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Electricity distribution investments: no country for old rules? A critical overview of UK and Italian regulations

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Abstract

The increase in distributed generation and the increasingly pro-active role of mass consumers demand "smart" distribution networks. To this aim, regulation too must innovate, in order to promote innovative and additional infrastructural investments. This paper develops, first, a methodological framework addressing the relevant drivers for the regulation of distribution network investments. In the light of this framework, we then perform a critical overview of the British and Italian regulatory approach to distribution network investments. Finally, we discuss some policy insights for the Italian regulator.

KEYWORDS: *electricity distribution network, investments, regulation*.

JEL Classification: L94, L98.

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1 Introduction

The rapid increase in renewable generation capacity connected to medium- and low-voltage distribution networks, together with the launch of many smart grid projects, has prompted a wide and lively debate on how the regulation of electricity distribution should change to accommodate this new environment.

Actually, the advancement of a more sustainable electricity sector will require DSOs to become responsible for the implementation of what is often called an "active network" (Jamasb and Marantes 2011). Medium and low voltage distribution networks have traditionally been a passive infrastructure meant to transport electricity from the transmission grid to final customers. This is swiftly changing. In the near future, DSOs will need to be able to influence generators' behaviors and, possibly, to offer ancillary services. Moreover, they could become responsible towards the transmission system operator (TSO) for ensuring the achievement of targeted standards of network functioning.

To successfully accomplish the managerial challenges the future low-carbon scenario brings to distributors, the latter are expected to undertake significant investments and, at the same time, to take up with new responsibilities. In particular, DSOs will be required to expand network capacity and improve its reliability in order to accommodate the increase of generation from renewable energy sources. In addition, the deployment of "smart grids" will accomplish greater end-user participation – through grids characterized by real time information exchanges between DSOs and the TSO – as well as speeding up greater market integration and operational network security (ERGEG, 2010).

This paper critically overviews the evolution of the regulation of distribution network investments in UK and Italy.

To this aim we develop a framework of analysis discussing the drivers of the regulation concerning distribution network investments which emerge as fundamental aspects either for the institutional and theoretical debate on regulation, either for the regulatory experiences we analyze.

The focus on the UK comes from the fact that it has been the Country to more comprehensively review its regulatory approach over the last three years. On the other hand, we discuss the Italian regulation because a new regulatory period has recently started, on January 2012, and a lively debate is ongoing about how to promote the necessary infrastructural interventions to move toward a low-carbon electricity sector.

The recent Italian and British regulatory reviews provide a unique opportunity to understand how regulators are facing the issue of a more sustainable and "smart" distribution activity. Specifically, our analysis aims at critically assessing the novelties and the eventual difficulties concerning the implementation of a pioneering and comprehensive regulatory revision such as the British one, and at eventually addressing some of the open issues of the Italian regulation which appear to be at risk of discouraging the needed distribution network investments.

Our analysis shows that Italy and the UK are taking a materially different stance on investment regulation. Specifically, UK regulation is quickly moving towards a performance-based approach, where revenues and investments are explicitly linked to different output targets. Theoretically, this new approach is convincing, but also extremely challenging, as it requires the regulator not only to define a consistent set of coherent and easily measurable outputs, but also to define proportional and just rewards and penalties, which have to avoid remunerating or punishing DSOs for situations which are beyond their control. As for Italy, we must first stress that, by law, investment regulation has to be organised in terms of Rate of Return. This constraint makes a move towards a fully-fledged performance-based mechanism, like the UK one, very difficult, if not impossible. This has inevitably led to an input-based approach to investment regulation, where the Italian regulator grants extra remuneration to certain specific investments. In this respect, the Italian regulator is aware that this is a suboptimal mechanism in the long term, as it could push DSOs along a potentially wrong technological trajectory; still, it has decided to confirm this approach also for the new regulatory period, as it is considered the best option given the abovementioned constraints.

That said, we notice that the Italian regulation is still designed following a "building blocks" approach. In fact, the relationship between DSOs' performances – in terms, for example, of RES connection and quality of supply – and the revenue they are allowed to earn, is not clearly structured in a unified framework.

Moreover, a number of distortions or over-simplifications of the current regulations that in the past had minor impacts on investment decisions are now becoming significant and deserve attention. For example, the two-year regulatory lag according to which the remuneration of capital expenditures is passed on to end users produces a reduction in the Internal Rate of Return of investments below the cost of debt. In addition, the abovementioned problems are likely to be exacerbated by the introduction of the so-called "Robin Hood tax" which represents an increase in the taxes paid by the DSOs, who, as a consequence, suffer a reduction in their actual return.

To sum up, under the current regulatory framework all investments, irrespective of their utility, are included in the Regulated Asset-based model (and paid for by consumers); however, the real allowed return on invested capital is too low to incentivise investments, unless they fall under one of the smart investment categories. Conversely, the lack of vision with respect to the scenarios we might expect in the future, mainly with respect to renewables, and to related investments in distribution and transmission networks, puts the system in an anachronistic backward-looking position.

The paper is structured as follows. Section 2 discusses the literature on the regulation of network investments. In section 3 we briefly describe a simplified methodological framework against which to assess the current regulations, and discuss the main issues the regulation of distribution network investments should address. Section 4 and 5 perform, respectively, a critical overview of UK and Italian regulations concerning investments in distribution networks. Finally, in Section 6 we draw some policy recommendations for Italy.

2 The literature

The development of active grids (EnergyLab, 2011) is one of the crucial steps for the realization of a low-carbon electricity sector. A "smart regulation" (Meeus et al., 2010) plays a fundamental role in promoting the needed investments to realize "smart" grids. Actually, DSOs have to be provided with the appropriate incentives to: (i) increase network capacity and replace aged infrastructures - to accommodate distributed generation and the progressive raise of RES generation; (ii) develop innovative infrastructures aimed at accomplishing greater end-user participation - through grids characterized by real time bi-directional information exchanges between DSOs and the TSO.

Many documents and papers addressing these issues have recently been published, mainly by national regulators and governments (see, e.g., ERGEG, 2010; CEER, 2011, European Commission, 2011). However, the institutional debate is sometimes confused, in particular when it comes to incentives: almost all types of regulations, in fact, claim to be incentive-based. The link between the theoretical literature and regulatory practice becomes tenuous and even the definition of what is meant by incentive-based regulation is open to question. On the one hand, it is true that almost all regulations contain incentive mechanisms, as incentives are a powerful tool to push regulated businesses to reveal their information and to do something that otherwise they would not (or would do less). On the other hand, the properties and the effectiveness of an incentive network regulation depend on several factors like e.g. the asymmetry on cost information, the task division between regulated segments, and externalities due to distributed generation - like CO2, and heat emissions, or noise and space occupancy (Agrell and Bogetoft, 2011). Moreover, incentives can be quite different in that they potentially respond to significantly different regulatory objectives and may produce mixed effects on DSOs' incentive to perform the needed infrastructural interventions.

A comprehensive survey of the main findings of the theoretical literature concerning the effect of network regulation on operators' incentives to invest in network infrastructures is provided by Guthrie (2006). Traditionally, this strand of the literature compares the effects, on the incentive to invest in network infrastructures, of a pure cost-based regulation and a price-cap regulation.

