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Territorial Approach to Energy Development Policies: Italian Regions in Transition

Energy development has been defined as an attempt to provide sufficient primary and secondary energy sources to meet society's needs: it involves the full development of already available energy technologies and research, and the development and enhancement of new technologies. Energy transition, in this context, implies the involvement and complex and non-linear (retroactive) change of all mutually interdependent dimensions involved in such development: institutional, financial, territorial and technological, plus governance and consumer behaviour. This process will give rise to new technological clusters, new socio-economic organizations and new behaviours and preferences: society will adopt an altogether new socio-technical paradigm. The areas relevant to energy development and policy-making in the European context are differentiated in regional terms. In fact, Union policy decisions that are adopted and translated into national strategic choices are «transposed» and adapted to different regional realities in order to produce specific energy development patterns. In this framework, this paper analyses the situation of the regions of Italy with respect to their role in energy development through the analysis of five areas – developing renewable sources, promoting energy saving and efficiency, reducing pollutant emissions, promoting applied research activities, and transferring innovation and technology for energy-efficient systems – all showing their positioning with respect to energy development policies in terms of Renewable Energy Systems (RES) development and regional specialization potential.

Approccio territoriale nelle politiche di sviluppo energetico: le regioni italiane in transizione

Lo sviluppo energetico è stato definito come il tentativo di fornire fonti di energia primaria e secondaria sufficienti a soddisfare le esigenze della società: esso comporta sia il pieno sviluppo delle tecnologie energetiche già disponibili sia la ricerca, lo sviluppo e il potenziamento di nuove tecnologie. La transizione energetica, in questo contesto, implica il coinvolgimento e il cambiamento complesso e non lineare (retroattivo) di tutte le dimensioni reciprocamente interdipendenti coinvolte in tale sviluppo: istituzionale, finanziaria, territoriale e tecnologica più la governance *e il comportamento dei consumatori. Questo processo darà origine a nuovi* cluster *tecnologici, nuove organizzazioni socio-economiche, nuovi comportamenti e preferenze: la società adotterà nel complesso un nuovo paradigma socio-tecnico. Sia le aree rilevanti per lo sviluppo energetico che il* policy making *nel contesto europeo sono differenziati in termini regionali. Infatti, le decisioni politiche dell'Unione che vengono adottate e tradotte in scelte strategiche nazionali vengono «trasposte» e adattate alle diverse realtà regionali per produrre propri specifici modelli di sviluppo energetico. In questo quadro, il contributo analizza la situazione delle regioni italiane rispetto al loro ruolo nello sviluppo energetico attraverso l'analisi di 5 aree – lo sviluppo delle fonti rinnovabili, il risparmio e l'efficienza energetica, la riduzione delle emissioni inquinanti, la promozione di attività di ricerca applicata, l'innovazione e il trasferimento tecnologico per sistemi efficienti dal punto di vista energetico – mostrando il loro posizionamento rispetto alle politiche di sviluppo energetico in termini di sviluppo delle fonti di energia rinnovabile (FER) e di potenziale di specializzazione regionale.*

L'approche territoriale dans les politiques de développement énergétique : les régions italiennes en transition

Le développement énergétique a été défini comme une tentative de fournir suffisamment de sources d'énergie primaire et secondaire pour répondre aux besoins de la société : il implique à la fois le développement complet des technologies énergétiques déjà disponibles et la recherche, le développement et l'amélioration de nouvelles technologies. La transition énergétique, dans ce contexte, implique la mobilisation et le changement complexe et non linéaire (rétroactif) de toutes les dimensions mutuellement interdépendantes qui concourent à ce développement : institutionnelles, financières, territoriales et technologiques, plus la gouvernance et le comportement des consommateurs. Ce processus donnera naissance à de nouveaux clusters technologiques, de nouvelles organisations socio-économiques, de nouveaux comportements et préférences : la société adoptera globalement un nouveau paradigme socio-technique. Les deux domaines pertinents pour le développement énergétique et l'élaboration des politiques dans le contexte européen sont différenciés en termes régionaux. En effet, les décisions politiques de l'Union qui sont adoptées et traduites en choix stratégiques nationaux sont « transposées » et adaptées aux différentes réalités régionales pour produire leurs propres modèles spécifiques de développement énergétique. Dans ce cadre, la contribution analyse la situation des régions italiennes en ce qui concerne leur rôle dans le développement énergétique à travers l'analyse de 5 domaines – le développement des sources d'énergie renouvelables, les économies d'énergie et l'efficacité énergétique, la réduction des émissions polluantes, la promotion des activités de recherche appliquée, l'innovation et le transfert de technologie pour les systèmes efficaces en énergie – montrant leur position par rapport aux politiques de développement énergétique en termes de développement des systèmes d'énergie renouvelable (SER) et de potentiel de spécialisation régionale.

Keywords: *energy transition; regional energy development; smart specialization.*

Parole chiave: *transizione energetica; sviluppo energetico regionale;* smart specialization.

Mots clés : *transition énergétique ; développement énergétique régional ; spécialisation intelligente.*

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Note*: although they were united in purpose, A. D'Orazio took the responsibility for sections 1, 3.1, 3.2, and 3.3, M. Coronato for sections 2 and 3.4, and both authors for section 4.*

1. Introduction

From several points of view, energy is a geographical matter. Nowadays, two approaches overlap: on the one hand, there is the traditional dimension of the distribution of particular resources spread around different parts of the globe and their exploitation potential, and on the other hand, there is the vision of (regional) territories within which it is necessary to explain, to make choices and to orient the development model, starting from the embedded energy model. The geographical dimension of energy refers at least two things: «first, the distribution of different energy-related activities across a particular space [and here the problem of different scale occurs] and the underlying processes that give rise to these patterns; and second, the geographical connections and interactions between that space and other spaces» (Bridge et al., 2013, p. 333). Relating to the second point, we consider the place of different energy systems (mainly nationally based) in the global economic, political and environmental dynamics. We use «energy system» in reference to studies (Coutard, 1999; Offner, 2002) which define technology as «not simply as designed and engineered material objects but as embedded components of socio-technical systems in which producers, infrastructures, users, consumers, regulators and other intermediaries are all embroiled» (Walker and Cass, 2007, p. 459). Following this conceptualisation, we can conceive of a specified territorial energy system «as not simply a series of artefacts performing energy conversions but as the configurations of the social and technical which have emerged contingently in particular contexts and which mirror wider social, economic and technical relations and processes» (*ibidem*). These conceptual references are useful to build a territorial approach to energy policy. Therefore, from an heuristic point of view, it is necessary both to consider energy systems as socio-technical systems and to focus again on the territorial dimension of resources and environmental and geographical patterns. The aim would be to individuate territorial energy potentialities. However, states and regions do not always operate with a territorial attitude in this respect, and they lack the capacity to face energy issues.

In Europe, in particular, the energy systems of member states are influenced by a mix of European and international commitments, European energy market liberalisation (COM, 2012) and the EU Emissions Trading Scheme (starting from Directive 2003/87/CE). More recently, the EU adopted the Energy Union, one of the 10 priorities of the Juncker Commission, as a major vector for and contribution to a global transition to a climate-neutral economy. The mainstream of the green economy promoted in the last decade by the United Nations (Barbier, 2010) and the Organisation for Economic Co-operation and Development (OECD, 2011), along with an emerging political consensus on the necessity to protect the global climate system, seems to also shape a new awareness, almost 30 years after Rio, on interrelationships among environmental problems, social justice and distributional equity inside the economic development model. Energy is an essential factor in overall efforts to achieve sustainable development. «The need for the "next" energy transition is widely apparent as current energy systems are simply unsustainable on all accounts of social, economic, and environmental criteria» (Grubler, 2012, p. 8). The new energy system should to be characterised by universal access to energy services, and security and reliability of supply from efficient, low-carbon sources. «Ensuring the availability and accessibility of energy services in a carbon constrained world will require developing new ways—and new geographies—of producing, living, and working with energy» (Bridge et al., 2013, p. 331). The present strategic policies devoted to economic and territorial development

