Silvia Grandi, Nicola Santocchi, Giuseppe Vico, Serena Zuppardi

Energy Transition in Italy: a Geographical Analysis of the Evolution of Oil and Gas Extraction Activities Towards Decarbonisation Objectives

This paper presents a first set of results of the research works done in the years 2017-2019 at the Italian National Mining Office (UNMIG) of the Ministry of Economic Development, in order to strengthen the UNMIG database and geodatabase with the long term time-series dataset (1957-2018) of the main exploration and production indicators. This work has provided a unique set of information to understand the actual trends in domestic productions from the mid-1950s' to the next decades, towards the decarbonization objectives. The objectives of this paper are to illustrate the main results and the first set of analysis of the main indicators characterizing Italian upstream activities with a long term, then to create a background to forecast potential trends to 2050; to set a basic theoretical framework for the social and economic geography of energy transition in case of offset the upstream hydrocarbon sector in Italy useful in support of just, safe and sustainable transition.

Transizione energetica in Italia: un'analisi geografica dell'evoluzione delle attività estrattive di petrolio e di gas naturale verso gli obiettivi di decarbonizzazione

Questo contributo presenta una prima serie di risultati dei lavori di ricerca svolti negli anni 2017-2019 presso l'Ufficio Nazionale Minerario Italiano (UNMIG) del Ministero dello Sviluppo Economico, al fine di rafforzare la banca dati e il geodatabase dell'UNMIG con il dataset delle serie temporali (1957-2018) dei principali indicatori di esplorazione e di produzione. Questo lavoro ha fornito un insieme unico di informazioni per comprendere le attuali tendenze delle produzioni nazionali dalla metà degli anni '50 ai prossimi decenni, verso gli obiettivi di decarbonizzazione. Gli obiettivi di questo lavoro sono: illustrare i principali risultati e il primo set di analisi dei principali indicatori che caratterizzano le attività upstream italiane in una prospettiva di lungo periodo per poi creare un background per la previsione del potenziale trend fino al 2050; stabilire un quadro teorico di base per la geografia sociale ed economica della transizione energetica in caso di compensazione del settore degli idrocarburi upstream in Italia utile a sostenere una transizione giusta, sicura e sostenibile.

Transition énergétique en Italie : une analyse géographique de l'évolution des activités d'extraction de pétrole et de gaz vers les objectifs de décarbonisation

Ce document présente une première série de résultats des travaux de recherche effectués en 2017-2019 à l'Office national italien des mines (UNMIG) du Ministère du développement économique, afin de renforcer la base de données et la géodatabase de l'UNMIG avec l'ensemble de données chronologiques à long terme (1957-2018) des principaux indicateurs d'exploration et de production. Ce travail a fourni un ensemble unique d'informations permettant de comprendre les tendances réelles des productions nationales du milieu des années 1950 aux prochaines décennies, en vue de la réalisation des objectifs de décarbonisation. Les objectifs de ce document sont d'illustrer les principaux résultats et la première série d'analyses des principaux indicateurs caractérisant les activités en amont italiennes à long terme, puis de créer un contexte permettant de prévoir la tendance potentielle jusqu'en 2050 ; d'établir un cadre théorique de base pour la géographie sociale et économique de la transition énergétique en cas de compensation ; le secteur des hydrocarbures en amont en Italie utile pour soutenir une transition juste, sûre et durable.

Keywords: *geography of energy, history of oil and natural gas, energy transition, Italy*

Parole chiave: *geografia dell'energia, storia del petrolio e gas naturale, transizione energetica, Italia*

Mots-clés : *géographie de l'énergie, histoire du pétrole et du gaz, transition énergétique, Italie*

Silvia Grandi, Ministero dello Sviluppo Economico e Università di Bologna – silvia.grandi@mise.gov.it

Serena Zuppardi, Ministero dello Sviluppo Economico – serena.zuppardi@mise.gov.it

Nicola Santocchi, Ministero dello Sviluppo Economico – nicola.santocchi@mise.gov.it

Giuseppe Vico, Ministero dello Sviluppo Economico e Politecnico di Torino – giuseppe.vico@mise.gov.it

Nota: *the opinions expressed in this scientific paper are to intended solely and exclusively personal responsibility of the authors and are not intended to represent in any way the official position of the administrations to which they belong. Although the contribution is the result of an integrated research work, it is specified that paragraphs 1, 3, 4 were written by Silvia Grandi; paragraph 2 was written by Nicola Santocchi, Silvia Grandi, Serena Zuppardi and Giuseppe Vico.*

1. Introduction

Energy transition is a widely used term in energy studies and it is often incorporated in national energy policies (Bridge and others, 2013; Magnani, 2018). Despite there is not a clear agreed definition of this expression, in a geo-historical perspective it refers to major shifts in the role of different fuels and energy conversion, such as the transition to coal during the first industrial revolution or to oil in the mid-XXth century. Lately, however, a new transition phase can be acknowledged, aiming at changing the energy mix towards low-carbon sources (*ibidem*). IRENA defines the energy transition as a pathway toward transformation of the global energy sector from fossil-based to zero-carbon by the second half of the XXI century. It states that energy transition is a more climate-resilient course that entails a large-scale shift to renewable energy, electrification and ramped-up energy efficiency in the period to 2050 (IRENA, 2020).

