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MED & Italian Energy Report

Energy sources, flows and strategies of Italy between Europe and the Mediterranean

1st Annual Report

2019

In cooperation with
Joint Research Center of the European Commission
regarding the analysis of natural gas infrastructure
and security of supply

MED & Italian Energy Report

Energy sources, flows and strategies of Italy between Europe and the Mediterranean

Annual Report 2019

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SRM and the Department of Energy of the Politecnico of Turin take full responsibility for the overall design of this work and for its coordination. Nonetheless, it is the individual authors who take responsibility for the data, analyses and information shown in each chapter. Contributions are as follows:

- Chapters I-II: Consuelo Carreras and Luca Forte;
- Chapter III: Marco Zigon;
- Chapter IV: Ettore F. Bompard, Stefano Corgnati, Daniele Grosso, Francesco Profumo, Enrica Raheli, Alys Solly, Sergio Giaccaria, Marcelo Masera, Nicola Zaccarelli;
- Chapter V: Piero Boccardo, Ettore F. Bompard, Stefano Corgnati, Daniele Grosso, Francesco Profumo, Enrica Raheli, Sergio Giaccaria, Marcelo Masera, Nicola Zaccarelli;
- Chapter VI: Anna Arianna Buonfanti;
- Chapter VII: Olimpia Ferrara;
- Chapter VIII: Riccardo Fuochi.

See. page 213 for more specific information about the authors.

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Preface

I am honoured to present the first Annual Report on Med & Italian Energy as I believe this represents a clear sign of the fact that topics related to the energy sector have been included in SRM's regular research activities, which is a sign of this sector's significant economic importance in the Mezzogiorno and in the whole of Italy, where investments could further develop.

The competitiveness of a country depends not only on its ability to adopt a corporate attitude and make a name for itself on the market with products and services, but also on its know-how in sectors like energy and maritime logistics, which represent costs for companies while playing the role of drivers of growth calling for increased efficiency and higher quality. It is exactly on these two that SRM has decided to concentrate its efforts and invest its resources by creating two specific observatories with top-level partners.

It is precisely on energy, in fact, that SRM works jointly with the Department of Energy of the Politecnico of Turin and more specifically with ESL-Energy Security Lab, a centre boasting significant know-how in the sectors of Energy and Maritime Logistics. We are confident that this collaboration will add value to the research carried out by our centre which, on the other hand, is proud to hold significant experience and deep knowledge of the economic and maritime dynamics of the Mediterranean Area. Our main goal is to find partners to start research projects ultimately resulting in mutual benefit.

The first of the two threads running through this Report is represented by some analyses of the sector investigating the economic value, the European policies for energy, the emerging sectors and, last but not least renewable sources. The other thread is more concerned with the maritime sector which, in turn, is closely related to the energy. These two threads share the common vision that SRM and the Politecnico have of the Mediterranean as a key strategic area for a country like Italy aiming to become protagonist.

Pipelines, oil tankers and global Natural Gas chokepoints are mainly transported via sea and create connections, trade relations and widespread development. Even China, within its initiative called Belt & Road, has allocated resources to investments and infrastructure in the energy sector.

Therefore, we wish to embark upon this new adventure keeping in mind that one of the stepping stones to revamping our economy might be represented by investments in the sectors where our know-how is more solid or in other areas where prospects of development are particularly favourable in terms of technologic advances. It is precisely in this context that the energy sector needs to be valued.

Nevertheless, also in the energy sector and especially in business investments, Italy needs to streamline its bureaucratic system which now represents a serious issue for economic growth. It is also of utmost importance to clearly establish and communicate information about available funding to infrastructures through appropriate medium-long term planning. In terms of financing, the next EU resources from the 2021-2027 Agenda might represent a big opportunity, provided that they are used in the best way.

The Italian economy is one where great attention must be paid to the solution of structural issues that continue to affect growth. Nonetheless, nowadays these problems can only be solved through a strategic approach which takes into account the systemic and complex vision of the interventions and development processes that we aim to favour.

Finally, I would like to thank the whole research team for carrying out this important work representing SRM's contribution to the efforts of those who operate aiming for widespread and equal development of our territory and with the main goal of making our country increasingly more competitive, with the Mezzogiorno as a key player.

Paolo SCUDIERI

President of SRM

The context and the present (energy) situation

From the energy point of view, presently (2016 data[1]) the Mediterranean countries are characterised by a total primary energy supply (TPES) of 39.8 EJ (950.6 Mtoe), corresponding to about 7% of the world total, which in turn is equal to 576.2 EJ, mainly related to fossil fuels (31.0% for oil, 27.1% for coal, and 22.1% for natural gas). The same share (about 7% with respect to the global values) applies to the total final energy consumption (TFC) of the Mediterranean countries, accounting for 27.6 EJ.

The production of energy commodities in the Mediterranean area, however, is equal to just 3.9% of the global energy production (about 22.5 EJ), and it is not sufficient to fulfil the internal energy demand. This makes the Mediterranean region a net energy importer, with a total net import of 19.1 EJ, which can be compared with the total trade of energy commodity at global level of 230.5 EJ for import and 235.2 EJ for export (the difference is related to the stock changes).

