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From the Location of Fossil Fuels to Decarbonisation. New Perspectives for the Geography of Energy in Italy

The Paris Agreement of 2015 likely charts the beginning of the current energy transition, with new environmental, economic, and social challenges for our society. Geography is a multidisciplinary discipline covering several areas of study and frequently dealing with energy issues. Since the early 1990s, the Italian specialty group on the Geography of Energy has been working to advance these studies on quite heterogeneous topics (i.e., fossil fuels, geopolitics, renewable energy, governance of energy policies etc.), as we also see in the articles of this special issue of «Geotema». As was the case thirty years ago, still today «geographers want to have their say» about these issues, especially now when the Recovery and Resilience Plan calls for the installation of about 70 GW of new renewables by 2030. It is important to be involved in the present debate on the best decarbonisation strategy so as to ensure landscape preservation and local communities' participation in decision making.

Dalla localizzazione delle fonti fossili alla decarbonizzazione: nuove prospettive per la Geografia dell'Energia

Con la firma degli accordi internazionali di Parigi (2015), siamo entrati nell'attuale fase di transizione energetica che ci pone di fronte a sfide di natura ambientale, economica e sociale. Per la propria natura di carattere interdisciplinare, molto frequentemente la geografia tratta tematiche connesse alle questioni energetiche. Attivo dal 1992, il Gruppo AGeI per l'Analisi geografica delle fonti di energia propone in questo numero di «Geotema» alcuni contributi centrati su diverse tematiche: geopolitica delle fonti fossili, potenzialità e limiti delle rinnovabili e recenti politiche energetiche adottate in Italia. Anche oggi, come trent'anni fa, i geografi intendono «far sentire la loro voce» su queste problematiche, soprattutto in seno alle recenti indicazioni del Piano nazionale di ripresa e resilienza sul settore energetico. Con le loro competenze, essi vogliono attivamente contribuire all'attuale dibattito su quale sia la migliore strategia da adottare per procedere urgentemente verso la decarbonizzazione, garantendo al contempo la tutela del paesaggio e il coinvolgimento delle comunità locali.

De la localisation des sources fossiles à la décarbonisation. Les nouvelles perspectives pour la Géographie de l'Énergie

L'accord de Paris sur le climat (2015) marque probablement le début de la transition énergétique actuelle, avec de nouveaux défis environnementaux, économiques et sociaux pour notre société. La géographie est une discipline multidisciplinaire et, très souvent, elle traite des questions énergétiques. Depuis les années quatre-vingt-dix, le Groupe de géographes italiens sur la Géographie de l'Énergie travaille sur des problématiques assez hétérogènes (combustibles fossiles, géopolitique, énergies renouvelables, politiques énergétiques etc.), comme en témoignent les articles de ce numéro spécial de « Geotema ». Il y a trente ans, mais aussi aujourd'hui les géographes « veulent avoir leur mot à dire » sur ces questions, surtout maintenant, alors que le Plan de relance et de résilience prévoit l'installation de 70 GW de nouvelles énergies renouvelables d'ici à 2030. Il est important d'être impliqué dans le débat en cours sur la meilleure stratégie de décarbonisation, également pour assurer la conservation du paysage et la participation des communautés locales au processus de décision.

Keywords: *Geography of Energy, decarbonisation, renewables, energy policies*

Parole chiave: *Geografia dell'Energia, decarbonizzazione, rinnovabili, politiche energetiche*

Mots-clés : *Géographie de l'Énergie, décarbonisation, énergies renouvelables, politiques énergétiques*

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1. An «insightful» relationship: geography and energy

Energy has always been one of the key issues for societal development. This becomes even more evident during energy transition phases, such as the one in which we are now living. Similar to the advent of coal in the late eighteenth century, later replaced by oil in the twentieth century, the next decades could be a time of new global challenge: the decarbonisation of our «fossil-fueled society» (Smil, 2017). The share of renewable resources in the world's total consumption must reach at least 70% by 2050 to meet the agreed climate goals of Paris 2015 (IRENA, 2019a).

