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Chapter 2: Continental incentive regulation

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No panacea exists for the regulation of electricity grids. A blind implementation of a 'foreign' regulatory model, even a successful one like the British model presented in the previous chapter, is not necessarily the best course of action for practitioners and policy-makers. Caution is required first because not all regulators are the same. Even in Europe they differ in administrative powers, financial endowment, staff and technical skills available. As a result, the choice of which regulatory model to follow should take into consideration what the involved regulator can actually handle. Second, network operators perform several different network tasks with their own economic and regulatory characteristics. Hence, a plurality of regulatory tools, each of them addressing a specific task, could be the wisest approach. Finally, the context is not the same everywhere. Apart from differences in the legal framework, countries can be at an alternative point of the investment cycle: one may be building its electricity transmission network and require a swift accumulation of capital, while another may already have its grid in place and need simply to promote its efficient use. One country may be a small electricity island where the market does not have the minimum size for a workable competition, while another may have a large system that is strongly interconnected with that of neighbouring countries.

In this chapter, we first describe the landscape of energy regulators in Europe, with a specific focus on their heterogeneity and their frequently limited resources. Then, we look at the tasks network operators usually perform in the electricity industry (system operation, grid maintenance, customer relationship management and grid expansion); we look also at the new or renewed tasks network operators are called to perform in the current context of energy transition, national markets integration and digitalization. Finally, we present the main tools suggested by the academic literature and the industry practice for the regulation of network operators. They are ranked according to a scale of growing implementation complexity for the regulator. On this basis, a decision tree is proposed for aligning the abilities of the regulator, the characteristics of a network task and the implementation complexity of a regulatory tool, so that a model of workable incentive regulation can be identified.

2.1 The national energy regulators' landscape in Europe

The establishment of an independent authority in charge of the regulatory oversight of network operators at the national level is one of the key pillars of the restructuring of the European electricity industry, which occurred between the mid-1990s and the first decade of the twenty-first century. Under the pressure set by subsequent directives and regulations, EU Member States have created national regulatory authorities (NRAs) that share similar powers and duties. Nevertheless, even though their institutional design has been somewhat harmonized, regulatory authorities are not all equal, in particular in terms of the skills and resources available to perform their legal obligations.

In this section, we start by presenting the basic features common to all EU NRAs as a result of the current European legislation on the internal market for electricity. Then, we provide an overview of the heterogeneity of powers, responsibilities and, above all, economic and technical resources, characterising the reality of the European energy regulators.

2.1.1 Some common basic features

Currently, all Member States of the EU have one NRA dealing with the electricity industry. These 28 NRAs were established during the 1990s and early 2000s. Their institutional design, powers and responsibilities have been progressively harmonized under the pressure of European legislation, although differences remain due to national specificities and laws.

The Third Energy Package adopted in 2009 foresees the designation of a single NRA at the national level and the obligation for the Member States to guarantee its independence from any other public or private entity. Moreover, Member States must ensure that NRAs exercise their powers impartially and transparently (art. 35 of the Directive 2009/72/EC, hereafter Electricity Directive). In close cooperation with each other, the European Commission and the Agency for the Cooperation of Energy Regulators (ACER), NRAs are mandated to promote a competitive, secure and environmentally sustainable internal market for electricity within the Community (art. 36).

In order to be truly independent and neutral vis-à-vis the interests of the industry and the wishes of the political power, NRAs must be able to take autonomous decisions and their members of the board are appointed for a fixed term of five to seven years, possibly renewable but only once. Additionally, NRAs have separate annual budget allocations, which they can autonomously implement. Finally, NRAs are supposed to benefit from adequate human and financial resources to carry out their duties (art. 35).

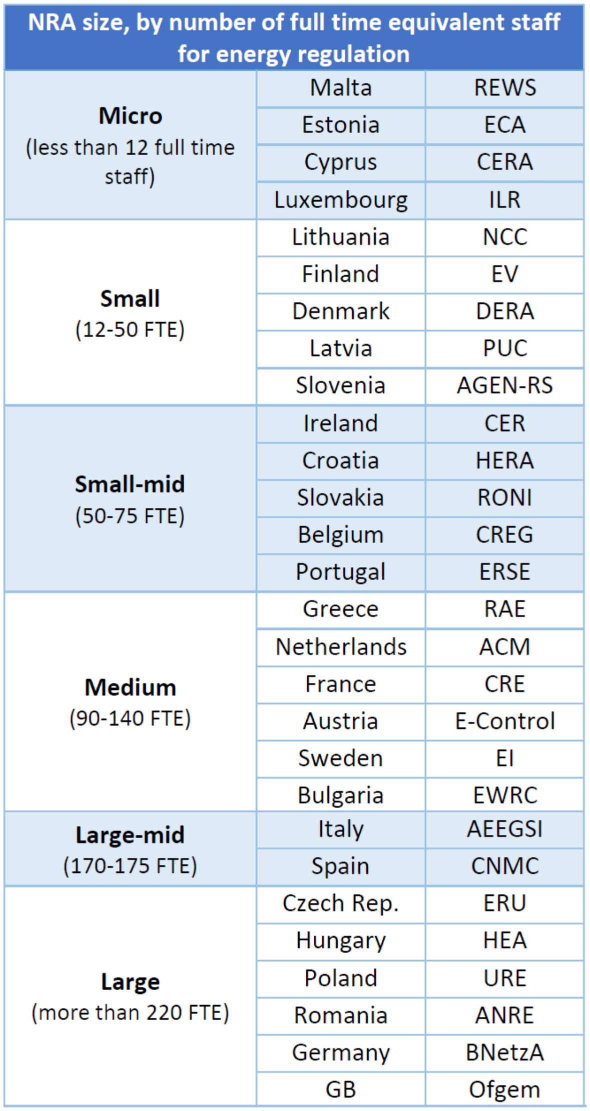
2.1.2 Heterogeneous conditions and resource bounded regulators

Despite the above-mentioned provisions contained in EU law, the situation of the electricity regulators in Europe is far from homogeneous and does not often resemble the theoretical model of the perfectly endowed regulator, described in the textbooks or assumed by academics and policy-makers.

First, EU NRAs are quite heterogeneous in terms of the tasks they perform, because national situations and laws apply on top of the European common denominator. In some cases they have to regulate both the gas and the electricity industry, while in others, where natural gas is not consumed in the country, they focus only on electricity.[i] In some cases they also deal extensively with renewable support schemes or consumer protection, while in others they focus mainly on the core duties foreseen by the Electricity Directive, that is, the regulation of transmission and distribution networks and the oversight of energy markets. In some cases they watch over small isolated electricity systems, while in others they have to cope with large grids, highly meshed with those of the neighbouring countries.