This energy scenario corresponds to an area that comprises 23 countries (Gibraltar, Spain, Portugal, France, Monaco, Italy, Malta, Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Albania, Greece, Cyprus, Turkey, Syria, Lebanon, Israel, Egypt, Libya, Tunisia, Algeria and Morocco) facing around 2,500,000 km^2 of sea, crossing point of three continents: Europe, Asia and Africa. It extends over 8,516,704 km^2, corresponding to about 6.3% of the overall world surface. The area is currently (2017 data) populated by almost 517 million people, i.e. roughly 7% of the global population. This area has a total Gross Domestic Product (GDP) of more than 9,000 G$ (almost 12% of world GDP), the majority of which (more than 70%) is contributed from three European countries, France, Spain and Italy[2].

Energy and historical evolution of Mediterranean

The Mediterranean area historically played a key role in the evolution of the humanity, representing in fact one of the cradles of the global civilisation. The development of the ancient and classical Mediterranean societies has been accompanied and – to some extent – promoted by the exploitation of energy, which can be considered a crucial element for the survivability and the multiplication of the human species, and for its quality of life.

To exploit energy basically means to have available energy sources and to convert them into useful work. According to this concept, the Mediterranean civilisations arose and became protagonists thanks to the "biological" energy source, obtained from agriculture and cattle breeding, and to the conversion in useful work through human labour (often delegated to slaves) and animals.

[1] IEA. *IEA Statistics* [https://www.iea.org/statistics/].

[2] The World Bank. *Open data* [https://data.worldbank.org/].

In particular, the so-called "Fertile Crescent" (Mesopotamia, Levant and Egypt), due to the presence of the large fertile valleys of the four main rivers of the region (Nile, Tigris, Euphrates and Jordan) and of suitable climatic conditions, offered the possibility of a first significant development of agriculture, with the beginning of crops cultivation since about 10000 BC in the Levant area.

Furthermore, the presence of four of the most important domesticated animal species (cows, pigs, goats and sheep) allowed for the development of breeding: for instance, in the Mesopotamia area (spreading also over territories belonging to the Mediterranean zone, like those of modern Syria and Turkey) oxen were domesticated around 6000 BC, like pigs (11000 BC) and sheep (approximatively between 11000 BC and 9000 BC). Domestication of animals and breeding played a key role, as it permitted from one side to increase the availability of food (and especially of protein) – thus enhancing the availability of energy sources – and from the other side to increase the possibility of energy conversion (through animal power).

Examples of the utilisation of usable work produced by the two types of energy conversion above mentioned can be found in Egypt, where human labour was widely used for building cities and monuments while animal power provided by oxen was used to move plough for cultivations.

Besides "biological" energy sources, other two types of energy sources (wind and water) were exploited during ancient times in the Mediterranean area.

Egyptians were the first (followed by Grecians and Phoenicians) to actively use wind energy, mainly for navigation: this energy was, in fact, converted through sails in useful work for moving sailing boats, as documented since 4000 BC. This was a milestone that allowed for the development of modern navigation and of commerce and trade.

Wind energy has been also used in windmills, being converted into mechanical work used for grinding grain or drawing up water. Windmills were probably invented in Persia (the first references are dated 644 AD) and then spread in the Mediterranean area well before being introduced in continental Europe (in the 12th century).

More relevant than windmills, for the same purposes (converting energy into mechanical work usable for grinding grain or drawing up water) were watermills, which use water energy as source. The prototypes of watermills were waterwheels, probably invented in the ancient Near East (a region including Mesopotamia, Levant, ancient Egypt, ancient Iran, Cyprus, Anatolia, Armenian Highlands, and Arabian Peninsula) during the 3rd century BC, evolving into vertical watermill in Syria and Anatolia during 2nd century BC and then spreading to Greece and the Roman Empire. Descriptions of waterwheels have been provided by the Greek epigrammatist Antipater of Thessalonica and by the Roman architect Vitruvius in the 1st century BC.

One of the main advantaged of using wind and water energy and windmills and watermills as converters is the highest efficiency in comparison with the use of "biological" energy through human or animal conversion. For example, it has been estimated that a watermill for grinding grain could produce, in one hour, the same output of 40 slaves[3].

[3] Schobert H.H. (2014). *Energy and Society: An Introduction*, CRC Press, p. 720.

These energy sources and conversions thus allowed the Mediterranean area to become one of the three cradles of civilisation in Eurasia, together with the valleys of the Indus river, in the central-southern Asia (in the modern Pakistan) and of the Yellow river in China.

In particular, urban civilisations started in the Chalcolithic period ($5^{th} \div 4^{th}$ millennium BC) in the "Fertile Crescent" and was fed by the surplus of "biological energy" with respect to that strictly needed for survival. Civilisation significantly grew during the Bronze Age (started around 3300 BC), with the introduction of key innovations like writing systems (cuneiform script invented by Sumerians and hieroglyphs created by Egyptians), centralised governments and laws, social structure and classes, economy and embryonic development of science branches like mathematics and astronomy. This more structured organisation allowed for the establishment of the first Empires, like the Egyptian and Hittite ones, which dominated Eastern Mediterranean during the second millennium BC, and the Mycenaean kingdom, which was founded in the last phase of Bronze Age in Greece and that represented the first civilisation of Greece itself. The transition from the Bronze Age to the Iron Age showed the crisis of these empires and kingdoms and the rise of the Neo-Assyrian Empire and of Phoenicians. The last ones, in particular – located in the modern Lebanon and organised in independent city-states – were mainly relevant as allowed to involve in the civilisation process, through their commercial routes, not only the eastern part of Mediterranean area (as happened during the Bronze Age), but also the entire north-western African coast, the south of the Iberian Peninsula, Sicily and Sardinia and Corsica. Furthermore, Phoenicians introduced the alphabetic writing, which represents one the ancestors of modern alphabets. This paved the way to the Classical Antiquity, and to the rise of Greek city-states, to the Persian Empire, to the Hellenistic Empire (under Alexander the Great) and, finally, to the Roman Empire – that put the Mediterranean Sea ("Mare Nostrum", fully surrounded by territories belonging to the Empire itself) at its centre – and to the Byzantine Empire.

