POLITECNICO DI TORINO

Master of Science in

Engineering and Management

Master's Degree Thesis

The Renewable Asset Managers in the Energy Transition

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INTRODUCTION

The work performed is the outcome of six months of internship in the Operation and Maintenance unit of Enel Green Power, in which I had the opportunity to gather knowledge, information and carry out a market analysis regarding the growing position of Asset Management Companies in driving the energy transition.

The falling costs of renewables, the electricity's penetration in many developing countries and the necessity to prevent the global warming, has led many non-industrial investors to perceive in renewables assets an attractive form of investment.

With the escalation of investment portfolios worldwide and the lack of investors' technical expertise, the market has placed ever higher expectations on Asset Managers in performing not only technical services but also commercial and financial asset management services. Thus, becoming expert in optimizing a portfolio of assets or managing a corporate rather than a single asset.

In this framework, Enel Green Power is implementing a new business model through which important services, products or know-how are offered through platforms that mobilize third-party investments in renewable assets. Among others, the company also offers its partners Asset Management services for the Operation and Maintenance of renewable plants.

Thus, during my traineeship period, I had the change to carry out a benchmark analysis in relation to the renewable asset management companies and, through a data analysis and cost comparison, support the company in identifying whether to outsource or internalize the asset management services for the new wide upcoming capacity.

Starting from a scanning of more than 37 asset management providers, a restricted selection was made in order to finally identify 8 main asset management companies and carry out dedicated interviews.

Through the identification of specific KPIs and the comparison of costs the work delivered valuable contribution to the company in making strategic future decisions.

After a brief introduction regarding the main factors that are driving the energy sector in achieving the carbon neutrality, the first chapter aims to identify the change in paradigm that is taking place in financing the energy transition and the figure of Asset Managers in managing investment portfolios.

In the second chapter, focusing on the management of a single asset, the focus is to understand the meaning of asset management and the importance of the Asset Manager in the overall lifecycle of the project, starting from the development phase and then following the construction, operation and finally the extension, repowering and decommission of the renewable power plant.

Finally, the last chapter get to the heart of the matter by analyzing the added value that an Asset Manager can create in the optimization process of a plant or a portfolio of plants, responsibilities, and the organizational structure in order to manage a multitude of plants in different countries and with different shareholders' needs. Technology is playing a key role in optimizing the technical performance of an asset, provide predictive maintenance, analyze the huge amount of data generated and manage commercial al financial activities in a single asset management platform. In recognizing the importance of digitalization, Asset Managers will continuously deal with a huge amount of data and therefore digital skills should be complemented with existing technical, commercial and financial competences.

From the analysis carried out the role of the Asset Manager is following the changing and dynamic market, subject to the technology trends and performance improvements. Thus, considering the forecasted renewable installed capacity and the unseen amount investments that are expected in the coming years, this thesis can be seen as a guideline for all those parties that are approaching this new type of market: for developer to better understand how to integrate an asset management service in their pool of services, for investors, to know the added value provided by an Asset Manager in optimize an investment portfolio and finally for asset management company itself in order to carry out a own self-assessment.

CHAPTER 1

1.1. CLIMATE CHANGE: NEED OF A GLOBAL AGREEMENT

The world is continuously changing. The melting of glacier and the raising of the sea water, the collapse of ecosystems, the heavy rainfall and the intense weather conditions, such as storms, floods and wildfires are always more frequent and with increasingly harmful effects. According to the World Meteorological Organization, the 2020 was one of the warmest years with a global average temperature of 1.2 °C Celsius above the pre-industrial level. [1]

The effects of the global warming are evident. The average monthly reduction of the Artic sea ice between 1979 and 2020 showed a decline of 13,1% per decade respect to 1981-2010 [2] while the overall average sea level rose of 0,20 meters from 1901 to 2018. [3]

Throughout history, there has always been talk of climate change, but the increased anomalies in the last few years have started to make various technicians and scientists talk about a climate crisis and a possible tipping point.

Looking at the history, starting from the industrial revolution, the growing human activities began to become even more frequent pushing in the atmosphere millions of tons of carbon dioxide, methane and other gases leading the human activities to be considered one of principal causes of greenhouse emissions in the atmosphere and thus, of the climate warming.

According to the Intergovernmental Panel on Climate Change (IPCC), "*human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels […]. Global warming is likely to reach 1,5 °C between 2030 and 2052 if it continues to increase at the current rate.*" [4] Thus, immediate actions shall be taken by the entire society to prevent the condition from worsening.

Although there are different gases such as methane, nitrous and F gases that contribute to the increase of greenhouse emissions in the atmosphere, carbon dioxide has been considered the main driver accounting around 74% of the total anthropogenic emissions. [5]

Moreover, excluding CO_2 emissions related to waste, land use and fertilized used in agriculture, nearly the totality of CO_2 emissions come from the energy sector, especially related to the combustion of fossil fuels and its consumption in transportation, buildings, electricity and heating distribution, heavily dependent on coal, gas and oil resources.

According to the International Energy Agency, electricity, heat generation and transport sectors, "*accounted for over two thirds of total emissions in 2019 and have been responsible for almost all global growth since 2010*" [6]. Thus, considering that the 38% of the electricity is originated from coal source, it remains the most widely energy source consumed but also the most polluting one, accounting in 2019, around 40% of the global energy-related emissions. [7]

As showed in the figure below, [9] looking at the CO_2 emissions by the major worldwide countries, China is currently the most carbon intensive country in the world with around 10 thousand of metric tons of carbon dioxide equivalent, followed by United State with almost half of CO_2 releases compared to the former and finally Europe and India accounted respectively 2 and 3 $MtCO_2$[1] .

Noteworthy is the changing trend between developed and developing countries. While many countries such as the Unite State and the European Countries have seen a slight decrease of CO_2 during the recent years, developing countries such as China and India have drastically increased their emissions in the atmosphere. The underlying reason is that population growth, greater prosperity and energy demand are coupled. Population growth usually presents new challenges for countries to secure their energy supply. Indeed, as demand increases, even more people will resort to using fossil fuels to meet their energy needs, thus, leading to an increase in CO_2 emissions into the atmosphere.

Despite the increase of emissions in developing countries, an important factor to consider are the emissions per capita. It should be noted that although developed countries have seen a downward trend in emissions in recent years, they remain the ones with the highest per capita emissions. For instance, United Arab Emirates with around 20 tons of CO_2 per capita and the United States with 16

[1] Metric tons of carbon dioxide equivalent

tons of CO_2 emissions per capita have more than double the per capita emissions of China and almost sixteen times that of India, which accounts for around 1 ton of CO2 per capita. [8] This means that although developing countries are seeing an increase in air emissions, the challenge of reducing global emissions is an issue for all countries, especially developed ones.

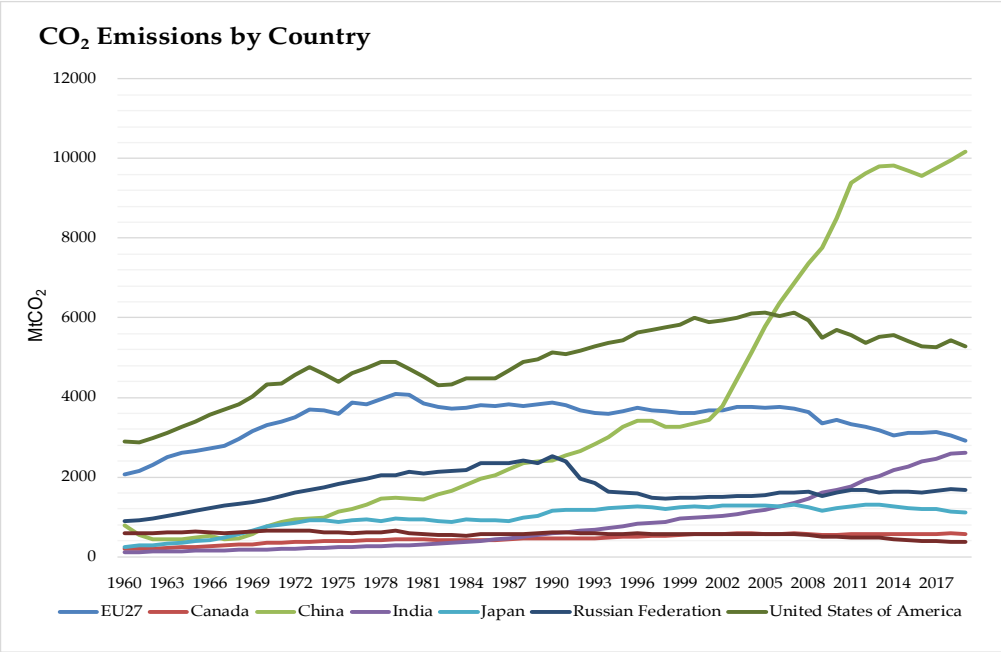

Figure 1 CO2 Emission by Country. Source: Global Carbon Atlas

In this framework, considering the urgency of taking some actions to reduce the causes of the climate change and the CO_2 emission into the atmosphere, in December 2015 at the Paris climate conference (COP21) was signed the first universal, legally binding climate change treaty: The Paris Agreement. [10]

It was the first agreement in the history to be signed by 196 countries with the common aim to tackle the global warming. It required to the parties to make commitments in order to maintain the global temperature below 2 °C and in particular to limit it to 1,5 °C compared to pre-industrial levels. [10]

As specified in the Article 4 of the Paris Agreement, it requires to the parties to reach the peak of greenhouse as soon as possible and "*achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century*".[11]

Always in the article 4, in order to reach this target, the Treaty imposed to the States to release a nationally determined contribution (NDC) and revise it each five years. [11] In this document, the parties are asked to define a short and long-term financial and strategic plan in order to achieve their commitments and reduce the greenhouse emissions.

Although there have been other COP conferences before the Paris Agreement, it was considered the first binding agreement and most importantly for the first time, there was a recognition and participation of all stakeholders including citizen, national governments and local authorities, public and private entities to cooperate to achieve a world's common objective.

Almost six years after the Treaty of Paris, the world is still far from achieving its climate target.

According to the Global Energy Perspective 2021 of McKinsey & Company, [12] although COVID-19 has led a decrease of CO2 emissions of about 7%, the scenario remains far from the 1,5 °C defined in the Paris Agreement. In the Reference Case, which is simply a continuation of existing trends, the emissions are supposed to reach a peak in 2023 and start a steady fall of around 25% until 2050. In case of a more rapid shift to renewable energy, the emissions by 2050 will be 20% lower than the reference case but, in both cases, they are far from the defined pathway. Results shows that from achieve the 1,5 °C target, emissions should drop for the next 30 years with the reduction rate occurred during the pandemic year. [12]

Recognizing how far we are from reaching the target, in 2020 States were being asked to redefine their NDCs. Furthermore, 2021 can be considered a decisive year for climate change as a new COP 26 will be held in Glasgow.