Second, EU NRAs are quite heterogeneous because of the different economic resources and administrative powers they are granted. They can be funded by fees directly charged to the electricity sector or be financed out of the State budget. They can benefit from the experience gained from several years of operation or conversely have little or no institutional memory due to their recent establishment. They can rely on a large and well-paid staff of highly skilled and motivated professionals or conversely have to perform their numerous duties with a small team and only a handful of economists and lawyers. Finally, they can have the legal power to directly fine misbehaving electricity firms or they can only propose penalties to the competent court.

A rough idea of how heterogeneous the NRAs are in terms of resources can be obtained by comparing their size expressed in terms of full-time equivalent staff (FTE).[ii] Building on a survey conducted among its members, ACER provides a classification of the EU NRAs based on the number of FTEs devoted to energy regulation, i.e. for both gas and electricity (see Table 2.1). NRAs are gathered in six categories. On the one hand there are micro regulators like those of Malta, Estonia or Cyprus with less than 12 equivalent employees; while on the other hand there are large regulators like those of Great Britain, Germany or Romania with more than 220 equivalent employees each. The overall average is just above 117 FTE.

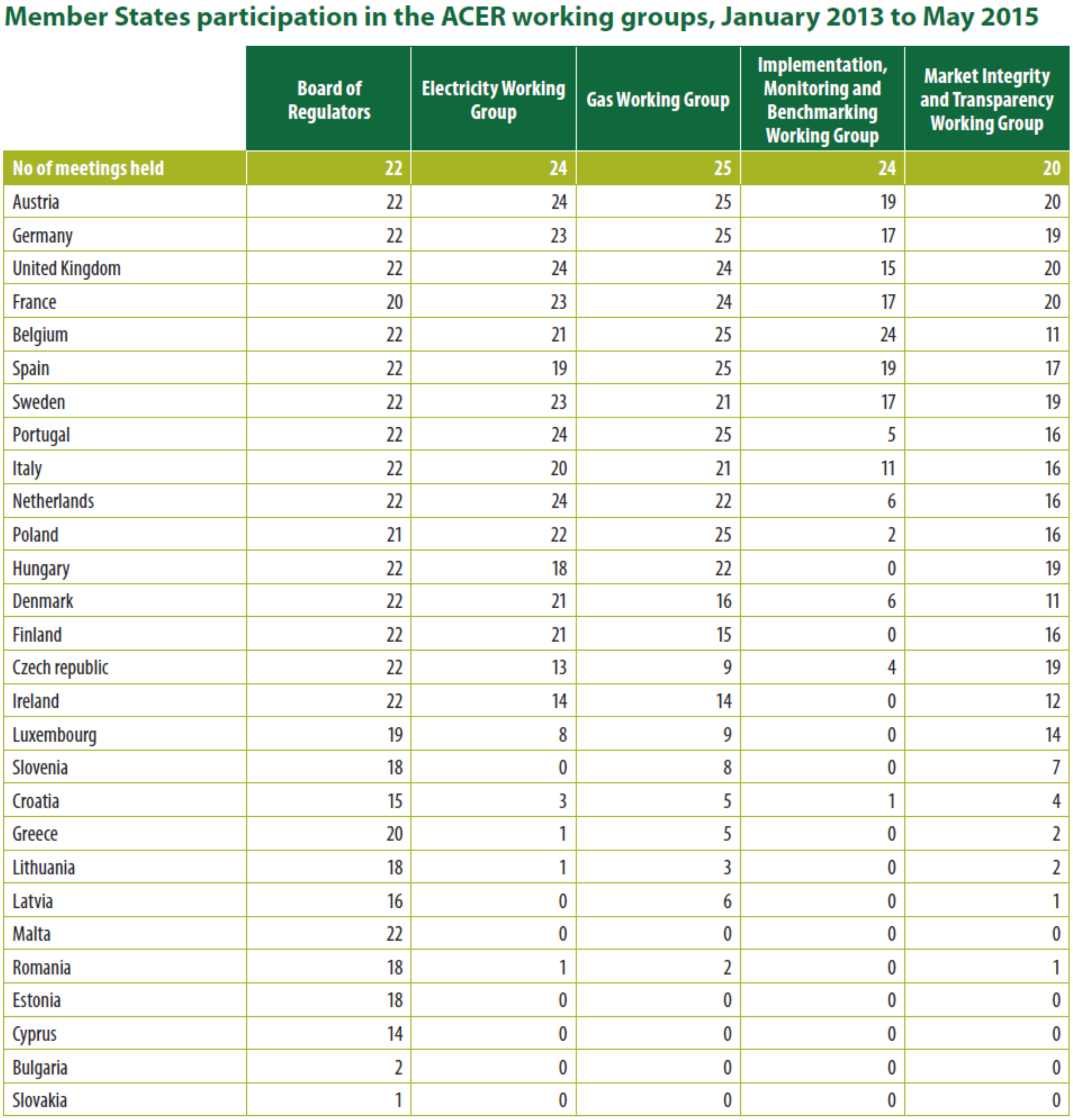


NRA size, by number of full time equivalent staff for energy regulation		
Micro (less than 12 full time staff)	Malta	REWS
	Estonia	ECA
	Cyprus	CERA
	Luxembourg	ILR
Small (12-50 FTE)	Lithuania	NCC
	Finland	EV
	Denmark	DERA
	Latvia	PUC
	Slovenia	AGEN-RS
Small-mid (50-75 FTE)	Ireland	CER
	Croatia	HERA
	Slovakia	RONI
	Belgium	CREG
	Portugal	ERSE
Medium (90-140 FTE)	Greece	RAE
	Netherlands	ACM
	France	CRE
	Austria	E-Control
	Sweden	EI
	Bulgaria	EWRC
Large-mid (170-175 FTE)	Italy	AEEGSI
	Spain	CNMC
Large (more than 220 FTE)	Czech Rep.	ERU
	Hungary	HEA
	Poland	URE
	Romania	ANRE
	Germany	BNetzA
	GB	Ofgem

Table 2.1 – List of the NRAs in order of total human resources for energy regulation in full-time equivalent staff units (FTEs). Source: ACER (2016), ACER Taking stock of the regulators' human resources. Summary of findings.

Undoubtedly these numbers must be interpreted with caution, as they inevitably reflect the differences in size and structure of the national markets, the duty to regulate only electricity or natural gas too, and possibly the additional tasks and powers introduced at national level. Nevertheless, given the relevance of overheads and the minimum scale required to perform certain regulatory tasks, it is clear that not all the regulators have the same capabilities and that some of them, in particular the smaller ones, face significant constraints in what they can effectively achieve.

This is all the more apparent if we look at the participation of national regulators in the activities within ACER or other international initiatives and forums. Large and medium size regulators are able to send representatives to most of the meetings of the ACER board of regulators and the working groups, while smaller or less wealthy NRAs are not (see Table 2.2). The excessive workload and the lack of skilled employees able to work in an international context frequently represent a constraint. Sometimes, even travel and accommodation expenses can be a financial burden that is difficult to bear for these regulators.