From the first industrial revolution to the present, global primary energy consumption has grown exponentially; currently, we use more than 27 times the energy used in the early nineteenth century (Ritchie, Roser and Rosado, 2020)[1]. The massive use of fossil fuels (carbon, oil, and gas) introduces into the atmosphere carbon dioxide (CO_2) and other greenhouse gases, key drivers of global climate change. Thirty years after Kyoto, the transition to a new more sustainable age of energy is only just beginning; in a world still heavily dependent on fossil-based fuel sources, the renewables share is still minor (about 13.6% of total primary energy supply; IEA, 2019a). However, this green revolution is already underway; in recent decades, the growth of renewable resource use has been remarkable and sometimes unexpected. The rapid cost decline of wind and solar photovoltaic (PV) power accelerated their global spread, making them leaders in this sector. Renewable resource capacity rose quickly in many emerging economies and developing countries in the Middle East, North Africa, and parts of Asia (IEA, 2019a). The Covid-19 pandemic has accelerated this process; 2020 was a tumultuous year for the global energy system, and new scenarios seemed to be emerging. The most radical one, Net Zero, envisages an almost total reduction in greenhouse gases by 2050 (IEA, 2020).

The world's main energy market, China, represents the current situation well. Having tripled its coal consumption since 2000, it is still investing in several new coal-fired plants; however, its coal consumption peaked in 2014, and now it is in decline (Wang and Li, 2017). At the same time, China has become the world leader in renewable resources; biomass, wind, and solar PV power were 0.3% of Chinese energy consumption in 2008, whereas, in 2018, they were 4.4% (BP, 2019a). In the future, China plans to double the capacity of these renewable sources, from 22% in 2020 to 41.5% in 2040 (IEA, 2017). Meanwhile, «old Europe» aims to become the first climate-neutral continent in the world by 2050[2], supporting investments in green technologies, sustainable solutions, and new activities with the new European Green Deal.

Geography is central to understanding the current energy dynamics and «dilemmas» (Zimmerer, 2011, p. 705); hence, recently, we have observed an increasing number of energy studies in geography (Huber, 2015; Calvert, 2016). Defined as «the study of energy development, transportation, markets, or use patterns and their determinants from a spatial, regional, or resource management perspective» (Solomon and Pasqualetti, 2004, p. 831), energy geography could be considered as the «earth of geography tradition» (Calvert, 2016, p. 106), because energy production and use are crucial factors «in the social production of space» (Huber, 2015, p. 1). As an example, we can refer to the close relationship between the geographic pattern of industrialization in the nineteenth century and the geological distribution of coal and its relevance in the pattern of contemporary urbanization in Europe (Strange, 1998). On the other hand, if we consider as another example the technological aspects of oil (sites of power plants, refineries, pipelines etc.), its environmental costs (pollution of air and water), its social consequences (inequalities, population distribution, and growth due to production of oil etc.), we can easily understand the spatial dimension of energy. Therefore, the link between energy and geography is probably even deeper, so much a part of each other that their ties «escape casual notice» (Pasqualetti, 2011, p. 972).

Perhaps for this reason, geographers have always studied a wide range of topics (technological, economic, ecological etc.) related to this «insightful» relationship. However, their subjects have changed over time. The location of resources and their finite nature (with a particular emphasis on oil) were the focus themes of the first studies in the early Fifties until the late Sixties. Energy geography has increased its relevance from the Seventies, when nuclear energy production (also in terms of safety), as well as renewable energies and, more generally, the territorial impact of energy became the main topics. In recent decades, the new emerging trends are geopolitics and the economics of energy related to one of the most pressing issues of our time, the climate change driving the current energy transition (Pasqualetti, 2011).

Bridge and others (2013) provide an interesting conceptual framework for the spatial organization of energy and economic activities, focusing on several geographical aspects (location, landscape, territoriality, scaling etc.), in order to understand space and spatial changes occurring during any energy transition phase. The spatial differences, the relationship between position and connection, the spatial organization, and the scales of organization are some of the geographical concepts relevant to understanding how also the energy low-carbon transition is «spatially-constituted». In addition to the engineering solutions required in the energy chain (from energy efficiency to transport and distribution networks), a further corollary of this change is the «territorial energy transition» (Riggio, 2013, p. 116); the new urban and rural spatial organization will be influenced even by local energy production (mainly, microgeneration and cogeneration). Therefore, it is necessary to enhance local energy situations through a shared energy governance between multiple territorial actors (political, economic, and social). The territorial reorganization of energy production requires adequate planning to avoid a «landscape risk» (Dansero and Puttilli, 2009) related to the impact of new energy plants such as, for instance, wind or photovoltaic farms[3]. Without clear rules, historical cultural landscapes will be vulnerable; their aesthetics as well as their socioeconomic systems are facing a very high risk of deterritorialization.