Within the main key points the countries are called to [13]:

- Accelerate the transition from combustion fuels towards more renewable sources
- Provide incentive in order to reduce deforestation
- Increase the penetration of electric vehicle
- Promote higher investment in renewables involving public and private sectors.

Thus, in the coming years, there will be great expectation and actions from governments will be taken by governments in driving all the actors in taking more sustainable paths.

1.2. SOLUTION TO CLIMATE CHANGE: ENERGY TRANSITION

As a matter of fact, one of the foremost ways to achieve the Paris Agreement goal, is through the so-called energy transition.

The energy transition has been defined as the transition process from the production and consumption of energy systems based on fossil fuels - oil, natural gas and coal - to a greater use of renewable forms – solar, wind, hydro, geothermal, biomass - with the main objective to achieve carbon neutrality by the second half of this century.

In the decade between 2009 and 2019 the economic growth registered an increase of around 3,5% per year and after a drop in 2020 rebounded of 6,5% in 2021. [14] The population has continued to growth at an average rate of 1% each year achieving in 2020 around 8 billion of people. [15] The consumption of energy growth of around 2% per year until to achieve in 2019 unprecedented levels of 162.189 terawatt hours of which about 84% derived by fossil fuels. [16]

Although, in the energy mix, the share of fossil fuels is still high, in the last decade, the technological innovation, the political and social pressure have led to an irreversible and rapid growth of renewable energy sources.

The reduction of CO2 emissions into the atmosphere is only one of the benefits to shift towards renewable energy sources. Among the main advantages, these sources are always present in nature ensuring greater security of supply and sustainable targets. Moreover, their constant technology evolution is increasingly bringing an economic advantage in installing a renewable plant instead of thermoelectric power plant or extracting oil and coal.

Furthermore, IRENA in its annual report "Renewable energy and Jobs "(2019) estimated that "*global renewable sector employed eleven million people in 2018, compared to 10.3 million in 2017*". [17] Of those, one third of employments were in

the solar energy compared to other resources and especially in developing countries such as India, Southeast Asia and Brazil creating a great opportunity to narrow the inequality gap. [17]

Until now, although the demand of energy worldwide was high, the cost of renewable sources was still too high to compete with fossil fuel. Hence, the primary source of energy has always been the use of coal.

Over the past decade, the depth electrification, the reduction of renewable costs and the greater accessibility of renewable resources has brought an irrevocable changing trend accounting in 2019, a low-carbon generation mix of around 16%, of those 11,4% from renewables technologies and 4,3% from nuclear. [18]

Moreover, a total renewable installed capacity of 2802 GW worldwide was set in 2019, a 7% compared to the previous year. New record was determined in 2020 with an increase of around 10% in installed capacity respect to the previous year and with more than half of new generation capacity in wind and solar technologies. [19]

As showed in the figure below, [19] looking at the generation capacity by sources, leaders of this transition can be attributed to the solar PV power with an installed capacity of more than double respect to ten years ago and with a total share of onshore wind technology of 24,9% respect to 6,4% in 2005. [19]

Although hydro is still the most popular technology in 2020, this source has grown by an annual average of only 2% over the past five years, compared to 12% and 43% respectively for solar and wind powers. Today, these two sources account for more than half of the electricity generation mix. [19]

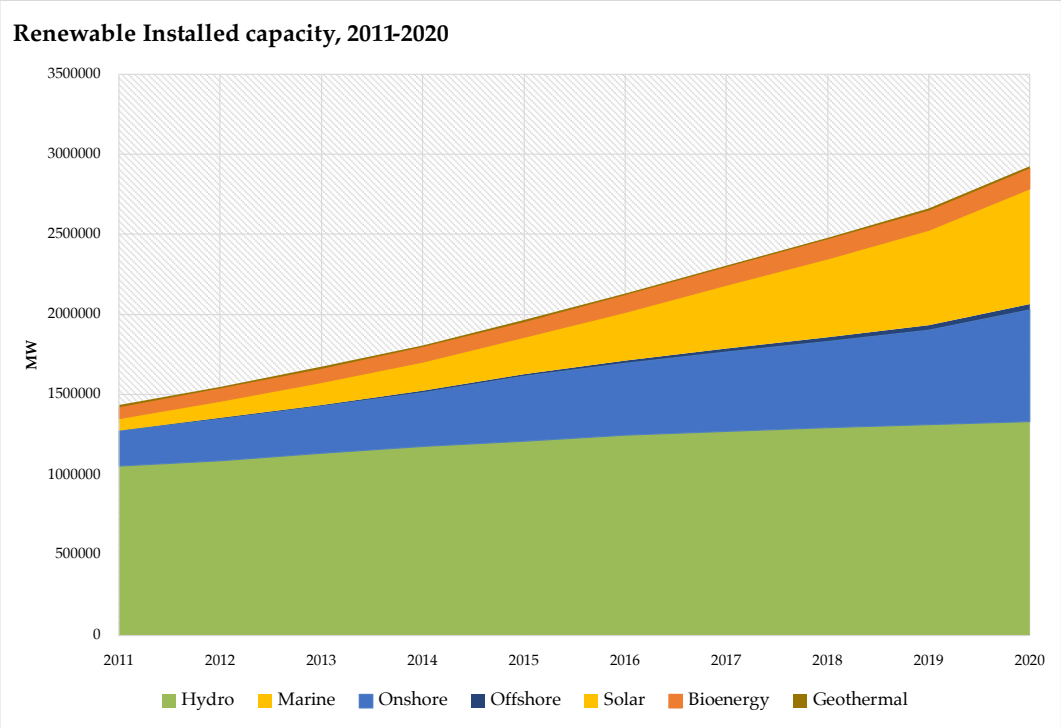

Figure 2 Renewable Installed Capacity by technology. Source: Renewable Energy Statistics 2021

Although the main sources of energy remain due to the combustion of fossil fuels, there are different drivers that in recent years are accelerating this energy transition towards a greater renewable market penetration and with wind and solar leading the way.

Within the main drivers that are handling this energy transition there are:

1.2.1. GOVERNAMENTS' PRESSURE

The Treaty of Paris was one of the first major international agreements reached in history. Within the 196 participating countries, nowadays, 117 parties have submitted or update their nationally determined contribution with stronger goals to fight climate change, 3 countries have proposed new intentions and 46 countries have not update and of these, 100% covered the topic regarding the energy sector. [20] Almost all of them providing numerical numbers.

Within the main countries, the European Union defined to achieve the carbon neutrality reducing at least of 55% of emission by 2050 binding other EU members to release each one their climate plan. [21]

In the Green Deal, the Europe Commission pledged to increase its renewable electricity mix between 55% and 60% by 2030 until to achieve an 84% of share by 2050 and becoming a leader on offshore renewable energy which potentially could reach an installed capacity from 300 to 450 GW by 2050. [22] Further, in the updated "Fit for 55", in 2021, the EU has planned "*to increase the overall binding target from the current 32% to a new level of 40% of renewables in the EU energy mix*". [23].

Among the developing countries, in Japan, in 2021, the government has committed to promote a legislative framework and tax incentive systems in order to stimulate 1,7 trillion yen of private investments and satisfy the increasing electricity demand through an introduction of 50% - 60% from renewable sources [24] while South Africa government planned to have a total installed capacity of 8,2 GW solar PV and 17,8 GW wind power by 2030. [25] Although, the Integrated Resource Plan 2019 intend to decommission around 35000 MW of coal plants by 2050, the "*coal will continue to play a significant role in the electricity generation in South Africa in the foreseeable future*". [25]

Another major industrial power is China, which among different sectors, committed to install a total capacity of 1200 GW by 2030 from solar and wind sources and introduce policies such as risk management system or required environmental and sustainable standard to attract internal and external investments. [26]

In America, Joe Biden, after rejoining the Paris Agreement in early 2021, announced that the nation will achieve net-zero emissions in 2050 with a promise to identify fossil fuel sources by abolishing subsidies on sources such as oil and gas. Despite this, it is one of those regions that has not identified quantifiable targets and insufficient policies to achieve the pathway. [27]

So far, India remains the fourth country with the most renewable capacity installed accounting in July 2021 96,96 GW of renewable installed capacity with an annual growth rate of around 15% between 2016 and 2021. [28] Moreover, the ministry of New and Renewable Energy have set ambitious targets planning to achieve a 450 GW of renewable power capacity by 2030 whose over 60% in solar energy. [28] Considering the increasing energy demand in the next twenty years,

energy efficiency commitments and support in attract financial investments in new technologies are considered key principles by India's government.

Even though governments and international associations are implementing policies, the amount of fossil fuel use is still high, and the Paris agreement is far away, requiring governments to enforce tighter regulations and increase the amount of renewable source in their generation mix.

1.2.2. REDUCTION OF RENEWABLE COSTS

The main index for comparing the cost of different renewable technologies is the so-called Levelized Cost of Energy (LCOE). It can be thought as the average total cost of the power plant per each unit of energy generated during the overall lifetime of the project.

As described in the formula below, the costs considered are related to the initial investment for building the project (I), operation and maintenance expenditures during the operating years (M) and finally the ordinary fuel expenditures (F) to keep the system operational divided by the total energy produced (E) during the lifecycle of the considered power plant.

$$\text{LCOE} = \frac{\sum_{t=1}^{n} \frac{(I+M+F)}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E}{(1+r)^t}}$$

This implies that an investor will never invest in a resource whose LCOE is high as it would lead to an increase in the price of electricity for the end-customer.

Whereas until now the installation of renewable resources was still too expensive, causing a low market penetration, in the last ten years, the market has seen a sharp drop in the levelized cost of energy, leading many investors to consider renewable resources as a comparable source of energy respect to fossil fuel.

As the chart below shows [29], over the past three years, the levelized cost of electricity from three main technologies - solar, hydro and onshore - has been

lower than that of fossil fuels, making it cheaper for an investor to build one of these renewables than to invest in a fossil fuel plant.