The Italian Integrated Plan for Energy and Climate (MISE, MATTM and MIT, 2020), following the European Union long term climate strategies, set ambitious targets towards decarbonization. Among the main targets, one can find that the renewable energy source (RES) rate over the final energy consumption should increase from about 20% in 2020 to 30% in 2030. Yet, a higher increase in the RES consumption in the case of transport is forecasted, i.e. 22% in 2030 versus 10% in 2020. Energy transition, therefore, in this institutional perspective, is conceived as a set of targets in terms of more sustainable generation and consumption mainly in energy, transport, industries and living standards to reduce greenhouse gases. From a geographical point of view, it can be argued that this vision tends to be techno-economic and does not take territorial configuration into consideration enough (Putilli, 2009; Bagliani and others, 2010); moreover, the expected societal changes and shifts (Magnani, 2018) are not fully addressed and generally limited to new job creation by RES. While focusing on a more desirable future based on RES, current and future pattern of energy consumption are quite overlooked as a path-dependency on fossil fuels will be certainly still important in figures, i.e. about 80% of the energy consumption in 2020 (MISE, 2019) and 70% in 2030 is still based on fossil fuels, mainly oil and natural gas, the latter conceived as «transitional» source of energy. For instance, in 2017 natural gas consumption was about 75.15 billion of Sm^3 of which 92.28% imported and 6.96% extracted in national reservoirs (MISE, MATTM, MIT, 2020). Thus, despite the fact that Italy shows a general declining trend in primary energy consumption, fossil fuels are still relevant and mainly dependent to import in the energy balance sheet. Data shows a that primary energy consumption moved from 191 million tonnes oil equivalent (Mtoe) to 156.3 in the decade 2008-2017, where in 2018 the primary energy consumption by fuel was composed of 60.8 Mtoe of oil (39.4%); 59.5 Mtoe of natural gas (38.5%); 8.9 Mtoe of coal (5.8%); 10.4 Mtoe of hydro-electricity (6.7%) and 14.9 Mtoe of other RES (9.6%) (BP, 2019).

Thus, within the Italian geography of energy, it seems still remarkable reasoning around fossil fuels for some decades – especially around hydrocarbons, namely oil and natural gas – even if trends and auspices are clearly moving towards RES. Italian main recent energy policies (i.e. the National Energy Strategy - SEN in 2017, the Italian Integrated Plan for Energy and Climate - PNIEC, the Plan for the Sustainable Energy Transition of Hydrocarbon areas - PiTESAI) are directly planning the phasing out of coal as first step, ideally in 2025 (MISE, MATT, MIT, 2020). Yet, indirectly these policies are working on a faster decline in hydrocarbon use and even more in extractive activity. This is a result of several factors placing Italy in a forefront position worldwide in this process.

This paper presents a first set of results of the research works done from 2017 to 2019 at the Italian National Mining Office (UNMIG) of the Ministry of Economic Development, in order to strengthen the UNMIG database and geodatabase with the long term time-series dataset of the main exploration and production indicators. This is providing a unique set of information to understand the actual trends in domestic productions from the mid-1950s to the next decades, towards the 2050 European decarburization objectives. This paper aims to achieve two main objectives (*a*) to illustrate the main results and the first set of analysis of the main indicators characterizing Italian upstream activities with a long term perspective from the establishment of the first Italian Law for Hydrocarbon exploration and production activities (Law 6/1957) to 2018, then to create a background to forecast potential trend to 2050; (*b*) to set a basic theoretical framework for the social and economic geography of energy transition in case of offset the upstream hydrocarbon sector in Italy useful in support of just, safe and sustainable transition.

2. The Evolution of the Italian Exploration and Production of Hydrocarbons

Italian upstream exploration and production of hydrocarbons dates back to the end of the XIX century (Macini and Mesini, 2017; Grandi; 2017a) or even earlier (Macini and Mesini, 2019) starting from the natural outcrops that were known since centuries, especially in Emilia-Romagna, Abruzzo regions and in the province of Frosinone in Lazio and Sicily (Squarzina, 1958). However, only in 1957 a fully dedicated law created a significant and a stable legal framework for domestic hydrocarbon exploration and production (i.e. Law n. 6/1957). Among others, this law set up the National hydrocarbon office (UNMIG), the Hydrocarbon Official Journal (BUIG) where all main administrative acts are published. Since then, the statistical reporting has been either stated in the BUIG or in the annual reports, providing the main indicators for this sector.

The first part of this research, thus, has been to reconstruct the time-series for the years 1957-2018 of the main indicators regarding hydrocarbon activities, creating a dedicated database and a geodatabase[1]. The main selected indicators are related to (*a*) licenses; (*b*) production; (*c*) drilled wells and (*d*) reserves.

In particular, permits (also mentioned as licences) are specified as total number of active ones in the given year, distinguished in typologies according to the industrial phase, i.e. exploration permits and production licenses. Moreover, these data are broken down in the main localization (onshore and offshore); the full mining cartography (Grandi and Coppi, 2018) has been analyzed and further elaborated.

Information regarding permits provides indications on the evolution of upstream activity over the decades, investments and localization. Similarly, production data, distinguished in oil and gas, onshore and offshore are further indicating the overall actual evolution and results of the upstream activities, showing the effect of the intertwined dynamics of exploration and production that characterize the hydrocarbon sector in Italy.

The number of drilled wells according to typology, i.e. exploratory or development ones, shows the investment that has been done in proving potentiality for new oil or natural gas fields, or the actual activities in further cultivation of existing ones. The number of exploratory wells, i.e. deep test borehole drilled to locate proven reserves of recoverable gas and oil, both onshore and offshore, help to gather more detailed geological data on rock and fluid properties, initial reservoir pressure, reservoir productivity, etc. These enhance chances to have knowledge on new potential future productions. As in general exploratory wells can lead to success or failure, if the number of exploratory or new field wells fells, new oil and gas discoveries drop accordingly. This could led to a fall of the national proven reserves, reducing the overall domestic production future profiles. If oil or gas is discovered, a development well will be eventually be drilled to extract the oil, thus these data show the actual activities and investments in known hydrocarbon fields.