(Europe 2020 and Territorial Agenda 2011) highlight energy as the pivotal issue, both from the sector point of view and as a systemic approach more related to climate change. The relationship between energy and environmental themes and economic development interventions is where the main European policy focus begins. On the other hand, energy demand and production are considered as both indicators and receptors useful for measuring the effects of crises and impacts of globalization dynamics. With Europe 2020, a new economic model based on knowledge, low-carbon economy and high employment levels was underpinned: besides the general objective of the *20/20/20* climate and energy targets, the fourth flagship initiative *Resource efficient Europe*, supports the shift towards a resource-efficient and low-carbon economy. Europe should stick to its 2020 targets in terms of energy production, efficiency and consumption. The effects of the policy mix on achieving the 2020 climate and energy targets show some partial successes (CSWD, 2014). European documents and many strategic national documents call for a low-carbon energy transition, which implies a major shift in the roles of different primary fuels and conversion technologies in the energy mix. Clearly this shift is not only a technological or economic problem. A transition to low-carbon energy is likely to be as significant as past historical energy transitions that have been associated with broad social change, such as industrialisation, urbanisation and the growth of the consumer society. Historical studies on transition (Grubler, 2012) demonstrate the influence of a broad territorial and economic context in shaping the pattern of technology and organizational diffusion. «Despite this, contemporary work on low-carbon energy transition has paid only very limited attention to questions of scale and space» (Bridge et al., 2013, p. 333). In achieving the European targets at the national and regional level, questions arise regarding the national and regional paths to choose and the increasing role of European integration in the sector. Questions arise as to which technologies, at what sizes, through what type of governance and regulatory framework regarding ownership, management, operation, return and networking, and what the implications are for embedding relations between the environment, people, technology and institutions. The major issue is to compare action guidelines, development potential and development priority choices that regions and states should operate based on local demand. In investigating the ways to address these questions, when identifying energy as a strategic sector useful in responding to climate change, reviving territories and shifting towards green economic development in Europe and Italy, often conflicting approaches, proposals and initiatives have emerged. What we therefore call «decarbonisation» is a process of transition (post-carbon transition) through which the use of fossil fuels will be progressively and massively replaced and new technological clusters, new socio-economic organisations, new behaviours and preferences will be formed, and thus society as a whole will adopt a new socio-economic paradigm.

2. Territorial approach to energy development policies

If we define energy development as an attempt to provide both sufficient primary energy sources and sufficient forms of secondary energy to meet the needs of society, then it implies both the full development of already available energy technologies and research, and the development and enhancement of new technologies. This development includes many elements (or drivers) that can be grouped into subsets that remain mutually interdependent: the institutional, financial, territorial and technological frameworks. To these we must add two other intimately linked factors: governance and consumer behaviour, both linked to the communication sphere (ESPON 2010, p. 111). Transition in this context implies the complex and non-linear (retroactive) involvement and change of all of these areas. The areas relevant for both energy development and policy-making in the European context are differentiated in regional terms. In fact, Union policy decisions that are adopted and translated into national strategic choices are «transposed» and adapted to the reality of different regions[1] in order to produce their own specific energy development patterns.

The European Union tends to establish strong links between global initiatives (such as the *Kyoto Protocol* and IPCC reports) and its own policy choices[2]: its «translation» into subsidiary form in the member states, through specific plans and measures, tends to emphasise context characteristics, and in particular highlights that at the regional level, the greater the autonomy, the better the progress towards a low-carbon economy (ESPON, 2017a). In the case of energy policy, territorial diversity refers not only to different combinations of localized energy resources but to more complex local (regional) energy systems considered within national, European and global

Tab. 1. Strategic areas and components in energy development

Institutional	Territorial	Financial	Technological	Communication	Governance
Institutional framework	Structure of settlements	Market price of energy	Availability	Education and training	Stakeholders and players
Regulatory framework	Economic structure	Profitability	Ability to innovate	Information	Levels
Energy planning	Energy accessibility	Availability of economic resources	Territorial correlation with available sources		
		Available income			
		Financial system			
		Support mechanisms			
		International agreements on GHE			

Source: our synthesis from ESPON 2010

relationships. The policy options should be measured taking into account these drivers to also achieve cohesion policy objectives and balanced polycentric development. Given that reducing the use of fossil fuels is a long-term trend, the lack of planning and implementation of a specific strategy can have very high economic and social costs, even if there is clearly no single way to address the transition. One of the central aspects appears to be the degree of local independence achievable among the possible planning choices. However, the transition implies the coexistence, at least in the medium term, of a multiplicity of sources to meet the energy needs of a given region; each source and technological solution, as well as the priorities to be considered, is context-dependent. This means that in direct and indirect ways, any choice oriented towards energy transition requires high levels of coordination between the many actors involved in governance and mobilises a wide range of interests, generating tension, disputes, conflict and resistance. As in any planning activity, one of the central concerns is to consistently combine the choices and activities of different levels of government in terms of policy and regulation. Regional authorities and cities play a central role in the success of the transition process, because at these levels localisation factors, regional economic conditions and structural factors can be carefully considered; moreover, these authorities are able, with appropriate policy choices, to involve the private sector, both households and businesses, also from the investment point of view (fig. 1).

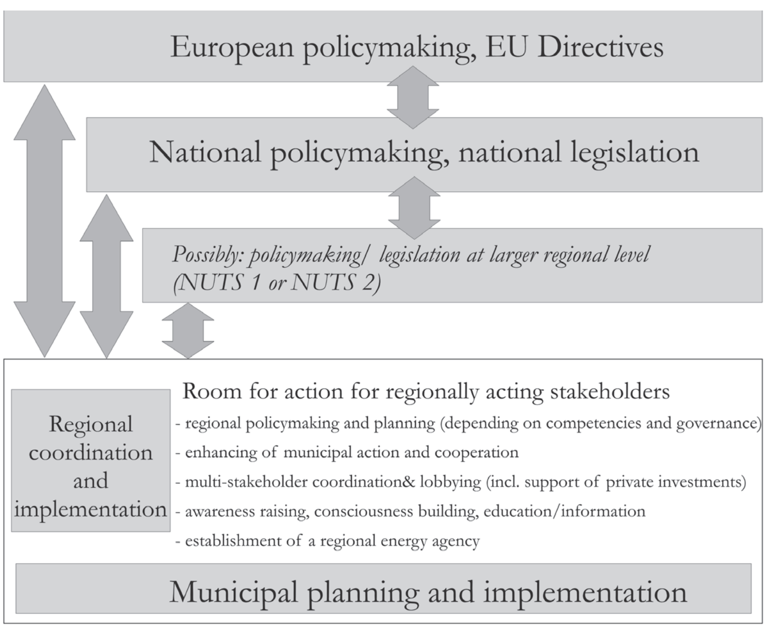

Fig. 1. Interrelations between levels of government and room for action at regional level
Source: ESPON, 2017, p. 32

As part of such a territorial approach, the main challenge from a policy-making perspective is to mobilise the considerable potential of renewable energy in regions that lack financial resources and to coordinate a broad set of instruments acting at different levels (local, regional, national and European) to provide access to efficiency measures for both industries and households. Under the EU Cohesion Policy 2014-2020, which is overall aimed at economic growth and job creation, regions and member states have been asked to channel EU investment into four areas: research and innovation; information and communication technologies (ICT); competitiveness of small and medium-sized enterprises (SMEs); support for the transition to a low-carbon economy. At the European level, in the previous programming period (2006-2013), only a small part of the Cohesion Fund was dedicated to energy-related projects: the energy theme covered 4.5% of the total in all countries and only 6.6% in the «competitiveness regions». However, it should be borne in mind that compared to the 2000-2006 period, the allocation of funds for renewables has increased five-fold for «convergence regions» and seven-fold for «competitiveness and employment» regions. In terms of priorities in the «convergence regions», the European Regional Development Fund (ERDF) and the Cohesion Fund could also support trans-European energy networks, with the aim of improving the security of supply, completing the internal market, integrating environmental aspects, improving energy efficiency and developing renewable energies. In both the «convergence regions» and the «competitiveness and employment regions», an important priority of the ERDF was energy efficiency, the production of renewables and the development of efficient energy management systems[3]. Within this framework, there is great variability at the national and regional level with respect to decarbonisation strategies. Ex-post evaluations highlight the complexity of supporting the transition through Cohesion Policy funding schemes. The reform of the Cohesion Policy in 2013, essentially as a result of the strategic priorities of Europe 2020, oriented EU support towards energy transition. For the 2014-2020 funding period, the ERDF rules established for the first time a mandatory minimum proportion to be allocated by member states to the low-carbon economy: 20% of national ERDF resources in more developed regions, 15% in transition regions and 12% in less developed regions. In the decisions taken for the allocation of funds, these proportions have been largely exceeded, and EUR 68.9 billion between the Cohesion Fund and the ERDF was targeted for and invested in the low-carbon economy between 2014 and 2020. Other investments in transport, sustainable mobility and intelligent energy distribution, storage and transmission systems are eligible under *Thematic Objective 7*.

3. The role of Italian Regions in energy development

With respect to the institutional area, in the Italian context, the commitment of the Regions to energy issues since the early 2000s has led to important steps forward: starting from the constitutional reform of 2001, which made the subject a shared one, conditions have been created to enable the Regions to effectively contribute to the development of the country's energy system by involving various local levels in the development of policies aimed at promoting energy efficiency and renewable sources. Today, all Regions have enacted energy laws taking into account national and European Union guidelines. The main objectives concern the following: the development of renewable sources; energy saving and efficiency; the reduction of pollutant emissions; the promotion of applied research activities; innovation and technology transfer for energy efficient systems. For each of these areas, it is possible to identify some dynamics useful for understanding the role of the regions in the current transition.

