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Sustainable electricity supply in a decentralised market: an analysis of business models, operators and regulation

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The difficulty lies, not in the new ideas, but in escaping from the old ones, which ramify, for those brought up as most of us have been, into every corner of our minds.

J.M. Keynes
Preface to “The General Theory of Employment, Interest and Money

Abstract

The operational conditions of European retail electricity markets are evolving, due to the completion of the liberalisation processes, the flattening demand and the growing share of renewable generation and low-cost control technologies. Suppliers receive lower and more volatile returns, consumers are gradually becoming more familiar with generating electricity on-site and network operators are putting in place innovative strategies to accommodate larger amount of Decentralised Energy Resources. However, it is not yet clear how the process of supplying sustainable and decentralised electricity will be implemented. This work evaluates the evolving role of market operators adopting a co-evolutionary approach; it examines the regulatory and market framework for the establishment of innovative and sustainable business models for electricity supply; and provides policy recommendations to enhance low-carbon innovation in the governance of electricity system across Europe.

Introduction

Electricity markets across Europe are affected by significant challenges which are altering their traditional operational conditions. The completion of liberalisation process and the establishment of the European Energy Union are driving the governance of energy system towards more competitive and integrated markets; the economic crisis resulted in a flattening electricity demand and in lower and more volatile returns for conventional suppliers, as well as into the deterioration of investment capacity from consumers. The rapid growing share of renewable sources in the electricity mix and the development of low-cost Information and Communication Technologies (ICT) are displacing the conventional technologies used in the market and therefore call for innovative strategies from National Regulation Authorities and from network operators. The traditional low-cost volume-based business model for electricity supply with limited customer engagement and standardized contracts has proved outdated: traditional utilities are restructuring and are looking for novel revenue streams; consumers are more aware of the environmental impact and costs of their energy usage and are gradually becoming more familiar with producing electricity on-site; network operators will undertake huge investments to manage flexibility in case of bidirectional power flows.

In this evolving framework, the economic advantage of Distributed Generation (DG) is now unquestionable, and a wide range of ICT may adequately respond to concerns in terms of the reliability of the system. However, it is not yet clear how the process of supplying decentralised electricity will be implemented, in a context in which electrification of transport and heat will be needed to comply with decarbonisation commitments of the Paris Agreement.

This research work, made of three papers, is an attempt to describe the main dimensions of the transition as well as the most important drivers for the establishment of sustainable and decentralised retail electricity markets.

The first paper, entitled **"Innovative business models for sustainable and efficient electricity supply: the evolving role of market operators"**, was presented at the 4th European Conference on Behaviour and Energy Efficiency in Coimbra (8-9 September

2016) and was submitted to **Ecological Economics**. The study adopts an analytical framework that integrates co-evolutionary theory and business model theory to provide a detailed analysis of novel and decentralised schemes currently available in Italy; an overview of the evolving strategies and role of market operators in the perspective sustainable market is also given.

The analysis of the main aspects which enable the development of a specific business model aimed to large industrial consumers is the core of the second paper, "**Integrated Energy Services: an innovative regulatory and market framework for sustainable electricity supply**" submitted to **Utilities Policy**. The study examines in depth the main characteristics of a business model devoted to large industrial customers: under the Integrated Energy Services scheme, Enel (a conventional operator and former incumbent) installs a Combined Heat and Power or Combined Cooling Heat and Power power plant on the premises of the consumers and captures revenues by selling electricity and heat through a Take-or-Pay contract for 8-12 years. This contribution includes a cross-country analysis to verify whether the conditions for the implementation of similar schemes are available in other European markets (UK and Spain); this paper was written during my 6-month research period at the **Smart and Green Networks Research Group** of the **Institute for Research in Technology** of the **Comillas University** in Madrid.

The third paper, submitted to **Renewable and Sustainable Energy Reviews**, is entitled **"The governance for Distributed Energy Resources in the Italian electricity market: a driver for innovation?"**. It focuses on the role of governance as a driver for innovation in the power sector: through the assessment of the Italian regulatory framework for electricity markets, it reflects on the instruments that allow the full integration of Distributed Energy Resources and the creation of a distributed grid control system across Europe.

The research work as a whole provides insights on the multiple dimensions of transition pathways towards decentralised energy systems across Europe, with a focus on the Italian market: the wider propagation of DER will require dramatic changes both from the side of governments (in terms of policy and regulatory innovation) and entrepreneurs (in terms of business model innovation), to find instruments that allow suppliers, users and network operators to adopt sustainable strategies and innovative technologies across Europe.

Innovative business models for sustainable and efficient electricity supply: the evolving role of market operators

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ABSTRACT

The operational conditions of European retail electricity markets are rapidly evolving: the traditional utility business model for electricity supply has proved to be outdated, while the economic advantage of Distributed Generation is unquestionable. However, it is not yet clear how the process of supplying decentralised electricity will be implemented in the future. Adopting innovative and sustainable business models, all parties modify their conventional strategies and put in place energy-efficient behaviours; to enable these options, dramatic changes are required, from the side of governments (in terms of policy and regulatory innovation) and entrepreneurs (business model innovation). This study employs an analytical framework that integrates co-evolutionary theory and business model theories to evaluate three schemes available in Italy and focuses on the evolving role of market operators. The paper describes the regulatory and market barriers that are hindering the deployment of Distributed Energy Resources and the instruments that can instead empower users in the adoption of sustainable behaviours across Europe, with particular reference to Italy: while the traditional business model is expected to persist, novel schemes are possible under the current paradigm, and their proliferation can establish positive feedbacks for the replacement of the dominant alternative.

1) Introduction

A significant portion of the efforts required by the Paris Agreement to "limit the temperature increase to 1.5°C above pre-industrial levels" (UNFCCC, 2015) will be implemented in the decarbonisation and decentralisation of the energy system, which is responsible for the majority of greenhouse gas emissions (IPCC, 2013). Positive feedbacks between technologies, institutions and user practices have locked-in centralised carbon-based energy systems (Unruh, 2000) and energy-related emissions will not peak before 2027 (IEA, 2016). The inertia is persisting in spite of the ongoing developments of the European electricity markets: utilities receive lower and more volatile returns thanks to the economic crisis, the flattening demand and the competition in the generation segment (Eurelectric, 2015a; Robinson, 2015); coal and gas prices are declining and are making fossil-fuel investments less attractive (BP, 2016). On their side, domestic and industrial customers are more aware of the energy costs and of the environmental impact of electricity usage: they respond to rising retail tariffs with the use of more efficient appliances (Sioshansi, 2014) and a growing share become *prosumers* thanks to the fall of renewable installation prices, to the financial incentives they receive and to the progress of Information and Communication Technology (ICT) (IEA, 2015; Kiesling, 2010; Pérez-Arriaga et al., 2013).

Scholars so far have focused on the market structure and the effects of liberalisation (Joskow, 2000; Littlechild, 2000), the market governance (Kuzemko et al., 2016), the concerns on investments in generating capacity (Joskow, 2006), the impacts of Distributed Generation (DG) (Cossent et al., 2011), the companies' structure (Haney and Pollitt, 2013). Another research line is devoted to the understanding of which factors affect a wide range of energy behaviors (Osti, 2012; Sk Skjølsvold et al., 2015; Steg et al., 2015), focusing on households (Lopes et al., 2015) and firms (Andrews and Johnson, 2016). With respect to the transition towards a sustainable and decentralised retail electricity market, contributions from regulatory (OFGEM, 2015) and institutional (Eurelectric, 2015b) sources shifted their attention also on business models for electricity supply, which represent how organizations implement their strategies and how operators interact with each other. The structure of conventional markets favoured the proliferation of the standardized low-cost volume-based business model, but it is not clear yet how the process of supplying decentralised electricity will be put in place, in a context in which electricity will become a more important vector for decarbonised transport and heating (European Commission, 2015b).

The aim of this contribution is to shed light on the characteristics of innovative and sustainable business models for electricity supply, in order to understand whether their development support the transition towards decentralised retail electricity markets across Europe; Italy is a significant case study for the analysis. A co-evolutionary framework is adopted to evaluate the role of market operators and to improve the understanding of how the main dimensions of the energy system (ecosystems, technologies, institutions, business strategies, user practices) causally influence each other, to promote sustainable strategies.
The contribution is organized as follows: the second section describes the main features of current electricity markets and of decentralised models for electricity supply; a description of the reasons why the Italian market is significant is also provided. The third section introduces the analytical framework which is used in this contribution, combining co-evolutionary theory and business model building blocks analysis; the evaluation of the three Italian schemes is presented in the fourth section. The fifth section is mainly devoted to describe the evolving role and strategies of market operators; the sixth section includes an overview on the adoption of disruptive technologies, and the last section proposes concluding remarks.

2) Towards the decentralisation of European retail electricity markets

The European Directives (1996/92/EC; 2003/54/EC; 2009/72/EC) were aimed to create a single energy market, to boost long-term investments on security of supply, competitiveness and sustainability and to give benefits to customers in terms of higher quality of electricity service at lower prices. In spite of these institutional measures and of technological innovation, progress in retail electricity markets have not turned into reality, due to the peculiar characteristics of the energy business which are described in the first subsection.
As a matter of fact, non-technological innovation plays a significant role in driving forward sustainability transitions (Steward, 2012), because technologies evolve within particular social and economic contexts, which are in turn shaped by the technologies that are used (Grübler, 1998). Similarly, the wider propagation of Distributed Energy Resources (DER, including renewable energy generators, Demand Resources, electric

vehicles) calls for an active role from consumers and network operators, which is possible in a fully competitive environment.
The following subsections describe the evolution from nationalised to liberalised markets and the pathways for the decarbonisation of the retail energy sector, through the description of innovative, sustainable and efficient business models; an overview of the reasons why the Italian case is significant for the analysis is provided.

2.1) The structure of liberalised electricity markets

For decades in Europe large fossil-fired power plants have been supplying low-cost electricity for any amount of consumer demand through national vertically-integrated monopolies, which were able to undertake significant investments on the grid thanks to economies of scale (Keay, 2016). From the end of the 1970s, Combined-Cycle Gas Turbine units (CCGTs) gained market shares at the expense of coal facilities, given the possibility to reduce the optimal size of the plants and to improve flexibility of the system (Clò, 2014). The liberalisation process that followed was primarily meant to the creation of new institutional arrangements to provide choice in purchase contracts and a reduction in retail prices to ensure consumers' protection (Joskow, 2008). However, after opening retail markets, peculiar characteristics of electricity business (the scarce elasticity of demand, the standardization of contracts and the consequent low consumer engagement, the strong role of incumbents and the increasing costs due to the development of DER) have hampered the development of some of the expected outcomes of liberalisation.
Current market structures, based on flat electricity prices in the retail sector, do not give useful operating signals for the stochastic supply of DER and therefore do not support their proliferation (Eid et al., 2016; Keay et al., 2014); on their side, climate policies eventually led to less competition, because they were enforced through expensive incentives and a significant amount of new regulation (Stagnaro, 2015). Traditional suppliers, challenged by the persisting flattening demand, are facing a "utility death spiral": growing electricity bills are likely to result in larger investments on energy efficiency and low-carbon technologies, further shrinking the residual demand (FTI, 2015; Richter, 2013). Among the largest European energy companies,

RWE decided to discontinue the operation of 10 units of total 4.3 GW and EON decommissioned 30 units of total 11 GW (Groot, 2014).

The supply-oriented market structures need to change to reflect the technical realities and opportunities of digital dispatched control and sustainable power systems (Keay et al., 2012). The deployment of smart meters and ICT enables a paradigm shift in the way electricity markets are operated and transforming passive end-users into active market players. However, dramatic changes are required, from the side of governments (in terms of policy and regulatory innovation) and entrepreneurs (business model innovation), to find instruments that allow suppliers, users and network operators to adopt both sustainable behaviours and innovative technologies across Europe. The next subsection explores how business models can respond to the challenges of a decentralised retail sector.

2.2) Innovative, sustainable and efficient business models

The institutional system described above and based on competitive markets for suppliers was a favourable environment for the development of a small number of large energy companies, which traditionally compete on prices rather than on other attributes in customer supply. Their main aim is to keep prices as low as possible to maximize their volume of sales. End-users themselves are scarcely engaged and assume a reliable, low-cost and standardized provision of electricity at affordable prices, for any amount of demand; network operators are remunerated for their investments.

This system is under pressure from growing awareness on climate change and security of supply; conventional operators are looking for new revenue streams in a context of shrinking demand, and customers are willing to pay less and to consume electricity in a more sustainable way: for example, local authorities engage with Energy Service Companies (ESCOs) to boost their influence on local energy systems and to contribute to "public good" objectives (Hannon and Bolton, 2015). In the prospective decentralised context, electricity supply will be provided by DG, close to the point of consumption. The business value will shift from the mere supply of a commodity to the provision of energy-related services. Suppliers will become fee-based service providers of customized solutions, possibly being reflective of the operational needs of the system. This requires new relationships among users and actors, and between them and the system operators: tailored solutions may increase the complexity of energy bills, but the integration of DG is inevitably calling for a different weight given to principles such as cost recovery and allocative efficiency, which are likely to be given a higher value with respect to simplicity (Picciariello et al., 2015). Regulators are required to shift their emphasis from rate structures to an innovative market design, considering demand-side resources and on-site generation on an equal basis than traditional generation. Differentiated contracts and offers should be available in the market, responding to the actual operational needs of the customers and to different generation options, including integration of generation and demand resources and installation of efficient appliances (He et al., 2013; Lorenzoni, 2014).

The central question will be how to create added value for suppliers, customers and regulated entities and for the system as a whole, taking advantage of innovative technologies currently available: the main challenge is the integration of supply and demand, and not only meeting demand itself. Traditional schemes are not able to capture all these dimensions, and innovative and sustainable ones are required to be profitable for suppliers, attractive for customers and reflective of the operational needs of the system. The next subsection provides an overview about the electricity market and regulatory context in Italy, to describe the conditions that are driving the change and supporting the development of novel business models.

2.3) Italy as a significant case for the transition

From 2011 to 2014, the Italian electricity market was characterized by an impressive increase of intermittent power generation (+23 TWh) and simultaneously by a dramatic decrease of electricity demand (-43 TWh) due to the economic recession (Clò et al., 2015). Enel, the former vertically integrated utility, still plays a leading role: it holds 25% of electricity generation (the second operator is Edison with 8.5%), and Enel Distribuzione (operationally unbundled Distribution System Operator) manages 86% of the national electricity volumes (AEEGSI, 2015b). In 2016, 17 years after liberalisation begun, 68% of households are still supplied in the captive market (“mercato tutelato”) and purchase electricity according to the regulated price (AEEGSI, 2016f). Among other reasons, the possibility to remain in the captive market is preferred because consumers are aware that switching supplier does not generate savings by itself: taxes, network costs and general system charges account for nearly 55% of the total energy bill. The captive market was established after the beginning of the liberalisation process (Decreto Legislativo 79/1999): the first step was to give free access to the grid to generators and “eligible consumers”, while the others were supplied in the regulated market, where price and quality conditions were predefined by the Regulation Authority. Since July 2007 all customers are allowed to access the free market. With reference to Italian industrial entities, the average prices of electricity (particularly the low consumption cluster, between 500 and 20.000 MWh) are higher than the rest of Europe (around 0.15 €/kWh compared to 0.10 €/kWh) (ENEA, 2016).

The Italian wholesale market (IPEX) is managed by Gestore dei Mercati Energetici (GME), and entails a spot electricity market (MPE), a forward electricity market (MTE) and a platform for physical delivery of financial contracts. The Italian market is also involved in the Multi-Regional Coupling (MRC) with France, Austria and Slovenia: the scheme coordinates the allocation of capacity and electricity sales, integrating markets thanks to an optimal exploitation of interconnection capacity. Overcapacity is the main cause of low profitability for conventional generators and utilities: recently, the Regulation Authority itself has recognized the need to encourage “favourable conditions for investments, creating value for the electricity system” (AEEGSI, 2015a).

In the perspective of the development of a decentralised system, the Italian regulation has promoted two significant support schemes: “Scambio Sul Posto” and “Ritiro Dedicato”. The former, which is a form of net metering, is a commercial agreement with Gestore dei Servizi Energetici (GSE, a public entity for the management of subisidies for DER) valid for low-carbon units up to 200 kW, in which the electricity generated by an on-site installation and injected in the grid can be used to offset the electricity withdrawn from the grid (AEEGSI, 2008; AEEGSI, 2012). According to the latter model, which can be translated as “Simplified Purchase and Resale Agreement”, low-carbon facilities under 1 MW of capacity sell to GSE the electricity generated and in turn receive guaranteed minimum prices, instead of facing the risk of selling through bilateral contracts or directly on wholesale markets.

The significant amount of decentralised resources in the generation mix and the need to fully exploit the opportunities of liberalisation pushed the electricity suppliers to shift their focus to new offers. The business models which are presented in Section 4 are feasible under current arrangements and at the same time represent a shift towards a decentralised market, employing DER and providing electricity in a more sustainable way and on the basis of a bespoke relationship with energy customers. The different types of suppliers are covered, with a scheme developed by a traditional supplier (Integrated Energy Services), one which is promoted by regulation and is mainly proposed by Energy Service Companies (SEU) and the latter that is offered by a cooperative (enostra).

