at a 3.993% nominal post-tax value[49] but following the fall of the OLO in 2012 (2.98 % in average), it was updated for the 2013-2015 period at 3.6413%. We will apply 3.6413% value for the TSO regulation comparison, hence focusing on the 2012 regulation for Belgium.
- The market risk premium Rp_t is fixed at a 3.5% nominal post-tax value by the regulator.
- The individual Beta factor is defined as the seven-year average of a correlation factor between ELIA share prices and the BEL 20 index. It is yearly updated. It was estimated *ex ante* at 0.1475 for 2012-2015, but it was updated at a 0.2 *ex ante* value in the last approval. Indeed, the regulation specifies that the product $\beta_t \times Rp$ must be at least equal to a 0.7 value[50].

[49] CREG, 2013. Décision relative à "la proposition tarifaire rectifiée de ELIA SYSTEM OPERATOR S.A. du 2 avril 2013 pour la période régulatoire 2012-2015"
[50] bp in the formula stands for base point.

- The value of allowed RoE that will be considered for comparisons between EU TSOs is then RoE = 4.3413% (nominal, *ex post*)

The regulator applies a fixed gearing to define how much of the Regulated Asset Base is remunerated at the allowed cost of equity. The notional level of gearing was fixed by CREG at 67 %. Therefore, if the share of equity in the RAB is higher than 33%, only 33% of the RAB will be remunerated at the previously described cost of equity, while the equity in excess will be remunerated at the minimal possible value of the RoE: $RoE_{t,excess} = OLO_t + 70bp$.

The cost of debt is subject to a different sort of pass-through, as the TSO's embedded financial costs are directly passed through in tariffs. The costs and the loans themselves were preliminary approved by the CREG for the regulatory period. No data is available on the actual embedded cost of debt of Belgium. We make the assumption that the minimal value of the RoE, applicable to the equity in excess, is a good estimate of the cost of debt.

The primary remuneration of investments (depreciation, financial costs, and remuneration of equity investors) can finally be established by valuating the Regulated Asset Base, since investors are remunerated based on its annual value (RoE or RoE_{excess}). The RAB was estimated at a € 3,753 M nominal value[51] in 2011, and is updated annually on the basis of the previous year's value. It is increased by the new investments (either expansion or restructuring investments) and decreased by the year depreciation value. The investments are approved *ex ante* and an *ex post* evaluation can also be realised with regard their effective cost. The RAB also integrates changes in Working Capital Requirements. In contrast, it does not account for inflation. The depreciation method is fixed by the regulator accordingly: the assets are depreciated at their historic value on a straight line basis. Their lifetimes are fixed depending on the asset types (33 years for posts and cabins, 33-50 years for connections, until 50 years for cables). It is noticeable that the RAB remuneration does not integrate any financeability check.

The Belgian regulator applies other measures to ensure that ELIA is able to realise the right level of specific investments. A Y2-incentive applies *ex post* to a part of the capital expenditure for replacement and reliability investments. A fund of approximately €5 M is available each year and can be distributed on an individual basis for projects which approved costs are below 90% of their budgeted costs. ELIA indicates that it could represent a 35 bp addition to the fair remuneration of equity investors for projects approved for Y2-incentive[52].

As the costs incurred relatively to investments and remuneration of capital are considered as non-controllable, they are not included in the application of the effective X-factor for efficiency and productivity.

Complementary mechanisms for risk reductions

The risk for the operator of not controlling costs and revenues is reduced through two *ex post* reassessment mechanisms. On the one hand, a volume correction is applied *ex post* to ensure that

[51] CREG (2013). Décision (B)130516-CDC-658E/26 relative à « la proposition tarifaire rectifiée de ELIA SYSTEM OPERATOR S.A. du 2 avril 2013 pour la période régulatoire 2012- 2015» http://www.creg.info/pdf/Decisions/B658E-26FR.pdf

[52] To ensure an actual incentive effect, CREG limits the Y2-incentive to a maximum of 10% of the annual replacement investments, and approves the grant on an individual basis.

the operator is remunerated as expected. There is a volume risk because the tariff is predetermined with an assumption of network use that may be different from the realised network use. The volume correction hedges the TSO against this risk. On the other hand, a settlement mechanism applies to non-controllable costs components. It ensures that the deviation between budgeted and the actual costs approved by CREG is accounted and passed through in tariffs during the following regulatory period. In particular, the *ex post* reassessment of the RoE parameters plays a role at this level.

5.2 The regulatory regime applied by CRE in France

5.2.1 General context

The French transmission power system is operated and owned by RTE. RTE was first created in July 2000 as a service inside the EDF company independent from the financial, managerial and accounting point of view. It then became a limited liability company as a subsidiary of the EDF group in September 2005 following the 9th August 2004 law relative to the electricity and gas public service and gas and electricity companies (applying the 2003 energy directive). Consequently, RTE is an Independent Transmission Operator under the Third Package denomination. Despite EDF is a listed company (84.44% owned by the French state), RTE is considered to be 100% public.

As a legal monopoly in France, its activities of transmission and system operation are regulated by the French energy regulatory commission CRE. CRE sets the network tariff paid to RTE. For every regulatory period, CRE defines, after negotiation with RTE and a consultation process with stakeholders, the tariffs to be applied to electricity network users for the period. Concretely, CRE decides the global volume of costs to be passed to consumers and to be remunerated to RTE plus incentive mechanisms to be applied during the regulatory period. The next regulatory period will begin from August 2013 and lasts 4 years (until 2016 included). It is based on the decision by CRE relative to the public power transmission network use tariff dated 03.04.2013[53]. The description that follows is based on this decision.

It is important to note that the investment trend considered in this new regulatory period is expected to be high with respect to the past trend (around 13% investment to RAB ratio while compared with 8 and 11% in the two previous regulatory periods).

5.2.2 Regulatory design

Length and scope of the revenue cap

The French regulatory regime is based on a periodic revenue cap mechanism (4 years). The budgeted costs supported by the TSO for regulated activities (operation and investments) are taken into account to define revenue allowances for the regulatory period. The revenue cap mechanism applies to budgeted costs following a "building blocks" approach. The revenue cap thus makes a distinction between different types of costs and associated revenues. The revenue from tariff of the year N is then computed as the sum of the forecasted annual OPEX costs $OPEX_{Nf}$ and the forecasted annual capital expenses (comprising both asset depreciation D_{Np} and remuneration of the forecasted Regulatory Asset Base RAB_{Nf} at the WACC, that is to say WACC x RAB_{Nf}), the financial incentive from the N-1 year and the clearance of the "buffering" regulatory account (so called CRCP see below) $CRCP_N$ to integrate that some variations of costs and revenue are passed through to consumers.

$$R_N = OPEX_{Nf} + D_{Nf} + WACC \times RAB_{Nf} + I_{N-1} + CRCP_N$$

[53] CRE, 2013. Délibération de la Commission de régulation de l'énergie du 3 avril 2013 portant décision relative aux tarifs d'utilisation d'un réseau public d'électricité dans le domaine de tension HTB. The previous regulatory period applied from 2009 to 2013.

The costs that must integrate productivity efforts include “other purchases and services” and “salaries” (with constant perimeter compared to the previous regulatory period). Other purchases and services are OPEX except mainly system operation costs (losses, ancillary services, etc.), salaries, securing costs (to reinforce poles and make the network mechanically more resilient to storm), and taxes. Besides, a new regulatory scheme is introduced to incentivise the development of new interconnections. The other costs are considered non-controllable and are passed through in tariffs following a cost-plus mechanism in a “buffering” regulatory account (CRCP)[54] whose clearance is limited to 2% increase or decrease of the yearly tariff variation[55].