While hydro has always been the most popular renewable source, mainly because of its lower cost, solar has seen an exponential decline from 0.381 USD/KWh to 0.010 in 2015 and achieving a record of 0.06 USD/KWh in 2020. [29]

Also, onshore wind saw a decreasing, less than solar, but reaching a final value of 0.039 USD/KWh, well below of 0,01 USD/KWh compared to fossil fuel. This means that a wind farm with 30 wind blades of 3MW, capacity factor of around 40% and consequently a capacity of 17 million KWh/year could require for an investor around 13 millions of dollars. [29]

For this reason, considering the energy mix of renewable sources; solar PV and onshore wind power account for more than half of the total renewable energy installed and are considered the technologies that are driving the energy transition. Moreover, an even higher grow will occur in the future years.

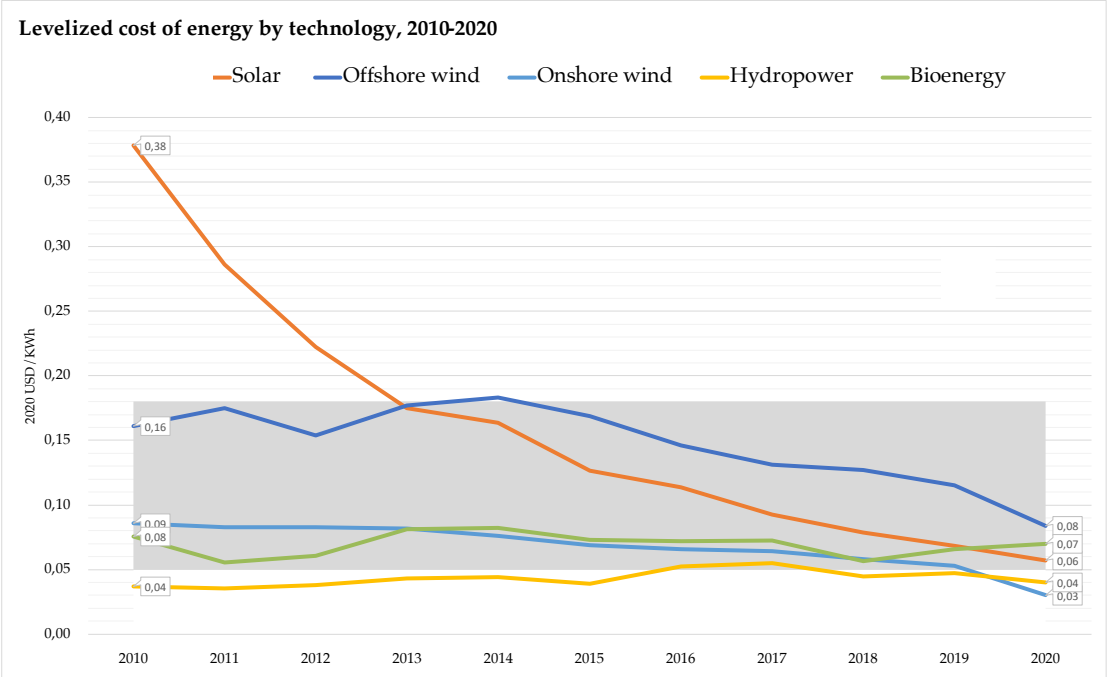

Figure 3 LCOE by technology. Source: IRENA Renewable Cost Database

Several reasons can be linked to this phenomenon. The first is mainly due to the increase in market's competitiveness. Indeed, during the last few years, the

installed capacity through auctions and power purchase agreements has increased, thus generating a lower cost of purchase.

Secondly, the renewable sources, especially solar and wind power, benefit of the learning curve. This mean that as the installed capacity increase, the technology became more cost-effective leading a reduction on cost and an increased market demand. Moreover, increased demand leads to a higher number of installed capacities through PPAs and auctions thus, reducing costs even further.

This phenomenon is not only due to improved human experience, but above all to the increased technological transformation that has led to a higher level of power plant's efficiency and consequently a higher production capacity.

Today, a utility PV power plant could reach up to 20% of capacity factor compared to 14% ten years ago, while an offshore wind plant can reach up to 40% of efficiency. [29]

For instance, in order to increase the efficiency of solar PV plants, nowadays, there is the possibility to install bifacial modules or innovative trackers able to rotate according to the position of the sun.

As defined by U. Pillai in his article "Drivers of cost reduction in solar photovoltaics", other two contributions that have led to the reduction of levelized cost of electricity for solar technology are attributed to the decrease of price of polysilicon[2] and its total quantity to make a watt of solar panel. [30] In fact, the price of this material dropped from around 120 US/kg in 2008 to around 22 US/kg in 2012 while the grams per watt used shifted from 7 to around 5 grams per watt in the same period. [30] In 2019, the polysilicon spot price registered a price of 9,50 US/Kg, the lowest price in the history. [31]

The same trend occurred for wind power plants. In this field, the main drivers that are driving down total costs could be attributable to the ability to build more efficient inverters and higher wind turbine's size capable of capturing more energy from the wind.

[2] Polysilicon is the main material used to produce solar cells.

In recent years, the heights and installed power of turbines have been increasing rapidly. While in the early 2000's year, wind turbines reached a capacity of about 1MW and a height of about 70 meters, today the range is between 3 and 3,5 MW and in the next few years will reach around 6MW. [32] Different size it is expected for future offshore power plants, that could also reach 12-15 MW. [32]

Furthermore, technological innovation has given a huge contribution to operation and maintenance phase, allowing greater efficiency in preventive failures, monitoring the performance plant and analyze root cause, thus, decreasing the overall maintenance costs.

1.2.3. NEW TECHNOLOGIES: ENERGY STORAGES AND HYDROGEN

One of the main problems that led renewables to be a niche source was mostly due to the market variability and its strong dependence on external factors such as weather conditions, geographical location and limited fulfilment of energy demand.

The increasing innovation technology has partly solved this problem through the current storage systems and their integration to the renewable energy mix. They are innovative technologies which through an electrochemical process are able to directly transform chemical into electrical energy. Storage technologies coupled with renewable power plants allow centralized and distributed systems to optimize the dispatching of energy, predict the load of grid and better respond to periods of high demand.

The last market trends are showing how different power and utility players are moving towards a strong vertically integration operation acquiring storage companies and their know-how offering to the customer a final renewable plant plus storage solution.

Although at present the costs for battery production are still too high to be competitive with other resources in the market, even more solutions are being sought to lower battery costs. If this were to happen, the possibility of complementing a renewable system with a storage system would further increase the market penetration of renewable resources.

Another technology that will lead to decarbonization from fossil fuels and it is accelerating the spread of renewables can be attributed to hydrogen technology.

Up to now, hydrogen has always been used by the chemical industry to produce ammonia, methanol, agricultural fertilizers as well as petroleum products and the production of this source is currently achieved through a chemical process using fossil fuels as coal and natural gas and only a slightest part is obtained by electrolysis.

Electrolysis is a chemical process whereby water is split into hydrogen and oxygen by a flow of current. If the necessary electricity were produced from renewable sources, this would lead to the production of so-called green hydrogen.

Technology is driving the deployment of this resource in more sectors such as transport, heat production in industrial plant or for electricity distribution, thus bringing in turn an additional necessity of renewable demand.

One of the main problems of these new technologies is related to their high cost and low market penetration. Even on this area, giant steps are being taken by private and public sectors, thus that in the next few years the same trend as for solar and wind technologies may emerge.

1.2.4. INCREASED ELECTRIFICATION AND POWER GENERATION DEMAND IN DEVELOPING COUNTRIES

Another trend taking place in the market is the intensification of electrification in many sectors previously driven by fossil fuels.

Starting from the everyday life in which we are surrounded by electronic devices, the most affected field has been the transport sector, in which in the last decade experienced an incredible shift of paradigm from petrol and diesel to electric cars. According to IEA, the number of registered electric cars increased by 41% by 2020 to reach a total of 10 million cars on world's roads. [33] Moreover, following a slower path due to technological issues, bus and trucks have also increased their global fleet, thus, accelerating the decarbonization process. [33]

The transport sector is the most obvious but building and industry sectors have also undergone profound changes.

As showed in the figure below [34], from 2000 to 2020, all worldwide countries have seen an increase of electricity share in their final energy consumption and most of this electricity produced from renewable sources.

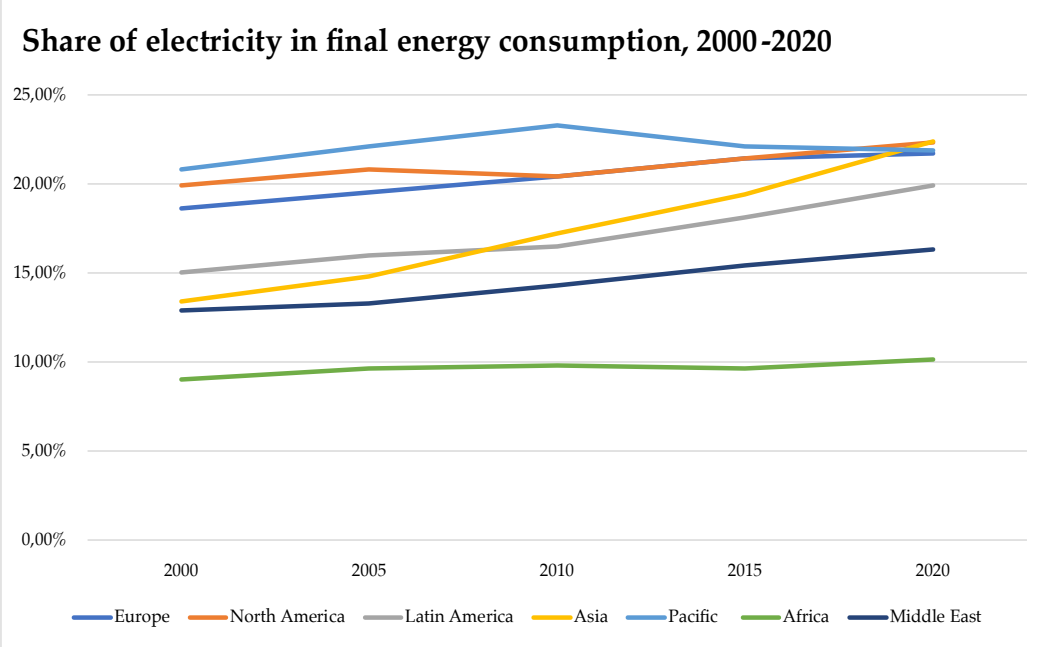

Figure 4 Share of electricity in final energy consumption. Source: Enerdata

However, while in the last decade, developed countries such as Europe and North America have seen a slightly increase of around 1% in electricity share in the overall energy consumption, a radical change has taken place in underdeveloped countries. In fact, in Latin America the electricity share shift from 15% to 20% between 2000 and 2020, in Asia rose of around 10 percentage points until to achieve 22% electricity share of the final energy mix, whereas in the Middle East rose of around 5 percentage points from 12% in 2000.