3) Analytical framework: Co-evolutionary analysis and building blocks theory

Sustainability transitions have already been at the centre of the analysis of several scholars. The Social Shaping of Technology approach assumes that science and technology are mainly social activities and emphasizes that the individuals responsible for developing technologies (scientists, engineers, etc.) are influenced in their behavior by the institutions of each community (Sismondo, 2010). Conversely, the multi-level perspective describes how innovation emerges in a specific socio-technical regime: the destabilisation happens inside market niches (where socio-technical interactions are not well structured), expands into landscapes (the wider context, including political, cultural and social institutions) and eventually affects the regime (the prevailing set of routines and practices which create and reinforce a particular technological system) (Geels, 2011). However, this research line does not identify causal mechanisms that promote or inhibit the proliferation of novel and sustainable business models.

Recently, (Bolton and Hannon, 2016) clarified that without deep reforms of political, regulatory and market structures, it is unlikely that business model innovation will be sufficient to enact a system change; in spite of this, the authors made clear that the understanding of the synergies between socio-technical systems and business activities is helpful for the conceptualisation of the challenge of governing sustainability transitions. Most of the research on business model innovation so far has regarded the adoption of innovative technologies like storage or electric vehicles: however, business models have the potential to bring multiple benefits for the customer, the energy system and the wider economy. To monitor these benefits the concept of "complex value" has been defined, as the "production of financial, developmental, social and environmental benefits which accrue to different parties, across multiple spaces and times and through several systems" (Hall and Roelich, 2016).

On its side, the aim of evolutionary theory is to focus on the response of the firms and the industry to changed market conditions (Nelson and Winter, 1982); co-evolution provides a framework for analysing the mutual causal influence between different dimensions of the system (Kallis and Norgaard, 2010; Murmann, 2003; Hannon et al., 2013). This approach helps to provide insight into how technological, industrial and economic evolution has been responsible for shaping wide-scale, long-term system change in the past, including business models. Such dynamics have contributed to the establishment of a preminent scheme (the traditional electric utility business model described above) and to the marginalization of alternative ones: carbon lock-in arises because institutions and users benefit from increasing returns of the adoption and therefore a favourable selection environment is created for a technological system based on large-scale centralised electricity generation. At the same time, the analysis of key co-evolving dimensions provides insights to understand how innovative models will develop.

This paper relies on the analytical framework proposed by Hannon (Hannon et al., 2013), which integrates co-evolutionary and business model theories. The co-evolutionary analysis reflects on the centrality of business models to enhance the transition to a sustainable low-carbon economy, because innovative schemes have been causally influenced by the different dimensions of the wider energy system (ecosystems, technologies, institutions and user practices) and these schemes in turn influence the evolution of the energy system itself. The business models building blocks theory provides a methodology to develop a detailed picture of the main components and characteristics of each business model. This paper widens the scope of Hannon's study, originally devoted only to ESCO's business model in the UK market, and employs it to analyze the innovative business models currently available in the Italian market and proposed by traditional suppliers and cooperatives or promoted by regulation; the analytical framework highlights the importance of business models and evaluates the major characteristics of a decentralised and sustainable retail electricity market as well as the evolving behavior and strategies of market operators. As a matter of fact, what is missing in the literature is a comprehensive analysis of the role that business models (and in particular business model innovation) play in the transition, taking also into account the novel interactions that market entities will put in place.

A qualitative methodology is applied in order to provide detailed description of case studies and to develop a context-dependent analysis (Baxter and Jack, 2008; Flvbjerg, 2006). The description of the business models is possible thanks to the examination of websites and presentations and materials provided by the companies, as well as discussions with company managers.

3.1) The co-evolutionary framework

The contribution by Hannon is based on the specific co-evolutionary framework developed by Foxon (Foxon, 2011) for analysing the transition to a sustainable low-carbon economy. Business models are centralised, because they represent the realization of a firm strategy and the locus of established routines and behaviors; these routines and behaviors mutually influence and are influenced by other dimensions of the system: technologies, ecosystems, institutions and user practices. Technologies include methods and designs for transforming matter, energy and information, while ecosystems are defined as the systems of interactions that maintain and enhance living systems; institutions, on their side, are ways of structuring human interactions and user practices represent routinised and culturally embedded patterns of behavior. Thanks to this background, the barriers for the uptake of innovative business models are described, together with the drivers that can instead support their further development. Under this framework, each dimension evolves under its own dynamics and is endogenous to the system, but none is considered more fundamental than the others.

With reference to the Italian retail electricity market, the main dimensions which have influenced the evolution of innovative and sustainable business models can be described in terms of:

- *Technology*: the rapid and significant increase of intermittent power generation;
- *Ecosystems*: the former vertically-integrated utility still plays a leading role in generation and distribution;
- *User practices*: 68% of households are supplied in the captive market, 17 years after liberalisation;
- *Institutions*: 55% of total energy bill is not negotiable (taxes, network costs and general system charges).

Moreover, the co-evolutionary approach to technological, industrial and economic system change places emphasis on *variation*, *selection* and *retention* processes. The former explains the variants of the model, while the selection dynamics describes the extent to which these variants have been adopted; the retention process investigates how the factors that have enabled variants persist and are replicated by other organizations (Mackenzie, 1992). This analysis therefore explains how the proliferation of different models is created, how some characteristics are retained or inherited in the models that proliferate and how selection occurs among successful and unsuccessful models. These co-evolutionary processes take account of uncertainties, and are path dependent: key events in the transition to a sustainable economy occur after the establishment of technological changes, after the forming of *ad-hoc* institutions and after revisions to business strategies or modifications in user practices.

In general, an innovative, sustainable and efficient business model for electricity supply proposed by an actor of the system overcomes the barriers that favour the selection of the traditional electric utility business model and enables the adoption of novel low-carbon technologies. The formulation of transition pathways follows an approach based on three elements:

(1) *The characterisation of the existing energy regime*, and this was provided in the second section.

(2) *The identification of dynamic processes at the niche level*, where a range of low-carbon technologies and business models are competing and looking for further public

support and private investment. The fourth section describes three schemes available in the Italian electricity market.

(3) *The specification of interactions strongly influencing transition pathways*, which promote the shift to a low-carbon electricity regime. The fifth section reflects upon the evolving role and strategies of suppliers, consumers and regulated operators.

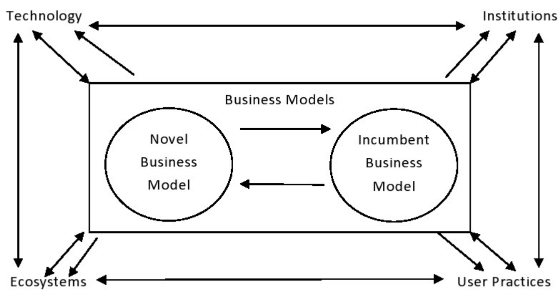

Figure 1 The co-evolutionary framework (Hannon et al., 2013)

3.2) Business models building blocks

Business models can be defined as a "set of interdependent organizational activities" (Zott and Amit, 2010) and their function is to create value and capture a portion of that value through the series of activities from raw materials to the final consumers (Chesbrough, 2006). Business models are the core of the analysis, because they describe how organizations develop their strategies and represent how market operators interact with each other. When novel business models enter the market, different products and services attract novel customer segments (Markides and Oyon, 2010). Among many reasons why a firm would decide to innovate business models (opportunity of bundling activities, operational efficiency) there is the substantial advantage of being a first mover (Amit and Zott, 2012); initiatives of this kind are also the result of internal factors (organization, strategy, and technology) and the external environment (competition, legal and environmental framework) (Osterwalder, 2004). Although traditional electricity suppliers are usually large and not flexible corporations, facing significant difficulties in changing well-established practices, they are aware that there is a need to change their conventional strategies.

The business model building blocks framework (Osterwalder and Pigneur, 2010) provides a structure around which it is possible to populate the components of the innovative schemes. The framework explains that business models are made up of the following: key partners, key activities, key resources, customer value proposition, customer relationships, channels, customer segments, cost structure and revenue streams. The value proposition is the bundle of products and services that create value for the firms and the customers, and is at the center of the canvas, strictly related to customer relationships and the way through which firms communicate with customers (customer channels). Customer segments are the different groups of people or organizations suppliers aim to reach and serve, through the implementation of key activities. The key resources are the most important internal assets required to make the business model work, and key partners are the network of suppliers and partners which cooperate (some activities are outsourced and some resources acquired outside the enterprise). The canvas considers also the major costs operators incur to implement their business model and the revenue streams they generate (result from value propositions successfully offered to customers).

The following section analyzes innovative and sustainable business models available in the Italian market, in order to verify their common characteristics and their role in the development of a decentralised retail electricity market.

<table>
<tr><td rowspan="2">Key Partners

The networks of suppliers and partners that make the business model work</td><td>Key Activities

The most important things a company must do to make its business model work</td><td rowspan="2" colspan="2">Value Propositions

The bundle of products and services that create value for a specific Customer Segment</td><td>Customer Relationships

Relationships a company establishes with its Customer Segments</td><td rowspan="2">Customer Segments

The different groups of people or organizations an enterprise aimes to reach and serve</td></tr>
<tr><td>Key Resources

The most important assets requie to make the business model work</td><td>Channels

How a company communicates with and reaches its Customer Segments</td></tr>
<tr><td colspan="3">Cost Structure

All costs incurred to operate a business model</td><td colspan="3">Revenue Streams

The money a company generates from each Customer Segment</td></tr>
</table>

Figure 2 The business model building blocks framework (Osterwalder and Pigneur, 2010)

4) Innovative business models in the Italian retail electricity market

Innovative, sustainable and efficient business models for electricity supply are a viable option under current arrangements, and provide a shift towards a more active integration of low-carbon technologies: they are profitable for suppliers, attractive and affordable for customers and are reflective of the operational needs of the system.

The growth of decentralised resources in the generation mix and the need for both consumers and suppliers to take benefit from liberalisation (due to highest retail prices in the Eurozone) are the conditions that made possible business model innovation in Italy: the next subsections are devoted to the detailed description of these schemes, which meet the characteristics described above.

4.1) Integrated Energy Services

In the scheme of Integrated Energy Services (IES), a traditional supplier (Enel) installs a small power plant and energy-efficient solutions at its own expense directly on the premises of the customers (typically industrial consumers) under an Energy Performance Contract. Enel captures revenues by owning the equipment and selling electricity and heat and withdrawing a portion of the savings with respect to business-as-usual load profile (with results up to 20% of former energy bill). The customer signs a Take-Or-Pay contract on a quantity of electric and thermal energy to be supplied (in general, 60-70% of the total expected consumption), with residual demand paid through a pre-determined tariff, negotiated on a yearly basis; these general conditions can differ according to the industry's needs. At the end of the contract (usually after 8-12 years), the customer is given the possibility to purchase the plant. The service includes the whole permitting and design processes and turn-key installation, as well as the operation and full-service maintenance of the plants, typically Combined Heat and Power (CHP) plants or Combined Cooling Heat and Power (CCHP) plants, which are eligible for the Italian White Certificates energy efficiency support scheme (Ministero dello Sviluppo Economico, 2012; GSE, 2015).

So far, Enel's offer has included generation facilities from a minimum capacity installed of 500 kWe up to 5 MWe, in order to provide up to 95% of electricity self-consumption. On their part, industrial customers are not required any financial guarantee and are enabled to concentrate on their activities without facing the risk of trading in the energy market or operating a power plant; at the same time they improve their power quality and reliability of energy supply while cutting costs: the energy price is indexed and discounted with respect to the market benchmark. Consumers can also benefit from a full risk guarantee on the plant and on the grid supply in case of malfunction of the plant itself. From the point of view of the System Operators, this business model increases the local dispatchable generation and improves security and safety of the electricity system: CHP plants can provide multiple operating modes (IEA, 2014) and they boost the capacity to adequately respond to growing quantities of non-programmable plants. The former incumbent Enel has been proposing this offer since two years, among other initiatives aimed to change its strategy (such as the intention to turn off 23 thermoelectric stations, for a total capacity of 11 GW (Starace, 2014)) and with the purpose to gain market share in the industrial sector.

4.2) Sistemi Efficienti di Utenza (SEU)

A regulation-driven business model, with many similarities to the previous one, mainly devoted to industries and large commercial users, is represented by SEU ("Sistemi Efficienti di Utenza", Efficient User Systems). In this scheme, where generation and consumption are coupled, the low-carbon stations are managed by a single supplier and are connected through a private network to the consumption point of only one customer. The customer and the supplier can be the same entity, but the former is obliged to be the owner of the area over which the generation unit and the network are installed (AEEGSI, 2013). These plants are exempted from the payment of distribution and transmission charges for the self-produced electricity, but pay 5% of the variable components of general electricity system charges (AEEGSI, 2014). The regulation for SEU, with regard to the one-to-one restriction, the ownership of the whole area where the plant is installed with no interruption and the partial payment of system charges represents a significant barrier to the development of this scheme: the cost allocation is inefficient and is not reflective of the real system costs.

These offers are usually proposed by Energy Service Companies (ESCo): they normally seek to fulfil the customer needs with lower levels of energy supply with respect to traditional utilities, through energy demand management and more efficient forms of generation. The typical ESCo business model implies a strong relationship with the customers, that are highly involved in the design phase and are allowed to cover the costs as efficiency gains. The revenues are ensured by final customers who buy self-produced electricity and their entity varies according to the pre-agreed price on electricity as well as on the technical aspects (e.g. whether the system is designed to maximize self-consumption or not). The Italian framework, which has so far mainly incentivized PV schemes with a capacity installed under 20 kWp via this model (GSE, 2016), gives the possibility to cumulate other incentives (white certificates and tax deductions); the creditworthiness of the customers and the possible mortgages on buildings represent a barrier in case financial institutions are involved. However, the major risk which operators are dealing with is regulatory instability: changes have already affected this scheme.

4.3) Enostra

This offer[1] is presented in Italy after the European experience of the project Rescoop (Rescoop, 2013), which is dedicated to promote the renewable energy sources cooperative model. Citizens engaged in REScoop initiatives could be at the same time investors, producers and consumers: they are involved in the governance structures and have access to transparent information. Enostra is a cooperative firm, whose aim is to favour bottom-up transition towards a renewables-based system and to supply sustainable electricity at a fair price to the partners. The cooperative itself is not the owner of any generation plant, but it purchases electricity from renewable suppliers selected on the basis of a matrix that evaluates their responsibility according to social, environmental, and governance aspects (generating portfolio, lawfulness, transparent governance, environmental and social responsibility). Firms characterized by unfair commercial behaviours or related with large groups of extraction and exploitation of fossil fuels are not accepted. Conversely, the preference goes to small production facilities where local communities participate to the decision-making process and

[1] www.enostra.it

share economic revenues. With regard to customers, households are given the possibility to choose among three commercial offers, each in line with captive market prices, while NGOs and firms are proposed one offer each.
Enostra addresses a niche market, with a model based on the principles of the sharing economy and of mutuality (the cooperative ensures benefits to all parties involved, and acts as a reliable interface), transparency (simplicity towards customers), sustainability. From the point of view of the producers, the eligible units have a capacity installed higher than 10 kW and supply electricity to the grid (therefore those incentivized via net metering or feed in tariffs are excluded). Installations so far included PV units from 19 kWp to 255 kWp, mostly built by "Retenergie" after having obtained the surface right on areas owned by farmers, schools, local markets, in exchange for the installation of a smaller plant. The peculiar barrier for community energy initiatives is the lack of technical and legal skills of local populations (REN21, 2016). With specific regard to enostra, probably the restrictions on aggregation and storage in the Italian regulation hampers the development of this scheme (so far 534 contracts have been signed), because it is highly probable that these highly-engaged customers may will to further improve the sustainability of their consumption.

4.4) Discussion

The co-evolutionary theory gives the possibility to analyze transition processes and to provide insights on the future design of retail electricity markets; the building blocks methodology offers instruments to reflect in depth on the most peculiar characteristics of every single model. In the European context, Italy represents a significant case for the analysis of the transition: the availability of regulation-driven business model for coupled generation and consumption, the tax reductions on gas for CHP and the incentives for energy efficiency (White Certificates) were drivers for the implementation of the analyzed business models, even in presence of barriers like the impossibility to aggregate loads and to sale electricity to adjacent potential consumers.
In spite of some degrees of heterogeneity (*variation*) in response to similar problems (rising retail prices, economic crisis), a reflection on the adoption of innovative and sustainable business models (*selection*) is possible. In general, with respect to the

traditional business model, firms undertake higher degrees of financial and technical responsibility with regard to their customers in order to provide them with services to satisfy their energy demand. Under these models, the provision of energy services is part of a long-term relationship based on tailored solutions and contracts. However, the variation explains to a certain extent the persistency of the traditional model (*retention*): the ambition of innovative and sustainable business models is to focus on bespoke contracting to fulfill a wide variety of customers' energy needs. Other barriers are represented by the market power of incumbents, the unstable and to a certain extent incoherent policy framework, the lack of consumer awareness and the general higher costs (including transaction costs) of low-carbon technologies.

According to the main dimensions of the energy system and the co-evolutionary analysis, the authors reflect on the relationship of novel schemes with:

- *Ecosystems*: suppliers were encouraged to implement solutions to improve the system security and sustainability. From their side, the impact of novel schemes on ecosystems has so far been negligible, because regulatory and financial barriers are still strong and the traditional business model is still in place;
- *Institutions*: policies that either require or incentivize organisations to engage in sustainable energy supply helped to improve the business case. Nonetheless, greater certainty that there is a significant national commitment to a low-carbon transition is needed.
- *Technology*: the financial viability of the contracts analyzed is influenced by the costs and performance of the energy conversion and demand management technologies. The adoption of the innovative models has triggered small-scale investments from suppliers, but most of the technologies already used are established ones (CHP, PV). The role of disruptive technologies will be analyzed in the following section.
- *User Practices*: the high level of demand for energy services, coupled with falling real wages due to the economic downturn, has meant that the costs of energy services have become less affordable for most domestic and commercial consumers. This has increased the need for services to reduce customers' current energy costs, but at the same time has limited the capacity for investments.

