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► **To cite this version:**

Haikel Khalfallah. An assessment of Incentive Regulation in electricity networks: The story so far. 2013. halshs-00931301

**HAL Id: halshs-00931301**

**<https://shs.hal.science/halshs-00931301v1>**

Preprint submitted on 15 Jan 2014

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**ÉCONOMIE DU DÉVELOPPEMENT DURABLE  
ET DE L'ÉNERGIE**

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**Haikel Khalfallah**

**December 2013**

**Cahier de recherche EDDEN n° 9/2013**

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# **An assessment of Incentive Regulation in electricity networks: The story so far**

**Haikel Khalfallah<sup>1</sup>**

**December 2013**

## **Abstract**

Network regulation is playing an active role in a context of restructuring energy systems for long term transition to a smart grid. Regulation of network companies' activities should consider both cost efficiency objectives and other objectives such as quality and network innovation. It is in this context that incentive regulation tools are discussed and assessed in this paper. The aim is to show their key features and how they could be aligned with the main regulation goals. This paper concludes that they should be considered as complementary tools to address conflicting regulatory aspects in an efficient manner.

## **Keywords**

Incentive regulation, electricity, cost efficiency, quality, innovation

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## 1. INTRODUCTION

Electricity network regulation has been conceived to ensure that network services are provided at minimum transmission and system costs and sold at the corresponding efficient tariffs. The regulator has therefore been attempting to put in place the regulatory tool that could alleviate the information advantage the network company holds regarding the real cost of his activities –the adverse selection problem- and the effort he made to perform them –the moral hazard problem. From an economic point of view, it consists of ensuring allocative and productive efficiencies of the provided service<sup>2</sup>. Recently, major changes have occurred with electricity systems that have yielded to the emerging of new regulatory objectives. For instance, new network quality concerns have appeared. Network companies are requested to provide services with respect to system reliability standards and beyond by integrating consumers' preferences. Moreover, climate change policy is now a key driver of the EU energy policy and grid innovation becomes a reality<sup>3</sup>.

Several incentive regulation tools could in theory incentivize companies to provide services in an efficient manner, by considering both classic and new regulatory objectives; and to engage them in a continuous process allowing the revelation of their private information.

The literature proposes a large number of research projects that have focused on describing different incentive regulation tools either theoretically (Decker, 2009, Joskow 2008) or by looking to their practical implementation (Camboni and Rondi, 2010, Joskow, 2006, Jamasb and Pollit ,2007, 2008). The textbook model of regulation assumes that the regulator could control the network operator's costs as a whole while in reality they are the outcome of different tasks with different characteristics. Rather, some regulatory aspects such as uncertainty on network environment and risks consideration by network players would require adopting the appropriate regulation mechanism that internalizes the specific regulatory constraints. How to align the regulatory tools with the regulatory objectives should also be thoughtfully addressed before the construction of the regulatory regime.

The focus of this paper is so to compare, rather than describe, incentive regulation tools in relation to the most relevant regulatory aspects and their possible alignment with regulatory goals. This comparison study aims also to analyze whether the tools complement or substitute each other, and how they could be combined within a standard regulatory arrangement.

This paper starts by wondering why regulation must be incentive. The paper then discusses theoretically the most relevant incentive regulation tools –price cap, menu of contracts, performance-based and yardstick regulations- by providing a brief description, considering some of their major advantages and disadvantages and showing some examples of their use in practice. They are then compared with each other regarding the most relevant regulatory aspects. The

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<sup>2</sup> The classical objectives of the electricity network regulation were to seek for allocative efficiency which means that the regulated prices of services should be as close as possible to the regulated companies' costs; and productive efficiency which implies that company should produce at minimum cost.

<sup>3</sup> Dynamic efficiency is the third classic goal of regulation. Companies have to develop efficient and applicable innovation in their internal activity process. However, grid innovation required for instance, to ensure the integration of renewable energy sources and to improve the demand side management could be considered as a new regulatory objective. The network company has therefore to consider them as a new task in its activity process that would need new input and costs to provide the required output.

paper focuses in the third section on how these regulatory tools could be aligned with the main regulatory goals.

## **2. WHY INCENTIVE REGULATION?**

Before discussing the need for incentive regulation, it is useful to start by reminding the main regulatory objectives and then to show why the historical regulation in terms of cost of service regulation fails to meet, to some degree, these regulatory goals.

### ***2.1 Regulatory objectives***

An optimal regulation should pursue at least four objectives. Firstly, to guarantee productive efficiency by ensuring that the regulated firm is providing services at the lowest cost. Allocative efficiency is the second objective. Prices must be as close as possible to the costs of the provided services to prevent the grid companies from earning excessive rents while ensuring their economic and financial sustainability. These two classical objectives are constrained in practice by the degree of asymmetry of the information shared between the regulator and the regulated firm. The regulator is by far not able to observe the real level of firm's cost and to investigate whether the firm is making its best managerial effort in terms of reducing costs and increasing efficiency. Another two new or renewed objectives which have arisen recently are: the improvement of quality of service<sup>4</sup> and the development of an innovative grid.

One could argue that these objectives are conflicting and difficult to realize if they are considered separately. For instance, encouraging companies to reduce costs could indirectly lead to a deterioration of the quality of the provided service. Rather, innovation is costly and presents a high risk for the investor. Regulation should indeed strike a proper balance between innovation objectives and efficiency objectives while guaranteeing the firm's financial sustainability in the long run.

It is to say that the best regulatory regime would be the one that could resolve the information asymmetry problem and propose the right tools that mitigate the conflicting implementations needed to meet all regulatory objectives.

### ***2.2 Failure of cost based regulation***

Regulation of electricity network companies after liberalization has obviously focused on controlling the costs of services provided by the regulated firm<sup>5</sup>. The aim was to prevent it from exercising market power and protect consumers' economic interests. The regulation proposed for a long time was a cost-based regulation, known as cost-of-service or cost+ regulation. It is based on the simple principle of compensating the regulated firm up to its cost. The regulator audits and observes, generally each year, the firm's operating and investment costs and sets the allowed

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<sup>4</sup> In the electricity industry, quality is related to the reliability of supply and to consumer satisfaction. It is clear that the quality standards the network company should meet are directly related to operation and maintenance costs, as well as to investment. Cost efficiency could lead to the deterioration of quality. That is why regulation is explicitly defining quality standards, or more precisely preventing quality deterioration, which is an expected result of monopolistic activities seeking profit, as an economic objective to be fulfilled.

<sup>5</sup> In spite of the fact that some kind of incentive regulation has been used before the liberalization, the use was however scarce and specific to some cost items without acting as a whole regulatory arrangement.

revenue for the next year. This revenue includes a reward in the form of a rate-of-return that allows compensating the firm's capital assets.

It is widely argued that this kind of regulation would not be efficient to meet the main regulatory objectives (Joskow, 2008). Productive efficiency is difficult to get because no incentives are given to the regulated firm to reduce costs. Allocative efficiency would be ensured only if the regulator is able to confidently audit or observe the firm's incurred costs.