3.1. The development of renewable sources

In the first National Action Plan (NAP) for Renewable Energies of 2010, the Regions were given a «diversified» role in achieving the development objectives of renewable energy sources; this refers to «burden sharing», i.e.: forecasting the distribution of the target of penetration of renewable energy sources in the national energy mix. This distribution is a fundamental element in implementing a policy of developing renewables consistent with the opportunities and characteristics of the territory. These targets were based on an evaluation of regional potential for RES provided by ENEA[4]. At the national level, electricity from RES doubled from 4.8 Mtoe in 2005 to 9.5 Mtoe in 2016. At the same time, the country's renewable energy mix has become diversified, integrating the now significant contributions of solar and wind energy with historic hydroelectric and geothermal production[5].

In the Italian case, with regard to energy pro-

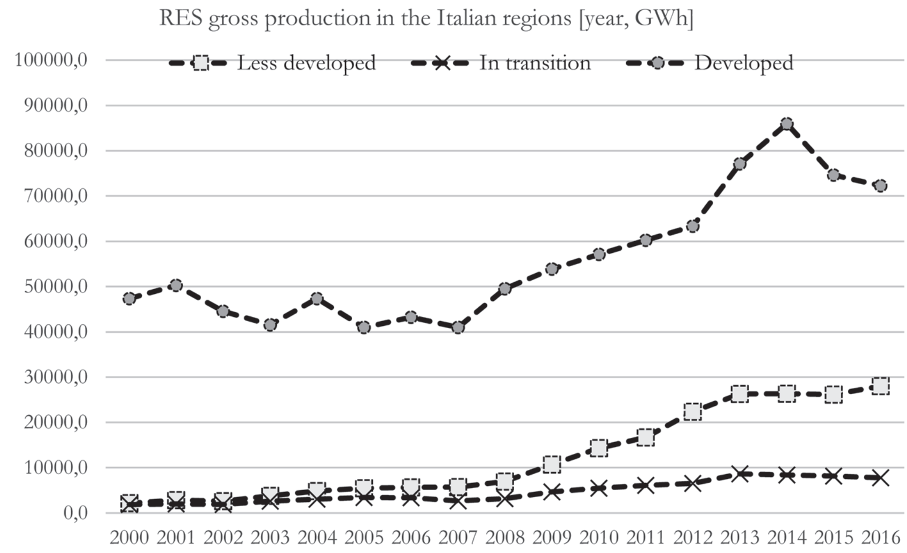

Figure 2. RES gross production in Italian regions
Source: our elaboration of TERNA data

duction from renewables, we can record a change of pace in the decade 2000-2010 (for some regions it started only in the second half of the decade). In particular, the results of the two previous programming cycles in the Objective 1 and Convergence regions seemed to have provided a major boost. With regard to the nomenclature for this programming period, these are developed regions, regions in transition and less developed regions[6] (fig. 2). Analysing the period, we can see that in the early 2000s, production from renewable sources amounted to 92% in developed regions, and at the end of the two programming periods/beginning of the present one, the share dropped to 66%. In 16 years, there was a significant increase in the absolute value of gigawatt hours produced in less developed regions (index 13), compared to a continuous increase in developed regions (index 1.5). At the same time, while total gross electricity production in Italy decreased overall, production in Southern Italy increased (fig. 3).

Overall, the share of electricity consumption covered by renewable sources increased in almost

Figure 3. Gross total electricity production in Italian regions (GWh for 10,000 inh.)
Source: our elaboration of ISTAT processing of TERNA data

Tab. 2. Gross electricity production from renewable sources as a percentage of gross domestic electricity consumption

Territory	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Index 2015/ 2004**
Piemonte	21.0	19.1	17.6	17.9	20.3	28.7	26.0	29.5	32.8	41.6	44.6	43.6	2.08
Valle d'Aosta/Vallée d'Aoste	242.2	229.2	220.2	227.2	235.2	304.7	251.4	232.7	265.8	310.4	310.2	323.1	1.33
Liguria	3.4	2.3	3.0	3.0	4.2	5.4	5.4	5.4	6.7	9.3	10.4	8.6	2.50
Lombardia	14.1	11.6	12.7	12.0	16.3	17.8	19.1	20.1	20.9	24.3	29.4	24.2	1.71
Trentino-Alto Adige/Südtirol	1291	97.0	106.7	101.7	135.4	150.6	148.9	141.7	150.2	176.8	209.5	141.2	1.09
Bolzano/Bozen	164.5	126.8	140.4	135.7	172.6	182.1	178.4	168.4	199.6	225.5	261.8	196.3	1.19
Trento	101.0	72.0	78.2	71.8	102.6	121.1	119.9	113.5	102.4	131.6	163.4	92.0	0.91
Veneto	12.3	10.2	10.8	10.7	12.9	15.9	15.8	18.2	20.4	25.9	30.2	24.2	1.97
Friuli-Venezia Giulia	16.5	12.8	13.4	13.6	17.3	23.4	22.0	21.4	21.9	27.5	36.4	25.8	1.56
Emilia-Romagna	5.8	5.1	5.4	4.9	6.1	9.1	9.9	11.9	14.9	18.7	21.5	20.0	3.47
Toscana	28.6	26.3	27.4	27.5	28.2	30.1	31.5	32.0	33.4	37.3	41.4	39.4	1.37
Umbria	28.2	26.7	26.9	15.9	18.8	26.3	37.4	32.1	26.0	47.8	47.0	39.2	1.39
Marche	7.6	7.7	6.2	3.1	7.1	9.2	10.9	14.8	19.8	28.1	27.8	27.6	3.64
Lazio	6.2	5.6	5.5	3.4	4.6	5.9	7.4	8.9	10.5	15.1	15.1	14.0	2.25
Abruzzo	27.0	28.4	28.3	15.4	20.7	36.0	34.0	34.9	31.9	48.7	51.8	53.2	1.97
Molise	24.6	22.0	16.4	20.2	26.4	42.0	59.1	67.4	78.6	89.3	91.1	85.5	3.48
Sardegna	4.2	6.5	6.7	7.9	7.6	11.4	15.9	19.0	25.3	38.0	37.1	34.8	8.29
Campania	6.2	6.0	6.4	5.8	7.0	11.3	15.1	15.3	20.3	24.6	24.9	24.1	3.87
Puglia	3.9	4.7	5.5	6.8	9.7	13.4	17.8	25.8	36.4	44.3	45.9	47.4	12.14
Basilicata	15.2	15.5	15.1	15.7	16.7	30.3	37.4	36.0	49.8	65.0	64.9	61.9	4.06
Calabria	27.5	31.2	26.9	21.9	22.1	44.7	53.9	51.2	58.0	79.8	80.8	71.7	2.61
Sicilia	1.5	2.6	2.7	4.2	5.0	7.3	11.0	13.8	20.8	23.6	24.8	23.7	16.28
Nord-west	17.6	15.3	15.6	15.3	18.8	22.6	22.5	23.8	25.6	30.8	35.2	31.4	1.78
Nord-east	20.4	16.1	17.3	16.6	21.2	26.2	26.4	27.4	29.2	36.3	43.5	33.1	1.62
Centre	16.9	15.6	15.7	13.3	14.8	16.8	19.3	20.0	21.3	33.5	29.2	27.3	1.62
Centre-North	18.3	15.6	16.2	15.2	18.6	22.3	22.9	24.0	25.7	28.0	36.4	30.9	1.69
Mezzogiorno	8.2	9.0	8.9	8.3	10.0	16.1	20.4	23.3	30.2	38.7	39.7	38.9	4.76
Italy	15.5	13.8	14.1	13.3	16.2	20.5	22.2	23.8	26.9	33.7	37.3	33.2	2.14

The indicator was calculated considering gross inland consumption including pumping. Values above 100 in Valle d'Aosta and Trentino-Alto Adige are due to energy production exceeding domestic demand. The data were adjusted with respect to previous years because only the biodegradable portion of waste, equal to 50% of the total, was accounted for in the production of electricity from renewable sources.
Source: our elaboration on ISTAT processing of TERNA data

all regions, but at widely differentiated rates (see table 2). As mentioned above, the so-called burden sharing decree established the contribution that the various regions and autonomous provinces are required to make in order to achieve the national RES target (RES share of gross final consumption equal to at least 17% in 2020), attributing to each of them specific regional objectives for the use of RES in 2020; each region is also associated with an indicative trajectory, in which intermediate objectives for 2012, 2014, 2016 and 2018 are identified. As with the overall national target, each regional target consists of an indicator obtained from the ratio between gross final energy consumption from RES and total gross final energy consumption, which is elaborated by applying precise definitions and calculation criteria set by Directive 2009/28/EC[7]. The monitoring methodology adopted by the GSE involves the use of data on regional consumption of energy from renewable sources collected by the GSE (which, for the electricity production illustrated here, in turn makes priority reference to TERNA data) and data on energy regional consumption from non-renewable sources processed by ENEA.

