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REVIEW

Combining Forward-Looking Expenditure Targets and Fixed OPEX-CAPEX Shares for a Future-Proof Infrastructure Regulation: the ROSS Approach in Italy

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Abstract

Purpose of Review Decarbonization of many energy sectors is led by a process of "new electrification", which poses great challenges to achieve in parallel a timely and cost-effective development of electricity networks. It becomes thus fundamental to assess the best approach on how to successfully regulate new investments in power grids, addressing their development in the general interest of consumers.

Recent Findings Over the last twenty years, many researchers and practitioners highlighted the bias towards capital intensive investments, induced by regulatory frameworks currently adopted, based on rate-of-return regulation for capital expenditure (CAPEX) and incentive regulation for operational expenditures (OPEX). This issue is exacerbated by the potential of digital-based solutions, that are often overlooked by system operators as they mainly entail operating costs (OPEX), often subject to incentive regulation.

Summary This work discusses an analytical model, combining total expenditures evaluation with a forward-looking approach (business planning and output-based incentives) and a fixed opex capex share, aiming at overcoming the CAPEX-bias. This is done leveraging on the Italian recent change in infrastructure regulation, introduced by the Italian regulatory authority (ARERA), that builds on a core incentive on productive total efficiency (i.e. CAPEX + OPEX) plus a scheme of output-based rewards and penalties. In the new ROSS (*Regolazione per Obiettivi di Spesa e di Servizio)* approach, several elements are in place in the first stage *("ROSS base")* to likely mitigate the capital bias effect, even though a more complete approach *("ROSS integrale"),* including the forward-looking dimension of planned expenditures, is still under consideration by the Italian regulator.

Keywords Total expenditures · Incentive regulation · Efficiency sharing · Forward looking approach

Introduction

The constitutional law of the Italian Regulatory Authority for energy, networks and environment, namely ARERA,[1] defines a set of reference objectives for its regulatory activity. On top of the search for efficiency, effectiveness and quality of service, a specific paragraph prescribes the need to harmonize the financial targets of system operators with the social, environmental and economic objectives of the society as a whole [1]. This aspect has become greatly relevant since when Europe set some ambitious decarbonization targets, culminating in a net-zero objective by 2050 [2]. Indeed, decarbonization of many sectors will be possible only through an enlargement of electricity final uses (a "smart electrification" process [3]), calling for a timely and huge development of electricity networks [4] [5]. The International Energy Agency (IEA) recently highlighted the need to double investments in power grids by 2030, reaching a level of 600 USD billion per year [6]: delays in grids development will put the 1.5°C goal out of reach, creating a bottleneck for the deployment of enabling technologies, such as renewables, electric vehicles and heat pumps. Several institutions, including IEA [6], the European Union Agency

[1] ARERA *(Autorità di Regolazione per Energia, Reti e Ambiente)* is the Italian NRA for electricity, gas, water, waste management and district heating.

The opinions expressed in this paper are the personal opinions of the authors; they do not necessarily represent ARERA's official position and do not commit ARERA to any course of action in the future.

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for the Cooperation of Energy Regulators ACER [7], the European Commission [8] and the European Network of Transmission System Operators for Electricity ENTSO-E [9], recently indicated the need to improve regulatory frameworks to prompt a cost-efficient network development process. In its position paper of November 2021 [7] and its report of June 2023 [10], ACER flagged two main issues for regulated investments in power sector: first, a capital expenditures bias arising from the different treatment reserved to operational and capital expenditures, where "*lower cost solutions seem unattractive compared to the higher profits of higher cost solutions*" (CAPEX-bias); second, higher monitoring and management costs, together with a greater risk of faults and errors, associated to a smarter, but also more intensive, utilization of network capacity, that pushes system operators towards traditional solutions (instead of innovative technologies). A typical example, quite common in the energy transition scenario, is the preference of network operators to build a new line (traditional, capital-intensive solution) for reinforcing the network due to distributed generation penetration, instead of other innovative solution for increasing hosting capacity, like for instance dynamic thermal rating or flexibility service procurement, that are not capital-based and therefore produce no or, if any, extremely limited change in the Regulatory Asset Base (RAB), on which the Weighted Average Capital Cost (WACC) index is applied to calculate the revenues of grid operators.

In its 2023 report on regulatory frameworks [11], the Council of European Energy Regulators (CEER) confirmed the greater focus put by the majority of European energy national regulatory authorities (NRAs) on incentivizing cost-saving solutions on operating expenditures (OPEX). In several EU countries, this is achieved through a hybrid approach for cost allowance of electricity and gas grid operators (both for transmission and distribution): OPEX are subject to ex-ante incentive mechanisms, while CAPEX are recovered through rate-of-return regulation. As signaled by ACER [10], such an hybrid approach, that is quite common among EU regulators, *"is currently a prominent issue in Europe"* because it risks to create a regulatory-induced CAPEX-bias, i.e. a preference for CAPEX-intensive solutions due to different remuneration scheme or business interests, that tops-up the "intrinsic" profit orientation of grid operators. Despite this, as signaled by Smith et al. in [12] and by Von Bebenburg et al. in [13], CAPEX-bias is also caused by other factors, such as a rate-of-return on capital higher than the true cost-of-capital, and by specific OPEX disadvantages, such as a different delay between costs and revenues for CAPEX and OPEX.