2. The Italian specialty group on the Geography of Energy

Since the early Nineties, the Italian specialty group on the Geography of Energy, supported by the Association of Italian Geographers (AGeI), has played an important role in advancing the study of the relationship between geography and energy. Over the years, several activities have been carried out: research projects in collaboration with research institutions such as the National Research Council (CNR); conferences locally (Trieste, 2011), nationally (Trieste, 1993 and 2009; Roma, 2019), and internationally (EUGEO; Rome, 2013); and several scientific publications in national and international reviews and conference proceedings.

In this special issue, several scientists deal with the following topics: *a)* fossil fuels and the geopolitics of the global energy transition; *b)* the movement toward renewable energy: issues and opportunities; *c)* the governance of decarbonisation with some examples from Italy. Without being exhaustive, given the complexity of the theme, in the following paragraphs we offer the readers a few aspects of the energy issues related to the geography of this «Geotema».

2.1. Fossil fuels and geopolitics of the global energy transition

The availability of sources and extraction sites has been and remains one of the main geographic questions related to energy, especially when we refer to oil, coal, or natural gas. During the last two centuries, fossil fuels have been the key energy supply for our industrial societies, so their consumption has grown exponentially[4]. Their finite nature has been a matter of discussion since the early Sixties; as is well known, Hubbert's peak theory (1962) predicted that US production of oil would peak around 1970. However, technological progress (i.e., the advances in horizontal drilling and hydraulic fracturing, the «hydrofracking») has increased the amount of reserves over the past decades in contrast to the forecast of the Sixties, sometimes classified as pessimistic (i.e., Maugeri, 2004).

The rate of the energy efficiency for extraction of traditional fossil fuels is decreasing, as evidenced by the oil, gas, and coal downward trend of the Energy Returned on Energy Invested (ERoEI) Index[5] (i.e., Hall, Lambert and Balogh, 2014) in recent decades. Despite this, the current global consumption of primary energy by fossil fuels is still more than 80% (27% coal, 33% oil, and 21% natural gas; BP, 2019b). Furthermore, several international agencies such as the International Energy Agency (IEA) or the International Renewable Energy Agency (IRENA), as well as oil companies, highlight how traditional fossil fuels will remain the leaders in the energy market in the coming decades[6]. Since the Covid-19 crisis, something appears to have changed, but perhaps it is still too early to see its effects.

In this framework, the first paper of this special issue by Grandi, Santocchi, Vico, and Zuppardi describes the history of the Italian exploration and production of hydrocarbon (oil and gas) since the late Fifties. Using time-series charts on several subjects (exploration permits, production licenses, hydrocarbon production etc.) and several maps about reserves location and hydrocarbon upstream sector jobs, they illustrate well the development of an important industrial sector of Italy, mainly in the late twentieth century.

Despite this relative «abundance of energy» (Nicolazzi, 2014), 860 million people, 11% of the world's population (mainly concentrated in the central and sub-Saharan Africa), do not have access to electricity (IEA, 2019b)[7]. There are still global inequalities in the average per capita energy consumption, which is steadily increasing (+45% in 2015, compared to 1970); even if the consumption in high-income countries is declining, in 2017 the average US citizen still consumes more than twelve times the energy of the average Indian and almost three times more than a person in China (IEA, 2019c; Ritchie, Roser and Rosado 2020). The unequal distribution of fossil energy reserves[8], energy prices, the fast dynamics of trade in fuel and electricity, and the security of energy supplies remain political factors with relevant consequences, mainly for economies heavily dependent on hydrocarbon exports (Smil, 2017). Although the USA maintains its predominant position (also through unconventional oil), the BRICS's[9] new role in the energy market (mainly as consequence of their fast industrialization) has deeply changed the geopolitics of energy. This means, for instance, that China has shifted from an energy producing country to an energy importing country since the early 2000s (Fasulo, 2014). In the meantime, primary energy consumption in Europe is declining (in 2017, it was 9% lower than 2005), even if the share of renewable resources is constantly increasing (EEA, 2020).

Battisti (this issue) describes in detail the current contradictions of our energy system and their complicated intertwining with the policies of the world's leading countries. Although fossil fuels are still the main players in the energy market, the recent changes in world geopolitics (i.e., the return of economic nationalism, the decline of OPEC's centrality, the changing relationship between the dollar and commodities such as oil etc.) could be the basis for the rise of renewables. On the other, Perrone (this issue) focuses on the global competition for «resources» such as conventional and unconventional energy reserves, the minerals needed for renewable energy production, and the technologies and know-how. The author also emphasizes their potential future impact on the energy market. For this reason, the creation of international institutions to ensure global energy governance is necessary (especially during an energy transition), in order to avoid the risk of disrupting the fragile world geopolitics in this area.