While quality of service and innovation could be improved with such a mechanism, since additional costs will be passed on to consumers, without any explicit requirement from the regulator to improve them, by defining the level and the type of quality and innovation targets, the firm has no incentive to do it – any potential gain will also be reflected in price reductions.

In very general terms, with this regime the regulated firm keeps the benefit from its informational advantage<sup>6</sup>. Rather, it is not incited at all to reveal one part or all of its own information. On the other hand, the firm has no financial incentive to get from any future costs and quality improvements. This can push the firm to act as a neutral or passive player. Consequently regulation needs to be more incentive. Incentives have to drive companies toward meeting regulatory objectives while guaranteeing their financial sustainability.

### ***2.3 Need for Incentive Regulation***

An incentive regulation is a regulatory regime that defines the implementation rules of regulating network companies to provide services in an efficient manner and aligning their individual interests with regulatory short and long term goals. Facing the significant problem of asymmetry information, the goal of an incentive regulation is to engage companies in a continuous process that allows them to reveal their private information.

Incentive regulation could be implemented totally or partially to regulate a firm's activities. This would depend on several criteria related mainly to the nature of the regulatory variables – input or output-, to the type of the regulated costs –whether they are controllable and predictable or not-, to the skills of the regulator that constrains his ability to choose and to implement the appropriate regulation scheme and to the regulated firm's profile in term of risk aversion. For instance, operating costs (OPEX) could be regulated by a cost based mechanism if the regulated firm is sufficiently efficient, meaning that there is no need to incentivize firms to reduce costs beyond those efficiently realized. On the other hand, in the case where the regulator is unable to observe a firm's effort in terms of cost reduction, an incentive regulation should be applied. Regarding investment decisions that induce investment costs (CAPEX), they are in most of the cases regulated by cost plus regulation, in order to avoid underinvestment and all risks related to network reliability. But on the other hand, this approach, it is argued, yields imprudent investment choices and overinvestment in assets and facilities (Averch and Johnson, 1962). Strongly linking costs and prices somewhat reduces the incentive for engaging efficient investments. That is why a major concern is now growing about regulating CAPEX with a specific kind of incentive regulation.

Quality on the other hand is an output variable. If the regulated firm does not provide services that meet at least the minimum standards of quality, the impact in terms of consumers' losses will

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<sup>6</sup> At least due to its unobservable effort.

be higher as well as difficult to quantify. In theory, consumers should be paid the costs they incur due to a deterioration of the quality of the service they pay for. In the same manner, firms providing services with high quality should be rewarded. It consists of creating an economic link between the social value of quality and its incurred cost. This could be done by applying a specific incentive mechanism that helps to value the quality and in turn reflect it in the pricing of the services.

The optimal implementation of incentive regulations tools regarding the regulatory variables and regulation aspects will be more developed in the further section when defining and comparing the most suitable regulatory tools applied nowadays.

### 3. INCENTIVE REGULATION TOOLS

Since an incentive regulation regime would mainly act on thwarting the asymmetrical information problem, we define the different regulatory tools by focusing mainly on how this issue is addressed. Second, we explain in which circumstances we need to move from the one to the other by showing their key features and drawbacks. We end the section by comparing them regarding the most important regulation issues.

#### 3.1 Price Cap Regulation

##### Description

Contrarily to cost-based regulation, price-cap regulation requires the regulator to set a maximum allowed price (or revenue<sup>7</sup>) that the firm can charge for each service/good provided for a specified period –several years- so as to be partially or totally linked to its regulated costs. As the regulatory period is relatively higher than cost + regulation, the incurred costs could be much lower than the earned revenue which allows the firm to benefit from its cost saving. The price cap over the regulatory period is set via a specific formula<sup>8</sup> that evolves according to three main factors: the reference price determined and settled by the regulator at the beginning of the regulatory period, the movement in general inflation (RPI) and an assumed rate of productive efficiency factor (X)<sup>9</sup>. These three factors may be set by the regulator unilaterally after negotiation with the regulated firms or via some technical models.

The reference price could be linked or unlinked to previous or expected costs (Grote et al. 2010). In the linked approach, the regulator assesses *ex ante* the efficient levels of both OPEX and CAPEX or separately, based on historical levels. The unlinked approach supposes an automatic adjustment revenue formula deduced from an initial firm's cost level in a pre-specified year.

However, the price path is completely linked to inflation by reflecting the effect of the unpredictable rates of inflation in an economy on the allowed revenue. It is also linked to the

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<sup>7</sup> The concept of revenue cap regulation is similar to the price cap one. The revenue of the firm is capped and adjusted according to an efficient factor while under price-cap regulation the price charged to consumers is adjusted.

<sup>8</sup> There are four basic types of price caps that have been applied in practice: setting *ex ante* a constant revenue cap and independent to demand fluctuations; setting an allowable revenue per unit of output; a hybrid cap that allows for both fixed and variable revenue constraints; and a weighted average price cap settled on the basis of a basket of prices of services.

<sup>9</sup> It is commonly called the RPI-X approach.



productive efficiency factor that defines the efficiency target the firm should respect. This factor is adjusted when moving from one regulatory lag to the next, by taking into account past efficiency performances and expected changes in growth and earnings.

Ideally, the price cap is formulated to cover all firms' controllable costs<sup>10</sup>. It is argued that a firm is able to influence them as to what it realizes efficient operations involving efficient costs. For the uncontrollable ones<sup>11</sup>, they are either recovered *ex-post* and separated or added in the revenue path via an adjustment factor that allows them to pass them through to consumers. In practice however, it is a difficult matter for the regulator and the regulated company to reach an agreement on the controllability nature of some cost items.

Another key aspect of price regulation is the length of the regulation period. The basic principle underlying this regulation regime is to extend the time period between two subsequent price reviews. A typical period in the energy sector is in the order of five years. It follows that the regulated firms could benefit from its cost-saving efforts in contrast to cost-based regulation where costs are reviewed yearly and any cost saving is passed directly to consumers.

### Evaluation

Regarding regulatory objectives, one could argue that price cap regulation would ensure productive efficiency. It provides simple and clear incentives for cost reduction which would increase social welfare in environments with asymmetric information. This does not mean that the asymmetrical information problem is totally resolved. The problem of adverse selection is still unresolved. In fact, in cases of a lack of regulator's expertise and ability to properly check and audit firm's costs, firms would earn excessive rents within the regulatory period<sup>12</sup>. But here one could say that since regulation is a repeated game, the regulator's learning curve is increasing with respect to the succession of prices reviews (Bauknecht, 2010). Firms' over profits will give the regulator good signals when adjusting initial prices at the beginning of next price reviews to reflect on it any changes in underlying costs.

How to set this price is an important issue faced by the regulator. Setting it sufficiently close to the incurred or projected costs would ensure more pricing efficiency but on the other hand deprive firms from the benefit of its cost saving. Firm experiencing or expecting this regulator's attitude can either limit its cost reduction efforts when getting close to the next price review or manipulate its declared costs or profit to "protect" its realized cost saving. In cases of higher price caps or unlinked caps<sup>13</sup>, firm keeps the total rents from cost reduction that drops off consumers' surplus. In sum, the attractiveness of this approach depends on the extent to which network operator's specific information is used when resetting prices. The regulator might set and adjust initial prices regarding the optimal trade-off it requires between allocative efficiency and productive efficiency objectives. Related, it was argued that a rolling price cap that ensures the

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<sup>10</sup> It typically includes the costs of operations, salaries, maintenance and investment costs.