From this short analysis it is possible to confirm that large non-technological barriers are hindering the development of decentralised retail electricity markets, because the technology is already available, while the capacity and the legal framework to effectively employ it is missing. Most suppliers and consumers do not feel familiar with engaging in innovative models, with only some attempts already available in this sense. Traditional utilities have shaped the energy industry and the implementation of these schemes so far has not altered their model, because they retain political power and wealth. For example, the ban on aggregation and storage, as well as on the possibility for small distributed generators to sell excess electricity to adjacent entities or to provide grid services to the network, is hampering the promotion of innovative schemes.

Nonetheless, a greater uptake of sustainable business models is expected to improve in turn the influence on ecosystems, institutions, technology and user practices and therefore to improve the degree of fitness of these schemes with the wider selection environment thanks to positive feedbacks. Traditional suppliers will gradually innovate their value propositions and deliver demand or supply energy services and non-traditional operators will enter the market (cooperatives, local authorities); consumers will become more familiar with the operational characteristics of these models and regulated operators will find appropriate strategies to accommodate DER. DER themselves will become key resources, with their related cost structures and revenue streams, which will evolve from the conventional incentives. These interactions will be analyzed more in depth in the following section, where a reflection is proposed on the evolving strategies of market operators.

5) The evolution of market operators in light of innovative and sustainable business models

In order to properly shift to a decentralised energy system, the behaviour of market operators should change (Termini, 2014). The market is becoming an environment where empowered and engaged consumers incentivize suppliers to compete with each other to deliver efficient and innovative products and services. In this market, there would be high levels of customer service, significant switching in response to price changes, and different supplier strategies around pricing and customer acquisition. Building trust between consumers and utilities is one of the key points: a non-transparent usage of detailed consumption data, as well as arid and rare billing communications, represent the status quo in utility-customer relationships.

5.1) Suppliers

The rapid pace of technological advancements make imperative for incumbents to adapt to a changing business. In the context of Distributed Generation, power stations will be close to demand, load-following and able to provide a set of ancillary services to the network; suppliers will still play a relevant role as the interface between customers and the electricity systems (Fuerriegel and Neumann, 2013). Although traditional suppliers are usually large and not flexible corporations, they are aware of the ongoing transition and they are paying more attention to customer loyalty, looking for alternative market-based revenue streams, considering that also non-traditional participants will enter the market (cooperatives, ESCOs). It is rare to find innovations that originated from incumbents, because they find it extremely difficult to respond appropriately to changes; however, traditional utilities could embrace innovative schemes and transform their own business, as it was the case of Enel with IES.
Retailers have a high potential to create added value integrating DG and Demand Resources but this is not yet possible in most countries, because regulated retail prices are still in place and consumers lack real-time price information (Lorenzoni, 2015). In general, suppliers are looking to differentiate their products and to integrate complementary technologies: the new digital technologies make the distribution grid control easier and cheaper through distributed self-dispatching. Non-monetary incentives will also gain importance to engage in the smart energy field less motivated end users, beyond early adopters. The other concern for suppliers is represented by financing (HSBC, 2015): in 2008 the top ten European utilities had credit ratings of A or better, while now only five do (The Economist, 2013). The crowdfunding option can provide a solution to raise money through internet and dedicated web platforms, and is particularly fit for decentralised projects involving smaller, local and sustainable

facilities.

5.2) Consumers

The Energy Union Framework Strategy (European Commission, 2015a) sets out the vision of an Energy Union "*with citizens at its core, where citizens take ownership of the energy transition, benefit from new technologies to reduce their bills, participate actively in the market, and where vulnerable consumers are protected*". However, many studies have shown that energy-using habits exhibit considerable inertia, and energy-related decisions are only in part influenced by rationality (Wilson and Price, 2007) and mainly by energy practices. In general, consumers are affected by bundled rationality and prejudices, overestimating or underestimating their own consumption with respect to an average consumption, and they interrupt their search for a new supplier as soon as they find a slightly cheaper offer (Vazio, 2014); other barriers for residential customer adoption of DER are large initial investments, lack of information and complex processes for installation (eLab, 2014).

Conversely, thanks to the development of smart technologies, nowadays customers should ideally be provided with tailored services: each consumer load has its own characteristics and different contracts should respond accordingly. The main efforts will be needed in terms of establishing new, strong and long-term relationships between customers and their suppliers: large consumers, with lower transaction costs for energy management, are more likely to be flexible in the electricity use and to value energy price certainty to minimize risks on the profitability of their business, while small consumers are more likely to be convinced by forms of relational information ("your neighbour saved 20% more energy than you"). Such contract arrangements should be implemented favouring energy efficiency and eliminating the risks of "rebound effect" (Winther and Wilhite, 2015). A balance must be found in terms of additional control options and more transparent and frequent billing on one side, and privacy issues and comfort gains on the other side. The final step of the transition towards fully decentralised electricity markets is the establishment of co-providers, considered as end-users contributing to balance supply and demand of electricity in smart grids, shifting electricity consumption to moments that are

favorable for the energy system (e.g. when renewable electricity is locally available, or consume when demand is low).
In general, liberalisation is related not only to the possibility to choose a supplier (formal liberalisation), but rather on the possibility to improve the initial conditions, increasing the quality of services purchased or reducing total costs (full liberalisation). Empowerment is at the basis of well-functioning retail markets, which are characterized by high level of awareness and trust from the consumers' side (CEER, 2015).

5.3) Regulation and regulated operators

The rapid transformation of the electricity system has not been developed together with a revision of regulation (Cassetta and Monarca, 2014): the decentralisation requires a more active role of the regulator in defining roles and responsibilities of system operators, because each stakeholder can be assigned many tasks (Glachant and Ruester, 2014). Regulation should evolve from the remuneration of infrastructure and capacity to a teleological approach pursuing grid technology innovation, system utility and greater participation from grid users (Meeus et al., 2010): the distribution system must become flexible, able to respond to changing system conditions. In this framework, efficient economic signals must be conveyed to all operators involved via regulated charges (Cossent et al., 2011; Polo et al., 2014), balancing low costs and long-term benefits. Output-based regulation will be adopted, enabling the companies to obtain incentives to innovate according to a defined scope of activities. With specific reference to households, regulation is also required to consider that cognitive sciences have discredited the paradigm of rational choice, and stressed that the behavior of consumers is mainly influenced by social norms and pressures (Di Porto and Rangone, 2013).
From their side, the Distribution System Operators (DSOs) are currently under pressure to improve reliability and system performance while dealing with the ongoing challenges of an ageing infrastructure. They will become neutral facilitators of new services rather than being mere distributors of electricity received by the transmission grid: they will guarantee to the players the information necessary to operate, and will

manage multi directional flows of electricity, deal with electric vehicle charging infrastructure, and with electric storage to manage congestions and shortages. Distribution operators may provide services with different degrees of reliability (with customers paying a fixed monthly fee for their desired level of reliability), with different rates paid by consumers according to the system costs of their use (proportional to connection voltage, peak demand, equipment) or a mixed model (retaining the existing model with some automatic adjustments in case DG producers use the system as a source of backup power or ask/provide other services to the grid or from the grid).

5.4) Innovative interactions among market operators

The early stage of the electricity industry was characterized by decentralisation, with local generators supplying local loads (windmills, watermills and steam engines) (Bodanis, 2005). To a certain extent, the local dimension will be a feature also of the prospective retail markets; however, it is likely that all parties will interact with each other in an innovative and sustainable way.

Suppliers will own and control units for the production and use of energy (the whole range of DER – *key resources*), while transport providers (distribution and transmission system operators – *key partners*) own and control the facilities for transport of energy, providing information to all parties involved. Customers (*customer segments*) become increasingly engaged in their electricity consumption and supply (*customer relationships*), generating electricity onsite, implementing energy efficiency initiatives and using demand-side management to tailor the services to their preferences (*key activities*). It is likely that in the next years the majority of consumers remain grid-connected, but they will purchase much smaller quantities of energy from the grid than at present: the grid is used for balancing and backup, not only as the primary source of electricity.

Revenues for suppliers will be related to performance-based incentives tied to the benefits that they provide to their customers or to the network through cost-effective initiatives to improve energy efficiency, integrate DER and provide services (*value propositions*). The remuneration of this supply will be possible through forward or spot retail transactions, with fixed payments for fixed services and with choices between different sorts of supply, like the "as-available power" at a low price and the "on-demand" power at a significant higher price (*revenue streams-cost structure*). Consumers should obtain incentives to make sustainable choices (*channels*): the literature has already shed light on the fact that self interests have an higher impact on energy behavior than social interests (explaining the gap between pro-environmental attitudes and pro-environmental behavior) (Ohler and Billger, 2014).

A decentralised electricity market is already happening and possible, but it is a completely different business: dramatic changes in market and regulation are needed to enhance the transition. Business models are required to innovate, and to take full advantage of disruptive technologies. Regulations should evolve and allow novel solutions being attractive for all users and reflective of the operational needs of the system.

6) New opportunities: aggregation, storage and electric vehicles

In the previous section, some barriers for the adoption of smart technologies have been presented, mainly from the point of view of existing designs and missing standards and protocols for such devices. Non-technological innovation, like the implementation of innovative business models, may provide instruments to overcome these barriers: however, the shift towards a more decentralised market structure rely on the possibility to integrate other forms of disruptive technologies, which enter into an existing ecosystem of niche applications.

Energy storage is eligible to supply regulation services to the grid and there is great interest in the possibility of installing batteries at the users' premises or in the distribution network, but their significant installation cost is still preventing this opportunity (Grünewald et al., 2012). The aggregator, in the form of an intermediary or network representative, offers services to put together energy production and energy consumption from different sources and acts towards the grid as one entity, shifting loads to lower price periods and/or injecting power in times of shortage (Smart Grid Task Force, 2015). To enable aggregation it is necessary to involve grid users (generators and consumers) and to ensure fair payment for the service provided

(SEDC, 2014). Electric vehicles are a revolution in terms of mobility and could also be programmed to charge when electricity prices fall below a trigger price set by the owner and serve as distributed energy storage devices (Weiller and Neely, 2014).

Further innovations in terms of business models for electricity supply should take into consideration these new opportunities: suppliers becoming fee-based service providers should be allowed to provide a wider full selection of options, and consumers should be empowered to benefit from these multiple services.

7) Conclusions

Electricity markets are evolving, with the completion of the liberalisation process and the increasing contribution of low-carbon generation technologies in the energy mix. However, these changes so far have had little impact on the main characteristics of retail markets. The development of innovative and sustainable business models gives the opportunity to all market operators to play an active role in the transition towards a decarbonised electricity system.

Energy governance so far has proved effective in the development of competition policies and in the promotion of technologies like smart meters, but it has not been able to engage traditional suppliers and customers in sustainability goals. This paper showed that the transition calls for new suppliers' strategies, for changes in the consumers' behaviour and for the expansion of network operators traditional tasks. As a matter of fact, in spite of the positive outlook towards low-carbon technologies, the co-evolutionary dynamics (the extent to which innovative business models influence the other dimensions of the energy system) explains that the dominant traditional business model is expected to persist across Europe. Nonetheless, the analysis of the Italian market made clear that novel schemes are feasible under the current centralised paradigm thanks to some favorable regulatory and market conditions (forms of subsidies for low-carbon sources and energy-efficient initiatives; and suppliers need for innovative contractual arrangements); moreover, their further development and related positive feedbacks will be able to influence the other dimensions of the energy system and promote a favorable environment for their proliferation and the replacement of the previous dominant alternative. Further research is needed, to analyze the main drivers for the establishment of DG business models in other countries; suppliers, from their side, should understand better how customers use energy and then integrate their cost drivers with the behind-the-meter energy use; consumers should be empowered and given easy options, providing a sense of opportunity and ownership.

A fully decentralised electricity market is possible, thanks to the expansion of DER, but in that context electricity supply will become a completely different business: the evolution may lead to a situation where services will be provided, rather than electricity (eg washing dishes instead of providing kWh). All parties will be required to actively participate in the market integrating their load with local generation facilities and implementing sustainable and efficient behaviours.

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Integrated Energy Services: an innovative regulatory and market framework for sustainable electricity supply

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ABSTRACT

Liberalization policies, the challenges of integrating Distributed Generation, and the recent flattening of electricity demand due to the economic crisis and to the technological change have led to lower and more volatile returns for European electricity suppliers. Innovative and sustainable business models are needed to serve electricity customers while reflecting the operational needs of the system and maintaining supplier profitability. This paper describes a novel model of "Integrated Energy Services" that integrates Distributed Generation and Demand Resources for industrial customers. We further reflect on the regulatory and market drivers for the development of similar schemes across Europe.

1) Introduction: the rise of innovative and sustainable business models for electricity supply

The traditional business model for electricity supply, based on low-cost volume-based provision of energy generated by large centralised plants with limited customer engagement and standardized contracts, co-evolved with the broader energy system;

market operators have greatly benefited from economies of scale and this dynamic contributed to the marginalization of alternative business models (Hannon et al., 2013).

Nonetheless, operational conditions across Europe over the last ten years have evolved rapidly and conventional strategies in electricity markets have proven to be outdated (Electricity Innovation Lab, 2013). The implementation of the three pillars of the European Energy Policy (competitiveness, security of supply, and sustainability) (European Commission, 2007) and technological improvements in Information and Communication Technologies (ICT) are shaping the transition to a less centralised power sector (Jenkins and Pérez-Arriaga, 2014). In spite of persistent market concentration at the national level, the European Union is the world's largest region undergoing liberalization. The wide diffusion of renewable energy sources, accounting for 27% of the EU's electricity production in 2013 (Eurelectric, 2015), has led to excessive generation capacity: the additional generation from renewable sources from 2000 to 2012 amounted to 350 TWh, with a total increase in demand of 267 TWh (Henriot and Glachant, 2015).

Domestic and industrial customers are increasingly aware of energy costs and the environmental impact of electricity usage; some are becoming *prosumers* due to the expansion of on-site small generation capacities (Pérez-Arriaga et al., 2013). The combination of these factors, together with the flattening electricity demand due to the economic crisis (-0.2%, -0.1%, and -0.2% year-on-year variations in 2011, 2012, 2013 respectively) (ACER/CEER, 2014), has resulted in lower and more volatile returns for electricity utilities (Figure 1).

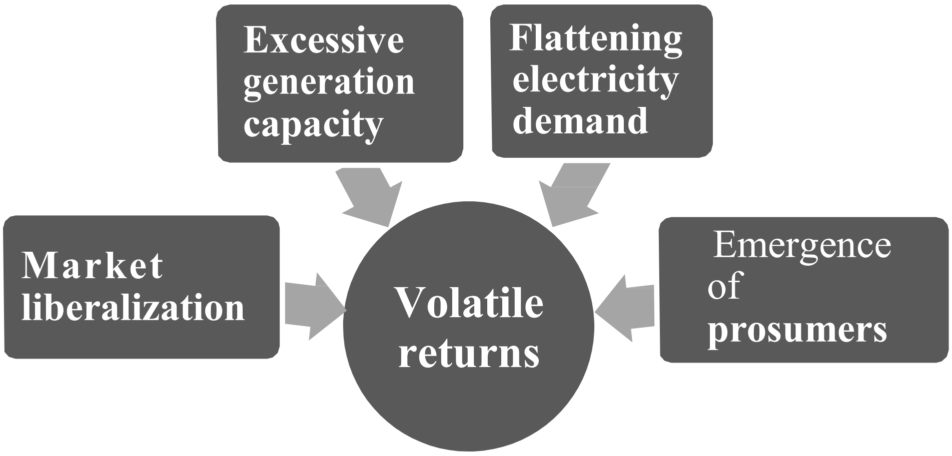

Figure 1 The need for innovative and sustainable business models for electricity supply

According to a report by *Eurelectric* (Eurelectric, 2013), the value of earnings before interests and taxes (EBIT), a measure of a firm's profitability, declined by 10% between 2011 and 2012 for conventional generation companies. On a market capitalization basis, the EU's five largest power generators, which collectively represent 60% of European generation (EDF, GDF Suez, Enel, E.On and RWE), lost more than 100 billion euros (37% of their value) between 2008 and 2013 (CTI, 2015).

Researchers have already tried to define the main element of business models for electricity supply in the new context, also considering the typical contracts of Energy Service Companies (ESCO) (Schoettl and Lehmann-Ortega, 2011; IEA RETD, 2012; Richter, 2012; Richter, 2013; Electricity Innovation Lab, 2013). The transition is calling for customized supply solutions, with bundled offers of energy and services, and suppliers are becoming fee-based service providers. In Italy, Enel Energia is currently proposing a scheme, to which we refer as Integrated Energy Services (IES), which has the potential to serve electricity customers while reflecting the operational needs of the system and maintaining supplier profitability (Lorenzoni, 2014).

This study has two aims: the first is to describe the characteristics of innovative and sustainable business models, with a particular focus on IES; the second is to reflect on the main patterns that can promote the development of IES. The remainder of the paper is organized as follows. Section 2 describes in general business models for electricity supply under the transition to a less centralised energy system, focusing on the most important features of IES. Section 3 and its subsections provide general comments about how regulatory policy in generation, distribution, and retailing activities is currently limiting the development of IES and how rules can be improved for a further penetration of this scheme. Section 4 describes the current regulatory environment and market framework for innovative business models in Italy and briefly illustrates the context in other representative European countries (UK and Spain), while section 5 draws some key conclusions.