Member States participation in the ACER working groups, January 2013 to May 2015

	Board of Regulators	Electricity Working Group	Gas Working Group	Implementation, Monitoring and Benchmarking Working Group	Market Integrity and Transparency Working Group
No of meetings held	**22**	**24**	**25**	**24**	**20**
Austria	22	24	25	19	20
Germany	22	23	25	17	19
United Kingdom	22	24	24	15	20
France	20	23	24	17	20
Belgium	22	21	25	24	11
Spain	22	19	25	19	17
Sweden	22	23	21	17	19
Portugal	22	24	25	5	16
Italy	22	20	21	11	16
Netherlands	22	24	22	6	16
Poland	21	22	25	2	16
Hungary	22	18	22	0	19
Denmark	22	21	16	6	11
Finland	22	21	15	0	16
Czech republic	22	13	9	4	19
Ireland	22	14	14	0	12
Luxembourg	19	8	9	0	14
Slovenia	18	0	8	0	7
Croatia	15	3	5	1	4
Greece	20	1	5	0	2
Lithuania	18	1	3	0	2
Latvia	16	0	6	0	1
Malta	22	0	0	0	0
Romania	18	1	2	0	1
Estonia	18	0	0	0	0
Cyprus	14	0	0	0	0
Bulgaria	2	0	0	0	0
Slovakia	1	0	0	0	0

Table 2.2 – NRAs participation in the ACER working groups between January 2013 and May 2015. Source: European Court of Auditors (2015), Special Report "Improving the security of energy supply by developing the internal market: more efforts needed", p. 67.

The prolonged crisis of public finances in several EU Member States and the necessity to contain public expenditure have generally not improved the situation for NRAs. On the contrary, the introduction of new obligations, like those related to the Regulation on Wholesale Energy Markets Integrity and Transparency (REMIT), and the increased speed of technological and business innovation observed in the electricity sector have further stretched the capabilities of the regulators to efficiently and effectively implement their legal duties.

Thus, the practice of regulation in Europe is significantly different from its theoretical frame. In the academic literature, regulators are thought to have all the desired cognitive, computational and administrative abilities to do their job. In particular, they can effortlessly identify the most efficient regulatory tool to apply to a specific case and they have all the desirable resources and skills to implement it. They may suffer from information asymmetry vis-à-vis the firms under their regulation, but they can nevertheless set adequate incentives by defining tariffs ex ante. Additionally, they are assumed to be independent of governments so that the regulatory framework they put in place is credible for both firms and investors.

The reality sketched out above does not reflect the theoretical assumptions. Many regulators are poorly endowed and are not inclined or able to apply the most complex or innovative regulatory tools to the network operators under their jurisdiction. Having only small teams and financial resources, they tend to be conservative with regulation in order to avoid negative judicial reviews or to enter into demanding and uncertain regulatory innovation. The identification of the best regulatory tool for a specific purpose often requires time and its proper implementation is achieved only through experience (learning by doing). The reality, in short, is that of resource bounded regulators that must take into account their relative endowment in terms of staff, skills and administrative power, when considering the more appropriate tools they should use to perform their regulatory functions.

2.2 Characteristics of the main tasks performed by network operators

The need to think in terms of the actual resources and abilities available to NRAs is not the only aspect that differentiates the practice of incentive regulation in Europe from the standard model developed by scholars. Another overly rigid assumption of such model is that the regulator is supposed to control the costs of the network operator as a whole with a single regulatory tool. However, both transmission system operators (TSOs) and distribution system operators (DSOs) perform in reality a set of tasks with heterogeneous economic and regulatory characteristics. Hence, the regulation of an electricity network calls for the implementation of adapted and finely tuned regulatory tools, each of them addressing a distinct task and giving a consistent enough incentive to the regulated firm.

In this section, we start by presenting the traditional tasks performed by electricity network operators, together with the new or renewed tasks attributed to them more recently by developments in energy policy. Then, we introduce three criteria to characterize the various tasks from a regulatory point of view. Finally, we apply these criteria to the network operators' tasks.

2.2.1 Network operators' tasks

An electricity network operator usually performs four main network tasks, each of them with different characteristics and cost structures. The first three tasks deal with short-term issues, while the fourth one looks more at the long term.

First, the firm operates the energy system on a daily basis, ensuring the balance between injections and withdrawals, managing congestions and contingencies (system operation). The network operator typically provides for energy losses as well and, in liberalized systems, it frequently contributes to market operation. Currently, these tasks are performed especially by the TSO. DSOs are also expected to play a growing role as well. This is because of the development of distributed energy resources (DER), which increases constraints on their networks and hence raises the necessity of making their infrastructure smarter (see Chapter 4). Second, the network operator maintains the assets of the grid, in order to ensure their reliable functioning under most of the foreseeable conditions (grid maintenance). Third, the network operator manages the relationship with its customers, i.e. the network users, metering and billing energy and power, and possibly providing complementary services to them (customer relationship management). Finally, the firm plans and builds the network to connect new users, both on the supply and the demand side, and relieves excessive congestions (grid expansion).

Depending on the specific characteristics of the system at stake, this broad classification can obviously be subject to adjustments and refinements. For instance, if system operation and transmission ownership are unbundled activities, then the transmission owner (TO) is usually in charge of maintaining and building the grid, while the system operator (SO) performs the other tasks. Similarly, a further distinction could be made between isolated and interconnected systems. As a matter of fact, the implementation of some of the tasks mentioned above could be significantly affected by the existence of direct connections with other electricity systems. An excellent example is represented by the operation of the transmission system of interconnected countries, a task that calls for specific coordination and cooperation among the involved TSOs.

Recent developments in the energy policy at the national and European levels have assigned new goals to network operators, which, in turn, have triggered new or renewed tasks alongside the four traditional ones. In particular, TSOs and DSOs have to contribute to the decarbonization of the energy sector and the completion of the internal market for electricity. On the one hand, the energy and climate targets adopted by the EU for 2020 and 2030 imply a massive deployment of renewable energy sources (RES) and a deep change in the generation mix, currently dominated by few, large and dependable nuclear or fossil-fired power plants. On the other hand, the wider and deeper integration of European electricity markets requires the creation of a seamless transmission system on a continental level, where any generator, trader or consumer of electricity is treated in the same way, irrespective of the specific national grid to which it is connected (see Chapter 3).

In this context, network operators are called to adapt their activities to integrate new classes of assets and processes, both on the supply side (intermittent generation from wind and sun) and on the demand side (smart meters, demand response, electro-chemical storage and electric vehicles), while making sure, at the same time, that the transition to a more decentralized system does not affect the high level of reliability and security of supply necessary to the well-functioning of modern digital societies. Moreover, TSOs and DSOs are called to involve and empower small producers and consumers of energy, by facilitating their participation to energy markets, directly or through aggregators. Finally, network operators – first and foremost TSOs – are called to act as market architects in liaison with the power exchanges and to couple national markets along the lines of the EU power target model.