2.1. Time-series of Permits and Lincences

In Italy, the period of maximum expansion of the hydrocarbons exploration and research activities has been extended until the first half of the 1980s. In this phase, the average annual number of explorations permits active in Italy was around 300 and exploration wells peaked to about 100 per year. In the 70s, the maximum offshore exploration and research activity was recorded likely as reaction to the 1973 oil crisis. In those years the offshore permits were twice the number of the onshore permits showing a strong belief on offshore geological potential mainly in the Adriatic Sea, especially in terms of natural gas (Fig. 2).

With regard to onshore activities, the main geographical areas of interest were the Po Plain, and the full eastern arch of the Apennine mountains from the Piacenza province to Basilicata. Most of the first has been an ENI exclusive area established by ENI's founding law in 1953 and opened to other operators in 1996 after its privatization process. Yet, since the second half of the 1980s, there has been a constant decreasing trend in the number of exploration permits (Fig. 1) with an exception at the end of the 1990s. Throughout the 2000s, the total number of exploration licenses has oscillated around an average of about 100 permits per year. The decline observed in last decade can be explained by different reasons: (*a*) the drop in operators' interest due to the increase of red-tape; (*b*) the adverse public opinion attitude exacerbated into territorial conflicts hindering activities; (*c*) the administrative «clean-up» campaign launched by the UNMIG offices leading to the cancellation of several permits and licenses due to natural end-of-life, to relinquishment or to other reasons.

The phase of greatest expansion of exploration and research activity of the 1980s, where explora-

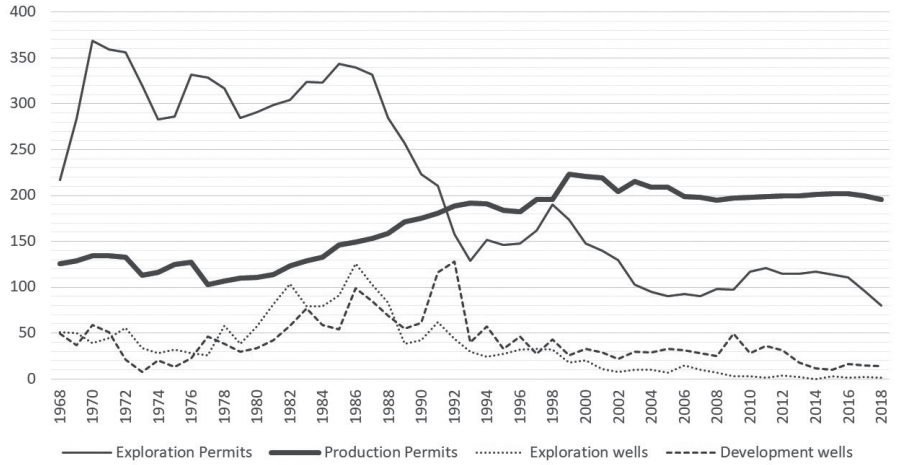

Fig. 1. Selected indicators: total number of exploration permits; total number of production licenses; drilled exploration well per years; drilled development well per years. Time series: 1968-2018
Source of data: UNMIG database elaborated by the authors, 2019

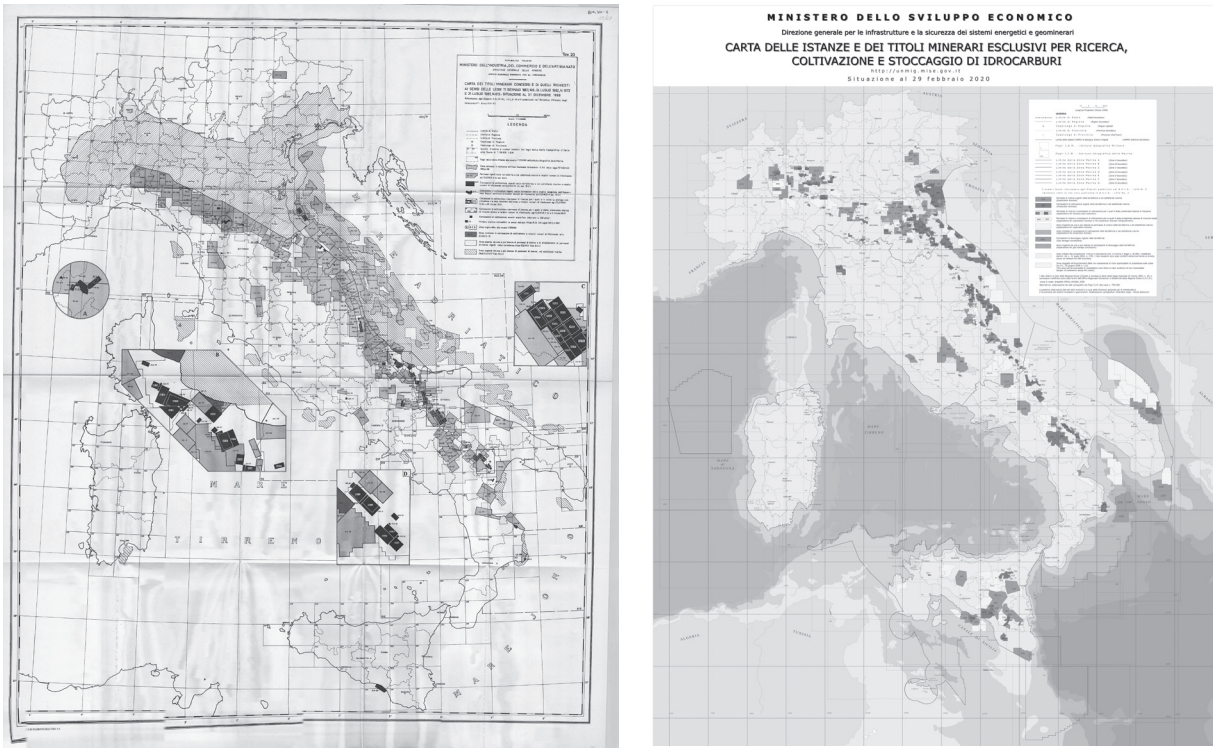

Fig. 2. Italian mining permit and license map years 1968 and 2020
Source of data: UNMIG archive, 2019

tion wells reached the top as previously described, has been followed by a period of growth in the number of production licenses in the 1990s following the discoveries made (Fig. 1). The trend in the number of production licenses[2] is more constant over time mainly due to the intrinsic long-term production timing of the oil and natural gas fields as well as of the decommissioning and eventual reclamation phase. Throughout the 2000's, the number of production licenses averaged around 200 with a smooth decline, consistent with the stable and the declining trend in exploration activity and the low drilling rate of new development wells.