In Italy, during the first regulatory period (2000–2003), a price-cap approach was applied to both CAPEX and OPEX (Fig. 1). Indeed, the hybrid approach was introduced in Italy since 2004 by the Italian NRA, distinguishing the remuneration adopted for CAPEX and for OPEX. Since the beginning, the Italian NRA accompanied the distribution tariff regulation with a substantive regulation for quality of service (especially continuity of supply), that over time was enlarged to encompass innovation (especially smart grid deployment) and grid resilience against extreme weather events. Meanwhile, an important change was introduced in 2015 when a common framework was adopted for all infrastructural regulated services as far as financial parameters of Weighted Average Cost of Capital (WACC) are concerned; and in 2017, when a first "exercise" of forward-looking CAPEX regulation was applied to the expenditure needed for roll-out of second generation of smart meters.

Also the transmission tariff regulation followed a similar path, including innovation (focused on dynamic thermal rating DTR[2] and storage for improving hosting capacity) and, at a later stage, grid resilience (against exceptionally strong wind storms).

In order to mitigate this CAPEX-bias, together with the need to give a regulatory response to the new challenges of decarbonization, system transformation and decentralization of electricity generation, ARERA launched in the last years a wide regulatory program [14] [15], called ROSS (*Regolazione per Obiettivi di Spesa e di Servizio)*,[3] to introduce major changes in its regulation for energy infrastructures, including a fixed OPEX-CAPEX share (FOCS), also widely referred to as total expenditures (TOTEX) approach [9]. The remainder of the paper introduces the ROSS idea moving from some international experiences on regulatory frameworks for the energy transition (Section 2), presents its first implementation in Italy starting from 2024 (Section 3), and defines the most important elements to be considered for its full deployment in the future (Section 4).

How Infrastructure Regulation Copes with Energy Transition: From Theory to Practice

In a seminal paper published in 1962, Averch J. and L. Johnson suggested that a rational regulated firm subject to a cost-plus remuneration would have used more capital and less labor to maximize its profit [16]. Moreover, according

[2] Dynamic Thermal Rating is the capability of the TSO to adjust the transfer capacity of an electrical circuit dynamically according to operating conditions, especially wind speed and air temperature, in order to keep safety requirements through an on-line monitoring and control of operational parameters (active current and reactive angle). Trials funded by ARERA showed that this technology is extremely cost-effective to improve hosting capacity of transmission lines [42].

[3] Literal translation: Regulation through expenditure and service performance targets.