<sup>11</sup> It consists of the costs where the network operator is unable to act on them.

<sup>12</sup> On the other hand, the main benefit of price-cap regulation compared to cost+ regulation is the reduction of regulation costs. Regulators require less auditing and information collecting of a firm's costs by assuming that by not controlling its costs, firms will have strong incentive to reduce them.

<sup>13</sup> Unlinked price caps do not link revenue to cost during the regulatory period and do not require cost projection. It is however defined based on a firm's incurred costs in a reference year or via benchmarking techniques (see section 2.4).

regulated firm keeps a part of its benefit from cost savings when regulator reviews reference prices would be the most efficient way to protect consumers' surplus and to continue providing firms incentives for cost efficiency (Saguan et al., 2008).

Price cap regulation may also expose the regulated firm to higher levels of inefficiency risk over his controllable activities. While with cost based regulation the risks associated with inefficient performances are completely shifted to consumers, inefficient firms would incur a greater risk<sup>14</sup>. In the same manner, the regulator faces a great risk of error when setting initial prices, demand evolution expectation and main parameters of the allowed revenue formula. That is why an adjustment factor is added to reflect the occurrence of any unexpected change or event. One could say that the learning effect has a potential positive repercussion on both regulator and regulated company's sides to adjust correctly the revenue formula for the former and to undertake only efficient decision for the latter.

Regarding this discussion, the nature of regulatory variables and the regulated costs have a direct influence on the implementation of this regulation regime. Firstly, we have to distinguish between controllable and non controllable costs. For the former, a price-cap regulation would be appropriate. Knowing the allowed revenue path that should in theory target the projected efficient cost, firms have to reduce these costs and operate efficiently. There are, however, a number of recognized uncontrollable costs associated with unexpected events or changes in taxes and environmental regulations that occur during the course of the price cap plan. There is little to be gained by making the regulated company responsible for these costs and to bear the total risk of their occurrence. Pass-through provisions are suitable for this. It is also reasonable to suppose a certain threshold from which they are eligible for pass-through.

Another important issue should be considered when evaluating price cap regulation is to look at whether operating and investment costs are assessed separately or as a total cost (TOTEX) approach. We can say that a separation is appropriate for two reasons<sup>15</sup>. Firstly, investments in network infrastructure are long term assets. The regulated company would incur a higher related risk due mainly to the uncertainty on future demand and to possible changes on regulatory regime, once actual regulation period is expired. Investment costs are high especially in the years that follow investment decisions, however, possible benefit and return on investment should occur for a long time after the regulation period when investments are made. Secondly, the regulator faces a higher information asymmetry and uncertainty when assessing the cost-benefit of investment cost compared to operating costs. On this basis it is suitable to separate CAPEX from price-cap regulation and compensate them by cost of service regulation –with a specific adjustment mechanism that prevents over investments<sup>16</sup> and incentives to shift some operating costs to investment costs<sup>17</sup>- or by a specific incentive regulation scheme that takes into account

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<sup>14</sup> A potential reward is also expected whenever it realizes a great cost savings.

<sup>15</sup> TOTEX regulation is still however more appropriate from a point of view internal coordination and trade-off between OPEX and CAPEX that a regulated firm undertakes when taking decisions.

<sup>16</sup> With cost of service regulation, the risk of over-investment is widely recognized since any capital expenditure is passed through to consumers (the so-called “Averch-Johnson” effect).

<sup>17</sup> In practice, investment planning is subject to intense negotiation between the regulator and the regulated firm. The regulator could use external audit to estimate the efficient investment plan and call for *ex post* control in order to make the right adjustment whenever a difference arises between the expected investment program and the realized one.

the factors discussed above. Price cap regulation is therefore appropriate to regulate only operating costs.

Costs linked to the improvement of quality of provided services should also be excluded from the price cap<sup>18</sup>. By giving incentives for cost reduction over a specified regulatory period, it can lead to the deterioration of quality of service as improving quality is costly. Quality consideration, and also innovation since both require additional costs in the short run, have to be incited via additional and separate mechanisms. This issue will be discussed in detail in the next section.

In sum, price cap regulation is a central regime that gives good incentive for cost reductions although it has to include additional schemes to mitigate some complexities that arise from the nature of regulatory variables and to address other regulatory objectives beyond the economic ones.

### Implementation in practice

Transmission and distribution networks in the world are usually regulated by a revenue cap regime, mixed with other incentive mechanisms. Controllable operating costs are the main variable on which the regulatory regime acts. Investment costs on the other hand are frequently treated separately as a building block approach. The application depends also on the way the main characteristics of revenue requirement path are estimated. For instance, revenue caps are linked to the operating costs projection in the UK and Australia. They are however unlinked in Austrian and Norwegian<sup>19</sup> models (Grote et al., 2010).

In United Kingdom, OFGEM (Office for Gas and Electricity Market) sets an annual amount of authorized income over the regulatory lag for operation expenditures and adjusts it according to the difference between observed and *ex ante* expected demand and the variation of certain items of expenses that are out of control. The productivity factor is set *ex ante* based on external audits and statistical comparisons<sup>20</sup> and the initial revenue is linked to the income observed in the last year of the previous regulation period (Ofgem, 2009). Risks due to the demand uncertainty and to uncontrollable costs are compensated *ex post*. A price-cap regulation that controls OPEX was also used in France since August 2009. A regulation period of four years is applied where annual maximum price is indexed to inflation, to an exogenous productivity factor and to a coefficient that compensates *ex post* non controllable charges. It is however somehow close to cost + regulation as any difference between real and projected costs is recovered *ex post*. However, the company has the opportunity of keeping 50% of cost savings when controlled operation costs are inferior to the ones estimated *ex ante* by the regulator (CRE, 2009).

In the Netherlands, while a price-cap regulation is applied to the distribution network with a productivity factor determined differently from OFGEM – average productivity of the sector observed over the previous period-, a revenue cap approach is used to regulate operation expenditure of transmission network (Source). Compared to the UK case, a TOTEX approach is implemented where the network company has incentive for improving all its categories of costs.

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<sup>18</sup> This doesn't mean that all costs linked to quality are completely separated from those needed to provide services. It consists in fact of setting up the price cap that corresponds to a standard level of quality and applying an additional mechanism to encourage improving quality or prevent it from deteriorating.

<sup>19</sup> Actually, the Norwegian regulator is using benchmarking techniques instead of revenue cap regulation.

<sup>20</sup> Principally for the distribution network.

This is also the case in the Norway electricity industry where a revenue cap approach controls total costs of the transmission system operator, for a regulatory period of five years. The Norwegian case has the particularity of defining maximum and minimum limits for the allowed revenue. In addition, any gap between the allowed revenue and the realized revenue will be completely reflected in terms of price variation in the next year. The regime is incentive as initial revenue level is estimated based on the realized average cost in the last regulation period, which consequently gives the regulated firm the opportunity to take benefit partially from its previous cost effort (Nielsen, 2010).

