University of Twente

Department of Governance and Technology and Sustainability (CSTM)

Master of Science in Environmental and Energy Management (MEEM)

Academic Year 2018/2019

Big Oil facing energy transition: implications, corporate strategies and role as incumbent regime companies

Final draft

August 30th, 2019

Giacomo Franco
s2208180, g.franco@student.utwente.nl

Supervisors:

- Dr. Frans Coenen
- Dr. Maarten Arentsen

Abstract

The biggest Western private Oil&Gas multinationals, collectively known as Big Oil or supermajors, have to face the implications of the energy transition, trying to balance different trade-offs in their corporate strategies. This final thesis both analyses these business strategies in detail and considers Big Oil companies' situation as examples of incumbent regime players, following the academic literature framework of multi-level perspective (MLP) and socio-technical transitions, which in fact divides the environment under study in landscape (exogenous context), regime (the established socio-technological system) and niches (the socio-technological innovations) levels.

The different companies developed different approaches, particularly depending on being based in Europe or in the US: a "Transatlantic divide" has actually emerged, given that the European supermajors show more relevant environmental and low-carbon commitments in their activities than the American companies. Even if all of them are still keeping investing mostly in upstream activities, indeed, common transition trends mainly include cutting emissions in their operations, refocusing to natural gas in their portfolio and, in particular for the European companies, especially diversifying their business towards biofuels and renewable energy sources.

However, as expected from the socio-technical transition and MLP literature, at the same time the supermajors still follow also a resistance strategy with regard to climate change-related energy transition, making use of several leverages to preserve their position as incumbent regime companies in the current energy system.

Both the reasons for the Transatlantic divide and the elements which will determine the future role of the Big Oil companies are to be found in landscape level factors identified in this study: the interdependencies with the political system and the action of market forces.

Keywords: Big Oil, energy transition, incumbent regime, Multi-level perspective.

Table of Contents

List of figures

List of abbreviations

$ – United States dollar
€ – Euro
CCGT – Combined Cycle Gas Turbine
CCS – Carbon Capture and Storage
CCUS – Carbon Capture, Utilization and Storage
CEO – Chief Executive Officer
CO_2 – Carbon dioxide
CPV – Concentrator photovoltaics
CSR – Corporate Social Responsibility
E&P – Exploration and Production
EPA – Environmental Protection Agency
ETBE – Ethyl tert-butyl ether
EU – European Union
EV – Electric vehicle
GW – Gigawatt
HVO – Hydrotreated vegetable oil
IOCs – International oil companies
IoT – Internet of Things
IRENA – International Renewable Energy Agency
LNG – Liquefied natural gas
LPG – Liquefied petroleum gas
MIT – Massachusetts Institute of Technology
MLP – Multi-level perspective
MW – Megawatt
NGO – Non-governmental organization
NOCs – National oil companies
NYSE – New York Stock Exchange
OGCI – Oil and Gas Climate Initiative
PLA – Polylatic acid
PV – Photovoltaics
R&D – Research and Development
R&M – Refining and Marketing
UK – United Kingdom
UN – United Nations
US or USA – United States of America
WW2 – World War II

1. Introduction

1.1. Background

The energy transition is defined as a fundamental structural change in the energy sector of a certain country (World Energy Council, 2014) or, more specifically, as “a pathway toward transformation of the global energy sector from fossil-based to zero-carbon by the second half of this century” by the International Renewable Energy Agency (IRENA).

The academic research has naturally developed instruments of theoretical analysis to understand all the implications of this process, and over the years the methodology known as multi-level perspective (MLP) “has emerged as a fruitful middle-range framework for analysing socio-technical transitions to sustainability” (Geels, 2011). The MLP (which will obviously be explained more in detail in the Methods section of this introduction) divides the environment of a socio-technical transition such as the energy and sustainability one into the landscape, regime and niche levels (Geels, 2002). Following this conceptual framework, it is reasonably easy to recognise the fossil fuel companies as prominent regime actors.

Therefore, the implications of the thus defined energy transition are particularly interesting for the companies commonly known as “Big Oil” or “supermajors”. These interchangeable terms refer to the 6 biggest Oil&Gas multinational private companies, meaning the major among the ones that are not state-owned (Ciura, 2019), which are: BP plc, Chevron Corporation, Eni S.p.A., ExxonMobil Corporation, Royal Dutch Shell plc and Total S.A. (in alphabetical order).

Facing the energy transition, these kinds of companies have to balance at least three trade-offs in their business strategies: maintaining their advantage position in their core business since fossil fuels demand is still rising, increasing investments in renewables and sustainability because of regulation, CSR issues and environmental responsibility, and respecting financial soundness and adequate profitability for reputation on the market.

Indeed, these private multinational supermajors are essentially exclusively subject to market constraints (other than to laws and regulations, obviously), unlike National Oil Companies (NOCs) like Saudi Aramco, Gazprom, Equinor, Petrobras and CNPC i.e. China National Petroleum Corporation (Tordo, 2010) which being (totally or majority) government-owned are typically chartered to work toward the interest of their home countries, paying revenues, taxes, and royalties to their parent government to drive the country’s economic development (Al-Fattah, 2013).

1.2. Goals and questions

The objective of this research is to analyse specifically the situation of the Big Oil companies in the energy transition scenario, following two levels of analysis:

1) at business level, identifying, investigating and comparing the corporate strategies of these companies for balancing and overcoming the energy transition-related trade-offs;
2) at the system level, assessing their role in the energy transition process as a whole as described by academic research, relying on multi-level perspective and socio-technical transition literature.

According to these two research objectives, the main research question will be followed by two different sub-questions. Overall, therefore, the thesis will try to answer this broad research question:

- Which are, both from a corporate and a system perspective, the role and the strategies of the companies known as Big Oil when facing the implications of the energy transition?

More particularly, the thesis will deal with two different but interconnected sub-questions:

1) Which are the business strategies of the Big Oil companies when facing the implications of the energy transition?
2) What is the role of incumbent regime companies like Big Oil in the energy transition according to the theoretical framework provided by socio-technical transition literature?

1.3. Approach and methods

In this paragraph, the thesis will be categorized using the framework provided by the book "Designing a research project" by P. Verschuren and H. Doorewaard (2010).

The overall working approach is basically desk research including both qualitative and quantitative considerations, with a depth view and of the literature survey type. However, consistently with the research objectives, the final thesis will try to answer the research questions in two separate but linked parts, with both specific methodologies and materials of different kinds:

- For the first part, relevant literature is mainly represented by corporate documents (such as investor presentations, sustainability reports, balance sheets and all the information disclosed in supermajors' websites), but also independent analysis by consultancy and NGOs, specialized press and very specific academic research. The detailed characteristic of this first part of the research are analysis and comparison of the corporate strategies for energy transition of each supermajor (and the reasons for the differences). So, the point of view is mainly empirical, and useful considerations were drawn by corporate documents which include many quantitative data, too.

- for the second part, a whole academic literature strand about multi-level perspective for analysing socio-technical transitions is available. Within this research field, the most appropriate and useful works are represented by the papers by Professor Frank W. Geels. The core characteristic of this part is the analysis of the position of incumbent companies like the Big Oil as identified in the socio-technical transition and multi-level perspective academic framework.

1.3.1. Research framework: socio-technical transitions and MLP

(Socio)-Technological Transitions are defined as "major, long-term technological changes in the way societal functions are fulfilled", and they "not only involve changes in technology, but also changes in user practices, regulation, industrial networks, infrastructure, and symbolic meaning or culture" (Geels, 2002). The "key of reading" developed by the academia for understanding and conceptualising how a socio-technical transition process actually works is represented by the multi-level perspective (MLP) which, in short, splits the relevant theoretical environment of a thus defined transition process in three parts:

- the landscape, an "exogenous context" (Geels, 2011) representing "the external structure […] for interactions of actors", or "a set of heterogeneous […] wider technology-external factors" like the broad political, social and economic system, but also "cultural and normative values" and "environmental problems" (Geels, 2002);
- the regime, namely the existing "routine based behaviours" or "semi-coherent set of rules carried by different social groups", meaning the (process and production) technologies, skills, procedures "that enable and constrain activities within communities" (Geels, 2002), and, by extension, the organisations which embody them, too;
- the niches, which are the (socio-technical) new entrants ("seeds for change") and the "incubation rooms" for their radical innovations, namely specific environments "protected or insulated from 'normal' market selection", that "provide locations for learning processes" and "space to build the social networks which support innovations" (Geels, 2002).

As shown in the figure below, the “technological trajectories” constantly cross these three levels (respectively known as macro, meso and micro), that however should not be intended as “ontological descriptions of reality”, but rather as “analytical and heuristic concepts to understand the complex dynamics of sociotechnical change” (Geels, 2002).

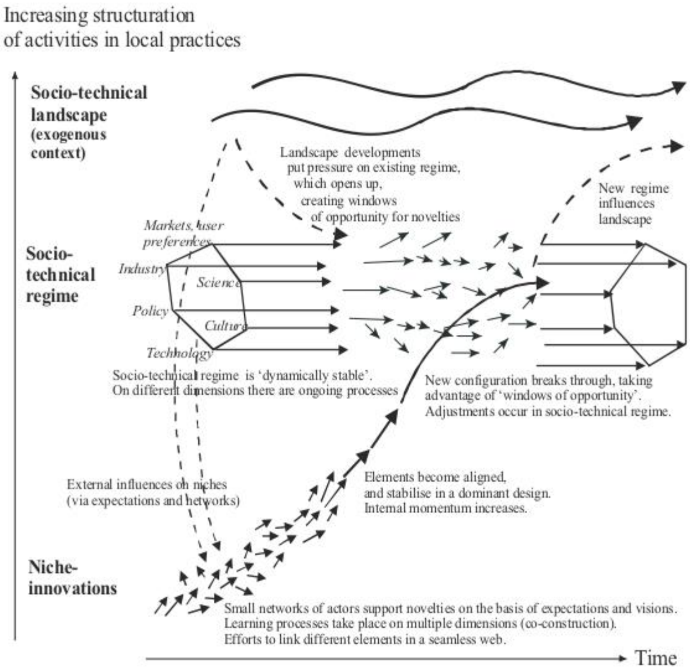

Figure 1 - Multi-level perspective on transition (Geels, 2011)

In parallel to the rise of MLP to “standard” academic framework for sustainability transition, the methodology has also “received constructive criticisms” (Geels, 2011), the most relevant of which, with respect to this thesis, are: the tendency to “neglect economic variables” (Foxon, 2011) and the determination of “socio-technical landscape as residual category” (Geels, 2011).

The first criticism points out that a “coevolutionary framework could incorporate insights from the multi-level transitions perspective, but, by using an explicit evolutionary framing, connect these to evolutionary economic understandings”, identifying “ecosystems, technologies, institutions, business strategies and user practices as key coevolving systems relevant for analysis of a transition to a sustainable low carbon economy” (Foxon, 2011).