2.2. Moving towards renewable energy: issues and opportunities

The current low cost of fossil fuels is due to their presumed availability for decades to come (see note 6), as well as the lack of implementation of their social and environmental negative externalities (i.e., the conflicts over energy sources, the greenhouse effect etc.). However, the fight against climate change leads towards a new energy mix in which renewable energies, after the age of fossil fuel, will become relevant again. Even before the pandemic, the falling costs of these technologies (particularly for solar and wind) as well as the technological innovations (i.e., increased efficiency of solar module, smart grids, new technologies for energy storage etc.) had accelerated the speed of this global energy transformation (IRENA, 2019b). A strong increase in solar and wind power can be expected in this coming decade, mainly due to the new energy policies proposed by major industrial countries (the USA, China, and India) on Earth Day 2021.

According to the IEA (2019a), solid biofuels are by far the largest renewable source (almost 68%). In fact, the traditional biomasses (the burning of wood, forestry materials, and agricultural waste biomass) have always been the dominant fuel source for cooking and heating across many low-income countries within Africa, Asia, and Latin America[10]. However, as also underlined by Grillotti Di Giacomo and De Felice (this issue), the biomass represents «a complex kaleidoscopic world», including even the modern biofuels. «No food» agriculture (necessary for producing ethanol, for instance) can conflict with food sovereignty, resulting in negative effects for the poorest population and the environment (reducing its biodiversity and the landscape variety). For this reason, the authors highlight how the geographic method could evaluate the territorial impacts of the large-scale agricultural crops for biomass production, in order to avoid these social and environmental risks.

By the late nineteenth century, hydroelectricity production became increasingly important at least before the oil era. Today its share is 2.5% of the total primary energy supply, and it is the second largest source (18.5%) of renewables (IEA, 2019a). In fact, wind and solar PV power seem to be the most promising sources for the near future; they have grown «at an unprecedented rate in the last decade and have consistently surpassed expectations» (IRENA, 2019b, p. 14). Between 2008 and 2018, global wind power capacity increased almost five times, while solar power capacity increased more than thirty times[11]. However, while the annual growth of wind power installations has been almost constant since 2014 (about 50-55 GW), that of solar PV is still increasing, and forecasts for the coming years seem to follow this trend (GWEC, 2019; SPE, 2019). Although solar PV energy production is still lower than wind[12], wind and PV power together provided about 6% of the world's electricity production in 2017 (in 2000 it was 0.2%).

Biofuels, hydroelectricity, wind, and solar PV power are currently the main renewable sources, while others (geothermal and tidal) are almost negligible on a global scale. However, the energy mix will probably be the key to the energy transition, so it is important to consider all available renewables. Therefore, in his paper Bencardino (this issue) argues for a resumption of research activities into an enormous energy potential, the ocean. In this sense, the author offers us a detailed framework of the projects active within the ocean energy, where tidal energy is just one component (the others are wave energy, ocean and river currents, ocean thermal energy, and salinity gradient). Currently, the UK and the USA are the leaders in ocean energy projects; however, in near future this renewable resource could be the «geopolitics test bench» for other energy leaders such as China, Russia, or India.

In recent years, the classic functional relationship between GDP and renewable energy consumption[13] has been gradually changing. In several OECD countries (and more) the transition to a post-industrial society is progressively decreasing their dependence on fossil fuels, while there is a growing trend towards investment in renewables. Iceland, Norway, New Zealand, Brazil, Croatia[14], Canada, and Denmark generate more than 60% of their electricity from a renewable energy mix (IRENA, 2018). In this special issue, Battino and Lampreu present the case of the Canary Islands as example of a closed system, able to reconfigure themselves as a «laboratory-space» in which to experiment a new approach to the energy issue. There, «where the world ends» (as the El Hierro island was once considered), new solutions are beginning to solve some environmental risks related to mass tourism in this archipelago. So, the new challenge for the Canary Islands is to use renewable resources able to relaunch themselves as smart islands and prove that «a new world can restart from here». In fact, the European Union has always been a world leader in the field of renewables, and many of its member States are today among the largest producers of sustainable energy. According to the Renewable Energy Directive[15], the Italian target for 2020 was 17% (as the percentage of renewable energy use); however, in 2018 its share was already higher (17.8%; GSE, 2020). A «green region of Europe» is Abruzzo, as Cavuta (this issue) has pointed out. This author describes how, in recent years, energy local policies have focused on renewable energy, mainly supporting the spread of wind farms and solar PV. However, local disputes over the new plants have highlighted the need for balanced governance of sustainable development to protect the huge variety of environments in this region and promote its sustainable future.