Finally, the role of AGIP, then ENI – the main Italian national oil and gas company – is signifi-

cant when analyzing the evolution of geographical pattern of hydrocarbon permits and activities. In particular, the privatization process held in 1996 seems to create a momentous: after the mid-1990s AGIP-ENI released a significant number of permits: the number of operators increased, but a decline in research, exploration and development can be observed.

2.2. Domestic Production of Hydrocarbons

Despite media narratives and citizen imaginary, where hydrocarbon productions are considered significant and mainly associated to crude oil, the situation has been quite different. Italy has been pioneering in natural gas extraction much earlier than in the rest of the world and, now, is facing a declining phase. In particular, domestic onshore natural gas production has fallen steadily throughout the period under review, from almost 10 billion Sm^3 in 1968 to around 2 billion Sm^3 in 2018. Offshore production, thanks to the development of all the fields in the Adriatic Sea, had a long period of significant increase until the end of the 90s (Fig. 3). In the last 20 years, on the other hand, there has been a marked and constant decrease in the value of production, from over 16 billion Sm^3 in 1996 to about 3 billion in 2018, returning in practice to the production levels of the 1960s. The decline, more marked in offshore production and more constant onshore, is mainly due to the depletion of the fields discovered in the XX century, which have not been compensated by new significant exploration campaign and, thus, discoveries. As well known, in the absence of a compensating exploration and investments, the production of natural gas tends to end in the short time. The rate of production over consumption of natural gas have the same trend. In 1997, the domestic production covered about 33,23% of the national requirements, whilst in 2018 this number is only 7,49%.

A different trend can be observed in domestic crude oil production, where the domestic production has raised over the year from 6.27% to almost 8% and this trend might remain constant considering expected reduction on oil consumption. Domestic oil production has been growing, although there was steady growth until the end of the 1990s and alternating between increasing and decreasing periods in the last 20 years. Offshore crude oil production peaked in 1988 (3.2 million tons) when the Vega field, located offshore in the Sicily Channel, became fully operational and then fell steadily to 0.5 million tons in 2018. In the absence of investments and with the progressive depletion of the currently productive fields, oil production in the sea tends to run out in the short term. On the other hand, onshore oil production has increased significantly in the last 30 years, mainly due to the contribution provided by the production fields in the Basilicata Region, namely Val d'Agri field *in primis*, which, except for some decreases due to temporary shutdowns in 2016 and 2017, has produced between 3 and 4 Mtoe a year since 2005 – setting this region as the largest onshore oil production area in Europe. At the end of 2019, the entry into production of the Gorgoglione field has lead to a further significant increase in onshore production of hydrocarbons, which is expected to grow over the medium to long term (fig. 3). The production values of natu-

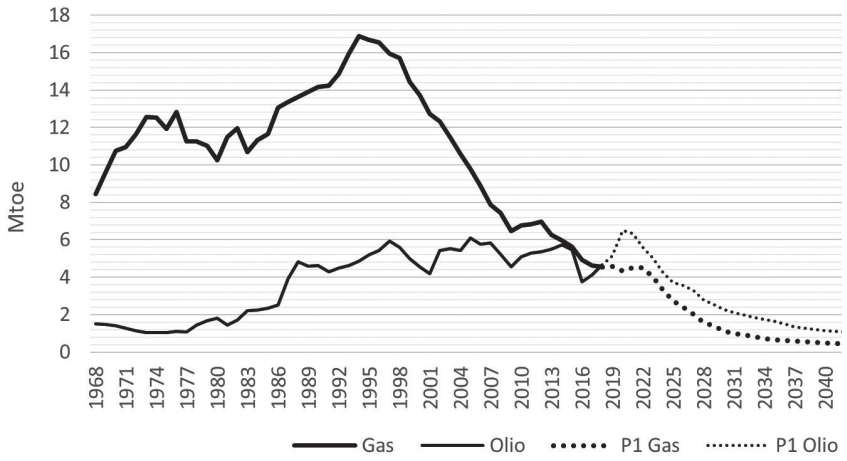

Fig. 3. Domestic hydrocarbon production in millions of toe: years 1968-2018 (full line) and estimates of forecast based on P1 recoverable reserves (dotted line) (2019-2040)
Source: authors' elaboration on BUIG and UNMIG database, 2019

ral gas have been converted from millions of Sm^3 to toe so that they can be directly compared with the production values of crude oil. It can be seen that until year 2000, natural gas production was much higher than crude oil production, but this difference has gradually narrowed over the last few years until it was eliminated in 2018 when gas production of 4.5 Mtoe and oil production of 4.7 Mtoe was recorded.

2.3. Research Activities - Drilled Wells

The greatest research activity took place in the second half of the 1980s (126 exploratory wells were drilled in 1986). In previous years, there has been a steady increase while, since the early 1990s, the research activity has been markedly reduced in the early 2000s until it almost disappeared in the last decade. In particular, the research activity for new deposits in the sea has been completely stopped since 2009.