The overall gross final consumption (as of 2017) is significantly lower (by around 9%) than the values forecast by the Ministerial Decree for

Table 3. Share of gross final consumption of energy covered by RES (excluding transport) (%)

	Measured data (%)						Forecast by DM 15/3/2012 on burden sharing (%)			
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2016**	**2018**	**2020**	**Delta 2017-2020**
Piemonte	16.0	17.2	17.9	17.8	18.1	18.5	*12.20*	*13.40*	*15.10*	3.40
Valle d'Aosta	62.5	75.9	74.6	80.2	87.8	82.1	*50.70*	*51.00*	*52.10*	30.00
Lombardia	11.2	12.4	13.1	13.2	13.5	13.8	*8.50*	*9.70*	*11.30*	2.50
Liguria	8.4	8.3	7.4	7.6	7.4	7.9	*9.50*	*11.40*	*14.10*	-6.20
Prov. Trento	40.5	42.1	41.6	43.2	43.9	44.6	*32.10*	*33.40*	*35.50*	9.10
Prov. Bolzano	59.3	60.9	61.4	63.4	65.5	64.3	*34.30*	*35.00*	*36.50*	27.80
Veneto	15.0	16.8	16.9	17.3	17.5	17.6	*7.40*	*8.70*	*10.30*	7.30
Friuli V.G.	16.7	17.3	18.9	19.6	19.6	19.7	*9.60*	*10.90*	*12.70*	7.00
Emilia R.	8.8	9.8	10.7	10.9	10.6	11.1	*6.00*	*7.30*	*8.90*	2.20
Toscana	14.4	15.4	15.9	17.1	17.0	17.8	*12.30*	*14.10*	*16.50*	1.30
Umbria	19.7	20.8	21.0	22.7	23.4	25.2	*10.60*	*11.90*	*13.70*	11.50
Marche	15.9	16.3	16.7	16.8	17.0	18.2	*10.10*	*12.40*	*15.40*	2.80
Lazio	8.3	9.3	8.9	9.1	8.5	9.3	*8.50*	*9.90*	*11.90*	-2.60
Abruzzo	22.5	23.0	24.5	25.3	24.9	27.1	*13.60*	*15,90*	*19.10*	8.00
Molise	33.6	33.3	34.9	36.6	38.2	40.3	*25.50*	*29.70*	*35.00*	5.30
Campania	15.3	15.8	15.5	16.4	16.1	16.6	*11.60*	*13.80*	*16.70*	-0.10
Puglia	12.2	15.0	14.6	16.0	15.5	17.6	*10.00*	*11.90*	*14.20*	3.40
Basilicata	31.3	32.8	35.0	33.7	39.6	45.0	*23.40*	*27.80*	*33.10*	11.90
Calabria	33.0	38.3	38.0	37.6	38.9	42.5	*19.70*	*22.90*	*27.10*	15.40
Sicilia	9.6	10.5	11.6	11.2	11.6	12.5	*10.80*	*13.10*	*15.90*	-3.40
Sardegna	22.7	25.3	25.0	25.2	24.2	26.3	*12.50*	*14.90*	*17.80*	8.50
Italia	14.4	15.7	16.2	16.6	16.6	17.4	*10.60*	*12.20*	*14.30*	3.10

Source: our elaboration on GSE (2019).

2018, both at the national level and in most regions. Without prejudicing the specific characteristics and conditions of individual regions, these phenomena, as already stated, are linked, on the one hand, to the remarkable performance of RES, which has been consolidated for several years now, and, on the other hand, to the trend of overall contracted energy consumption, mainly linked to the difficult economic situation and the growing diffusion of energy-efficiency policies.

The measured gross final consumption from RES was compared with that provided for by the Ministerial Decree on burden sharing (excluding the transport sector), showing values almost always higher than the forecasts of the decree for 2018; in 14 regions they are also higher than the forecasts for 2020 (see table 3).

Among the developed regions, Liguria appears to be in a difficult situation, along with Lazio, while Valle d'Aosta and the Province of Bolzano are particularly virtuous (30 and 28 points of positive difference from the target). The deltas of Umbria and the Province of Trento are very positive.

Similar largely positive values present Basilicata and Calabria among the less developed regions, while Sicily does not reach the objective.

All regions in transition present positive values.

On the national level as a whole, the figure for 2017 (17.4%, net of the RES contribution in the transport sector) is almost one percentage point higher than in the previous year and higher than the forecast for both 2018 (12.2%) and 2020 (14.3%). Growth in the renewable energy sector has progressed, albeit at a slower pace since 2014. In fact, thanks to a particularly incentivising legislative framework between 2009 and 2013, the renewable energy sectors (in particular wind, photovoltaic and bioenergy) in Italy showed an exceptional growth trend, with a peak in 2011. Since 2014, with the progressive disappearance of the most favourable measures and the European target for the coverage of renewable energy needs in 2015 being exceeded, the growth rate of the sector has stabilised at lower levels. As far as the contributions of individual renewable sources is concerned, following the 2019 GSE report[8], the primacy of photovoltaic was confirmed, which already in 2014 had surpassed the substantially stable hydroelectric in terms of installed capacity. Wind energy, too, has shown a very regular growth trend since 2005, while bioenergy, after a significant increase in installed capacity from 2009 to 2012, due to incentive policies, has continued at lower growth levels in recent years. Geothermal power remains even more stable, requiring significant investments within the reach of only the largest operators. Overall, in this phase, renewable energy in Italy has the characteristics of a mature sector, even if it still shows signs of growth.

3.2. Regional patterns of specialization

The contribution of regions to installed power for the exploitation of renewable energy sources[9] presents a diversified picture, with sources showing, on the one hand, a different weight for the contribution to the national budget and, on the other hand, a pattern of «specialisation» in the RES energy mix (see table 4).

Overall, 61 and 71.80% of the installations are concentrated in developed regions, with Lombardy in the lead with 15.70%. The amount in regions in transition adds up to 9.53%. The less

Tab. 4. Regional RES installed capacity (number of plants and power) by type of RES and rank

Year 2016	Hydropower		Wind power		Solar power		Geotherm. energy		Bioenergy		Total		
	% n plants	% installed capacity	% n plants	% installed capacity	% n plants	% installed capacity	% n plants	% installed capacity	% n plants	% installed capacity	% n plants on total Italy	% installed capacity on total Italy	rank
				–									
Piemonte	**20.92**	**14.59**	0.44	0.20	7.02	8.07	–		**10.90**	**8,79**	7.07	8.91	3
Valle d'Aosta/ Vallée d'Aoste	3.93	5.15	0.11	0.03	0.29	0.12	–		0.29	0,06	0.31	1.89	18
Liguria	2.04	0.48	0.94	0.62	1.05	0.52	–		0.59	0.76	1.05	0.53	20
Lombardia	**15.15**	**27.34**	0.22	0.00	**14.90**	**11.29**	–		**25.59**	**22.58**	14.87	15.70	1
Trentino/ AltoAdige	**19.52**	**17.69**	0.36	0.00	3.21	2.15	–		6.91	2.53	3.29	7.30	4
Veneto	**9.52**	**6.21**	0.47	0.10	**13.59**	**9.33**			**13.31**	**8.69**	13.50	6.36	6
Friuli-Venezia Giulia	**5.48**	2.69	0.14	0.00	4.19	2.66			4.53	3.28	4.18	2.20	16
Emilia-Romagna	4.34	1.82	1.83	0.26	**10.23**	**10.04**			**11.33**	**15.22**	10.16	560	7
Toscana	4.95	1.97	3.06	1.30	5.29	4.03	100	100	5.45	4.02	5.28	4.30	11
Umbria	1.05	2.74	0.64	0.02	2.31	2.42			2.63	1.18	2.30	1.97	17
Marche	4.26	1.33	1.39	0.21	**3.48**	**5.51**			2.45	0.95	3.47	2.62	15
Lazio	2.12	2.18	1.28	0.55	**6.38**	**6.42**			3.99	4.94	6.33	3.64	13
Abruzzo	**1.68**	**5.43**	1.11	2.47	2.50	3.71			1.39	0.77	2.49	3.81	12
Molise	0.79	0.47	1.17	3.96	0.52	0.91			0.37	1.10	0.52	1.30	19
Campania	1.40	1.84	10.78	**14.35**	3.89	3.92			**2.67**	**5.94**	3.90	5.15	8
Puglia	0.18	0.02	24.79	**25.94**	**6.09**	**13.60**			**2.30**	**8.33**	6.14	10.35	2
Basilicata	0.36	0.72	20.07	**9.21**	1.03	1.89			1.10	1.98	1.12	2.77	14
Calabria	1.33	**4.14**	6.78	**10.94**	3.05	2.60			1.61	4.88	3.05	4.79	9
Sicilia	0.54	0.71	14.56	**19.08**	**6.43**	**6.97**			1.21	1.80	6.42	6.40	5
Sardegna	0.46	2.50	9.84	**10.75**	4.55	3.85			1.39	2.20	4.54	4.42	10
Italia	100.00	100.00	100.00	100.00	100.00	100.00	100.0	100.0	100.00	100.00	100.00	100.00	

Source: our processing of GSE and TERNA data (data source GSE (2018) Energia da Fonti rinnovabili Rapporto Statistico 2016).