The second criticism, instead, “can be made productive by reformulating it as a need for more theorization”, for instance drawing some suggestions like “the landscape concept can be made more dynamic”, or “more attention could be paid to landscape developments that help stabilize existing regimes” and, finally, “scholars could investigate the reverse causality and ask how regime shifts contribute to landscape changes” (Geels, 2011).

While obviously retaining MLP as main methodological tool for the theoretical part of this thesis, these criticisms represent useful cues for the topics covered here, too.

1.4. Outline

After this introductive chapter, the study, coherently with the two separate research sub-questions, will both go more in deep and address the research topic from a broader perspective, namely:

- in the first part, a brief historical introduction and schematic lineup of the Big Oil companies will be followed by the detailed analysis, comparisons and explanations of their corporate strategies for the energy transition;
- in the second part, the theoretical implications for the Big Oil as incumbent regime actors in socio-technical transition and MLP research framework will be assessed;
- finally, the last section will be dedicated to drawing new relevant conclusions related to both parts.

2. Part 1: Big Oil’s corporate strategies for energy transition

2.1. Introduction to the Big Oil companies

As previously mentioned, today the 6 Oil&Gas supermajors, which are the main and most important among the International Oil Companies (IOCs), are considered to be the following: British based BP plc and British-Dutch Royal Dutch Shell plc, American based ExxonMobil Corporation and Chevron Corporation, Italian based Eni S.p.A., and French based Total S.A. (OilNow, 2017). Oil production, revenues and profits of these Big Oil companies are shown in the figures below: financial performances of the supermajors clearly suffered from the drop in the global oil price of the last years, which started roughly in mid-2014 and lasted at least until mid-2017 (Markets Insider, 2019).

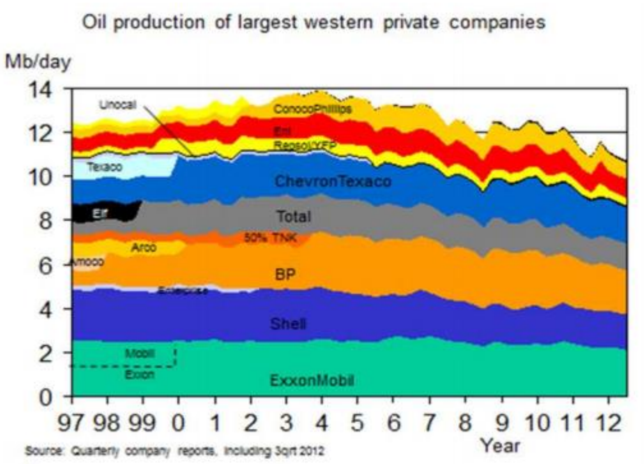

Figure 2 - Oil production of Western majors, 1997-2012 (Kohl, 2013)

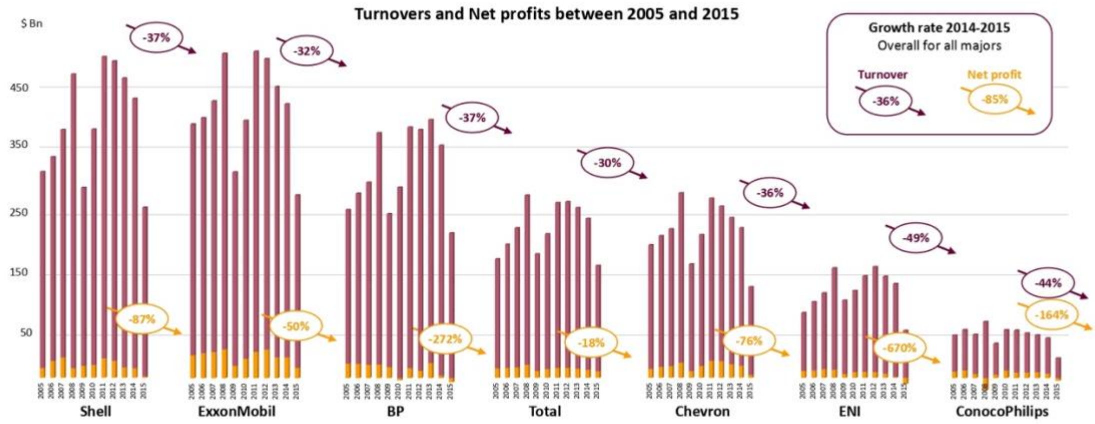

Figure 3 - Revenues and profits of Big Oil companies, 2005-2015 (De Lorgeril and Portenart, 2016)

The group can be restricted to 5, excluding the smaller Eni, or expanded to 7 or 8, including the American ConocoPhillips or Norway’s Equinor ASA, but for different reasons both of them are generally excluded: ConocoPhillips is not an integrated Oil&Gas company any more since it has spun off all the downstream activities in 2012 (ConocoPhillips, 2012), while Equinor is majority owned by the Norwegian Government with 67% of the shares (Equinor, 2019), and so it is usually listed among the National Oil Companies (NOCs) despite being a Western oil company.

In the '50s, Shell and BP (then Anglo-Iranian Oil Company) were among the "Seven Sisters", the most powerful oil companies in the world that formed the "Consortium for Iran" cartel, alongside the progenitors of what now are ExxonMobil and Chevron. The "Seven Sisters" designation was made famous by Enrico Mattei, the founder of then Italian State oil company ENI (Herold, 2017), who actually failed to mention an "eighth sister" which also was in that group: France's CFP, which was Total's ancestor. Today's Seven Sisters, according to the Financial Times, are instead the largest among the National Oil Companies, like Saudi Aramco, Gazprom and CNPC (Hoyos, 2007).

2.1.1. Overview of the Oil&Gas industry

For a complete and correct understanding of the energy transition strategies carried out by the supermajors, it is useful to briefly outline the core components of the typical value and supply chain of their core business: hydrocarbons.

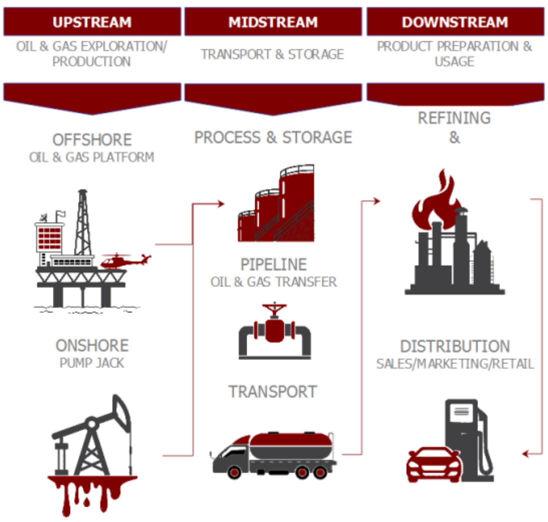

Figure 4 - Supply chain of the oil and gas sector (Davcheva, 2019)

As shown also in the figure above, the operations in the oil and gas industry are traditionally divided in three main sectors (Energy Institute, 2019):

- upstream, which comprises the phases, both onshore and offshore, of exploration for finding oil and gas reserves and of extraction of the hydrocarbons (these steps are indeed generally known as Exploration and Production, E&P);

- midstream, which focuses on the transportation and storage phases, involving infrastructures like oil and gas pipelines or the maritime services of oil tankers;
- downstream, which represents the final processing phases where the hydrocarbons are refined or transformed in chemical processes, and then distributed and sold to the consumers (Refining and Marketing, R&M).

Thus, a company is "integrated" in the Oil&Gas industry (like the 6 supermajors) if it includes to a varying extent all these components in its operations.

2.1.2. Brief history of the supermajors

BP was founded in 1909 by William Knox d'Arcy, as Anglo-Persian Oil Company, for exploiting a 60-year oil concession in Persia (today's Iran). It supplied the oil to British Navy in World War I and later to the Royal Air Force in WW2, gaining government's funding and ownership in return. It had expanded in Iraq when it was renamed Anglo-Iranian Oil Company in 1945, and then with many refineries across Europe and gas discoveries in the North Sea when it changed name again in 1954, as The British Petroleum Company. With the nationalization of the oil industry in many Middle East countries, British Petroleum focused on other areas with an acquisition campaign to the present day. The British Government sold all its stakes of the company by 1987. The company changed name again to BP in 2005 (BP, 2019).

Chevron's earliest predecessor, Pacific Coast Oil Co., dates back to 1879 in San Francisco, where it was incorporated for searching oil in California, USA. Standard Oil Company (California) was the result, in 1906, of the consolidation between PCO and Iowa Standard. Independent form its giant parent company Standard Oil since 1911, it kept expanding in California with new fields, refineries, pipelines and gas stations, becoming Socal (Standard Oil Co. of California), in 1926. With rising oil demand due to the world wars, Socal started searching for new resources beyond the US, expanding in Middle East, Latin America and South-East Asia and forming a joint venture with Texaco in 1936. Growing both in upstream and downstream activities, Socal then acquired Gulf Oil Corp. in 1984 and merged with Texaco in 2001, becoming the second US Oil&Gas company. It later changed name to Chevron Corp. in 2005 (Chevron, 2019).

On the initiative of Enrico Mattei, Eni was founded by the Italian Government in 1953 as "Ente Nazionale Idrocarburi" (ENI, National Hydrocarbons Authority), a re-establishment of its predecessor AGIP, dating back to 1926. The state enterprise initially focused on natural gas exploration in the Po Valley, later expanding in North Africa and Middle East and also towards nuclear power. Mattei died in a suspicious plane crash in 1962, but the company kept expanding the gas network in Italy as well as its upstream and downstream activities in Europe, Africa, US, Latin America and Asia, signing natural gas contracts also with USSR. Since the second half of the 70's, ENI was involved also in geothermal and solar power projects. In the 90's, ENI started its liberalization and privatization process (although, the Italian Government retains a 30% control stake in the company to date), listing at NYSE in 1995 and becoming Eni SpA. In 2001, the company gained the operatorship (later shared with other majors) of Kashagan field in Kazakhstan, one the biggest oil fields in the world. In the last decade, Eni discovered large offshore gas fields in Mozambique and Egypt (Eni, 2019).

ExxonMobil's first predecessor was the Standard Oil Company (Ohio) founded by Rockefeller and his associates in 1870, which later incorporated also Vacuum Oil Company, Jersey Standard and Socony. The conglomerate was then divided in 34 different companies by a US Supreme Court decision in 1911, but Jersey Standard kept expanding with acquisitions in Texas and introducing "Esso" as trade name for its fuels. On the other hand, Vacuum fuelled Pan Am's planes with its "Mobil" aviation fuel since 1958, and the company changed its name to Mobil Oil Corp. in 1966, followed by Jersey Standard which became Exxon Corp. in 1970. The two companies continued to introduce both upstream (like 3D oil-fields modelling) and downstream (synthetic motor oils) innovations in those years, and finally merged in 1999, forming ExxonMobil Corporation and achieving relevant Oil&Gas exploration accomplishments in the following decades (particularly in Qatar, Russia, Mexico and Guyana) (ExxonMobil, 2019).