Definition and application of the efficiency and productivity targets[56]

A cap allowance is applied to controllable costs, that is to say “other purchases and services” and “salaries” through the application of an X-factor to a predefined value of controllable costs. The base value for controllable costs is fixed *ex ante* based on the analysis by CRE (and possibly to some mandated external consultants) after a proposal by RTE. The “X” factor is defined too by the regulator after a proposal by RTE. CRE retained a 1% productivity effort (RPI-1%) on costs for “other purchases and services” and a 0.3% productivity effort (RPI-0.3%) for “salaries” costs. The current level of demanded cost reduction is around €4 million per year for other purchases and services and €0.2 million for “salaries” for the 2013-2016 regulatory period. This is to compare to the annual revenue expected from tariff between €4.2 and 4.5 billion during the regulatory period, which means the incentive is less than 0.1% of the total transmission revenue. Nevertheless, after its creation, RTE has experienced important decreases in its cost (-18.4% between 2000 and 2004)[57] and this policy has been continued.

The outperformance or underperformance relatively to the efficiency and productivity targets is 100% born by the TSO and is not reflected in the tariffs for final consumers for the duration of the regulatory period, which ensures a higher incentive for cost reduction. If actual costs are higher than budgeted costs, the revenue of RTE is further negatively impacted. If they are lower, the revenue is positively impacted.

Beside efficiency target applied on controllable costs, other complementary efficiency tools are applied to control to some extent the cost efficiency of other cost elements of the revenue (notably CAPEX). In this respect, there is an *ex ante* approval process of investments where the projected level proposed by RTE is challenged and finally approved. CRE has also the possibility to realise *ex*

[54] This regulatory account is called CRCP for *Compte Régulé de Charges et Produits* that is to say the regulatory account for expenses and incomes.

[55] An output regulatory scheme is also applied to incentivise RTE to improve supply continuity.

[56] A mechanism is also implemented to incentivise RTE to improve the supply continuity. RTE is hence incentivised to reduce the average shortage duration and the frequency of shortages (longer than 1 second). The financial incentive is defined by the following formula:

$$I_N = 10.4 \times ASD_{ref} \times ln\left(\frac{ASD_N}{ASD_{ref}}\right) + 72.0 \times SF_{ref} \times ln\left(\frac{SF_N}{SF_{ref}}\right)$$

I_N the financial incentive for the year N expressed in M€. It can be positive or negative and is bounded in absolute value by 30 M€. ASD_{ref} is the reference Average Shortage Duration expressed in minutes. Its value is set to 2.4 minutes per year during the whole regulatory period. SF_{ref} is the reference shortage frequency expressed in number of shortage. Its value is set to 0.6 shortage per year during the whole regulatory period. The Average Shortage Duration and the Shortage Frequency for year N (ASD_N and SF_N) is computed excluding exceptional events.

[57] RTE (2005), *Résultats annuels 2004. Conférence de presse du 24 mars 2005*.

post efficiency test and adjustment in the RAB if major divergences between budgeted and actual costs appear. Once the investment enters in the RAB, no efficiency target is applied.

Remuneration of capital and investments

The allowed WACC is computed at the beginning of the regulatory period using the Capital Asset Pricing Model (CAPM). The tariff decision by the CRE says that the values of parameters to set the WACC are based on a work by an external consultant. Nevertheless this work is not available and the rationale for setting the different WACC parameters is not public.

The allowed RoE is based on the following values. The risk-free rate is then fixed at 4.0% in nominal value. The equity risk premium is considered at 5.0% and the equity beta is set at 0.66. Compared to the previous regulatory period the risk-free rate has decreased and the equity risk premium has increased. The corporate tax rate is assumed to be 34.43%. All in all, the allowed ROE is set at 11.2% in nominal value before tax using the classical CAPM formula[58].

The allowed cost of debt is classically computed as the sum of the risk-free rate and the debt premium[59]. As for the allowed RoE, it is expressed in nominal value. Considering that the debt premium is worth 0.6%, the cost of debt is 4.6% in nominal value before tax[60].

The WACC is then computed in nominal value before tax considering a 60% notional gearing rate. The WACC is calculated using the classical formula[61]. All in all, the allowed WACC is set at 7.25% in nominal value before tax[62].

The WACC is then applied on the RAB computed from the depreciated historical values of assets[63]. The RAB is depreciated from the accounting depreciation. Most of the assets are depreciated over 45 years[64]. RAB is also increased by new assets. Note that the changes in working capital requirement and work in progress are not included in the RAB. Meanwhile work in progress is paid at RTE at the cost of debt. It is noticeable that financeability is not explicitly considered in tariff setting.

A major innovation of the new regulatory period is to introduce a mechanism incentivising the development of new interconnection. Even if the detail of the mechanism is not defined yet, its principles are already set. The mechanism will rely on a fixed annual premium and on a variable annual premium. The fixed premium aims at increasing social welfare at the European scale considering not only quantifiable elements like increase in cross-border flows and impact on national prices but also qualitative elements like security of supply. At last, the variable premium will incentivise RTE so that the newly developed interconnection provides the highest possible additional flows.

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[58] Nominal cost of equity = risk-free rate + equity beta x equity risk premium / (1 – corporate tax rate)
= 4.0% + 0.66 x 5.0% / (1-34.43%) = 11.2%.

[59] Cost of debt = risk-free rate + debt premium.

[60] 4.6% = 4.0% + 0.6%.

[61] WACC = (1 - gearing) x cost of equity + gearing x cost of debt

[62] 7.25% = (1 – 60%) x 11.2% + 60% x 4.6%.

[63] Work in progress is remunerated the cost of debt only and working capital is not remunerated.

[64] The assets are depreciated on their estimated usefulness duration that is to say 45 years for lines and cables, 40 years for transformers, 45 years for high voltage cells and busbars and 15 years for low voltage ones, 45 years for compensation and ancillary materials and 10 years for telecommunications and remote control materials

As the costs incurred relatively to investments (other than new interconnection) and remuneration of capital are considered as non-controllable, they are not applied the X-factor for efficiency and productivity. A distinct incentive scheme will be applied to prompt the TSO to develop new interconnections. As a result, we can assume that the efficiency targets might have an impact on the level of these investments only.

Complementary mechanisms for risk reductions

The CRCP "buffering" regulatory account helps to limit remuneration risk for the TSO. The following expenses and incomes are included in this special account: cost of network losses, some costs linked to interconnection management (that is to say international congestion cost, management cost of interconnection allocation mechanism), destroyed assets, congestion rent, revenues from contracts between TSOs, RD&D cost and capital expenses.

Besides, if there is any discrepancy between the forecasted use volume used to compute tariff and the realised use volume, any difference is integrated in the CRCP account to hedge the TSO against volume risk. To avoid any brutal change in the tariff value, the clearance of the CRCP buffering regulatory account is limited to 2% per annum in addition to the integration of yearly inflation. At last, the TSO is also hedged against the inflation risk because its tariffs are indexed on the inflation rate.

5.3 The regulatory regime applied by BNetzA in Germany

5.3.1 General context

The German transmission system operation is geographically split between four TSOs: TenneT TSO, 50Hertz, Amprion and Transnet BW. These operators are the result of fifteen years of mergers and acquisitions of integrated utilities and then on-going unbundling. It is worth mentioning that two of the German TSOs are owned by foreign companies operating transmission systems in their own countries: TenneT TSO is owned by the Dutch TSO TenneT while 50Hertz is owned at 60% by the Belgian TSO ELIA System Operator.