In the recent centuries, the paradigm changed: the main energy sources become fossil fuels (firstly coal and then oil and natural gas), while the energy converters are represented by machines (steam engines, internal combustion engines, turbines, etc.). The turning point is the "industrial revolution", started in Britain at the end of 18^{th} century and characterised by the introduction of steam engines and the related transition towards an economy based on fossil fuels, namely on coal, which is the key energy source for the entire first phase of the industrial revolution across the 19^{th} century. During the 20^{th} century, oil and natural gas progressively increased their role, with a sort of natural transition from more (coal) to less (gas) pollutant sources in terms of Greenhouse gas (GHG) emissions. In particular, the penetration of oil has been driven by the wide-scale diffusion of road transport, especially after the Second World War; it has been estimated that in the U.S. the primary energy consumption of oil overcame the primary energy consumption of coal before 1950.

Referring to the converters of energy into useful work, fossil fuels allow to convert thermal energy provided by the combustion of the fossil energy sources into mechanical work. In a steam engine, hot steam provided by a boiler, expands under pressure, and part of the heat energy is converted into work. In the internal combustion engines, the heat is instead generated inside the cylinder by ignition of a fuel-air mixture.

In steam turbines, steam is discharged at high velocity through nozzles and then flows through a series of fixed and moving blades, thus moving a rotor at high speeds[4].

The first steam engine of the history can be considered the aeolipile, described during the 1st century AD by Hero of Alexandria. However, the development of an improved version of the steam engine designed by Newcomen, carried out by James Watt between 1763 and 1775, is the energy converter that effectively opened the door to the industrial revolution. Its penetration allowed for the invention of new machine tools and for a relevant growth of economic activities, like mining (with an easier extraction of water from mines and the possibility of reaching greater depths), textile (with the introduction of power looms) and iron and steel manufacturing, significantly multiplying the productivity of those sectors. Steam engines also paved the way for the transport revolution, firstly with the development of railways (in the United Kingdom, in 1804, Richard Trevithick built the first working steam locomotive) and then – in the 19th Century – with the improvements in the maritime transport.

Furthermore, in the 19th century the penetration of electricity as energy commodity started. Electricity is a secondary energy source, as it derives from primary sources (like fossil fuels, but also nuclear and renewable sources) through a transformation process in power plants. In 1882 the first coal-fired power station was built in London, while in 1883 the Santa Radegonda station in Milan (one of the first power plants in Europe) began to produce electricity; in 1954 the Obninsk Nuclear Power Plant, in former Soviet Union, was instead the first world grid-connected nuclear power station.

These innovations, allowing for an increasing welfare and a circulation of people, goods, and ideas never seen before, led to essential social and economic changes that had a relevant impact on the development of modern society at global level, especially in the western world.

In this historical phase, however, the Mediterranean area has been no longer a protagonist, but rather has become more and more a sort of interface between the South, where resources of fossil energy (especially with reference to oil and gas) are located and exploited, and the North, where the energy conversion machines are installed and energy sources are consumed.

This situation still currently persists, with energy flowing along the direction South-North, from production to consumption areas, according to a sort of "energy interaction" among them that sometimes has been and is conflictual and critical under a geopolitical perspective, due to the strategic role that energy supply represents for the industrialised countries of the northern coast of the Mediterranean Sea, like Italy, Spain and France.

Energy systems evolution and energy transition

Energy plays a key role for the survivability and the multiplication of the human species, and for its life quality, despite an uneven allocation of resources and consumption worldwide, and also in the Mediterranean area.

[4] Encyclopaedia Britannica. *Steam engine* [https://www.britannica.com/technology/steam-engine#ref97834].

Nevertheless, the current world energy paradigm, strongly relying on fossil fuels, is no more sustainable. The limits of an energy system based on fossil fuels in terms of global warming, air pollutant emissions and resources depletion become more and more evident, requiring an energy transition that results – in a mid-/long-term perspective – in a shift from fossil sources to renewables.

In fact, from one side, the consumption of fossil commodities is responsible for the emissions of GHG leading to negative climate change phenomena due to global warming: the energy sector (including transport), in particular, accounts for two-thirds of total GHG emissions and for 80% of CO_2 ones[5] (in 2016, CO_2 emissions from fuel combustion accounted for 32.3 Gt). From the other side, the energy sector originates the largest part of air pollutant emissions at global level (more than 99% for nitrogen oxides and sulphur dioxide and about 85% for particulate matter 2.5)[6], which cause air and soil pollution and consequent critical impacts on the life of biological systems (plants, animals and humans). The potential further increase in energy consumption related to the expected contribution provided by the fast developing countries and, in the future, by the less fast developing countries that have to recover the gap could determine severe and unrecoverable effects if a radical transition is not undertaken in time.