Tab. 5. Regional mix as percentage of installed capacity and specialisation pattern

Year 2016	Regional mix: % installed capacity of total regional RES					RES share of total regional capacity	Patterns and regional specialisation profiles	Position in national framework (see table 4)
	Hydraulics	Wind	Solar	Geother.	Bionenergy			
Piemonte	58.41	0.40	33.41	0.00	7.78	46.00	RES-orientated pattern with hydraulics specialisation and important solar component	Third region for installed hydraulic power and sixth for solar power
Valle d'Aosta/ Vallée d'Aoste	97.22	0.26	2.25	0.00	0.26	99.00	Full RES pattern with exclusive hydraulics	Contribution to national RES power below 2%; seventh region for installed hydraulic power
Liguria	32.08	20.87	35.78	0.00	11.28	11.00	Traditional pattern with weak RES orientation	
Lombardia	62.11	0.00	26.54	0.00	11.35	42.00	RES-oriented pattern with hydraulic specialisation, important solar component and non-negligible bioenergy (>10%)	First region in Italy for total installed RES power and installed hydraulic power, second region installed solar power and first region for installed bioenergy power
Trentino/ AltoAdige	86.37	0.01	10.88	0.00	2.74	94.00	Full RES pattern with hydraulics specialization but a non-negligible solar component (>10%)	Fourth region in Italy total installed RES power, second region with installed hydraulic power
Veneto	34.84	0.28	54.10	0.00	10.77	53.00	Strategic RES pattern with solar specialization and important hydraulic component and non-negligible bioenergy component (>10%)	Sixth region in Italy for total installed RES power, fourth region for installed solar power, fourth region for installed bioenergy capacity
Friuli-Venezia Giulia	43.67	0.00	44.55	0.00	11.78	43.00	RES-oriented pattern with hydraulic and solar specialisation and non-negligible bioenergy component (>10%)	Fifth region for number of hydraulic installations
Emilia-Romagna	11.59	0.85	66.13	0.00	21.43	32.00	Traditional pattern with important RES, specialised in solar, important bioenergy component	Sixth region in Italy for total installed RES power, third region for installed solar power, second region for installed bioenergy power
Toscana	16.35	5.46	34.54	36.27	7.37	50.00	Strategic RES pattern with exclusive geothermal specialisation and hydraulic solar mix	Exclusive geothermal energy
Umbria	49.70	0.19	45.38	0.00	4.72	61.00	Strategic RES pattern with hydraulic and solar specialisation	Contribution to national RES power under 2%
Marche	18.15	1.42	77.56	0.00	2.86	73.00	Strategic RES pattern with solar specialisation	Eighth region for installed solar power
Lazio	21.35	2.75	65.18	0.00	10.72	25.00	Traditional pattern with weak RES orientation, with solar specialisation	Seventh region for installed solar power
Abruzzo	50.83	11.66	35.91	0.00	1.59	57.00	Strategic RES pattern with hydraulic specialisation and solar wind energy mix	Fifth region for installed hydraulic power
Molise	12.87	54.73	25.73	0.00	6.66	38.00	Traditional pattern with important RES and wind power specialisation	Contribution to national RES power below 2%; seventh region by installed wind power capacity
Campania	12.70	50.12	28.09	0.00	9.09	46.00	RES-oriented pattern, with wind power specialisation and important solar component, and non-negligible hydraulic component (>10%)	Eighth region in Italy for total installed RES power, third region for installed wind power, sixth region for installed bioenergy capacity
Puglia	0.05	45.12	48.48	0.00	6.35	42.00	RES-oriented pattern with solar and wind specialisation	Second region in Italy for total installed RES power, first region for installed wind power, first region for installed solar power, fifth region for installed bioenergy power
Basilicata	9.22	59.97	25.16	0.00	5.65	90.00	Full RES pattern and wind power specialisation and important solar component	Sixth region for installed wind power.
Calabria	30.80	41.11	20.05	0.00	8.04	42.00	RES-oriented pattern with wind specialisation and important hydraulic component	Ninth region in Italy for total installed RES power, fourth region for installed wind power
Sicilia	3.94	53.66	40.18	0.00	2.22	35.00	Traditional pattern with important RES with wind specialisation and important solar component	Fifth region in Italy for total installed RES power, second region for installed wind power, sixth region for installed solar power
Sardegna	20.18	43.76	32.13	0.00	3.93	49.00	RES-oriented pattern with wind power specialisation and solar and hydraulic mix	Tenth region in Italy for total installed RES power, fifth region for installed wind power

Source: our elaboration on data from GSE (2019).

developed regions contribute 29.46%, with Puglia contributing 10.35% (second region in Italy for installed power).

Particularly with regard to hydropower (which contributes almost 36% to national RES production), the top three regions for installed power (Lombardy, Trentino-Alto Adige and Piedmont) represent almost 60% of the total. On the whole, 84.19 and 93.27% of the plants are concentrated in developed regions, testifying to a trend towards a reduction in plant size, particularly in the northern regions.

Regions in transition account for 8.40%, with Abruzzo contributing 5.43% of the power despite having only 1.68% of the power plants. Less developed regions collaborate 7.41% with Calabria, which alone accounts for 4.14% of the installed power against only 1.33% of the installations.

The situation is reversed in the case of wind power (18% of national RES): less developed regions account for 79.5% of installed power, with Puglia in the lead, regions in transition 17.18 %, and developed regions the remaining 3.30%. However, almost 11% of the plants are located in the latter regions, testifying to the diffusion of micro wind power in some regions (in particular Tuscany, but also Emilia Romagna, Marche and Lazio). Regional development in terms of installed wind power is consistent with the wind generation potential (higher potential in Tuscany, Sardinia, Puglia and Sicily) as mapped by ESPON[10] based on European Topic Centre on Air and Climate change (ETC/ACC) data on wind intensity. The situation of solar generation (almost 37% of national RES) presents a contrasting picture, in which theoretical potential for higher generation in the southern regions[11], actual production is concentrated in the more developed regions (62.5%). The potential for photovoltaic generation (PV output for a 1 kWp system mounted at optimum angle, in kilowatt hours) is the highest in Puglia, Basilicata, Calabria, Sicily and Sardinia, and lower in the north, with the lowest values in Lombardy, Veneto, Friuli Venezia Giulia and Trentino Alto Adige. However, Lombardy is the second region for installed power and the first for the number of plants. Geothermal energy is practically exclusive to Tuscany, while the leading regions for bioenergy are in both the north and south. The first region is Lombardy, followed by Emilia Romagna, Piedmont, Veneto, Puglia and Campania. A comparison with the regional energy mix is shown in table 5. Analysing these data allows us to characterize the regional production structure as more or less oriented to production from renewable energy sources and the current production mix in the RES sector. We can identify five regional orientation patterns in relation to the RES share of production capacity: full RES pattern (>90%); strategic RES pattern (>50%); RES-oriented pattern (>40%); traditional pattern with important RES (>30%); traditional pattern with weak RES (<30%). Moreover, we can highlight some characteristics of specialization in RES within these typologies (column patterns and regional specialisation profiles).

3.3. Efficiency, energy saving and reduction of GHG emissions

Energy efficiency and saving as well as reduction of GHG emissions are fundamental short-term objectives in transition dynamics.

With respect to energy efficiency, a synoptic picture illustrating the energy investment percentages in the past programming period highlights significant differences in the priorities of regional energy policies.

Regarding the reduction of GHG emissions, the data source[12] is the National Pollutant Emissions Inventory compiled by ISPRA. This inventory records the production of pollutants for all macro-sectors (see table 7). It is possible to consider only the production of CO_2 (and not other greenhouse gases) in relation to its predominant weight; in fact, CO_2 accounted for about 82% of total emissions (expressed in CO_2 equivalent) in 2016. Following ISPRA (2018), between 1990 and 2016 there was a decrease of 20.4%; in the energy sector the decrease was 18.2%. Compared to the contributions of different sectors in terms of total emissions, the picture shows stable distribution between 1990 and 2016.

The main factor in the reduced CO_2 emissions was reductions in the energy industry and in manufacturing and construction, which decreased by 23.9 and 48.8%, respectively, in 1990-2016. On the other hand, the transport sector showed an increase until 2007 and then a decrease due to both the economic recession and the growing use of vehicles with lower fuel consumption. Emissions from non-industrial combustion (mainly heating and air-conditioning) are correlated to annual climate changes, while emissions from industrial processes decreased in the period by 49.8%, mainly due to a decrease in cement production.