The trend in development well drilling activities is similar to that recorded for exploratory wells with a shift of several years. In the early 1990s there was the highest level of development activity following discoveries in previous years (128 development wells were drilled in 1996). Since the second half of the 1990s, development activity has also seen a marked decline in the number of wells drilled and then settled at an average value of about 30 wells per year. In 2018, 14 development wells were drilled.

The graph below compares trends in the number of research and development wells drilled with gas and oil production values (in millions of toe). It is clear, as expected, that the trend in drilling activity and the trend in production in the following years are in line with each other.

2.4. Reserves

The historical time series of recoverable reserves shows a maximum value of gas reserves in 1990 (302 Mtoe) in correspondence with the period of maximum development activity of offshore fields. The significant reduction of new discoveries in the following years, consequent to the reduction of investments in exploration, did not allow to compensate the production values and led to a progressive reduction of residual volumes. In 2018, natural gas reserves stood at 66 Mtoe.

This is a different matter for crude oil reserves because during the period under consideration the values recorded a constant increase from 50 million tons in 1980 to 129 million tons in 2018, with a peak of 187 million tons recorded in 2010. The revalued figures for reserves at December 31st, 2018, which should be distinguished according to the international classification of certain, probable and possible reserves, shows – if compared with the figures at December 31st, 2017 and net of production obtained in 2018 – an increase of 23.9% for gas and 3.1% for oil. With regard to the location of proven reserves, 53.8% of the national total gas reserves are located on land, while 92.5% of the oil reserves are located on dry land, most of them in the Basilicata region.

Moreover, in term of spatial distribution, the geo-elaborations[3] show the main configurations of proven reserves, that are not yet explored - despite their geological potential. Southern Italy and the offshore areas seem the richest in natural

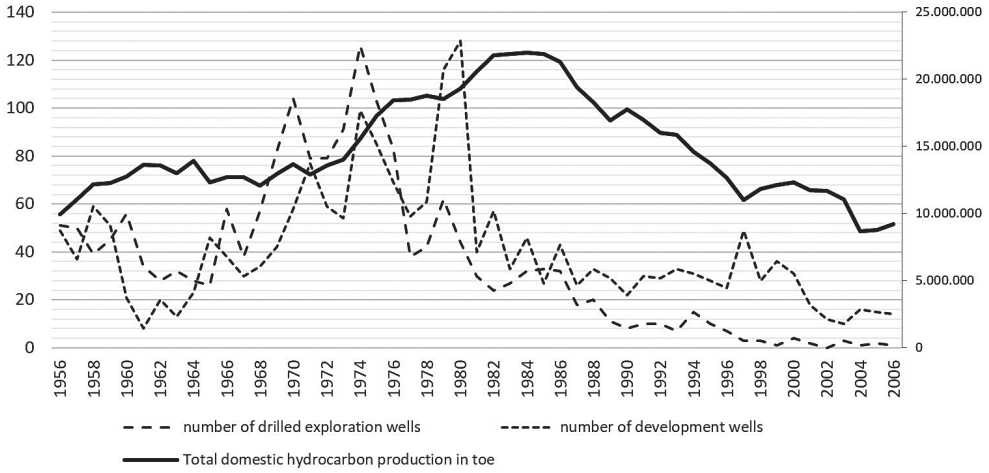

Fig. 4. Yearly total hydrocarbon domestic production in toe; number of drilled exploration well per years; number of drilled development well per years. Time series: 1968-2018
Source: authors' elaboration on BUIG and UNMIG database, 2019

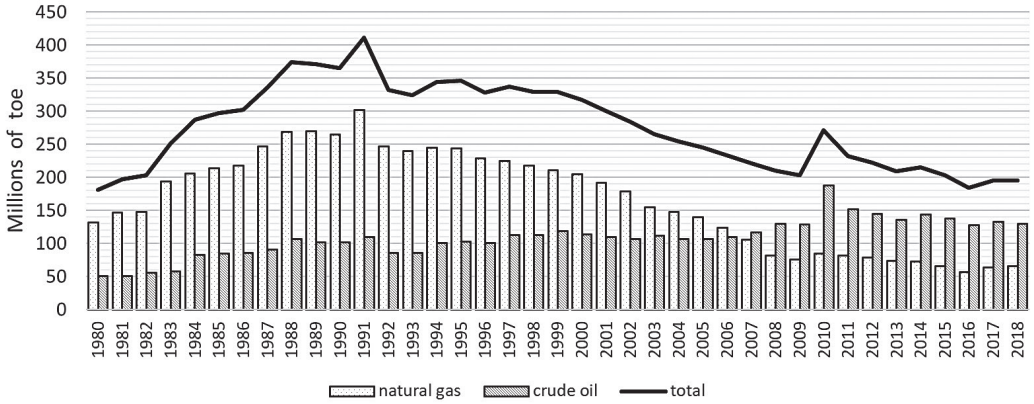

Fig. 5. Italian recoverable reserves of natural gas and crude oil. Time series: 1980-2018
Source: authors' elaboration on UNMIG database, 2019

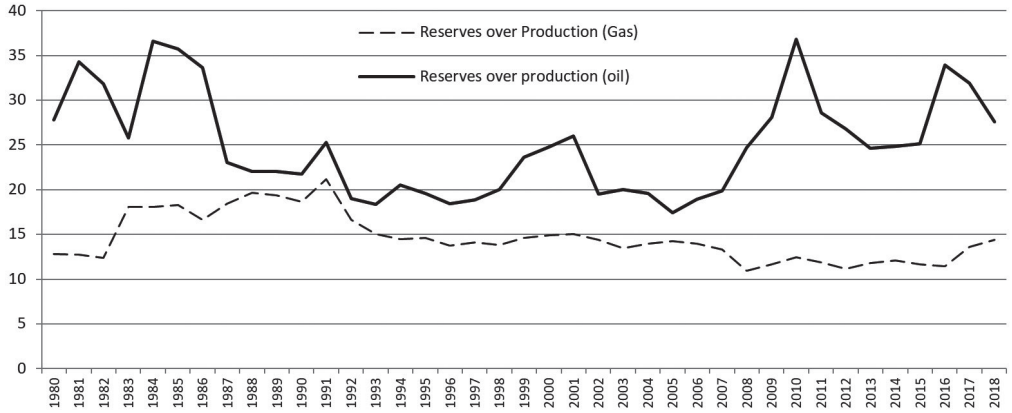

Fig. 6. Recoverable reserves over yearly productions. Years 1980-2018
Source: authors' elaboration on BUIG and UNMIG database, 2020