2) Innovative and sustainable business models and Integrated Energy Services

Thus far, the electricity markets in Europe have been designed according to a supply-oriented system, aimed at providing affordable and secure electricity for any amount of consumer demand; in the new context, service providers will still play a relevant role as the interface between customers and the electricity system (Kuzemko, 2015). Traditional suppliers are usually large and somewhat inflexible given the nature of their assets and the well-established practices in the sector, but they are aware of the ongoing transition.

Recently, some of the most important European operators announced significant changes in their business structure. E.ON[2] will focus on renewable energy sources, distribution networks, and customer solutions (establishing a new company for its conventional generation and trading businesses). RWE[3] declared that it would position itself as a "project enabler, operator and system integrator of renewables". The Spanish operator Iberdrola[4] has begun to offer energy supply contracts to their customers as well as the installation of photovoltaic equipment.

Generally speaking, a business model describes the rationale of how an

[2] http://www.eon.com/content/eon-com/en/media/news/press-releases/2014/11/30/new-corporate-strategy-eon-to-focus-on-renewables-distribution-networks-and-customer-solutions-and-to-spin-off-the-majority-of-a-new-publicly-listed-%20company-specializing-in-power-generation-global-energy-trading-and-exploration-and-production.html/

[3] http://energypost.eu/exclusive-rwe-sheds-old-business-model-embraces-energy-transition/

[4] https://www.iberdrola.es/clientes/hogar/eficiencia/energia-solar/smart-solar-iberdrola

organization creates, delivers and captures value, and guides the realization of a firm's strategy (Osterwalder and Pigneur, 2010). The analysis of business models for electricity supply is a central aspect of the transition towards a more sustainable and decentralised energy sector because they encapsulate how suppliers, customers, and operators interact with each other. This section explains why the integration of Distributed Generation (DG) and Demand Resources (DR) is considered a good solution in the transition and provides a description of the main characteristics of Integrated Energy Services.

2.1) The integration of DG and DR: combined heat and power plants and industrial customers

The possibility to integrate locally available DG with DR is still unexploited in most electricity markets (Lorenzoni, 2015). However, the high penetration of DG is jeopardizing the operation of the electricity system (Trebolle, 2013): the intermittency from variable resources such as wind and photovoltaic power plants is already creating today local issues of power quality and problems such as voltage variations and bottlenecks, when local injections are higher than local extractions.

Both the supply and the demand side are relevant to meet growing flexibility and predictability requirements (Directive 2012/27/EU; Eurelectric, 2013; IEA, 2014). Flexibility services are related to the ability to adapt to and anticipate uncertain and changing power system conditions in a swift, secure and cost-efficient manner while maintaining system stability (Van den Oosterkamp et al., 2014; ECOFYS, 2014). DR is defined as the "changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentivize payments designed to induce lower electricity use or when system reliability is jeopardized" (U.S. Department of Energy, 2006); it allows the Transmission System Operator (TSO) and the Distribution System Operator (DSO) to have an additional instrument to manage short-term problems in their grids, to improve sustainability of the system, to mitigate price volatility, and to reduce the need for future investments (Strbac, 2008; Torriti et al., 2010; Grünewald and Torriti, 2013). DR can be part of an ancillary service market or be provided through bilateral contracts with system operators (Behrangad, 2015). Electricity retailers can create added value by clipping load or shifting from peak to off-peak periods (Fuerriegel and Neumann, 2014); electricity customers can obtain financial benefits by reducing their bills (Koliou et al., 2013). These opportunities have not been fully exploited yet, because regulated retail prices are still in place and consumers lack real-time price information: existing flexibility services have been developed in a context characterized by higher management costs and by an emphasis on generation-side resources (Warren, 2014).

Currently, DR programs mainly focus on the industrial sector, as most European utilities include direct load control and interruptible programs, with fixed compensations (Torriti et al., 2010). The industrial business cases are positive because a significant amount of load can be accessed through one connection point. Energy-intensive industries (meaning business entities where the purchases of energy products and electricity amount to at least 3% of the production value, such as the iron and steel industry and paper and chemical manufacturing per Directive 2003/96/EC) are likely to invest in energy efficiency or in new generation facilities providing efficient local supply due to the high opportunity costs associated with shifting or shedding loads (Paulus and Borggrefe, 2011; Radulovic et al., 2012; Bernstein and Madlener, 2015). In addition, larger companies usually have more capacity to implement energy management strategies than small enterprises (IEA, 2012) and some industrial sectors may offer significant flexibility paths that can facilitate the integration of distributed energy resources (DER) (IndustRE, 2015).

Even though it is difficult to generalize on the costs and on the drivers of energy investments for industries (UN, 2009), the main benefits and barriers (Figure 2) of these measures are well acknowledged in the literature (de Groot et al., 2001; IEA, 2009; Mc Kane et al., 2009; IEA, 2012; IEA, 2014). It has been shown that energy initiatives contribute to business competitiveness and raise productivity, but they are not considered as a strategic investment in future profitability; managers also give much consideration to uncertainty about the energy policies and overall economic trends. A higher cost-share of electricity may encourage decisions regarding energy innovation; however, as electricity can be an important production factor, industrial managers are also concerned about the compatibility of load-shift programs with core business operations and possible reliability problems (Olsthoorn et al., 2015). In fact, energy-behavior habits exhibit considerable inertia and energy-related decisions are only in part influenced by economic factors (Sorrell, 2015).

Drivers	**Barriers**
• Significant amount of load easily accessed • Companies are able to undertake energy management • Consumption patterns can respond to market signals	• Energy investments are not core business • Risk of lower quality of supply • Compatibility of demand programs with production process

Figure 2 Drivers and barriers for industrial entities to integrate DG and Demand Resources

In conclusion, industrial customers have a high potential to provide flexibility to the grid and to integrate generation resources and demand management. It is therefore very important to find ways to encourage them to undertake new energy investments and to become involved in innovative energy-related retail activities.

2.2) The main characteristics of Integrated Energy Services

A novel business model for energy supply that combines many of the characteristics described thus far is represented by Integrated Energy Services, proposed by Enel Energia in Italy. The model integrates generation from low-carbon resources and demand management for industrial entities, with potential benefits for these companies as well as for energy suppliers and system operators.

In this scheme, Enel Energia installs a power plant at its own expense directly on the premises of the industrial customer: the company captures revenues by owning the equipment and selling electricity and heat. The customer signs a take-or-pay contract on a quantity of electric and thermal energy to be supplied (in general, 60-70% of the total consumption forecasts), with residual demand paid through a pre-determined tariff, negotiated on a yearly basis; these general conditions can vary according to the industry's needs. At the end of the contract (usually after 8-12 years), the customer is given the opportunity to purchase the plant. To date, Enel's offer has included generation facilities from a minimum capacity installed of 500 kWe up to 5 MWe, typically in the form of combined heat and power plants (CHP) or combined cooling heat and power plants (CCHP), both of which are eligible for the Italian White Certificates energy efficiency promotion scheme (Ministero dello Sviluppo Economico, 2012; GSE, 2014).

In IES framework (Figure 3), electricity suppliers can profit from design, financing, construction, and operation and maintenance of the plant, providing heat and power to the host site while putting their traditional core competencies to good use (Schoettl and Lehmann- Ortega, 2011). For their part, industrial customers are enabled to concentrate on their core activities without facing the risk associated with trading in the energy market or operating a power plant. At the same time, they improve the power quality and reliability of their energy supply while cutting costs. In fact, under the model, the energy price is indexed and discounted with respect to the market benchmark and the industrial customer also benefits from a full risk guarantee for the CHP plant and the grid supply in case of a plant malfunction. From the viewpoint of the system operator, this business model increases the local dispatchable generation and improves security and safety of the electricity system: CHP plants can provide multiple operating modes (IEA, 2014) and boost system capacity to adequately respond to growing quantities of non-programmable plants.

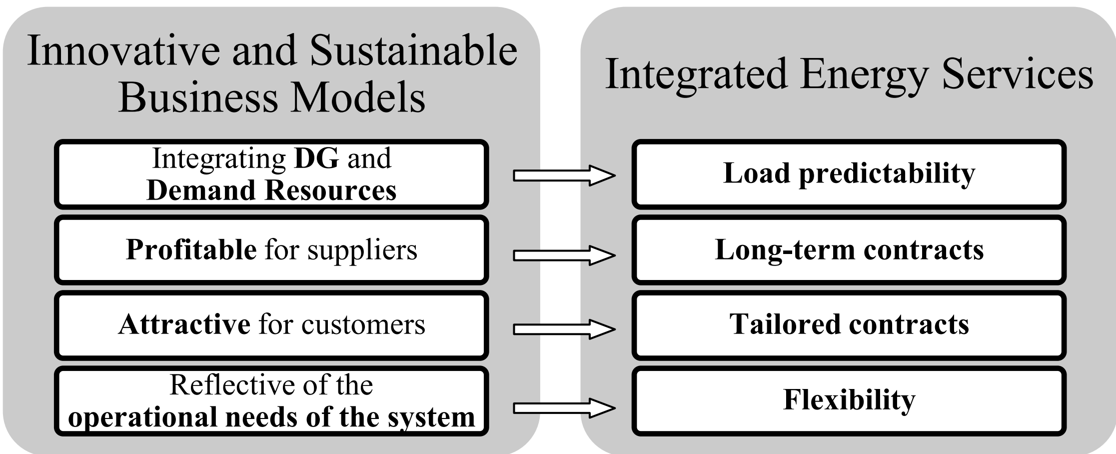

Figure 3 The main characteristics of Innovative and Sustainable Business Models and Integrated Energy Services

In the context of the transition to a sustainable energy system, IES may represent a viable mean for integrating low-carbon technologies within existing market arrangements. As a matter of fact, this scheme is more economical (cutting costs for consumers and increasing long-term revenues for suppliers) and more sustainable (employing local and efficient generation units) than the conventional model; so far IES have included only CHP, but other solutions can be implemented (e.g. photovoltaics). However, a modification of the traditional strategies of suppliers and customers as well as the criteria for grid operation are at the basis of a larger development of this business model. The following section discusses possible regulatory instruments for enhancing the adoption of this scheme.

3) The development of Integrated Energy Services: regulatory instruments for generation, distribution and retail

Several scholars (Trebolle et al., 2010; Schleicher-Tappeser, 2012; Bradford and Hoskins, 2013; Koliou et al., 2013; OFGEM, 2015) have recognized that regulatory practices established in the past should be revisited in the new context as the current rules can represent a major barrier to competitive innovation. In general, the regulatory policy framework should evolve from its focus on building and remunerating infrastructure and capacity to a teleological approach that promotes technological innovation, system optimization utility, and expanded participation of grid users (Meeus et al., 2010). Regulators should shift from traditional input-based cost-of-service regulation, where prices are set at a level that allows regulated firms to recover their costs plus a fair rate of return on investments, to incentive-based regulation, where the regulator caps allowed revenues or prices ex ante for a given period and promotes efficiency by remunerating services instead of reimbursing costs (Cossent et al., 2011; Polo et al., 2014). This section suggests innovative regulatory tools (Figure 4) for generation, distribution, and retail activities to advance the development of IES.

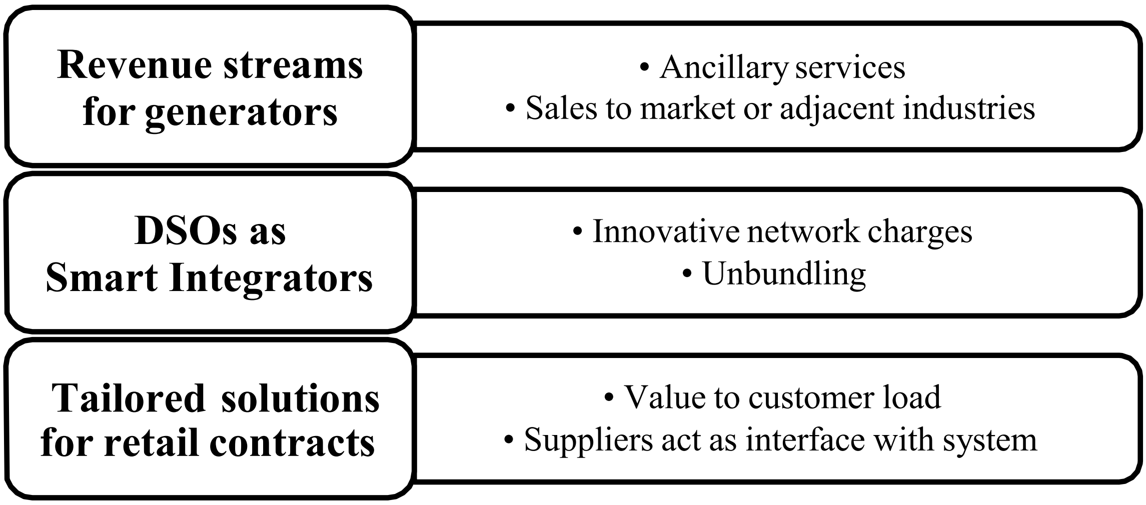

Figure 4 Main characteristics of innovative regulatory instruments for IES

3.1) Alternative revenue streams for generators

With the establishment of IES, generation will be located close to demand and able to provide a set of ancillary services to the network. These services can guarantee the reliability of the system in terms of short-term security (continuity of supply), quality of supply (maintaining voltage and frequency within acceptable levels), and integrity and stability of transmission and distribution systems in case of an unplanned event (balancing and congestion management) (IEA, 2003; Batlle, 2013; REservices, 2014; Van den Oosterkamp et al., 2014).

DER operators usually manage small units (in general, up to 50 MWp); minimum size requirements have hampered their participation in the procurement of grid services. To date, only CHP facilities have been required to deliver flexibility (CIGRE, 2013): due to their fast start-up time and reasonable start-up costs, CHP units are in fact able to modify generation profiles in reaction to an external signal, managing variability from the supply-side (Eurelectric, 2014). In addition, storage units are eligible to supply regulation services to the grid; there is great interest in the possibility of installing them at the users' premises or in the distribution network, but prevailing regulatory policies preclude this opportunity (Grünewald et al., 2012).

Another solution for small users and CHP generators is represented by an intermediary or network representative. Aggregators can offer services to combine energy production and energy consumption from different sources and interact with the grid as one entity, shifting loads to lower price periods or injecting power in times of shortage (Behrangad, 2015; Smart Grid Task Force, 2015). To enable aggregation, it is necessary to empower generators and consumers and to ensure fair payment for services provided (SEDC, 2014) with the implementation of dynamic pricing models and a policy environment that enables direct contractual arrangements (Henriot and Glachant, 2013; CEER, 2014; Dupont et al., 2014). In the IES framework, each industrial customer must evaluate whether it is more convenient to aggregate or to provide electricity services separately according to the characteristics of its generation and load.

In general, the commercial provision of grid support services and the sales of electricity and heat to the market or to adjacent industries (in the case of particularly profitable prices or in the case of excess production) can be used as an alternative revenue stream for generators and increase investor interest in the power sector (REservices, 2014; ACER/CEER, 2014). With the provision of long-term bilateral contracts that put both generation and demand to good use, IES can provide this opportunity.

3.2) A new role for Distribution System Operators

The objective of a DSO is to "ensure the long-term ability of the system to meet reasonable demands for the distribution of electricity […] and to operate under economic conditions a secure, reliable and efficient electricity distribution system" (Directive 2009/72/EC); however, the fast growth of renewable energy sources is substantially impacting grid operation, in terms of voltage quality, increased volatility of net demand, peak demand fluctuations, and reverse flows. Embedding DERs on customer premises may also have an adverse effect on the distributor's revenues in the short and medium term (Eid et al., 2014).

Within this context, DSOs should shift from the conventional design and development of distribution networks to the role of smart integrator (Goldman et al., 2013). DSOs can be provided with instruments to increase network capacity to accommodate DER, to manage real-time flexibility, and to develop innovative infrastructures to accomplish greater end-user participation; in other words, the focus of regulation should not be simply on investments, but rather on *innovative* investments (Benedettini and Pontoni, 2012). Regulated distribution charges (connection and system charges) should ensure full recovery of costs incurred to provide consumers with service as well as account for their contribution to system peaks and distribution losses, to convey efficient economic signals to the wide range of agents involved (Cossent et al., 2011; Reneses and Rodríguez Ortega, 2014).

More active involvement of DSOs also implies the further need to enhance unbundling rules to prevent discriminatory practices, such as asymmetry in accessing commercial information, lack of adequate switching procedures, and excessive charges. For DSOs, legal unbundling can provide functional and operational separation from other actors in the supply chain, without creating "an obligation to separate ownership of assets of the DSO" from the vertically integrated entity (Directive 2003/54/CE). Although in many EU countries the process is still ongoing (ACER/CEER, 2014), current unbundling provisions should be fully implemented prior to allowing DSOs to procure flexibility services in the competitive market. The unbundling requirement should also be extended to DSOs with less than 100,000 customers, which so far have been exempted.

In conclusion, for active network management and effective implementation of Integrated Energy Services, the prevailing regulatory framework should be reviewed with respect to the role of DSOs as network operators and owners, and in terms of a stronger commitment to unbundling (Pérez-Arriaga et al., 2013). In order to undertake this review, remuneration schemes for regulated companies should be aligned to general policy goals.

3.3) Tailored long-term retail contracts

In general, a customer will sign a new electricity contract if the expected cost reduction more than offsets the transaction costs of searching and negotiating (Sorrell, 2007). The IES business model puts in place a strong relationship between the supplier (who offers design, procurement, installation, and maintenance for the entire life of the project) and the customer (who accepts the long-term contract for the project).