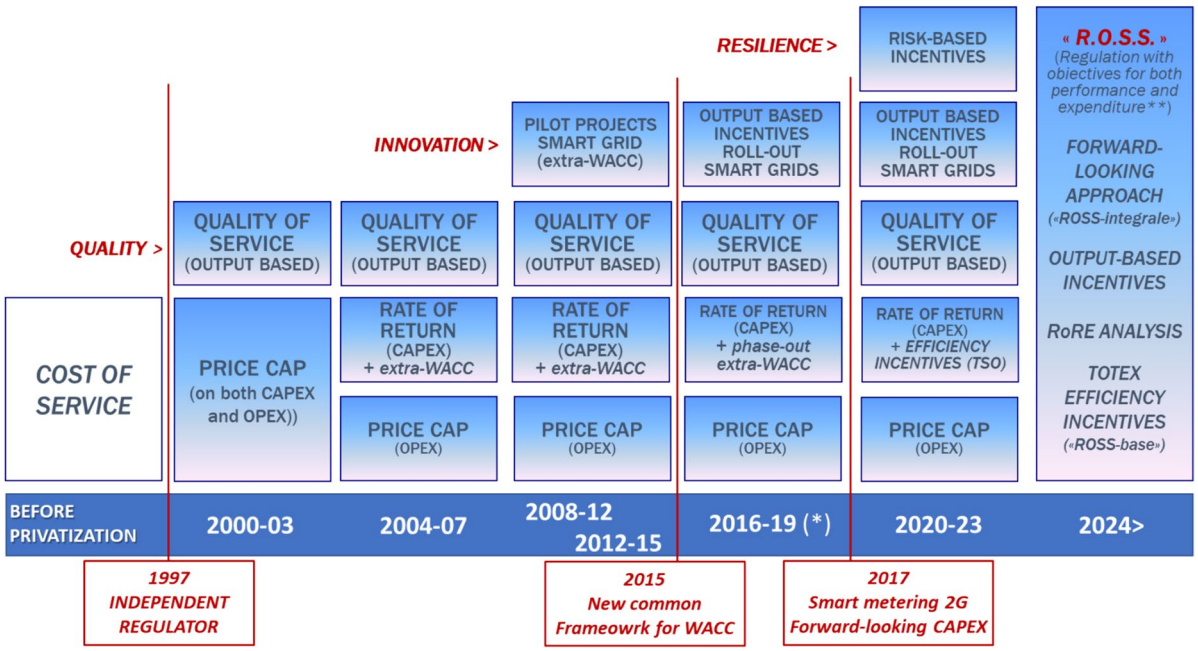

Fig. 1 Evolution of the regulatory framework for regulated infrastructures (electricity) applied in Italy

to this "gold plating" effect, the firm will inflate its costs as more costs would mean also more profit in absolute terms, also accelerating the pace of investments remunerated with a cost-based approach [17]. This view has been confirmed at different levels not only in theory, but also in practice [18]. To handle this issue, several NRAs have developed and implemented some incentive regulation approaches, mainly under the form of price or revenue cap, where allowed revenues for the firm are decreased in time by a productivity (or efficiency) factor (so called X-factor), also taking into account inflation via Retail Price Index (so called "RPI—X approach"). However, incentive regulation is affected by issues related to asymmetry of information between the grid operator and the NRA, and could bring to a detriment in the quality of service provided to the final users [19], especially in the long term. Because of this, incentive-based solutions are more often applied only to OPEX [11] than to CAPEX, which are frequently treated under rate-of-return regulation, and many NRAs have adopted in the last decades some form of output-based regulation: this consists in setting some service-related targets, set *ex-ante* and clearly defined through key performance indicators, and associate to them a scheme of rewards and penalties [19].

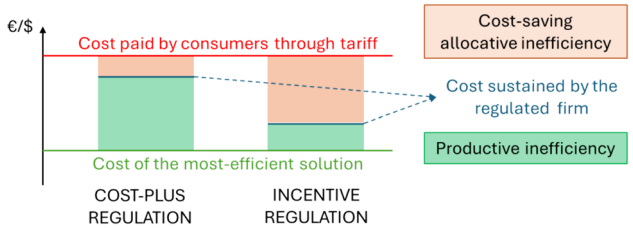

Fig. 2 Graphical representation of the productive and allocative inefficiencies problem for regulated investments

From an overarching standpoint, the problem that a proper regulatory framework should be able to deal with can be summarized in two questions (Fig. 2):

- how far are the costs paid by consumers through tariffs from the actual expenses sustained by the firm?
- how far are the expenses sustained by the firm from the costs of the most efficient solution?

A cost-plus or rate-of-return remuneration will be able to limit, or in any case better control, rent extraction by the monopolistic firm, but it will be heavily affected by a gold plating effect and will hardly promote any productive efficiency. On the other side, an incentive-based remuneration, such as RPI—X approach, will promote more efficient solutions, but possibly will not be able to fully transfer their economic advantage to the final users. Moreover, an incentive scheme, trying to replicate a merchant dynamic on a regulated firm, could potentially lead to some controversial issues if the firm is not able to fully recover its costs.[4]

Therefore, the fundamental regulatory challenge is to push the firm to adopt the most-efficient solution for a certain

[4] It is worth noting that yardstick regulation is not a feasible option in Italy due to a great heterogeneity among the different SOs. Indeed, a single DSO currently manages more than 80% of the Italian distribution network, making it not comparable to other DSOs.

activity, while effectively controlling the share of the realized cost-savings that remains in its hands. Under these hypothesis, different works have recently analyzed how regulatory frameworks may adapt to foster decarbonization, pushed by the relevant role that power grids will play in the decarbonization process and by the wide availability of low cost, innovative digital solutions. Overall, we identify two main challenges that should be discussed and possibly solved: how to handle the CAPEX-OPEX dichotomy [20] and how to promote the implementation of innovative solutions.

Regarding the CAPEX-OPEX dichotomy, also the European institutions, when amending the EU Electricity Regulation [21] identified the need to consider CAPEX and OPEX together, on both the short and long-term; moreover, it recommended to support the use of flexibility and the procurement of balancing services as cost-savings solutions, and to set performance targets to increase the efficiency of regulated activities.

Possible solutions to the CAPEX-bias have been proposed by Brunekreeft et al. in [20] and [13], including a possible OPEX mark-up system or a fixed OPEX-CAPEX share (FOCS). The former consists in a reduction of the rate-of-return on CAPEX coordinated with an increased profitability on OPEX; the balance between CAPEX deduction and OPEX mark-up is however very difficult to properly set, resulting in design challenges for the NRA. A simpler and effective solution to the CAPEX-bias consists in the adoption of a FOCS approach, which eliminates any difference between capital and operating expenditures setting a fixed capitalization share (valid within the regulatory period, and then adjusted), thus distinguishing between slow money (also named quasi-CAPEX in the mentioned references) as the one increasing the regulatory asset base (RAB), and fast money (quasi-OPEX) as the one for which the firm is immediately remunerated.