Excluding sector 11 at the national level, the majority of CO_2 emissions come from the energy industry (29.01%; macro-sector 1) and road transport activities (26.94%; macro-sector 7) which,

Tab. 6. Regional investment in energy efficiency in the 2017-2013 programming period

Region	ESI Funds: Regional Operational Programme (ROP) Regional Competitiveness and Employment ERDF/ Convergence ERDF		ESI Funds: Regional Implementation Program of Development and Cohesion Fund (PAR FSC)		ESI Funds: Cohesion Action Plan (CAP) ESI Funds		
	Financial endowment POR–FESR 2007-2013 (€)	Percentage invested in energy efficiency sectors (%)	Financial endowment PAR (FSC) 2007-2013 (€)	Percentage invested in energy efficiency sectors (%)	Financial endowment CAP 2007-2013 (Development and Cohesion Fund FSC) (€)	Percentage invested in energy efficiency sectors (%)	Percentage invested in sustainable mobility (%)
Piemonte	1,027,820,044	11.4	289,314,152	13.2	29.546.493	20,6	
Valle d'Aosta/Vallée d'Aoste	48,522,858	14.6	58,814,752	81.4	n.a		
Liguria	525,879,443	6.0	357,650,000	20.2	n.a		
Lombardia	531,752,571	11.1	613,993,538	67.8	n.a		
Province of Bolzano/Bozen	73,934,947	12.9			n.a		
Province of Trento	62,477,778	15.3			n.a		
Veneto	448,417,001	96.9	409,634,318	16.4	n.a		
Friuli-Venezia Giulia	233,195,227	6.2	168,386,000	70.8	n.a		
Emilia-Romagna	383,234,345	5.5	786,040,938	9.9	n.a		
Toscana	1,022,947,677	28.0	175,312,847	40.2	n.a		
Umbria	296,206,402	17.9	8,301,080	15.6	n.a		
Marche	285,830,711	23.0	66,991,252	44.9	n.a		
Lazio	736,934,888	4.2			n.a		
Abruzzo	308,635,055	2.4	581,825,450	10.6	66.127.398	8.8	
Molise	141,530,482	13.9	99,337,231*	24.0	33.726.816	2.5	
Sardegna	1,361,343,530	14.4	437,000,000	7.2	175.312.847	34.7	
Campania	4,576,530,132	49.0	861,244,352		861.244.352		21.9
Puglia	3,851,502,909	5.4	126,000,000	9.5 *	786.040.938	20.7	
Basilicata	601,749,098	11.2	260,500,000	1.2			
Calabria	1,998,826,702	8.4			700.786.000		0.6
Sicilia	4,359,736,734	7.7	100.000,000	100 %			

Source: Our elaboration on *Schede regionali* ENEA (*http://enerweb.casaccia.enea.it/enearegioni/UserFiles/Bilanci_energetici_regionali_2014.pdf*).

Tab. 7. Macro-sectors for greenhouse gas emission inventory

N.	Macro-sectors
1	Combustion in industry and power plants
2	Non-industrial combustion installations
3	Production processes (combustion in manufacturing industry)
4	Production processes (non-contact combustion)
5	Extraction and distribution of fossil fuels and geothermal energy
6	Use of solvents and other products
7	Road transport
8	Other mobile sources and mobile machinery (off-road transport)
9	Waste treatment and landfill
10	Agriculture
11	Other emissions and removals

Source: ISPRA, 2018.

Tab. 8. Regional contributions to national CO_2 emissions (2016)

Territory	A Contribution to total national CO_2 emissions (%) 2016	B Contribution to national total of macro-sector 1 (%) 2016	Ratio A/B
Piemonte	**6.42**	**5.45**	*1.18*
Valle d'Aosta/Vallée d'Aoste	0.04	0.00	
Liguria	2.32	3.87	0.60
Lombardia	**18.54**	**10.50**	1.77
Provincia Autonoma Bolzano/Bozen	0.89	0.09	10.30
Provincia Autonoma Trento	0.83	0.25	3.39
Veneto	**9.76**	**6.73**	1.45
Friuli-Venezia Giulia	2.52	3.12	0.81
Emilia-Romagna	**9.04**	**4.29**	2.11
Toscana	3.87	3.25	1.19
Umbria	1.29	0.25	5.14
Marche	1.73	0.43	4.03
Lazio	**9.80**	**10.88**	0.90
Abruzzo	1.30	0.47	2.77
Molise	0.49	0.42	1.17
Campania	**4.32**	**1.58**	2.74
Puglia	**12.07**	**21.68**	0.56
Basilicata	0.56	0.09	6.02
Calabria	1.99	4.06	0.49
Sicilia	**8.30**	**13.02**	0.64
Sardegna	3.90	9.58	0,41
Italia	100.00	100.00	1.00

Source: our elaboration on ISPRA (2018).

added to non-road transport activities (6.06%; macro-sector 8), accounts for 33%.

If we analyse the regional contributions to these quotas, we see a very diverse picture reflecting the regional production and settlement structure[13]; in particular for energy sector 1, in some cases, the sector weighs more than the weight of total emissions, while in others it weighs less (see table 8).

At present, the state has not provided an environmental accounting system regarding regional emissions directly related to national policy objectives. The transfer of political objectives to the regions without suitable tools results in missed assumption of responsibility. Effective regional accountability could make the permitting process more efficient in order to authorize (at both the regional and national level) new energy infrastructures aimed at achieving environmental objectives.

3.4. *Promotion of applied research activities and transfer of innovation and technology*

«In energy development the innovation capacity appears as the main driver alongside the availability and price of energy resources and the economic specialization of regions. Closely related to innovation and another central factor is the availability of technologies both for energy production and for achieving energy efficiency» (ESPON, 2010, p. 99).

In the last 20 years, social and political scientists have paid a great deal of attention to regions (as an alternative to nation-states) as privileged places of innovation and competition in the globalized economy, due to localized learning processes and relative to the knowledge intrinsically embedded in social interactions (Asheim and Isaksen, 2002; Gertler, 2004).

The development of an endogenous capacity of regions to innovate in order to create a competitive advantage is recalled today by the expression «regional constructed advantage», in which the constitution and conformation of regional innovation systems have a strategic function.

Cooke (2004) defines a Regional Innovation System as «interacting knowledge generation and exploitation subsystems linked to global, national and other regional systems».

In this framework, from the point of view of innovation policy development at a regional level in Italy, a reference experience is the creation in the early 2000s of technology districts recognised by the Ministry of University and Research (MIUR) based on a Memorandum of Understanding and Programme Agreements established on a regional basis (D'Orazio, 2011).

In the energy area, the experience of technology districts has included Trentino, with the Habitech Energy and Environment District (2006), the Technological District of Umbria (themes: sustainable building, renewable sources and land management, 2006) and the National Technological District on Energy (DiTNE) in Puglia (2008).

This experience was complemented by the possibilities offered by Regional Operational Programmes in different programming periods, which prompted the creation of regional research and innovation agencies.

The model implicit in the adopted policy is directly inspired by that of the triple helix (Etzkowitz and Leydesdorff, 2000), the basic idea of which is that the structuring of a local Innovation System is based on a continuous interaction between three types of well-defined actors, namely government (at all levels), the business sector and the world of public research. Applying the model in a simplistic way at the regional level, the function of local government would be to facilitate the transfer of research content and human resources from the public research sector to enterprises, so as to foster the economic development of the territory.

More recently, the national innovation policy has relied on the MIUR's creation of national technology clusters[14], which were also foreseen within National Operational Programme *Research and Innovation*.

In particular, in 2016[15], the National Energy Cluster was established, which includes activities related to innovative components and systems for the production and distribution of sustainable and low-carbon energy, as well as the production, storage and distribution of electricity according to the Smart Grid concept.

Cluster proposals had to contain a Strategic development plan[16], four Industrial Research projects[17] and a specific Letter of intent from the Region of reference.

The Energy Cluster is open to all stakeholders interested in energy issues, but the board of directors is composed of the Lombardy Energy Cleantech Cluster (region of reference) and the main players in the energy sector: Eni, Enel (e-distribuzione), General Electric (Nuovo Pignone), TERNA, CNR, RSE, EnSiEL and ENEA (which coordinates the Cluster).

Although 15 regions expressed their support, considering the strong presence of all Italian universities (as individuals and in thematic consortia), by the analysis of the formal structure, technology districts and regional public-private aggregations, in 10 regions emerged (see table 9).

With regard to factors influencing technology area, Basilicata (oil), Toscana (geothermal) and Sardinia (carbon) show a territorial correlation with available sources and the willingness to build on that to change their energy development pattern. The other regions are the first eight producers of RES in Italy and demonstrate the availability of technologies, but also the ambition and ability to innovate.

The territorial differentiation of regional energy patterns can be useful in the processes of smart regional specialisation currently promoted by the European Union in agreement with the OECD[18].