The four geographical legal monopolies are regulated by BundesnetzAgentur (BNetzA), which is in charge of the regulation of the electricity, gas and telecommunication markets. In particular, the TSO are remunerated for their regulated services through several regulatory (and legislative) pieces. The current regulatory approach for grid operator remuneration was established in 2009 based on the ARegV regulation. It is based on a revenue cap. Two 5-year regulatory periods were programmed for the application of this mechanism to TSOs: 2009-2013 and 2014-2018. No major changes except changes of regulatory parameters for revenue setting are expected from the first to the second period.

5.3.2 Regulatory design

Length and scope of the revenue cap

The German regulatory regime is based on a periodic revenue cap mechanism (for a 5 year period). The mechanism allows the remuneration of TSOs for their regulatory services based on their costs. These costs are treated by the mechanism following a TOTEX approach but some costs are excluded from the revenue cap. The distinction is thus made between four categories of costs[65].

The first category is defined as “Permanently non-influenceable costs” (PNIC). It includes several types of costs and revenues, in particular specific costs such as congestion rents and ITC. Otherwise, most of the PNIC consists of the Investment Budget (IB) costs. The IB category includes costs incurred for specific “investment measures”, *i.e.* the investments projects approved by BNetzA for the expansion and restructuring of transmission systems, as well as for the expansion of the offshore network. Their status as approved IB is generally valid for one regulatory period, with the exception of offshore assets. The projects are examined and approved by the regulator on an individual basis, and must in particular ensure the stability of the entire system, the integration of the national and international power network, as well as the necessary expansion of the power supply system in accordance with the German Energy Act. The investments approved under the Investment Budget are subject to individual rules for depreciation, and are therefore separated from the regulated asset base. The PNIC costs are budgeted *ex ante* and are passed directly in tariff through a “cost-plus” pass through mechanism.

[65] Elia, 2010. At the start of decade reshaping the European Electricity Network

The second category of costs is defined as "Temporary non-influenceable and Influenceable costs" (TNIC+IC). They include the majority of the TSOs OPEX, with the exception of costs for offshore measures, and some costs related to ancillary services. They also include capital expenses for the assets in the Regulated Asset Base. The TNIC + IC costs, also called "controllable costs", are finally applied a "TOTEX" revenue-cap with efficiency and productivity targets, and their remuneration level is thus capped.

The third category is defined as "Korridor model" costs. They cover the provision of certain ancillary services (namely, regulating power, redispatch and losses). Their remuneration is provided by a limited pass-through mechanism, which also contains a bonus-malus mechanism depending on the level of outperformance between budgeted and actual costs.

The last category concerns regulated activities for which the TSOs cannot make a profit. For example, the costs incurred by the coverage of the renewable feed-in tariffs are treated here. The costs are fully passed through and have in principle a zero impact on net profit.

Definition and application of the efficiency and productivity targets[66]

A revenue cap allowance is applied to TNIC + IC controllable costs (most of OPEX and assets on the RAB) through the application of a combined X-factor[67]. The *ex ante* base budget is defined by considering the corresponding costs for a specific base year (2006 for the 2009-2013 period, 2011 for the 2014-2018 one). The incentive on costs reduction combines three terms which can vary on a yearly basis.

- Firstly, a "static" progressive efficiency factor aims at getting rid of individual inefficiencies calculated in two regulatory periods thanks to a distribution factor. It only applies to influenceable costs, whose base level of inefficiencies is assessed by BNetzA through Pan-European benchmarking based on the DEA (Data Envelopment Analysis) method, establishing efficiency values for the German and European TSOs[68]. To increase the robustness of benchmarking application, the "relative reference network analysis" method can be used as a complementary tool. The analysed TSO closer to an optimised "reference network" is then given a 100% efficiency level, and the comparison of its costs with the costs of the TSO considered here in the base year allow the calculation of inefficiencies in the base year and the annual values of the X factor. No value is directly available for the efficiency factors of the four German TSOs except that of 50Hertz[69], which is assumed to be 0.04 % annually for the 2009-2013 regulatory period. However, according to BNetzA[70], the efficiency level of the different network operators is already quite high, with an average around 91%, which makes us assume that a maximum efficiency factor of 1% per year

[66] A quality factor is also applied considering adjustments on the revenue cap according to the reliability of the network. It accounts for the ability of the TSO to meet the demands of transmission. The more reliable the TSO network is, the lower the absolute value of the quality factor is. BNetzA has still not defined any methodology for this factor, which is not applied yet.

[67] Groebel A. (BNetzA), 2013. Role and structure of the German regulatory authorities and the role of BNetzA in implementing the "Energiewende"

[68] Bundesnetzagentur, 2013. Monitoring report 2012

[69] Elia, 2010. At the start of a decade reshaping the Euroean Electricity Network

[70] Bundesnetzagentur, 2008. Incentive regulation 2008-07-07

(allowing a reduction of a 10% inefficiency level over ten years) is a good approximation for the sole TSOs.

- Secondly, a "dynamic" sectorial productivity factor is applied to account for the deviation of the net economic productivity gains of the most efficient operator. The yearly factor is fixed at 1.25% for the first period and at 1.5 % for the second one. It applies to both TNIC and IC costs.

- Thirdly, an inflation index is applied as a positive balance to the productivity factor. It is based on the evolution of the Consumer Price Index.

In addition to the incentive described above, the outperformance or underperformance relatively to the efficiency and productivity targets is not reflected in the tariffs for final consumers and provides an additional incentive for the reduction of TNIC and IC costs, as the TSOs can directly pass 100% of the gains in their gross margin.

A secondary outperformance instrument is also applied to the Korridor costs, in the form of a bonus-malus mechanism. Thus, in the limit of 5% of the budgeted costs, the outperformance or underperformance with regard to efficiency target is shared between the TSOs and the final users with a 75-25% sharing rule.

Remuneration of capital and investments

The assets built or bought and depreciated for regulated activities are treated differently according to the design in Germany. As a result, the authorised remunerations of capital are also defined differently.

First of all, the same allowed RoE is applied to the assets subject to the Investment Budget mechanism (PNIC costs) and those included directly in the Regulated Asset Base (TNIC and IC costs). The regulation, however, makes a distinction between "new investments", approved from 2006 on after the creation of the BNetzA, and "old investments", approved before 2006 and constituting the "legacy network" (included in the RAB). Nevertheless, the regulator applies the same fixed 60% gearing to compute the WACC for each type of asset (whether RAB or Investment budget).

The parameters needed to compute the WACC (RoE and cost of debt) are defined as follows. On the one hand, the regulated RoE for "new investments" is based on the Capital Asset Pricing Model. It is applied at a nominal value, and it is calculated for the whole regulatory period using the classical CAPM formula, as follows[71]:

$$RoE_{"New\ investments"} = Rf + \beta \times Rp$$

- *Rf* is the risk-free rate applied to new investments. It is based on the historic 10-y average of current yields of debt securities for domestic issuers. The debt securities included in the calculation consist of bank bonds (mortgage bonds, public bonds, bonds of specialised credit institutions, etc.), corporate bonds, and public debt securities (including listed Federal securities, and with a residual maturity of 9 to 10 years). It was fixed for the 2014-2018

[71] Bundesnetzagentur, 2011. Beschlusskammer 4 30.10.2011

period at a 3.80 % nominal post tax value. We will apply this value for the TSO regulation comparison, hence focusing on the 2014-2018 regulation for Germany.