ARERA set out in 2023 (for its application from 2024 onwards) the company fixed opex-capex share as an average of historical and forward looking opex-capex shares of the same company. For the purpose of this definition, the traditional rules for qualifying an expenditure as CAPEX or OPEX were applied.

The first example of FOCS approach has been implemented in Great Britain by the British regulator, OFGEM, through the RIIO[5] model, which was applied to electricity transmission since 2010 and distribution since 2015. The first RIIO implementation was built on three key elements: an initial cost assessment based on a business plan drafted by the firm, an incentive scheme comprising both input and output-based rewards and penalties, and a set of innovation *stimuli* [22] [23]. Firstly, the firm had to write down a well-justified business plan, whose evaluation by the NRA was tuned according to its quality and past recorded efficiency of the firm. Efficiency incentives were designed upfront depending on both firm and NRA costs estimation, and regulated through a so-called Information Quality Incentive (IQI) matrix. Output-based incentives were defined according to six indicators, related to customer satisfaction, technical quality, and environmental protection. Finally, the innovation element was declined into two programs: a Network Innovation Competition (NIC) for large-scale trial of decarbonization technologies, and a Network Innovation Allowance (NIA) for small-scale projects, mainly preparing for NIC participation.

While RIIO was welcomed as a model able to prompt performance-depending incomes and innovation in regulated firms, it showed some failures during its real-life implementation, leading to some corrections in its second edition (RIIO-2) since 2020. In particular, Thomas [24] highlighted four issues: first, despite pretending to be performance-based, all companies were underspending with respect to the reference baseline; second, outputs weighted for only 6% on average of the firms' revenues, and almost all of the output-based remuneration was related to standard technical quality indicators; third, innovation *stimuli* were out-of-scope with respect to the whole RIIO concept and could have been implemented also independently from it; fourth, the designed model based on an upfront incentives scheme on investments resulted in costs over-estimation since rewards were bestowed based on revenues allowed for investments that were never done, mainly because of power demand or generation forecast errors.

This last issue was detected also by Bovera et al. [25], that proposed a Whole System Indicator (WSI) approach adding, among others, on top of RIIO concept an *ex-post* assessment of allowed revenues based on the actual commissioning stage reached by the different investments. This "actual commissioning" approach was also applied by the ARERA for the deployment of second generation (2G) smart meters on the Italian territory, showing its practicability, although it must be considered that the application of metering activities is easier vs. distribution activities because more than half of the total metering expenditures are linked to two specific equipment: meters and data concentrators [26] [27].

Despite all the above, a stand-alone FOCS approach is not able by default to promote productive efficiency because firms can still increase their profit inflating their overall costs if their rate-of-return is higher than their cost-of-capital. Because of this, most of the recent literature focuses on the promotion of innovation, with many contributes discussing some regulatory options to incentivize regulated companies to adopt innovative solutions towards a zero-carbon system. In its recent support to ACER consultation for a regulatory approach to prompt innovation, the Florence School of Regulation (FSR) individuated two possible situations [28]. On one side, innovations with more uncertain and less observable outputs should be remunerated through public grants and

[5] RIIO means Revenue, Innovation, Incentives and Output.

pass-through costs, similar to NIC and NIA schemes, but also to standard extra-WACC approaches adopted by some NRAs. On the other hand, when outputs are clearly measurable and easily definable, it is possible to design a performance-based incentive schemes, where firm's performances could be assessed either on input or output parameters.

In parallel to OFGEM's NIC and NIA contained in the RIIO model, ARERA implemented several innovation-oriented regulations between 2010 and 2020. Lo Schiavo et al. [29] and Bovera et al. [30] provide a full explanation of the strategy adopted by ARERA to prompt innovation deployment in different domains, including smart grids, smart metering, and electromobility. When regulated entities were involved, innovation was mainly pushed through extra-WACC remuneration; when instead dealing with liberalized activities of the power sector, new technologies and businesses were mainly favored through waives, regulatory exemptions, and in some cases *ad-hoc* tariffs provided to specific final consumers, e.g. electric vehicles users. More recently, ARERA also adopted an approach where innovation incentives were calculated based on CAPEX savings realized by the transmission system operator (TSO) with respect to a CAPEX target value. First, in 2020 the Italian TSO, Terna, implemented some capital-light solutions, partly based on dynamic thermal rating (DTR), increasing the cross-zonal capacity between Italian bidding zones by 1450 MW [31]; thanks to this, the TSO was awarded with a premium of about 143 M€ (against more than 1 B€ of estimated savings) linked both to the transmission capacity increases (103 M€ reward) and the over-performance with respect to transmission capacity CAPEX values (40 M€ reward). Second, in 2021, ARERA applied a similar scheme to dispatching costs sustained by Terna, setting a target expenditures value based on historical costs. In 2022, Terna was able to reduce the dispatching costs thanks to both technological and managerial innovative solutions, being awarded in 2023 a premium of about 800 M€ against an estimated year 2022 saving of 2.2 B€ [32], as long as these savings are confirmed for years 2023 and 2024. This kind of approach, where the NRA pre-defines an explicit target and the firm is challenged to reach it at lower costs, has been recently addressed as benefit-based regulation by the ACER-FSR [28].