All these changes and new regulatory goals require a revival of the research, development and demonstration activities (RD&D) of TSOs and DSOs to better address the business and operational shifts of transmission and distribution infrastructures and services. Indeed, due to the present wave of technological innovation and digitalization, the actual work of the electricity network operators is moving beyond the pure technical network monopoly area, as it is traditionally understood in the energy sector, and is taking a first step closer to the communication sector.

2.2.2 Regulatory characteristics of network operators' tasks

The different tasks performed by network operators are heterogeneous, including in terms of uncertainty and delivery time horizons. For instance, system operation is a short-term task because the instantaneous balance between electricity injections and withdrawals must be constantly preserved, while grid expansion involves very long-term decisions due to the lengthy procedures to follow for the approval and construction of new lines, usually intended to last at least several decades. Other assignments like grid maintenance or customer relationship management are recurrent in the medium term and present limited uncertainties. On the contrary, grid planning is highly uncertain because it is relatively difficult to foresee where generators and loads will be located in ten to 20 years from now. Similarly, uncertainty is high when undertaking RD&D, because the actual outcome of developing new technologies today for the network of tomorrow may be especially fuzzy.

Trying to regulate network operators as a whole with a unique regulatory tool would be rather inefficient and sometimes ineffective, given the diverse nature of the tasks they perform. A specific regulatory tool can foster the fulfilment by the network operator of a certain task, but it may, at the same time, undermine the implementation of another one. For instance, let us consider price cap, a regulatory scheme that induces cost containment (see Chapter 2.3.1 for additional information). The firm subject to regulation will be encouraged to reduce its operational expenditures (OPEX) in order to increase its profits. This tends to improve productive efficiency in the short term, at least as far as the same level of quality or the same quantity of the concerned service are provided to customers. However, price capping applied to OPEX may simultaneously damage long term productive efficiency growth, by discouraging the regulated firm from spending resources on RD&D activities that do not produce any benefit in the short term or whose outcome, even in the longer term, is rather uncertain.

In practice, the mixture of tasks performed by network operators requires a hybrid regulatory approach, consisting in the concurrent use of various regulatory tools able to deliver the various desired results. To seriously match its regulatory tools with the industry operation, the regulator has to address closely the different regulatory characteristics of the various tasks performed by the network operators. There are three key regulatory characteristics:

1) Controllability;
2) Predictability; and
3) Observability.

Controllability qualifies the network operator’s ability to manage a single task and its costs or a combination of tasks and their costs as to attain a defined level and quality of output. When a task is controllable, the regulated firm can undertake actions to reach an efficient level of operation. Hence, the firm is responsive to incentive regulatory schemes. On the contrary, when a task is barely controllable, the regulated firm can control the inputs but not the output. Therefore, any incentive scheme would probably not affect the efficiency in performing the task, but rather result in regulatory costs or profit hazards for the regulated firm.

Predictability qualifies the possibility to foresee the influence of external factors on a network task and its costs and the relationship between a given set of costs, incurred for a task, and the level and quality of the output. Then, in the case of a predictable task, the regulator and the network operator can reasonably foresee, ex ante, the future outcome for that task. In particular, they can distinguish the effect of the operator's effort on the efficiency in performing the task from the action of uncertain and uncontrollable variables like energy demand. In this case, an incentive scheme would be effective. On the contrary, when uncertainty about the future of the system is high and it is not easy or possible to filter the impact of uncertain variables on the operator's task, then predictability is low and it would make little sense to apply incentive regulatory tools. Risks, both for the firm and for the regulator, would be high.

Observability qualifies the possibility of verifying the influence of external factors on a network task and its costs and the relationship between a given set of costs, incurred for a task, and the level and quality of the output. Hence, in the case of an observable task, the regulator can check, ex post, the actual outcome for that task and effectively apply incentive regulation. Depending on what is observable, for instance whether inputs or outputs are observable, and the level of information asymmetry between the firm and the regulator, then it is possible to determine the specific implementable regulatory tool. However, it is important to note that observability of a task cannot be taken for granted, but requires the ex ante definition of key performance indicators (KPIs) and their accurate monitoring. Besides, data manipulation by the regulated firm must be avoided by implementing KPIs in a robust manner and allowing the regulator to audit the records kept by the firm. Finally, different degrees of observability are possible: at one extreme, the regulator may just have a small historical set of data from one network operator only; while on the other, a large data set spanning several years and covering several comparable network operators could be available to the regulator. Depending on the actual degree of observability, different incentive schemes are more appropriate.

2.2.3 Classification of the tasks in terms of the regulatory characteristics

The three regulatory characteristics presented above can be used to classify the main tasks performed by network operators and provide a first insight into the choices that a resource bounded regulator should make when aiming at a workable regulation of the operators under its jurisdiction (see Chapter 2.3.2).

To classify the network tasks in terms of controllability, predictability and observability is not always straightforward and unambiguous, because the industry context and the regulatory framework have an impact on the tasks' characteristics. Nevertheless, a broad assessment is possible.

Let us start with system operation. It is not a fully controllable task, especially in meshed electricity grids because cross-border energy flows can be large and dispatch choices by neighbouring network operators can heavily impact the efficient operation of the domestic system. Controllability is higher in isolated systems, where the network operator is usually able to better control the volume of energy losses, by managing grid topology and optimising the dispatch of power plants.[iii] System operation is observable to a certain level, since actual energy losses and congestion costs are measurable. However, predictability of system operation is not straightforward since energy losses and congestion costs depend on the behaviour of network users, both generators and consumers, inside and outside national boundaries. Predictability of system operation will then depend on the possibility for the network operator and, *a fortiori*, for the regulator, to distinguish the amount of losses and costs due to external factors from the amount due to actions by the network operator.

On the contrary, grid maintenance is a somewhat repetitive task over the medium to long term. The costs incurred by a network operator to perform this task are not frequently affected by uncertainty and unexpected events, except for major faults. Rather, they rely on the firm's productivity potential. Hence, grid maintenance is controllable and predictable. The observability of the task depends on the regulator's evaluation of both productivity improvement and the relative cost of the practices to maintain a reliable grid. Indeed, when dealing with grid maintenance, it is important to assess the quality of the network service provided to network users, because a reduction in the maintenance expenses could hide a reduced reliability of the grid and, as a result, a reduced quality for the users. Therefore, regulators must look at quality, a characteristic that is controllable by the network operator in the long term, exactly through grid investment and maintenance. Moreover, quality of service is predictable, if extreme events are filtered out from quality indicators, and it is observable by the regulator, if an adequate set of KPIs is conceived and used.

The management of customer relationships is similar to grid maintenance. It is a recurrent activity for the network operator, whose costs are essentially controllable and predictable, unless strong technological or process innovation occurs (e.g. digitalization and the roll-out of smart meters). Observability is trickier, since it requires the implementation of adequate KPIs regarding the speed and quality of the responses provided to users' requests.