At first glance, the interests of suppliers and customers appear to converge because both can hedge their risks: the former is protected against sustained low prices, while the latter is protected from high or fluctuating prices. Nonetheless, there are many reasons from both sides for reluctance to sign these contracts. Suppliers fear that market prices may rise to levels higher than contracted ones (price risk), while business consumers are reluctant to enter into long-term contracts when general economic trends are uncertain (Finon, 2011). Electricity-intensive industries, however, may represent an exception due to the attractiveness of fixed long-term prices and improvements in service quality (metering and billing) and technical quality (reliability of supply) (Cossent et al., 2009). Electricity can be a significant share of an enterprise's operational expenditures, representing a relevant input for the production process, and making service quality and price stability extremely valuable. IES contracts may also include non-recurring options for customers to participate in congestion management in exceptional cases (e.g,. sudden net demand fluctuations).

Contractual agreements between electricity suppliers and industrial entities should recognize that each consumer load has its own characteristics (He et al., 2013). Customers should be provided with tailored services (e.g., in terms of reduction of interruptions) and with the possibility to deal with the uncertainty associated with long-term contracts; suppliers, on their part, should be remunerated for providing services to the energy system (e.g., by managing flexible demand). Tailored solutions may increase the complexity of energy pricing and bills, but the integration of DER inevitably calls for weighing principles such as cost recovery and allocative efficiency against ease of implementation (Picciariello et al., 2015).

4) Practical cases: an overview of market and regulatory framework in Italy and the illustration of two European countries (UK and Spain)

The main dimensions of the transition towards a more decentralised and sustainable energy system have already been described. While some European countries have established demand management policies, following the example of the United States (Koliou et al., 2013), the integration of DR and DG has not been fully exploited, and there exists the need to understand which market conditions and policies might allow further development of this option.

It is clear that the behavior of grid users (both suppliers and customers) is not only driven by grid charges and regulation, but also by the activities for which they produce and consume various amounts of electricity and heat (Meeus and Saguan, 2011). It is also clear that energy governance, including the "broad categories of public policy objectives, policies, regulations and the rules and incentives that guide how instruments are implemented and delivered" (Kuzemko, 2015), represents an important enabler for innovative business models in electricity supply. Governance and regulation have a substantial impact on market design and corporate practices (the extent to which suppliers can be profitable by promoting certain business models or the extent to which customers are imposed barriers to switch supplier or to generate on-site). This section analyzes which factors have promoted the development of IES in Italy and also examines the market framework and regulation in the United Kingdom and Spain.

4.1) Italy

From 2011 to 2014, the Italian electricity market has been characterized by an impressive increase of power generation from variable resources (+23 TWh) and simultaneously by a dramatic decrease of electricity demand (-43 TWh) mainly due to the economic recession (Clo' et al., 2015). This path has given rise to a huge crisis of traditional plants, whose production decreased by one third between 2010 and 2014 (AEEGSI, 2015e). Under these circumstances, the CEO of Enel Group officially announced the intention to discontinue operations at 23 thermoelectric plants, for a total capacity of 11 GW (Starace, 2014). Enel, the former vertically integrated utility, still plays a leading role in the Italian electricity market, holding 25% of electricity generation (the second operator is Edison with 8.5%); Enel Distribuzione (operationally unbundled Distribution System Operator) manages 86% of the national electricity volumes (AEEGSI, 2015d). However, Enel Energia is not the most important supplier for industrial customers connected to Medium and High Voltage grids because Edison holds the largest market share for these customers

(AEEGSI, 2015e), which were the first entities taking advantage of market liberalization.

With regard to the main features of the Italian regulatory framework, an input-based mechanism with a four-year regulatory period was introduced in 2003 in order to increase the overall quality of supply and reduce transmission and distribution losses, and to bridge the North and South: operational expenses are remunerated through a price-cap mechanism, while capital expenses are remunerated through a rate-of-return system with a predefined interest rate (Muller, 2012; Lo Schiavo et al., 2013; Cambini et al., 2014).

Recently, the Regulation Authority itself has recognized the need to pay more attention to system benefits, promoting not only efficiency and quality of service but also "favourable conditions for investments, creating value for the electricity system" (AEEGSI, 2015a). To a certain extent, the Italian regulatory system has already implemented several initiatives promoting a more decentralised power sector; in addition to the high penetration of renewable sources, 95% of low-voltage customers are equipped with advanced smart meters and charged according to time-of-use (TOU) tariffs (peak/off-peak prices) (Meeus and Saguan, 2011; Lo Schiavo et al., 2013).

With reference to policies for the development of DER in the industrial sector, interruptible and load shedding programmes are in place (Torriti et al., 2010), and highly efficient CHP plants benefit from tax reductions on gas, priority dispatching, and eligibility for White Certificates (AEEGSI, 2005; Decreto Legislativo 8 febbraio 2007, n. 20; Ministero dello Sviluppo Economico, 2011; ENEA, 2015), About 80% of the total CHP capacity installed (around 12 GW) is based on industrial applications (Chiaroni and Frattini, 2015). Italian enterprises are affected by higher electricity prices in all consumption classes compared to the rest of Eurozone countries; 39.4% of the final electricity price for industrial customers is represented by taxes other than VAT and levies (the average for EU Member States is 30%), among which there are distribution and transmission charges and so-called "oneri generali di sistema" (general electricity system charges), covering the expenses for electricity-related subsidies. For these reasons, the Italian government (Decreto Legge 24 giugno

2014, n. 91) has put in place some adjustments to obtain a 10% decrease in the energy bill for industrial entities.

A relevant regulation-driven business model mainly devoted to industries and commercial users is represented by SEU ("Sistemi Efficienti di Utenza", Efficient User Systems), in which low-carbon generation plants are managed by a single supplier and are connected through a private network to the consumption point of a single customer. The customer and the supplier can be the same entity, but the former is obliged to be the owner of the area over which the generation unit and the network are installed (AEEGSI, 2013). These plants are exempted from the payment of distribution and transmission charges for the self- produced electricity, but pay 5% of the variable components of general electricity system charges (AEEGSI, 2014).

The regulation for SEU, with regard to the one-to-one restriction and the partial payment of system charges, represents a significant barrier to its development because cost allocation is inefficient and not reflective of the real system costs. The expansion of other non-traditional business models is hampered by the bans on integrating either storage or ancillary services with DG. In spite of this traditional policy framework, it is not surprising that Enel Energia has been the first electricity supplier in Europe to propose IES.

From the company's point of view:

- the Enel brand is very strong in the Italian market and is trusted by customers, especially in the areas where Enel Group is also operating as DSO;
- Enel Energia has significant technical and financial capability to promote new business models.

From the market point of view:

- the industrial sector is challenged by high electricity prices;
- government policies support remuneration of CHP and energy-efficiency initiatives.

Nonetheless, the Italian policy framework still has a long way to go to effectively encourage flexible and innovative solutions from programmable plants and positively manage the high penetration of intermittent energy sources.

4.2) An illustration of the context in other EU countries

This subsection is devoted to the overview of the market and policy context for the promotion of innovative and sustainable business models similar to IES in two representative EU countries.

4.2.1) United Kingdom

A recent consultation paper by the UK regulator (OFGEM, 2015) recognized that the emergence of non-traditional Business Models is transforming the electricity market, and can deliver both benefits for customers (namely lower bills, lower environmental impact, and better service quality) as well as additional costs for the system (e.g., coordination costs, because a larger number of market players make processes more complex) and risks in terms of reliability. The regulator also recognizes that its recommendations are able to stimulate investments and asset innovation, encouraging not only the network operators, but also other market participants, to implement smart solutions.

The UK was a pioneer in electricity industry privatization and unbundling, with price-cap incentive regulation starting in 1990 and service quality regulation in 1995 (Crouch, 2006; Jamasb and Pollitt, 2007; Shaw et al., 2010; Muller, 2012; Gómez, 2013). Since 2009, the political and regulatory context has not only focused on efficiency and cost reduction, but also on the reduction of greenhouse gases and funding for renewable electricity, smart metering, and CHP renewable heat. This evolution has led to a new approach (the so-called RIIO model, which stands for Revenue set to deliver Incentives, Innovation and Outputs), where the amount of revenues that the network operator is allowed to recover is set upfront; the earned return of regulated entities is strongly dependent on pre-defined performance in terms of cost reduction and innovation (Lo Schiavo et al., 2013). The model includes a package based on the Low Carbon Network fund and the Innovation Funding Incentive (IFI) aimed at financing demonstration projects, to reward network companies and third parties that successfully put in place sustainable commercial arrangements (OFGEM, 2009).

The UK has implemented direct load control tariffs and interruptible contracts for energy intensive users (Torriti et al., 2010; Warren, 2014), which also qualify for an 80% reduction of the climate change levy, on condition of meeting certain energy-saving targets set out in the Climate Change Agreement (European Commission, 2014). The newly established Capacity Market (DECC, 2013; OFGEM 2014b) provides incentives for demand resources, but in the first auction for 2018/2019 only 174 MW of flexible demand were rewarded and only for one year (compared to 2.6 GW of new large generators rewarded for 15 years). Compared to Italy, there is no dominant player in generation supply; six large companies dominate the electricity and gas supply market, with more than 90% of market share in the domestic sector and 80% in the business sector (OFGEM, 2014a; Kuzemko, 2015); nominal electricity prices have increased by 12.8% between 2008 and 2012, with grid charges increasing by more than 24.5% (RSE, 2014).

Until March 2013, the electricity generated by CHP units was exempted from the Climate Change Levy (OFGEM, 2008). This scheme was replaced by the exemption of Carbon Price Support on the fuel used for heating purposes (DECC, 2015). This instrument has proved particularly profitable for small installations; in 2013, 30% of UK CHP installations had a capacity of 100 kWe (DECC, 2014). The aggregation of CHP units is allowed, and can provide frequency control services and short-term operating reserve (IndustRE, 2015). However, the opportunities to install larger CHP plants in industries and to integrate storage facilities are unexploited, and the White Certificates scheme so far has focused solely on the residential sector (Bertoldi et al., 2015). The UK Regulatory Authority is proactively promoting innovative and sustainable business models, but the policy framework can still be improved in order to effectively encourage suppliers to find alternative revenue streams and to allow customers to realize value from their load profiles.

4.2.2) Spain

The scarce interconnection capacity of the Iberian peninsula with the rest of Europe (2.000 MW[5] instead of a minimum recommended by the European Council of 10

[5] http://ree.es/es/

GW) and the remarkable penetration of variable resources (21% of electricity demand in 2013) have created the need for improving the flexibility of the Spanish system, which so far has been granted by the involvement of large industrial consumers in direct load control programs (Costa-Campi et al., 2015). In 2013 these programs took the form of auctions managed by the TSO Red Electrica de España (Ministerio de Industria, Energia y Turismo, 2013). While in the previous framework the programs could be activated only for technical reasons, in case of an emergency in the system, today the TSO has the possibility to activate them also for economic reasons, when the curtailment option is cheaper than alternatives. In January 2014, the auctions covered a total capacity of 2.2 GW, and a recent paper by AEGE (an association representing 12% of total peninsular electricity consumption and 30% of total industrial consumption) declared that a proper remuneration of Interruptible programs is the "only measure to approximate competitive electricity prices for large energy-intensive industries, to guarantee security of supply and to improve the overall efficiency of the electricity system" (Soto Martos, 2014).

The Spanish regulatory framework for distribution networks is based on a revenue-cap formula with four-year periods, taking into account also inflation and efficiency requirements, with incentives to improve continuity of supply and reduce energy losses (Ministerio de Industria, Energia y Turismo, 2008; Gómez, 2013). The market is characterized by seven DSOs serving more than 100,000 customers (Cossent and Gómez, 2013) and by three large firms covering more than 60% of the total electricity generation (Gelabert et al., 2011). The energy efficiency of the industrial sector is generally lower than in the rest of Europe, and deteriorated by 3% between 2000 and 2006 (Alcántara et al., 2010), while energy intensity is much higher than in other countries (for example in the case of non-metallic minerals (42%), basic metals (82%), and chemicals (94%); Mendiluce et al., 2010).

Still, two trends in common with the rest of Europe are rising electricity prices (+46% from 2008 to 2012), mainly affected by regulated charges and subsidies for renewables (RSE, 2014) and the incentive scheme for CHP. Cogeneration in Spain is incentivized through the Special Regime (Ministerio de Industria Energia y Turismo, 2007) and it accounts for 6 GW of capacity installed, with industrial plants covering 6% of national electricity demand and 26% of national gas demand (Rodríguez Morales, 2014). The total number of installations has seen no significant increase over the last 12 years, and this is probably due to the fact that the regulatory framework has been modified several times. In 2012, a moratorium was established on new plants (Jefatura del Estado, 2012a) and the charges on electricity and gas increased (Jefatura del Estado, 2012b), while in 2013 incentives for efficiency were significantly reduced (Jefatura del Estado, 2013a). A new remuneration scheme for CHP was established in June 2014 (Jefatura del Estado, 2013b; Ministerio de Industria, Energia y Turismo, 2014a; Ministerio de Industria, Energia y Turismo, 2014b) and was considered with favor by the majority of operators, but so far has not led to significant developments (Jiménez de Castro, 2014; González-Pino et al., 2015).

Our overview shows that while there is room for further penetration of CHP installations in industry to increase the sector's energy efficiency, uncertain and unstable policies have
so far thwarted these investments, as well as other initiatives in terms of innovation in business models for electricity supply.

4.3) Discussion

Based on the analysis of the three selected countries, it is possible to say that a forward-looking and effective regulatory policy framework is essential for the development of innovative and sustainable business models, because regulatory stability is usually ranked among the top drivers for energy investments (IEA, 2014). However, general market conditions also play a significant role, as the Italian case demonstrates.

Table 1 summarizes the main aspects of the regulatory framework in Italy, UK, and Spain in case of the installation of a 2 MWe gas turbine CHP plant on the premises of an industrial customer.

	Italy	UK	Spain
Tax reduction on gas for CHP	✓	✓	X
Incentives for energy efficiency or CHP	✓	X	✓
Business models for self-consumption	✓	✓	X
Excess electricity sales to grid/users	X	✓	X
Excess heat sales to grid/users	✓	X	X
Integration with storage	X	X	X
Aggregation of generators and loads	X	✓	X

Table 1 Regulation for the installation of a 2 MWe gas turbine CHP plant

The financial incentives for energy efficiency initiatives in industry and the legal provision for business models for self-consumption (SEU) together with the possibility (still scarcely exploited) to sell excess thermal energy to third entities, provided favourable conditions for the development of IES in Italy. With regard to the UK, the establishment of business models for self-consumption is still at a very early stage; Spain so far has not placed any significant policy measures to promote innovative models for industrial electricity supply. With a wider look across Europe (Figure 5), increasing electricity prices, flexibility services for the network, the long-time experience with interruptible and direct load control programs and incentive schemes for CHP represent promising conditions for the development of IES or other types of innovative business models integrating DG and DR for the industrial sector, implemented according to each country's characteristics.

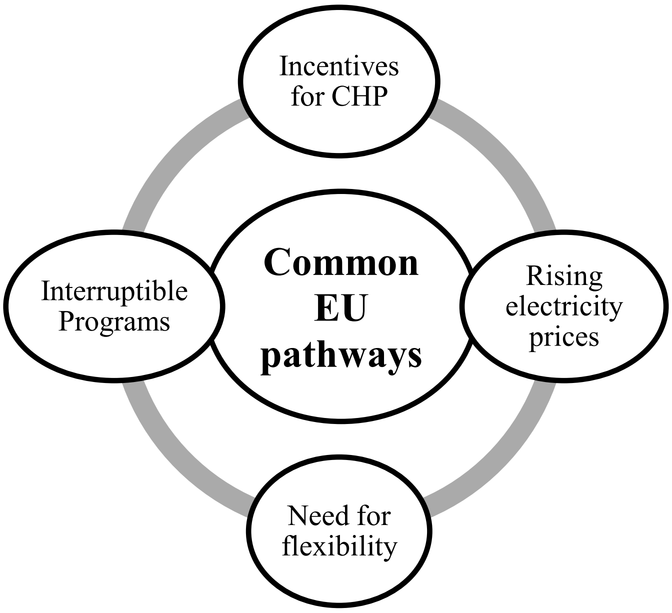

Figure 5 Common pathways across Europe for the development of Integrated Energy Services

In general, the analysis of the Italian framework and the illustration of UK and Spanish context demonstrate that there is not only the need for further policies and incentives for sustainable solutions, but also for a stable long-term governance that can effectively allow suppliers to offer customer-tailored contracts and to find alternative revenue streams, such as opportunities for aggregation, installation of storage facilities, and sales of excess electricity and heat to adjacent entities.

With reference to Italy, the most important barrier that the Italian Authority encountered in the implementation of its innovative smart grid projects has been the lack of involvement and participation of active users (prosumers); despite the fact that the distributor was bearing all the costs, some users rejected the experiment because they would not realize direct and immediate benefits and were afraid of uncertainty (AEEGSI, 2015c).

5) Conclusions

The analysis of innovative and sustainable business models for electricity supply provides the opportunity to study in depth an essential aspect of the transition to a sustainable energy system: how customers, suppliers, and system operators interact with each other.

This work focused on the integration of DG and DR, describing the main drivers that enabled the development of the Integrated Energy Services model in Italy, particularly the weight of electricity costs for industrial customers and the market share of Enel Group. We also studied the potential benefits of IES adoption for energy suppliers who can sell electricity and heat through a long-term contract to their customers, and can be remunerated for the provision of grid services. Conventional operators will implement flexible strategies, while non-traditional suppliers or other intermediaries may access the market and compete to deliver efficient and innovative services. DSOs can implement instruments to maintain network reliability and balance local supply and demand in real time, incentivizing predictable loads and generation profiles. Industrial customers benefit from low-carbon electricity and heat and economic savings, and can concentrate on their core business.