The link between productive efficiency, output-based regulation, and innovation *stimuli* has been extensively discussed in the recent literature, recognizing the need for an overarching approach on the matter. Biancardi et al. [33] compared 12 different European countries showing that a regulatory framework favoring innovation is actually able to promote investments by TSOs on innovative trends; in most cases, innovation is prompted by specific regulatory mandates to invest in research and development (R&D) or through economic incentives. Jamasb et al. [34] proposed an analytical model to handle innovation, characterizing five different approaches among which: four out of five are based on inputs, while one is based on outputs regulation; two of them include innovation costs into a return on assets components, being it the regulatory asset base (RAB) calculation or an extra-WACC grant; one option foresees a competitive playground to assign innovation funds, as it was done in Great Britain with the NIC/NIA, but also in Germany with the SINTEG programme.[6] Brunekreeft et al. discussed in [35] and [36] the influence of different regulatory parameters on the diffusion of innovative solutions, including the duration of the regulatory period, the OPEX-CAPEX relationship, and the productive efficiency incentives. They present an analytical framework where innovation can bring internal advantages or external advantages: the former means that costs and benefits are incurred by the decision-maker, the latter arises when costs and/or benefits are incurred by a third party. In the first case, internal advantage, they advise for a so-called budget approach scheme coupled with sharing factors which is similar to a core incentive scheme based on a sort-of menu of regulation. In the second case, external advantage, they propose a market facilitation mechanism which is similar a benefit-based regulation, already cited before.

Overall, looking at both real-life experiences and literature models, it seems that no one-size-fits-all solution has been individuated to tackle all the regulatory issues currently affecting the remuneration of transmission system operators (TSOs) and distribution system operators (DSOs). Consistently, Rious and Rossetto [37] highlighted how the regulatory approach depends on the ability of the NRA to control, predict and observe firms' expenditures and, more in general, activities. While a cost-plus regulation fits also in situations with poor regulatory knowledge, a proper assessment on inputs and/or outputs of firms' activity allows implementing more advanced solutions, such as incentive-based or performance-based regulation. In this framework, a menu of regulation, where multiple options are available and the regulated firm is allowed a free choice among them, seems to have a good potential. The ROSS proposal by ARERA is born within this context. The next section provides a description of its first implementation, valid for the Italian regulatory period of electricity transmission and distribution and gas transmission from 2024 to 2027.

[6] SINTEG stands for "*Schaufenster intelligente Energie—Digitale Agenda für die Energiewende*" (in English: Smart Energy Showcases – Digital Agenda for the Energy Transition"). SINTEG is a German government program in funding "showcases" to create a safe, efficient and environmentally friendly energy supply model, which aims to solve the problem of energy supply especially from renewable energy such as intermittent solar and wind. Germany's Federal Ministry of the Economy and Energy *(Bundesministerium für Wirtschaft und Energie*, BMWi) provided more than €200 million to fund the 5 showcase sites. Coupled with private sector investment, the funds raised reached €500 million to achieve the "smart energy supply" of the future.

Regulating Firms Through Targets on Expenditure and Service Performances: The Basic-ROSS

ARERA started a process of ROSS-oriented regulatory framework definition since 2017, with a first-of-a-kind application of a forward-looking approach to 2G smart meters roll-out under CAPEX-incentive and a detailed study of OFGEM experience in Great Britain accompanied by several public consultation rounds. More recently, since 2021, ARERA worked on the definition of a new regulatory approach to be applied from 2024 to 2031, namely *Regolazione per Obiettivi di Spesa e di Servizio* (ROSS). While this new approach was developed by means of several consultation documents, working groups and phased decisions, overall it holds on three main documents: a dedicated regulatory code, encompassing all regulated infrastructural services (*Testo Integrato ROSS* – TIROSS), a set of implementation rules dedicated to so-called "basic-ROSS" approach, and a series of regulatory decisions designing specific rules for transmission, distribution and metering costs allowance. These documents define the whole framework for core-incentives and remuneration schemes applied to Italian TSOs (electricity and gas) and electricity DSOs in the next regulatory period (2024–2027; while the previous regulatory period for gas DSO is ongoing and will end in 2025). The basic-ROSS is expected to be complemented by specific regulatory schemes dedicated to business plans definition and approval, including a definition of a CAPEX baseline, and is already now complemented by output-based incentives, especially for electricity transmission and, to some extent, distribution.