This trend is mostly due to the better living condition and gaining access to electricity of most developing countries. In fact, in 2019, in India, more than 99% of population gained access to electricity. [35] In China, instead, 100% the entire population achieved electricity in their homes. [35] On the other hand, "*the 75% of population without access now live in sub-Saharan Africa*". [35] In fact, it remains very fragmented.

Thus, as the costs of renewable technologies fall, even more demand of power generation will be met by renewable resources. According to IEA, "*the share of renewables in global electricity generation jumped to nearly 28% in Q1 2020 from 26% in Q1 2019.*" [36]

Looking at the renewable installed capacity, in the figure below, [19] ,it is possible to notice how the renewable sources have grown exponentially in the last decade. Moreover, following this trend, developing countries may be considered leaders of this energy transition accounting in 2020 more than half of the total renewable installed capacity worldwide.

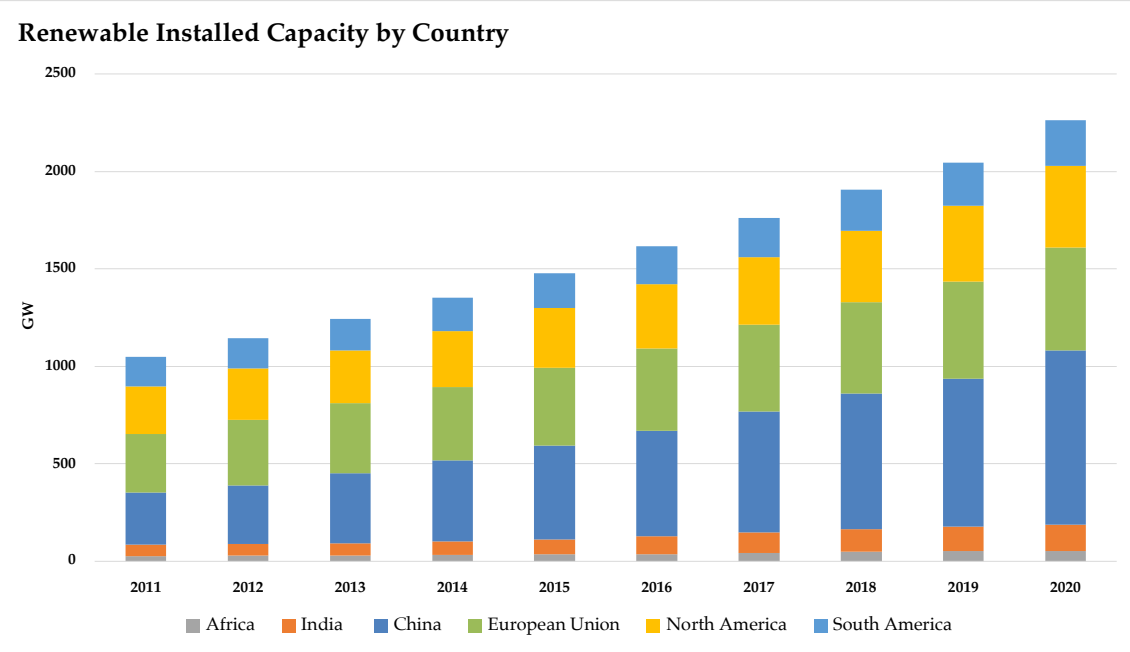

Figure 5 Renewable Installed Capacity, 2011-2020. Source: IRENA (2021) Energy Statistics 2021

Indeed, while Europe and North America have doubled their installed capacity accounting, in 2020, respectively 528 GW and 420 GW, China has seen its installed capacity quadruple from 267 GW in 2011 to around 894 GW, an average annual increase of around 23%. In Africa, an additional 26 GW were installed between 2011 and 2020. [19] In South America, instead, Brazil has always been the country with the higher installed capacity.

Meanwhile, population of undeveloped countries continues to grow and following the most recent trends, access to electricity is also expected to increase in the coming years.

Considering the high dependence of these region on fossil fuels, in order to make the energy transition happen, many private and public investments have to be made in developing countries.

In the last years, the falling costs of renewables, the strong favorable climate conditions of these territories and supporting targets defined in the Paris Agreement, have led governments, but also private investors of most developed country to find in emergent nations great investment opportunities and at the same time helping these nations to achieve their development process.

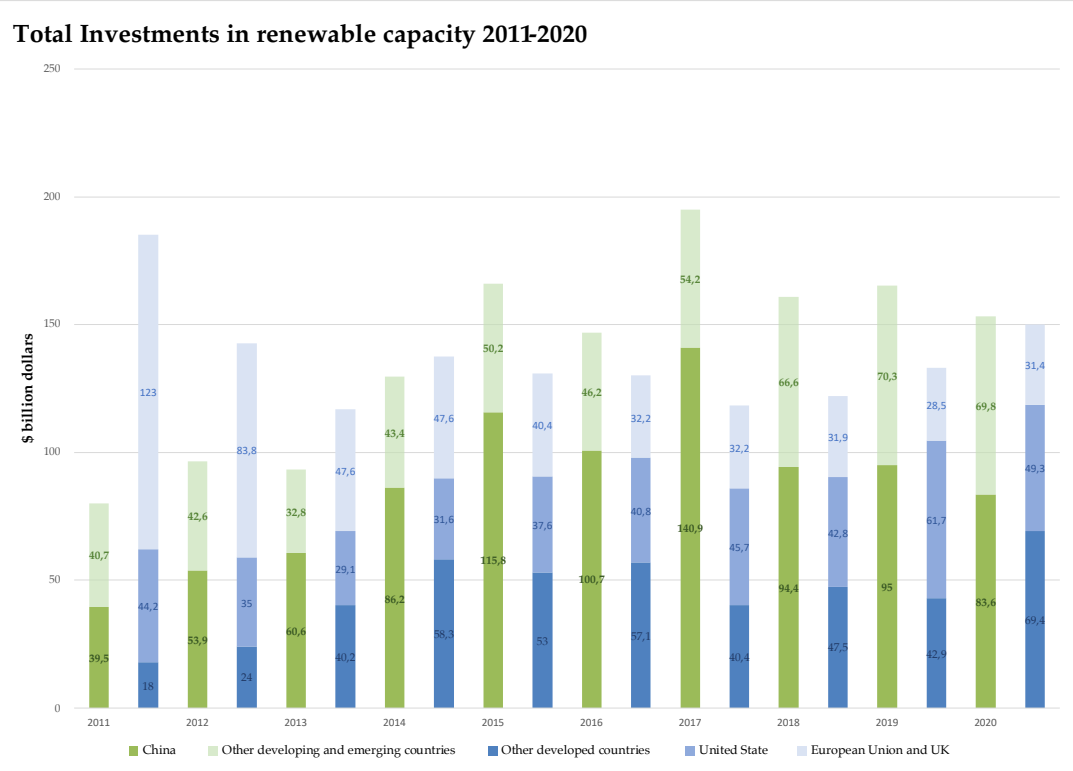

Figure 6 Total Investments in Renewable Installed Capacity 2011-2020. Source: REN21, Renewables 2021 Global Status Report

As showed in the table above, [37] while in the first half of this century the main investors in renewables sources were mostly made by developed countries, starting from the 2005, there has been a change in trend of renewables, with undeveloped countries, excluding China and India, playing an increasing role.

1.3. FORECASTED RENEWABLE ENERGY DEMAND

As seen up to now, the installation cost, the development of new technologies such as batteries and hydrogen, the government's targets and the steady population growth has led to an exponential growth of renewable energy driving the energy system towards a more sustainable and clean way to exploit the natural resources. Moreover, the digitalization and the electrification in different sectors is making everything much easier.

Despite a slowdown due to the covid, it is estimate that the energy demand will return to previous levels in two to three years, but this is still a lower growth rate than estimated in previous years. Several studies have been carried out concerning the energy sector in the long-term considering the current state and commitments made by different stakeholders in society. A common factor remains the increase of an energy demand over the next thirty years and the fulfillment of it through an expansion of renewable sources and future renewable technologies.

According to the International Outlook of U.S. Energy Information Administration (EIA) the global energy demand will double by 2050 achieving around 900 quadrillion British thermal units[3] of energy consumption.

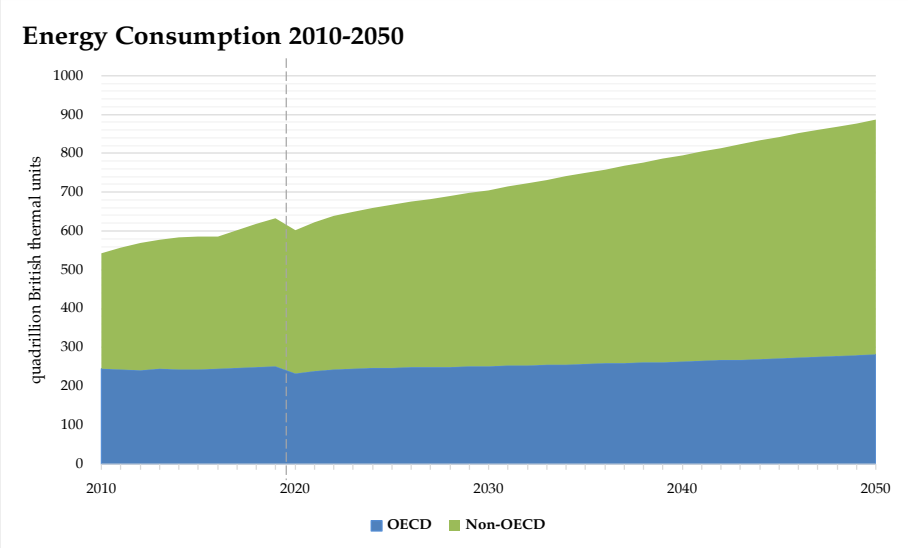

Figure 7 Forecasted Energy consumption. Source: EO2021 Release, CSIS, October 6, 2021

[3] A quadrillion British thermal unit is an energy mainly used in United State or United Kingdom. It is equivalent to 10^5 British thermal unit or 1,055 EJ.

As shown in the figure above [38] , among the countries that will drive this energy transition will be the non-participating countries in the Organization for Economic Co-operation and Development (OECD). Among these, the main nations will be China, India, South East Asia with major developing nations such as Thailand and Indonesia.