The IES model can be established at very low cost under the current paradigm, thanks to new ICT technologies. However, expanded adoption of this scheme will require changes to the regulatory framework. Conventional market rules in Italy and in Europe continue to protect the traditional business models of DSOs and suppliers, and do not adequately promote innovation and value opportunities for market operators. Effective policy and regulatory improvements towards a decentralised retail electricity market would support:

- dynamic real-time prices for the promotion of tailored retail contracts and for the possibility to sell electricity and heat to the market or to adjacent entities;
- aggregation and integration of storage facilities in distribution networks, supporting the participation of DG and DR in intraday electricity markets;
- further unbundling and better transparency, to avoid a situation where only former incumbents and large corporations can participate in new business models.

In conclusion, energy governance has not yet fully stimulated innovation and has not enabled suppliers and customers to explore new business models. So far regulation policies have proved effective in the development of liberalization policies and in the promotion of technologies such as smart meters, but less so in terms of increasing end-user participation and engaging energy suppliers in sustainability goals.

We have provided preliminary reflections on the characteristics of a regulatory framework to support innovative business models for electricity supply in a less centralised and more sustainable energy system. Further research is needed to examine the regulatory framework and markets of other European countries and the technological solutions (including different ones than CHP) that are more suitable according to different industries in which the IES model might be implemented, as well as the role of both incumbents and independent suppliers in the development of innovative energy service schemes.

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The governance for Distributed Energy Resources in the Italian electricity market: a driver for innovation?

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ABSTRACT

In spite of the significant changes that affected the electricity sector across Europe in the last decade, the governance of the system has not evolved accordingly, and the centralised regulation is still the norm. This paper focuses on the role of governance as a driver for innovation in the power sector: through the assessment of the Italian market and of selected Italian policies, it reflects on the instruments that allow the full integration of Distributed Energy Resources and the creation of distributed grid control systems across Europe.

1) Introduction

The significant cost reductions of renewable energy sources (RES), the development of low-cost control technologies and the availability of favourable market and regulatory conditions make Distributed Generation (DG) the first option for most of new electricity installations worldwide (REN21, 2016). The establishment of a sustainable power system is one of the most important efforts in order to comply with the decarbonisation commitments of the Paris Agreement (UNFCCC, 2015; IEA, 2016). Accordingly, the European Union set ambitious targets to reduce domestic greenhouse gas emissions (40%), increase RES share of energy consumption (at least 27%) and improve energy efficiency (at least 25%) by 2030 with respect to 1990 levels (European Commission, 2014): under this framework, each Member State is allowed to implement different instruments to enhance the transition (Kuzemko et al., 2016). Beyond climate policies, the energy industry across Europe is also affected by the completion of the liberalisation process and the perspective European Energy Union (European Commission, 2015), in a context of flattening electricity demand.

In spite of such evolutions, the institutions, policies and regulatory instruments which are still in force are not able to promote the development of decentralised resources: they were established at a time when generation was mainly relying on fossil fuels and supply was provided by national vertically-integrated utilities. The main policy objectives of such institutions were the promotion of universal access, the protection of consumers and the provision of fair competition among suppliers and fair remuneration to network operators for the services they provide and for their investments. A larger employment of Distributed Energy Resources (DER, including low-carbon generation facilities, storage systems, electric vehicles and a wide range of demand-response initiatives) raises concerns in terms of more complex operational characteristics and of the reliability of the system and calls for the inclusion of transparency and sustainability among the main policy goals.

The aim of this paper is twofold: it evaluates the role of governance in the promotion of innovation in the electricity sector, and then provides recommendations to support the transition towards a sustainable energy system, in terms of local production of distributed electricity, of the development of innovative strategies for network reliability (dispatch and imbalances) and of the adoption of disruptive technologies (storage and self-despatch) in a cost-effective and secure manner. While in general the paper takes into consideration similar characteristics across European energy markets, it makes reference to the governance of the Italian electricity system. Italy represents a significant case for the analysis of low-carbon transition pathways, thanks to the remarkable increase in renewable capacity installed in the last 6 years: if on one hand Italy has already met the 2020 decarbonisation goal for the electricity sector (AEEGSI, 2016h) and its governance system was able to implement some forms of innovation (like the massive installation of smart meters and the adoption of Time of Use tariffs for the majority of low-voltage customers), some policies currently in place may be detrimental for the further development of DER. The scope of the analysis is not on the traditional aspects of regulation and governance in the energy system (quality of supply and liberalisation) (Perez-Arriaga et al., 2013; Cambini et al., 2013), but rather on innovative initiatives promoting decentralisation of wholesale and retail markets.

The paper is organised as follows: Section 2 describes the main dimensions of the shift from a centralised energy system to a decentralised one, while Section 3 reflects on innovation in the energy sector and provides a definition of governance. The description of the governance of the Italian electricity system and of the main policy and regulatory instruments that promote sustainable innovation is provided in Section 4; in Section 5 the results are discussed and Section 6 includes conclusive remarks.

2) From centralised to decentralised energy system: the dimensions of the paradigm shift

The development of RES and of Information and Communication Technologies (ICT) for system integration are key dimensions for the enforcement of sustainable and decentralised electricity market. The traditional paradigm was based on centralised large-scale generation, which could provide electricity at affordable prices for any amount of demand through unidirectional transmission and distribution networks under an analogic control system; low-cost control technologies now give the possibility to aggregate or shift loads at more convenient time and to promote a more active involvement of the demand side, with a real-time control of any part of the grid. The architecture itself of electricity distribution grids is thus changing, with new functions available and new roles for participants.

2.1) Centralised energy system: the role of economies of scale

For decades, centralised energy systems were based on economies of scale along the value chain: the procurement of fossil fuels was the cheapest option to generate electricity and to feed large volumes into High-Voltage Transmission grids; the networks were built and operated to provide universal access to sustain economic growth. Conventional suppliers promoted a low-cost volume-based business model for electricity supply and competition among them was mainly made on prices, while consumers on their side assumed a reliable service for any amount of demand. The different dimensions of the system (institutions, technologies, user practices and ecosystems) established positive feedbacks which favoured this structure (Foxon, 2011; Hannon et al., 2013). In general, the arrangements for electricity markets designed a supply-oriented regulation: generation units are synchronously operated to automatically supply the actual demand of electricity from a generation-follows-demand perspective, to guarantee the balance and reliability of the system.

Since the 1990s, the European Directives (1996/92/EC; 2003/54/EC; 2009/72/EC) began to establish the conditions for liberalisation of the sector, in order to provide higher quality of electricity services at lower prices. In 2006 the Commission decided that the three main objectives of the European energy policy were competitiveness, security of supply and sustainability, and provided the conditions to changes in the operational conditions of national markets.

2.2) Decentralised Energy Resources: from passive end-users to active market players

After the enforcement of European policies, the electricity systems have been evolving and becoming more complex: consumers are gradually becoming more aware of energy costs, and have the opportunity to generate sustainable electricity on-site from small low-carbon plants (Perez-Arriaga et al., 2013), introducing bidirectionality of energy flows in the distribution network. The active participation of demand-side and the integration of DG will require changes in the way grids are operated (Koliou et al., 2014), also because the electrification of transport and heat is needed to comply with decarbonisation scenarios (Foxon, 2013; Virdis et al., 2015). Significant investments in distribution networks will be needed to accommodate a further increase of DG, in a context in which conventional utilities are affected by lower and more volatile returns because nearly-zero marginal cost intermittent supply from RES displace traditional power plants in wholesale markets: the large integration of DER will cause reliability

and stability problems in the grid, like congestion and voltage issues (Eid et al., 2016).
In conclusion, there are many technical, economic and regulatory barriers which hamper the development of DER, and limit the reach of a stage where DG is embedded in innovative distribution networks (Colmenar-Santos et al., 2016). A proper governance is needed, which shifts the focus from economic regulation and customer protection to a greater number of dimensions including transparency, flexibility, sustainability, promotion of non-traditional business models and encouragement of non-traditional suppliers, towards a more active role of network operators and users.

3) Governance as a driver for innovation

Apart from the technological advancements described above, non-technological innovation plays a significant role in driving forward sustainable transitions, because technologies evolve within particular socio-economic contexts (Grübler, 1998; Steward, 2012). Institutions are defined as the "humanly devised constraints that shape human interactions" (North, 1990) and they typically change incrementally, because even if rules can change overnight after political or judicial decisions, informal constraints in user practices and business strategies take longer time before changing. To cope with the challenges of climate change, the State should not act as a top-down agency, but rather as an "enabling entity" to provide the conditions to reach solutions to collective problems (Giddens, 2011).

In the European framework, energy governance is the result of the interactions between the supra-national, national and regional level; it is still not entirely clear how the Energy Union will establish an integrated and coordinated internal energy market and boost energy security (Froggatt and Hadfield, 2015; Keay and Buchan, 2016). The main problem is how to reconcile the completion of the liberalisation process with a more active involvement of governments in the promotion of decarbonisation policies; such policies are costly, and the costs are charged on electricity consumption, discouraging the electrification of heat and transport. Moreover, effective policies to promote the transition have not been put in place yet to the extent expected (e.g. carbon price), not only on a national basis but also on the European level (Carraro et al., 2013).

Therefore, from the EU side, the concept of energy governance must be better defined. This section explores the source of innovation in the energy market, and evaluates the role of governance in promoting the modernization of the energy sector.

3.1) The difficult pathways for innovation in the power sector

Significant barriers to innovation are present in the energy industry, which is usually characterised by a large market share of the incumbents, long technical life of devices and plants, and by well-established practices from the side of suppliers and customers. However, the sector is challenged in many of its activities and segments, to mitigate climate change, to increase efficiency and to guarantee energy security: fostering innovation is crucial to meet these challenges. Nevertheless, the level of Research and Development (R&D) investment in the energy industry remains quite low (GEA, 2012). The empirical literature on innovation in the energy sector has focused on the impacts of liberalisation process on R&D projects and on the effects of the size of the firms (small size is a barrier to entry, but sometimes smaller and younger companies make a greater effort in R&D with respect to incumbents) (Costa-Campi et al., 2014). In general, innovation is driven by technological development (technology push) or demand factors (market pull) (Rennings, 2000): technical maturity and cost competitiveness are important for the success of the different technology options, but non-technical issues and barriers could slow down their worldwide diffusion, and in order to further enhance the diffusion of DER policy instruments should include R&D and carbon pricing policies (Bosetti et al., 2011). According to a recent study, the most fundamental challenge in the transformation of the energy sector "is not technical, but rather one of governance, and specifically inertia within governance" (Mitchell et al., 2016): the next subsection describes the different dimensions of the governance of energy industry.

3.2) Governance in the energy sector

In a context characterized by significant technological advancements, the legal framework and the institutions still play an important role to build the capacity to take advantage of innovation. This section provides a comprehensive definition of governance, and elaborates on the peculiarities of policies and regulation in the energy sector. Within the EU legislation, energy policy is responsibility of each State's national government, which normally defines the structure of the electricity system and the rights and duties of different players, and decides which technologies are subsidised. The regulator, on the other hand, is the entity responsible for the remuneration of operators and for creating a framework that enables the integration of new technologies in the electricity network, while apportioning any extra costs in a fair way among the stakeholders who benefit from the solutions.

3.2.1) Innovative regulation and flattening demand

Regulation can be defined as "measures and forms of intervention introduced by the state or other actors (industry bodies) which are intended to guide or control the behaviour of firms or individuals" (Decker, 2015). It impacts on the decisions of firms on "pricing, investment, quality and coverage of service, as well as the terms on which access is provided to other firms, including competitors". Recently, the scope of regulators expanded, and it is not only limited to the traditional tasks of protecting consumers through price regulation, quality of supply and ownership unbundling, but includes initiatives to promote sustainability. While the main goal of establishing fair tariffs was to ensure economic efficiency, sending price signals to users of the network with respect to the costs they impose on network operation and development (Mutale and Strbac, 2007), national regulators gradually shift their focus to remunerate the large investments needed to upgrade networks in the development towards Smart Grids (Cambini et al., 2016).

Broadly speaking, regulators are required to turn their attention from traditional input-based cost-of-service regulation, where prices are set close to realized costs and an allowed rate of return is determined, to incentive-based regulation, where the regulator delegates certain pricing decisions to the firm and the firm can increase profits from cost reduction (Cossent et al., 2011; Polo et al., 2014). In between the cost-based and incentive-based models are different combinations of the two types of regulation, or so-called hybrid models, where capital expenses follow a cost-based approach and operating expenses follow an incentive-based approach. The Italian regulatory framework, which is presented below, is an example of hybrid model.

With reference to the promotion of innovation, recently National Regulation Authorities (NRAs) across Europe developed dedicated incentive mechanisms, including the provision of higher rates of return, to enhance initiatives that DSOs are unlikely to undertake in the absence of incentives. In particular, the focus of innovative regulation is not only to limit the emissions of the energy sector, but rather to deal with the flattening demand (Decker, 2016): if storage facilities are widely adopted, and a growing portion of consumers generate much of their electricity needs on-site, this may lead to a situation where network operators will no longer be able to cover their costs. This aspect is significant in the analysis of the Italian regulatory framework.

3.2.2) Policies for the promotion of DG

Following the implementation of climate polices, the environmental component of sustainability is likely to improve (Campagnolo et al., 2016). In the European context, policies for the reduction of greenhouse gas emissions have concentrated on the promotion of RES even at the expense of significant costs (in 2013, 452 TWh of electricity generated from RES were subsidized in Europe and the total subsidies amounted to 50.6 billion euro) (De Paoli, 2015). Several different policy designs have been implemented in order to support sustainable production technologies; they usually include targets (in terms of capacity installed or quota in total electricity consumption) to remove entry barriers or allocate a budget (public or financed by consumers) to reduce risks for investors (Nicolli and Vona, 2016).

In general, across EU, the policies to support DG were based on the following schemes (Duscha et al., 2016):

- Feed-in-systems: remunerate electricity production as a fixed total payment (feed-in-tariff) or as a guaranteed premium (feed-in-premium) on top of the electricity market price. Traditional schemes are technology-specific mechanisms often in combination with priority dispatch.
- Quotas with tradable green certificate schemes: certificates on renewable electricity can be sold in the market in addition to the revenues from the sales to the grid. The demand for certificates is granted from the obligation in charge of electricity distribution companies or other obligated entities; the price of certificates covers the gap between the marginal cost of renewable electricity and the price of grid electricity.
- Competitive bidding procedures: auctions or tenders are used to allocate financial support. The government invites renewable generators to compete for a financial budget or a certain amount of capacity.
- Net metering: a regulated commercial arrangement in which consumers with their on-site generation system pay the net electricity sold by the utility (total consumption minus on-site self-generation).
- Fiscal incentives: exemptions or rebates on (energy, corporate or income) taxes, tax refunds, lower VAT rates.

3.3) Governance as a driver for innovation in the electricity system

The previous subsections have described the separate items of innovation and governance in the energy sector. In order to understand how governance can be a proper driver for innovation, this paper relies on the conceptual framework proposed by (Kuzemko et al., 2016) and evaluates the Italian electricity market. The literature has focused on policies and drivers for the development of RES (Cadoret and Padovano, 2016), but as yet are missing studies which propose a comprehensive approach on the creation of an enabling innovation environment including market rules, in order to "embed the new technologies fully into the more and more sustainable regime" (Kitzing and Mitchell, 2014). The energy challenges presented above, which are summarized in the "energy trilemma" concept (including the dimensions of security, equity and sustainability) (World Energy Council, 2016) require a crucial infrastructure component and call for a corresponding adequate polycentric governance (Goldthau, 2014). In presence of disruptive technological innovations governance often lacks the capacity to give proper incentives and the adoption of favourable technologies can be delayed. This case could be very negative for European companies, that have the opportunity to gain a competitive advantage in the deployment of low-carbon and ICT technologies for energy management, whose market is expected to develop worldwide.

In order to establish a proper framework for the analysis, it is important to consider the interactions between governance and practice (Kuzemko et al., 2016). National energy systems are the result of the interactions among the domestic and international political institutions and the energy resources. With the aim to study the links between governance and practices, this framework is not limited to the analysis of policies for the promotion of RES, but includes regulatory instruments for decentralisation; the authors refer to governance as the "broad categories of public policy objectives, policies, regulations and the rules and incentives that guide how instruments are implemented and delivered" (Kuzemko, 2015).

It is not yet clear what will be the outcomes of decarbonisation, and how innovation will be considered in the regulatory framework. It is possible to expect that incumbents will resist to changes: so far weaker forms of unbundling and liberalization can be explained by the influence and market power of traditional utilities in the reference country (Van Koten and Ortmann, 2008); overarching market structures and inadequate institutions and infrastructure for change have hampered the diffusion of clean power technologies (Smith et al., 2005). However, the advantage of DER is now unquestionable, in terms of lower costs and of the reduced environmental and climate impact: it will be the role of governance to build the conditions to promote system innovation.

4) The Italian governance for electricity markets: an analysis of institutions, regulation and policies

This section aims to shed light on the most important characteristics of the Italian electricity system, and describes the policies and regulation for the development of a decentralised market.

4.1) From nationalisation to liberalization: a short description of institutions and market players

In 1962, at a time when the Italian per-capita electricity consumption was still lower than most other European countries, the center-left government nationalised the industry and established the single vertically-integrated utility Enel, with the explicit goal to give access to all consumers under the same conditions and to sustain economic growth (Ranci, 2014). Thirty-three years later, the creation of the NRA to promote competition, efficiency and transparency and to maintain high quality of supply was the pre-condition for the liberalisation of the market. The NRA task is to set fair rules for a competitive market, defining a transparent tariff system in order to balance the economic viability of operators with social, environmental and system efficiency goals (Decreto Legislativo 491/1995).