«The Smart Specialisation approach combines industrial, educational and innovation policies to suggest that countries or regions identify and select a limited number of priority areas for knowledge-based investments, focusing on their strengths and comparative advantages»[19].

The smart specialization strategy is a «bottom-up» policy approach in which identifying productive sectors with the greatest development potential on which to concentrate public investment as a priority is left to the regions, and then the strategy is put into practice by policymakers at both the national and regional level.

According to EU Regulation 1303/2013, the elaboration of a national strategy for Smart Specialisation is an *ex ante* conditionality for access to European Structural and Investment (ESI) funds for the 2014-2020 programming, and therefore for the adoption of National Operational Programmes (NOPs) and Regional Operational Programmes (ROPs).

For Italy, MISE and MIUR validated the national Smart Specialisation Strategy 2015-2020, approved in April 2016 by the EU Commission. The Strategy identified 5 national and 12 regional thematic areas of specialisation, around which PNR 2015-2020 was organised accordingly. Among them, the energy area refers to «innovative components and systems for the production and distribution of sustainable and low CO_2 energy, as well as the production, storage and distribution of electricity according to the smart grids concept». It is considered a strategic area because «it plays a

Tab. 9. Regional stakeholders participating in National Energy Cluster (2019)

Region	Participant name	Note
Basilicata	Associazione Cluster Energia Basilicata ETS (CSB ETS)	Regional cluster implemented by regional smart specialization strategy (S3)
	Consorzio per lo Sviluppo Industriale della Provincia di Matera Ente Pubblico Economico (CSI)	Consortium for Industrial Development runs three medium-sized industrial areas and has holdings in an industrial services management company in Valbasento (Tecnoparco)
Campania	Smart Power System High-Tech Energy Cluster	District
Emilia Romagna	Attrattività Ricerca Territorio (ART-ER)	Regional research and development agency
	INRETE Distribuzione Energia SpA	Energy distribution company mainly active in the region
	IREN Spa	Multi-utility active in Emilia, Liguria and Piedmont
Lombardia	Lombardy Energy Cleantech Cluster	Represents Lombardy's production system for energy and the environment
Piemonte	Environment Park Torino	Parco Scientifico Tecnologico per l'ambiente S.P.A with participation by the City of Turin and the Metropolitan City of Turin
Provincia di Trento	HIT–HUB Innovazione Trentino Scarl	Designated by province to participate in national and European clusters for innovation and technology transfer
	SET Distribuzione SpA	Electricity distribution companies in province of Trento
Sardegna	Sardegna Ricerche	Regional Agency for Research and Technological Development (which manages science parks)
	CRS4 - centro di ricerca, sviluppo e studi superiori in Sardegna	Centre for research, development and higher studies in Sardinia, under Sardegna Ricerche
	Società Tecnologie Avanzate Low Carbon SpA (Sotacarbo)	Shareholders ENEA and Regione Sardegna, a company for converting the Sulcis coalfield and dedicated to developing RES and innovative fossil fuel technologies
Sicilia	Consorzio Ecodomus – Edilizia sostenibile, risparmio energetico e tecnologie alimentate dalle fonti rinnovabili	Sustainable construction, energy saving and renewable energy technologies, industrial district of Regione Siciliana
	Distretto Tecnologico Sicilia Micro e Nano Sistemi Scarl	Technological district
Toscana	CoSviG Scrl, Consorzio per lo Sviluppo delle Aree Geotermiche,	Consortium company whose capital is entirely owned by public entities: region of Tuscany and local authorities of geothermal areas, traditional and Amiata.
Veneto.	Consorzio Coverfil (CONfindustria VERona per le FILiere) – Rete Innovativa Veneto Clima ed Energia	System made up of highly specialised thermomechanical sector companies and public and private entities operating in various sectors, capable of developing initiatives and projects relevant to the regional economy

Source: our elaboration

central role in increasing the competitiveness of the national territory through the implementation of sustainable growth interventions that can have an impact in all sectors: residential, production, services and public administration».

In 2016, the agency for territorial cohesion, in charge of monitoring National and Regional Smart Specialisation Strategies, published a national strategic document, which outlines efforts towards integrating policy measures and R&I programmes. In 2016, each region released a regional strategy with a monitoring system, usually with attention also paid to other innovative policies, such as the start-up law and innovative financing tools. The policy instruments available for implementing the national strategy are described in the national strategic document and are integrated with current measures for R&I.

Following Invitalia's (2013) evaluation, in general, a consistent effort by regional administrations can be seen in the analysis and development of a methodology to identify intervention strategies rather than areas of specialization. Moreover, greater attention is given to identifying the supply of innovation (generated by universities and research centres, mainly public) rather than the demand for innovation in the productive sectors present in the regions. Specializations indicated by regional documents often do not correspond to those indicated by the National Strategy of Smart Specialization, particularly in the energy sector.

With regard to the energy sector, the indications that emerge from the descriptions of the specializations reported in the regional documents mainly concern the use of the resource rather than the industry of the energy chain. ln other words, it seems almost always more a correlation with Regional Energy Plans than with an industrial policy for support and technology transfer to the production chain.

The documents analysed seem to be more oriented towards territorial management than industrial policy. Only in a few cases is it possible to identify industrial supply chains (or even individual industrial subjects) of excellence already present in the territory on which to act, and thus the actions to take to consolidate their presence and stimulate the development of innovation and technology transfer. Moreover, there is not always a clear link to the basic themes indicated by the 8th Framework Programme of the EU's Horizon 2020.

A large policy effort has been developed around the smart specialisation strategy; however, its implementation is still at an early stage at both the national and regional level, and a proper assessment of its operation and impact is not yet available.

However, on the basis of the information included in the specific S3 Platform provided by the Joint Research Centre in Seville, which advises member states and regions on developing their smart specialisation strategies, it is possible to identify the 10 Italian regions active in energy partnerships (S3PEnergy[20]). These partnerships are aimed at supporting the formulation of regional policies based on in-depth analysis at the territorial level by comparing EU regions and member states sharing similar S3 energy priorities.

The regions have the opportunity to combine complementary strengths, exploit their competencies in R&I, get the necessary research capacity, strengthen critical mass as well as fragmentation and access to global value chains. develop joint investment projects and, more generally, scale up regional efforts and have a greater impact.

Acting as leader, the Lombardy region has confirmed its strategic attitude towards the development of RES coupled with R&I policy, and the Tuscany region enhances the background with

Tab. 10. Regional participation in S3 energy partnerships (2019)

Selected energy partnership (S3)	**Bioenergy**	**Geothermal energy**	**Marine renewable energy**	**Bio-economy - Interregional cooperation on innovative use of non-food biomass**	**Smart grids**	**Solar energy**	**Sustainable buildings**	**Hydrogen valleys (industrial modernisation)**
Campania							Partner	
Friuli Venezia Giulia							Partner	
Emilia Romagna			Partner	Partner				
Lazio							*Interested*	
Liguria							*Interested*	
Lombardia		Partner	Partner	**Leader**				
Provincia di Trento	Partner						Partner	
Provincia di Bolzano	Partner							
Piemonte								Partner
Puglia					Partner			
Sicilia						Partner		
Toscana		**Leader**						
Veneto						Partner	*Interested*	

Source: our elaboration on *https://s3platform.jrc.ec.europa.eu/*, accessed November 2019.

know-how on geothermal power (confirmed by its participation in the national energy cluster). The other active regions in the partnerships are the first 8 to engage in RES production (Lombardy, Puglia, Piemonte, Trentino/Alto Adige, Sicilia, Veneto, Emilia-Romagna, Campania), except for Friuli Venezia Giulia, which has confirmed an interest in efficiency (such as in EU funds investment; see table 10).

4. Some concluding remarks

Most of the Regions have prepared and, for the most part, implemented environmental energy plans with the aim of determining the most favourable conditions for meeting energy supply and demand. The objectives are to make energy efficiency and the use of renewable sources available and more convenient through the use of innovative energy production technologies, and to raise the quality of energy services on the grid in their territory, sometimes promoting experimentation with local systems of production/consumption.

The Regions have therefore tried to translate national targets for the containment of greenhouse gas emissions into energy plan guidelines, highlighting the extent and environmental effectiveness of the various options and technological choices provided in the plan scenarios.

However, the State-Regions dialogue mechanism of resolving conflicts that arise at the regional and local level in the process of promoting innovation and restructuring the national energy system does not seem to work. In fact, in recent years, at the national political level, there has been growing scepticism about the process of energy decentralization.

In recent years, as in other sectors, the transfer of energy competence to the Regions has not gone hand-in-hand with the necessary endowment by the State of instruments for the regulation and synthesis of national policies.

The availability of Cohesion Policy funds devoted to energy transition offers significant opportunities to national and regional authorities; however, it also poses important challenges in terms of the readiness of member states and regions to ensure the qualitative uptake and meaningful absorption of such investment.