Moreover, in the mid-/long-term fossil energy sources will be exhausted at the present consumption rate: current estimations for the Reserves/Production ratio at global level (i.e. the remaining lifespan of reserves if the production will continue at the present rate) are 50.2 years for oil, 52.6 years for natural gas and 134 years for coal[7].

Fossil fuels currently play a key role in the energy systems of Mediterranean countries: in 2016, the overall production of the Mediterranean area has been equal to 1,047 PJ for coal, 5,937 PJ for crude oil and 5,771 PJ for natural gas; 92.2% of crude oil and 87.6% of natural gas have been produced in North African Mediterranean countries, while 61.9% of coal has been produced in Turkey. Focusing on the final consumption of energy, oil products and natural gas show a major contribution, accounting for 46.7% and 20.4% of the TFC of the Mediterranean countries respectively; the three main European countries (France, Italy and Spain), in particular, jointly considered are responsible for 50.0% of the final consumption of oil and for 57.9% of the final consumption of natural gas in the Mediterranean region[1].

From the economic point of view, fossil fuels represent one of the main contributors to export in the country balance of southern Mediterranean Countries. For instance, in 2016 the three top exports of Algeria were gas (13.1 G$), crude oil (10.3 G$) and refined petroleum products (5.6 G$), accounting for 92.9% of the total export (31.2 G$). In Libya, instead, among the top exports crude oil, gas and refined petroleum products account for about 8.6 G$, corresponding to 95.2% of the total export. Considering importing countries, in Italy in 2016 the import of fossil fuels was of 35.5 G$, i.e. about 9% of the total import.

[5] IEA. *Climate change* [https://www.iea.org/topics/climatechange/].

[6] IEA (2016). *Energy and Air Pollution. World Energy Outlook Special Report*, IEA Publications, Paris.

[7] British Petroleum (2018). *BP Statistical Review of World Energy.*

A similar share can be found in Spain (9.5%), while in France is slightly lower (7.7%), mainly due to the role of nuclear in the national energy mix[8].

The above mentioned criticalities related to the exploitation of fossil fuels put into evidence the urgent and undeferrable need for an energy transition towards decarbonised energy and economic systems. The energy transition thus necessarily implies a shift from fossil commodities to renewables (wind, solar, hydro, geothermal, biofuels) as energy source. This shift, in turn, will involve significant modification of the entire energy chain, from production to end-uses (e.g. through the electrification of the final uses, coupled with an electricity generation from renewables), requiring the definition of proper supporting strategies and relevant investments to be implemented.

This process could not be obviously immediate, but it will take time (at least some decades) to be fully developed. For this reason, it can be expected that, in the mid-term, fossil fuels will continue to play a relevant role in the energy systems: in particular, natural gas – characterised by lower emissions with respect to coal and oil – could be helpful in reducing GHG level in comparison with the current situation, thus accompanying, in this first phase, the transition towards renewables.

The structural relevance of energy in the society and economy of the Mediterranean area and the incipient energy transition make evident the importance of monitoring the evolution of energy scenarios in terms of sources, corridors (both captive and open-sea), trades and final uses of energy with respect to the fundamental goals related to environmental sustainability, efficiency, economic affordability and energy supply security.

Integrating the social dimension into energy system

Science, technology, engineering and economics have played a strategic role in shaping energy policies while social and humanity sciences historically have played a minor role. But today a broad approach is growing consensus because building the social acceptability of some energy policies (i.e. limitation in the use of individual cars) or pushing behaviors and consumption patterns (i.e. energy saving) is an essential and crucial part for the success of energy transition and decarbonisation.

Moving from individual behavior to international level, also geo-politics and geo strategic analysis, are more and more important to understand the global impact of the different national energy policies and their evolution.

Incorporating this social sciences approach in energy researches, especially when the scale of the analysis is the Euro-Mediterranean perspective, is essential in order to develop a more holistic view.

Energy is a global issue, but the impact of energy policies is not equal for all people. Some populations are more vulnerable to the effects of energy choices than others. Energy decisions have economic, social, and environmental consequences. Poor, marginalized, or underdeveloped populations can most benefit from positive consequences and are the most susceptible to negative consequences.

[8] The Observatory of Economic Complexity. *Country profile* [https://atlas.media.mit.edu/it/profile/country].

Moreover, the world is strongly dependent on a finite supply of fossil fuels. Increasing demand for limited supplies of fossil fuels affects quality of life. As demand increases and supply becomes scarce, the problem increases more and more, with severe economic and social consequences.

In addition, access to energy resources affects quality of life too. Access to energy resources, or lack of them, affects human health, access to education, socioeconomic status, gender equality, global partnerships and environment.

Individuals and society, at national and international level, continuously make energy choices that have both political, environmental and economic consequences. A better mainstreaming of social sciences and humanities into energy policies still is (and will become more and more in the future) a crucial component to take into consideration in energy analysis and researches.

Why a focus on Energy & Mediterranean

The Mediterranean area is characterised by a significant presence of fossil fuels, especially oil and natural gas, which are exploited and exploitable in the short/mid-term: in particular, referring to the production, coal corresponds to 0.7% of the world total, crude oil to 3.2% and natural gas to 4.5%; with reference to final consumption, instead, Mediterranean countries are responsible for 1.7% of the global final uses for coal, 7.9% for oil products and 9.3% for natural gas[1].