Within the main reasons there will be the strong economic growth that they will experience in the coming years. It is estimated that, the European countries or as well as the United States, which until now have been the main consumers of energy, will have a very slow energy demand with an average annual growth rate of about 0.7%, flat compared to developing countries.

Looking at the resource mix of consumption by 2020, as reported in the figure below [38] , it is clear that renewable sources will double be compared to 2020 with a 5% of annual growth, overtaking the consumption of coal and gas and reaching almost the same share as oil. Notwithstanding this, fossil fuels will still be the most widely used energy source.

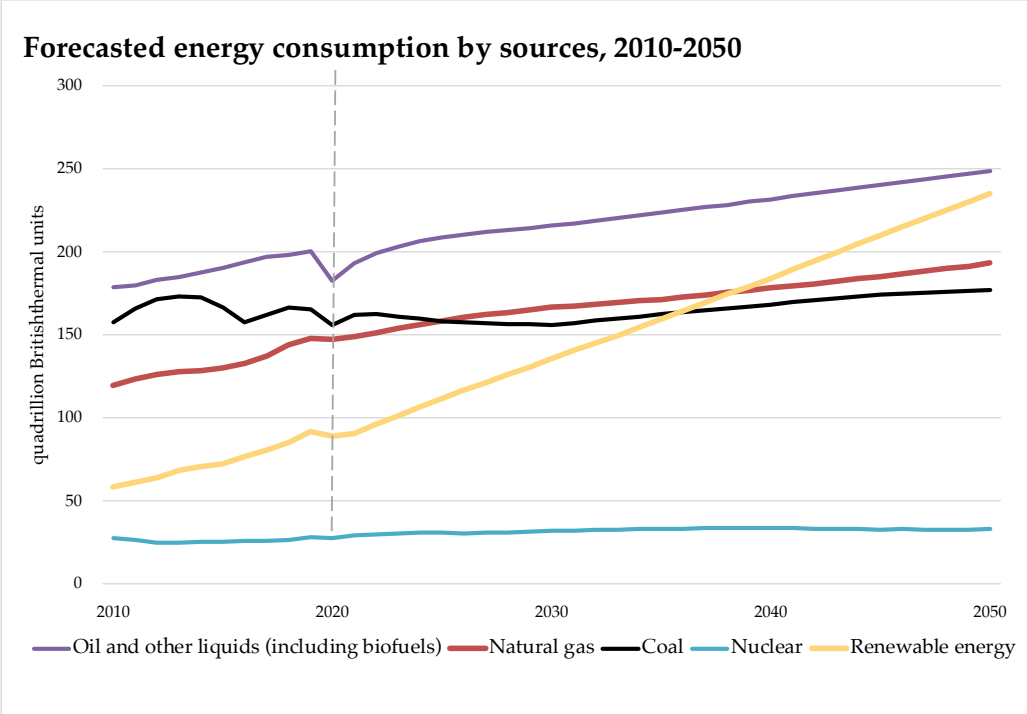

Figure 8 Forecasted Energy consumption by sources. Source: EO2021 Release, CSIS, October 6, 2021

The share of fossil fuels will continue to be relatively high mainly due to the use and continued use of these forms by undeveloped countries especially China, India and other Asian nations which will remain a form of security over renewable resources.

Coal consumption will drop from a 25% of share in 2020 to 18% in 2050. The reason will be mainly due to the decommissioning of many power plants in United States in the coming years and the use of cheaper resources such as renewables and natural gas. Moreover, it is the resource with the highest CO_2 emission into the atmosphere, thus, in order to achieve the Paris Agreement, it should be the first resources to see a reduction in the next three decades.

The electrification of the transport system, in which the use of oil was the main source of fuel, and consumer awareness of this source of consumption will lead a slightly drop of around 3% of oil consumption in the next thirty years. However, it will remain the highest source's share in the energy consumption mix.

The recent stepping-up of electrification in various sectors such as transportation, home and commercial offices sector, industry mainly for goods and services' production or heating and cooking are among the main drivers which are leading the energy sector towards a greater use of renewable sources.

Looking at the power generation from now to 2050, as reported in the figure below [38], it is estimated that around 80% of the electricity will be supplied from renewable sources in the coming years. Among the technologies, solar will be among the sources that will predominate with an offer of about 10 KWh compared to just over 1 KWh produced in 2020.

With an increase of about 5% per year, also the onshore and offshore wind will tend to grow reaching about 7 KWh of electricity and supplying together with hydroelectric and solar more than 70% of the total electricity production from renewable sources.

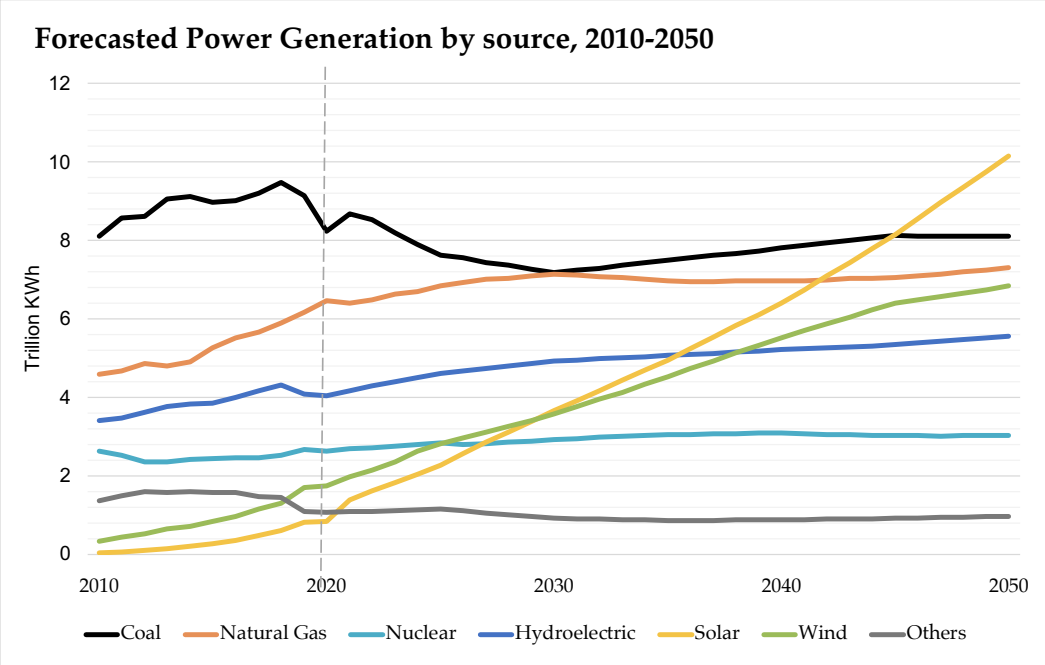

Figure 9 Forecasted Power Generation by sources. Source: IEO2021 Release, CSIS

A different trend will happen for the fossil fuel. Coal after peaking around 2025 will tend to decline until it reaches its lowest ever recorded level of electricity production of around 7 KWh in 2030. After 2030, it will tend to grow slightly but will never reach previous levels.

Natural gas, on the other hand, will grow until 2030 in which it will reach the production levels of coal, but after that, it will also tend to decrease in the coming years. Noteworthy, the main two sources of fossil fuels will have an opposite trend from now to 2050.

1.4. FINANCING THE ENERGY TRANSITION

Satisfy the increasing demand of electricity from renewable sources and achieving the net zero path require large amounts of investments.

Considering the period from 2011 to 2020, about 2,7 trillion of dollars have been invested in renewable power capacity of which 303,5 billion only in 2020, thus, registering an increase of 2% compared to the previous years. [37]. Within the leading technologies remain solar and wind power generation, accounting respectively of 148,6 and 142,7 billion of dollar invested in new installed capacity in 2020, an increase of 64% and 60% compared to the previous decade.

As showed also in the Figure 6 of Total investment in renewable capacity, it should be noted that although the installed capacity has dropped in recent years, the last years there were a decrease in investments compared to 2017. One of the main reasons can be associated with the reduction of installation costs and the learning curve discussed in the previous paragraph. Thus, in future years it might be expected the same or higher amounts of investments but with a greater installed capacity and energy production.

The fast digitalization and the covid phase have accelerated the energy transition by leading governments to make greater commitments, increase market competitiveness and raising awareness that renewable energy is the only flexible source capable of satisfying energy demand even in times of crisis.

Moreover, the drop in the levelized costs of electricity which has made renewable energy a comparable source of fossil fuels, the average economic growth of the population especially under-development countries and the increasing number of instruments to invest in the renewable sources has led many non-industrial stakeholders to capitalize their funds through direct or indirect renewable investments based on their level of risk.

Although this investment trend is in line with the achievement of the targets committed by individual states, according to IRENA, around $110 trillion needs to be invested between 2016 and 2050 to achieve the energy transition. [39] Of this, 27 trillion in power generation and end-use application. It implies that around 800 billions of annual investments should be made by private and public sector compared to 350 billion described in the planned energy scenario which includes investments planned by individual states to achieve net zero emissions by 2050. [39]

Moreover, not all states are identical. According to what emerged from COP26, 100 billion euros per year must be invested by developed countries in emerging countries in order to support them in the energy transition through the construction of an electricity grid, new renewable installations and by creating an accessible market for domestic and foreign investors. [40] Thus, there is a huge gap to be bridged and a need for greater participation by all investors, public and private companies through different financial instruments.

1.4.1. RENEWABLES INVESTORS

As in all high-risk sectors, private and public actors have two different roles.

Public actors have always been concentrated on developing countries in order to guarantee the public service or higher riskier projects, where the cost of capital required is overpriced, the return on investment is not profitable and any investor would be willing to capitalize their funds.

Private actors, instead, who account for most of the renewable's investments, have typically a lower risk appetite so their role is mainly base on investing in more developed technologies or in countries where the expected return on investment is certainty higher.

Although private investments have always played a key role, counting for most of the investments, public investments are crucial in setting policies, incentives and tax breaks to mobilize private investment in clean energy.

Looking at the main renewable private actors a distinction could be made according to the reasons which they decide to invest and why to invest in the renewable project or renewable portfolio.

TYPE OF INVESTOR	INVESTOR	WHO	WHY	HOW
Private Investor	**Project Developer and International Oil Companies**	They are mostly industrial parties such as developers and oil companies, manufacturers or Independent power producer that construct and operate the renewable facility and with technical competencies in the renewable sector.	Their core business is to develop, build and operate a power plant to obtain an economic return from the energy's sale.	Mainly through balance sheet project finance or issuing green bonds in the market.