Shell was born in London as import-export business in 1833, when Marcus Samuel started selling shells from the Far East. His sons turned to oil shipping in the 1880s, commissioning the first steamers able to carry oil in bulk and introducing the Shell brand. The company merged with the smaller competitor Royal Dutch in 1907, forming Royal Dutch Shell Group, which expanded in Europe, Asia and Americas and then fuelled the Allies in both World Wars. The post-war effort made Shell launch new exploration programmes in Africa and Latin America and build refineries in the UK. In the 1960s, Shell strengthened its position in Middle East (particularly Oman) and in Europe, with large gas discoveries in the Netherlands and the North Sea and diversification towards new growth areas such China and Russia, but also LNG, chemicals, coal and nuclear power in those decades. In 2005, the Group restructured unifying under a single holding company, Royal Dutch Shell plc, which kept the innovation and expansion pace with new exploration successes and, more recently, also renewables diversification (Royal Dutch Shell, 2019).

Total's predecessor, the Compagnie Française des Pétroles (CFP) was created on initiative of the French Government in 1924, to "develop oil production under French control in producing regions". The first oil interests of the company were in Iraq, with initial discoveries in 1927, and then in Morocco in 1929, when the company was listed in Paris, too. CFP's subsidiary for oil tankers started operating in 1931, while the company inaugurated its first refinery in France in 1933 and the pipelines from Iraq to French Lebanon and British Palestine in 1934. CFP kept expanding in Middle Est in the next years, and this process restarted after the sequestrations during World War 2. The Total fuel brand was first introduced in 1954, and its distribution network the following year. In the next decades, the company developed chemical and solar power research activities as well as global operations, opening branches and acquiring exploration interests in Europe, Africa, Asia and the Americas. The company changed name to Total CFP in 1885 and then to Total in 1991, when it was also listed at NYSE. In the 90's, the French Government reduced and then completely dismissed its Total stakes (1998). In the same year, Total merged with Belgian oil company Petrofina, creating Totalfina, and with Elf Aquitaine. The new TotalFinaElf group was later renamed Total in 2003, and further expanded globally acquiring some of ExxonMobil branches (Total, 2019).

2.2. Energy transition strategies of the supermajors

2.2.1. Common trends

As can be easily verified in the information disclosed by the oil companies in their corporate websites, the energy transition process has forced the entire Oil&Gas industry to develop some sustainability business trends, common in varying degrees to all the supermajors (but in particular to the European firms), which can be summarized as the followings:

- emission reduction and identification of natural gas (and LNG) as "bridge fuel" with consequent reconversion of reserves portfolios (upstream);
- expansion of biofuels and biochemical activities (downstream);
- global-range investments in renewables sources (especially wind and solar power).

In addition, other sustainable diversification business areas are represented by involvement in e-mobility, energy storage, smart grid and hydrogen technologies; carbon capture or reforestation projects, instead, usually go in parallel with the emission reduction targets.

While the first two points are related to incremental innovations and sustainable strategies within the traditional operations of the business model in the oil and gas sector, the last one and most of the ancillary activities listed above represent a diversification to the power sector: the business expansion of electricity generation and supply has always been quite common for many oil companies (as easily verifiable from their corporate websites, supermajors like Shell, Total, Eni and Chevron already ran gas-fired and CCGT power plants, while ExxonMobil has interests in cogeneration systems in its industrial facilities), but in all likelihood it is set to grow further, in particular for the European companies, with the implementation of renewable sources, digitalisation and of the innovations related to the power grid.

2.2.2. "Landscape" factors: the "Transatlantic divide"

The executive summary of a 2016 report by CDP (formerly the Carbon Disclosure Project), an NGO dealing with global disclosure of companies' environmental performance, highlighted a "Transatlantic divide" regarding environmental resilience of oil majors (also NOCs and smaller IOCs were comprised): the European ones were found outperforming their American counterparts on natural gas percentage of reserves, climate governance and strategy and low-carbon activities; even if such investments were "dwarfed by upstream capital expenditure" in all the oil majors (Soliman et al., 2016). This concept has been later analysed more in detail to understand the reasons for this divide.

The most interesting explanation (and the most relevant for the aims of this study, too) had been already developed previously, examining companies' reactions to the 1992 Kyoto Protocol, and it regards "company-specific factors, particularly corporate histories of profitability and location, market assessment, degrees of centralization and the presence of climate scientists" (Kolk and Levy, 2001, as cited in Andreasson, 2018). Indeed, these considerations not only fully apply also to the current situation of the Big Oil companies, but they highlight the importance and the influence of the landscape level for the transition processes, too: all these elements are, in fact, related either to both the landscape and, obviously, the regime level or to one of them.

In particular, the "(corporate history of) location" aspect is probably the one which carries the widest implications at landscape level, because it reasonably comprises not only merely geographical factors, but more importantly all the exogenous social components implicit in the countries where the companies were founded and developed, such as political system and business-state relations, cultural background and education (but also customs and traditions) of ruling class and consumers. Furthermore, linking these concepts to the "(corporate history of) profitability and market assessment" elements, broad economic factors like historical trends in the energy prices can most likely be included, too.

So, given that there are plenty of examples of both the traditional influence of the oil industry in the American political system (resulting from conspicuous elections funding and lobbying, and personified for example by former Vice President Dick Cheney and former Secretary of State Rex Tillerson, who previously were heads respectively of oil field services company Halliburton and of ExxonMobil) and the large energy consumption patterns of the average American, one could therefore reasonably argue that such landscape-level elements are the true determining factors for the Transatlantic divide in question, probably alongside regime-level technological components like the stronger involvement of American majors in shale oil resources compared to their European counterparts.

Nevertheless, a simpler explanation, this time related solely to pure and basic economic logic, comes conceivably abreast the reasoning expressed above: it can be identified in the plain relation between "the oil majors proved reserves and their renewable energy strategies" (Pickl, 2019). This relation can be properly investigated in the following chart "representing the oil majors based on the metrics proved oil reserves (x-axis) and activity in renewable energy (y-axis)" (Pickl, 2019)

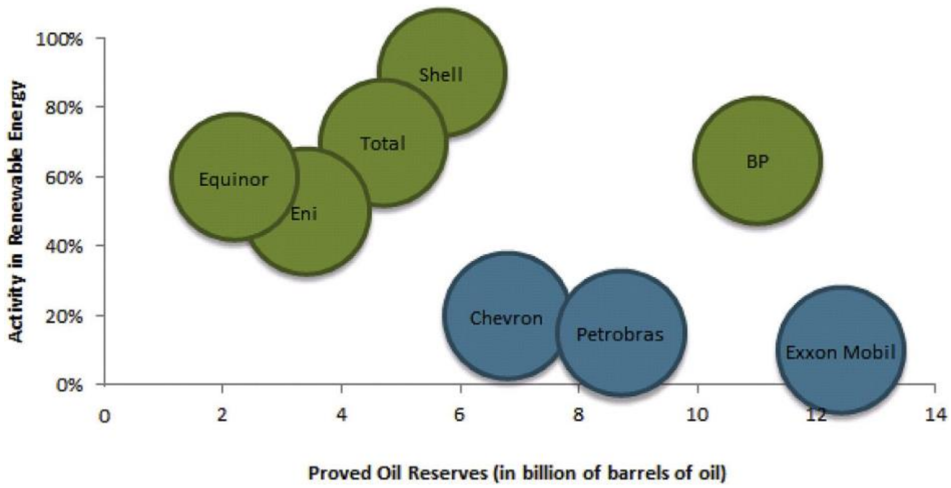

Figure 5 - Linkage of renewable energy activity of oil majors and their proved oil reserves (Pickl, 2019)

Looking at this linkage as drawn in the figure above, indeed, it can be easily observed that "oil majors with less proved oil reserves to tap into seem to be moving into the renewable space faster with the aim of developing more diverse and less volatile portfolios sooner. Those companies with large pools of oil reserves, remarkably including US majors with especially low breakeven oil assets, are rather selecting the strategy to embrace the renewable industry at slower pace" (Pickl, 2019). But probably it would not be correct to ascribe all the responsibility for the Transatlantic divide to this linkage, because it is interesting to notice that "BP is somewhat of an outlier to this overall trend as it is becoming increasingly active in renewable energy" (Pickl, 2019).

Anyway, formally all of the Big Oil companies, alongside other majors like Equinor and Spain's Repsol and prominent NOCs like Saudi Aramco, CNPC and Pemex, have "explicitly recognised" the Paris Agreements as members of the Oil and Gas Climate Initiative (OGCI), a voluntary CEO-led initiative among major oil companies for practical actions on climate change which, since it was established in 2014, has collected in 2016 comprehensively $1 billion for its new investment fund, OGCI Climate Investments, and launched collective targets for methane emissions in 2018 (Oil and Gas Climate Initiative, 2019). Resuming the frame of mind of the Transatlantic divide, it is very interesting to notice that while BP, Eni, Shell and Total were among the founding members of OGCI back in 2014, Chevron and ExxonMobil only joined the initiative in September 2018 (Oil and Gas Climate Initiative, 2019).

2.2.3. Energy transition strategies of the European supermajors

As of 2016, a study by Sia Partners' analysts identified Total, Shell and Eni as "early movers" in the energy transition among Oil&Gas companies, even if with different strategies (De Lorgeril and Portenart, 2016). Indeed, mainly regarding renewable energies, both the French and the British-Dutch majors, later followed by BP, chose to grow primarily through acquisitions (even if initially there were just some false starts at the turn of the century), while Eni dedicated to developing mostly in-house activities.

Besides, even though it can probably be considered only in part a sustainability strategy, all the European Big Oil companies also share the same point of view about the role of natural gas: the least emitting fossil fuel is the perfect "bridge fuel" for accompanying the gradual shift to renewables. Consequently, particularly Total and Eni have disclosed a clear commitment for increasing the percentage of natural gas in their production and reserves mix: as of 2016, Eni was stating that gas already represented 58% of its portfolio (Eni, 2016), while the figure was slightly over 48% in Total's one (Total, 2017). Shell's performance was close to Total's in 2015, whereas BP was lagging behind, with less than 40% of natural gas in its portfolio (De Lorgeril and Portenart, 2016).

2.2.3.1. BP

BP first became involved in renewables in 1973 with solar power, and by 2005 its subsidiary BP Solar was one of the largest solar operators in the world, with over 2000 workers and activities in the US, Spain, India and Australia. Despite BP's announcement that this business (after $500 million invested in the previous 5 years) had turned out profitable in 2004, and the then head of BP Solar Steve Westwell declaring in 2005 that solar power, thanks to technological progress in the efficiency of the panels and thus to price reduction and higher demand, had "an immense growth potential for the future" (Geary, 2005), in the years following BP appeared to be unprepared precisely for the fall in the price of the panels, cutting its workforce by about 1650 and stopping most of its manufacturing operations in the US, Spain and Australia between 2008 and 2010, and then exiting completely its solar activities after 40 years in 2011, citing the commoditization of the business and the subsequent impossibility of "sustaining long term returns" as main reasons for the shutting down (Clark and Pfeifer, 2011). The 50% drop in the cost for solar photovoltaic panels of the previous two years (Lamonica, 2011), driven primarily by the oversupply caused by the unstoppable growth of low-cost panels manufacturers in China, undoubtedly contributed to BP Solar's fate, but the failure in commercializing innovations developed in-house (like a cost-reducer new way of producing silicon wafers for high efficiency solar cells) played an important role, too (Bullis, 2011).