To accomplish the new low-carbon scenario, the focus of regulation should be not simply on investments, but rather on *innovative* investments. According to the theoretical literature, the effects that either a price-cap either a cost-based regulation produces on the incentive of grid operators to innovate are mixed. On the one side, a price-based regulation allows DSOs to benefit from the cost savings arising from innovation (Armstrong et al., 1994; Littlechild, 2006). On the other side, given that regulators periodically review tariffs and transfer the achieved cost savings to customers, a price-cap regulation has the effect to incentivize distributors to contain costs (Bauknecht, 2010). Similarly, a cost-based regulation is deemed to promote DSOs' R&D activity to the extent that distributors do not bear any cost risk, and additional capital expenses are covered by higher tariffs. Conversely, under a price-based regulation, distributors bear a greater risk of losses from the R&D activity. Actually, under a price-cap regulation, R&D expenses are recovered through efficiency gains which are then shared with customers at the end of each regulatory period. Therefore, R&D investments that do not produce enough cost savings will imply losses for the distributors. As for a price-cap regulation, the cost-based approach does not prevent to translate to customers, through lower tariffs, the cost efficiencies DSOs gain from innovation. This aspect may lead to a sub-optimal innovation activity given that distributors – despite the tariff review occurs with a regulatory lag which allows DSOs to retain the achieved cost savings in the medium term (Bailey, 1974) – will contain to some extent their capital expenses.

Actually, with the aim of allowing network operators to retain for a longer period the cost efficiencies arising from innovation, some scholars suggest to extend regulatory periods and thus to introduce a lag in the review process (Bailey, 1974; Burns and Riechmann, 2004). However, a similar measure may have the effect of producing a delay in the innovation activity which would be postponed by distributors (Baucknecht, 2010).

However, regulation may produce sub-optimal innovative network investments not only in the sense that the latter may result inadequate - both with reference to their quality and volume, that to their timing – but also in the sense that over-investment may occur. Actually, when a cost-based regulation is adopted to remunerate infrastructural intervention, gold plating may occur (Averch and Johnson, 1962).

The recent and only empirical paper assessing the effects of different regulatory regimes on network investments (Cambini and Rondi, 2010), shows indeed that network operators' investment rate is sensitive to the level and variations in the WACC. However, these scholars' empirical analysis demonstrates that a price-cap regulation is more effective than a cost-based regulation in promoting network investments.

Recently, the debate on the regulation of network investments enriched its focus by considering two further approaches for the regulation of infrastructural interventions: the so-called input and output-based regulation. The opposition between these two approaches refers essentially to the responsibility about the decision process concerning the investments that must be undertaken. Generally, as it happens for both the British and the Italian regulation, the two approaches coexist. The input-based regulation is characterized by a strong involvement of the regulator in the definition of the network investments that should be realized during a given regulatory period. The regulator, actually, defines the volume, the quality, the timing, and the location of the investments. In other terms, the regulator is involved in the definition of the production function of DSOs. The output-based approach – which is receiving a growing interest in the regulatory experience of many countries (see e.g. CEER, 2011) – is characterized by a complete autonomy of DSOs in deciding the investments to be carried out during the regulatory period. The regulator limits only to define a set of outputs – like e.g. certain standard levels for the reliability and the quality of the service, or certain target volume for the connection of distributed generation - that should be achieved through network investments. The over or under performance with respect to the outputs set by the regulator is then compensated through incentives or penalties. According to Baucknecht 2010, an input based regulation has the effect to reduce the risks borne by DSOs with reference to the innovation activity. At the same time, however, an input-based approach may have the effect to put DSOs on the wrong technological pattern. To this aim, an output-based regulation seems more attractive given that DSOs are left free to realize the investments they evaluate more appropriate according to the economic and technological development of the sector. However, the focus of different regulatory experiences on the contraposition between input and output-based regulation is very recent. Therefore, the literature lacks of papers empirically addressing the effects of both an input and an output-based regulation on DSOs incentive to invest.

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3 Regulatory drivers

We can derive three main drivers of incentive regulation by looking at current common practices in the electricity distribution service: short-run cost minimisation; timing of the implementation by DSOs of some specific investment or action; achievement of given standards of performance.

- The first driver has to do with *cost minimisation*; any regulatory mechanism, in fact, can be classified according to its power to spur productive efficiency. For instance, "pure rate of return regulation" and "price/revenue cap regulation" are usually taken as the two paradigmatic examples of "low" and "high" power mechanisms to achieve cost minimisation. So far, incentive-based regulation and cost minimisation have often been considered synonyms. In what follows, in contrast, we will refer to incentive-based mechanisms designed to minimise costs as "efficiency-based regulation". In fact, there are other incentive-based mechanisms whose primary aim is not cost minimisation.
  In the rate-of-return approach, allowed revenue for DSOs (Distribution System Operators) equals actual costs, including a fair return on capital. In this case, the main duty of the regulator is to determine whether those costs are justified or not. In the efficiency-based approach, in order to incentivise the DSO to increase productivity, the link between revenues and costs is weakened. The regulator, in fact, sets *ex-ante* the revenue (or price) level that the DSO is allowed to earn. The lower the DSO's costs, the higher its profit margin. This type of efficiency mechanism, at least as usually applied, focuses mainly on short-run efficiency. Moreover, little attention is usually paid to the detailed framing of the service that the DSO is required to provide. This is coherent with a framework where, on the one side, this service is relatively standard and, on the other, it is possible to identify simple indicators measuring the output the DSO supplies;
- The second driver has to do with the *timing of the implementation by DSOs of some specific investment or action*. One might assume that well-designed, efficiency-based regulation should deliver an optimal and timely choice of actions/investments by the DSO. However, there are situations where the optimal mechanism is either too complicated or too costly to implement. In these situations, the regulator can opt for a different mechanism design, focused more on the DSO's choices – for example, on its investment strategy – than on the service provided. The literature sometimes refers to this type of regulatory mechanism as "input-based regulation": in this case, the introduction of any incentive primarily aims at encouraging the DSO to implement a specific investment or action;
- The third driver, in contrast, has to do with *DSOs' outputs* and we will refer to it as "performance-based" regulation, which can be particularly effective when the regulated business has to perform multiple tasks and costs cannot be easily known in advance by the regulator. For example, in an output-based framework, the regulator would only specify the high level of supply continuity as the output, whereas in the abovementioned input-based framework it would specify the scale, location and type of investments required to achieve that output (Frontier Economics, 2010). A performance-based regulatory framework is similar to efficiency-based regulation, but with a greater focus

on the relationship between revenue and performance. The result should be an incentive for DSOs to (out-) performs certain predefined outputs.

Of course, these drivers are somewhat arbitrary and, moreover, often intrinsically interconnected[1]. When it comes to incentives, this interconnection might generate an "overlapping effect", which occurs when different incentive mechanisms end up incentivising the same behaviour more than once. This situation can happen often as regulators are prone to mix different incentives, particularly when regulation is conceived with a "building blocks" approach. For instance, a regulatory framework might simultaneously contain investment incentives, designed to stimulate capital additions via an extra WACC remuneration, and output incentives, designed to allow extra revenues for the delivery of certain defined quality standards. In this case, an investment that increases reliability might benefit from a double incentive, that is, the extra WACC remuneration and the extra revenues for quality standards. In the end, being able to suggest the optimal choice among these drivers rests on the clear specification of the regulator's objective function and on the magnitude of the information asymmetry between the regulator and the DSO.

When it comes to translating this methodological framework into an actual set of rules, there are many problems to solve. It is beyond the scope of this paper to investigate them all; here, we will concentrate on problems related to investment regulation. In this respect, we see three major issues:

- How to treat costs;
- How to shape incentives;
- How to remunerate the investment.