### ***3.2 Menu of Contracts***

#### Description

Cost + and price-cap regulations are, in theory, the two extreme cases in term of risk and gain sharing. The menu of contract lies somewhere between these two extremes. The price that the regulated firm can charge is linked partially to the realized costs observed *ex post* as well as to a reference cost determined *ex ante*. The regulator offers companies a set of profit sharing contracts<sup>21</sup> and the firm chooses the more suitable one regarding its projected expenditures, its efficiency capability<sup>22</sup> and its risk aversion.

This regulation mechanism is proposed to be applied for regulating total firms' costs as well as some items of its controllable costs. For instance, applied to investment costs, once correctly constructed, the mechanism allows consumers and firm to share the risk of very high profits or losses i.e. the rate of return that the firm will earn within a specific period is linked to the observed changes in these costs and prices will be adjusted to meet the targeted rate of return. Regulators could also propose a set of revenue-productivity couples that relies the corresponding revenue to the realized productivity improvement. Any gap between the target and the observed efficiency improvement will be reflected in the final price by an adjustment factor that specifies how profit gains or losses are shared between the network company and consumers (Decker, 2009).

#### Evaluation

It is clear that theoretically such mechanisms would ensure both productive and allocative efficiency objectives. It provides incentives to reduce costs by giving the firm the opportunity to benefit from its cost savings and on the other hand ensuring that prices follow underlying cost variations within a reasonable group.

As regards to the asymmetric information problem faced by the regulator, by proposing a menu of sharing contracts, this instrument allows a wide range of trade-offs for controlling levels of adverse selection and moral hazard problems. It is well appropriate when the regulator faces a high level of asymmetric information. In fact, it is designed so that the firm has an incentive to reveal its true type. In optimal conditions and assuming that the menu of contracts is correctly

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<sup>21</sup> A profit sharing contract is a contract that sets up the efficiency target the firm should meet within the regulatory period and how gains and losses will be shared between the regulated firm and consumers. However, when proposing different profit sharing contracts and offering the regulated firm the opportunity to choose one, it is called a menu of contracts scheme.

<sup>22</sup> By efficiency capabilities we mean the real firm capacity to operate more efficiently. This information is however private and firms should be incited to reveal it.

constructed, the firm will choose the optimal contract that fits with its characteristics (Joskow, 2008).

However, it requires a high regulation cost in term of collecting past data and estimating the appropriate relation ship trend between the regulatory variable target, i.e. CAPEX, and the respective remuneration and profit sharing path. The regulator stills facing a high risk of error mainly at the first periods of its implementation. We can expect that its learning curve will highly increase after observing a firm's choice so that further proposed contracts would fit more with the firm's type and the risk of error would be significantly decreased. From the regulated firm's point of view, any risk of inefficient performances or a bad expectation of its efficiency target will be shared with consumers. They are so much more protected against risk compared to regulation with price cap. We can also add that it is appropriate when a conflict arises between the regulator and the regulated firm concerning the appropriate level of investment or the method of cost recovery. Indeed, the projected efficient costs or investment programs of the regulated firms are frequently far from those accepted by the regulators which are estimated via external audits.

We notice that it could be used in combination with price/revenue cap to control for instance CAPEX or the productivity factor. The regulator could leave network managers choosing their desired productivity target among a menu of options. Consequently, it is allowed to obtain higher profit if it chooses more demanding productivity targets. The problem, however, is how to set the upper bound of profit *ex ante* so the menu of contracts remains attractive for firms to select an ambitious contract.

Regarding the nature of the regulatory variables, it would be most suitable to control investment costs rather than operating costs. Investment is much riskier for the regulated firm than other decisions and requires a recovering regime that evolves closely to the payment of future capital costs. A commitment from the regulator for a recovering scheme over the length of the investment project is therefore needed to enhance investments. On the other hand, under the previous regulatory tools, the company could inefficiently invest or be encouraged to capitalize some operation costs. Both these issues are widely addressed by this regime as the company has incentive to choose its true and efficient investment plan as well as it is assured to be protected against risks in financial and energy markets and independently on the length of the regulatory period applied for the remaining activities<sup>23</sup>.

In sum, it is well suggested to adopt this scheme to aspects where there is substantial information asymmetry between a firm and the regulator.

#### Implementation in practice

In practice, this regulatory tool was first introduced by OFGEM in its previous price control review 2005-2010 to incentivize CAPEX in electricity distribution. The distribution network company chooses a target of investment among a set of incentive contracts. It was observed that when the chosen contract is close to the one recommended by the external audit, a high remuneration is obtained by the company in case of cost savings. In contrast, the remuneration will be low.

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<sup>23</sup> The menu of contract should specify how the capital expenditure would be covered within the lifetime of the investment project.

### ***3.3 Performance-Based Regulation (PBR)***

#### Description

Performance-based regulation has been recently used to replace or combine targeted incentive plans in the electric utility industry. It gives a direct link between a financial reward and penalty and the company's performance (Vogelsang, 2006). The regulator sets a specific formula *ex ante* that relies on the financial reward-penalty scheme for the expected firm's performance for some regulated tasks. This formula requires that the regulator properly defines three parameters. Firstly, the targeted performance is set to reflect past firm's performances and so, those the regulator believes the company could meet within a specific period. It therefore links the company's remuneration to its past or projected controllable costs rather than its realized one. Second, the regulator should estimate the economic link between firm's performance to the financial counterpart that will be either a reward or a penalty. Finally, it should be able to set a rational boundary on the financial incentive to ensure an adequate incentive that reflects the system's need for efficiency.

To achieve substantial improvements in long term performances, a commitment period of several years is usually applied.

#### Evaluation

Performance-based regulation is more incentivizing compared to previous mechanisms as it defines an explicit financial incentive for achieving specific performance goals. Moreover, the company obviously knows how it will be rewarded once it goes on efficiency objectives and how it will be penalized when it fails. This however, requires that the mechanism is well-structured to reflect on the one hand the true industry's need for efficiency, in terms of cost reduction, additional investment and quality improvement for instance, and on the other hand, the real capability of the regulated company to meet the efficiency target and avoid an over-reward or over-penalty. The regulator's risk of error is so much greater and needs a huge investment in collecting data and estimating the performance target. On the other hand, the regulation costs are high at the beginning of the regulatory period but lower in the next. Indeed, no cost observations are required within the regulatory period. The regulator gives grid company a significant discretion in how it achieves the efficiency goals.

One could assume that this mechanism is a specific case of menu of contracts regulation. Assuming that the regulator is facing a great information asymmetry problem, it defines an earning sharing rule without controlling neither the firm's realized cost nor the allowed revenue. It gives, however, the rule of sharing the gap between the realized performance and the targeted one. Once performances are observed, the regulator will know more about the firm's type and next adjust the reward-penalty formula. Instead of offering different contracts with various combinations of how potential profit will be shared with customers, the performance-based scheme constructs a more explicit function that properly relies a firm's remuneration and customers benefits on a firm's performances. In menu of contracts regulation, by choosing one profit sharing scheme among those proposed by the regulator, the firm knows how it will be rewarded and penalized when it delivers superior performances and sub-par performances respectively. This is the same functioning with a performance-based regulation, except that firm here will only decide its performance level.