The same story was at risk of being repeated with BP's wind power activities: after having entered the business focusing in the US onshore wind sector in 2007 (Trabish, 2010), in 2012 Katrina Landis, then head of BP's alternative energy division, declared that the company wanted to "achieve scale" with its North American wind farms, using "its existing procurement relationships to drive down costs, and enjoy good rates of return", while admitting of not seeking a dominant position (Ferris, 2012); however, only a year later BP put its American wind assets (worth about $1.5 billion) on sale, deciding that it could "create more value for shareholders by selling the business", if it was possible to "elicit a sufficiently attractive offer" (Crooks, 2013). This move would have left the company which once had "launched a 'Beyond Petroleum' public relations campaign" (Keaver, 2013) with basically only some biofuel activities left in Brazil as low-carbon diversification (Crooks, 2013). Nevertheless, BP turned back just four months later, after failing to attract an acceptable bid, thereby deciding of retaining the American wind farms (Reuters, 2013).

The British oil giant re-entered the solar business in 2017, investing $200 million over three years for acquiring a 43% stake of Lightsource, "Europe's largest solar development company", which has been therefore renamed Lighsource BP (BP, 2017). Dev Sanyal, chief of alternative energy in BP, stated that the operation differed from BP’s previous solar activities because the investment regarded a solar power generator rather than a producer of panels as before (Bousso and Twidale, 2017). The plan was expanding Lightsource BP’s operations worldwide using BP’s global scale (BP, 2017). The company manages now 2 GW of solar installed capacity with solar power plants in UK, Spain, Italy, US, Brazil, Egypt, India and Australia, employing 300 people worldwide; and it has an interest in an IoT (Internet of Things) business in Ireland, too (BP, 2018).

As already mentioned, BP’s wind power assets are instead limited to the US: after having divested its three wind parks in Texas in 2018 “as part of a broader restructuring designed to optimize its U.S. wind portfolio for long-term growth”, the American branch of the British supermajor currently runs nine wind farms in six other US states, for a total gross generating capacity of approximately 1,8 GW, and holds a separate stake in a facility in Hawaii. The Titan 1 wind farm in South Dakota is of particular interest, because in 2018 BP partnered with Tesla to install a high storage battery, enhancing the reliability of the wind plant for managing internal electricity demand with no wind (BP, 2018). According to recent reports, BP is also holding talks with industry players to enter the offshore wind sector in the US (Lee, 2019).

Regarding the downstream activities, BP started developing biofuels operations in 2008 with a joint venture with Tropical Bioenergia (later completely acquired in 2011) in Brazil for producing agrofuels from sugarcane with “life cycle greenhouse gas emissions around 70% lower than conventional transport fuels”. With a workforce of approximately 4500 people, BP Brazil operates three sugarcane processing facilities in the country, producing 765 million lithers of ethanol equivalent in 2018, and commercializes the fuel thanks to a terminal in São Paulo operated in joint-venture with leading ethanol and sugar trader Copersucar, generating 1000 GWh per year of biomass energy with sugarcane bagasse, too (BP, 2019). The company has just announced a new joint-venture, with agricultural trader Bunge ltd, to further boost its biofuels and biopower activities by 50% (McFarlane, 2019), seeking “opportunities for synergies, operational performance, modernisation and future growth” in “one of world’s largest fast-growing biofuels markets” (BP, 2019). Indeed, Brazilian government is set to introduce additional mandates for fuel distributors to increase their biofuels sales from 2020, and Brazil “is already the world’s leading biofuels market as a share of the country’s transport fuel mix” (McFarlane, 2019).

BP also runs Butamax, a 50/50 biochemical joint-venture with DuPont in Kansas, US, which has developed technologies for converting sugars from corn to bio-isobutanol, with applications both as biofuel and as paint, coating and lubricant component (BP, 2019).

2.2.3.2. Eni

The (now former) Italian state oil monopolist ENI was first involved in renewable energy research in 1976, when it started collaborating with its counterpart ENEL (then monopolist in the Italian electricity supply) on geothermal energy, while in the following years the first R&D projects about thermal solar and photovoltaic conversion were conducted (Eni, 2019).

In more recent times, Eni has committed again in renewables, but with relevant differences compared to the other supermajors: 1) the company has chosen to develop the business in-house (namely without acquiring already established renewables player but rather using proprietary patents and technologies); 2) following a circular economy path, Eni is betting not only in new greenfield projects, but also in the reconversion of some of its productive plants in brownfield renewables projects, even for self-consumption of the power generated (Eni, 2019).

In Italy (Eni's home country), the oil major is using its existing industrial sites, remediated by Syndial (its subsidiary for environmental services), for implementing 25 renewables project (mainly solar plants), targeting a combined installed capacity of 220 MW by 2021. Three of them are already operational, one of which partially fuels Eni's new Green Data Center: digitalization is, indeed, another pillar of Eni's strategy, and in 2018 the company has launched HPC4 (Eni, 2019), the new supercomputer which (combined with the IT system already in service) represents the second most powerful industrial supercomputing system in the world, only very recently overtaken by Total's new one (TOP500 Supercomputer Sites, 2019). Such supercomputer systems are used in the Oil&Gas industry, and by Eni in particular, mainly for analysing and processing subsoil data in the upstream phases but also for increasing "reliability and technical integrity" of all the productive plants (Eni, 2018).

But Eni's Energy Solutions renewables division is active abroad, too: solar plants are being built in Algeria, Tunisia, Pakistan and Australia (where also a battery storage system will be integrated), while in Kazakhstan the oil major is partnering with General Electric for the joint development of a 48 MW onshore wind farm (Eni, 2019). In these cases, too, some of the plants will be used to supply power directly to the nearby industrial sites, with the renewables sources acting in hybridization with the traditional systems of the industrial facilities. Overall, Eni targets 1,6 GW of comprehensive renewable installed capacity by 2022 and 5 GW by 2025, investing €1,4 billion as part of the 2019-2022 strategic plan (Eni, 2019).

Moreover, Eni through its subsidiary Enipower is already an established player in the conventional Italian electricity market, with 5 GW of installed capacity comprised of five CCGT power stations and one cogeneration plant, representing the second electricity producer in the country after Enel, the Italian-based multinational utility (Eni, 2019).

In 1958, at the beginning of its history, the then state oil firm ENI was also involved in research in the nuclear energy sector (Eni, 2019), but it was 60 years later, in 2018, that the now Italian-based oil multinational set an authentic milestone among Oil&Gas companies, being the first in investing in nuclear fusion, “a technology considered so uncertain that Eni remains the only global oil company prepared to place a bet on it” (Navach, 2018). The company, in fact, has bought a $50 million stake of Commonwealth Fusion Systems LLC (CFS), a spin-out of the Massachusetts Institute of Technology carried out by former MIT scientists (Eni, 2018). CFS plans to complete a commercial nuclear-fusion reactor by 2033, and its managers stated that their project, although using the same “tokamak” design, differs from large-scale intergovernmental programs like ITER (the €20 billion experimental fusion reactor under construction in France by a partnership between European Union, US, China, Japan, India, Russia and South Korea) mainly for innovative superconducting electromagnets that would allow to confine the plasma in a smaller chamber. Then Eni’s chief of development, operations and technology, Roberto Casula, estimated that it would cost “$3 billion to develop a 200-megawatt fusion reactor by 2033”, and that the company was even considering stepping up its investment (Navach, 2018). Eni is also partnering with Italian public research centres and institutional agencies on this research field (Nuclear Engineering International, 2018, and Eni, 2019).

Again according to a circular economy course, in 2014 Eni was also the first in reconverting a conventional refinery in a biorefinery at the Marghera facility (Venice, Italy), where “green diesel, green naphtha, LPG and potentially also jet fuel” are produced using vegetable oil and, up to 15%, also purified used cooking oils. The same reconversion process is ongoing for the Gela refinery in Sicily, and Eni forecasts a processing capacity of 560.000 tons of oil for Venice and 750.000 for Gela by 2021, with a general increase in the use of animal fats and used cooking oils and a green-diesel production that will reach 420.000 tons/year in Venice and 600.000 tons/year in Gela. In particular, the Venice plant is the “technological hearth” of the Ecofining™ project, which produces Eni Diesel+, a new fuel with up to 15% of biological renewable component that reduces CO_2 emissions by 5% compared to normal diesel (Eni, 2019).

Moreover, the Eni group is also active in the green chemistry field with Versalis, Eni’s chemical subsidiary. In 2011, it has launched Matrìca, a partnership with Novamont for producing bioplastics, biolubricants and cosmetics from plant-based (cardoon) raw materials through the reconversion of the Porto Torres plant, in Sardinia. Again at Porto Marghera, Versalis is instead committed, alongside US based Elevance Renewable Sciences, in engineering and developing new detergents and biolubricants to be used in oil drilling. Furthermore, a partnership with leading tyre industry player Bridgestone Americas, launched in 2013 (with a pilot cultivation in Sicily since 2014), is active in developing applications of natural rubber extracted from guayule (a shrub indigenous to Mexico) both for the tyre and the medical sectors (Eni, 2019).

Finally, Eni plans to reach "net-zero" upstream emissions by 2030, both eliminating operational flaring and drastically reducing methane leaks (-80%) by 2025 (Eni, 2019) and availing of huge reforestation and forest conservation projects in Africa (Sheppard and Hook, 2019).

2.2.3.3. Royal Dutch Shell

The British-Dutch Oil&Gas giant is operating in different ways in the renewable energies field. Indeed, Shell has been directly involved in wind power since 2001: it operates firsthand in the US onshore wind sector, running four wind farms in three American states alongside American operator Terra-Gen, while it has interests in offshore wind power plants in development both in Europe (Netherlands and a floating project in Norway) and in the US (Shell, 2019). The company declares that, "once fully built", the total installed capacity of its wind assets will reach a potential of 5 GW (Shell, 2019).

Concerning solar power, instead, Shell's story is similar to BP's one: after having dismissed all its solar activities between 2006 and 2009 (Renewable Energy World, 2006, and Cheyney, 2009), the company has re-entered the business in 2018, acquiring relevant stakes in US based solar developer Silicon Ranch (Pyper, 2018) and Singaporean operator Cleantech Solar (Beetz, 2018). Through these two solar platforms, Shell owns over 1,6 GW of solar generating capacity including both the plants in the US and in South-East Asia (Shell, 2019).