The case of grid expansion is different. Though a recurrent task for network operators, it is affected by high uncertainty due to the long lead time of network planning and building activities. Indeed, although the cost of wires, pylons, transformers and other devices is quite stable and under the control of the network operator, overall costs for the construction of a line may be less controllable and predictable due to lengthy permitting procedures and possible local opposition to infrastructure development, as well as the uncertainty on the nature of the soil (hardness, stability) to set wires. Besides, the future use of long-lived physical infrastructures is intrinsically uncertain. As a consequence of that, the benefits of those infrastructures and the efficiency of grid expansion are difficult to calculate. For a similar reason, grid expansion is not easily observable for regulatory purposes. To build an electric line takes time, in particular an interconnection among different national systems, and the actual benefits of this activity emerge only over the years. To verify the influence of external factors on the costs and the relationship between a given set of costs and the level and quality of the output is then difficult.

Finally, innovation is a controllable task in the sense that the management provided by the network operator influences the quantity and quality of innovation that the operator itself will produce: by spending more in RD&D, the operator will be able to innovate more and introduce new technologies or processes faster. However, although controllable, innovation is not very predictable, because the outcome of any research activity and the associated trade-off between costs and benefits are by definition unknown. Innovation is not even easily observable, since it is difficult to define adequate KPIs about something that does not yet exist or whose usefulness is hard to assess. In any case, both predictability and observability increase as long as the technological and managerial maturity of an innovation grows. Indeed, innovative technologies and processes that are closer to commercialization or wide-scale deployment by the network operator suffer from less uncertainty and bring more identified benefits than innovations in their infancy.[iv]

2.3 How to adapt the regulatory tools to the tasks and the regulator's abilities

During the 1980s and 1990s, the restructuring of network industries like the electricity one was coupled in Europe with the introduction of incentive regulation. Scholars and practitioners, recognising that regulators are neither omniscient nor omnipotent, tried to cope with information asymmetry, a problem normally affecting the relationship between regulators and the firms they regulate. New regulatory tools like price capping were developed and implemented, starting with the British telecommunication sector. Nevertheless, despite all the fanfare in the academic and public debate of the last decades, incentive regulation is usually not applied to all the tasks performed by a network operator (not even in the UK, see Chapter 1 for more details). Indeed, a lack of adequate financial resources and technical expertise often drives regulators to apply less sophisticated and more traditional forms of regulation. Moreover, even if the endowment of the regulator is not an issue, there can be other arguments in favour of a limited use of incentive regulation. The controllability, predictability and observability of the costs related to some of the tasks performed by network operators are among those arguments.

In this section, we start by presenting the most common regulatory instruments developed by the practice and theory of network industry regulation. The different tools are introduced according to a scale of growing implementation complexity. Then, we provide a decision tree suggesting how the regulatory instruments can be matched with the key regulatory characteristics of the tasks performed by the network operators subject to regulation. Finally, we apply the decision tree to three network tasks as a way to illustrate its usefulness in finding a workable alignment between targeted network tasks, regulator's abilities and regulatory tools.

2.3.1 The five main regulatory tools

In the 1970s and 1980s economic theory began to recognize and take seriously the fact that regulators have limits in terms of what they know and what they can do. It was progressively acknowledged that regulated firms know better than the regulator the situation in the industry (e.g. the level of demand, the willingness of customers to pay and the available technological solutions), their actual production costs and the efforts undertaken in containing them. Benefiting from this information asymmetry, regulated firms like electricity network operators can act strategically and exploit the regulatory process to increase their profits or to pursue other managerial goals, to the disadvantage of customers. In this sort of principal-agent relationship, two kinds of problems can arise, respectively the adverse selection problem and the moral hazard problem.[v] Essential in both cases is the information asymmetry between the principal and the agent (the principal does not know entirely the characteristics of the agent and/or cannot fully control his actions). Hence, regulatory tools are needed to address the gap suffered by regulators.

Through the application of incentive regulation, a regulatory authority is supposed to be able to alleviate the information advantage the network operator holds regarding the real costs of its activities and the effort it makes to perform them. Consequently, the firm can be incentivized to reveal its private information on the economics of its output (adverse selection problem) and to provide its services to customers in a cost efficient way (moral hazard problem).

Reviewing the literature and the practice of regulation, it is possible to identify five main regulatory tools:

1) Cost of service or cost plus regulation;
2) Price/revenue cap regulation;

3) Output or performance-based regulation;
4) Menu of contracts; and
5) Yardstick competition.

The implementation of these tools by a regulatory authority requires different administrative powers, technical skills and abilities. Broadly speaking, it is possible to rank the tools according to a scale of growing implementation complexity (see Figure 2.1).

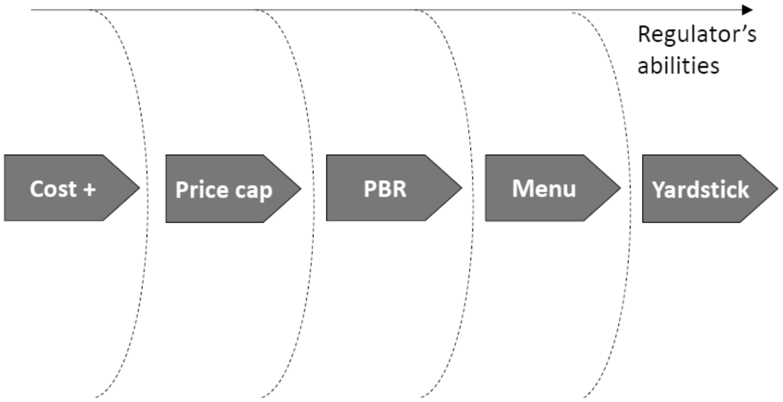


Figure 2.1 – Alignment of the regulatory tools with the regulator's abilities. Source: Glachant *et al*. (2013), p. 275.

Cost of service or cost plus regulation is the simplest tool for the regulation of electricity networks. It is based on the principle that the regulated firm is allowed to recover up to the costs actually incurred for service provision, including a fair rate of return on the capital invested.[vi] From time to time, the regulator opens, under the request of the regulated firm or the public, a rate case where it collects and audits evidence from the firm on its operating and investment costs. Based on the level of operating costs, on the used and useful investments undertaken and on the cost of capital, the regulator defines the revenue requirement or rate level for the firm. Then, it sets a tariff for the regulated service that enables the firm to raise such revenue requirement. In this regulatory framework, the network operator is incentivized to declare its costs but not to avoid managerial slack and optimise its processes.[vii] Indeed, although the regulator can disallow an investment that is not considered to be 'used and useful', the firm will tend to be affected by x-inefficiencies and gold-plating.[viii] In this case implementation requirements for the regulator are relatively small: a good team of accountants, a few engineers and some lawyers are enough to audit the company's books, monitor and evaluate the investment programme, and eventually defend the regulatory decision in front of a judge.