Nevertheless, the Mediterranean region could also allow a significant exploitation of renewable sources, like wind and – above all – solar. Estimations of the renewables potential in the Mediterranean quantified the technical potential for concentrated solar power (CSP) for the southern and eastern countries (Israel, Lebanon, Syria, Algeria, Egypt, Libya, Morocco, Tunisia, Cyprus and Turkey) in 424,204 TWh/y (with the highest contribution provided by Algeria and Libya), while for northern countries (Italy, Portugal, Spain, Greece and Malta) jointly considered the potential reaches only 2,216 TWh/y. With respect to wind, the estimated technical potential is equal to 21,868 TWh/y (mainly concentrated in Algeria and Egypt) for southern and eastern countries and to 648 TWh/y for northern countries[9].

Consequently, this potential could be exploited in a relevant way in the mid/long-term, also leading to a new energy flow across the Mediterranean Sea from South to North – through new interconnections (mainly power lines) – and to an economic flow from North to South. The change of paradigm with the enhancement of renewables penetration, in particular, will determine substantial modifications in countries belonging to the southern coast of Mediterranean, with crucial impacts from the economic, social and geopolitical point of view.

In this direction, in the past, projects and ideas like DESERTEC, promoted by the homonymous foundation established in 2009, have been proposed; it aimed at generating electricity from renewables in zones where they are more abundant, transmitting this electricity to main consumption areas through high-voltage direct current (HVDC)

[9] DLR. *MED-CSP. Concentrating Solar Power for the Mediterranean Region* [https://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6575/].

power lines. It firstly focused on solar energy and on the connection between the MENA (Middle East and North Africa) region and the EU[10].

Starting from these considerations, the emerging scenario makes the analysis and the monitoring of the Mediterranean energy system particularly relevant because of four main reasons.

The first reason is that the Mediterranean area is intimately related to fossil fuels, as both producer (African countries belonging to the southern coast) and consumer (mainly European countries belonging to the northern coast). The main producers of crude oil and natural gas are Algeria, Egypt and Libya. Referring to crude oil, in 2016 Algeria produced 3,043 PJ, Egypt 1,453 PJ and Libya 874 PJ. Considering instead natural gas, the majority of it is produced in Algeria (3,373 PJ in 2016), followed again by Egypt (1,244 PJ) and Libya (339 PJ). Focusing on the consuming countries, the three main European countries, i.e. Italy, France and Spain, are those with the highest TPES of crude oil (2,940 PJ for Italy, 2,767 PJ for Spain and 2,449 PJ for France). With reference to natural gas, in absolute value the most relevant TPES is still the one of Italy (2,432 PJ), but Egypt shows a value (1,877 PJ) higher than the one of both France (1,603 PJ) and Spain (1,048 PJ), while comparable values can be seen for Turkey (1,602 PJ) and Algeria (1,451 PJ)[1].

The second reason is that the Mediterranean area supplies and transfers energy towards central and northern Europe. In this sense, interconnections like the TAL oil pipeline, starting from the Trieste oil port in Italy and running for 465 km to Ingolstadt, in Germany, with an annual capacity of about 45 million tons, and the reverse flow for natural gas between Italy and Switzerland (Passo Gries) and between Italy and Austria (Tarvisio) – allowing for gas export (up to 40 mcm/d) towards the markets of Switzerland, Germany (up to 22 mcm/d), France (up to 9.5 mcm/d), Belgium, the Netherlands and Austria – can be mentioned.

The third reason is that the Mediterranean region can play a role as "energy highway" for flows coming from other areas and directed to Europe and to the world. For instance, currently Mediterranean countries import more than 160 bcm/y of natural gas coming from areas located outside the Mediterranean region, mainly from Russia, which covers about 43% of these imported flows[1,7,11,12].

In addition, the Mediterranean is a privileged seaborne route for energy flows. 30% of world oil and almost two-thirds of all the other energy resources – including those transported by pipelines – transit through this basin directed towards Italy and the other European countries. In this context, the Suez Canal is a transit route (chokepoint) crucial for the transport of oil and natural gas from the Gulf to Europe and to the North America. The Canal, in 2015 object of an expansion that allowed the passage in both directions of "giant ships", reducing the overall transit times, holds 9% of global seaborne oil trade and 9% of LNG.

[10] DESERTEC [http://www.desertec.org/].

[11] IHS Markit (2018). *Algeria, Egypt, France, Greece, Israel, Italy, Spain, Turkey: LNG Market Report*.

[12] Eurostat. *Statistical Database* [http://ec.europa.eu/eurostat/].

In addition, benefiting from the crucial role of Suez, another strenght of the Mediterranean Sea is the presence of a fairly large number of fields, in particular oil and gas, concentrated mainly in some countries on the Southern side that are among the major producers worldwide, and mainly addressed to the North side.