These issues are extremely complex. First, the regulator has to decide whether to regulate operating expenses (OPEX) and capital expenditures (CAPEX) differently or not. This first choice can significantly impact DSOs' investment choices, as it could bias them towards OPEX or CAPEX, according to the most profitable regulation. For instance, efficiency-based regulation for OPEX mixed with cost-based regulation for CAPEX, without making any further assumption regarding the other two drivers, could lead to overspending in capital assets, even when it is not efficient, from a purely economic perspective, to do so.

Irrespective of any potential difference in treatment between OPEX and CAPEX, the regulator has to decide where to position its regulation with respect to each single driver and, accordingly, how to shape incentives. This decision primarily depends on the cost and technical uncertainties related to new investments. For instance, a regulator can opt either for efficiency mechanisms or input mechanisms: if there is no uncertainty with regard to costs (such as a mere replacement of depreciated assets), then pushing on efficiency can be a winning solution; on the other hand, efficiency regulation may hinder investments in risky assets, as wrongly designed efficiency parameters could potentially eliminate any remuneration; in this case, the regulator might decide to act as a "guiding mind" (Shaw et al. 2010), by incentivising certain specific technical

[1] The real difference between input and output regulation is how each element is implicitly or explicitly treated and incentivized. For instance, a pure input-based regulation, which tells the operator which assets and goods to use, has implicitly deemed that those inputs are the best option for achieving any given outputs, even if they are not specifically indicated (e.g. a certain quality standard).

solutions. Of course, a third way might be to incentivise output delivery, leaving DSOs to choose regarding efficiency and inputs.

The final point regards capital remuneration. Here the regulator's task is simple in principle but can have perverse effects in practice, as we shall see later on. For instance, rate-of-return regulation, which in principle could even lead to overinvestment (known as the Averch-Johnson effect: Averch and Johnson, 1962), in practice might not bring any investment at all, if the capital remuneration is set too low[2].

In the following paragraphs, we will discuss both UK and Italian investment regulation according to the abovementioned drivers. In doing so, we will specifically answer the following questions, all related to at least one dimension of the space: (i) Who is the subject responsible for deciding which investments have to be made? (ii) How are decisions about investments in distribution infrastructure networks performed? and (iii) What are the components of the Regulatory Asset Value and how is it remunerated? (iv) Are there additional incentives for the promotion of a sustainable sector, such as specific incentives for distributed generation and losses?

4 Some considerations about the regulation of electricity distribution network investments in the United Kingdom

In the UK, there are 14 distribution licence areas which derive from the originally designated Area Electricity Boards (AEBs). At present, the 14 licences are held by seven companies, following a number of mergers and acquisitions which took place after privatisation came into force. These companies are: EDF Energy (EDFE), CE Electric (CE), E.ON Central Networks (CN), Western Power Distribution (WPD), Scottish and Southern Energy (SSE), Scottish Power (SP) and Electricity North West (ENW).

Distribution is a fully regulated business with specific requirements set by both the Electricity Act of 1989 (and subsequent amendments) and the Utilities Act of 2000. Among their responsibilities, the DSOs have legal duties to maintain and develop economic, efficient and coordinated distribution networks. Moreover, they have to supply reliable electricity, restore power promptly in the event of a supply interruption and connect new end users and local generators to their network quickly and efficiently.

Given the new challenges that electricity distribution has to face, OFGEM has decided to review its regulatory framework, so to stimulate infrastructural upgrades. Figure 1 shows that, at least on paper, the new regulation is aiming at a sharp increase of investment in electricity distribution networks.

[2] For a survey on the literature on the investment implications of different regulatory schemes, see Guthrie, 2006.

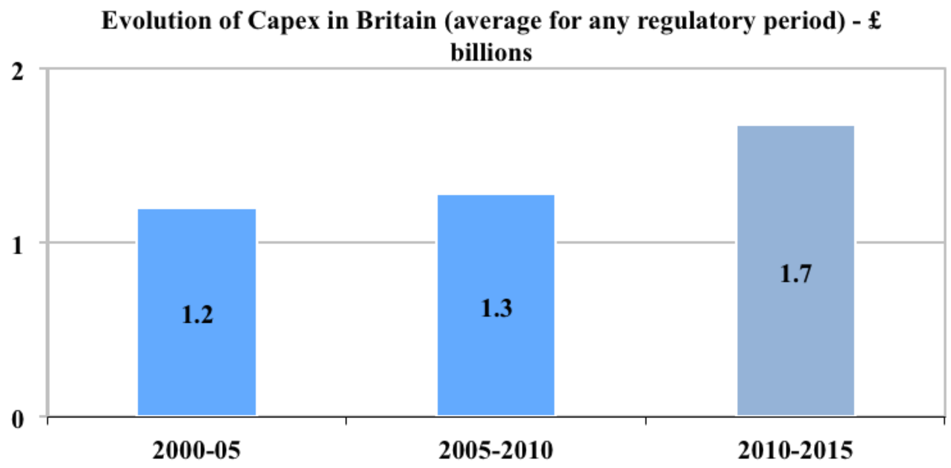

Figure 1: Evolution of investment in electricity distribution.

Below, we will discuss the main features of the new regulation, focusing our attention on investments.

4.1 RIIO, an innovative regulatory approach: linking outputs and TOTEX

OFGEM has historically adopted an efficiency-based regulation, on the basis of a revenue-cap mechanism. Moreover, attention to DSOs' output delivery has constantly increased throughout subsequent regulatory periods, up to the point where the UK regulator has decided to review the whole framework, so as to adopt a more comprehensive and rational approach named RIIO (Revenue, Innovation, Incentives and Output). In this respect, the current distribution price control review (DPCR 5, which commenced in 2011) is a bridge between the "old" system and the "new" one. Below, we will discuss the main features of RIIO and, where appropriate, we will highlight where the current DPCR departs from the new framework.

The new regulatory framework deals to a large extent with investments. In all previous DPCRs, in contrast, the focus was more on short-term efficiency and on OPEX reduction (Jamasb and Pollit, 2007). This was achieved through standard efficiency-based regulation with the addition of certain specific quality standards that DSOs had to meet. The overall mechanism (from efficiency gains to quality standards) was designed in a way that forecast OPEX received far more scrutiny than CAPEX: the former, in fact, was set with the application of benchmarking techniques, while the latter was basically set through different negotiation rounds between each distributor and OFGEM. It is also important to point out that both OPEX and CAPEX were defined at the beginning of the regulatory period and not scrutinised at a later stage. To sum up, the underlying objective function was a "constrained minimisation": the regulatory objective was to minimise DSOs' (operating) costs while achieving certain predefined standards.

Clearly, in an era of an expected increase in investments and in the number of tasks to be carried out by DSOs, the old framework appears unsustainable. The principal aim of the new approach is to harmonise three issues:

- preserving the forward-looking efficiency-based spirit;
- not distorting DSOs' investment decisions;
- focusing on DSOs' performance.