A price or revenue cap is a more complex way to regulate network operators. It assumes that it is possible to induce the firm to reduce its costs by decoupling incurred costs from the earnings the firm is entitled to. When this tool is applied, the regulator unilaterally sets a maximal allowed revenue or unit price that the firm can charge for the service it provides over a regulatory period, usually lasting from three to five years. As the length of the regulatory period is relatively longer and more certain than with cost plus regulation, the incurred costs could be lower than the earned revenue. This allows the firm to benefit from the cost reduction it is able to attain. At the same time, the firm is not incentivized to reveal its costs. In turn, this can represent a problem for the regulator when it is the time to fix the revenue or the price cap for the next regulatory period. If the regulator aims to promote productive efficiency and, at the same time, avoid that the regulated firm enjoys windfall profits or suffers from systematic losses, then it has to set the revenue/price cap close to the firm's efficient total/average costs.[ix]

It is apparent that this regulatory tool requires more abilities by the regulator. If, on the one hand, the burden of detailed auditing is smaller because the regulator needs information about the firm's costs only at the beginning or at the end of each regulatory period, then, on the other hand, the regulator must spend highly qualified resources to correctly set the reference price and its dynamics over time, in order to avoid that it becomes too disconnected from the actual network performance potential. This implies the ability to forecast the trajectory of efficient costs for the whole regulatory period and it explains why in the revenue/price formula additional parameters are often introduced in order to deal with changes in the general price level and with unexpected shocks to the demand or the supply side. To prevent the worst cases, the regulator might mix revenue/price cap regulation with cost plus regulation and share gains and losses between the consumers and the network operator. Finally, a positive remark: in the framework of revenue/price cap regulation, learning effects may have a likely positive influence on the regulator who might be able to better adjust the price formula when moving from one regulatory period to the next (see Chapter 1.2 on the British experience with price cap regulation).

Output or performance-based regulation is more sophisticated than revenue/price cap regulation. The focus here moves from the inputs employed by the regulated firm to the level of outputs delivered. In order to address some of the limits experienced in the application of revenue/price cap, the regulator defines ex ante a formula linking a financial reward-penalty scheme to a firm's expected output, expressed in a pre-established set of KPIs. The firm has a significant degree of freedom in how it achieves the target set by the regulator for the given output: if it reaches the target, it will be rewarded; otherwise, it will be penalised, for example through a reduction in the maximal allowed revenue it can recover from customers (see Box 1.1 for a graphical representation of the mechanism).

The implementation of this regulatory tool calls for an expert regulator, able to identify the relevant output and the associated performance target, to be coupled with a financial incentive to reach it.[x] Then, to optimally regulate the firm, the regulator needs to have an idea of how the firm produces the identified output and how expensive it would be to increase the level of the output delivered. The regulator should also be able to weigh, at least approximately, the gains that any improvement in the output may have for customers and the society as a whole vis-à-vis the value left to the operator in the financial incentive. Only under these conditions might the regulated firm be able to make an efficient arbitrage between the costs and the benefits that an operational effort for improving the output will generate for society. In short, since the regulator must be able to measure the benefits for the society, the costs for the firm and its performance over time, a significant amount of expertise and adequate resources for monitoring the firm's output are required.

In a context of imperfect and asymmetric information, a regulatory authority, rather than proposing a unique input or output related target, can obtain better results by offering a menu of different regulatory contracts to the regulated firm . The contracts contained in the menu are characterised by different incentives and cost-sharing schemes: some of them provide high-powered incentives that foster an optimal managerial and cost-containment effort, while others provide low-powered incentives, ensuring the recovery of realized costs, without leaving any rent to the firm. On the basis of the information it owns, the regulated firm will choose the contract most suitable to its characteristics (managers' risk aversion, efficiency capability belief, projected expenditures, etc.) and to its view on future market conditions (e.g. expected demand development). Hence, a menu of contracts is a tool that promotes the improvement of productive and allocative efficiency by addressing the issues of moral hazard and adverse selection at the same time. On the one hand, it provides incentives to perform much better by giving the firm the opportunity to benefit from its own knowledge of feasible cost saving and better serving. On the other hand, it ensures that information is progressively revealed to the regulator through successive regulatory reviews and that prices follow an underlying cost variation within a reasonable distance.

Sharper abilities are required for the implementation of a menu of contracts. The regulator must be aware of the existence of different types of network firms with intrinsically different efficiency improvement profiles. On this basis, the regulator must design low-powered inventive schemes, which will be chosen by firms with low potential efficiency gains or low appetite for risk/effort, and high-powered incentive schemes for firms with high potential efficiency gains or high appetite for risk/effort. Regulatory expertise is an essential condition to construct fine-tuned, appealing menus of contracts that are effective in addressing the network operators' different forms of management and shareholders.

Yardstick competition is the last and more complex tool usually employed to regulate electricity network operators. In its full form, yardstick competition decouples the allowed revenues of the regulated firm from the firm's actual costs and links them to an index built on the costs and performances of other comparable network firms, to which the regulated one is benchmarked. The firm is incentivised to improve its processes and to be more efficient than the average level, because in this way it can earn a profit.

Clearly, the implementation of yardstick competition rests on a number of assumptions that are not always satisfied. First, a set of several comparable network firms, performing the same tasks and operating under similar environmental conditions must be available.[xi] If this is not the case, effective benchmarking is not possible at all or would require the use of sophisticated econometric techniques, able to fictitiously create a ceteris paribus condition.[xii] This leads to the second assumption: since crude data are hardly sufficient for yardstick competition, the regulator must be able to collect an important and coherent amount of information from the firms under comparison, to standardize such information and to analyse it with the help of advanced statistical instruments. Time, skills and budget are necessary. Due to the frequent lack of a sufficient number of homogeneous network firms and/or to the limited resources available to regulators, yardstick competition is usually applied only to distribution networks and rarely in its pure form. More often, regulators employ it as a starting point for the definition of the regulatory contract and as a way to estimate the productivity trend factor or the initial price in a price cap scheme. Alternatively, in the context of output-based regulation, the benchmarking process can be used to calculate the ex ante target of a task performance.