2.3. *The governance of decarbonisation: some examples in Italy*

The Paris Agreement of 2015 drives climate change governance from an overall reduction in carbon emission toward promoting new low-carbon policies. In a long-term vision, the different politics of decarbonisation imply several steps toward a sustainable transition, giving rise to a new concept of a green state as not only a normative ideal but an evolving institutionalization of ecological responsibilities (Hildingsson and Khan, 2015). «A complex set of variables rooted in institutional arrangements and social and political culture» (Wolsink, 2007, p. 2693) determines the success of specific policies, such as those concerning the renewables. They are «the planning regime, the financial support system, the values attached to landscape quality and preservation, and the degree of local ownership of schemes to build the renewables» (*ibidem*). In the last decades, differing energy policies combined with differing sensitivities both to the environment and to the landscape have produced a different spatial distribution regarding these technologies that we can now consider to be «mature».

The «planning regime», often need for a detailed knowledge of these topics, also uses geo-referenced information. Moreover, it would be desirable to address these issues to different audiences to emphasize the importance of social values in matters of debate. So, publishing data on renewables (location, metadata etc.) through WebGIS platforms can be considered a public geography activity (Morri, 2020), as Martinotti, Stella, Vergata, Antoncecchi, Di Simone, Rossi, Bevilacqua, and Grandi evidence in their paper for this issue. Using this tool, the Directorate general for the safety of energy and mining activities and the National mining office of the Italian Ministry for the economic development present the progress of mining disposal activities for offshore platforms. In this way, a computer-based and updated census is freely available for citizens. On the other hand, Favretto (this issue) illustrates how to use a crowdsourced map, OpenStreetMap (OSM), to obtain geographic data. Specifically, the author uses OSM in order to map the ground-mounted PV systems in a northeastern region of Italy (Friuli Venezia Giulia). These cartographic data could be organized in a GIS, so other technical information can be added. Despite some limitations inherent in crowdsourced maps, the distribution of these data in a WebGIS platform may be suitable way to raise awareness about the environmental issues of solar PV such as land use and land takeover by PV etc. (i.e., Mauro and Lughi, 2016).

In terms of energy planning, before the Covid-19 crisis, the Integrated national energy and climate plan 2030 (PNIEC 2030; MISE, MATTM and MIT 2019) drew a roadmap to decarbonisation for Italy. After almost thirty years of waiting[16], this national energy plan confirmed a 32% share of renewable resources in total energy consumption (transport, electrical, and thermal) by 2030, in accordance with the European Green Deal aims. However, although there are several ambitious green targets[17], environmental associations (and others) see the PNIEC 2030 as a missed opportunity for a massive divestment from fossil fuels. However, these targets have to be revised because the current *Recovery and Resilience Plan* has set even more challenging objectives for Italy in the energy sector, providing for the installation of about new 70 GW of renewables (mainly PV and wind power) by 2030 (currently, they are 55 GW in total). Doubts remain also about the real timing of the «phase out» of coal's energy production (theoretically by 2025) but also about the role of gas, which is still central for many people in the coming years. In fact, D'Orazio and Coronato (this issue) point to a slowdown in renewable resource growth in Italy since 2014; therefore, the high share of renewables in energy consumption may be partially due to the current economic crisis and the resulting contraction in energy demand. In addition, the authors highlight how, in recent years, regional differences have emerged mainly with regard to efficiency, energy security, greenhouse gas emissions, and research. For this reason, the PNIEC 2030 could be the first step to ensure greater coordination in the policy and governance of sustainable development in terms of energy for Italian regions.