gas proven reserves, whilst oil reserves are mainly located onshore and offshore in the central Adriatic zone and offshore Sicily. In Northern Italy, even if natural gas is more diffuse, over 3,000 m deep oil reservoir are potentially present in carbonates rock deposit. However, after the shutdown of the Villafortuna-Treccate plant in and because of the Emilia Romagna earthquake in 2012, only one plant is still residually producing and no more crude oil resources have been explored, as significant adverse societal opinion has been encountered.

The reserves-to-production ratio has a certain strategic importance in evaluating perspective of the oil and gas sector in a country, even if it has to be recalled that this ratio is dependent not only to the exploration and production relationship (i.e. if constant suggest that there is a quite good balance), but to geological features of the reservoirs too. The curves in figure 6 shows that the ratio related shows that the ratio related to natural gas has been quite stable ranging between 10 to 22 years, reaching the peak in 1992. During the 2000s the values change smoothly, showing that no significant new giant assets have been identified and that production is declining with a pace proportional to recoverable reserves. On the contrary, the reserves-to-production ratio regarding oil is significantly higher and two peaks can be detected in 1984 and in 2010 coherently to discoveries in the Basilicata regions, as previously described.

3. Some Economic Geography Consideration for Sustainable Energy Transition Policies

Despite Italy has never scored very high in the worldwide statistics in the oil and gas upstream sector, a technological leadership in developing

and adopting innovative and strong technology advances could be recognized to this country. For instance, Italy has played a significant role as a forerunner in the oil and natural gas exploration and extraction activities. It has to be recalled that in the parliamentary acts[4] of 1966 it is stated that ENI had «the pride of having been the first operator in Europe to carry out offshore exploration and research of hydrocarbon activities. [...] Drilling [...] began on 26 March 1959 with the well of "Gela Mare 21", which was carried out on the Scarabeo mobile platform, a technology developed by Italian firms» (Grandi, 2017a).

The technological leadership has been a result of national policies balancing state intervention (AGIP and later ENI have and are still playing a significant role) with more liberalism approaches. Moreover, a further characterizing element can be found in the growth of small and medium size firms specialized in services and technologies along the supply chain and following the evolution of the exploration and extraction sector. This leads to recognize the multilevel dynamics of the Italian domestic hydrocarbon extractive sector balancing: (*a*) global and local forces, (*b*) global supply and production chain mechanisms and (*c*) localized and specialized industries.

However, the economic geography of this sector has rarely been investigated and this results as a weak point in the just transition perspective. Therefore it seems important to provide a set of concepts that can guide the analysis of the social and economic elements related to the complex dynamics of structural change that can leave some collectives behind if not properly identified and supported. Dependencies on fossil fuels exist in all countries, with the share of the society being affected depending on entrenched fossil fuels economic activity. Just transition implies the need to understand these dynamics activities in order to plan, restructure, diversify, and proactively anticipating and addressing these challenges (IRENA, 2020). Past economic adjustment processes suggest that re-orienting fossil-fuel-dependent regions is likely to take time and is not always certain to succeed as acquiring new skills can be a resource-intensive process; yet new job creation in the renewable energy sector will not necessarily be temporally or geographically aligned to fossil fuel job loss in the affected communities (*ibidem*).

Media and political imaginaries often offset this complex territorial reality (Magnani, 2018), thus the following paragraphs aims at presenting a theoretical and research framework to highlight and unpack the geographical and spatial elements related to the decline of hydrocarbon exploration and production in Italy, that can be a useful support for sustainable energy transition policies.

3.1. A Multi-theoretical Approach to Analyse Spatial and Place Dynamics of Hydrocarbon Extraction in Italy

With a rather holistic approach, four main theoretical geographical approaches are considered useful in analyzing Italian hydrocarbon extractive sector to support sustainable, placed-based, and just energy transition policies.

First, the classical Dicken and Lloyd (1972) location theory and models, especially related to multinational companies and their architectures.

Second, the industrial district and cluster models following the seminal work of Becattini (1987; 1991) inspired by Alfred Marshall's work on positive externalities of agglomeration as well as Porter's one (Porter, 1990 and 1998). Later the local system theory (Becattini and Sforzi, 2002; Dematteis and Governa, 2005) can be argued to be useful in analyzing concentration patterns of labour, skills, and knowledge as well as path-dependency and cultural embededness that explain success and failure in economic development of SMEs. Yet, these approaches can be useful to understand the rise of social conflicts following oil and gas extractive activities in the various Italian regions.

Third, the innovation systems (Nelson, 1990) and *milieu innovateur* GREMI (Aydalot, 1986) would stress the technological, knowledge and spatial components.

Fourth, the resource curse thesis, also known as the paradox of plenty (Auty, 1993), would help to capture the under-performance of underground resource rich regions and related pathologies with further highlight risks and conflicts that arises in and among communities.

Thus, the consideration of these theoretical approaches set four main determinants that characterize the geography of hydrocarbon sector: the localization of georesources, the spatial organizations of economic activities, the communities, and the knowledge/technologies.

Unfortunately, none of these have been significantly investigated so far in the Italian case study nor extensively can be traced in scientific literature, at least in the last two decades. Therefore, this paper aims at setting a frame for further research in order to stimulate a richer and the search of fruitful set of information to support future policy making based on geographical and territorial elements.