2.3.2 Decision tree for a workable regulatory alignment

In choosing the most appropriate tool for regulating a specific task of the network operator under their oversight, NRAs must find a workable alignment between the advantages and drawbacks of any regulatory tool, the regulatory characteristics of the task considered, and the skills and resources available to the NRAs themselves. A possible way to identify the appropriate match is to adopt the decision tree represented in Figure 2.2.[xiii]

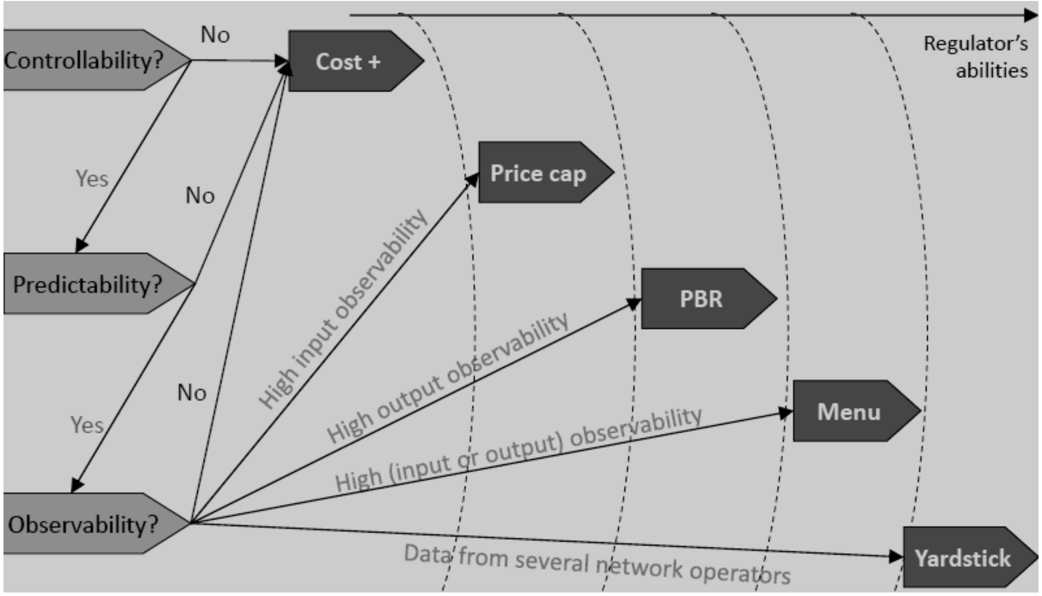


Figure 2.2 – Decision tree to align tasks, regulatory tools and regulator's abilities. Based on: Glachant *et al.* (2013), p. 283.

The first criterion to look at is the controllability of the task performed by the network operator under consideration. If the operator is unable to significantly influence the cost or the outcome of a task, the economics of the output are mainly out of the firm's control and it will not make much sense to regulate such a task with an incentive scheme. Cost plus regulation is the most appropriate tool in this case. Minimum accounting capabilities as to audit the firm's uncontrollable costs and to set a tariff for their recovery are sufficient for the regulator to adequately implement the regulatory scheme.

On the contrary, if a task is controllable, then the network operator can undertake actions to reach an efficient level of operation and an incentive regulatory scheme makes sense. In practice, however, the choice of the appropriate tool depends on the predictability of the task and on the regulator's own capability to manage more complex and hazardous decision processes to influence the targeted outcome. Indeed, predictability represents a second fundamental criterion: if the outcome or the costs of a task are controllable but difficult to predict by the firm or by the regulator, then a cost plus scheme can still be applied as a satisfactory solution. Otherwise, if the degree of predictability is higher and the regulator has adequate financial resources and a skilled and experienced staff, then more complex incentive schemes can be conceived and implemented with less risk.

The third and final criterion to look at is the observability of a task and its costs. Different degrees of observability exist, ranging from a small historical set of data from one network operator only to a large set of data from several comparable network operators. If observability is too low or the regulator thinks that its limited resources are not enough to collect the relevant information on the actual management and results for a specific task, then the effective implementation of incentive regulation is not possible and the choice of a cost plus scheme is advisable. However, if the regulator is well endowed and benefits from a relevant experience, it makes sense for it to invest in more advanced regulatory tools like a menu of contracts, where the regulated firm is pulled into a voluntary efficiency revelation scheme. Another sophisticated way to address the observability problem is to apply some benchmarking techniques and regulate the firm by means of yardstick competition (as previously mentioned, this possibility requires that the regulator manages to gather enough pertinent information from several comparable firms and that the regulator has the cognitive and computational abilities necessary to interpret benchmarking results).

If a task's observability is high, a regulator may conveniently choose simpler regulatory tools that require less experience and resources. When only inputs are easily observable, revenue or price cap regulation represents a good choice, because in this way it is possible to induce an efficient behaviour in the regulated firm without excessive regulatory involvement and costs. On the other hand, if the output of a task is easily observable as well, then performance-based regulation is more appropriate than a revenue or price cap, because it allows to control for the quality of the service provided to customers (as previously stated, performance-based schemes require that the regulator is able to properly define ex ante and measure ex post the relevant characteristics of a task's output).

To summarize, if a particular network operator's task does not satisfy any of the controllability, predictability and observability criteria, then the cost plus scheme is the most likely regulatory tool able to ensure the recovery of costs, the protection of customers and fairly efficient productive decisions. Otherwise, if the criteria of controllability, predictability and observability are fulfilled, then the appropriateness of the different regulatory tools mainly depends on the actual regulator's endowment of economic and technical resources.

2.3.3 Three illustrations

The framework proposed above can be usefully illustrated by applying it to three different tasks, commonly performed by firms operating electricity networks. They are energy losses management, grid maintenance and RD&D activities (innovation).

Energy losses management is a relevant element of system operation and a short-term task. Its regulatory characteristics and the best regulatory alignment depend, first of all, on whether an electricity system is isolated or highly interconnected with other systems. In the case of ‘electricity islands’, the volume of energy losses in the transmission and distribution of electricity is relatively controllable and partially predictable by a network operator.[xiv] The observability of losses and the choice of the most appropriate regulatory tool then rest with the regulator’s experience and the information gap it suffers from. If the regulator has limited experience in regulating energy losses, observability is likely to be low and a cost plus scheme will be the right regulatory tool to implement. Otherwise, the regulator can try and apply adapted incentive regulation tools. If he has a historical database of loss volumes for the firm under his regulatory oversight, output-based regulation will be tempting. With a more experienced regulator, a menu of contracts could be a suitable tool. Finally, if the regulator has information from several comparable network operators, yardstick competition will represent a viable solution.

In a highly interconnected electricity system, energy losses are no longer so controllable and predictable by the network operator. This is particularly true in the case of systems that are crossed by relevant external energy flows. Since controllability is limited, an incentive for losses minimization would not be really effective; on the contrary, it would increase the risks for the network operator. Therefore, the best regulatory alignment in this case is to implement cost plus regulation and pass through the cost of energy losses to network users.

Grid maintenance is a task that is particularly suited to incentive regulation, because it scores quite well in terms of controllability, predictability and observability. As mentioned in section 2.2.3, it is a rather repetitive task, whose costs are not much affected by uncertainty and unexpected events. The ability of the firm’s management to efficiently organise the task and implement it is relevant. Both the firm and the regulator can evaluate the productivity improvement and the relative cost of the practices to maintain a reliable grid. As a result, a firm can be incentivised to keep the maintenance costs to the lowest level: price or revenue cap, output-based regulation or yardstick competition are all theoretically sound possibilities. The most appropriate choice among the three depends mainly on the regulator’s abilities.