With regard to the first point, the revenue-cap mechanism has proved effective in stimulating OPEX reduction: the aim has thus been to upgrade the mechanism to stimulate efficient capital spending too. However, efficient spending can take place only if DSOs' investment decisions are not distorted by any regulatory bias: as such, harmonisation of the first two issues has been achieved by treating OPEX[3] and CAPEX in a unified manner, known as the TOTEX approach. Treating OPEX and CAPEX differently may in fact distort operators' choice in favour of the most highly remunerated solution (i.e. costs that can be capitalised vs. costs that cannot). The TOTEX approach means that DSOs are incentivised to choose the most cost-effective solution over a longer-term horizon: they have in fact to opt for the solution that minimises the overall cost and not a solution that minimises just OPEX or CAPEX. On the other hand, the TOTEX approach expands DSOs' choice of alternatives, thus reducing the effectiveness of OFGEM's benchmarking techniques against which to measure DSOs' costs, as it is more likely that different distributors will opt for different solutions. This means that OFGEM has more uncertainties with regard to DSOs' cost functions. To overcome this issue, the regulator has decided to adopt an "upside-down" approach to the problem: OFGEM sets different outputs which DSOs have to deliver, while distributors have to find and justify the most efficient way to deliver. On the one hand, this new framework introduces a clear link between costs that have to be borne and outputs that DSOs have to deliver, reducing OFGEM's asymmetric information regarding costs; on the other hand, the clear measurement of predefined outputs makes it possible to grant financial rewards or penalties according to each DSO's performance. The reward/penalty system, if properly designed, reduces OFGEM's asymmetric information still further, as DSOs should find it profitable to deliver a given output till the marginal cost of delivery equals the marginal revenue. These pieces of information should allow OFGEM to design better output measures and the whole reward/penalty system in the subsequent regulatory periods.

As such, the Copernican revolution is completed: the new underlying logic can thus be described as a "standard optimisation problem", as DSOs, in order to maximise their profits, have to optimise their performance.

A unitary approach clearly emerges from the preceding discussion: OFGEM is clearly pushing towards strongly incentivising, performance-based regulation. Theoretically, this new approach seems convincing but also extremely challenging, as it requires the regulator not only to define a consistent set of coherent and easily measurable outputs, but also to define proportional and just rewards and penalties, which have to avoid remunerating or punishing DSOs for situations which are beyond their control.

In the following, we will discuss the relevant issues concerning investments; in particular, we will focus on the business plan moment of the regulation. The new framework, in fact, is strongly characterised by a forward-looking approach, given the great importance of the

[3] Not all OPEX items are included in the TOTEX, but only network-related OPEX; for instance, costs related to network maintenance fall within TOTEX, while administrative costs do not.

business plan that DSOs have to submit at the beginning of each regulatory period, as it is the document that OFGEM will use to set allowed revenues.

4.2 The regulation of distribution network investments

4.2.1 Investment responsibility and the regulatory approach to DSOs' investment activity

Within the new framework, at the beginning of each regulatory period, prior to the definition of DSOs' investment plans, there is a procedural stage aimed at defining the outputs that each DSO will have to deliver. Output definition is, in fact, a preliminary process that involves different stakeholders, in particular network users, the distributor itself and the regulator. On the basis of the agreed output objectives, the DSO has to prepare a business plan. In its business plan, the DSO has to set out in detail the investments it wishes to make and the expected impact on outputs. As we will see in more detail below, the DSO's business plan is used by the regulator as a relevant piece of information in quantifying allowed revenues within the regulatory period. However, the DSO's actual revenue is conditional on its performance, not on its actual investments. As such, the responsibility to decide which investments have to be carried out rests with DSOs.

At present, OFGEM has set six output categories, and each contains a certain number of outputs. The categories are:

- customer satisfaction;
- reliability and availability;
- safety;
- conditions for connection;
- environmental impact, and
- social obligations.

To illustrate matters, we shall consider, for example, the first output category (customer satisfaction). This category will be assessed by measuring different outputs, among which we find: surveys assessing customers' and network users' overall experience with DSOs, measures of unresolved and repeated complaints and the assessment of the level of engagement of different stakeholders in the DSOs' activity. For each of these outputs, OFGEM will set a baseline performance; subsequently, DSOs will have to justify the option they think will optimise output delivery and minimise long-term costs. For instance, if there are three options available (commit to small upgrade; commit to large upgrade; and commit to small upgrade now but combined with preparatory work that retains the possibility of expansion works later in the control period), OFGEM expects that a well-justified business plan should discuss all of them "*by comparing the net present value cost and choices in terms of impact on, and risk to, delivery of primary outputs".* Moreover the DSO *"will separately need to show how its choice is affected by the degree of uncertainty in its volume forecasts*".

4.2.2 Timeframe and scrutiny

Each business plan has an eight-year timeframe (the current regulatory period, which we previously defined as a bridge to the new regulatory framework, still lasts only five years). This means that DSOs have to plan their investment eight years in advance, with all the risks and uncertainties which this inevitably entails. In this respect, as we shall see later, OFGEM has introduced a number of adjustments properly designed to smooth uncertainties.

Once submitted, the business plan is scrutinised by the regulator, which can ask for additions and amendments, before issuing a final binding decision. Costs are reviewed both with benchmarking techniques and with *ad hoc* analyses performed by engineering consultants. This scrutiny allows OFGEM to formulate its own view regarding expected costs. OFGEM's view is then translated into an incentive mechanism proposed to DSOs, called the IQI (Information Quality Index), which, at least in principle, should incentivise distributors to reveal their actual view with regard to future expenditures, prior to OFGEM's final decision being issued.

The mechanism stems from the "menu of contracts" theory, which suggests that the regulator has to offer companies a "menu" of possible combinations of TOTEX expenditures and marginal incentive rates, that is, the proportion of gains and losses DSO may keep or bear if they outperform or underperform the baseline TOTEX[4]. The menu must be designed in such a way that the DSO will find it profitable to choose exactly the contract which reflects its expenditures, as any other combination would reduce its profits.

The scrutiny is clearly the most controversial phase of the whole regulation: as the approval of the cost forecast implies the determination of the allowed revenues, OFGEM must review them thoroughly. This review, which can last more than six months, introduces – at least implicitly – an input-based flavour into regulation. In fact, in order for OFGEM to offer a menu of contracts, it has to test whether the same outputs can be obtained in a less expensive way. This does not mean that OFGEM explicitly contends the inputs chosen by each DSOs; still, by challenging the overall cost of the planned investments, it could well be that the regulator has an optimal cost function which it tries to impose on DSOs through its menu of contracts.

In the final analysis, DSOs are responsible for deciding what investments to perform, according to their long-term outlook regarding costs. However, their justification and approval derive from the outputs that OFGEM requires DSOs to deliver.

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[4] The mechanism of the approach involves scaling each DSO's TOTEX forecast relative to that of OFGEM's. The result is a ratio that can vary from 1 to (theoretically) infinity. If the result is precisely one, than it means that OFGEM's and DSO's forecasts coincide. If it is more than one, than the DSO's spending estimates are greater than what OFGEM deems efficient. OFGEM then sets the allowed revenues: if the ratio is one or close to 1, then OFGEM recognizes revenues higher than the forecast investment; then, after a threshold ratio, OFGEM sets allowed revenues lower than the forecast investment. Finally, OFGEM sets different marginal incentive rates to be linked to each ratio (and consequently, to each allowed revenue). The marginal incentive rate represents the proportion that each DSO will keep or bear if it under- or overspends compared to allowed revenue (not surprisingly, the remainder of the amount of under- or overspending will be borne by end users). Higher incentive rates are recognized at ratios close to 1, while lower incentive rates are associated with ratios significantly higher than 1. The whole mechanism is designed so that each DSO will find it profitable to choose from the menu the contract designed to meet its investment needs. Once chosen, the capital expenditure is added to the RAV. To sum up, this structure permits the DSOs to choose between obtaining a lower cost allowance but higher incentives that allow them to retain significant benefits if they can do even better than the estimated investment, and obtaining a higher allowance, but with low incentives that give relatively small rewards for under-spending.