The Regulatory Code Dedicated to Overall ROSS Approach

Through its decision 163/2023 [38], ARERA approved a new regulatory code[7] introducing ROSS's main characteristics. The regulatory code defines the general criteria for the definition of the expenditures baseline and the remuneration of grid operators along eight years (2024–2031), thus covering any single decision independently of the two regulatory periods (RPs) encompassed (for electricity: 6th RP: 2024–2027; 7th expected RP: 2028–2031). Allowed revenues for grid operators directly influence users' tariffs, which are differentiated for each network service, including for the power sector: transmission, dispatching and emergency services, distribution and metering. The overarching framework of the ROSS concept is summarized in Fig. 3. It includes three steps: the definition of the expenditures baseline, the calculation of monetary incentives, and the computation of the allowed revenues.

First, the total expenditures baseline is determined as the summation of a CAPEX-based and an OPEX-based baseline. The CAPEX-based baseline is, in the first application, set equal to the actual CAPEX. Therefore no incentives are set on CAPEX yet. In the future, the CAPEX-based baseline could be composed by: some pass-through costs that are remunerated as-is and *ex-post* to the firm; some standard costs obtained multiplying a unitary standard cost considered for the specific asset or activity, by the volume of assets or activities actually commissioned or deployed during the considered year. In the first application, electricity metering expenditures are under a stand-alone CAPEX incentive, while all distribution and transmission CAPEX are evaluated *ex-post*. In the total expenditures baseline is also included the OPEX-based baseline that is entirely determined on a unitary base: a reference OPEX is assigned per connected user (euro per point of delivery), and the baseline is determined based on the actual number of connection points.

Second, core-incentives are calculated as the difference between the TOTEX baseline and the actual total expenditures sustained by the firm. This difference represents the productive efficiency gained by the firm and it is further distinguished into an OPEX and a CAPEX efficiency component: for the 6th regulatory period all efficiency gains will be assigned to the OPEX component of costs (the metering efficiency gains will be continued to be treated accordingly to the 2017 experimental forward-looking scheme, based on IQI matrix[8] [25]). Both OPEX and CAPEX efficiency gains realized by the firm are partially shared with grid users through a sharing factor. Regarding OPEX, a menu of options has been designed by ARERA, in which the firm can choose between a high-incentive and a low-incentive baseline with different sharing factors. This model is better described in the next section on ROSS implementation rules.

[7] A regulatory code (in Italian *Testo Integrato*) is an overarching regulatory decision, that has an "umbrella" coverage for different regulated service (ET, ED, GT, and so on); more specific regulatory decisions can be taken under the regulatory umbrella of the *testo integrato,* for each distinct regulated service. It has nothing to do with industry codes implemented by OFGEM in Great Britain, because its governance is entirely handled by ARERA, hence it contains only regulatory provisions.

[8] Information Quality and Incentives (IQI) Matrix is the tool conceived by OFGEM in RIIO-1 for providing incentives to grid operators to both, first submit a credible and robust business plan (information quality) and then deliver an efficient and effective implementation of the plan (incentive linked to the difference between the expenditure baseline and the actual expenditure). In terms of economic impact, the latter is the main feature of the IQI matrix. After the first implementation, the IQI matrix has been abandoned by OFGEM in RIIO-2, in favour of other tools.