- *Rp* is fixed at a 4.55% nominal post-tax value. It corresponds to the average risk of an alternative investment. It is provided through the evaluation of long term series of capital market data from 17 countries.
- *Beta* is fixed at 0.79. It is calculated relatively to the general market development, with the use of international market data and an adjustment method.
- The value of RoE considered in the comparison of EU regulatory regimes is then:
  RoE = 7.39 % (nominal post-tax)

On the other hand, the authorised RoE for the pre-2006 legacy network is based on the return on equity for "new investments" but is adjusted for inflation, as the German regulation applies a <u>nominal</u> RoE to "new investment" and a <u>real</u> RoE to legacy networks[72].

$$RoE_{legacy\ network} = RoE_{\text{"}New\ investments\text{"}} - Inflation\ based\ component$$

$$= 7.39\% - 1.56\% = 5.83\% \text{ (real, post tax)}$$

The cost of debt also depends on the categorisation of the different assets. For assets approved as part of the Investment budget, the financial costs are included in the permanently non-influenceable costs. Since 2012, the costs have been based on forecast values. For assets categorised as incentivised, the cost of debt is included in the incentivised costs, and is subject to the efficiency and productivity incentives. In addition, the cost of debt is capped at the regulatory cost of debt, which is the 10-year average yield of domestic fixed-income securities for the base year. As it is not possible to assess the actual cost of debt of the different assets for the 4 TSOs, we will assume a uniform cost of debt at its regulatory value, which is the 10-year average yield of domestic fixed-income. The value considered for comparison is based on the works of ELIA on 50Hertz acquisition from 2010[73] and is equal to 4.23 % (nominal pre-tax).

The remuneration of investments (depreciation, financial costs, and remuneration of equity investors) can finally be established by valuating the regulated assets. The valuation depends on the characterisation of these assets, which are sorted between the Regulated Asset Base and the Investment Budget category[74]. It is noticeable that the RAB and Investment Budget remuneration does not integrate any explicit financeability check. Besides, a different valuation of RAB is provided for "old" and "new" investments. Indeed, an indexed historical cost method is used to evaluate the part of "old" assets financed through equity, while an historical cost method is used to evaluate the rest of the RAB (part of "old" assets financed through debt + "new" assets). This is coherent with the definition of two levels of return on equities and one level of cost of debt. The same depreciation method is however applied to the whole RAB: a straight-line method is applied, with a useful life of

[72] Dehmel, 2012: a distinction is made between the remuneration of net asset maintenance (through real RoE) and the remuneration of acquisition and production costs (through nominal RoE).
[73] Source: ELIA, 2010. At the start of a decade reshaping the European Electricity Network.
[74] Dehmel F., 2011. Anreizregulierung von Stromübertragungsnetzen: Eine Systemanalyse in Bezug auf ausgewälte Renditeeffekte

assets of 40-50 years for EHV lines and cables, 35-45 years for transformers, and 25-30 years for remote control.

The efficiency and productivity targets impact investments in the Regulated Asset Base, as the relative costs are defined as incentivised. The effect is lower for investments included in the Investment Budget category, as their costs are directly passed through in tariffs. However, it should be mentioned that onshore investments in the IB category are planned to be included in the RAB after one or two regulatory periods. They could then be also applied the efficiency and productivity factors.

<u>Complementary mechanisms for risk reductions</u>

The risk for the operators of not controlling costs and revenues is partially reduced through two *ex post* reassessment mechanisms. On the one hand, the deviation between actual and budgeted upstream network costs, decentralised power supply compensations, and outperformances for meter operation and measurement, are passed through in tariffs during the next regulatory period. On the other hand, the deviation between allowed revenue and actual revenue, depending on the annual consumption profiles, is also passed through in tariffs for the next regulatory period. An exception is made if the deviation exceeds 10% of the budgeted revenues. In this case, the deviation is passed in tariffs the year after. The same mechanism is used for both types of risk reductions: it is the regulatory account. In particular, a t+0 transfer of costs to tariff is performed for PNIC costs, including IB during the construction phase (i.e., work in progress). The actual costs incurred for year t are considered to adjust the regulatory account for the same year. The t+0 instrument only exists since 2012, when it replaced a t+2 mechanism (the actual costs incurred for year t are considered to adjust the regulatory account for the year t+2), and made the associated instrument obsolete. Finally, the revenue is also adjusted by an “expansion” term.

5.4 The regulatory regime applied by OFGEM in Great Britain

5.4.1 General context

The British transmission power system is operated by National Grid Electricity Transmission (NGET). Nevertheless the ownership is shared between NGET for the English and Welsh territories and Scottish Hydro-Electric Transmission Limited (SHET) and Scottish Power Transmission Limited for Scotland (SPT), respectively in the North and South of Scotland. The three companies are private one but their organisation differs. NGET is fully unbundled from any generators while Scottish Hydro Electrify Transmission and Scottish Power Transmission are respectively subsidiaries of Scottish Hydro and Scottish Power[75].

These four companies (one system operator and three transmission owners) are regulated by OFGEM (Office of Gas and Electricity Markets) the British regulator for gas and electricity. OFGEM is considered as a pioneer in Europe and even worldwide in the application of incentive regulation to regulate power and gas network operators (Joskow, 2008). OFFER (before merging with OFGAS[76], the British regulator of gas) was the first power regulator to apply revenue cap regulation (RPI-X) in 1990 on the power transmission and system operator National Grid.

After 20 years of incentive regulation, OFGEM decided in 2009 to initiate a rethinking, recognising both achievement and difficulties. The wide consultation process then concludes that focus in the RPI-X regulatory framework was mainly on short term and cost reduction, which has led to forget the outputs of transmission network and its usefulness to network users (Jenkins, 2010, Crouch, 2012). That is why the activity of the regulated company should be user-oriented and so focused on outputs to improve services to users, innovation to provide new services & cost reduction in the long run and only at last incentives for cost reduction in itself.

A brand-new regulation called RIIO for Revenue = Innovation + Incentive + Output has so been designed. Its idea is that the prescription of a set of outputs to be delivered, rather than a set of inputs to control, provides powerful incentives for companies to innovate and seek least cost ways to provide network services. The earned return will then vary with output delivery performance.

The RIIO regulation was then discussed with the stakeholders and the first regulatory period relying on the RIIO principles has just opened (01/04/2013) for 8 years until 2021. While the RPI-X regulation primarily relied on input regulation, the RIIO regulation will primarily rely on output regulation. Besides, the use of benchmarking and menu of contracts will be generalised to the more difficult situation of transmission (because of the small number of companies to compare) to set OPEX, CAPEX and TOTEX allowances[77].

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[75] Transmission Ownership and Operation in Great Britain differs from the organisational model implemented under the Third energy directive. Nevertheless it is found to ensure more effective independence of the transmission system operator than the one provided under the unbundling model of independent transmission operator. Consequently, the arrangements already in place before the Third energy directive enactment is allowed to be kept. (See COMMISSION DECISION of 14.5.2012 on the application of Article 9(9) of Directive 2009/72/EC to Transmission System Operation in Scotland).

[76] OFGAS, the British regulator of gas was then the first gas regulator worldwide to apply price cap regulation in 1988.

[77] While the interactions between the regulatory mechanisms were initially taken into account only on a case-by-case basis in the RPI-X regulation, it is now considered in the core of regulation. A part of OPEX (maintenance) is now included in the

5.4.2 Regulatory design

Length and scope of the revenue cap

The British regulatory design is based on a periodic revenue cap mechanism (8 years), oriented to output regulation. The budgeted costs supported by the TSOs for regulated activities (operation and investments) are taken into account to define revenue allowances for the regulatory period and different incentives are targeting improvement of some network outputs (GHG emissions, reliability, etc.). The revenue cap mechanism applies to budget costs following a TOTEX design on controllable costs. A fixed part of the TOTEX is capitalised to inflate the Regulatory Asset Base. It is called Slow Money because it is paid as depreciation of assets *Dp* along the depreciation duration (45 years). The rest of TOTEX and non controllable costs are passed through and paid on a yearly basis and it is so called Fast Money. 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.). It is also updated by inflation level. It is remunerated at the *WACC* value. Besides, a two years lag is introduced to make the tariff predictable enough. The authorised revenue R_N for year *N* is hence determined:

$$R_N = FastMoney_{N\text{-}2p} + D_{Np} + WACC \text{ x } RAV_{Np} + A_{N\text{-}2} + I_{N\text{-}2}$$

With A_{N-2} adjustment from the *N*-2 year

And I_{N-2} financial incentive from the *N*-2 year

Definition and application of the efficiency and productivity targets

The efficiency mechanisms implemented in the RIIO regulation are a combination of cost efficiency incentive scheme and output incentive schemes[78]. We focus here on cost efficiency schemes.