The sustainability of ports is another key question for the governance of the energy transition because today harbours are essential components of the international trade and goods movement. Port cities and port areas can be considered industrial and logistics sites contributing significantly to pollution in coastal urban areas (i.e., Zhao and others, 2013) and also at a global level[18] (IMO, 2015). In this special issue, Bizzarri and Crea show how several important Italian ports such as Genoa, Trieste, Naples, Palermo etc., are often equipped with old infrastructure and suffer the consequences of many logistic and environmental problems, such as pollution. Therefore, they underline how urgent new planning is to improve the governance of harbours from a sustainable perspective. This means, for example, implementing directives aimed at the use of low-sulphur diesel for ships or encouraging the use of renewable resources in the ports. On the other hand, the role of ports could become very important «in launching a smart sustainable development model» when «the port's economic, logistic and industrial activities combine with a cultural heritage regeneration» (Fusco Girard, 2013, pp. 4330). Unfortunately, Greco (this issue) describes a rather different situation; in a two-speed Europe with a deep divide between the ports of Northern Europe (usually more competitive and decarbonised) than those of the Mediterranean basin, the Italian harbour system presents an even more complex framework. If the recent planning tools (i.e., the 2015 National strategic plan for ports and logistics) have started several activities toward sustainable development (for example, the use of biofuels or LNG as marine fuel inside ports), their current governance is unable to compensate for the differences still existing at a national level.

At the same time, the governance of the energy transition has further geographical challenges tied to landscape quality and preservation. The reorganization of the electricity sector introduced a new figure, the «prosumer»: often, a household (or organization) produces surplus fuel or energy and feeds it into a national distribution network (the owners of PV panels on roofs, for instance). While this implies a greater democratization of energy, on the other hand, it deeply changes the geographic perspective on the territorial effects of new power plants, such as ground-mounted PV systems or wind farms (Mauro, 2019). While until a few years ago, geographical research mainly examined the environmental impact of the large energy infrastructures such as, for example, the dams in the Alpine region (Battisti, 2004), today we talk about a new kind of landscape, called the «landscapes of energies» (Nadaï and van der Horst, 2010). As well pointed out by Ferrario, Puttilli, and D'Angelo in the last paper of this issue, the tensions surrounding new projects or new power renewables plants are often due to a vision of the landscape that concerns its intangible aspects (for example, the intrinsic and symbolic significance of a place), overcoming a purely aesthetic vision of landscape. From a detailed analysis of several regional landscape plans and the national plans for energy, the authors try to understand how this geographic theme is dealt with in current Italian energy policies. Although there is greater landscape awareness than in the past, the hope suggested by the authors of a «landscape as a tool for the governance of the energy transition» still seems far off in current Italian spatial planning.

3. A new role for the Geography of Energy?

In this issue we attempt to cover the main research topics of the geography of energy in order to understand the current energy questions at a global and regional level, such as the new scenarios of production, the renewables outlook, and the new role of spatial planning in the present long-term energy transition.

Even if we still live in a fossil fuel era, we are increasingly aware that the only possible choice for a sustainable future is a return to renewables. The papers of this issue deal with quite varied topics, but there is a growing interest in issues related to environmental policies and the governance of our changing world. Many relevant geopolitical questions, mainly related to fossils and their role in the near future, are still pending. We are still debating the «real» potential and the objective limits of renewables. However, the main current challenge of the geography of energy is probably how to properly manage the territorial changes that each energy transition brings about (Puttilli, 2014). Regional policy makers are often faced with land issues determined by recent climate policies. The consequences due, for example, to de-industrialization of the coal mining regions or the construction of new renewable installations (such as ground-mounted PV systems or wind farms) must take account of the resulting demographic, economic, environmental, and social problems. Loss of population, poor economic competitiveness, land takeover, or identity problems could become key issues in the energy planning arena.

As thirty years ago (Battisti, 1993, p. 5), even so today (maybe, especially today!) «geographers want to have their say» about these issues that are so important for local, national, and international policies. Especially now, in the *Next Generation EU* age, «the time for debate» on the best decarbonisation strategy, geographers certainly need to be involved. Therefore, there are still great opportunities for further studies and case studies in this area to focus on the geographical issues of the current energy transition.