Recently the company, which already operates a conventional power division made of CCGT plants both in Europe and North America (through its subsidiary MP2), has also disclosed the aim to become the first world electricity producer in the 2030s if the expected results are achieved, because as declared by Maarten Westelaar, Shell's director of gas and new energies, for cutting greenhouse emissions by 2035 in line with what was announced "the amount of power - of clean power - we will need to be selling... will make us by far the biggest power company in the world" (Crooks and Raval, 2019).

But the supermajor is very active in the broad field of the ancillary energy innovations, too: e-mobility, hydrogen technologies, storage and distributed energy systems. In fact, it owns NewMotion, "one of Europe's largest electric-vehicle charging providers" which operates over

40.000 private electric charge stations for private homes and businesses in the Netherlands, Germany, France and UK; while through not only NewMotion, but also the subsidiary Shell Recharge and a partnership with IONITY (an e-mobility joint-venture between some large car makers) Shell also contributes to a wide network of public charging stations across European countries and China (Shell, 2019). Furthermore, between 2018 and 2019 the oil major has bought the battery storage systems German operator Sonnen, the British digital platform Limejump, which helps managing and integrating independent commercial assets remotely, and a majority share of American GI Energy, focused on building commercial or industrial microgrids and onsite systems (Shell, 2019). Regarding the fuel potential of hydrogen, in Germany Shell is working in joint venture with industrial gas manufacturers Air Liquid and Linde, car producer Daimler and other energy players Total and OMV for developing a national network of 400 hydrogen refuelling stations by 2023 (with funding from German government and the EU), while the British-Dutch oil major is also active in installing hydrogen filling stations in Los Angeles (California, US, in partnership with automotive player Toyota), Vancouver (Canada) and the Netherlands (Shell, 2019).

Similar to BP's approach is Shell's involvement in the biofuels business, too: in 2010, the company has launched Raízen, a joint venture with Brazilian multinational agro-energy conglomerate Cosan, which ranks now as one of the world's largest producers of biofuels. It mainly extracts ethanol for biofuels from sugarcane, stating that it "can reduce CO_2 emissions by 70% compared with conventional petrol" (Shell, 2019); plus, waste sugarcane fibres are used to generate biomass electricity for the mills. In 2015, Raízen has also started the first cellulosic ethanol plant, to produce "advanced biofuels made from sustainable feedstocks such as waste and cellulosic biomass". In 2018, the joint venture produced about 2 billion litres of sugarcane ethanol, while Shell in its entirety blended around 9 billion litres of biofuel in its petrol and diesel sold worldwide in 2017.

Lastly, similarly to Eni' initiatives, also Shell has announced a relevant plan of "nature-based solutions": up to €300 million between 2019 and 2021 will be invested in programs of ecosystem restoration, wetlands remediation and reforestation in many different areas of the world (Kaye, 2019).

2.2.3.4. Total

After minor involvements in solar interests in the previous years, in 2011 the French oil giant bought 60% (then brought to 66%) of American solar panels maker SunPower Corporation for $1,38 billion (Macalister, 2011), a business move clearly at odds with the divestments in the same sector of the other European oil supermajors in the years before. But recently, in addition to SunPower (which manufactures not only technologically efficient solar PV panels with a 25 years warranty but also solar cells and integrated storage systems), Total has invested in EREN Renewables Energy, a French independent renewables operator, and launched the Total Solar division within its group (Total, 2019). Between 2017 and 2019, in fact, Total has finalized the acquisition, for €237,5 million, of a 23% stake of EREN RE, now renamed Total Eren, a renewables player founded in 2012 which manages a portfolio of solar, wind and hydropower plants for the size of 650 MW of installed capacity operating or under construction (Woods, 2019). Total Eren plans to reach a global installed capacity of 3 GW within 5 years, and after that period Total will have the option of taking full control of the firm, too (Total, 2017). Overall, the Total group targets instead a renewable (mainly solar) installed capacity of 5 GW by 2022, inclusive of Total Solar, Total Eren and SunPower, and a comprehensive electricity production capacity (including also its CCGT power stations) of 10 GW by 2023 (Total, 2019).

Before Shell, also Total had acquired an established battery maker: French energy storage specialist Saft, for $1.1 billion in 2016 (Wesoff, 2016). Even boasting 4000 people employed worldwide and a turnover of around €750 million, in that occasion Saft representatives stressed that they remained a niche player, active in the development and manufacturing of technologically advanced customized industrial storage solutions, batteries (also for defence and aerospace industries) and "grid-scale energy storage", but not in "consumer-type products" like "the standard electric-vehicle market" (Wesoff, 2016). But other business units of Total group in part offer that kind of service, too: the French oil multinational has developed a "dense network of electric recharge points" in correspondence of its gas stations in Western Europe, and it is partnering with Shell and the other actors in programs for public recharge points, both for electric and hydrogen cars (Total, 2019). Only very recently Saft has signed a new deal with Chinese group Tianneng "to grow in China's energy storage and EV markets", for a joint venture (40% Saft and 60% Tianneng) that will enhance Saft's involvement in mass-production of lithium-ion batteries (Bellini, 2019). Furthermore, Saft is working with Solvay, Manz and Siemens for "an ambitious R&D program to develop the battery of the future" (Total, 2019).

Turning to the downstream operations, Total was the other supermajor deciding to reconvert one of its existing French refining facilities in a biorefinery: the La Mède plant near Marseille, operating since 2019, has a biofuel capacity of 500.000 tonnes of green-diesel with hydrotreated vegetable oil (HVO) additive per year, processing mainly certified plant oil (Total's pledge is to use at most 300.000 tonnes of palm oil per year, favouring the use of 50.000 tonnes of French-grown rapeseed instead) but also treated waste oils like animal fats and cooking residuals, up to 40% (Total, 2019). Total has been already active in biogas and biofuels from 20 years, with the production both of HVO and of ethyl tert-butyl ether (ETBE), a gasoline additive, and it states of representing “Europe’s leading retailer of biofuels, with more than 2,4 million metric tons incorporated into our gasoline and diesel in 2018” (Total, 2019). Moreover, the French major is partnering with Air France (Lab’line project), the aircraft manufacturer Airbus and two Chinese airlines (buyers of its airplanes), Cathay Pacific and Air China, to implement the use of biojet fuels (Total, 2019).

Total is also involved in bioplastics development, focusing in particular on (renewable) polylatic acid (PLA), “a fully biobased and biodegradable polymer with a carbon footprint one third that of conventional polymers”, used in food packaging, textiles, medical, electronic and automotive industries and “able to compete with existing polymers in terms of performance” (Total, 2019). The company, working with Dutch bioplastics player Corbion, in 2018 has launched a plant in Thailand for producing 75.000 metric tons of PLA per year (Total, 2019). Furthermore, Total’s R&D teams has focused on “the utilization of lignocellulose (plant waste) and microalgae (microorganisms that can transform CO_2 directly into molecules of interest for our markets)” for more than ten years (investing over €500 million in the period), partnering with various start-ups or academic and industrial actors (Novogy and Renmatix, for instance), like in the BioTfueL consortium, which “aims to transform lignocellulosic biomass such as straw, forest wastes and dedicated crops into biofuels using a thermochemical pathway”. About the industrial potential of microalgae, instead, Total is conducting a variety of R&D projects alongside some university research centres in Europe and China (Total, 2019).

Eventually, Total has been committed in carbon capture projects since 1996, too. Around 10% of Total’s R&D budget is currently dedicated to carbon capture, utilization and storage (CCUS) technologies (Total, 2019). The company is part of the Lacq CO_2 capture and storage pilot project, started in 2010, which enabled the testing of a complete CCUS chain in one of Total’s sites; the Clean Gas Project is instead a partnership organized by the OGCI Climate Investments fund, involving in addition BP, Eni, Equinor, Occidental Petroleum and Shell for the implementation of “the first commercial-scale, fully integrated CCUS project in the United Kingdom” (Total, 2019). But with Equinor and Shell, Total is also working alongside Northern Lights in Norway for a project that “aims to create 1,5 million tons of carbon storage capacity per year”, focused in particular “on transporting and storing carbon emissions produced by cement factories” with new commercial-scale carbon capture solutions (Total, 2019). And nature-based solutions are present in the carbon sink strategies of the French supermajor, too: the company plans to create a dedicated business unit with agro-environmental experts which, alongside the Total Foundation and with an annual budget of €100 million in 2020, will deal with protection, preservation and restoration of forests, mangroves and wetlands, but also with initiatives for the remediation of degraded soil (Total, 2019).

2.2.4. Energy transition strategies of the American supermajors

As of 2016, none of the two American *supermajors* had relevant commitment in transition-related activities: between 2014 and 2016, in fact, Chevron had sold most of its interests in renewables, while ExxonMobil basically had never entered such a market; essentially, they only retained some biofuels activities (De Lorgeril and Portenart, 2016).

Also regarding the percentage of natural gas reserves in the majors' portfolios, the two American supermajors showed poorer performance than their European counterparts in 2016, probably due to their larger involvement in sand oil resources in the US and to the low oil prices scenario of those years, which forced the majors to refocus on their most profitable assets, namely petroleum rather than natural gas (De Lorgeril and Portenart).

2.2.4.1. Chevron

Chevron, already active in the power generation sector with gas-fired cogeneration plants through its branch Chevron Power and Energy Management Company (Chevron, 2019), had acquired a renewables subsidiary from PG&E Energy Services in 2000, denominated Chevron Energy Solutions, but between 2014 and 2016 the American supermajor decided of selling first the renewables business unit, which until then had developed "hundreds of renewables and energy efficiency projects", to California based OpTerra Energy Services (Gallucci, 2014), and then also all its geothermal assets in Indonesia and the Philippines, valued at $3 billion, to local conglomerates (Dela Cruz, 2016). However, in 2014 a Chevron's spokesman stated that the company had not "exited or abandoned renewables", and that the sale of the subsidiary was just "part of an internal strategic focus on supporting Chevron's upstream and downstream businesses" (Gallucci, 2014). Probably the geothermal sales two years later would have changed the validity of those statements at least to some extent, even if it is also true that the major actually retained some renewables activities: a few solar research and testing projects in California as well as a 1 MW concentrating photovoltaic (CPV) solar plant in New Mexico, both located in Chevron's decommissioned facilities, respectively the former Bakersfield refinery and the Questa molybdenum mine (Chevron, 2014); and, in addition, the 16,5 MW

Casper Wind Farm, operating since 2009 in another former refinery in Wyoming, and since 2012 a 49 MW-capacity joint venture geothermal plant in California (Chevron, 2019).

Since then, Chevron's involvement in renewable energies has not changed so much: Chevron has basically just expanded its solar portfolio, with five joint ventures in photovoltaic facilities in California, Arizona and Texas for 73 MW of combined capacity (Chevron, 2019).

However, recently the Californian supermajor has also moved on e-mobility and energy storage: through its emerging technology venture capital arm, Chevron Technology Ventures (founded in 1999), the company has launched the $100 million Future Energy Fund in June 2018, which thenceforth has invested in electric vehicles (EV) charging company ChargePoint in November 2018 and in battery storage operator Natron Energy in January 2019 (Foehringer Merchant, 2019).