According to the European Directive 1996/92/CE, the first step towards liberalisation was to give free access to the grid to generators and "eligible consumers", which were identified according to decreasing annual consumption thresholds (from 100 GWh down to 0.1 GWh from 1999 to 2007) (Decreto Legislativo 79/1999); the other consumers must be supplied in the regulated captive market, in which price and quality conditions were defined by NRA. This hybrid solution was clearly unstable and since July 2007 all customers have access to the free market; the captive market, where a Single Buyer ensures electricity supply, is still available for consumers that do not want to have access to free trading.

Another public owned body, Gestore dei Mercati Energetici (GME), manages the wholesale market according to neutrality, transparency and competition criteria among

producers and Terna is the Transmission System Operator. With respect to Distribution Networks, in 2015 Enel Distribuzione managed 85% of total volumes (AEEGSI, 2016e) in a market where 137 DSOs are working. Enel still plays a leading role also in supply, being by far the largest entity (85,4 TWh): a recent deliberation from NRA is stricter in terms of the obligation of functional unbundling (AEEGSI, 2015c). As a matter of fact, 17 years after liberalization, the majority of households (68%) are still supplied in the captive market and purchase electricity according to the regulated price. Even if households accessing the free market are increasing (AEEGSI, 2016e) prices on the free market are often higher than regulated ones, also because these offers include electricity-related services. With reference to Eurostat data (available in ENEA, 2016), the average prices of electricity paid by Italian households are lower than most EU countries; conversely, prices for industrial consumers (particularly the low consumption cluster, between 500 and 20.000 MWh per year) are higher than the rest of Europe (around 0.15 €/kWh compared to 0.10 €/kWh). With the aim to promote the shift to the free market and to empty the role of Single Buyer, a reform (AEEGSI, 2015b) envisions that in 2017 customers in regulated market will be given the possibility to undersign a contract for 12 months ("tutela simile") with one of the pre-defined suppliers and according to standard contractual conditions pre-approved by the NRA; at the end of the contract, the customer will access the liberalised market (AEEGSI, 2015d; AEEGSI, 2016b).
In general, the Italian electricity industry deals with scarce natural resources and fossil fuels available in the national territory, and is largely dependent on foreign imports (Unione Petrolifera, 2016): the dependence from foreign sources is 75%, with oil and gas still accounting for around 60% of the energy mix. Nuclear energy is banned after two referenda which blocked the development of this technology, in 1987 and in 2011.

4.2) The impacts of decarbonisation policies

In 2015, the Italian Gross Domestic Product slightly increased (+0,8%) and the electricity demand followed the same dynamics (provisional result accounts for

+1,5%), mostly thanks to an exceptionally hot month of July (AEEGSI, 2016e). In spite of this signal, the electricity demand confirmed a long-term decreasing tendency (from 319 TWh in 2007 down to 291 in 2014 and -2% in the first semester 2016), due to the improved efficiency of the system and to the lost demand from energy-intensive sectors. The electrification of heat and transport sectors, envisioned according to decarbonisation scenarios, is not yet appreciable, as electricity consumption accounts around 20% in total final energy consumption. This shrinking demand pattern does not facilitate the transition to a sustainable system, with the sector heavily involved in managing overcapacity, in dealing with the compliance with take-or-pay contracts for fossil fuel supply and in the ancillary services market reform. Another significant problem is represented by overcapacity, because the generous incentive schemes for RES have determined since 2008 a significant increase in the share of such units (40,3% of total capacity installed) (GSE, 2016).

SOURCE	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***
Hydro	*17.623*	*17.721*	*17.876*	*17.950*	*18.232*	*18.366*	*18.418*	*18.543*
Wind	*3.538*	*4.898*	*5.814*	*6.860*	*8.119*	*8.561*	*8.703*	*9.162*
Solar	*432*	*1.144*	*3.470*	*12.750*	*16.420*	*18.053*	*18.609*	*18.892*
Geothermal	*711*	*713*	*772*	*772*	*772*	*773*	*821*	*821*
Bioenergy	*1.555*	*2.019*	*2.352*	*3.020*	*3.802*	*4.033*	*4.044*	*4.056*
TOTAL	***23.859***	***26.519***	***30.284***	***41.352***	***47.345***	***49.786***	***50.595***	***51.475***

Table 1 *Gross installed capacity (MW) by renewable energy sources in Italy.*

Source: GSE, 2016

Since 1991 the Italian law declared that RES projects were of "public interest" and "public utility", and the related works "urgent" and "not deferrable" (Legge 9/1991). After the Directive 2001/77/EC, Italy promoted a policy (Decreto Legislativo 387/2003) which simplified the permitting process for these facilities. Gestore dei Servizi Energetici (GSE) is the legal entity in charge of managing the incentives for

RES and purchases electricity from these generators. The main support schemes adopted by GSE are the following (GSE, 2016):

- Tariffa Onnicomprensiva (feed-in-tariff): for renewable generators (excluding PV) entered into operation before 31 December 2012 with a capacity installed up to 1 MW (200 kW for wind); it envisions a fixed amount for each kWh produced, differentiated according to the source, for 15 years;
- Green Certificates (GC): for net electricity produced by RES facilities entered into operation before 31 December 2012; from 1 January 2016 GC are replaced by feed-in-premium incentives until the end of the right to obtain GC (20 years). GC are titles, released by GSE, which certify the production of sustainable electricity, to allow conventional operators to comply with the mandatory goal to generate or import a minimum quantity of renewable electricity;
- Conto Energia, incentive scheme for PV, which comprises:
  - a feed-in-premium scheme for PV projects entered into operation before 26 August 2012;
  - a scheme for PV plant entered into operation from 27 August 2012 to 6 July 2013: feed-in-tariff for projects with a capacity installed lower than 1 MWp and feed-in-premium for larger units, with a prize for net electricity self-consumed.

The diversity of instruments and dates highlights the fact that the Italian regulatory framework has not provided a stable environment for the promotion of DER. The story of the support to PV is particularly interesting in these terms, with frequent and sometimes random changes of rules. In 2005 the PV support started and the incentive was modified in 2007 (D.M. 19 Febbraio 2007), in 2010 (D.M. 6 Agosto 2010; Legge 129/2010), in 2011 (D.M. 5 Maggio 2011), and finally in 2012 (D.M. 5 Luglio 2012). In these years, the cost of installations decreased faster than the premiums and in 2011 nearly 10 GW were installed. With the 2012 Decree the Government decided to end the support for PV shortly, as soon as the overall cost of the programme achieved 6.7 billion €/year.

Other very important support schemes in the perspective of the development of a decentralised system are “Scambio Sul Posto” and “Ritiro Dedicato” (Nextville, 2013). “Scambio sul Posto” (net metering) (AEEGSI, 2008; AEEGSI, 2012) is a commercial agreement with GSE (adopted by 524.600 plants, for a total capacity of 4,5 GW) (AEEGSI, 2016h) valid for low-carbon units up to 200 kW, in which the electricity generated by an on-site installation and injected in the grid can be used to offset the electricity withdrawn from the grid. Since 2009 it is based on market values: the user pays the whole amount for its consumption and receives in turn a fair contribution at market prices for its electricity production; until 2012 this scheme was compatible with other incentives, but now it is not anymore. “Ritiro Dedicato” (Simplified Purchase and Resale Agreement) (AEEGSI, 2007) is a simplified formula for low-carbon facilities under 1 MW of capacity. Producers sell to GSE the electricity they generate, instead of selling it through bilateral contracts or directly on the wholesale market; they are remunerated with guaranteed minimum prices, while larger units receive the average monthly price set on their zonal wholesale market. This scheme is adopted by 51.119 plants, for a total capacity of 11,6 GW (AEEGSI, 2016h).

In spite of the numerous regulatory turnarounds, the Italian governance was able to comply with its decarbonisation targets: in 2011 the goal was 69% achieved and at the end of 2015 the reduction in CO_2 emissions was 34% higher than the 2020 target (ENEA, 2016). From 2010 to 2015, 23 GW renewable facilities were installed, with nearly 16 GWp of PV: with the steady growth of the last decade, RES gained a central role in the energy sector operation. However, the decrease of incentive schemes in 2012 and 2013 impacted the sector: in 2015 only 890 MW were added, less than a quarter with respect to 2010 and 1/12 in comparison with the peak of installations in 2011 (AEEGSI, 2016h).

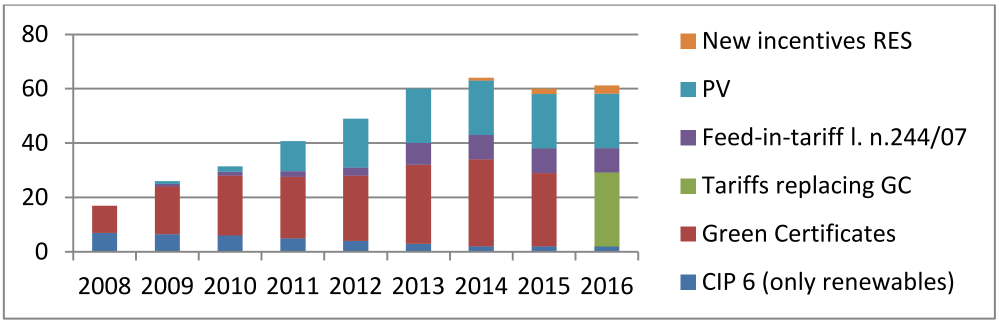

Figure 1 *Subsidized Electricity (TWh) generated from RES, according to incentive instrument. Source: AEEGSI 2016i.*

The large share of RES impacted the operation of wholesale market IPEX: the average price in 2015 was 52,31 €/MWh, the second lowest of the last decade: the financial viability of many conventional units is under threat with a negative spark spread for Combined Cycles in many months since 2012. In general, GSE operates on IPEX as a non-programmable RES collector and bids in the day-ahead market at zero, driving more expensive marginal units out of the market and favouring a decline in the clearing wholesale electricity price. Traditional thermal units are pushed out of merit-order in a growing number of hours, especially during day-time, and therefore are forced to bid at higher prices at night (when PV generation is not available) and on the Ancillary Service Market (MSD), where most of them recover the profits lost on the Day-Ahead-Market (Clò et al., 2015).

In 2004 IPEX started as a Pool (central dispatch) and also bilateral contracts were allowed. IPEX is managed by GME and it actually entails a spot electricity market (MPE), a forward electricity market (MTE) and a platform for physical delivery of financial contracts. MPE is currently divided into three specific segments: Day-Ahead Market (MGP); Intra-Day Market (MI); Ancillary Services Market (MSD, operated by Terna). MGP is a zonal market, with the particularity of a single price on the consumer side (PUN, the weighted average zonal price) and a zonal price whenever a congestion rises on the supply side. The Italian market is also involved in the Multi-Regional Coupling (MRC) with France, Austria and Slovenia: the scheme coordinates the allocation of capacity and electricity sales, integrating markets thanks to an optimal exploitation of interconnection capacity.

In this context, the introduction of a proper capacity market would be aimed to maintain the adequacy of generating capacity, to meet expected consumption and reserve margins (AEEGSI, 2015a). The approved scheme (Decreto Legislativo 102/2014) will replace in 2017 the transitory mechanism in force since 2004, which was structured as capacity payment. The new mechanism establishes a capacity market where producers will receive a remuneration for the generation capacity they make available. The risk is the subsidization of unnecessary capacity, while a different framework for the provision of grid services could better fit the requirements of the new system in terms of cost recovery: every unit, including the low-carbon ones connected to medium and low voltage networks, should participate to the regulation of network services, thanks to the low-cost control technologies now available.

4.3) The regulation towards a decentralised electricity market

In Italy, electricity generation is a liberalised activity and Grid Operators are obliged to connect all renewable generators at a cost which is proportional to the distance from the connection point. However, the owner of a renewable energy plant does not have alternative solutions to self-consumption or sales to the grid: the direct sale of electricity to other consumers, as well as load aggregation, are forbidden, with the exception of the one-to-one supply under well-defined schemes (described below). In general, the conundrum of the Italian regulator is related to the payment of system costs when a growing number of consumers are becoming self-producers, reducing the withdrawal from the grid, but taking full advantage of grid services. However, the compulsory payment of all grid and system charges is a heavy burden for innovative solutions with self-regulated exchange with the grid and makes the present regulation outdated compared to the technical solutions currently available to integrate DER.

The current remuneration system for transmission and distribution services is based on law 290/2003, that introduced a price-cap mechanism on operating costs (to encourage cost reductions in managing infrastructure) and a rate of return mechanism on capital costs (to stimulate investments for network adequacy). This regulation was able to promote investments in Transmission and Distribution networks (from 1995 to 2012, 7 billion € in Transmission and 18 billion € in Distribution) (Polo et al., 2014). In a recent consultation (AEEGSI, 2015m) the NRA proposed the introduction of an approach based on total costs (*totex*) for the remuneration of services and suggested the aggregation of smaller DSOs. In general, the NRA itself recognized the need to increase attention to system benefits related to the development of infrastructures (benefits in terms of social welfare, of quality and security of service, of integration of RES), as well as to establish mechanisms to coordinate the strategies of generation facilities and to take advantage from the flexible demand (AEEGSI, 2015f; AEEGSI, 2015h).

The following subsections describe the most important aspects of the Italian governance which can affect sustainable innovation and provide a shift towards decentralisation.

4.3.1) Households' electricity tariff reform: displacing efficient consumers and on-site generators

The structure of the electricity bill is made up of four components (AEEGSI, 2016f): in 2016 the energy supply component accounts for 44%, while taxes and network costs represent respectively 13% and 17% of the whole amount. The second largest component is general system charges (overheads), which are responsible for 25% of the total bill, and nearly 80% of them are devoted to incentive schemes for RES. Therefore, only 40% of the electricity bill is exposed to market and is not regulated by law. The current structure of electricity supply was decided in the 1970s to maintain low tariffs, to avoid inflation due to high fossil fuel costs and to promote efficiency offering a low-cost contract for small capacity withdrawals for households (3 kW) (Ranci, 2014). This tariff was given a progressive structure for the recovery of network costs and overheads: the price which consumers pay for electricity grow proportionately to consumption and therefore the burden of recovering fixed costs relies mainly on larger consumers.

Under the reform in place (AEEGSI, 2015i), an increasing part of the bill will be charged per unit of available capacity and not according to consumption, and the final price will be more cost-reflective. According to NRA, the new tariff structure will be beneficial in terms of energy savings, because the energy component will still represent at least 70% of the total bill, and it will promote the replacement of other vectors with electricity (electric vehicles and heat pumps) and avoid cross-subsidies. However, in spite of the savings for larger consumers (164 €/year for families consuming 4.000 kWh/year) this reform seems detrimental for efficient consumption and on-site generation, as well as for the promotion of technological innovation, in a context which is still far from the massive electrification of transport and thermal consumption. Because of the increase in payments per unit of capacity, the adoption of ICT in energy management could be delayed, if not fully displaced, because part of the value of savings is lost.

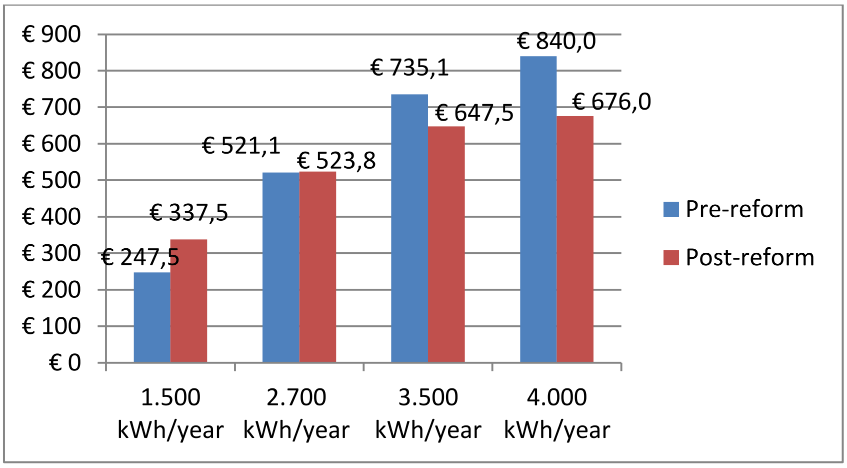

***Figure 2** Comparison of final electricity bill pre and post reform for 3-kW user.*

Source: Energy and Strategy, 2016.

4.3.2) Smart meters and Demand Response

Even if the Italian market was the first to open the Day-Ahead-Market to demand side in 2004, demand-side resources do not have access to the balancing market and are not allowed to provide ancillary services, because only generators with installed capacity above 10 MVA are eligible.

The participation of demand resources to grid management is feasible, considering that the Italian electricity market adopted smart meters on a large scale, with more than 95% of low-voltage consumers currently equipped with this technology (Meeus and Saguan, 2011). Since 2010, a Time-of-Use tariff (peak and off-peak) is mandatory for consumers in the captive market, and time-of-use prices are offered by retailers.

According to the NRA (AEEGSI, 2016e), within 2020 around 20 million first generation smart meters will have been operating for 15 years and more sophisticated internet-linked meters that can engage consumers and promote a more interactive role will be needed. From a technical point of view, they should allow measurements every 15 minutes, record specific indexes of voltage quality and manage specific contractual information, with forms of remote control: the supplier should be allowed to manage some parameters remotely (prices, variation of capacity, switching, forms of pre-payment), in order to implement commercial offers which are more adherent to the load profiles and to the customers' needs. An incentive-based cost recovery mechanism for DSOs for the replacement of old meters was recently approved (AEEGSI, 2016a).