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Notes

[1] At the beginning of the nineteenth century, global primary energy consumption was around 5,650 TWh, while today (2018) it is 157,063 TWh (Ritchie, Roser and Rosado, 2020).
[2] It means that the EU greenhouse gases will have to fall to a net-zero level by 2050. Any surplus of emission will have to be so low that forests, wetlands and perhaps technology can absorb it.
[3] A wind (or photovoltaic) farm is a group of wind turbines (or several solar PV panels) in the same place to produce energy.
[4] Coal mining increased from 10 Mt in 1810 to 1 Gt in 1910, peaking at 8.25 Gt in 2015; the crude oil extraction rose from less than 10 Mt in the late 1880s to 3 Gt after a century and it reached 4.4 Gt in 2015; finally, natural gas production raised from 2 Gm^3 in the late 1880s, to 2 Tm^3 in 1990 until 3.5 Tm^3 in 2015 (Smil, 2017).
[5] The Energy Returned on Energy Invested (ERoEI) Index «is simply the energy gained from a unit of energy spent in the process of obtaining energy» (Lambert and others, 2014, p. 154). It changes over time for different reasons (technological progress, price volatility, market conditions etc.), but it could be applied to the energy sources to measure their energy efficiency (or convenience).
[6] As well known, the debate about peaks of fossil fuels is open. For instance, Ricci (2010) refers about the oil peak in 2008, the gas peak in 2025 and the coal peak between 2020 and 2025. On the other, Maggio and Cacciola (2012) predicted as value 30 Gb/year in 2015 for oil, 132 Tcf/year in 2035 for natural gas, and 4.5 Gtoe/year in 2052 for coal (Gb: Giga or billions of barrels; Tcf: Trillions of cubic feets; Gtoe: Giga or billions of tonnes of oil equivalent). Instead, British Petroleum (2019b) estimates the oil reserves in 1,730 billion barrels (while in 1998 they were 1,141 billion barrels). The same for natural gas: the proven reserves were 130 Trillion cubic meters (Tcm) in 1998, whereas now are estimated in almost 200 Tcm. At the current production to reserves (P/R) ratios, proven reserves of oil and natural gas are sufficient to supply more than 50 years of demand, but in the near future the role of gas could be central (Grandi, 2017). Cheap and plentiful coal, globally estimated in about 1,055 billion tonnes in 2018 (like twenty years ago), at current P/R ratio ensure more than 130 years.
[7] Actually, this means a great improvement in respect of 2000 when people having access to electricity was the 7.9% of the world population (IEA, 2019b).
[8] The reserves of oil are mainly located in Venezuela (17.5% of global reserves), Saudi Arabia (17.2%), Canada (9.7%), Iran (9.0%) and Iraq (8.5%). Russia (19.8%), Iran (16.2%) and Qatar (12.5%) are the countries with the biggest reserves of natural gas. US (23.7%), Russian (15.2%), Australia (14%), China (13.2%) and India (9.6%) lead the global distribution ranking of coal (Ricci, 2010; BP, 2019b). For global reserves values of oil, natural gas and coal (estimated by BP, 2019b) see note 6.
[9] As well known, BRICS is an acronym for the five major emerging countries, namely Brazil, Russia, India, China and South Africa.
[10] Actually, in many low-income countries a significant share of biomass consists of residual woody matter from small tree groves or bushes, from tree plantations (i.e., rubber, coconut

etc.) and from roadside and backyard trees usually gathered by women and children (Smil, 2010).

[11] The global installed wind capacity rose from 121 GW in 2008 to 591 GW in 2018 (GWEC, 2019), while the global installed solar capacity from 16 GW in 2008 to 509 GW in 2018 (SPE, 2019).

[12] In 2017, the global generation of wind energy was 1,134,493 GWh, while for solar PV it was 437,360 GWh (GWEC, 2019; SPE, 2019).

[13] Mainly due to the large use of wood biomass, the relationship is the following: low-income country, high percentage of renewable energy consumption and vice versa.

[14] Brazil and Croatia are not OECD (Organisation for Economic Co-operation and Development) countries.

[15] As well known, the Renewable Energy Directive 2009 (2009/28/EC) set the levels of renewable energy use to achieve to the target of 20% of energy consumption produced from renewable energy sources by 2020.

[16] Italy drew up its first national plan in 1975 as a consequence of the international oil crisis. The last one dates back to 1988, when renewable energies were not even considered.

[17] The PNIEC includes several other green targets like, for example: a strong reduction in energy consumption (-43% compared to 2007) through energy efficiency; a strong reduction of greenhouse emission from industries or other (-43% compared to 2005 for energy-intensive industries; -30% compared to 2005 for sectors such as transport, residential, tertiary, agriculture, and waste).

[18] According to the third IMO Greenhouse Gas Study 2014, the average global greenhouse gas emissions from maritime transport in the period 2007-2012 was 2.4% of global emissions (IMO, 2015).