A cost efficiency incentive schemes is applied on network companies with a menu of contract mechanism. This scheme is known as the Information Quality Incentive (IQI). It is a menu of contracts applied on TOTEX and it is used by the regulator targeting two purposes. The first idea is to decrease information asymmetry as the network companies select the incentive scheme they think is more appropriate to their situation revealing their target cost. Second, this incentive scheme defines the sharing factor applied to the gains or losses it may incur compared to the target cost. For

Regulated Asset Base and is so remunerated through the WACC. Besides, the profit-sharing rules for OPEX and CAPEX are now harmonised.

[78] The core of the RIIO regulation is that the network companies provide output to their customers at the cheapest possible cost. Consequently, a set of 7 categories of output measures has been defined and different output mechanisms have been designed. These outputs categories are namely safety, reliability, availability, customer satisfaction, connections, environmental impact, and wider works for new investments. The 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 general enforcement of legal policy. Reputational incentives apply on availability, environmental impact of losses and business carbon footprint publication and visual amenity. Otherwise, incentive mechanisms apply to the other categories, namely reliability, customer satisfaction, environmental impact of SF6 and wider works for new investments. Output regulation also partly applies on safety for network replacement, and visual amenity in the framework of the baseline and uncertainty mechanism. Besides output regulation, OFGEM allowed that 0.7% of base revenue is dedicated for funding innovation (under the so-called Network Innovation Allowance – NIA).

instance, the proposed contracts go from 40% to 50% sharing of efficiency gains above the target and a +/-2.5% additional income reward/penalty.

TOTEX is defined as the sum of CAPEX (i.e., new investment only that are all considered completely controllable, but not the historical asset base)[79] and controllable OPEX. Non controllable OPEX are outside TOTEX and the Information Quality Incentive and are 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 TSO compensation scheme[80].

The TOTEX allowances and efficiency targets are computed based on a combination of several methods (efficiency audits, consultation process, benchmarking)[81]. 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. It is used in the stakeholder consultation process for the regulator to assess the cost of the TSOs business plan and set the TOTEX allowances[82].

The maximal level of efficiency mechanisms is high whereas the effective level depends on the contract selected by the regulated company. OFGEM measures this with the return on regulated equity (RoRE). Because of efficiency mechanisms, it may increase or decrease the RoRE by 3% (under an assumption of 60% gearing rate) for a value of regulated cost of equity set at 7%. This means that the remuneration of a TSO in Great Britain can be increased by more than 42% if it reaches all the efficiency and output objectives set in the RIIO regulation. The efficiency objectives account for more than 75% of the whole level of incentives.

Note that the SO costs (balancing, network constraints, black start and transmission losses) are incentivised in a different mechanism. NGET plans three periods for the SO incentives are planned during the new 8-year RIIO regulatory period. The first one is expected to last 2 years, with a £30 million cap and collar and a 30% sharing rule. The second one is expected to last 2 years, with a £40 million cap and collar and a 40% sharing rule. And the last one is expected to last 4 years, with a £50 million cap and collar and a 50% sharing rule. The parameters of this regulatory scheme could be

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[79] Only few CAPEX related to one specific incentive scheme (Transmission Infrastructure for Renewable Generation – less than 1% of total CAPEX) is not included in TOTEX. This is a mechanism designed to fund transmission projects specific to connecting renewable generation outside of the price control allowance to minimise delays. It is comprised of four projects. (Source: http://www.ofgem.gov.uk/Networks/Trans/ElecTransPolicy/CriticalInvestments/TIRG/Pages/TIRG.aspx)

[80] OFGEM, 2012. RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Grid Gas. Cost assessment and uncertainty Supporting Document. 17 December.
OFGEM, (2012), RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Grid Gas. Finance Supporting Document. 17 December.

[81] OFGEM 2011. Decision on strategy for the next transmission price control - RIIO-T1 Tools for cost assessment. 31 March.
OFGEM, 2012. RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Grid Gas. Cost assessment and uncertainty Supporting Document. 17 December.

[82] 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*".

modified during the mid-term review (of the 8 year RIIO regulatory period). OFGEM has not decided yet how these schemes will be concretely implemented[83].

Remuneration of capital and investments

Under RIIO, assets are classically remunerated based on the definition of a WACC and a RAB. The WACC is computed using first a CAPM approach detailed now. The allowed RoE is determined *ex ante* at the beginning of the regulatory period and is fixed during the whole regulatory period. A range is calculated using the CAPM method and relying on ranges of the different parameters, namely the risk free rate, the beta and the equity risk premium.

Following this consultation process, OFGEM has progressively narrowed the range of the allowed RoE going from 4.0%-7.2% in December 2010[84], to 7.0% as final decision in 2012 for NGET[85, 86] with 6.0-7.2% as an intermediary range[87]. If the value of the different parameters is precisely considered during the consultation process, OFGEM sets the final value "*put[ting] more weight on the overall cost of equity rather than the unobservable asset beta*". The decision by OFGEM grounds not only on the use of the CAPM method but also on evaluations by stakeholders relying on other methods. NERA for the TO SPTL hence used the Dividend Growth Model as has done FTI consulting for OFGEM in July 2012[88]. Moreover, NERA (for SPTL) considers CAPM including specific adders, as one relative for CAPEX risk (0.5%) and other for longer asset lives (0.5%). KPMG for National Grid used the Residual Income Model that FTI consulting found unreliable to provide an estimate of the cost of equity for the network companies.

A major change has been introduced in the RIIO regulation with an indexation of the cost of debt[89]. The idea is to rely on a 10 year simple average index that will be updated each year. The index chosen is the pound sterling Non-Financials A and BBB 10+ year's indices published by iBoxx. Following this rationale, at the beginning of the regulatory period, the cost of debt was set at 2.92% in real value.

To complete the determination of allowed cost of debt and RoE, a financeability test is performed to ensure that the network companies can finance their activities both through debt and equity and deliver the network services that consumers expect. This test is then used by OFGEM to set the final allowed RoE, the notional gearing and eventually change the depreciation profile. Consistency is also sought between the notional gearing, allowed RoE and cost of debt. Indeed, higher gearing would reduce allowed cost of equity and inversely. The notional gearing has then been set at 60% for NGET. Note that it is lower for SPT and SHET at 55%.

[83] NGET, (2012), Electricity SO Incentives Overview.
OFGEM, (2013), Electricity System Operator Incentives: consultation on a scheme for 2013
[84] OFGEM, (2010), Consultation on strategy for the next transmission price control - RIIO-T1 Overview paper. 17 December.
[85] OFGEM, (2012), RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Grid Gas. 17 December.
[86] Note that SPT and SHET benefit of the same value of RoE with a lower gearing nevertheless (55% against 60% for NGET). See OFGEM, (2012), RIIO-T1: Final Proposals for SP Transmission Ltd and Scottish Hydro Electric Transmission Ltd.
[87] OFGEM, (2011), Decision on strategy for the next transmission price control - RIIO-T1. 31 March.
[88] FTI Consulting, (2012), Cost of capital study for the RIIO-T1 and GD1 price controls. 27 July.
[89] It was previously computed *ex ante* as the sum of the risk-free rate and a debt premium.