In theory this scheme could be applied to regulate all of the regulatory variables. However, regarding the nature of operating and investment costs, where the regulator is generally unable to observe past firm costs or it is very costly to do so, it would be inappropriate to target economic efficiency goals on the basis of reward-penalty scheme. However, a firm's performance on quality is much easier to control and to improve via this scheme. The regulator is well informed about the quality standard that the system should ensure and can so encourage network companies to maintain or improve service quality by adopting this scheme. Companies proposing services below some quality standards should be penalized due to the consumers' welfare loss. Conversely, improving the quality beyond the target should be rewarded by compensating the incurred cost of improving quality and giving good signals to maintain reliable systems. The main difficulty is however to determine the economic link between the cost of quality improvement and the consumers' value of quality of service. The efficiency of this scheme depends therefore on how the regulator is evaluating the value of quality for consumers and coupling it to prices<sup>24</sup>.

#### Implementation in practice

Initially, performance-based regulation was used to regulate plant availability and operating costs in the U.S electric utility industry. We can also observe that it was applied either via a price adjustment within a price regulation scheme and for a specific regulatory variable .i.e. quality; or as a separate scheme with a specific revenue formula.

Nowadays, it is widely used to encourage improvement of quality of supply. In the UK for instance, targets in terms of the frequency and the duration of the cuts of supply might be reached by the electric distribution companies. The gap induces a reward or penalty capped by an upper limit for gains and a lower limit for losses. The same scheme is applied for the transmission system where rewards or penalties induce a variation in the annual revenue. The marginal penalty/reward is based on an analysis of the companies' historical performance. In Italy, the total penalty/reward is not capped but depends on the estimated difference between the actual and projected quality improvement. In France, a capped and continuous Bonus/Malus is used to regulate transmission and distribution system quality in terms of the continuity of supply.

### ***3.4 Yardstick Competition***

#### Description

Yardstick competition is a way to set regulated prices not based on past or projected regulated firms' costs but on the performance of other similar network companies. The company is benchmarked with the remaining companies in the industry or with efficient companies that operate in other regions. In its full form, companies have no control on their revenues. Their allowed revenues are fully linked to an index of the performance of other suppliers. A second approach links only one part of firms' revenues to external performance.

In summary, yardstick competition is a mechanism that offers a technique to measure the performance that regulated firms have to achieve regarding regulation objectives. There are three general techniques generally used. The frontier-based benchmarking method estimates the efficient performance frontier on the basis of the most efficient firm in the industry. Several

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<sup>24</sup> The regulator could estimate the value of quality by consulting grid users (Glachant and Brousseau (2010)).

techniques like Data Envelopment Analysis or Corrected Ordinary Least Square are used for the benchmarking. Mean and average benchmarking is another tool to estimate a specific performance target. The benchmark is for instance estimated based on the mean or average of the costs of a group of firms or on the historical productivity growth of the sector. Techniques like Ordinary Least Square are typically applied. International comparisons are another group of benchmarking methods applied mainly when the industry is characterized by a small number of distribution and transmission utilities.

### Evaluation

We can say that the main reason why a regulator uses yardstick competition to regulate network companies' activities is its inability either to set properly regulated prices or to control firms' costs. Since information is crucially important in the regulatory process, benchmarking could be a good way of regulating several firms so as to let them take advantage of their information superiority in a way that induces them to reach the targeted performance. Compared to price cap and profit sharing regulations, where the information asymmetry is the central problem, with benchmarking the regulator is addressing this lack of information by assuming that given that efficiency and improvement are reached in other similar sectors or for other firms, the regulated firm under its control is able to improve similarly its functioning, all other things being equal.

While the regulator could lower the risk of error when applying this scheme, the least efficient suppliers bear a great risk of failure, unless it is applied as a complement to other regulatory tools where firms' risks are partially shared with consumers. That is why it is a well suited tool for a sector where companies are sufficiently homogenous in terms of cost structures and where they are providing similar services and facing the same market conditions.

The regulation costs induced by benchmarking are much higher compared to previous regulatory tools. In fact, it requires a costly information collection and analysis in terms of time and money to carry out the appropriate analysis properly. Indeed, collecting and standardization of data and ensuring a significant quality of data is a complicated issue. A considerable effort has to be made by the regulator to improve data standardization and accuracy. Regulators should also seriously consider the risk of strategic behavior or gaming by firms that can sometimes produce illusory efficiency improvements. The risk of tacit collusion is great by presenting for instance performance in a more favorable light or by distorting the efficient operation and investment decisions in order to lower efficiency targets.

Despite these issues, benchmarking can provide strong incentives for efficiency performance. Applied separately or combined with price cap approach, the target performances in terms of indicators such as operating costs, required investment plans and quality would be thoughtfully reached once relevant adjustments are made to consider structural differences between the reference sector or firm and the regulated firm.

### Implementation in practice

In practice, a yardstick approach has been applied mostly as a complement to price/revenue cap regulation, especially to estimate the possible productivity gains and to set the target for quality improvement or acceptable thresholds for losses. Distribution firms' operating costs in the



UK are actually regulated based on a benchmarking approach that imposes an annual productivity target of 3% on average. Similarly in the Netherlands, benchmarking techniques are used to regulate operating costs of both distribution and transmission network companies. A comparative DEA cost analysis determines the average productivity of the sector over the previous control period and re-sets it for the next one. The Dutch regulator regulates quality of supply based on the yardstick competition concept. After setting a pre-defined quality target, any gap is reflected by dynamic prices adjustments and any benefit from better cost and quality tradeoffs are transferred to consumers.

### ***3.5 Mapping incentive regulation tools to regulation (exogenous) aspects***

The purpose of the above section was to briefly describe and evaluate the key attributes of the main incentive regulation tools that have been applied nowadays. We look now at how the approaches are relevant regarding various regulation aspects that are likely to be important in any form of regulatory arrangement.

#### **Skills, resources and information requirement for the regulator**

As noticed above, one of the aims of an incentive regulation is to reduce the information asymmetry between the regulator and the regulated firm. The regulator lacks information about the firm's cost structure as well as its risk profile. The perfect incentive regulation tool will be the one that helps knowing the type of the company. It consists of designing a super revelation mechanism that gives the firm a pass to how it gets money in order to know its type. We can argue that both menu of contracts and performance-based mechanism are the most helpful in terms of type revelation process. By choosing its optimal contract in the former and its performance level in the latter, the firm is giving the regulator the right signals about its type which will help the regulator to adjust its proposed regulation to fit more with the right capability of the firm under control. Price/revenue cap regulation is not an information revelation mechanism as it still ensures that the firm is making its best managerial effort. However, the firm's costs are not observed over the regulatory period and the regulator is still unable to set the price that reflects really the pricing efficiency goal.