4.2.3 The low-carbon network fund

Within the new regulation, OFGEM has set up a specific mechanism aimed at stimulating innovation, which is set aside from other investments. The mechanism is called named "LCN (Low Carbon Network) Fund" and it has been set up with £500 million to support the DSOs in testing new technologies, operating and commercial arrangements. The Fund consists of two tiers plus up to £100 million over the five-year period, available on a discretionary basis in order to reward outperformance of innovation targets.

The First Tier is set up to fund a high number of small local projects and to cover a proportion of set up costs. It allows up to £16 million per year over the five-year regulatory period. The mechanism of the first tier is simple: DSOs have to self-certify the projects, demonstrating that they respect the criteria set by OFGEM[5]; then, allowable project expenditure must be netted against the revenues saved with the project implementation and cannot exceed 90% of eligible costs. The allowed revenues are then collected directly by DSOs through the tariff.

More interesting is the Second Tier, which provides total funding of £320 million over the five-year regulatory period, that is, up to £64 million every year. This Tier is set up to fund partial expenditures for a small number of large projects (the DSO's contribution is expected to be at least 10% of the overall expenditure). In this case, OFGEM's involvement is significant, as DSOs compete against each other for the allocation of the fund and the selection process lasts multiple rounds. Final approval is granted by a panel of experts, nominated by OFGEM.

It is important to highlight that even in the Second Tier, central funding does not exist. As specified in the funding directive issued by OFGEM, each DSO must recover, each year, an amount that depends on its total number of end users, so that the overall amount collected from all UK customers equals the approved amount of yearly funding. Then, each DSO transfers, on a monthly basis, the collected amount to the winner(s), net of the money that it may be allowed to keep in case it is a winner itself.

4.3 The components of the Regulatory Asset Value and its remuneration

The final approval of the business plan means the approval of the regulatory asset value (RAV) and of the base allowed revenues[6]. The RAV is made of two "sub-blocks": one is represented by the carrying charges of historical components, while the other one is made up of the allowed TOTEX, derived from the approved business plan. To be more precise, only 85% of the allowed TOTEX enters the RAV, as the remaining 15% is entirely recovered the year of the expenditure. As a consequence, the RAV used to set tariffs for any given year *n* is derived from the sum of:

- the carrying charges, which are the algebraic sum of the RAV for year *n-1* and the allowed depreciation for year *n-1*;

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[5] The eligibility criteria are linked to four project targets: accelerating the development of a low-carbon energy sector, having a direct impact on the operation of the distribution network, generating new knowledge that can be shared amongst all network operators and delivering net benefits to end users.

[6] The term base is used as each year actual revenue will also depend on DSOs' performance, which, of course, can be measured from year to year. DSOs have the right to recover their base allowed revenues each year. That is why the tariff system has to contain automatic adjustments so that DSOs receive exactly what they are entitled to.

- the 85% of allowed TOTEX additions at year *n-1*.

This formula implies that, on the one hand, there is a one-year "regulatory lag" between the investment and its inclusion in the RAV; on the other hand, in contrast, the remunerated RAV for year *n* is gross of the allowed depreciation for year *n*. The RAV is then multiplied by a WACC net of fiscal effects (termed "vanilla" WACC, set for DPCR5 at 4.7%)[7].

Once the return on the RAV for year *n* has been determined, in order to define the allowed base revenues for the same year *n*, one has to include all other allowed costs (such as pension costs, the abovementioned 15% of allowed TOTEX, depreciation and all other indirect operating costs) to be recovered the same year of the expenditure.

Let us now show in the tables below an example of RAV determination.

	n	**n+1**
Opening RAV	0	1000
CAPEX additions (85% of TOTEX)	1000	0
Allowed depreciation	0	50
RAV for tariff (Opening RAV)	0	1000

Table 1: Allowed Base Revenues

Let us now make some "back-of-the-envelope" calculations to assess the net present value and the IRR of a new investment. If we consider the following assumptions:

- the lifetime of the new CAPEX addition is 20 years;
- WACC is expressed in nominal post-tax terms (just to make calculation easier) at 6.0% (equivalent to 4.7% real "vanilla").

The IRR of a new investment is equal to the WACC guaranteed by the regulation (6.0% in nominal post-tax terms). It also implies that the Present Value of cash flows related to an investment is equal to the upfront investment itself. These statements are verified since the correct financial principles are applied (1-year regulatory lag and opening RAV).

Finally, each year, the allowed base revenues are adjusted with four main instruments: the first one is linked to DSOs' output delivery (the reward/penalty system, cited above); the second one is a specific incentive for connecting distributed generation (which basically recognises a unitary extra-revenue per DG connected, in DPCR 5 set to be equal to £1/kW/year); the third one is the extra revenues deriving from the LCN fund; the final one is a set of uncertainty mechanisms, which we will discuss below.

[7] In the UK, in fact, taxes get a separate allowance. To be more precise, the tax allowance is calculated to allow distributors to cover their whole tax burden: not only taxes paid on allowed remuneration of the RAV, but also the taxes paid on other earnings, for instance taxes deriving from higher earnings gained because regulatory depreciation is higher than accounting depreciation.

4.4 Specific issues concerning losses and uncertainties

4.4.1 Losses

Within the current DPCR, OFGEM, in accordance with its performance-based regulation, has introduced a specific output target for losses: DSOs will benefit or be penalised according to overall percentage losses. The reference benchmark is based on past performance as a percentage of energy distributed. The baseline for the performance review is updated every regulatory cycle and set at the actual level of losses. In principle, this should incentivise distributors to invest in loss reduction. Nevertheless, this scheme has been criticised, as it does not properly take into account the effect of distributed generation. In particular, two problems arise: the first one has to do with fixed losses, while the second one as to do with reverse flows, from lower to higher voltages. With regard to the first issue, according to Shaw *et al.* (2010), DSOs can be penalised for a generator that reduces losses: "*if a generator offsets demand, this reduces both energy distributed from the network and resistive losses in the network. However, in the short term, it cannot reduce the fixed losses, which relate to the number of transformers and network configuration (which on average account for 30%)*". This problem is exacerbated by the fact that this statement is correct only when a strong hypothesis is satisfied, that is, that all distributed generation is consumed at the same point where it is generated. However, if we consider that distributed generation is peripheral, it follows that the energy produced flows along the grid (including up to higher voltage levels, and then down to lower voltage levels), consequently resulting in grid losses that are even higher than those that conventional generation would have created.

4.4.2 Managing uncertainty

Uncertainty mechanisms have been introduced to smooth risks[8]. Within their business plans, DSOs have to forecast the evolution of network usage as well as the demand for new connections, in particular that of distributed generation. Forecasts are generally subject to error, and this implies that DSO could face over or under spending, if the market evolves differently from what was foreseen at the beginning of the regulatory period.