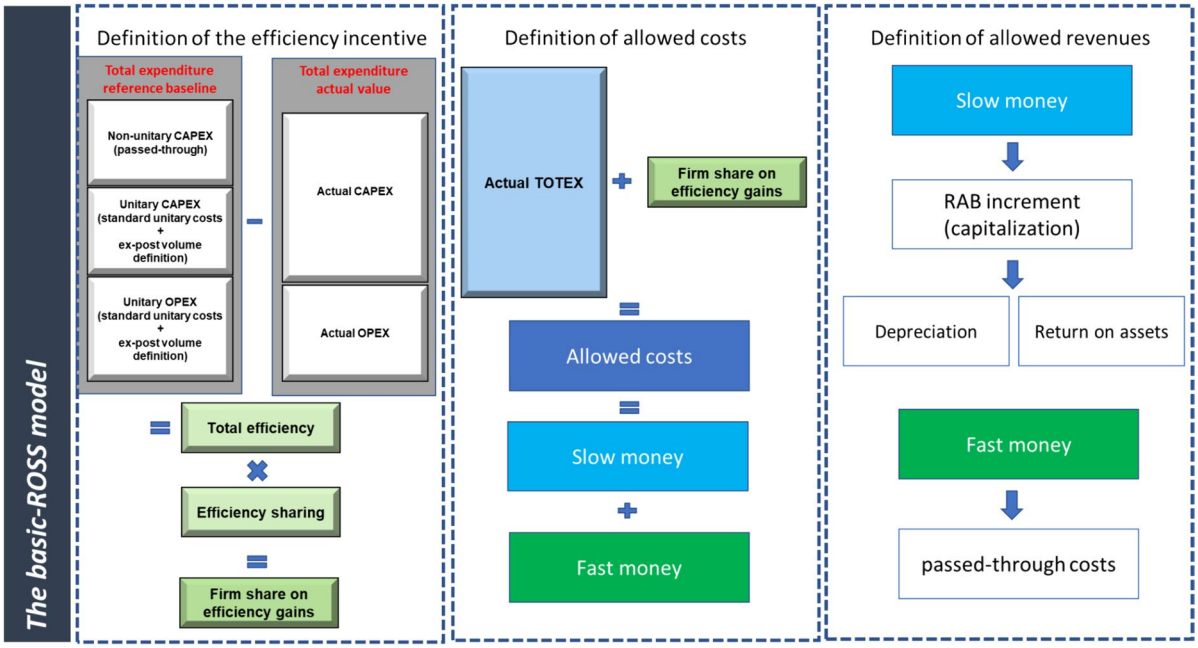

Fig. 3 Schematic representation of the ROSS framework in its future full configuration (including a forward-looking defined baseline of capital expenditures)

Third, and finally, firm's allowed revenues are computed as the sum of the actual expenditure and the firm's share on efficiency gains. Afterwards, a FOCS approach is applied to calculate slow and fast money, remunerating the firm based on the sum of fast money, return on capitalized costs, and depreciation. The latter is calculated with a straight-line method based on standard regulatory lifetime of the different income sources identified for the capitalized costs (slow money). The capitalization rate is calculated every two years, based on the weighted average of capital costs share reported in the previous three years, and of the projected capital costs share for the two years under consideration.

Implementation Rules for Basic-ROSS and Tariff Design for the 6th Regulatory Period

Decision 497/2023 [39] by ARERA set out the implementation rules for the basic-ROSS, i.e. the first step in the ROSS deployment for the 6th regulatory period (2024–2027). The basic-ROSS applies to both electricity and gas transmission system operators, and to electricity distribution system operators with more than 25.000 clients (as of January 2024, 18 DSOs). Overall, implementation rules provide details on OPEX and CAPEX regulation, and foresees the future definition of two further aspects: some indicators to monitor costs and commissioning stage of assets and activities; a financial model to monitor firms' financial performances.

Concerning OPEX, the most important aspect consists in the OPEX baseline definition, that is determined according to the following formula (except the first year):

$$Baseline_t^{OPEX} = Baseline_{t-1}^{OPEX} * (1 + Inflation - X + Y + Z)$$

The baseline for the first year (2024) of ROSS implementation in the electricity sector is set using 2022 as a test year, hence it is calculated dividing 2022 OPEX by the number of clients served in 2022, multiplying this ratio by the number of clients served in 2024, and actualizing everything through an inflation index. This baseline is updated taking care of the inflation[9] and of the following three factors.

The X-factor is determined based on the choice of the firm for a low or high incentive. In the low incentive solution, the firm has an X-factor equal to zero and retains (pays) 100% of the efficiency gained (lost) in the reported year, 50% of it in the subsequent three years, for a total of four years in which the firm benefits from its productive efficiency (and loses in case of underperformance). In the high-incentive solution, instead, the firm has a 0.5% X-factor applied and retains (pays) 100% of the efficiency gained (lost) in the reported year, 75% of it in the subsequent three years. This model applies a rolling incentive scheme, where possible strategic behaviors of the firm associated to increasing OPEX in the

[9] Discussion about the most reflective inflation index to be used is quite technical and not reported here in sake of simplicity [for details, see 43].

base-year are solved because there is no longer a single base year for OPEX for the entire regulatory period.

The Y-factor takes care of events linked to *force-majeure*. It includes unforeseeable events, including extreme weather events, and variations of the legislative or regulatory framework; this factor, which has an *ex-post* nature, was already available in the hybrid model used by ARERA until 2023.

The Z-factor is another important novelty of the basic ROSS approach: it refers to additional costs possibly related to new activities and investments linked to the energy transition, and differently from Y-factor has an *ex-ante* nature. The Z-factor is used to foresee a relevant variation of the perimeter of the services provided that implies an expected change in operational expenditures, e.g. the deployment of new solutions or technologies (previously not deployed) which are OPEX-intensive. The activation of the Z-factor could be requested *ex-ante* by the firm, with respect to each year of the regulatory period and with the possibility to update the request yearly. It is up to the firm to demonstrate the need for the Z-factor activation, providing evidence of incremental and recurring costs implicated by a different service perimeter (for instance, for the commissioning of new investments, e.g. new lines) and linked to the energy transition (for instance, for "capital-light" smart solutions that can imply specific incremental OPEX). If the company individuates the perimeter within which it expects incremental costs, it has to propose some indicators to measure *ex-post* the increased activities, and keep a separated accounting for the related incremental expenditures.