In contrast, with yardstick competition the regulator is looking forward to what the regulated firm could efficiently realize regarding the best performance observed in similar sectors or firms. It should be a right tool to counterbalance the information asymmetry problem only if the performance target is well estimated.

In spite of the way used to reduce the asymmetry problem, all incentive regulation tools need a somewhat high regulation cost, mainly at the beginning of the regulation process, in terms of collecting relevant data and estimating the appropriate efficiency target, either based on statistical comparisons with yardstick competition or by past data and performance collection and analysis with the others. Although this cost decreases when passing from one regulatory period to the next since the learning capability of the regulator is an increasing function of the firm's information revelation process. It follows that the risk error of the regulator is higher in the first round of regulation but much more controlled the next, except with yardstick competition and performance-based mechanisms where they are supposed to give strong information to the regulator on what the regulated firm is able to carry out.

The type of the information requested to set allowed revenues and performance targets differs significantly under the different frameworks. Linked price cap regulation will typically refer to historical costs to estimate the projected ones and on the basis of this, to set the allowed revenue. It is attractive as revenues are linked to the projected costs. In the unlinked regime, the allowed revenue will be adjusted via an automatic formula based on the calculation of an initial cost level in a pre-specified year. Performance-based regulation will look backward to past firms' performance which is quite similar to unlinked price cap regulation while yardstick competition looks to the past overall sector performances. One could argue that when a regulator's skills are lower at the collecting information stage and at estimating regulated firm's costs, yardstick competition would ensure more secure information on the potential efficiency of the regulated firm and in turn, links the allowed revenue within the regulatory period to the company's optimal performance much better. It also could be used as an input to the other approaches to estimate some important parameters such as the productivity factor with price cap regulation and the performance target with the performance-based regulation. When the regulator has more access and control on regulated firms' private information –when the network is recently privatized for instance- price cap regulation would be sufficient.

#### Uncertainty and risk for the network company

Network companies are affected by technological and demand changes as well as uncertainty about the future regulatory regime. Undertaking specific decisions –investment and long term innovation decisions- where the expected return is obtained for a long period of time will expose the company to high risk. While cost-based regulation allocates most of the risk onto consumers, incentive regulation tools protects them much more and shifts a large part of risk to the regulated companies. Broadly speaking, with price cap regulations the supplier faces a high level of risk. Yardstick competition increases the risk faced by an inefficient company if the efficiency target is far from its real capability. However, profit sharing mechanisms and performance-based regulation allocate the risk between supplier and users. Even inefficient companies will observe low risk when undertaking risky decisions.

#### Nature of regulated costs

Regarding our evaluation of the different regulatory arrangements, we can summarize that a hybrid approach that combine various elements of the regulatory arrangements would better address specific issues in individual contexts. Broadly speaking, the different tools are on one hand a complement for dealing with the nature of the regulated costs and somewhere could be taken as input variable in another regulatory approach. We can first assume that uncontrollable costs should not be regulated via an incentive mechanism. In fact, they are beyond the control of the supplier and principally linked to unexpected changes in regulation environment. It is appropriate to be passed-through to consumers by adjusting the final price via a kind of correction mechanism that reflects any change of their value in the allowed revenue.

Second, price/revenue cap regulation is more appropriate for controllable operating costs. OPEX are less affected by uncertainty and unexpected events and rely much more on short term efficiency potential. CAPEX however involves a high risk and requires a long period of time to be covered. With price cap regulation, suppliers may have incentive to inflate their need of capital expenditure and it is difficult to reach an agreement between both parties on the assessment of the

required level of investment. Menu of contract could deal with this by diversifying the possible choices of investment plans as regards to different target levels of capital expenditure and their respective returns on capital.

Quality could not be regulated under price cap regulation or within a mechanism that is proposed to increase cost efficiency due to their conflicting objectives. One solution will be, as usually applied in practice, to complete cost regulation by a specific quality regulation scheme. Performance-based regulation is an efficient way to improve the quality of supply since a firm's performance on quality is much easier to estimate by the regulator than, for instance, efficient cost target. Moreover, the optimal quality is reached when the cost of quality equals the benefits that consumers derive from this. A penalty-reward scheme ensures that the cost of improving quality beyond the standard is covered by the reward and that firms are penalized if they fail to provide the minimum quality requirement. Naturally it supposes that the regulator is able to link the consumers' value of quality improvement to the cost that is involved.

Finally, yardstick competition is more appropriate to act as an input in the price-cap regulation regime as well as the performance-based regulation than a full regulation mechanism. Since estimating main parameters of cost efficiency or quality improvement require that the regulator is able to observe or expect firms' costs, yardstick competition proposes a more robust technique to measure them and to deal with incomplete information problem faced by the regulator at this stage.

In summary, an efficient regulatory regime would be a sum of complementary tools that together address conflicting regulatory aspects in an efficient manner.

#### Characteristics of the regulated sector

The number of the regulated companies and their homogeneity are important issues to be considered when looking at the efficiency of an incentive regulation tool. Transmission networks in most of the cases are composed of a small number of companies which involve a high degree of information asymmetry. A regulation that takes the form of menu of contract would therefore be appropriate. Adopting performance-based regulation will however give rise to a difficulty of estimating the performance target if the regulator cannot properly observe the firm's past performance. In the same manner, the benchmarking method would not be promising due to the lack of inter-firm data unless one calls for international comparisons.

In contrast, the distribution network is characterized by a large number of regulated firms. Under a price cap regime, one difficulty is about how to set a unique price cap for all the regulated firms that in practice are experiencing differences in their cost structure and their environment. A yardstick competition would bring a solution to estimate efficiency indicators. We can say that it is more suited for the distribution network where suppliers are homogenous. In contrast, either an adjustment has to be made to account for their heterogeneity or the regulator should discriminate between different types of firms on the basis of their relative efficiency which is however a very costly measure.

#### Length of the regulatory period

Compared to cost-based regulation, incentive regulation mechanisms require a long regulatory period to improve efficiency (Saguan et al., 2008). Reducing energy losses and

improving the quality of service would involve a managerial effort from the company for a long period of time. Under price cap regulation, the regulatory lag does not exceed five years in practice so that the regulator's risk of error is alleviated. The length of the period should also be sufficiently high under the other regimes to allow the regulated firm reaching the efficiency target. For long term issues such as investment and innovation, one could say that a clear commitment from the regulator should be guaranteed beyond the regulatory period. Regulator credibility significantly affects firms' incentives for undertaking costly long term decisions.

Table 1 summarizes the relative positive and negative points and specific characteristics of the four types of incentive regulation tools as discussed in the previous paragraph.

#### **4. ALIGNING THE TOOLS WITH THE GOALS**

The previous section highlighted the main key features of the incentive regulation tools and how they fit with major regulatory aspects. This section presents a description of how the tools could be aligned with the regulatory objectives and regarding the main tasks of network companies.