OFGEM distinguishes three major families of instruments to manage uncertainty[9]:

- Mechanisms calibrated at the beginning of a price control review, such as:
    - *The marginal incentive rate*, which is chosen by each DSO at the beginning of the regulatory period; for instance, a very low marginal incentive rate means that a significant proportion of any overspend is passed on to end users[10];
    - *Volume or unit drivers,* which are revenue adjustments linked to volumes or other precise numbers, e.g. £ per unit of connected generation or a percentage of pass-through (for DG, DPCR5; has set a pass-through rate of 80% for all

[8] On the importance of the regulatory mechanisms managing uncertainties, see Pollitt, 2008.
[9] RIIO Handbook.
[10] On the other hand, in case of under-spend, very little will be kept by the DSO.

connection-related costs which are beyond the costs included in the original business plan);

- Special re-opener, which is the revision of allowed revenues if trigger events occur and the company has to invest more (a forward-looking measure);
- Revenue allowance determined after the company incurs the relevant expenditure: in this case, once data on actual expenditure is available, the magnitude of the revenue adjustment is set.

Of these measures, OFGEM clearly prefers the first family, as, on the one hand, they are automatic adjustments, not involving any scrutiny, and, on the other, are known *ex-ante* by all relevant stakeholders.

5 An insight into Italian regulation of electricity distribution network investments

The electricity distribution service in Italy is supplied by a large number of companies – approximately 140 – of extremely uneven size. *Enel Distribuzione* is the main distributor, serving around 85% of the Italian market, followed by *A2A Reti Elettriche* (4%), *Acea Distribuzione* (3.4%) and *Aem Torino Distribuzione* (1.3%).

Since 1997, DSOs have been regulated by an independent regulator (*Autorità per l'Energia Elettrica e il Gas - AEEG*) in accordance with Law no. 481/95 (and subsequent amendments). Regulation was initially efficiency-based, with elements of performance regulation. In 2000 a price-cap mechanism with a 4-year regulatory period, supplemented by quality-of-service regulation, entered into operation. However, the initial approach has been modified over time, gradually moving away from standard efficiency-based mechanisms. The first step in this evolutionary process was a split between OPEX and CAPEX regulation. Specifically, since 2004, CAPEX have been subject to rate-of-return (RoR) regulation, while OPEX are still price-capped[11]. The second step forward has been the introduction of input-based elements, in the form of an increase in the rate of return applied to specific types of investments, mainly designed to facilitate the hosting of renewable capacity on distribution networks.

The current regulatory period began on January 2012 and will end on December 2015[12]. Infrastructural developments are at the centre of the debate, in Italy as well as in many other countries.

As shown in Figure 2, investments made in the Italian distribution sector have been decreasing over time.

[11] Note that this change was decided by the government and not by the regulator: Law no. 290/2003.

[12] Italian Regulatory Authority for Energy and Gas, 2011c. Decision Arg/elt 199/11.

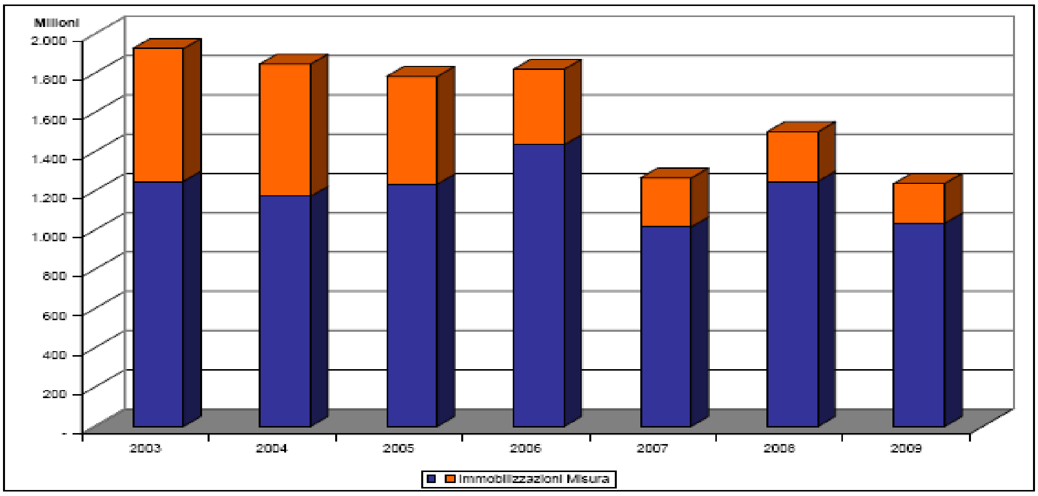

Figure 2: Dynamics of distribution network investments in the whole electricity distribution sector (millions of euros). Period: 2003 - 2009. Blue columns refer to distribution network investments, while orange columns refer to investments for metering services. Source: Italian Regulatory Authority for Energy and Gas, 2011d. Consultation Document 29/11.

To accommodate the move towards a low-carbon electricity sector, a reversal in these dynamics is needed. To this end, as shown by the proactive UK experience, regulatory design will play a fundamental role.

Italy is approaching the new regulatory period with a hybrid system characterised by:

- a tariff regulation mechanism in which incentives towards efficient investment decisions are confined to the *ex-ante* definition of the WACC value;
- a regulatory framework which on paper is extremely favourable to infrastructural investments, but in practice critical;
- significant elements of performance-based regulation, still implemented as the sum of independent parts, mainly related to quality (continuity) of service. This quality regulation has partially offset the critical issues of RAV remuneration, allowing for a certain level of specific investments. In the future, this phenomenon may gradually disappear due to the reduction of potential quality improvement.

If the main challenge of regulation over the coming years is to stimulate adequate infrastructural interventions by DSOs in order to promote a low-carbon electricity sector, current Italian regulation needs to address some open issues.

The first one is the need to broaden the performance-based elements of network regulation, especially with reference to the connection of new renewable generators to the distribution grid. The current regulation follows a “building blocks” approach. In fact, the relationship between DSOs’ performances – in terms, for example, of RES connection and quality of supply – and the revenue they are allowed to earn is not clearly structured in a unified framework. From the Consultation Document no. 34/11[13], regarding tariff regulation for the regulatory period 2012-2015, it emerge that the Italian regulator is concerned about the importance of the adoption of a

[13] Italian Regulatory Authority for Energy and Gas, 2011e. Consultation Document 34/11.

more unified regulatory approach based to a greater extent on output-based regulation. The Consultation Document discussed the opportunity to adopt a hybrid incentive mechanism (both input-based and output-based) with reference to those distribution network investments considered as strategic for the development of a low-carbon sector, such as "smart grid" investments. Actually, since the previous regulatory period (2007 – 2011), these investments are incentivised through a corresponding extra-remuneration granted *ex-ante*, in addition to the WACC. During the consultation period, the Italian regulator evaluated the opportunity to partially link this extra-remuneration to the achievement of a given set of predefined outputs. As stated by the regulator itself, the choice of input-based mechanisms to spur investments on "smart grids" is clearly suboptimal in the long term in that it could push DSOs along a potentially wrong technological trajectory, given the uncertain development patterns of the electricity sector. Moreover, the combination of an input-based approach to incentivise strategic investments with performance incentives may generate cost inefficiencies. Actually, it is reasonable to assume that infrastructural interventions may help to improve the reliability and the quality of the services provided by DSOs. Therefore, the provision of penalties to stimulate distributors to meet the required targets with reference to the reliability of the electricity supply, the fulfilment of deadlines in the connection activity and the commercial services related to the distribution activity may generate cost inefficiencies. However, in the current regulatory period, the corresponding of an extra-remuneration to "smart grid" pilot project appears still to fully rely on an input-based regulatory approach.

Second, some distortions or over-simplifications of the current regulations that in the past have had minor impacts on investment decisions are now becoming significant and deserve attention. For example, the two-year regulatory lag according to which the remuneration of capital expenditures is passed on to end users produces a reduction in the Internal Rate of Return of investments.