Regarding transition in downstream operations, instead, Chevron is assessing the possibilities for including biomass processing in its transportation fuels businesses in California, but the effort of producing "second-generation biofuels that are economical at scale without subsidies", including a joint venture with Weyerhaeuser (which was the largest landowner in the US) for the commercialization of cellulosic biofuels, has not paid off so far (Chevron, 2019). The company in 2017 has nevertheless started to distribute diesel with 6% to 20% renewable biomass-based component (vegetable oils like soy, corn, conola, or animal and poultry fats, used cooking or municipal waste oils, but also wastewater sludges) in its Californian fuel terminals (Chevron, 2019).

Finally, Chevron is involved in developing carbon capture technologies, investing over $75 million in the last decade: within the context of the large Australian natural gas and LNG Gorgon project (47,3% of Chevron's ownership), the company has installed one of the biggest carbon capture and storage projects in the world, where the carbon dioxide (CO_2) present in the natural gas is "injected into a sandstone reservoir more than 1,5 miles (2,4 km) below Barrow Island" (Chevron, 2019). In addition, Chevron Technology Ventures' Future Energy Fund has also invested in carbon capture developer Carbon Engineering (Foehringer Merchant, 2019).

2.2.4.2. ExxonMobil

The engagement of ExxonMobil in energy transition and low carbon activities was limited to research projects about biofuels and carbon capture until 2017. In that year, indeed, the management of the Texan oil multinational was defeated by a shareholder proposal (even if non-binding), backed by the most important institutional investors like BlackRock and Vanguard and voted in the shareholder's meeting with 62,3% agreement, requiring a broader and more detailed disclosure about the company's strategies for climate change-related business risks (Cardwell, 2017). Similar proposals, rejected at that time, were submitted also in the previous years, but what changed the situation in favour of the supporters in 2017 was precisely the approval of "two of Exxon's largest investors", Blackrock and Vanguard, whose fund managers were increasingly reporting "concerns about the risks to companies whose assets were based in fossil fuels that could lose significant value as climate policies and market forces reduce demand" (Cardwell, 2017).

On that occasion, ExxonMobil's CEO Darren Woods declared that "the board would consider the result because it reflected the view of a majority of shareholders" (Cardwell, 2017), but even after that, ExxonMobil just started developing marginal diversification towards energy transition activities: regarding renewable energies, for instance, ExxonMobil only moved for the first time in 2018 and not even with a direct involvement, but merely signing a 12-year agreement, although relevant, with Danish power player Orsted A/S for buying 500 MW of wind and solar power for self-consumption in the drilling operations of Permian Basin oil field in Texas, US (Martin and Crowley, 2018). Besides, the American oil major is present in the conventional power sector mainly for self-consumption in this case, too: cogeneration systems fuel its industrial facilities, typically refineries, "in more than 100 installations around the world", for a total capacity of 5,4 GW (ExxonMobil, 2018).

ExxonMobil's biofuels research dates back only a few years earlier and, despite claiming that over $300 million have been invested in the past decade, it has also shown relevant results only recently: the oil majors carries out a research portfolio alongside biotechnology player Synthetic Genomics (SGI) since 2009 and with some American universities since 2012, regarding advanced biofuels from algae (not impacting on the total food or fresh water supply and with 50% lower life cycle greenhouse gas emissions compared to petroleum-derived fuels); but succeeding only lately in increasing "algae's oil content from 20 percent to more than 40 percent" using advanced cell engineering technologies, and working now on "the technical ability to produce 10,000 barrels of algae biofuels a day by 2025" (ExxonMobil, 2018). In January 2019, instead, a partnership between ExxonMobil, North America's largest producer of advanced biofuels Renewable Energy Group (REG) and Swiss globally leading specialty chemicals company Clariant was announced for a joint research agreement "to evaluate the potential use of cellulosic sugars from sources such as agricultural waste and residues to produce biofuel" (ExxonMobil, 2019).

On the other hand, the Texan supermajor has been involved in carbon capture and storage (CCS) since 1970, currently representing a leading player with about one fifth of the world's total carbon capture capacity with 6,6 metric tons of CO_2 captured and stored in 2017. The previous year in particular, ExxonMobil signed a partnership with FuelCell Energy for the development and application of carbonate fuel cells "to concentrate carbon dioxide from large-scale industrial and power plants"; this technology could capture 90% of CO_2 emissions of a typical gas-fired power plant, enhancing its power output at the same time (ExxonMobil, 2018).

3. Part 2: Big Oil as incumbent regime companies

After the “multi-level perspective” theoretical framework for socio-technical transitions was introduced in 2002 by Frank W. Geels in its paper “Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study”, and later developed until emerging as “one of the most popular approaches to investigating transitions in energy and other sustainability-related issues” (Heiskanen et al., 2018), further research mostly focused on the “green niche-innovations” as observed by Geels himself in 2014.

It is interesting, instead, to consider specifically also the role of the incumbent regime (and thus of the companies which embody it), like he started doing right in that 2014 paper (using the UK electricity system as a case study); because, as he suggested, “socio-political struggles with fossil fuels companies and other incumbent firms will be crucial in the case of low-carbon transitions”, since “politically-inspired regime destabilization may be necessary to create opportunities for the wider diffusion of renewables […] against resistant regimes” (Geels, 2014).

3.1. The standard perspective: resistance

Since the Big Oil companies are very specific actors, taking specifically them into account for an analysis is slightly different than the general case study of the entire UK power sector, but nevertheless some remarks and conclusions reasonably apply to the situation of the supermajors, too.

For instance, Geels points out that fossil fuels companies and the political level are usually conceptualized as forming an alliance within the regime for maintaining the status quo (Geels, 2014). This alliance, highlighting several different overtones, has been named “minerals-energy complex”, “carbon lock-in”, “carbon capital” or “fossil fuel historical bloc” (respectively Fine and Rustomjee, 1996; Unruh, 2000; Urry, 2013; and Phelan et al., 2012; as cited by Geels, 2014), and, as discussed in the chapter about the Transatlantic divide, a different level of effective interdependence in this alliance is probably among the main causes for the differences in the sustainability performances between the American supermajors and the European ones.

According to Geels (2014), the interdependencies between governments and large businesses such as big energy players, intrinsic of capitalistic societies, enables these firms to influence the policymakers (and the socio-technical system in general) through several transmission channels and using different strategies: for example, making use of *instrumental* (mobilizing resources), *discursive* (affecting public debate), *material* (improving the technology of the existing regime), and "*broader institutional power*" (the assistance from status-quo factors inbuilt in the institutional system) leverages, which are worth of being examined more in detail.

First, the "*instrumental* forms of power refer to actors using resources […] in immediate interactions with other actors to achieve their goals and interests" (Geels, 2014). Regarding the Big Oil companies, it is extremely interesting to notice that traditionally their instrumental influence have been targeted not so much against direct market rivals like renewables (that reasonably is what small niches are increasingly becoming), but rather on lobbying actions (which are probably the most common practical instrumental leverage for such companies) "to delay, control or block policies to tackle climate change" (Laville, 2019) as a recent report by British non-profit organisation InfluenceMap has found, pointing out that the supermajors have spent about $1 billion since the Paris Agreement "on misleading climate lobbying and branding activities", and with the "overriding intention and net result […] to stall binding and increasingly crucial policy designed to implement the agreement by national governments" (InfluenceMap, 2019). Companies like Shell and Chevron, anyway, rejected premises and findings of the report (Laville, 2019).

Discursive strategies are also a tool of incumbents for resistance "when they result in dominant discourses that shape not only *what* is being discussed (thus setting agendas) but also *how* issues are discussed" (Geels, 2014). This can easily be verified exactly in the self-defence of Shell and Chevron against the report of InfluenceMap, where they stressed the increasing need of reliable and affordable energy, other than cleaner (Laville, 2019), as basically all the supermajors do in their corporate websites, too.

Thirdly, the incumbent companies can also "defend themselves with *material* strategies, drawing on technical capabilities and financial resources to improve the technical dimension of socio-technical regimes" (Geels, 2014). This is basically the case of all biofuels, biochemicals and carbon capture activities of the supermajors (not to mention the emission reduction and mitigation targets), which represent precisely environmental improvements of an established technological regime.

Last, regime companies like the Big Oil can benefit from *broader institutional power* factors, meaning the "wider institutional context" which is "embedded in political cultures, ideology, and governance structures" (Geels, 2014). In this respect, general economic policy guidelines (rather common in the Western world even if to different extents) such as primacy of market forces or, on the other hand, preservation or jobs may both foster the resistance of large corporations, and in the energy sector of the Oil&Gas majors in particular.

3.2. Is a new perspective possible in the case of Big Oil?

As outlined above, the standard perspective in which incumbent fossil fuel companies like the Big Oil (and in general the established socio-technical regime) are framed, with respect to energy transition, is obstructive resistance to such transition.

However, it is also useful to assess the possibility that companies like the supermajors could not only resist to change, but potentially try to exploit new transition-related business opportunities, first diversifying and then shifting their operations. The need of considering this possibility is clear, since environmentalist popular call, followed by political leaders more sensitive to such matters, particularly in Western countries is increasingly pushing towards environmental issues (the FridaysforFuture movement founded by Swedish teen activist Greta Thunberg is a good example), arguably making it harder for the more conservative political system to cover incumbents' uncompromising resistance, particularly since the awareness of the business risks due to sustainability matters is starting to spread also in the market environment, as confirmed by the ExxonMobil-BlackRock episode.

In this case also it is possible to highlight a Transatlantic divide at least from the political point of view. Indeed, going against the policies of previous Obama administration, in 2017 US President Trump announced his intention of leaving the Paris Climate accord, and even if the Democratic-controlled House of Representatives has recently passed a law aimed at preventing the withdrawal, the president has the support of the Senate and "could begin withdrawal procedures in November and formally withdraw from Paris a day after the 2020 election" (Duke, 2019); in addition, consistent with his administration's "goal of reducing environmental regulations on oil and gas companies while increasing their ability to explore for reserves on federal land", the president has also named a former oil executive, very critic about man-made global warming in the past, as head of the American Environmental Protection Agency (EPA) in South-Central region, the section which comprises Texas and the surrounding states, "a hub of fossil fuel industry" in the US (Banerjee, 2019). The EPA recently has proposed of rolling back methane emission regulations, at odds even with some oil majors, too (Voytko, 2019).

In Europe, on the other hand, the institutional environment seems to be more likely to adopt more determined legislation about climate change and energy-related carbon emissions: for instance, German Chancellor Angela Merkel and French President Emmanuel Macron, backed by most of the other EU member states, recently pushed for passing European net-zero carbon emission target for 2050, signalling ambition ahead of an upcoming UN climate summit, and the clear reference to the 2050 deadline was blocked by the leaders of three Eastern European states only (Poland, Czech Republic and Hungary), and relegated to a vaguer footnote in the final common document (Rankin, 2019). In 2018, in France Mr Macron himself was forced to frozen and then cancel an increase of carbon tax on transportation fuels following the violent protests of the Gilet Jaunes movement (Willsher, 2018). But European countries and the European Union as supranational entity remain overall set to be the first movers in introducing stricter and binding environmental regulation.