As a consequence, the real vanilla post tax WACC is currently set at 4.55% for NGET and 4.76% for SPT and SHET considering an assumed 2% inflation rate and a 23% corporate tax rate[90].

A major change from the RIIO regulation is the way to define the RAB and the RAV. In the RPI-X regulation, the RAB was classically defined as the non depreciated network assets (namely powerlines and substations). Other short life assets as IT were otherwise included in the OPEX and so didn't generate any return on investment. Consequently, there was an incentive for the company to prefer CAPEX over OPEX since CAPEX was generating return on investment whereas OPEX was only paid at cost (except incentive mechanisms). To avoid this pitfall, OFGEM decided to change the way the RAV is defined. The RAB is not only made of CAPEX but also of a part of OPEX. Hence a fixed part of total expenditures (TOTEX) whether CAPEX or OPEX is included each year in the RAV. The TOTEX capitalisation rate then defines the part of TOTEX that is included in the RAV. An 85% of TOTEX capitalisation rate has been set for NGET and a 90% capitalisation rate for SPT and SHET for the RIIO-T1 regulatory period (based on historical share between OPEX and CAPEX)[91]. The non capitalised part of TOTEX will be expensed and funded in the year of expenditure. The RAV is then depreciated assuming that the new capitalised TOTEX is depreciated in a straight-line manner during 45 years on average[92]. Note that 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).

Complementary mechanisms for risk reductions

The cap imposed on the remuneration of TSOs is adjusted to different changes in drivers of its activities, in particular of its investments. 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 TSOs activities. Changes in these drivers lead to additional TOTEX allowances. These drivers are the volume of new generation connection, new demand connections, additional transfer capability to relieve internal network constraints, integration of cost of mitigation measures to gain planning consent reducing visual amenity and funding for delivering outputs in RIIO-T2.

Besides, we already mentioned that different costs (uncontrollable OPEX) are passed through to the tariff. These costs are the licence fees, the business rates (a tax on the occupation of non-domestic property), pensions and pensions schemes administration, and the costs related to the Inter TSO compensation scheme. Besides, the network companies are hedged against inflation with RPI indexation of tariff and partly hedge against cost of debt thanks to a 10 year average indexation. Changes in tax rates will also be passed through into the tariff.

Other revenue adjustments mechanisms are implemented in the RIIO regulation. A mid-term review (after 4 years of the regulatory period) is planned to review possibly the targets of outputs that defines output regulation. Two reopeners in May 2015 and May 2018 are also possible for the transmission owners to ask for recovering additional costs (with more than 1% increase to enhance physical security of the network) or the regulator to ask for reducing allowed revenues where there is evidence that they are no longer required to deliver outputs which funding was provided for (after

[90] The corporate tax rate is to fall to 21% in 2014 in the United Kingdom (http://www.hmrc.gov.uk/rates/corp.htm).

[91] OFGEM, (2012), RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Grid Gas. Finance Supporting Document. 17 December.

[92] The pre RIIO existing assets of the power transmission companies will continue to be depreciated over 20 years, like before the introduction of the RIIO regulation.

the regulator being informed by third parties). More generally, price control parameters could be also reset if TO experiences financial distress.

Under the RIIO regulation, the TSO is also hedged against volume risk. The regulator hence proposes to introduce lags on some costs and incomes changes (costs pass through, uncertainty mechanisms, incentive rewards and penalties). Tariff changes will only be allowed on a yearly basis and in a 6% bandwidth of over or under recovery (a penalty is otherwise applied)[93].

[93] OFGEM, 2012. Decision in relation to measures to mitigate network charging volatility arising from the price control settlement. Final decision. October 2012.

5.5 The regulatory regime applied by ACM in the Netherlands

5.5.1 General context

The Dutch 380-220 kV transmission system is operated by TenneT, which was appointed as the independent operator at the beginning of the liberalisation of the electricity market. TenneT is controlled and owned by the Dutch government[94].

The legal monopoly is regulated by ACM, a new entity aggregating since April 2013 the OPTA (Independent Post and Telecommunications Authority), the Netherlands Consumer Authority and the Netherland Competition Authority (NMa), formerly in charge of the regulation of the electricity market. The activities of TenneT as the Dutch TSO have been regulated since 2000, and have been subject to the fifth regulatory period beginning in 2010. The regulatory mechanism for TSO remuneration detailed in this report is based on our understanding on the rules proposed by ACM in the May 2013 draft for the 6th regulatory period[95].

5.5.2 Regulatory design

Length and scope of the revenue cap

The Dutch regulatory design is based on a periodic revenue cap mechanism (3 years[96]). The regulation can be summarised as the combination of two revenue-cap mechanisms[97].

The first mechanism is a typical incentive-based revenue cap mechanism which is supposed to cover the efficient costs of the TSO for transmission services. The same incentive approach is applied to both operational and capital costs. The revenue cap is then based on a "TOTEX" design, which applies to total costs (OPEX, new investments and old investment already integrated in the RAB) a CPI-X based incentive for efficiency and productivity. The TOTEX character means that the revenues are only related to the aggregated costs of the network. This implies, among others, that investments are not treated separately[98].

The second mechanism is a sliding scale mechanism which applies to system operations. It remunerates TenneT for the actual costs incurred for the provision of system services (balancing mechanism as well as reserves and voltage control). Since 2011, the mechanism includes a complementary incentive element, as a part of the deviation between actual and expected costs. In the limit of a 20% deviation, the TSO is subject to a bonus-malus component amounting to 25% of

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[94] It also owns one of the four German TSOs since 2010 (TenneT TSO).

[95] https://www.acm.nl/nl/publicaties/publicatie/11228/Ontwerp-methodebesluiten-TenneT-2014-2016/

[96] The regulatory period can be defined between 3 to 5 years but the regulator uses in general the shortest length.

[97] http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/NATIONAL_REPORTS/National%20Reporting%202012/NR_En/C12_NR_Netherlands-EN.pdf

[98] Three different types of CAPEX are considered (regular replacement CAPEX, regular expansion CAPEX and special CAPEX). Some investments (so called "special" investments) receive a specific treatment, including a separate efficiency assessment plus the option to raise revenues during the regulatory period.

the deviation. The component, which accounts for outperformance or underperformance of system services, is directly passed in the gross margin of the TSO.

Definition and application of the efficiency and productivity targets

A revenue cap allowance is applied to the TSO transmission costs through the application of a combined efficiency and productivity X-factor to a preliminary defined level of cost. The *ex ante* cost base is determined from the costs incurred by the TSO two years before the beginning of the regulatory period (*e.g.*, the costs incurred in 2012 will be used to define the base level of costs for the 2014-2016 regulatory period). The base costs act as a snapshot of the transmission cost structure at that date. From this basis, the evolution of the authorised revenues for the regulatory period is decided by assessing an assumed level of efficient costs to be reached by the TSO at the end of the regulatory period.