	Corporate Actors	Facebook, Apple, Microsoft and other corporate companies.	Secure the supply of energy, achieve ESG targets and increase visibility.	Power Purchased Agreements, Renewable Energy Credits or installing small solar panels for self-consumption.
	Commercial Banks	Banks who generally finance projects granting a loan. The amount of debt usually depends on the level of risk of the project, stability of the company and revenues stream that the project is able to generate in order to repay the debt.	Obtain an economic return from interest paid by the borrower.	Three different ways: 1. Financing the entire operation of the project 2. Lending an initial amount of money 3. Refinancing the project during the lifecycle.
	Institutional Investors (pension funds, insurance companies, endowments and foundations, hedge funds)	Companies whose goal is to create a pool of money from investors (called fund) in order to take equity or debt in different projects and create a diversified portfolio.	Generate a stable steam of cashflow to support their liabilities. Long and short-term investment, low return on investment required. (around 15%)	Direct or indirect investments through equity or debt. Usually, they invest in operational and maintenance phase of a solar or wind power plant.
	Private Equity	Private funds whose objective is to raise money from different sources and invest equity into mature and stable renewable projects or project portfolio.	Achieve a higher return (around 25%) during the short-term investment period.	Providing equity to renewable project mainly in the development phase. Once the plant is built, operational and has yielded an economic return, they recover the

Private Investor				investment made by selling shares in the market exiting from the business. Short term investment.
	Venture Capital	Companies similar to private equity aimed at investing in green start-ups or new renewable technology systems mainly in the very stage of the project.	Given the risk taken, they can achieve a higher return (around 50%). Medium investment period with the higher return on investment.	Investing money in innovative companies or green technologies and disinvesting after a certain timeframe period.
	Infrastructure funds	Companies similar to pension funds whose main goal is to invest in infrastructures to obtain a return on investment.	Obtain a return on investment from key assets characterized by low risk (15%) and long duration.	Direct investment in the operating phase of the asset or indirect investments such as bonds
Public Investor	**Development finance institutions**	Companies whose role is to support and help private companies in investing in projects in developing countries.	Promoting investments in high-risk projects in which otherwise any private actor would invest.	Through debt securities, equity, guarantees or loans
	Governments	National bodies that hold political power in the country and manage economic, political and social relations.	To promote job creation, country's growth, energy security, achieve environmental targets	Through grants, loans, incentives or acting as guarantor.

	Climate funds	Entities that invest in projects aimed at achieving sustainable and development goals defined by the United Nations.	To incentivize climate projects and bridge the financial gap.	Through equity, loans, grants or loan guarantees

While the role of governments is to create the right conditions of risks and certainty that fit perfectly with the attitude of each individual investor, private actors, which accounts for around 80% of investment, are the main player in driving the energy transition.

Depending on the level of risk, internal rate of return and the ability to acquire the necessary funds, venture capital, private equity, developers can enter the value chain of an asset at different stages.

Whereas venture capital and private equity companies due to their higher risk prefer to invest mostly in the development of new renewables technologies such hydrogen power or storage systems or in clean energy start-ups, institutional investors are potential key actors in capitalize new funds in the power generation sector and cover the investment gap needed in order to achieve the energy transition. [41]

According to IRENA, between the 2013 and 2018, on average the 46% of investments in renewables were made by developers, followed by commercial banks with 22%, corporate actors and households. Respectively 16% and 14%. [41] Institutional funds covered less than 1% of the total investment. [41]

As mentioned in the table above, they are non-industrial parties whose objective is to manage private funds on behalf of investors and invest them mainly in indirect instruments such as bonds, liabilities or securities and only a minimal part in direct renewable investments such as utility-scale projects.

Among the main reasons why these actors are reluctant is mainly due to their high risk's perception in investing in renewables. According to the OECD working papers on Finance, Insurance and Private Pensions [42], there are different barriers that limit institutional investors in directly invest in renewables asset, among these, there are:

1. Regulatory instability and policy risks

Uncertainties on the part of governments in establishing incentives, tax breaks and the lack of a common strategy and coordination between different states or national sub-levels also lead to uncertainty on the part of investors. As their objective is to invest in long-term projects, transparency, investment stability and a common framework are necessary to induce these actors to invest in assets.

2. Lack of Infrastructures

Renewable energy sources compared to fossil fuels have shown a higher variability of energy produced with respect to unpredictable external factors, thus, creating grid connections and infrastructure problems in energy distribution. This is especially true in developing countries where access to electricity has only recently been achieved.

3. High auctions and PPA

The price of an action is influenced by many factors such as the cost of financing, the exchange rate, the cost of technology or simply the structure of the tender. As previously mentioned in the previous paragraphs, there has only recently been a dramatic decrease in the cost of actions, thus decreasing the investment cost.

4. Lack of capabilities and intermediators

Investing in renewables requires financial institutions to consider additional risks when assessing a project such as technological, construction and operational risks as well as social, political and environmental risks. Considering that institutional investors have always invested mainly in public traded companies through debt or equity and with stable income, renewable projects require more technical expertise. Thus, the figure of an intermediary is necessary to guide the investor in identifying risks and opportunities offered by the market and to guide him in the process of making strategic decisions.

5. Liquidity needs

Investing mostly in liabilities, financial investors need a certain level of liquidity to cope with unforeseen needs. Depending on the type of financial investor, they may require a different level of liquidity. For example, pension funds are the most likely to invest in long-term projects as they have a more stable and certain

liability duration. Thus, that not all the potential of their investments could be invested in renewable assets but there is a need to diversify the portfolio according to their risk and duration.

6. Credit Rating Discrepancy

Institutional investors are usually only willing to invest when there is a high bond or corporate credit rating. Due to their variability, renewable assets typically have lower ratings, usually around BBB, thus creating a mismatch between financial institutions and their propensity to invest in renewable assets.

Furthermore, making a distinction between domestic and foreign investors there are other constraints that limit financial institutions, especially in investing in emerging countries. An example is the off-taker risk due to the high probability of insolvency of buyers and that they will not fulfill their contractual obligations or the exchange rate risk, exposing the investor to a strong dependence on market volatility.

Among the various barriers described, of particular interest will be the point related to the lack of technical, commercial and financial capacities of these actors in the renewable sector and the lack of an intermediator, partly filled by Renewable Asset Managers.

1.4.2. ASSET FINANCE INSTRUMENTS

Although there are many actors involved and willing to invest in renewables assets, the main stake remain largely made by developers, manufacturers, or other energy companies.

Within different financial methods hold by companies to financing a project, the two mainly process applied in the market can be identified through the Corporate Finance or a Project Financial Structure. They are both composed by a different mix of debt and equity, but the main difference is given by the risks and the collateral protection offered.

In a Corporate Finance structure, the contribution to develop the project derive from the balance sheet of the company itself. Raising equity from the market through common or preferred share or asking a loan from commercial banks, all

the projects financed are consolidated under the single corporate entity who plays the role of guarantor. This implies that the risks are shared between the different projects and in case of project's default, the lender asserts its claims through the remaining part of the assets, thus impacting the corporate's balance sheet and the investors' return. For this reason, in financing a corporate structure the commercial banks are mainly interested in the balance sheet rather than the cash flows generated by the energy sales of the project itself. Furthermore, if from one side this structure is characterized by high risks and consequently higher return for the investor, on the other, it results the simplest financial structure and characterized by low transaction costs.

Completely different is the Project Finance structure. As showed in the figure below, in this case, the developer entering in partnership with another sponsor, which can be a public sponsor, financial investors, contractor partners or finally another industrial investor, set a separate entity called Special Purpose Vehicle (SPV), with the simple aim of running the project. Thus, associating the risk with the project itself. Collateralizing the renewable project, in case of default, the commercial banks can only rely on the cashflows generated by the energy sales. Considering the high risk made by lenders in defining the creditworthiness of the project, a careful analysis and due diligence process must be carried out by technical advisors, commercial banks and insurance companies in order to define the feasibility of the project and negotiate the contractual terms between the actors involved. [43]. Thus, requiring high transaction costs.

In a project finance structure, considering that during the development and construction phase there is no cash outflow, the debtors can only rely on cashflow during the operational phase. Therefore, requiring parties such as suppliers, EPC, and other contractors to take significant risks during the construction phase.

A measure for mitigate the risk of insolvency and define a stable income cashflow is given by the Power Purchased Agreements. (PPAs). They are long-term contracts in which the off taker decides to purchase the necessary electricity directly from the producer, thus, guaranteeing to this latter a fixed cashflow partially used to repay the liabilities. The remaining part of the cashflow will be distributed to shareholders according to the percentage of share invested in the SPV.

Having numerous actors involved with different responsibilities, stable cash flows and a separate entity from the sponsor's corporate, one of the benefits in setting up a Project Finance structure is to reduce agency costs avoiding opportunistic behavior of shareholders at the expenses of debtholders. [43]. In fact, through a cashflow waterfall, each payment to debtholder will be based on the level of seniority, thus, providing a rigorous monitoring and control of managers.

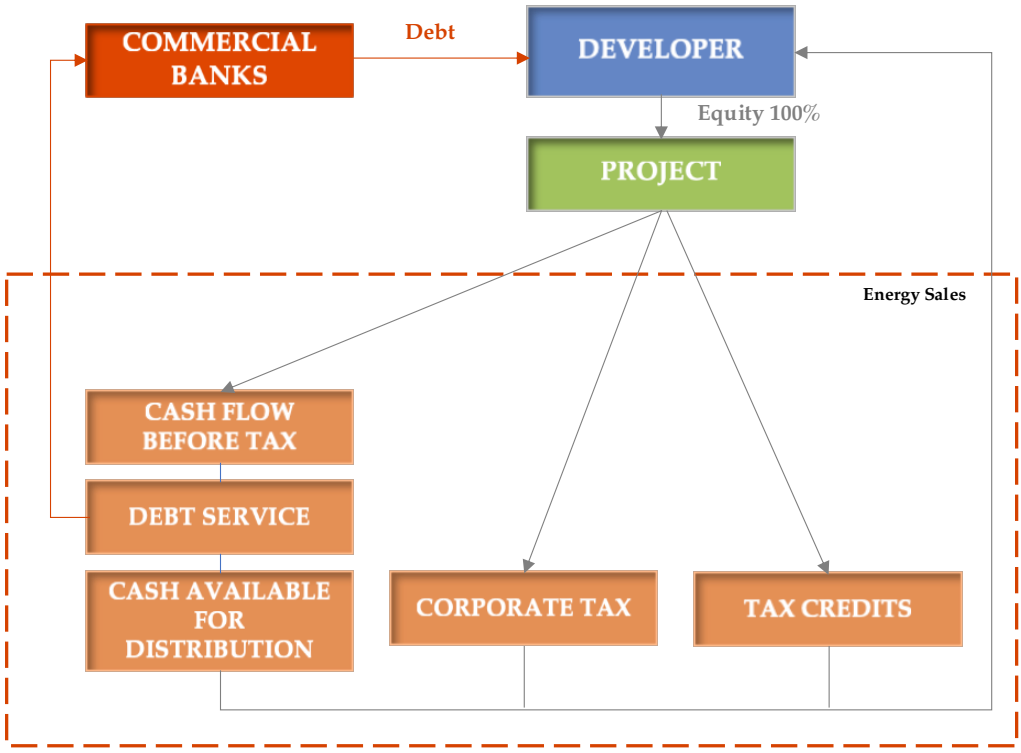

Figure 10 Project Financing Structure

In investing in renewable projects, each country has implemented its own public incentives to encourage the development of renewable sources. For instance, in U.S., the IRC Code Section 48 allows owners or investors of certain types of renewables projects to be eligible for investment tax credit and claim a certain percentage of tax relief on the construction cost of qualified renewables facilities. The same principle is given by the production tax incentive, which provide to the SPV a certain percentage of tax credit for each KW/h of energy production from renewable sources.