##### ***4.1 Productive Efficiency***

Network companies like any other company use inputs –resources and technologies- to produce outputs –quantities and qualities-. This process involves a cost that has to be minimized. All incentive regulation tools are designed in theory to reach productive efficiency. We can also observe that in practice, whether the regulatory period is sufficiently high, firms regulated under different types of regulatory tools succeed in cutting grid costs (Meeus et al., 2010).

The incentive regulation tools discussed in this paper define the network company's remuneration *ex ante* and before costs are made. It is widely argued that *ex ante* approaches limit the risk for grid users to pay too much for the services compared to an *ex post* approach that reduces the incentive to minimize costs and can also lead to over-investment. Firms under the latter approach would prefer capital to operating costs<sup>25</sup>. But regarding uncertainty and information asymmetry problems, the regulatory frameworks are in practice between *ex ante* and *ex post*, depending on the nature of the grid company's costs.

We consider now the main items of grid company's costs and whether it would be efficient to regulate them *ex ante* or *ex post* and with which tool.

##### Operation costs

Network companies' operating costs (e.g. labor, maintenance) are a resource input to produce and provide services (i.e. electricity transmission, generators' connection to the grid, etc.). Incentive regulation tools give incentive to minimize operating costs, especially at the front end of each review period to capture benefits early. On the other hand, benchmarking could be more appropriate to target optimal efficiency levels if the regulator is lacking complete information on firm's operating costs. This would lead to unlinking the firm's remuneration to its projected cost but could however increase the risk in regard to firm sustainability and consumers' surplus when the gap between remuneration and incurred costs is important. A correcting mechanism that adjusts the allowed revenue *ex post* to the incurred cost could mitigate this.

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<sup>25</sup> The risk of capitalizing OPEX is widely observed under cost of service regulation (LITT).

**Table 1: Incentive regulation tools comparison**

	Price Cap	Menu of Contract	P-B-R	Yardstick
Revenue Setting	Linked / Unlinked to cost Difficulty in setting efficiency target Trade-off: allocative VS productive efficiency	Menu of Revenue-Efficiency couples	Remuneration Formula Difficulty in setting efficiency target	Indexed to the performance of other network operators
Information Asymmetry	+ Incentive for cost reduction - Over-profit	+Incentive for cost reduction +Allocative efficiency	+Incentive for cost reduction +Allocative efficiency	+ but risk of gaming and tacit collusion (at least in theory)
Uncertainty and risk	- Regulator's risk of error - Network operator faces a high level of risk	- Regulator's risk of error +Network operator protected against risk	- Regulator's risk of error (performance target) + Network operator protected against risk	+ Regulator's risk of error - (full form)
Nature of costs	Controllable costs OPEX	CAPEX Some OPEX items	Quality	Input to calculate efficiency target
Network characteristics	Large number of firms, how to set unique price?	Appropriate for both transmission and distribution	Transmission (well-informed Regulator) Distribution (homogeneity)	Distribution (homogeneity)

Investment costs

Capital expenditure is the main part of resources needed to provide fair service to consumers. Investments are difficult to be regulated because their resulting output is typically realized after several regulatory periods from the one in which the costs are made. This implies that incentivizing grid companies to reduce costs is more complex for CAPEX than for OPEX. Another complicated issue comes from the distinction that should be made between investment needed to expand the network to support changes in supply and demand for network services and

the ones needed to meet non-economic objectives<sup>26</sup>. This yields significant differences between what the regulated firms need and what the regulator believes efficient to meet safe and reliable service. One way to address this conflicting assessment is the menu of contract scheme as discussed in the previous section.

#### Network energy losses

Energy losses refer to physical losses during transmission and distribution through a network. They are a part of system operating costs that occur at the service providing stage. They incur a cost to the network companies to be regulated via an output regulation. A separate performance-based regulation would be the more appropriate for energy losses regulation for two reasons. Firstly, the regulator faces a substantial information asymmetry regarding how the regulated firm is managing its energy losses. Second, giving incentive for cost reduction would involve companies choosing for instance more conventional technologies rather than low-loss ones in order to reduce costs. They have so to be decoupled from the revenue cap regulation and a penalty-reward scheme may be appropriate<sup>27</sup>.

#### System balancing

Transmission network companies have the task of balancing the demand and the supply for energy in real time. It has to buy and sell power in the balancing market to balance supply and demand, to manage congestion and other tasks that keep the system reliable. This implies a cost which again is characterized by a high degree of asymmetry. The cost of system balancing and especially the congestion cost could be related to a lack of adequate transmission capacity as well as to inefficient management of the network. Incentives for reducing these costs can be implicitly given under the right regulatory tool that properly includes adequate capital costs in the revenue requirements. For instance, a new transmission project can diminish congestion by connecting more suppliers that are available to serve load. The right incentive tool should also take into account that grid companies may have incentive to keep their system congested due to the congestion rent they earn in scarcity situations<sup>28</sup>. A cost-benefit assessment of congestion should be widely assessed by the regulator when incentivizing for new capacity addition, especially in the case of interconnection projects.

Benchmarking would give strong incentives to reduce congestion if it is treated as a monitored attribute. Price cap regulation would not be appropriate for reducing congestion. Under this regime, the grid company is incited to go toward cost minimization which implies a little increase in transmission capacities. We can say that a sharing scale approach is suited to regulate the costs of system balancing services, to counterbalance the lack of information about firms' managerial effort of reducing these costs<sup>29</sup>.

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<sup>26</sup> Recent climate change policies in the European Union have led the regulators to consider new regulatory objectives beyond the ones of cost efficiency and system reliability. It consists, among others, of pushing network operators to undertake RD&D spending and to invest in new technologies to connect large-scale renewable sources and distributed generation for instance.

<sup>27</sup> For instance, overall system losses have largely decreased in the UK since a penalty-reward scheme was applied (Jamash and Pollit ,2007).

<sup>28</sup> In Spain, congestion revenues are deduced each year from the allowed revenue.

<sup>29</sup> Ofgem sets a sharing scale formula each year to regulate the level of the costs of system balancing services. The formula defines a target and a sharing level of profits and losses.

## ***4.2 Allocative Efficiency***

Incentivizing grid companies to reduce their costs will indeed increase social welfare while an optimal level is reached only if the pricing of the regulated services ensures both financial sustainability of the service provider and that consumers are paying the right cost of these services. That's to say that likely cost savings have to be beneficial for both service providers and consumers.

Regarding this optimality condition which is the second economic goal of regulation, all the incentive regulation tools discussed in the above section would ensure pricing efficiency, once some adjustments are made on their implementation and upon the condition that the regulator is able to observe a firm's realized costs or to estimate it. Price-cap regulation in its pure form relies on how the regulator uses actual costs to adjust the remuneration for the next period. By linking the remuneration to the actual costs, we can however expect that the grid company would act strategically by reducing the weight of its cost savings, at least in the last year of the review period. This behavior would induce a decrease in social welfare due to the loss of cost efficiency. Unlinking the remuneration to the observed cost –by using benchmarking for instance- could mitigate this whether the regulator sets an appropriate rate of cost saving sharing between grid companies and consumers. The using of error correction mechanism to partially adjust the allowed revenue regarding the gap between *ex ante* projected costs and the realized costs is another possible tool to reach allocative efficiency. In summary, price-cap regulation could ensure pricing efficiency depending on how the allowed revenue is linked to the projected cost and probably at the expense of productive efficiency due to the gaming behavior of the regulated company unless both sides agree on a sharing level of cost savings.