- First, the static efficiency level of the TSO transmission costs structure is assessed based on an "efficient cost reference" benchmarking. A Unit Cost Model based on a comparison of a number of European TSOs (cf. E3GRID2008 study) is performed resulting in the definition of a fictional best practice benchmark as the average of the three best-performing firms[99]. The levels of efficiency of the benchmark and TenneT are then calculated and compared to set an efficiency score for TenneT. The static efficiency effort demanded to the TSO is then fixed with regard to the number of years given to TenneT to reduce its assumed static inefficiencies.
    - The ratio between these two efficiency levels is the efficiency score (ES) of TenneT, stating how efficient TenneT is assumed to be in comparison to the benchmark.

$$ES_{TenneT} = \frac{\left(\frac{Output}{Costs}\right)_{TenneT}}{\left(\frac{Output}{Costs}\right)_{\substack{Benchmark \\ best\ practice}}}$$

    - The efficiency score is not directly included in the revenue cap formula. As the regulator considers that achieving the assumed best practice level of efficiency would not be immediate, it defines a number of years in which the actual costs should be reduced to the assumed level of the costs of the best practice (Y). This results in a parameter theta (θ), which is defined as: $\theta = (1 - ES)^{\frac{1}{Y}}$
    - The proposed θ for the period 2014-2016 is 0.887 for EHV assets (the regulator has defined a score level of TenneT of 0.6[100] TenneT. It is expected to achieve a theoretical score of 1 in 2025).

[99] OXERA (2012). Unit costs comparisons have been calculated using TOTEX, OPEX, CAPEX and adjusted TOTEX with the grid size as the output measure of choice. Brunekreeft (2013) reports that DEA analysis has been declined given that the Netherlands are so densely populated that TenneT creates a standing alone position in the DEA, creating methodological problems. International benchmarking has assessed the TenneT score with a rage among 0.2 and 1.

[100] Benchmarking results bring the regulator to initially define the assumed efficiency of TenneT at 48%. However, recognising the problems of robustness the assumed efficiency has been increased at 60%.

- A frontier shift is then assessed as the annual productivity improvement expected during the regulatory period and due to the general technological progress within the sector. This is the dynamic efficiency effort demanded to the TSO to follow the frontier. It is also provided by an international comparison.
  - CEPA has recommended a range between 0.5 to 2.3%[101]. The regulator took the average value: 1.4%
- It is then possible to assess the assumed efficient cost structure expected from the TSO at the end of the regulatory period as a function of the base costs, the efficiency factor (static efficiency), and the productivity factor (dynamic efficiency). The X-factor is then calculated so that to draw a progressive revenue path for the operator to reach the assumed "efficient" cost structure at the end of the regulatory period (Mulder 2012). The factor is finally corrected by a CPI element to account for inflation.
  - Once the benchmarking data are known (θ; FS), the assumed level of "efficient cost" for last year of the new regulatory period (EC_{ln}) is defined using cost base for the beginning of the new regulatory period ($TOTEX_{t=0}^{a=tr}$). It is computed as follows:
    - $EC_{ln} = TOTEX_{t=0}^{a=tr} * \theta * (1 - FS)^N$ (N is the length of the regulatory period in years)
  - Once the assumed "efficient cost" for the last year of the new regulatory period is defined (EC_{ln}), the X factor can be computed using the level of allowed revenue of the last year of the previous regulatory period (R_{lp}^{Tran}). It is computed as follows:
    - $X = 1 - \left(\frac{EC_{ln}}{R_{lp}^{Tran}}\right)^{\frac{1}{N}}$

The demanded level of cost reduction through the application of the TOTEX mechanism seems significant (following benchmarking results, TenneT is considered on having an inefficiency of 40 % with respect to the other TSOs). Ambitious efficiency targets set using these benchmarking results are in line with announced preferences of the Dutch regulator as explained in the May 2013 draft proposal, giving as a main objective a further reduction in the rates paid by consumers.

[101] Cf. CEPA (2012)

Remuneration of capital and investments[102]

First of all, the same allowed RoE is applied to all investments, regardless of the type of assets or their age. The capital is thus remunerated based on a uniform real pre-tax RoE fixed for the whole regulatory period as follows:

$$RoE = Rf + \beta \times Rp$$

- The risk-free rate Rf is computed as a nominal pre tax value and is set at a 2.5 % (between the German and Dutch bonds).
- The equity market premium Rp is set at 5%.
- Beta is fixed at 0.61.
- Using an inflation rate of 2%, the regulator arrives to a value of RoE of 3.6% (real post tax). This value of RoE is adopted in the rest of the report.

The regulator applies a fixed gearing to define how much of the invested capitals are remunerated at the authorised RoE. The notional level of gearing is fixed by ACM at 50% and is supposed to reflect the optimal financial structure of TenneT. Therefore, the equity investors are remunerated at the authorised RoE in the limit of 50% of the capital expenditure. The extra-equity is remunerated at the cost of debt.

The cost of debt is also fixed *ex ante* for the whole regulatory period. It uniformly applies to all assets and is not adjusted *ex post*. It is calculated as follows:

$$CoD = Rf + Dp + Tc$$

- The risk-free rate Rf is the same as for RoE computation.
- The debt premium is set at 1.2%.
- A transaction cost of 0.15% is added.
- The value of cost of debt adopted in the rest of the report is: 3.85 % (nominal post tax).

The WACC is then computed in nominal value before tax considering a 50% notional gearing rate and a tax rate of 25.0%. The WACC is calculated using the classical formula[103]. All in all, the allowed WACC is defined at 5.6% in nominal value before tax[104]. Then using an inflation rate of 2.0% the real WACC before tax is defined at 3.6%.

The remuneration of investments can be fully established by valuating the regulated asset base. The RAB is updated annually with the new assets, depreciations and decommissions. In particular, it is depreciated on an indexed historic value basis, which means that the RAB is reassessed annually to account for inflation. The depreciation method is a 40-55-year straight line one. The method differentiates investments with regard to their "vintage": a distinction is thus made between the

[102] https://www.acm.nl/nl/publicaties/publicatie/11228/Ontwerp-methodebesluiten-TenneT-2014-2016/
[103] Pre-tax cost of equity = post tax cost of equity / (1-25%). WACC = (1 - gearing) x pre tax cost of equity + gearing x cost of debt.
[104] 5.625% = (1 – 50%) x 5.6% / (1-25%) + 50% x 3.85%.

investments realised before 2001, the assets transferred in 2007, and the investments realised since 2008.

In contrast to the annual reassessment of the actual RAB, the valuation of the RAB for TSO remuneration is fixed for every regulatory period. The “snapshot” actual value of the RAB for period Y will thus be impacted in the cost benchmarking and the allowance revenue from period Y+1 or Y+2, depending if the depreciation begins before or after the “snapshot”. It is noticeable that financeability is not considered in tariff setting.

The impact of efficiency and productivity targets is complete for investments in the Regulated Asset Base even if their costs can no more be influenced. As a result, they are included in the base costs, as well as in the benchmarking, and are subject to both the static efficiency effort and the frontier shift incentive, even assets before the existence of TenneT (2001).

Complementary mechanisms for risk reductions

A compensation mechanism is implemented for “special” and “expansion” investments which are not included in the initial revenue allowance. Their costs are integrated in the tariff computation once the assets are completed and with 2 years of lag.

6 Appendix B: Assumptions for the comparison of RoE, CoD and WACC

Table 14 gives a summary of assumptions about the Return on Equity, Cost of Debt, and gearing of each regulatory regime.