In addition, since this structure has a strong debt component as banks usually provide between 45%-60% financing, the corporate has the advantage of taking advantage of the tax shield from taxable income.

Initially used for high-risk projects as it allowed sponsors to use a separate entity and mitigate the risk of default, recently, a project finance structure can also be seen for less complex, low-risk projects such as solar or wind. [44] According to IRENA, during the period between 2013-2014, on average, 56% of annual renewable energy investments were made through project finance structure and the remaining part through balance sheet. [41] Moreover, trends show an increased use of debt in defining a project finance structure, probably due to the stability of solar and wind technologies which lead banks to have a greater awareness of risks and tools to mitigate them. [41]

With the increase in installed capacity and the need for developers to attract more institutional capitals to finance renewable projects, in the last two-decade, two other forms of financial structures have emerged in the market: green bonds and yieldco structures.

Green bonds can be defined as any type of debt securities issued to exclusively finance or refinance new or existing projects that promote climate and environmental purposes. [45] Issued by any public or private entity such as utilities, developers or corporates, depending on the type of bonds issued, these can be considered as common bonds whose proceeds are released based on the solvency of the issuer (proceeds bonds), revenue-backed bonds whose proceeds depend on the cash flow guaranteed by the issuer, green project bonds linked to the single project or finally green secured bonds linked to a group of projects. [45]. These instruments are particularly effective in obtaining financing from financial institutions who usually require low returns and long project duration. Moreover, due to the high risk incurred in the development and construction phase, bonds are particularly useful in case of refinancing as these actors are usually inclined to invest in the operation phase of the project.

A new emerging financial structure born out of the need for many renewable developers, and utilities to raise funds from third parties to finance new renewable projects is the use of a Yieldco. Popular since 2010 and used mainly for the construction and production of solar and wind power plants, the yieldco

can be defined as a subsidiary of the parent company, or sponsor, created through the sale of part of the asset's shares to the market once it enters in the operational phase. The developer assumes all the risks of constructing and developing the asset and once it is in the operational phase, transfers the asset to a yieldco and, maintaining a majority share, sells the remainder to the market in exchange for a stable dividend payment. The capital raised from the market is subsequently used to finance new plants under development.

Defined as a new corporate and not as a partnership, it allows shareholders to benefit of tax efficiency by avoiding paying double taxes and at the same time ensuring the liquidity required by public investors in investing in renewable assets. [46]

Considering the low risk of the project in the operation phase and stable and growing dividends offered, yieldco were born as a tool to attract additional private investors such as private equity and institutional investors hitherto reluctant to make direct investments of renewable assets.

1.5. INVESTMENT TRENDS AND THE ROLE OF ASSET MANAGERS

Although the barriers that limit many of private investors in capitalizing on renewable projects is still a matter of great debate, the growing demand for renewable resources especially in developing countries, the commitments of governments, corporations, developers and financial institutions to achieve the Paris Treaty and finally the heavily drop of installation costs and consequently of auctions and PPAs have led many new investors to perceive renewables assets as a prominent source of revenue. Within these investors, institutional investors are playing a key role in capitalize new renewable funds.

In the field of power generation, they have always played a minor role mainly due to their tendency to invest in stable and low risk markets, however, a change in trend has led many pension funds, insurance companies and hedge funds to diversify their portfolio looking for project finance investments.

Currently, solar and wind power plants through digitalized predictive maintenances, manufacturer’s guarantees and power purchased agreement

aimed at ensuring the bankability of the project, could also achieve a life of 20-25 years, thus, making them a perfect investment for institutional investors looking for a long-term project and stable rate of return.

Moreover, after the financial crises, the increasing liquidity and risk reduction required by many commercial banks and financial institutions have led them tighter requirements for financing a long-term project with their own equity and making it difficult for a developer obtain financial capital, except at higher cost.

Within this framework, a paradigm shift has occurred in the renewables sector, leading many developers to finance a project through the creation of a special purpose vehicle and enter in partnerships with these non-industrial partners.

This new trend allows developers to obtain lower overall project's cost of capital and, at the same time, to institutional investors to get stable and long-term revenues creating entire asset's portfolio.

Currently, mainly due to the new planned capacity in the coming years, many developers are trying to attract these players through the creation of platforms able to capitalize third-party funds in the construction of renewables projects, especially in developing countries such as India, South Africa, Chile and other countries where there is a high necessity to mobilize financial funds. Thus, increasing the transparency and creating a pipeline of bankable projects in which these actors might invest.

Furthermore, considering the amount of funds needed to decrease CO_2 emissions and comply with the Paris Treaty, many governments are trying to implement incentives and provide that regulatory security and stability necessary to attract institutional investors to directly invest in the renewable sector.

Thus, while until now it was mainly developers who invested in renewables energy, the introduction of pension funds, hedge funds, insurance companies and others financial institutions, has seen a revolution in the renewable's asset market, bringing new players into the value chain of a renewable power plant.

One of the main reasons why these financial institutions have always invested mainly in indirect investments such as liabilities, bonds or securities have been due to their lack of technical expertise.

By introducing assets into their portfolio and entering into partnerships with industrial partners such as developers, oil companies or independent power producers, they brought the need to acquire these technical competencies or appoint a figure capable of managing a portfolio of plants from a financial, commercial and technical prospective and keep them informed regarding policy changes, risks and opportunities in the renewable market in order to ensure a return on their investment. These actors are the so-called renewable Asset Managers.

Thus, over the last ten years, with the inception of non-industrial partners in the energy power generation, professional figures have been defined ensuring the correct supervision of the overall plant throughout its overall life cycle aimed to interact with different stakeholders involved.

The figure of the Asset Manager has always existed in the management of the facility. Mainly identified in the same figure of the O&M Contractor whose objective was to operate and maintain the plant, in recent years, the introduction of non-industrial partners has called for a profound shift in the role of the Asset Manager in renewables sector, requiring a redefinition of the services and competencies offered to the clients.

In the market, almost all renewable asset management companies are completely new entrants and born with a managerial need to coordinate all activities with the result of optimizing the performance of the power plant and the return of investment for the ending shareholders. Only few of these companies were born as operational and maintenance service providers.

In a project finance structure, among different stakeholders, there is also another important non-industrial party, the commercial bank.

These institutions usually, signing a loan agreement with the Project Company, participate in the project with a majority stake of about 60% of the investment. To ensure the loan will be remunerated, banks require stringent clauses and conditions before the construction phase and during the overall operational phase of the plant, ensuring that the renewable project is able to generate the economic outcome to repay the debt incurred. Within these conditions, quarterly and annual financial and operational information on the plant such as technical availability of the plant, regulatory and organizational information and

environmental and social performance shall be submitted by the corporate to the commercial bank.

In this framework in which multiple actors interact in financing a renewable project, the figure of the Asset Manager becomes a necessary player, acting as an intermediary between the banks who require guarantees by the project company, the developer who wants to find partners to share the renewable project's cost and the institutional partner who simply desire to get an economic return of the asset.

As showed in the figure below, three important agreements define the relative responsibilities and warranties guaranteed by these four parties. These include:

- ***Shareholder Agreement*** in which the developer and the partner or multiple partners agree to invest part of their equity in an SPV with limited liability in return of an economic return.
- ***Loan Agreement*** in which the banks lend a large part of the funds for the realization of the project in exchange of economic and financial guarantees able to repay the loan.
- ***Asset Management Agreement*** in which the Asset Manager undertakes to act on behalf of the project company and manage the plant from an administrative and operational point of view.

Thus, in this framework in which all the parties involved have the only common objective to have an economic return, the Asset Manager is the only actor with technical expertise able to monitor the financial and operational performance of power plant from multiple perspective and capable of optimize the overall renewable power plant. In processing the data and delivering to technical advisors the necessarily documentation, the Asset Managers are able to reduce the risk of project's defaults and ensure to the bank the proper operation of the facility.

Regarding non-industrial partner, on the other hand, the Asset Manager is the only person with technical expertise in order to supervise the developer and maximize the internal rate of return not only of the individual renewable asset but of the entire portfolio.

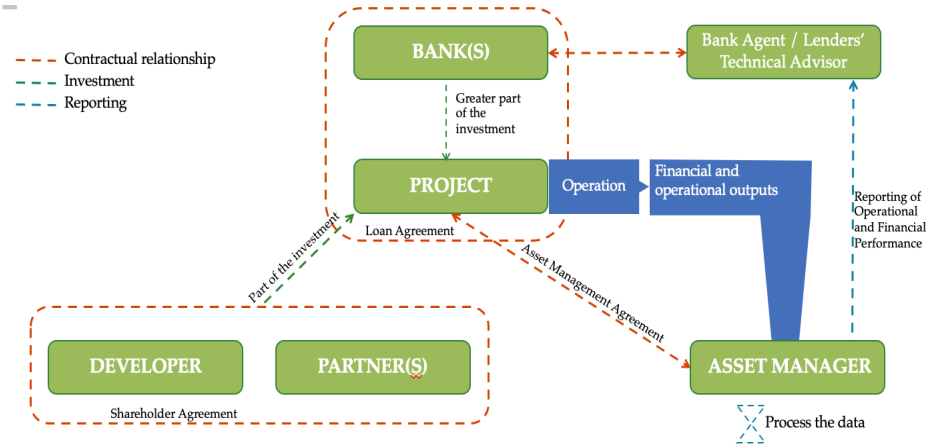

Figure 11 The figure of the Asset Manager in Project Finance Structure

According to IRENA, to reach the Paris treaty about 800 billion euros per year will have to be invested in capacity generated from renewable sources in order to achieve the carbon neutrality. [41] Of these, although in 2018 direct investments by financial institutions accounted for only 2% of total investments in renewables, it is estimated that there will be strong growth by these entities in financing the energy transition. [41]

Commercial banks, private equity, infrastructure funds, pension funds and other private investors will all be involved in backing renewables investments over the next 30 years.