However, menu of contracts and performance-based mechanisms with loss and profit sharing are the more suited instruments to ensure both allocative and productive efficiency. The process of information revealing and the repeated game character of these tools involve that the regulated company will give right signals on its efficiency capability. The risk sharing aspect should on the other hand guarantee that the final price is much more closed to the incurred cost than under price-cap regulation in its pure form.

Finally, yardstick competition is the best way to improve pricing efficiency if a firm's actual or expected costs are subject to high information asymmetry. It is always used as an input for estimating the main efficiency target parameters such as initial price and productivity factor in price-cap regulation and performance indicators within a performance-based regulation.

## ***4.3 Quality of service***

Quality is a non-tradable output of the grid company's activity. Regulating quantity and incentivizing cost efficiency via incentive regulation tools will involve a deterioration of quality of service. Consequently all the input tools discussed in this paper have generally weaker incentive to improve quality as they look principally at how incentivizing firms can reduce costs. It is widely argued that quality has to be regulated complementarily to quantity regulation (Jamasp and Pollit, 2008). To do this two important issues have to be thoughtfully considered. Firstly, improving quality involves operating and capital costs for the utilities. This specific cost is generally difficult to estimate by the regulator where the regulated firm has generally better information on its ability to improve quality and its associated cost. For instance, network density

and structure, the climate, customers' localization, etc., complicate the issue of defining and measuring costs of quality. The best design that gives right incentive for quality should indeed efficiently measure its economic cost. Secondly, to value quality we need to measure how customers are evaluating the gains and the losses for improvement or deterioration of the quality of the service they pay for. The social cost-benefit of quality requires first defining properly quality indicators and second, the marginal value of improving and deteriorating quality to customers. This is a very difficult task due to the lack of relevant analysis and to the cost of consumers' answering that could be high.

Regarding the variety of incentive regulation tools, performance-based regulation and yardstick competition as output regulations for quality are the more suited. Firstly, the former with a penalty-reward scheme fits the more with the condition of creating an economic link between quality and cost. Once quality indicators or quality performance targets are defined, such as level of supply interruption and number of minutes lost which are the most common performance standards in practice<sup>30</sup>, any quality improvement above the standards induces a reward for the grid company. This reward should in theory cover the incurred cost of improving quality. In contrast, if quality drops below a threshold, the company should pay a penalty that corresponds to the consumers' social losses in term of quality degradation. On the other hand, incorporating yardstick competition to the performance-base regulation should be an attractive solution to solve the information problems when estimating optimal quality performances. Rather, companies should have a strong incentive to perform better than average as this increases income and thus profit. Finally, a less attractive solution is to regulate quality under price-cap regulation by adjusting the allowed revenue by an amount that reflects the social value of improving or deteriorating quality<sup>31</sup>.

#### ***4.4 Dynamic Efficiency***

The effect of regulation on network innovation has started to receive more attention from academic and policy making sides in the last decade. Encouraging and improving R&D and innovating the sector would be benefit for all network actors since it implicitly leads to improve system efficiency. Innovation measures focus on R&D spending and new technologies progress such as large-scale renewable sources and distributed generation (DG) connections with active responsive demand side (Jamash and Pollit, 2008).

How regulation mechanisms influence network innovation and encourage R&D spending is a major issue to be evaluated when assessing future electricity systems and their technical progress. From the network company's point of view, innovation is costly and they have no incentive to do it since they are looking to meet cost efficiency objectives and to increase cost savings. Moreover, innovation's risk and gain would not be shared symmetrically with other network's actors.

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<sup>30</sup> In France, the quality target for transmission system operators is based on the average unsupplied duration. A Bonus/Malus is calculated based on RTE performances. The UK's distribution network is similarly addressed with a penalty-reward scheme. Quality target is based on supply interruption and number of minutes lost.

<sup>31</sup> Based for instance on network users consultations.



With incentive regulation, utilities are more incited to conduct R&D spending – if regulatory periods are sufficiently high to benefit from cost savings. However, they would face a downside risk if the innovation fails. Benefit from innovation is shared by both firm and consumers but only firms will carry all the risks if it fails.

Some regulatory measures can mitigate this or that possibly bad outcome. First of all, the regulator may judge where innovation is necessarily and set its performance criteria to R&D development target. One good way is, for instance, to measure innovation output by defining R&D indicators and DG connection targets (Bauknecht, 2010). As innovation is a long-term issue, it is preferable that the regulator commits to retain performance criteria beyond the regulator period. It is also suggested that giving additional revenues allowances by raising the cap imposed by the regulator in price-based regulator would increase benefit companies from innovation.

Performance-based regulation and yardstick competition are not appropriate nowadays to incentivize network innovation. It is in fact a new issue that we are missing relevant performance indicators worldwide. In summary, innovation could be incentivized under a price-cap regime either by setting the rate of return on capital high enough that it covers innovation investments and extra risk that could be involved or by applying a specific ad-hoc scheme to directly incentivize network companies to invest in R&D and DG connections<sup>32</sup>.

Table 2 summarizes the pros and cons of the four types of incentive regulation tools as regard to regulatory objectives.

**Table 2: Aligning the tools to the goals**

	Price Cap	Menu of Contract	P-B-R	Yardstick
Productive Efficiency	+	(Not appropriate)	+ (If high uncertainty)	+ (If unable to observe cost and to set prices)
Allocative Efficiency	-	+	+	++
Quality	-	(Not appropriate)	++	+
Dynamic Efficiency	-	(Not appropriate)	-	-

<sup>32</sup> For instance in the UK, Renewable Obligations was introduced in 2002 and the funding mechanism in 2005 for promoting distribution system innovation. The success of these measures is not yet confirmed.

## 5. CONCLUSION

The purpose of the above review was to briefly describe and evaluate the key features of the different incentive regulation tools that have been proposed and applied nowadays. The evaluation principally considered their applications regarding relevant regulatory aspects and how they could be aligned with the main regulatory goals.

While no single or dominant approach can be observed, we could argue that an efficient regulatory regime would be a sum of complementary tools that together address conflicting regulatory aspects in an efficient manner. A price-cap regulation could be used as the central regime for reaching cost efficiency and should be adjusted to include additional schemes to mitigate some complexities that arise from the nature of regulatory variables and to address other regulatory objectives beyond the economic goals. On this basis, it would be suited to regulate investment costs via a menu of contract scheme and to use performance-based regulation as a tool to incentivize for quality of service improvement. In addition, yardstick competition can provide strong incentive for reaching efficiency performance by providing a robust tool to estimate performance indicators and mitigate the problem of information asymmetry faced by the regulator.

Secondly, regulation of network innovation needs to be addressed separately. The main issue that the regulator should focus on is defining a clear commitment to retain performance criteria beyond the price regulatory period and to find out an appropriate measure that economically allocates the right cost-benefits of technology innovation to the right beneficiaries.

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