Italy has a strong interest in these transits. It is well known that our country has a high energy dependence on foreign countries: the ratio between net oil imports and the domestic consumption shows an Italian subordination of 77%, a value higher than other European countries. Regarding to natural gas, this percentage reaches 90%. Italy, for its strategic position, can play a link role between North Africa and Central Europe, in fact, it is often directly involved in the development of new pipeline projects as well as in their construction. In this sector, ports play a role of 71% of imported oil transits by ship while 25% through is conducted though pipelines. Furthermore, there is a close correlation between ports and refineries where the crude is refined, to be then allocated to the internal market or to re-export. For Italy, liquid bulk cargo is the most important type of goods in terms of tonnes and therefore it is very strategic with high revenues for ports. According to the latest available data, with a clear prevalence of imports, around 188 million tons have been handled by the Italian ports.

ENEMED approach

SRM and ESL@Energy Center are planning and implementing a project for an annual survey on Energy & Mediterranean; the project foresees the development of ad hoc science-based methodologies able to dynamically track along time the evolution of the energy system in the Mediterranean area and to assess the different impacts of this evolution.

This approach implementation is ongoing, and consequently the current version of the report is more like a manifesto that contains the seeds of the proposed methodology than the first issue of the foreseen annual analysis. The overall goal of the project is, in fact, to implement a tool that could allow to accompany the energy transition in the Mediterranean region, providing a picture of primary energy supply, final uses and energy transfers through captive (oil and gas pipelines, power lines) and open sea (maritime routes) corridors, with a special focus on Italy and the energy interconnecting European and non-European areas (import / export countries and countries crossed by energy corridors supplying Italy). The port-logistic and maritime approach will play an important role in the analyses carried out on this new Energy Project.

In particular, the study focuses on the following aspects of the energy system: the Total Primary Energy Supply (TPES), referred to the main energy commodities (oil, natural gas, solid fuels, electricity, renewables) and taking into account local production, trades and stock changes, the total Final Consumption (TFC) required by the end-use sectors for the fulfilment of the services demands (like residential space heating and cooling, industrial production, passengers and freight mobility, etc.), the energy exchanges, through both open sea and captive energy corridors, and mainly their economic impacts, with environmental and geopolitical issues on the background.

The analysis involves the most relevant dimensions, i.e. the physical energy flows, taking into consideration the main items of the national energy balance (supply, transformation and consumption), with a focus on the energy trades and a particular attention to the seaborne flows, the economic impacts of these energy trades, in terms of effects on the GDP, the geopolitical implications, mostly related to the composition of the national energy supply and to the effects on the energy security, and the environmental implications, related to the national energy mix, to the contribution of fossil fuels and renewables and to the level of GHG and air pollutant emissions.

The tool will be based on a new conception of science-based think-tank developed around the ESL@Energy Center lab and SRM, which links vision and technology in order to provide a science-based support to different types of stakeholders.

The stakeholders include supranational bodies, international organizations, policy decision-makers, research and academic institutions, companies related to production, transmission and distribution of energy, industries, think-tank, banks and financial institutions. Each of these stakeholders could provide specific instances or share common instances with other stakeholders.

The goal of the proposed vision is to create a link among data, numbers, words and signs, in order to provide a perspective view of the Mediterranean energy system as much integrated and holistic as possible. In particular, data includes all the numerical information related to the physical, technical and economic dimensions of the energy systems, taken from different datasets and elaborated for building suitable and usable information, stored in a database. Numbers include the numerical analyses and models (planning, optimisation, contingency management, risk, economic and environmental impacts, etc.) performed starting from the information included in the database. Words are related to the qualitative aspects (like the geopolitical and social ones) that, even if not directly measurable, can be associated to numerical quantities thus allowing to include them in the overall analysis and to design specific scenarios. Finally, signs are constituted by geomatic representations (as maps and satellite images) of energy infrastructures, data and quantitative results, thus taking into account the spatial and geographical dimension of energy systems. This integrated perspective could therefore allow to build tools able to consider the multilayer nature of energy.

In order to implement this vision, ad hoc technical solutions are adopted. In particular, raw data from datasets are transformed in useful information through an Open Source Intelligence approach and the use of data injection techniques and stored in a relational database, then validated in order to ensure its full consistency. Specific algorithms are developed and applied for performing numerical analyses and elaborations, using data from the database as input. Furthermore, a web interface allows the user to visualise (also in a georeferred way) the obtained results, to perform specific queries to the database and to define scenarios to be analysed, with a "live" interaction between the user itself and the tool. Finally, the outputs can be made available in both a static form, as reports, tables, charts and maps, and a dynamic form, by adopting computational narrative techniques, created through computation notebook systems.

Volume guideline

The analysis involves the most relevant dimensions of the energy system, starting from the world energy trends, and providing a picture of the main aspects of the energy system in the Mediterranean area, with a brief mention of the European context and a focus on Italy and the energy interconnected European and non-European areas. The study focuses on the role of fossil fuels with particular attention to the natural gas, one of the main commodities for global energy systems and a key sources for the power system flexibility. It analyses the flows inside and towards the Mediterranean area, the perspectives and the possible scenarios. In order to respect the maritime strategic vocation in the analysis approach to the energy flows, the study deepens the major seaborne trade routes of the oil and gas flows; providing in particular an overview of Singapore's leading role in the energy sector, which is mainly linked to its characteristic of global bunkering hub; and giving a framework of Chinese investments in the energy sector under the Belt and Road Initiative.

The analysis path unfolds through these contents and has been structured into 8 chapters.