So, it appears appropriate trying to outline some conditions and factors which might be instrumental, as long as the residual (political) resistances mentioned above are overcome, in permanently changing the status quo in the energy system, both enabling and forcing the supermajors (especially the European ones) to speed up the green diversification process and prospectively shifting their core business:

- further technological and cost-efficiency improvements of renewable sources, energy storage and non-fossil transportation systems (e-mobility, hydrogen);
- reaching the peak in the fossil fuels demand, which so far is still rising, pushing oil companies to keep investing in upstream operations. In late 2018, influential think tank Carbon Tracker set 2023 as probable peak year, a projection "much more bullish than estimates by the global energy watchdog and oil and gas companies, which mostly expect demand to peak in the mid-2030s" (Vaughan, 2018);
- further increase in the environmental concerns of institutional investors.

Regarding ExxonMobil and Chevron, instead, starting this business transition would probably require, in addition, a political leadership more inclined to actually care for environmental matters.

Of course, however, also assuming a serious commitment and the realization of the aforementioned conditions, there are many doubts about the actual capacity of the Big Oil companies of successfully "taking the lead" in the energy transition: analysts point out that "a bad track record of diversification and the wrong skill sets in their management teams" diminish supermajors' possibilities of "assuming a leading role in sectors like wind and solar", particularly because "senior management teams below board level […] are still dominated by geologists, geophysicists and chemical engineers", lacking the professional profiles (for instance in the field of electrical engineering) suited to "a changing business environment" (Lee, 2019). Even the investments in offshore wind, "widely seen as the best crossover point for the fossil giants" due to "common factors such as marine engineering and supply chain synergies, and the lower risk profile offered in the production phase of projects", still have not reached a scale significant enough (Lee, 2019).

4. Discussion and conclusions

As examined in the core parts of this study, the Big Oil companies have heterogeneous strategies to face the climate change-related energy transition.

On the one hand, particularly over recent years the supermajors have actually entered to varying degrees the new businesses in the energy system as analysed in the detailed dedicated section, even with discontinuity and different commitments according to the Transatlantic divide which has become apparent, placing the European companies as leaders and their American counterparts as laggards in this process. Anyway, all the companies have started to diversify towards low-carbon technologies. Nevertheless, following the standard perspective whereby socio-technical transition and MLP literature frame the incumbent regime players, it is important to notice that some of these activities represent in truth resistance moves of the *material* kind: except the investments in renewable energies and alternative transportation like e-mobility and hydrogen, basically the full range of the other transition involvements of the supermajors are in fact incremental improvements of the existing technological regime, frequently connected to core operations of the Oil&Gas industry, i.e. upstream and downstream. Moreover, in all the supermajors the traditional business, and in particular the upstream investments for Exploration and Production, still largely outspend the entire amount of capital expenditure for transition-related activities.

On the other hand, the Big Oil companies offer active resistance to the energy transition, making use of all the other strategies identified in the socio-technical transition framework which, unlike the *material* leverage, do not even provide any diversification: *instrumental* with lobbying actions, *discursive* with their communication strategies, and *broader institutional power* exploiting the mutual dependence of their vested interests with the political system for gaining political cover.

It is therefore extremely difficult to foresee ex ante which side of this corporate strategies will prevail, and if the Big Oil companies will be significant part of the future low-carbon energy system (assuming that this will be actually achieved).

But in the case of the supermajors, hopefully this study has highlighted that the landscape level of the socio-technical transition environment will make all the difference in defining the future role of such companies, essentially through two substantial key elements: political pressures and market factors.

The political level, particularly in its cultural and ideological aspects, is already instrumental in the emergence of the Transatlantic divide, representing one basic reason for the poorer environmental and low-carbon performance of the American supermajors in comparison to the European companies, as explained above in the study. Therefore, it is reasonable to say that in the absence of radical change in the levels of environmental awareness and of oil industry's traditional influence in the American political establishment (specifically in the current Republican ruling class), the two US based Big Oil companies will keep exploiting the lacking of stricter environmental regulations and national emission targets, maintaining an approach more focused on resistance. The European supermajors, instead, will conceivably need to face growing political pressure in their countries and from the EU institutions into the direction of a faster business transition.

But in all likelihood the market incentives will prove to be even more crucial in shaping the fate of this process, in particular through the evolutionary trend of fossil fuels demand and the attitude of institutional investors towards the investment risks related to climate change and environmental regulation. As long and oil and gas demand is rising globally, in fact, companies like the supermajors will have basically no decisive market incentive in accelerating a complete business transition to the detriment of their remunerative upstream operations, and equally their investors will have no decisive interests in pushing the companies' managements into that direction. Whenever the fossil fuels demand should peak, conversely, this market mechanism will arguably represent, alongside the political pressures, the biggest stimulus for the Big Oil companies to radically shift their operations.

Of course, in that scenario the European companies appear better positioned to potentially embrace the new low-carbon energy system without simply leaving room for the new regime presumably made of former niche-level players (i.e. mainly renewables, energy storage and e-mobility companies): Shell, Total and BP will be able to exploit the acquisitions of already established niche actors of recent years to gradually make them their main core business, while Eni will rely on all the low-carbon activities developed in-house (and hypothetically also in its early bold entry in the nuclear fusion technology), also leveraging, alongside the British-Dutch and French supermajors, on a consolidated presence in the conventional power generation sector.

ExxonMobil and Chevron, on the other side, probably plan and got a better chance in harnessing their know-how on carbon capture and biofuels to extend the life of their business model.

5. References

Al-Fattah, S. (2013). The Role of National and International Oil Companies in the Petroleum Industry. *SSRN Electronic Journal*, 13-137. doi:10.2139/ssrn.2299878.

Andreasson, S. (2018). Survival of the fittest: what future for Big Oil in the transition to a low carbon economy?. *European Consortium for Political Research*. Retrieved from https://ecpr.eu/Filestore/PaperProposal/9896faec-c39e-4310-911c-6debe871be72.pdf

Banerjee, N. (2019, August 7). Trump EPA Appoints Former Oil Executive to Head Its South-Central Region. *Inside Climate News*. Retrieved from https://insideclimatenews.org/news/07082019/oil-executive-mcqueen-appointed-epa-region-administrator-texas-new-mexico-louisiana-oklahoma-arkansas-tribes

Beetz, B. (2018, December 19). Shell acquires 49% stake in Singapore's Cleantech Solar. *PV Magazine*. Retrieved from https://www.pv-magazine.com/2018/12/19/shell-acquires-49-stake-in-singapores-cleantech-solar/

Bellini, E. (2019, April 4). Saft, Tianneng plan 5.5 GWh lithium-ion venture in China. *PV Magazine*. Retrieved from https://www.pv-magazine.com/2019/04/04/saft-tianneng-plan-5-5-gwh-lithium-ion-activity-in-china/

Bousso, R., and Twidale, S. (2017, December 15). BP returns to solar with investment in Lightsource. *Reuters*. Retrieved from https://www.reuters.com/article/us-lightsource-bp-stake/bp-returns-to-solar-with-investment-in-lightsource-idUSKBN1E90H9

BP plc. (2019). Corporate website. Retrieved form https://www.bp.com/

Bullis, K. (2011, December 21). Why BP Solar Failed. *MIT Technology Review*. Retrieved from https://www.technologyreview.com/s/426461/why-bp-solar-failed/

Cardwell, D. (2017, May 31). Exxon Mobil Shareholders Demand Accounting of Climate Change Policy Risks. *The New York Times*. Retrieved from https://www.nytimes.com/2017/05/31/business/energy-environment/exxon-shareholders-climate-change.html

Chevron Corporation. (2019). Corporate website. Retrieved from https://www.chevron.com/

Cheyney, T. (2009, August 12). Shell to exit solar PV, sell share of CIS venture Avancis to Saint-Gobain. *PV-Tech*. Retrieved from https://www.pv-tech.org/news/shell_to_exit_solar_pv_sell_share_of_cis_venture_avancis_to_saint-gobain

Ciura, B. (2019, July 23). The 6 Big Oil Supermajor Stocks Ranked From Best To Worst. *Sure Dividend*. Retrieved from https://www.suredividend.com/big-oil-supermajors/

Clark, P., and Pfeifer, S. (2011, December 21). BP to exit solar business after 40 years. *Financial Times*. Retrieved from https://www.ft.com/content/80cd4a08-2b42-11e1-9fd0-00144feabdc0

ConocoPhillips. (2012, April 4). *ConocoPhillips' Board of Directors Approves Spin-off of Phillips 66*. Retrieved from http://www.conocophillips.com/news-media/story/conocophillips-board-of-directors-approves-spin-off-of-phillips-66/

Crooks, E. (2013, April 3). BP puts US wind power units up for sale. *Financial Times*. Retrieved from https://www.ft.com/content/41d4f8ca-9bdd-11e2-8485-00144feabdc0

Crooks, E., and Raval, A. (2019, March 13). Shell aims to become world's largest electricity company. *Financial Times*. Retrieved from https://www.ft.com/content/87cfc31e-44e7-11e9-b168-96a37d002cd3

Davcheva, M. (2019, February 12). Oil and Gas Industry Overview. *ScheduleReader*. Retrieved from https://www.schedulereader.com/blog/oil-and-gas-industry-overview

De Lorgeril, C., and Portenart, P. (2016). Big Oil facing the end of the golden age. *Sia Partners*. Retrieved from http://www.energie.sia-partners.com/sites/default/files/2016_-_sia_partners_-_energy_lab_-_oilgas_-_etude_diversification_des_petroliers_episode_4_en.pdf

Dela Cruz, E. (2016, December 23). Indonesia, Philippine groups acquire Chevron's $3 billion geothermal assets. *Reuters*. Retrieved from https://www.reuters.com/article/us-chevron-sale-geothermal/indonesia-philippine-groups-acquire-chevrons-3-billion-geothermal-assets-idUSKBN14C0OW

Duke, R. (2019, May 19). Leaving the Paris Agreement Is a Bad Deal for the United States. *Foreign Policy*. Retrieved from https://foreignpolicy.com/2019/05/19/leaving-the-paris-agreement-is-a-bad-deal-for-the-united-states/

Energy Institute. (2019). *Oil and Gas*. Retrieved from https://www.energyinst.org/exploring-energy/topic/oil-and-gas

Energy Transition. (2019). Irena.org. Retrieved from https://www.irena.org/energytransition

Eni S.p.A. (2019). Corporate website. Retrieved from https://www.eni.com/en_IT/home.page

Equinor. (2019). Corporate website. Retrieved from https://www.equinor.com/en.html

ExxonMobil Corporation. (2019). Corporate website. Retrieved from https://corporate.exxonmobil.com/