The different regional patterns in energy transition call for a new effort in policy coordination and governance and point out the need to strengthen public expenditure on research and development in a more cooperative way among regions. Low innovation, but also weak diffusion of innovation could slow down the transition to a low-carbon green economy. Improving Italy's innovation performance requires further investment in education and institutional capacity, as well as a stronger focus on technology transfer, taking into account regional weaknesses and potentialities.

References

Asheim Bjørn T. e Arne Isaksen (2002), *Regional Innovation Systems: the Integration of Local «Sticky» and Global «Ubiquitous» Knowledge*, in «Journal of Technology Transfer», 27, pp. 77-86.

Barbier Edward B. (2010), *Global Green New Deal. Rethinking the Economic Recovery*, Cambridge University Press, New York.

Bridge Gavin, Stefan Bouzarovski, Michael Bradshaw and Nick Eyre (2013), *Geographies of Energy Transition: Space, Place and the Low-carbon Economy*, in «Energy Policy», 53, pp. 331-340.

European Commission (2012), *Making the Internal Energy Market Work,* Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2012) 663.

Cooke Philip (2004), *Evolution of Regional Innovation Systems - Emergence, Theory, Challenge for Action*, in Philip Cooke, Martin Heidenreich, Hans-Joachim Braczyk (a cura di), *Regional Innovation Systems. The Role of the Governance in a Globalised World*, London, Routledge, pp. 1-18.

Coutard Olivier (a cura di) (1999), *The Governance of Large Technical Systems*, London and New York, Routledge.

CSWD - Commission Staff Working Document (2014), *Impact Assessment Accompanying the document «A policy framework for climate and energy in the period from 2020 up to 2030»*, communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions (SWD, 15 final).

Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC.

D'Orazio Angela (2011), *Technological districts: a tool for territorial innovation policies*, in *11th EURAM Conference «Management Culture in the 21st* - Track 9 *Governance In Public And Non Profit Organizations: Territorial Governance»* (June 1-4, Tallin), EURAM Estonian Business School.

ESPON (2010), *Re-Risk - Regions at Risk of Energy Poverty*, final report, (*https://www.espon.eu/rerisk*; ultimo accesso: 5.V.2021).

ESPON (2017), *Territories and low-carbon economy (ESPON Locate)*, Applied research, draft final report, 17 July, (*https://www.espon.eu/low-carbon-economy*; ultimo accesso: 5.V.2021).

Etzkowitz Henry and Loet Leydesdorff (2000), *The Dynamics of Innovation: from National Systems and «Mode 2» to a Triple Helix of University-industry-government Relations*, in «Research Policy», 29, pp. 109-123.

Gertler Meric S. (2004), *Manufacturing Culture: The Institutional Geography of Industrial Practice*, Oxford, Oxford University Press.

Grubler Arnulf (2012), *Energy Transitions Research: Insights and Cautionary Tales*, in «Energy Policy», 50, pp 8-16.

GSE (2019), *Fonti rinnovabili in Italia e nelle Regioni 2012-2017*,

Rapporto di monitoraggio 2019, (*www.gse.it*; ultimo accesso: 25.V.2021).
Invitalia (2013), *Accompagnamento all'attuazione delle politiche nazionali e regionali dl ricerca e innovazione 2014-2020 (Smart Specialisation Strategy -S3)*, Report di analisi 12 Aree di specializzazione.
ISPRA (2018), *Italian Greenhouse Gas Inventory 1990-2016 National Inventory Report*, ISPRA, Reports 283/2018.
OECD, (2011), *Towards Green Growth*, (*http://www.oecd.org/greengrowth/48536972.pdf*; ultimo accesso: 25.V.2021).
Offner Jean-Marc (2002), *«Territorial Deregulation»: Local Authorities At Risk From Technical Networks*, in «International Journal of Urban and Regional Research», 24, 1, pp. 165-182.
Walker Gordon and Noel Cass (2007), *Carbon Reduction, «the Public» and Renewable Energy: Engaging with Socio-technical Configurations*, in «Area», 39, 4, pp. 458-469.

Note

[1] This was the case of the Renewable Energy Directive (2009/28/EC), under which member states had to adopt national action plans to achieve the targets of renewable energy share in final consumption. In order to reach these targets, member states could use support mechanisms and cooperation measures.

[2] Between 2000 (the EU formally adopted the Kyoto Protocol in 2002) and 2015, a considerable amount of policy documents (not counting legislative acts) were produced, and the main ones were: first EU Climate Change Programme (2000); second EU Climate Change Programme (2004); 2020 Climate and Energy Package (2009); Low-Carbon Economy Roadmap (2011); Energy Roadmap (2011); 2030 Climate and Energy Framework (2014); Energy Union Package (2015) with four agreements by the European Parliament and the Council on Important Legislative Proposals: Energy Performance in Buildings Directive 62, Renewable Energy Directive, Energy Efficiency Directive and Regulation on the Governance of the Energy Union and Climate Action.

[3] In 2007-2013, funds allocated for renewable energy projects amounted to EUR 4.8 billion; for energy efficiency, co-generation and management, EUR 4.2 billion; and for investments in traditional energy sources, EUR 1.7 billion, of which EUR 674 million was for investment in trans-European electricity and gas networks.

[4] On 15 March 2012, the Decree of the Ministry of Economic Development (the so-called burden sharing decree) established the required contributions of various regions and autonomous provinces in order to achieve the national RES target (RES share of gross final consumption equal to at least 17% in 2020), attributing to each one specific regional objectives for the use of RES in 2020; each region is also associated with an indicative trajectory, in which intermediate objectives for 2012, 2014, 2016 and 2018 are identified.

[5] In 2005 the mix was hydroelectric 78%, geothermal 9%, bioenergy 8%, wind 5% and solar 0.1%, and in 2016 the mix was hydroelectric 42%, solar 20%, bioenergy 18%, wind 15% and geothermal 6%.

[6] Current developed regions: Piemonte, Valle d'Aosta, Liguria, Lombardia, Veneto, Friuli-Venezia Giulia; Emilia-Romagna Provincia autonoma di Bolzano/Bozen, Provincia autonoma di Trento, Toscana, Umbria, Marche, Lazio; regions in transition: Abruzzo, Molise, Sardegna; less developed regions: Campania, Puglia, Basilicata, Calabria, Sicilia.

[7] Unlike the national target, however, in calculating the numerator of regional targets, the consumption of energy from RES in the transport sector is not taken into account, as it is generally dependent on centrally established policies (primarily the obligation to release biofuels for consumption).

[8] GSE (2019) *Fonti rinnovabili in Italia e nelle Regioni* 2012-2017, *Rapporto di monitoraggio* 2019, *www.gse.it*.

[9] Renewable energy sources, including bioenergy (biomass, biogas, bioliquids and municipal solid waste), hydroelectricity from natural contributions, photovoltaic, geothermal and wind power.

[10] ESPON (2009) ReRisk Regions at Risk of Energy Poverty Applied Research Project 2013/1/5 Updated Interim Report: Area Typologies - Clustering, p. 80.

[11] PV potential in the EU regions (NUTS II) based on Joint Research Centre, Renewable Energies Unit (ESPON, 2010, p. 81).

[12] Recorded as point of emissions and then aggregated at regional and sub-regional (municipal, provincial) levels.

[13] A useful indicator is constructed by selecting total CO_2 production (substance code 006) from all production macro-sectors in a given administrative area (NUTS3 and NUTS2) and dividing it by the relative population.

[14] As part of the research and development policy from 2013, the MIUR promotes the creation of national technology clusters as «drivers of sustainable economic growth of the territories and the entire national economic system» as a strategy to pursue a line of actions and interventions consistent with the community and national strategic agendas.

[15] Decreto Direttoriale 3 agosto 2016 n. 1610 *Avviso per lo sviluppo e potenziamento di nuovi 4 cluster tecnologici nazionali*.

[16] The plan, with a minimum duration of 5 years, being dynamic, flexible and capable of responding to emerging needs in the referenced sectors, must promote solutions to supply chain problems by connecting with other Technology Districts and public-private aggregations, and must improve the attractiveness of investments and the training of qualified human capital.

[17] Also includes experimental development and training activities. At least two projects must be carried out under international collaboration agreements, and the maximum duration of projects is 36 months.

[18] Smart Specialisation in Energy, Driving Societal Challenges. Presented at Sustainable Energy Week in June 2017. Report at: *http://www.eusew.eu/smart-specialisation-energy-driving-societal-challenges* (last access: 15.VII.2017).
http://s3platform.jrc.ec.europa.eu/s3p-energy.

[19] OECD, *http://www.oecd.org/sti/inno/smartspecialisation.htm* (last access: 1.XII.2017).

[20] The S3 interregional partnership aims to pool regional resources and expertise in order to create new business opportunities and increased growth for different energy-related research sectors.