Table 14. Assumptions of allowed Return on Equity, Cost of debt, and gearing for each regulatory system

Country	Component	Values used for comparison	Assumptions
Belgium[105]	Return on Equity	4.3413 % (nominal post-tax)	Assumption based on CREG (2013)
	Cost of debt	4.3413 % (nominal pre-tax)	Assumption based on CREG (2013)
	Gearing	67 %	Notional value
France[106]	Return on Equity	11.2 % (nominal pre-tax)	Allowed value (CRE, 2013)
	Cost of debt	4.6 % (nominal pre-tax)	CRE (2013)
	Gearing	60 %	Notional value
Germany[107]	Return on Equity	7.39 % (nominal post-tax)	Allowed value (BNetzA)
	Cost of debt	4.23 % (nominal pre-tax)	Assumption based on ELIA (2010) [108]
	Gearing	60 %	Notional value
Great Britain[109]	Return on Equity	7.0 % (real pre-tax)	Allowed value (OFGEM 2012)
	Cost of debt	2.92 % (real pre-tax)	Assumption based on OFGEM (2012)
	Gearing	60 % (NGET)	Notional value

[105] CREG (2013). Décision (B)130516-CDC-658E/26 relative à « la proposition tarifaire rectifiée de ELIA SYSTEM OPERATOR S.A. du 2 avril 2013 pour la période régulatoire 2012- 2015» http://www.creg.info/pdf/Decisions/B658E-26FR.pdf

[106] CRE, 2013. Délibération de la Commission de régulation de l'énergie du 3 avril 2013 portant décision relative aux tarifs d'utilisation d'un réseau public d'électricité dans le domaine de tension HTB.

[107] http://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/DE/2011/111102EigenkapitalrenditeInvestitionsStromGas.html

[108] ELIA (2010). At the start of a decade reshaping the European Electricity Network. http://www.elia.be/en/about-elia/newsroom/news/2010/~/media/files/EliaGroup/investor-relations/2010/Analystpresentation01062010.pdf

[109] OFGEM, (2012), RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Grid Gas. Finance Supporting Document. 17 December.

Country	Component	Values used for comparison	Assumptions
Netherlands[110]	Return on Equity	3.6 % (real post tax)	Allowed value (ACM draft proposal)
	Cost of debt	3.85 % (nominal pre-tax)	Allowed value (ACM draft proposal)
	Gearing	50 %	Notional value

In order to compare the allowed return on equity, the cost of debt and the cost of capital of these different regimes, comparability must be ensured. Therefore, preliminary hypotheses must be set with regard to the comparison between pre-tax and post-tax rates, as well as between real and nominal rates.

- The transformation of the return on equity rate from pre-tax to post-tax values is based on the integration of the impact of corporate tax on the TSO gross margins. It is eventually established as follows: $RoE_{post-tax} = RoE_{pretax}.(1-\tau)$, with τ the fictional tax rate accounting for the impact of the corporate tax.

- The transformation of the cost of capital from nominal to real value is based on the impact of inflation on the interests and returns given by the TSOs. To ease this calculation, it is eventually established as a simple difference:

$$WACC/RoE/CoD_{real} = WACC/ROE/CoD_{nominal} - i,$$

  with *i* the common inflation rate. We will apply a global assumption of *i* = 2.0 % for the comparison. Note that it is an approximation of the Fischer formula applicable with a good enough accuracy because the rates are low enough. Besides, regulators often use this approximation.

Table 15 presents the assumptions for the corporate tax rates used by regulatory regimes τ and the inflation rates *i* for each country.

Table 15. Corporate tax rate and inflation assumptions for RoE and WACC calculations

Country	τ	Assumptions and sources	i	Assumptions and sources
Belgium	33.99 %	Official corporate tax rate	2.0 %	The same inflation rate is assumed for all regulatory regimes
France	34.4 %	Regulatory tax rate, CRE		
Germany	30.0 %	Fictional tax rate (corporate, solidarity, trade taxes)		
Great Britain	23.0 %	Regulatory tax rate, Ofgem		
Netherlands	25.0 %	Regulatory tax rate, ACM		

[110] https://www.acm.nl/nl/publicaties/publicatie/11228/Ontwerp-methodebesluiten-TenneT-2014-2016/

As a result, the WACC can be differently calculated according to the corporate tax and inflation considerations. We will calculate two different types of WACC. Table 16 describes these types of WACC and their calculation, for a **nominal post-tax** return on equity *RoE*, a **nominal** cost of debt *CoD*, a notional gearing g and a corporate tax rate τ.

Table 16. Formulas of the different possible types of WACC

Type	Description	Formula
Nominal pre-tax	Nominal value + increase of RoE for tax	$WACC_{N,preT} = g.CoD + \frac{(1-g)}{1-\tau}.RoE_{N,postT}$
Nominal vanilla post-tax	Nominal value, simple formula	$WACC_{N,VpostT} = g.CoD + (1-g).RoE_{N,postT}$

As the notional gearing is not the same in the different regulatory regimes, we used, for the case of RoE, an adjusted value corrected for a notional gearing of 60% (this value will only be different for the regulatory regimes using a gearing different from 60%, i.e., the Dutch and the Belgium regimes). This allows to have a better comparability between the regulatory regimes. The formula used to do so is as follows:

$$RoE_{nominal,post-tax,g=60\%} = \frac{WACC_{nominal,post-tax} - CoD_{nominal} * 0.6\,(1-\tau)}{1-0.6}$$

Tables 17, 18 and 19 then respectively compare the levels of RoE, CoD and WACC for the five regulatory regimes after adjustment for comparability (corporate tax, inflation). Two types of values are presented in these tables. The values given by the regulators are indicated as bold. And we have computed the values identified with a star * the bold values and other assumptions provided by the regulated documents. Note that WACC is computed considering the notional gearing decided by the regulation (which may vary from one country to another).

Table 17. Comparison of Returns on Equity

Country	Nominal pre-tax RoE	Nominal post-tax RoE	Nominal post-tax RoE (g=60%)
Belgium	6.6 %*	4.3 %*	4.1 %*
France	**11.2 %**	7.3 %*	7.3 %*
Germany	10.6 %*	**7.4 %**	7.4 %*
Great Britain	11.7 %*	9.0 %*	9.0 %*
Netherlands	7.4 %*	**5.6 %**	6.2 %*
Average value	*9.5 %**	*6.7 %**	*6.8 %**

Table 18. Comparison of Costs of Debt

Country	Nominal CoD
Belgium	4.3 %*
France	**4.6 %**
Germany	4.2 %*
Great Britain	5.0 %*
Netherlands	**3.9 %**
Average value	*4.4 %**

Table 19. Comparison of Weighted Average Costs of Capital

	Nominal WACC	
Country	**Pre-tax**	**Vanilla Post-tax**
Belgium	5.1 %*	4.3 %*
France	**7.2 %**	5.7 %*
Germany	6.8 %*	5.5 %*
Great Britain	7.7 %*	6.6 %*
Netherlands	**5.6 %**	4.7 %*
Average value	*6.5 %**	*5.4 %**

7 Appendix C: Efficiency targets and cost base

Table 20 summarises information collected on efficiency targets and cost base for the different regulatory regimes.

Table 20. Efficiency targets and cost base for the different regulatory regimes

Country	Efficiency targets (X-factor)	Cost base
Belgium	€25 million for 2012-2015 (0.8% of total allowed revenue and 2.3% of controllable costs)	Controllable costs (OPEX, with exception of ancillary services, usage fees and pension costs)
France	-(RPI - 1%) “other purchases and services” -(RPI-0.3%) “salaries” costs (0.1% of total allowed revenue)	Other purchases and services (OPEX, with exception of losses, ancillary services, salaries, securing costs, taxes) + Salaries
Germany	Static efficiency factor (from ~ 0% to ~ 1%) applied on IC Dynamic sectorial productivity factor (1.5%) applied on TNIC and IC	TOTEX (IC+TNIC) IC → influenceable costs, TNIC → temporarily non-influenceable costs
Great Britain	40% to 50% sharing of efficiency gains +/- 2.5% of additional income reward/penalty	TOTEX (controllable OPEX + CAPEX, excluding RAB)
Netherlands	Static efficiency target (theta = 0.887 for the period 2014-2016) Dynamic efficiency target (1.4% p.a.)	TOTEX (OPEX + CAPEX + RAB)

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