Ferris, D. (2012, June 14). How Serious Is BP About Wind Energy?. *Forbes*. Retrieved from https://www.forbes.com/sites/davidferris/2012/06/14/how-serious-is-bp-about-wind-energy/#5b2aeaa84f23

Foehringer Merchant, E. (2019, January 30). A Look at Chevron's Dip Into Clean Energy Investing. *Green Tech Media*. Retrieved from https://www.greentechmedia.com/articles/read/a-look-at-chevrons-dip-into-clean-energy-investing

Foxon, T. (2011). A coevolutionary framework for analysing a transition to a sustainable low carbon economy. *Ecological Economics*, 70(12), 2258-2267. doi: 10.1016/j.ecolecon.2011.07.014

Gallucci, M. (2014, March 9). Chevron Finalizes Sale Of Its Clean Energy Subsidiary, Marking Latest Oil Industry Move Away From Renewables. *International Business Times*. Retrieved from https://www.ibtimes.com/chevron-finalizes-sale-its-clean-energy-subsidiary-marking-latest-oil-industry-move-1677212

Geary, P. (2005, May 25). Solar Power Profitability: BP Solar. *Environmental News Network*. Retrieved from https://web.archive.org/web/20090328235849/http://www.climateark.org/shared/reader/welcome.aspx?linkid=42124

Geels, F. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy*, 31, 1257-1274. doi:10.1016/S0048-7333(02)00062-8

Geels, F. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovations and Societal Transitions*, 1 (2011). 24-40. doi:10.1016/j.eist.2011.02.002

Geels, F. (2014). Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective. *Theory, Culture & Society*, 31(5), 21-40. doi: 10.1177/0263276414531627

Heiskanen, E., et al. (2018). Incumbent energy companies navigating energy transitions: strategic action or bricolage?. *Environmental Innovation And Societal Transitions*, 28, 57-69. doi: 10.1016/j.eist.2018.03.001

Herold, T. (2017). What are the Seven Sisters Oil Companies?. *Herold's Financial Dictionary*. Retrieved from https://www.financial-dictionary.info/terms/seven-sisters-oil-companies/

Hoyos, C. (2007, March 11). The evolution of the Seven Sisters. *Financial Times*. Retrieved from https://www.ft.com/content/2103f4da-cd8e-11db-839d-000b5df10621

InfluenceMap. (2019). *Big Oil's Real Agenda on Climate Change* (InfluenceMap report, March 2019). Retrieved from https://influencemap.org/report/How-Big-Oil-Continues-to-Oppose-the-Paris-Agreement-38212275958aa21196dae3b76220bddc

International Renewable Energy Agency. (2019). *Energy Transition*. Retrieved from https://www.irena.org/energytransition

Kaye, L. (2019, April 9). Can a Massive Wave of Tree-Planting Turn Around Big Oil's Reputation?. *Triple Pundit*. Retrieved from https://www.triplepundit.com/story/2019/can-massive-wave-tree-planting-turn-around-big-oils-reputation/83106

Keaver, J. (2013, April 3). BP wind sale highlights renewable energy struggles. *Houston Chronicle*. Retrieved from https://fuelfix.com/blog/2013/04/03/bp-to-sell-wind-business/

Kohl, K. (2013, May 10). Exxon Gambles on Gas. *Energy & Capital*. Retrieved from https://www.energyandcapital.com/articles/exxon-gambles-on-gas/74508

Kolk, A., and Levy, D. (2001). Winds of Change: Corporate Strategy, Climate Change and Oil Multinationals. *European Management Journal* 19(5): 501–509. Retrieved form https://www.sciencedirect.com/science/article/pii/S0263237301000640

Lamonica, M. (2011, December 21). Another one bites the dust: BP Solar shuts down. *CNET*. Retrieved from https://www.cnet.com/g00/news/another-one-bites-the-dust-bp-solar-shuts-down/?i10c.ua=4&i10c.encReferrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8%3d&i10c.dv=19

Laville, S. (2019, March 22). Top oil firms spending millions lobbying to block climate change policies, says report. *The Guardian*. Retrieved from https://www.theguardian.com/business/2019/mar/22/top-oil-firms-spending-millions-lobbying-to-block-climate-change-policies-says-report

Lee, A. (2019, June 21). “Big Oil” bad choice to take wind and solar lead: Macquaire analyst. *Recharge News*. Retrieved from https://www.rechargenews.com/transition/1812030/big-oil-bad-choice-to-take-wind-and-solar-lead-macquarie-analyst

Lee, A. (2019, June 28). Oil giant BP eyes US for offshore wind market debut. *Recharge News*. Retrieved from https://www.rechargenews.com/wind/1816821/oil-giant-bp-eyes-us-for-offshore-wind-market-debut

Leipprand, A., and Flachsland, C. (2018). Regime destabilization in energy transitions: The German debate on the future of coal. *Energy Research & Social Science*, 40, 190-204. doi: 10.1016/j.erss.2018.02.004

Macalister, T. (2011, April 29). Total invests £800m in US solar power firm. *The Guardian*. Retrieved from https://www.theguardian.com/business/2011/apr/29/total-solar-power-renewables

Markets Insider. (2019). *Oil (Brent) price commodity*. Retrieved from https://markets.businessinsider.com/commodities/oil-price?type=brent

Markets Insider. (2019). *Oil (WTI) price commodity*. Retrieved from https://markets.businessinsider.com/commodities/oil-price?type=wti

Martin, C., and Crowley, K. (2018, November 28). Exxon Will Use Wind, Solar to Produce Crude Oil in Texas. *Bloomberg*. Retrieved from https://www.bloomberg.com/news/articles/2018-11-28/oil-giant-exxon-turns-to-wind-solar-for-home-state-operations

McFarlane, S. (2019, July 22). BP Boosts Its Biofuels Business with Brazilian Joint Venture. *The Wall Street Journal*. Retrieved from https://www.wsj.com/articles/bp-boosts-its-biofuels-business-with-brazilian-joint-venture-11563805710

Navach, G. (2018, April 13). Italy's Eni defies sceptics, may up stake in nuclear fusion project. *Reuters*. Retrieved from https://www.reuters.com/article/us-nuclearpower-fusion-eni/italys-eni-defies-skeptics-may-up-stake-in-nuclear-fusion-project-idUSKBN1HK1JJ

Nuclear Engineering International. (2018, May 14). *Italy's Eni looks to fusion*. Retrieved from https://www.neimagazine.com/news/newsitalys-eni-looks-to-fusion-6146917

Oil and Gas Climate Initiative. (2019). Retrieved from https://oilandgasclimateinitiative.com

OilNow (2017, August 29). *The super-majors... what and who are they?*. Retrieved from https://oilnow.gy/uncategorized/the-super-majors-what-and-who-are-they/

Pickl, M. (2019). The renewable energy strategies of oil majors – From oil to energy?. *Energy Strategy Reviews*, 26, 100370. doi: 10.1016/j.esr.2019.100370

Pyper, J. (2018, January 15). Shell Takes a Major Stake in US Solar Developer Silicon Ranch. *Green Tech Media*. Retrieved from https://www.greentechmedia.com/articles/read/shell-takes-major-stake-in-us-solar-developer

Rankin, J. (2019, June 20). Central European countries block EU moves towards 2050 zero carbon goal. *The Guardian*. Retrieved from https://www.theguardian.com/environment/2019/jun/20/eu-leaders-to-spar-over-zero-carbon-pledge-for-2050

Renewable Energy Word. (2006, February 2). *SolarWorld Acquires Shell's Solar Business*. Retrieved from https://www.renewableenergyworld.com/articles/2006/02/solarworld-acquires-shells-solar-business-42840.html

Reuters. (2013, July 30). *BP scraps sale of U.S. wind farm business*. (Reuters market news). Retrieved from https://www.reuters.com/article/bp-results-wind/bp-scraps-sale-of-u-s-wind-farm-business-idUSL6N0G028J20130730

Royal Dutch Shell plc. (2019). Corporate website. Retrieved from https://www.shell.com/

Sheppard, D., and Hook, L. (2019, March 15). Eni to plant vast forest in push to cut greenhouse gas emissions. *Financial Times*. Retrieved from https://www.ft.com/content/7c4d944e-470d-11e9-b168-96a37d002cd3

Soliman, T., et al. (2016). In the pipeline: Which oil and gas companies are preparing for the future? Executive Summary. *CDP*. Retrieved from https://6fefcbb86e61af1b2fc4-c70d8ead6ced550b4d987d7c03fcdd1d.ssl.cf3.rackcdn.com/cms/reports/documents/000/001/327/original/oil-gas-report-exec-summary-2016.pdf?1479834286

TOP500 Supercomputer Sites. (2019). *TOP500 List, June 2019*. Retrieved from https://www.top500.org/lists/2019/06/

Tordo, S. (2011). National Oil Companies and Value Creation. *World Bank Working Papers*. doi: 10.1596/978-0-8213-8831-0

Total S.A. (2019). Corporate website. Retrieved from https://www.total.com/en

Trabish, H. K. (2010, October 6). BP Wind Energy: Undiscouraged and Still Building Wind Farms. *Green Tech Media*. Retrieved from https://www.greentechmedia.com/articles/read/bp-wind-energy-undiscouraged-and-still-building-wind-farms

Vaughan, A. (2018, September 11). Global demand for fossil fuels will peak in 2023, says thinktank. *The Guardian*. Retrieved from https://www.theguardian.com/business/2018/sep/11/global-energy-demand-fossil-fuels-oil-gas-wind-solar-carbon-tracker

Verschuren, P., Doorewaard, H., Poper, R., and Mellion, M. (2010). *Designing a research project* (2nd ed.). The Hague: Eleven International Publishing.

Voytko, L. (2019, August 29). EPA Proposes Methane Emissions Rollback—Oil And Gas Industry Not Entirely In Favor. *Forbes*. Retrieved from https://www.forbes.com/sites/lisettevoytko/2019/08/29/epa-proposes-methane-emissions-rollbackoil-and-gas-industry-not-entirely-in-favor/#2e165e223162

Wesoff, E. (2016, May 9). Oil Giant Total to Acquire Battery Maker Saft for $1.1 Billion. *Green Tech Media*. Retrieved from https://www.greentechmedia.com/articles/read/oil-giant-total-to-acquire-battery-maker-saft-for-1-1-billion

Willsher, K. (2018, December 5). Macron scraps fuel tax rise in face of gilets jaunes protests. *The Guardian*. Retrieved from https://www.theguardian.com/world/2018/dec/05/france-wealth-tax-changes-gilets-jaunes-protests-president-macron

Woods, A. (2019, March 1). Total partners with EREN Renewable Energy to expand renewable business. *Chief Sustainability Officer Magazine*. Retrieved from https://www.csomagazine.com/sustainability/total-partners-eren-renewable-energy-expand-renewable-business

World Energy Council. (2014). Global Energy Transitions. Berlin: Weltenergierat. Retrieved from https://www.worldenergy.org/wp-content/uploads/2014/12/Global-Energy-Transitions-2014_EfG2014-mit-AT-Kearney.pdf