4.3.3) Regulatory arrangements for local distribution and generation

In the Italian system, the distribution and transmission activities are appointed through concession, but, under certain conditions, there is the possibility for the establishment of private networks. According to the NRA classification (AEEGSI, 2015e):

- Simplified Systems for Generation and Consumption (Sistemi Semplici di Produzione e Consumo, SSP): systems where the transport of electricity to consumption units is not a proper transmission/distribution activity, rather it is more appropriately self-consumption. They are simple configurations with one connection point and one supplier, that manages generation plants. They include the net metering scheme described above, and also Efficient User Systems, Sistemi Efficienti d'Utenza

(SEU). In this model, DG power stations are managed by a single supplier and are connected through a private network to the consumption point of only one customer. The customer and the supplier can be the same entity, but the former is obliged to be the owner of the area over which the generation unit and the network are installed (AEEGSI, 2013). SEU systems are exempted from the payment of distribution and transmission charges for the self-produced electricity, but pay 5% of the variable components of general electricity system charges (AEEGSI, 2014c). The regulation for SEU, which has already been affected by retroactive changes, has so far mainly supported PV and Combined Heat and Power (CHP) projects; however, the one-to-one restriction and the ownership of the whole area where the plant is installed represent a significant barrier for the development of the scheme. The partial payment of system charges introduces inefficiency in costs allocation, separating the electricity costs from the purchased quantity; this can be acceptable in principle, but only if these units are also allowed to participate to the ancillary services market to provide them with a further revenue stream.

- Closed Distribution Systems (Sistemi di Distribuzione Chiusi, SDC): can be divided into User Internal Networks (Reti Interne d'Utenza, RIU) and other SDC (Altri SDC, ASDC). These are systems with complex configuration, which cannot be reconciled to a simplified scheme where there is only one connection point, one supplier, one customer. This configuration lacks a proper regulatory framework for new installations, because it is related to established situations where industrial or commercial entities are already connected to generating facilities, provided they are on the territory of not more than three adjacent municipalities (three provinces in case of RES) and provided they do not supply electricity to civil customers (Legge 99/09). The managers of the network are not obliged to connect third parties, and they do not apply the distribution tariffs established by the NRA, but can apply independently defined tariffs to their consumers. Conventional distribution and transmission charges and general system costs are charged only on the electricity purchased from the public network.

The main problem with local distribution grids and supply is the allocation of general system charges, in a context where they are still significant: while transmission and distribution tariffs are defined on a cost-reflective basis (effective use of the network), the allocation of general system charges is more complex because they take into consideration energy policy goals and must be set without altering competition between generation schemes or consumers.

4.3.4) Smart Distribution systems and storage

To promote the integration of RES and new dispatching criteria of transmission and distribution grids, many European and national programs have financed investments for storage facilities and smart grid solutions; one of the largest which was put in place in Italy financed the refurbishment of 1.605 km of transmission and distribution lines in Southern regions (Ministero dello Sviluppo Economico, 2014). In these initiatives, incumbents had a major role, thanks to the possibility to include expenses in the cost-recovery mechanism: Enel Distribuzione in 2015 committed itself into several projects across Italy for a total amount of 343 M€, under different financial agreements (Mori, 2015); Terna installed 35 MW of storage units in Italian Southern Regions to increase the flexibility of the system and to absorb excess power from non-dispatchable RES in off-peak hours (Terna, 2016).

The Smart Grid pilot projects (AEEGSI, 2012) provided benefits in terms of increasing energy injections from RES, incentivising plants which could participate to voltage regulation through aggregation, optimisation of power flows with storage systems and demand response technologies. The demonstration phase envisioned that distributors could earn an extra remuneration for a period of 12 years. The most important barrier that the Italian NRA encountered in the implementation of its innovative smart grid projects has been the lack of involvement and participation of active users: in spite of the fact that the distributor was bearing all the costs, some users have rejected the experiment because they were missing direct immediate benefits and were scared by the problems that could occur during the process. From the point of view of institutions, relying on grid operators to test smart grid solutions gives guarantees to the NRA, but excludes other operators that could supply more innovative technologies to regulate DG.

A consultation document from NRA (AEEGSI, 2015l) defined the mechanisms for the selective promotion of investments towards smart distribution systems in areas with a large penetration of DG. These systems can be developed from DSOs without enabling communication with DER and without requiring challenging performances of communication devices, and include:

• observability of power flows (the DSO sends to the transmission network operator real data or forecasts of DG power injections);

• voltage regulation in MV networks.

These functions are coherent with the new paradigm: their aim is a secure management of the networks with significant penetration of DG, exploiting the potential for flexibility services from these resources. With the present tariff system, the benefits from these two functions are not captured by DSOs, which therefore do not have the incentive to develop these solutions. The incentive mechanism to be defined should be "output-based" (related to an indicator which expresses the benefit from the intervention and allows the firm to focus on efficient choices) and should be "selective", orienting investments towards the areas where they allow larger net benefits (e.g. where inverse power flows affect electricity networks for a significant period of time every year). The implementation of this mechanism would reduce the quantity of electricity purchased on ancillary services market for tertiary regulation and would increase the hosting capacity of medium voltage networks.

With reference to storage systems, they can be installed at a consumption point or at a generation point, and theoretically can be employed to provide ancillary services, voltage control, manage imbalances and shave peaks or maximise self-consumption (AEEGSI, 2014b). The NRA is evaluating the possibility to allow network operators to manage storage systems, without hampering the development of more efficient services supplied by other market operators, and to consider separately storage systems with an active role on networks and the others with simplified configurations, which are used to give more flexibility to electricity generation (AEEGSI, 2016c). Future initiatives can give value to grid users (intermediated or aggregated) to provide services, but the NRA has not yet implemented any form of remuneration for these investments (AEEGSI, 2015g).

4.3.5) The reform of dispatch services

According to the current rules for dispatch, which exposed the balancing market to extensive manipulations, the eligible resources (traditional generation facilities) are used to manage congestions, to provide secondary and tertiary reserve capacity, and to balance the system.

The NRA decided to reform the market for dispatch services in a context of evolving European strategies, which are trying to coordinate TSOs and to favour integration and harmonisation of balancing markets and reserves. The consultation document which provides the basis for reform (AEEGSI, 2016c) is based on the current discipline for dispatch, but broadens the eligibility criteria, including generation and consumption units and storage. The characteristics of the infra-day market, which is not yet close enough to real time and does not allow to optimally define the program of injections/withdrawals, represent a barrier for the development of more advanced dispatch services. The consultation document includes the possibility to introduce different levels for aggregation: congestions can be managed at nodal level, while secondary reserves can be supplied on the larger market areas, or at the geographic level which is considered more suitable by Terna. In the transition from current system to the new one, every generation and consumption unit may have access to the ancillary service market (MSD) through their proper dispatch user ("utente del dispacciamento"): this entity will be in charge of managing generation and load profiles to comply with the dispatch order from Terna.

In the new framework, renewable units will be considered eligible, because the restriction is not anymore coherent with the technological developments; aggregations of generation units are included as well, provided they comply with geographic location constrains; they can constitute Virtual Eligible Units ("Unità Virtuali Abilitate", UVA). In this context, former eligible units will still be obliged to participate to MSD, while the other entities can decide to participate to MSD on a voluntary basis. Terna would be in charge of setting the requirements in terms of technical performance, differentiating between voluntary and obliged entities. However, in the transition phase, consumption and generation units which are not measured on an hourly basis (usually low-voltage units, with a total capacity lower than 55 kW) will not be considered, because it would be difficult to dispatch electricity from these resources. In this phase, the aggregation between generation and consumption units will not be allowed neither, but it is recognized that this evolution will be needed in the future.

NRA is also working on the reform for imbalances: until 2012, the price for imbalances of non-programmable plants was equal to the zonal market price, and the costs of imbalance were charged on end-users. This configuration was not coherent after the rapid growth of RES. Following a judicial sentence (AEEGSI, 2014a), NRA established that non-programmable plants as well are subject to imbalances regulation and the burdens must be charged on the units themselves in order to obtain secure management of the system. RES are charged with a given tolerance (49% for wind plants, 31% for PV, 8% for run-of-the-river hydro plants, 1,5% for the rest of RES). The price for imbalances is differentiated between eligible and non eligible units: the former pay the negative imbalance according to a dual system, which depends on the behaviour of the unit and on the generation profiles of the reference market area, while the latter pay for negative imbalances according to a single pricing system, which depends on the unit itself. The system for eligible units charges higher costs for their imbalances with respect to the real costs; conversely, the system for non eligible units assigns them the real costs of their imbalance.

In this framework, traditional operators are incentivised to plan injections and withdrawals in order to make a profit following price mechanisms, and not according to their actual generation profiles. In the first semester of 2016, such manipulations led to an increase of dispatching costs of 745 million € with respect to the first semester of 2015 (Biancardi, 2016): thermal plants do not bid on MGP, and therefore their reference market zone is affected by a shortage. The same plants are then called to increase their electricity generation in MSD, and receive high prices (up to 600 €/MWh). One problem is represented by the locational constraint: Terna purchases and sells balancing resources on a nodal basis, while imbalances are regulated per market area. The NRA has committed itself to allow the consideration of nodes as reference location for imbalances, or to eliminate locational constraints.

The reform of imbalance charges for RES (AEEGSI, 2016d) is based on a mixed system: they can choose if they want to participate to a standard regulation or to the zonal regulation within a tolerance band. In the former case, dual pricing system is applied in case these bands are exceeded; in the second option, they are applied a single pricing.

5) Discussion

Many sectors of the Italian electricity system are under reform; in general, in spite of some positive efforts, it seems that the governance as a whole is not encouraging innovation. According to the NRA itself, the main priorities of regulation are "operational security on the short term and adequacy of the system on the long term" (AEEGSI, 2015n). The authors agree that regulatory reforms are gradual and that must take into high consideration stability in sectors of public interest; however, the authors also believe that governance could play a central role in the promotion of innovative solutions in the electricity system. As a matter of fact, governance is also hampering the development of decentralised electricity markets to many different extents:

- the shift of general system charges in the households tariff is not in favour of efficient consumers or small PV generators;
- the development of innovative smart meters is at risk with being identified as a subsidy for DSOs, rather than as a proper instrument for innovation, in particular

because the benefits of the first generation of innovative meters have not been fully exploited yet;

- the restrictions on aggregation and on the provision of services from RES, as well the barriers to coupling storage units and generators, are inhibiting the adoption of novel technologies;
- the prohibition to sell electricity from local plants to adjacent entities is preventing the establishment of decentralised supply.

The sum of these policies result in the protection of the rent of incumbents, without providing real value to the system as a whole or to consumers, and without promoting sustainable system innovation. Enabling aggregators or virtual power plants can represent a solution, taking advantage of control technologies to allow DER to provide reliable power: these units can participate to tenders from network operators to ensure contracts for demand reduction. In the centralised regulatory framework, other non-traditional operators (cooperatives, intermediaries, Energy Service Companies and demand-side operators) are not encouraged to enter, while instead it is more likely that these entities will be able to provide the higher value in the perspective retail markets.

6) Conclusions

The operational conditions of energy systems, which are established since decades, are changing: this paper showed that the most significant challenges are related to the political and institutional dimensions, which can guide and promote innovation.

Advancements in ICT allow RES to provide services to the grid, which can also become a source of income to producers. Network operators do not want to share the responsibility of grid management, but the evolution of electricity markets is oriented towards distributed dispatching and bottom-up optimization: the entire spectrum of users must be entitled to participate to the management of the system. This was not possible in the centralised framework, because control systems were expensive, but nowadays this cost has dramatically decreased. In general, there is the need to find new regulatory and commercial arrangements to facilitate smart grid development, with a more open approach on the demand side; tariffs for network use should be cost-reflective and should be able to send price signals to all the operators, making them responsible for the balance of the system and encouraging sustainable behaviours, responding to the operational needs of the system.

The Italian regulation of electricity market built a proper framework to meet European decarbonisation targets, but could not promote a coherent strategy for the transition towards a decentralised paradigm, in spite of the unquestionable economic and environmental benefits related to the deployment of DER. Concentration is still high in retail market, and it is not clear if the evolution of the retail tariff will obtain desired outcomes in terms of electrification of final uses. On the contrary, the shift of system charges from energy to capacity displaces the growth of DG. Low-carbon facilities and demand aggregators should be allowed to participate to the regulation of network services, thanks to the low cost control technologies now available. Efficient solutions in terms of integration of thermal and electric loads are also needed, to facilitate the management of intermittent electricity sources. Driving the change in the energy sector requires great regulatory vision and the ability to overcome opposition from incumbents in the generation and distribution business. This is not easy in a time of weak demand and shrinking prices. However, many instruments are available and it is now desirable to establish a new market design better fitting with decentralised energy sources.

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Conclusions

The three papers give insights for the analysis of the transition towards a sustainable and decentralised retail electricity market.

The co-evolutionary approach provided a framework to evaluate appropriately the conditions for a further adoption of innovative, sustainable and efficient business models for electricity supply, and to describe the evolving role of market operators: consumers, suppliers and network operators are called to innovate their conventional strategies and to be more active in the market. Conventional schemes and strategies are likely to persist in the next years, but increasing adoption of niche models will likely improve the degree of fitness of these schemes with the wider selection environment, in order to facilitate sustainable changes in every dimension of the energy system.

The focus on institutions (regulatory framework) and ecosystems (market environment) was the core of the second contribution, aimed to analyse the conditions for a larger uptake of an innovative and sustainable business models for industrial consumers. The Italian market represented a fertile environment for the adoption of this novel scheme, mainly thanks to the weight of energy bill for industrial consumers, the market share of the former incumbent and the availability of incentives for Combined Heat and Power plants and energy efficiency initiatives. The rising electricity prices and the need for flexibility services are common situations across Europe which can boost the development of similar models, but regulated prices and barriers to the integration of demand and generation resources are hindering such solutions.

This research work has focused on the different dimensions of the energy system, but it has showed the central role of governance for the roll out of innovative solutions and for the establishment of a sustainable and decentralised energy system. The interaction of incentive policies and enabling regulation is essential to ensure forms of distributed grid control, which can provide higher value to all the stakeholders involved in the energy market. The Italian electricity sector was the reference for the analysis, because it was characterised by a rapid increase of renewable capacity in the last six years in a context of a centralised and concentrated market; nonetheless, driving the change in the energy sector requires great regulatory vision and the ability to overcome opposition from incumbents.

This doctoral work provided reflections on the market and governance characteristics for the development of sustainable retail electricity markets: further research will be needed, in terms of the conditions for the adoption of disruptive technologies, of the examination of the governance of other European countries as well as on the impact of the establishment of the Energy Union.

The realisation of decentralised electricity market is possible, but it will be a completely different business with respect to traditional operations: dramatic changes are therefore needed to enhance the transition. The governance should innovate and promote innovation instead of protecting conventional solutions; business models will be required to evolve, in order to take full advantage of technological innovation; market operators would change their strategies, to actively participate and implement sustainable behaviours and strategies.

Summary of tables and figures

Innovative business models for sustainable and efficient electricity supply: the evolving role of market operators

Integrated Energy Services: an innovative regulatory and market framework for sustainable electricity supply

The governance for Distributed Energy Resources in the Italian electricity market: a driver for innovation?

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Estratto per riassunto della tesi di dottorato

L’estratto (max. 1000 battute) deve essere redatto sia in lingua italiana che in lingua inglese e nella lingua straniera eventualmente indicata dal Collegio dei docenti.
L’estratto va firmato e rilegato come ultimo foglio della tesi.

Studente: MICHELE GASPARI matricola: 956090

Dottorato: SCIENZA E GESTIONE DEI CAMBIAMENTI CLIMATICI

Ciclo: 29°

Titolo della tesi[vi]: **Sustainable electricity supply in a decentralised market: an analysis of business models, operators and regulation**

Abstract

The operational conditions of European retail electricity markets are evolving, due to the completion of the liberalisation processes, the flattening demand and the growing share of renewable generation and low-cost control technologies. Suppliers receive lower and more volatile returns, consumers are gradually becoming more familiar with generating electricity on-site and network operators are putting in place innovative strategies to accommodate larger amount of Decentralised Energy Resources. However, it is not yet clear how the process of supplying sustainable and decentralised electricity will be implemented. This work evaluates the evolving role of market operators adopting a co-evolutionary approach; it examines the regulatory and market framework for the establishment of innovative and sustainable business models for electricity supply; and provides policy recommendations to enhance low-carbon innovation in the governance of electricity system across Europe.

Le condizioni operative dei mercati Europei per la fornitura di elettricità stanno cambiando, per via dei processi di liberalizzazione, dell’appiattimento della domanda, e del crescente sviluppo delle fonti energetiche rinnovabili e delle tecnologie a basso costo di controllo della rete. I fornitori ottengono ricavi inferiori e più volatili, i consumatori stanno gradualmente acquisendo familiarità con le opportunità di produrre elettricità localmente e gli operatori di rete stanno implementando strategie innovative per integrare le fonti energetiche decentralizzate. Tuttavia, non è ancora chiaro come verrà realizzato il mercato di fornitura di elettricità sostenibile e decentralizzata. Questo lavoro valuta il ruolo degli operatori di mercato adottando un approccio co-evoluzionario; esamina il quadro regolatorio e di mercato per la diffusione dei modelli di business innovativi; e include raccomandazioni per innovare in senso sostenibile la governance dei sistemi elettrici in Europa.

[vi] Il titolo deve essere quello definitivo, uguale a quello che risulta stampato sulla copertina dell’elaborato consegnato.