3.2. Main Localization Determinants of Extractive Activities

The geographical pattern of this sector is strongly related to the localization of the georesources, as the underground assets are associated to the geological and geophysical characteristic of the earth subsoil and its knowledge. The official mining map of permits and concessions of the peak of the so called «oil era» (Fig. 2) can be used to depict the main distribution of the hydrocarbons area. It has to be recalled that the surface and the actual distribution is much larger than the effects on surface that are localized in few points: in the onshore activities these are in mainly wells areas, in the treatment plant and in business offices. In the offshore ones, the surface main effects are the offshore platforms and/or floating production storage and offloading units, the underwater sealines, the service ship harbour port serving offshore platforms, the onshore offices and treatment plants.

A further insight study of the typologies of reservoir in Italy (Zuppardi, Santocchi, Vico and Grandi, 2019) shows that only few large reservoirs are active, most of them range between small scale to medium operations. Yet, a significant number (about 20-25 fields) can be classified as micro-operations close to the proto «zero-km production», «energy communities», «marginal fields» approach or «historical fields». Something that might be interesting to develop a further stream of research for geographers and territorial policy scholars.

3.3 Spatialities of Company Locations, Labour, and Knowledge Systems

When the fields are relatively small and the exploration and start-up activities are concluded, the operations are not labor intensive compared to other sector and with remote control systems the localization of workers and of the supply chain firms can be located at a distance. These are tendentially located in the main oil and/or natural gas treatment plant or in the port service hub supporting the cluster of offshore fields. A significant territorial pattern of the firms' activities has been given by larger enterprises or first enterprises entering into the business.

AGIP-ENI system set in Ravenna the operating northern headquarter, so called DICS-Northern-Center District), in Gela the basis for Sicilian activities and in Viggiano the so called Southern district. Around these area several SMEs, R&D and educational activities have been grown over the year as well as other multinational service companies set their Italian branches in these locations. Similarly, Edison Exploration and Production has the main headquarter in Milan, but operating main branches in Pozzallo and in the area of Pescara and Ortona. SPI-Gas Plus system, as the oldest oil and gas Italian company, developed skills and set their main technical offices in Val Taro, where they develop industrial heritage initiatives.

One of the most controversial discussions in hydrocarbon sector territorial impacts is related to labour and job creation, with significant differences among point of views according to operating companies, trade unions or civil and environmental organizations. The Italian statistical system on primary activities does not have a specific ATECO dedicated to fluid natural resource extraction sector, therefore, no official data can be extracted from ISTAT or the Unioncamere statistical reports. UNMIG collects data on labour hours related to safety on the job, thus with a different perspective. Only seldom regional *ad hoc* analysis or ENI sustainable district reporting are available (ENI, 2019). This fact is creating social distress and leaving space to significant heuristic guesswork when impacts have to be estimated in term of reallocation of labour and potential

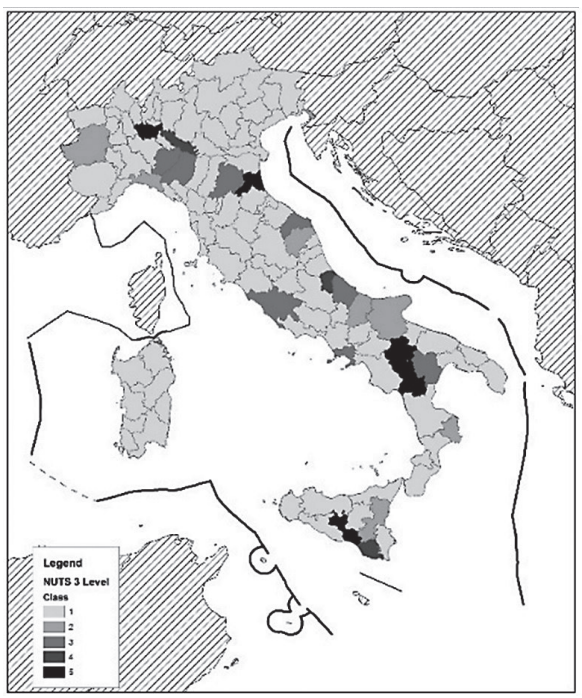

Fig. 7. Preliminary map of the distribution of hydrocarbon upstream sector jobs in Italy
Source: authors' elaboration, 2019

unemployment differentials in term of energy transition.

However, an UNMIG preliminary creation of a dataset has been done starting from the CTE-UNMIG database and expert analysis. This led to a first spatialisation at NUTS 3 level (fig. 7) showing that the location of the industrial hydrocarbon specialized areas has been significantly influenced by historical evolution of the first discoveries, the localization choices of headquarters of the main operators, and the existence of a close port, in case of offshore activities. The areas of Milano (Lombardy region), Fornovo Val di Taro; Piacenza; Ravenna (Emilia-Romagna region), Gela and Pozzallo (Sicilian region), Val D'Agri (Basilicata region), Falconara and Ancona (Marche region) Pescara and Ortona (Abruzzo region), and Crotone (Calabria region) could be named as the main Italian areas where direct (and a significant part of indirect) employment is located. Notwithstanding this, this preliminary spatialisation highlighted the presence of several research or technological providers units related to this sector mainly located in Turin, Rome, Milan, Bologna, and Naples research and innovation area.

Moreover, it has to be observed that highly specialized services in the hydrocarbon extraction sector – especially in the exploration and development phases – are highly internationalized and mobile. Rather than localized they are part of global value chains networks following investment and orders. This is the case, for instance, for drilling, workover, and jack-up services or wireline, testing and geophysical campaign services. In this case this sector is activating, instead, indirect business tourism services, and other temporary works and services at local level that can stem in the growth of new local «learning» companies but not necessary. The drop of labour involvement when a site moving from development to standard operation, can change of a numerical order, and this fact probably affect perception and narratives of the parties.