In addition, the abovementioned problems are likely to be exacerbated by the introduction of the so called "Robin Hood tax"[14] which represents an increase in the taxes paid by DSOs, who, as a consequence, suffer a reduction in their actual return. In Italy, unlike in the UK, taxes do not get a separate allowance: as such, any change in the tax system directly impacts DSOs' profits.

Finally, an increasingly significant problem for distribution network investments arises from the connection of distributed generation. Indeed, given that distributed generation operates at the same voltage level as distributors, the regulator assumes that the latter do not face any further network losses. Therefore, though the assumption of zero losses is technically impossible, the regulation does not grant DSOs any compensation for network losses, in the presence of connected distributed generation. This aspect, which is becoming increasingly important as distributed generation increases, may actually hinder the incentive of DSOs to make adequate network investments to accomplish the connection of distributed generation.

[14] Law no. 133/2008.

5.1 The regulation of distribution network investments

5.1.1 Investment responsibility and the regulatory approach to DSOs' investment activity

Under the Italian regulatory framework, investment decisions on electricity distribution networks are taken by DSOs. The regulator intervenes only *ex-post* by checking the actual deployment of the investments reported by the DSOs and the correspondence between investments and reported costs. Each year the regulator updates distribution tariffs to take into account the actual changes in invested capital.

Unlike UK regulation, DSOs' investments are not decided on the basis of a business plan submitted by the distributor and approved by the regulator. In this perspective, the Italian regulation is backward-looking and only weakly linked to DSOs' performance.

The only exception to this general rule is represented by those pilot projects concerning investments the regulator considers as fundamental for the development of the distribution grid. Indeed, as we will discuss further in the paper, for these infrastructural intervention – which receive an extra-remuneration above the standard WACC - DSOs have to present to the regulator a project three years in advance illustrating costs, timing and expected outcomes.

5.1.2 Timeframe and scrutiny

The time horizon of the Italian regulation is four years. At the end of each regulatory period the Italian regulator reviews the regulatory mechanism, setting, among other things, the new rules for calculating the WACC to be applied to capital expenditures.

In contrast to the UK experience, Italian regulation does not require an *ex-ante* scrutiny process for the definition and evaluation of costs to be included in the Regulatory Asset Value. Generally, the regulator's scrutiny intervenes only *ex-post* by verifying whether the investments DSOs claim to have made during the previous year have actually been made, and whether their effective value corresponds to the costs reported in the DSOs' annual reports.

As mentioned previously, the only exception to this general rule is represented by those pilot projects concerning "smart grid" and batteries receiving an extra-remuneration. These investments, indeed, are subject to an *ex-ante* written communication to the Italian Authority. Moreover, the Italian regulator appoints a commission of experts to select those "smart grid" pilot projects, and investments in batteries, which appear to deserve the extra-remuneration, according to different performance criteria

5.2 The components of the Regulatory Asset Value and its remuneration

The Regulatory Asset Value consists of the sum of historical charges, capital expenditure additions and the net circulating capital (set at 1% of all the capital assets included in the RAV).

In contrast to UK regulation, AEEG includes capital additions in the RAV with a two-year lag. This means that investments carried out in year *n* are added to the RAV only in year *n+2*.

The other peculiarity is that remuneration for year *n* is defined by multiplying the WACC (pre-tax 7%) by the RAV for year *n* net of the depreciation for the same year.

The following table shows an example of how the RAV is determined and how revenues are set. In this respect, it is important to highlight that the real pre-tax WACC of 7% corresponds to a real vanilla WACC of 4.2%, that is, 0.5% lower than the same real vanilla WACC applied in the UK.

	n	**n+1**	**n+2**
Opening RAV	0	0	**1000**
CAPEX additions	1000	0	0
allowed depreciation	0	0	**50**
RAB for tariff (Closing RAV)	0	0	**950**

Table 2: Allowed Base Revenues

The table shows that:

- an investment in Italy is remunerated one year later than in Britain, and
- RAV for tariff in year n+2 is lower than in Britain since it is the closing RAV (i.e. net of the depreciation granted in the same year n+2).

This timing aspect of CAPEX remuneration has an impact in terms of IRR. In particular, we repeat herewith the same "back-of-the-envelope" calculation we presented in previous section for the UK. We assume that:

- the lifetime of new CAPEX addition is 20 years;
- WACC is expressed in nominal post-tax terms (just to make calculation easier) at a 5.3% level (equivalent to 4.2% real vanilla).

Our calculations indicate that the present value of the cash flows associated with an investment in Italy is only 92.5% of the amount invested. Internal Rate of Return is 4.5% instead of 5.3% (as it would be under UK provisions).

Timing provisions regarding capital remuneration in Italy mean that investors cannot recover, in discounted terms, the upfront value of their investment. This situation is worsened by the recent introduction of the so called "Robin Hood Tax", which is not reflected in the regulatory tax rate, and, consequently reduces the IRR even further.

5.2.1 Specific issues concerning innovation

Certain strategic investments receive an extra-remuneration above the standard WACC (set to be 8.6% pre-tax). For these investments, DSOs have to present a project three years in advance illustrating costs, timing and expected outcomes. In particular, a 2% extra-remuneration is granted for the following kind of investments realized during the regulatory period 2012 - 2015:

a) investments designed to develop automation, protection and control systems for medium voltage "smart grids". These investments are granted the extra WACC for twelve years;

b) pilot projects concerning the realization of batteries, for twelve years. In this case, the extra-remuneration is corresponded if and only if investments for the realization of batteries are included in pilot projects for “smart grids”, and aim to ensuring the injection in the grid of the electricity produced by intermittent renewable resources.

Similarly, a 1.5% extra-remuneration is corresponded to the following kind of investments:

a) construction of new high-voltage/medium-voltage power transformation stations. These investments are granted the extra WACC for eight years;
b) replacement of the existing power transformation stations of medium/low-voltage transformation cabins, with new low-loss transformation stations. These investments are granted the extra WACC for eight years;
c) renewal and development of medium-voltage network in historic centres. These investments are granted the extra WACC for twelve years;
d) development of the transformation capacity of primary cabins in provinces or municipalities characterized by a large part (90%) of the total capacity of high-medium voltage transformation cabins minor that the difference between the injected requested capacity and the loading capacity during the fifteen minutes of minimum peak in the region[15]. However, all these categories represent a minor part (less than 1%) of the overall investments that DSOs are required to perform. These investments are granted the extra WACC for twelve years.

The assignment of an extra-remuneration to investments in “smart grid” and batteries is decided *ex-ante* by a commission of experts appointed by the Italian regulator. The commission selects those “smart grid” pilot projects found to be the best-performing ones with reference to a given set of criteria. For each project the so-called *Priority Index* is computed. This is a synthetic indicator used to assess the expected performances of a “smart grid’’ pilot project with reference to their development costs (for a discussion of the selection of “smart grid” pilot projects see Lo Schiavo *et al.* 2011). Specifically, the expected benefits of each pilot project are evaluated with reference to four areas of performance: (i) the size of the project: e.g. number of distributed generators involved in the project, increase in the amount of electricity injected from distributed generation units, etc.; (ii) the feasibility of the project: e.g. time needed to implement the project, improvement in the quality of the service with respect to the standards of the period previous to the implementation of the project; (iii) the innovative content of the project: e.g. participation of distributed generation in voltage regulation, involvement of system in bidirectional communication and demand response, presence of storage system and active power modulation, etc.; (iv) the replicability of the project; e.g. consistency between the costs of the project and its expected benefits, percentage of costs accounted for by unregulated subjects like distributed generators and storage units, etc.[16] For each of the four criteria a score is assigned to each project. The scores obtained are then weighted by means of a normalisation coefficient to account for projects of different sizes. The amount thus obtained is then divided by the costs of the project to finally obtain the value of the *Priority Index.*

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[15] Italian Regulatory Authority for Energy and Gas, 2008: Decision Arg/elt 99/08.