However, it is important to remember that a firm can minimise grid maintenance costs by simply postponing or reducing the number of maintenance interventions. This eventually endangers the network service quality, with negative consequences for network users. For this reason, it is widely argued that service quality has to be regulated complementarily to maintenance costs. Output regulation with service quality indicators generally supports the regulation of maintenance costs. The regulator can implement it on a stand-alone basis, inserted in a menu of contracts or integrated in a yardstick competition scheme.

The development and deployment of innovation by network operators is a long-term task that is becoming increasingly important in the context of the energy transition and the current wave of digitalization. Regulating innovation is a rather recent necessity and experience so far is quite limited.

Although innovation costs are quite controllable, it is difficult to predict (ex ante) and observe (ex post) the benefits that will follow an investment in RD&D over the long term. Uncertainty is inherently high, especially for immature technologies and solutions. In this case, it is not appropriate to put in place an incentive regulation tool, because the regulated firm will probably prefer not to spend resources in such risky activities. Rather, an innovation fund, possibly financed by grid tariffs, can provide a cost of service regulatory framework able to trigger an early innovation in accordance with the regulator's objectives. An alternative is to align certain key revenue parameters, like the rate of return or the depreciation rate, with the risk increase born by more innovation from the network. The regulator can make such a decision relying on the analysis of the balance between the costs and benefits that the network firm, its customers and all the other relevant stakeholders will bear.[xv] By doing so, the regulator simplifies the innovation process, while letting the regulated firm undertake what it considers economically more attractive in the innovation field covered by the new rules. Regulatory help can go up to the exemption of certain basic regulatory tools like third party access or the use of congestion rents for financing daring interconnections.

On the contrary, when innovation maturity is growing and the innovative technology or process is integrated on a more business-as-usual basis within the network operator, both predictability and observability tend to increase. In this case, a rule of risk sharing between the operator and the grid users may be considered, in order to provide the firm with stronger incentives.

2.4 Conclusion

National energy regulators present a manifold landscape in the EU. Although they all share a common legal framework set by European legislation, plenty of differences are detectable in terms of administrative powers and resources' endowment. Heterogeneity also characterises the transmission and distribution network operators they regulate at the national level. Besides, no network operator is a monolith, but rather a set of different tasks, each of which has its own economic and regulatory characteristics that may change over time and over space due, for instance, to technological progress, demand development and country-specific conditions.

In the past decades, the theory and practice of regulation have developed an array of tools that regulators can use to regulate network operators and manage a context of imperfect and asymmetric information. Each of these tools has its own advantages and disadvantages. In particular, each of them requires certain capabilities by the implementing regulator and will fit one network task better than another.

The limited amount of resources usually available to NRAs and the multi-faceted nature of network operators do not leave room for any single 'silver bullet'. Sophisticated incentive schemes, for instance, are not always the best option; sometimes, they are not practically implementable at all. A hybrid, and realistic, approach to network regulation is more appropriate. Such approach must be based on the identification of a workable regulatory alignment by the NRA, able to match the most suitable regulatory tool with the characteristics of the targeted network task and the NRA's capabilities.

The identification of a workable regulatory alignment is not carved in stone, but reflects a continuous process of trial and error by the NRAs that must constantly reassess the alignment and control its consistency with the evolution of the regulatory goals, the resources available to them and the characteristics of the tasks performed by network operators.

In the context of enduring differences among the EU Member States and the often scarce resources available, it is of the highest importance that all European regulators continue sharing their experience with the design and the implementation of the various regulatory tools, through their dedicated cooperation institutions – ACER and the Council of European Energy Regulators (CEER).[xvi] By doing so, NRAs can learn from each other and possibly identify or revise, more easily and quickly, the choice of the best regulatory tool for a specific network task, given their specific resources' endowment.

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[i] In certain countries like Italy the energy regulator is entrusted with the regulation of other network industries as well. Typical examples are water and district heating.

[ii] Although information on the annual budget can be useful too, as it provides an insight on the ability to pay attractive salaries and to outsource tasks to consultants, the total number of people employed is a fundamental measure, since it gives a basic understanding of how many activities and duties the regulator can effectively follow and carry out.

[iii] In the medium to long term, a network operator can also reduce the operating cost of managing the system by upgrading and expanding the grid.

[iv] In other words, a more mature innovation allows the network operator to better foresee first hand, and the regulator second hand, the usefulness and likely output of the deemed innovation, while a less mature innovation implies a low predictability and observability, because even the network operator can only guess the possible interaction of the innovation with the rest of the power system and, as a consequence, the associated costs and benefits.

[v] Adverse selection refers to a situation in which an actor (agent) does not have any incentive to reveal the sensitive information he holds to his counterpart (principal). On the other hand, moral hazard refers to a situation

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in which the agent does not have any incentive to undertake the maximum effort in order to perform a task assigned him by the principal.

[vi] Rate of return regulation is another way to identify this traditional regulatory tool.

[vii] From a principal-agent perspective, it is possible to say that cost plus regulation solves the problem of adverse selection but does not do anything to solve the problem of moral hazard.

[viii] X-inefficiency is the difference between the output a firm can theoretically obtain from the most efficient use of a given set of inputs and the output the same firm practically obtains from the very same set of inputs. The difference is usually attributed to a lack of clarity in the goals of the firm, imperfect organization of productive processes and managerial slack. The absence of competitive pressure is usually assumed to be one of the ultimate reasons for X-inefficiency. Gold-plating refers to a tendency of regulated firms, entitled to cost recovery, to invest in assets of an excessive and unnecessary high quality.

[ix] A price/revenue cap tackles the issue of moral hazard but does not solve the problem of adverse selection.

[x] The relevant output and the associated performance target may be identified also with the involvement of the industry stakeholders.

[xi] From a theoretical point of view, it is important that the firms under comparison do not collude against the regulator as well. The number of compared firms may be important with this regard. However, there is no evidence that any case of this type of collusion actually occurred in the electricity industry.

[xii] Failure to define this condition may lead to inefficient and unfair regulation of the network operator. Litigation in courts is likely to follow and the regulator's decision may be overruled by the judge.

[xiii] It should not be forgotten that a regulator does not have an *ex nihilo* knowledge of the best regulatory tool for each network operator's task. On the contrary, even a well endowed regulator may understand how the regulatory tools match with its goals and the targeted network tasks only through a trial and error process that can follow the decision tree depicted in Figure 2.2.

[xiv] Losses can be controlled, for instance, by modifying the topology of the grid, and predicted by forecasting the future level and distribution of energy injections and withdrawals within the system.

[xv] A good example is the extra-remuneration awarded to investment in innovative grid technologies like batteries by Italian network operators. The decision to award the companies was taken on the basis of a net present value (NPV) analysis of the proposed projects.

[xvi] Forums that involve all the main industry stakeholders, like the Florence Forum for electricity and the Madrid Forum for natural gas, are an important platform for knowledge exchange as well.