3.4 Communities

A final consideration is related to the most recent development and learning related to sustainability of transition, i.e. in the latest decades the evolution of the Italian geography of hydrocarbons is entwined with the development of social-ecological systems, and social effects of global changes. As of the mid 80s', the attitude and policy have been slowly changing, by incorporating first environmental protection principles (Grandi, 2017b); then, as of the 2000s, corporate social responsibility, environmental economics elements, social acceptance, and climate-related technologies (low-carbon, lower emission, etc.) have been started to be implemented by early adopter or by law or regulatory guidelines.

In the second decades of the XXI century, however, in Italy a strong societal and territorial conflict has risen against hydrocarbon exploration and production (Coppi and others, 2017), leading towards a phase-out of hydrocarbon extraction (but not in consumption as it is argued in the introduction). The most significant happenings are the moratorium for the Gulf of Venice (art. 9 Law 9/1991); the ban of future activities within the 12-miles from the coastline (DL 128/2010); the so called «No Triv» referendum (April 2016); and the art. 11-ter of the Law n. 12 of the 11th of February 2019 establishing a 24-months stop for the exploration activities and a significant rise in licences' surface state fees. Some of these phenomena could be connected with the growth of Nimby syndroms that, however, affect RES too (Bagliani and others, 2010; Ferrario and Reho, 2015; Magnani, 2018) creating further challenges for decarbonisation processes.

As often is the case, these conflicts bring positive counter effects: first of all they started to show the need of codify the communities intertwined with the hydrocarbon sector, showing that understanding energy local and national cultures, path-dependency and embededness, technological spill overs, technological and territorials interlinks were not sufficiently studied, thus, leaving space to multiple and uncoherent societal imaginaries. The sense of de-territorialisation highlighted by Bagliani and others (2010) might be recognized less overlooked, especially considering the just transition discourses. Crisis helps to unfold forces of societal changes over time as well unveiling territorialisation, de-territorialisation, and potential re-territorialisation proceses (Raffestin, 1984).

4. Final considerations

The complex geological history of Italy has not led to the formation of large hydrocarbon basins to fulfill the energy demand of this country, however it has created local situations that became favorable to the formation of numerous reservoirs of a certain importance that have been discovered, studied, and turned into industrial activities.

In Italy, this has created an interesting phase

of development of an industrial sector mainly started after WWII and peaking in the last decades of the XX century. Probably this sector, due to the greatest worldwide importance and techno-economic paradigm that has led it, has not fully perceiving its peaking nor the socio-technical changes occurring as of the 1990s and, more clearly, flourished in the second decades of the XXI century.

An unlooked-for and a specificity of the Italian exploration and extraction hydrocarbon system is the reverse trend observed in oil and natural gas. The latter is worldwide considered the transition fossil fuel, but in Italy it was developed and extracted since the early years of the oil era. This led to some interesting advances both in upstream and downstream technologies as well as in social habits (i.e. methane powered cars especially in Emilia-Romagna area). However, natural gas production tendentially is in as stronger decline versus oil as recoverable reserves (and not geological potential). The analysis of the time series data collected and presented in this study shows that peaks does not seem related to geological limitations but rather to a mix of techno-economic, policy and social decisions. The decline in exploration investments, the growing Nymby syndromes, the emergence of the sustainable development paradigm, and the recently influential climate change perspective paved the way to a new energy transition phase, generally addressed with the decarbonisation objectives.

From a geographical perspective, territorial changes triggered by the energy transition, affects the absolute and relative locations of energy systems and of its elements (Bagliani and others, 2010; Bridges and others, 2013), landscapes (Bridges and others, 2013; Ferrario and Reho, 2015; Mauro, 2019), territoriality (Putilli, 2009; Bridges and others, 2013; Magnani, 2018); spatial differentiation and uneven development extended to financial flows (Bridges e altri, 2013), scaling, spatial embeddedness, and path dependency (*ibidem*). In term of social impact, they are not the only ones affecting employment across the economy, but energy transition can lead to potential misalignments paradoxically leading to employment crisis and the rise of environmental risks (IRENA, 2020) as well in just transition perspective. Moreover, these wider dynamics place increasing pressure on institutions charged with energy security objectives. Decarbonisation policies next to matching demand and supply of labour; aligning the skills of the unemployed with requirements inherent in emerging jobs, and distributing the burdens of technological change for employment (Tirole, 2017).

Therefore, next to a geography of hydrocarbons related to geological and technical aspects, an urgent need for a more extended attention to the geography of hydrocarbons in its economic, geopolitical, and social aspects, seems to be a fundamental need for a future sustainable development of energy systems.

Acknowledgements

The authors would like to thank Ombretta Coppi and Rosalba Urtis of the editorial staff of the BUIG of DGS-UNMIG, Division VI.

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Note

[1] Throughout the first decade of implementation of Law 6/1957, statistical data still show an evolving situation: in the first issue of the BUIG the first 235 applications for exploration permits were published and only during the first decade were the first discoveries made and then the granting of cultivation concessions for the development and production of deposits. In this work the data analysis has therefore been restricted to the period 1968-2018 as only from the second half of the sixties are the available data consolidated and comparable with those of the following decades. For the period 1957-1968 refer to the work of Corsetti in Coppi and others (2017).

[2] Following the fact that in Italy subsoil georesources are state resources, the liceces are given in form of concession in the legal terms.

[3] For confidentiality reasons, regional data and certain hydrocarbon maritime zone are grouped.

[4] Parliamentary Acts – Italian Chamber of Deputies - Act C. 3442 - sitting of 21st September 1966, presentation of the Legislative Decree «Research and production of liquid and gaseous hydrocarbons in the territorial sea and continental shelf».