[16] For more details on the computation of the Priority Index see: Italian Regulatory Authority for Energy and Gas, 2010. Decision Arg/elt 39/10.

5.3 Some specific issues concerning losses and uncertainties

5.3.1 Losses

A troublesome aspect of Italian regulation concerning the distribution sector involves the regulation of network losses. The Italian regulator sets standard values for losses occurring on electricity distribution networks and establishes a performance-based regulation through which it rewards DSOs if actual losses are lower than the baseline and penalizes them otherwise[17].

Specifically, for low-voltage networks the standard value is equal to 10.4% of withdrawn electricity, while for medium- and high-voltage networks this value is set at 4.7% and 1.1% respectively. In other words, this means that if a plant injects 110.4 kWh of electricity into a low-voltage network, the amount of electricity considered to have been delivered to the end user is 100 kWh.

With reference to the losses relative to the point of interconnection between different networks, these conventional percentages are set at: (i) 6.6% for interconnections between medium- and low-voltage networks (whether electricity is measured and evaluated at a low-voltage network level); (ii) 2.5% and 4.7%, respectively, for interconnections between high- and medium-voltage networks, and between medium- and low-voltage networks when electricity is measured and evaluated at a medium-voltage network level; and (iii) 1.1% and 1.8% for interconnections between, respectively, high-voltage networks, and between high-voltage and medium-voltage networks when electricity is measured and evaluated at a high-voltage network level.

Therefore, if we consider, for example, low-voltage networks, we find that losses of 3.8% of injected electricity (i.e. 10.4% - 6.6%) are implicitly assumed for DSOs. Similar considerations hold for the other network voltages. Indeed, the regulation compensates DSOs for the losses that they are implicitly assumed to take, in the following way: for 100 kWh of electricity delivered, end users pay for a value corresponding to 110.4 kWh, but the generator receives a value for only 106.6 kWh. In this way, DSOs are compensated for 3.8% of the lost transported electricity.

Nevertheless, the above mechanism does not take distributed generation into account and, as a consequence, related network losses are not correctly acknowledged, thus unfairly penalising DSOs. Indeed, if distributors and distributed generators operate at the same voltage level, the regulator assumes that no network losses occur. However, this is technically impossible, since generation is generally dispersed and the result is that DSOs are not remunerated for network losses which actually occur. With reference to electricity injected at a medium-voltage level, what happens is that for 100 kWh of electricity delivered, end users pay a value corresponding to 105.1 kWh, and the generator receives a value corresponding to 105.1 kWh of electricity delivered. Therefore, no compensation for network losses is granted to DSOs and, with the increase in distributed generation, the economic losses incurred by DSOs appear to be increasingly significant.

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[17] Italian Regulatory Authority for Energy and Gas, 2011b. Decision Arg/elt 196/11.

However, the regulator appears concerned about the necessity of considering the impact of the increase in distributed generation on network losses. Actually, in 2011[18], an evaluation process about the adequateness of the established network losses' standard began. The process, among other things, aims at considering the possibility to take into account - in the definition of network lossess'factors - the interaction between distributed generation and the electricity network, in the light of the increasing weight of distributed generation.

5.3.2 Managing uncertainties

Another specific issue faced by Italian regulation is the provision of an adjustment mechanism dealing with the uncertainty related to market dynamics. Indeed, some tariff components, among which those aimed at covering the costs related to the remuneration of capital investments, are updated yearly on the basis of the variation which is expected to occur in the volume of the service provided at the national level during the subsequent regulatory year. However, the adjustment mechanism operates with reference to the closing values of two years before, and thus with a two-year regulatory lag, and is corrected by the change that has occurred in the consumer price index and by the yearly reduction that has occurred in allowed unit distribution costs.

6 Final Remarks

The rapid increase in renewable generation capacity connected to medium- and low-voltage distribution networks, together with the launch of many smart metering projects, will dramatically change the way DSOs operate and invest: as such, a new regulatory framework has to be set up. Within this broad issue, this paper performs a critical overview of distribution network investment regulation, directing its attention to the UK and Italy. Focusing on investment regulation means that we have set aside a number of important topics, such as DSOs' role in active network management, which would all require a separate paper.

The analysis of investment regulation is performed with a specific toolbox that discusses all the three relevant drivers and incentives which guide regulators in setting their rules, and precisely: (i) efficiency; (ii) input; (iii) DSOs' performance. In the light of these regulatory drivers, our critical review shows how the UK regulation has evolved towards a purely performance-oriented approach, where revenues and investments are explicitly linked to different output targets. Theoretically, this new approach seems convincing but also extremely challenging, as it requires the regulator not only to define a consistent set of coherent and easily measurable outputs, but also to define proportionate, fair rewards and penalties, which have to avoid remunerating or punishing DSOs for situations which are beyond their control.

Italian regulation, in contrast, does not appear at the moment to be committed to a comprehensive review, notwithstanding the challenges that it has to face. In particular, Italian regulation still lacks a unified approach, and, as a consequence, it is made of different blocks, each of them regulated with different mechanisms. This "building blocks" approach is due both

[18] Italian Regulatory Authority for Energy and Gas, 2011a: Decision Arg/elt 52/11.

to a legal constraint, as Italian law specifically sets different rules regarding OPEX and CAPEX, and to the significant number and heterogeneity of Italian DSOs.

This has inevitably led to an input-based approach for investment regulation, where AEEG grants extra remuneration to certain specific investments. In this respect, the Italian regulator is aware that this is a suboptimal mechanism in the long term, as it could push DSOs along a potentially wrong technological trajectory; still, it has decided to confirm this approach also for the new regulatory period, as it is considered the best option given the abovementioned constraints.

From these considerations, we can draw some policy recommendations for the regulation of the Italian electricity sector. First of all, it appears desirable to promote a forward-looking approach – similar to that characterising UK regulation – for the remuneration of network investments. The adoption of a forward-looking approach, combined with a dynamic adjustment of the remuneration for distributors' investments, would help to overcome the problem of the two-year regulatory lag and at the same time would help to fine-tune DSOs' investment pattern to the evolution of the electricity sector.

To this end, given the high number of DSOs operating in Italy, as well as their heterogeneity, it might be worth introducing a more simplified scrutiny process for the investment decisions of small DSOs, and a more comprehensive one for the major distribution companies.

This can be gradually achieved through the adoption of a "test" regulatory period, during which the *ex-ante* scrutiny process is applied only to the biggest DSOs. A regulatory "learning" period might also be adopted for the introduction of a more performance-based regulatory approach. Indeed, a general output-based regulation would prevent DSOs from following a wrong investment pattern – as might happen, conversely, through an input-based regulatory approach – and link remuneration of distribution network investments to the achievement of measurable and coherently defined output targets, as already happens for the regulation of the quality of the distribution service.

In addition, it appears desirable to extend the present research by performing a quantitative analysis that could empirically verify which regulatory approach stimulates efficient investments. This investigation might help both regulators and policy-makers to address the major issues concerning the regulation of distribution network investments.

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