The OPEX baseline includes also operational costs associated with extreme climate and weather events, looking at the historical expenditures during emergency conditions (e.g. extra-shifts of personnel during emergencies, costs of people transferred to the place of emergency instead of their regular work location) reported in the last three years.

Differently, the OPEX baseline does not include some costs, including those related to pilot projects and experimentation for the energy transition, conducted by TSO and DSOs. These costs are added "on top" of the allowed revenues, as a pass-through.

Concluding Remarks Towards a Complete Framework for the Future: The Full-ROSS

In the first stage, ARERA has defined the general criteria for cost allowance on the basis of an intermediate step, the basic-ROSS. In a second step, a full, sector-specific TOTEX methodology will be applied to largest operators only, so-called "full-ROSS".

In the current application of basic-ROSS, performance-based regulation (e.g. reducing interruptions and reducing losses) and new output-based incentive mechanisms are carried out separately from the "basic-ROSS" activities, with specific rewards (and penalties, depending on the actual performances).

This section summarizes some of the most important features of the ROSS approach, both in its basic and full form.

- Cross-sector and cross-activity scope: following the positive experience with the WACC regulation, in which since 2015 a single common decision is taken by the regulator for all economic and financial parameter of WACC formula but beta (systematic risk, assessed at the beginning of the regulatory period of each sector), also the ROSS regulation now defines common criteria for all infrastructural activities (transmission and distribution, electricity and gas), aligning regulations that have been so far partially different. With Decision 163/2023 [38], therefore, the following aspects have been set contemporarily for different activities, while other aspects will be decided afterwards following common criteria [39].
- Efficiency incentives: in the full-ROSS, efficiency incentives are calculated on the basis of the (positive or negative) difference between the total expenditure baseline and the actual total expenditure (total efficiency gain). Provisionally, in the basic ROSS, an OPEX efficiency-gain is shared between operator and customers according to two different options (low risk—low efficiency and high risk – high efficiency), one of which is selected by each operator at the beginning of each regulatory period.
- Forward looking and Z-factor. At the beginning of each 4-year regulatory period, the regulator collects forecast of expenditure and activity of grid operators in order to assess their total expenditure baseline. Provisionally, in the basic ROSS, a new mechanism (Z-factor) is introduced, allowing the OPEX baseline to be adjusted upwards, to reflect changes in expected costs (compared to the OPEX in the base year); this is allowed in the event of significant increases in the size of the service, resulting from new investments which by their nature cannot be reflected by the price-cap mechanism.
- Ex-ante fixed opex capex share: fixed opex-capex rates are set by the NRA per each regulated company, with a motivated decision based on both retrospective and prospective assessments, weighted according to the specificities of each infrastructure service. From 2024 the actual capitalization rates of each single operator, therefore, are no longer fully incorporated in the tariff decisions as it happened in the past.

- Evolution of performance-based regulation: from 2024, the incentive regulation for continuity of supply based on indicators like SAIDI, SAIFI and MAIFI has been amended to set the performance objectives only on the basis of past individual performances; also, a new incentive scheme has been devised for accompanying energy transition and focusing grid development on most valuable investments. Based on an experimental initiative developed since 2018 to promote investment aimed at improving grid resilience to extreme weather events, in the new regulatory scheme the incentive is related to a share for the distribution company of the benefit that the investment is expected to reach over time, considering a wide range of key performance indicators (monetized benefits), including continuity of supply, RES integration (hosting capacity), grid losses, environmental impacts in terms of variation of CO2 emissions, saved DSO costs, improving voltage quality, and grid resilience [40].

The basic-ROSS approach, and even more the future full-ROSS approach, are expected to facilitate the investment growth needed to support the energy transition, while reducing the risks linked to CAPEX biases. Looking at the design and implementation challenges of the full-ROSS, we find two main aspects that should be particularly considered. First, the utilization of unitary costs for CAPEX is challenging, especially in the distribution sector, where firms are characterized by different financial and territorial characteristics [41]. Second, generation and demand scenarios heavily influence the evolution of needed network investments, thus the timing and location of new network uses constitute the most important uncertainty element to deal with. The implementation of a forward-looking approach during the definition of the firm's business plan is therefore fundamental. In this sense, it is important to properly manage both the possibility of the firm to recover its costs, and the working load that it is subject to. In the future, we believe that the discussion on full-ROSS implementation should be deepened, looking at past experiences that Italian, and European, Regulatory Authorities have done on efficiency improvement in investments' regulation.

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Declarations

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