The *first chapter* analyses the main global trends and deepens the challenges of the energy transition in a scenario in which the trade-off between growth and sustainability is becoming increasingly central. It starts from a global vision on economic, social and energy trends, providing a picture of needs, production dynamics, investments in fossil sources (oil & gas, coal) and in renewable ones. Some topics touched: world energy demand, growth forecasts, the role of China in the world energy transition, the shale revolution in the USA, the explosion of LNG demand. Then it focuses on the MENA (Middle East & North Africa) countries, where there are over 51% of the world oil reserves and over 44% of the natural gas reserves, in order to illustrate data on the production, available reserves consumption and trade of energy products.

The goal of the *second chapter* is to focus on the national dimension of energy trends. After a brief mention of the European Energy strategy and of the role of energy as a key element of the European competitiveness program, the study analyses some special aspects of the energy system in Italy. In particular, the chapter provides a picture of the mix of electricity generation and energy security in Italy, its level of energy dependence in comparison with the level of the principle European countries, the National Energy Strategy, and in conclusion a territorial analysis on production and consumption with an overview of renewable sources.

The *third chapter* involves the centrality of electric infrastructures to sustainable development. The strategic character of energy supplies makes efficient infrastructure crucial to government and supranational institutions. The "non-storability" of electricity undoubtedly requires – alongside the development of storage technologies as a medium-long term response – the creation of a sufficiently extensive and reliable power grid infrastructure (supergrid), which is able to meet both the growing domestic needs of producer countries and to export the surplus energy to the Northern shore of the Mediterranean. The quality of electric grids seems to be strategic to the growth of non-developed areas as low efficiency of infrastructures appears to be one of the factors that discourage industrial investments.

Also, an efficient electric grid represents a necessary mainstay for advanced economies, where the slowdown of production processes caused by macro and micro interruptions results in a disadvantage for the whole competitive system.

With the *fourth chapter* we enter the relevant dimension of the natural gas flows, providing an overall picture of the current situation in the Mediterranean region, in terms of production, trade among countries, total primary energy supply and total final energy consumption by sector. Furthermore, the main gas pipelines and LNG liquefaction and regasification plants are considered and described, and the diversification of gas supply for all the analyzed countries is assessed. This allows, in particular, to estimate the role of the Mediterranean area with reference to natural gas supply to Europe, and to highlight the possibilities for future infrastructural investments able to guarantee the implementation of a more connected European gas network and to support the evolution towards a really integrated market.

Gas resources are still the core of the *fifth chapter*, which provides an overview of the major Mediterranean gas fields and of their potential, and it analyses the possible new infrastructures (like the EastMed, IGI Poseidon, IGB and TAP pipelines) that could play a major role in the next decades, impacting on the gas supply composition of Europe, eventually lowering the import dependency from Russia and enhancing the diversification and, consequently, the energy security. Furthermore, the effects of these future perspectives on Italy are discussed through a scenario analysis, investigating, in particular, the possibility for Italy itself of becoming a natural gas hub for Europe.

The maritime approach to the analysis of energy flows opens with the *sixth chapter*. In this chapter a perspective is provided on the main data related to the major seaborne trade routes of the energy flows, with an in-depth analysis of port traffic as well as of transits through big canals. The chapter also contains a deepening on the economic phenomena that affect the global seaborne oil and gas flows. In our country ports are a platform for the energy serving the continent and the entire Mediterranean. Suffice to say that in 2017 liquid bulk traffic of Italian ports reached almost 200 million tonnes (37.5% of the overall goods traffic) with a 3.3% increase on 2016. Southern ports account for 47.4% of the country's total for this kind of traffic. Additionally, it needs to be pointed out that there is a new and impressive impact of new fuels for ships such as LNG, a type of fuel used by many megaships currently in the order book.

The *seventh chapter* aims to provide an overview of Singapore's leading role in the energy sector, which is mainly linked to its characteristic of global bunkering hub. This country is located near the Strait of Malacca, a strategic chokepoint for maritime traffic and in particular oil flows to/from the Far East. This geographic position in the vicinity of the second most important oil chokepoint in the world has allowed Singapore to become a pivot of global maritime traffic. The port, in fact, has played a key role in the development of the country and with time it has also boosted the high-tech manufacturing sector, financial services and tourism which have also benefited from state-of-the-art and efficiently running infrastructure. This has improved Singapore's competitiveness and has made it one of the most important hubs in the world. It was precisely the bunkering activity, as highlighted in the chapter, that improved development perspectives for Singapore and helped make this port one of the most important in the world.

Therefore, this chapter also highlights the different activities that are carried out in the port and that are somehow connected to the refueling procedure.

The *eighth chapter* provides a framework of Chinese investments in the energy sector under the Belt and Road Initiative in order to fulfill the 4 pillars defined in the BRI overall strategy: 1. Promoting energy cooperation with the aim of creating a community of interests, responsibilities and destinies; 2. Upgrading the safety of regional energy supplies and improving the distribution of energy resources; 3. Integrating regional energy markets; 4. Developing green energies with low carbon emissions.

Massimo DEANDREIS
General Manager of SRM

Ettore F. BOMPARD
Director of ESL@Energy Center

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Piero BOCCARDO, Professor of Topography and Cartography at the Interuniversity Department of Regional and Urban Studies and Planning of Politecnico di Torino and Director of the ITHACA centre *(Chpt. V)*

Ettore F. BOMPARD, Professor of Power System at the Energy Department of Politecnico di Torino and Director of the ESL@Energy Center Lab, Politecnico di Torino *(Chpts IV-V)*

Anna Arianna BUONFANTI, Senior Researcher, Maritime Office, SRM *(Chpt. VI)*

Consuelo CARRERAS, Senior Researcher, Energy Office, SRM *(Chpts. I-II)*

Stefano CORGNATI, Professor of Building Physics and Environmental Quality at the Energy Department and Vice-Rector for Research of Politecnico di Torino *(Chpts. IV-V)*

Massimo DEANDREIS, General Manager, SRM

Olimpia FERRARA, Head of Maritime Office, SRM *(Chpt. VII)*

Luca FORTE, Head of Statistics and Periodic Reports Office, SRM *(Chpts. I-II)*

Riccardo FUOCHI, Chairman Italy-Hong Kong Association, Chairman Propeller Club of Milan e CEO of Omlog *(Chpt. VIII)*

Sergio GIACCARIA, Scientific/project officer at the unit "Energy Security, Distribution and Markets" of the Directorate "Energy, Transport and Climate" of the Joint Research Centre of the European Commission *(Chpts. IV-V)*

Daniele GROSSO, Post-doc research fellow at the ESL@Energy Center Lab, Politecnico di Torino *(Chpts. IV-V)*

Marcelo MASERA, Head of the unit "Energy Security, Distribution and Markets" of the Directorate "Energy, Transport and Climate" of the Joint Research Centre of the European Commission *(Chpts. IV-V)*

Alessandro PANARO, Head of Maritime & Energy Dept., SRM

Francesco PROFUMO, President of Compagnia di San Paolo and professor of Electrical Machines and Drives at the Energy Department of Politecnico di Torino *(Chpts. IV-V)*

Enrica RAHELI, research assistant at the Energy Department of Politecnico di Torino *(Chpts. IV-V)*

Alys SOLLY, post-doc research fellow at the ESL@Energy Center Lab, Politecnico di Torino *(Chpt. IV)*

Nicola ZACCARELLI, Scientific/project officer at the unit "Energy Security, Distribution and Markets" of the Directorate "Energy, Transport and Climate" of the Joint Research Centre of the European Commission *(Chpts. IV-V)*

Marco ZIGON, Chairman Getra Group and Chairman Matching Energies Foundation *(Chpt. III)*

38/16, Via Paolo Borsellino – 10129 Turin - Italy
Phone: +39 011 090 8570
info-esl@polito.it
www.esl.polito.it
www.energycenter.polito.it

177, Via Toledo - 80134 Naples - Italy
Phone: +39 0817913758-61 - Fax +39 0817913817
comunicazione@sr-m.it
www.sr-m.it

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Currently fossil fuels are crucial for the Mediterranean region in terms of production, consumption and transfer toward Central/Northern Europe. Mediterranean plays a role of "energy highway" for flows coming from other areas and directed to Europe and to the world; 30% of world oil and almost 75% of all the other energy resources transit through this basin directed towards Italy and the other European countries. In the future, Mediterranean can play a major role in energy transition toward renewable energy sources. SRM and ESL@Energy Center are planning and implementing a project for an annual survey on Energy & Mediterranean, based on a new conception of science-based think-tank, integrating data analytics, numerical modelling, geo and socio-policy analysis and geomatics. The MED & Italian Energy Report 2019 is the first output of this joint effort. It considers three main points. The first one aims at providing a picture of the energy scenarios at different geographical scales: global level, Mediterranean region and Italy (in the European context), in terms of resources, production, trade and consumption of energy commodities. The second one analyses the energy corridors and infrastructures, focusing in particular on the role of electric infrastructures in supporting the sustainable development, on the present and future scenarios for natural gas production, trade and consumption in the Mediterranean region and on the analysis of the major seaborne trade routes and maritime transport of liquid bulk. The third one investigates the Chinese investments in energy infrastructures at global level along the Belt & Road.

SRM

Study Centre based in Naples, connected to the Intesa Sanpaolo Group, originally an intellectual and scientific safeguard, has the objective to improve the knowledge about Italy's territory in terms of infrastructural, productive and social assets with a European and Mediterranean vision in mind. Specialized in the analysis of regional dynamics, and with a particular eye on the Southern Italy, it runs two research observatories monitoring maritime transport, logistics and energy.
www.sr-m.it

ESL@Energy Center

ESL@Energy Center is a research laboratory located in Torino, at the Energy Center, an initiative by Politecnico di Torino, Regione Piemonte, Città di Torino, Compagnia di San Paolo and Fondazione CRT. The lab devoted to the development of scientific methodologies and tools for scenario analyses of energy systems and policy making support with respect to all the involved dimensions (technical, economic, environmental, and socio-political) and with a special focus on the energy security aspects.
www.esl.polito.it | www.energycenter.polito.it

The activity fits with a new proposed initiative, the Energy Transition Club Torino (ETCT). It is intended as dynamic think-tank that aims at allowing several players belonging to different areas (university, research, industry, economy, institutions, etc.) to meet together sharing common views and topics. The goal of the ETCT is to provide answers, in the area of energy, to the instances of different stakeholders through ad hoc science-based tools able to link several perspectives related to the energy systems that are being currently developed at the Energy Center in Torino, around the ESL lab.