At the last conference of the parties in Glasgow in October 2021, one of the main points discussed by the countries, was to create a transparent framework in which, through risk mitigation and opportunities, all private investors are able to create the right conditions and allocate funds to finance the energy transition.

According to Mark Carney, UN Special Envoy for Climate Action and Finance and Prime Minister's Finance Advisor for COP26, four key points shall be implemented in the financial system to allow everyone to take climate change into account. [40] In addition to improving the quality of reporting to achieve greater transparency, ensuring that the financial sector is able to measure and manage risk and in mobilizing private funds in emerging countries, the last pillar is to "*helping investors identify the opportunities in the transition to net zero and report how their own portfolios are aligned for the transition*". [40]

Taking into consideration this point, a key role will be played by Asset Manager in leading institutional investors and the whole financial sector in driving this energy transaction and bridging the gap needed to reach the net zero path.

Thus, with the rise of these new non-industrial investors in the market, an equally exponential growth of asset management companies is expected in the coming years. These corporations, having technical and managerial expertise in renewables field and acting as advisors to new non-industrial players in the market, will play a key role in optimizing asset portfolios and leading more private investors to believe in renewables assets as a form of high return investment.

CHAPTER 2

In the first chapter, the main objective was to analyze the changes that are occurring in the energy sector and what we should expect in the next 20 years. The Paris Agreement has defined ambitious targets and more investments are needed in order to shift towards a low carbon neutrality.

As aforementioned, the decline of installation costs and better efficiency of power plants, the governments' pressure in reducing CO_2 emissions, the growing need for electricity in developing countries and consequently the increase of capital invested in these regions has led new non-industrial investors to enter in the renewables market through project finance structures. These actors lacking technical skills, crucial to manage large portfolios of plants, have led to the emergence of a new figure able to manage, on behalf of the SPV, all financial, commercial and technical performance of the power plant or portfolio of plants with the final outcome to maximize the value creation of the assets.

After having introduced the historical context, we are living in and the importance of the asset management companies in driving the energy transition, in this chapter we are going to deepen this figure and identify its role throughout the life of a plant and the interaction with different stakeholders involved during the operation and management phase.

2.1. WHAT IS AN ASSET MANAGEMENT?

Applying the Publicly Available Specification 55 released in 2008 by the British Standards Institute, an asset management is defined as "*the systematic and coordinated activities and practice through which an organization optimally and sustainably manages its assets systems, their associated performance, risks and expenditures over their life cycles for the purpose of achieving its organizational plant.*" [47]

This publication can be defined as the first effort to delineate the meaning of asset management and the importance of implementing procedures and processes aimed at creating value from an asset or portfolio of assets providing practical guidelines about how to implement them.

During the time it was adopted by an increasing number of parties in the industrial sector until to release in 2014 the ISO 55000, the international standard of Asset Management.

Despite its diffusion, different concepts and definitions of asset management have been developed during the years and to date, it is still confusing. Found in field of financial industry as the management of an investment portfolio on behalf of multiple actors and the related mitigation of risks and revenues, the concept has been extended to all sectors and industries.

Following the definition of the ISO 55000, the asset management is the '*coordinated activity of an organization to realize value from assets*.' [48]

Value which, once identified by the organization's objectives and strategy, is the result of a balance between costs, risks, opportunities, and performance throughout the life cycle of the asset.

Thus, the aim of the asset management could be identified as the achievement of the strategic objective of a company or their stakeholders and the generation of value through the creation, operation, maintenance and finally dismission of an asset. [47]

In case of a renewable assets, typical objectives of an organization could be:

- Technical performance availability
- Compliance with contractual commitments
- Health and Environmental targets
- Sustainability targets
- Social and reputational image
- Reporting activities
- Cost reduction
- Technical skilled personnel
- Return on investment
- Level of risk
- And others…

Obviously, each stakeholder could have different objectives. Once these are identified and the strategy to achieve them have been defined, actions and constant monitoring must be carried out.

Comparable to other certifications, such as the ISO 14000 for the correct management of the working environment, 9001 for improving the quality of the service offered or the one on safety at work, the ISO 55000 identifies the correct process for the management of an asset from a financial perspective in order to support the company to take the right decision process and deliver the greater value for the organization.

Translating the conceptual model of the Institute of Asset Management [49] in the renewable sector, some of the key elements for the management of a renewable asset are:

Planning and Strategy

This requires to an Asset Manager to translating the corporate's objective in concreate actions assessing all internal and external factors that could affect the assets. Examples are cultural economic and social factors, competition, regulations, permits and authorizations, legal frameworks or KPIs for the monitoring of the power plant. A strategy must be implemented for each process. Typical example of strategies regards the choice of specific contractors in order to improve the component life, how to manage the spare parts process or site visit inspection, have good relations with authorities, landowner or subcontractors. All strategies in order to maximize the performance and reduce costs.

People and Organization

In managing a renewable asset or portfolio of assets, the people must be proportionate to the size of the installed capacity. Important are the technical skills of the staff and the responsibilities of each member in contributing to the creation of the final value. Key role is the coordination of all stakeholders and other functional contractors such as O&M, EPC Contractor, suppliers, technical advisor.

Decision-making process and management during the lifecycle

An asset management means to participate, coordinate and ensure support in all the tasks to be performed guaranteeing synergies between all of them. During the overall lifecycle, the asset manager should valuate and manage the risks and costs, monitor the operating activity and resources in respect of targets, risks, legislation in force and people's culture. All the decisions shall be taken in order to increase the return of investment of the final customer. In managing the power plant different services are offered to the client starting from the development and construction cost until to the technical, commercial and financial services with the final purpose to provide continuous monitoring and optimization process of the renewable.

Management of information

Having a digital system for exchanging information between plants or portfolios and managing technical and commercial activities is essential. An Asset Manager should implement and exploit current information tools such as smart devices, internet of things and digital platforms to implement strategic optimization processes, monitor activities at site, collect data, manage contractual and regulatory obligation, perform reporting activities and communicate with the different organizational units involved. Typical information system are ERP systems, Cybersecurity systems, SAP for the spare parts monitoring or platform for the creation of interactive dashboard.

Performance evaluation and improvement

Each plant has its objectives, leading KPIs and lagging KPIs to evaluate and improve. Moreover, based on experience, each asset has its own set of lesson learned which are of fundamental importance to an Asset Manager in order to improve current installations, avoid mistakes in the future and better manage a portfolio of assets.

In monitoring and optimizing the performance of different power plants and different client's needs, an Asset Manager has a great experience in evaluate the performance and apply lesson learned in future power plants.

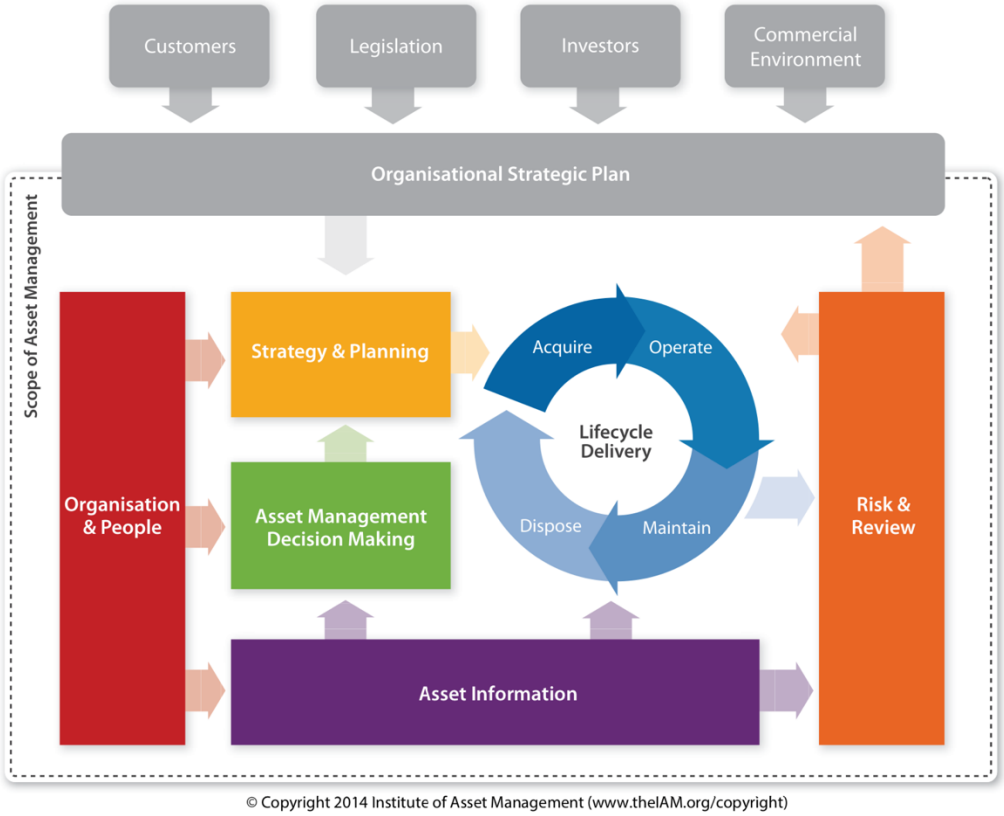

Figure 12 The Asset Management Model. Source: Institute of Asset Management

2.2 STAKEHOLDERS DURING THE LIFECYCLE OF THE RENEWABLE ASSET

Different players are involved during the overall lifecycle of a power plant or wind farm, each one with different roles and responsibilities. Thus, an excellent Asset Manager shall interact with all of them trying to maximize their economic return.

In some cases, due to the multiple activities performed by different parties, there could be possible overlaps between them causing conflict of interest and misalignment of incentives.

A background of all the parties involved is of fundamental importance to understand the role of the Asset Manager in interacting with all these stakeholders and provide value added to the project company.

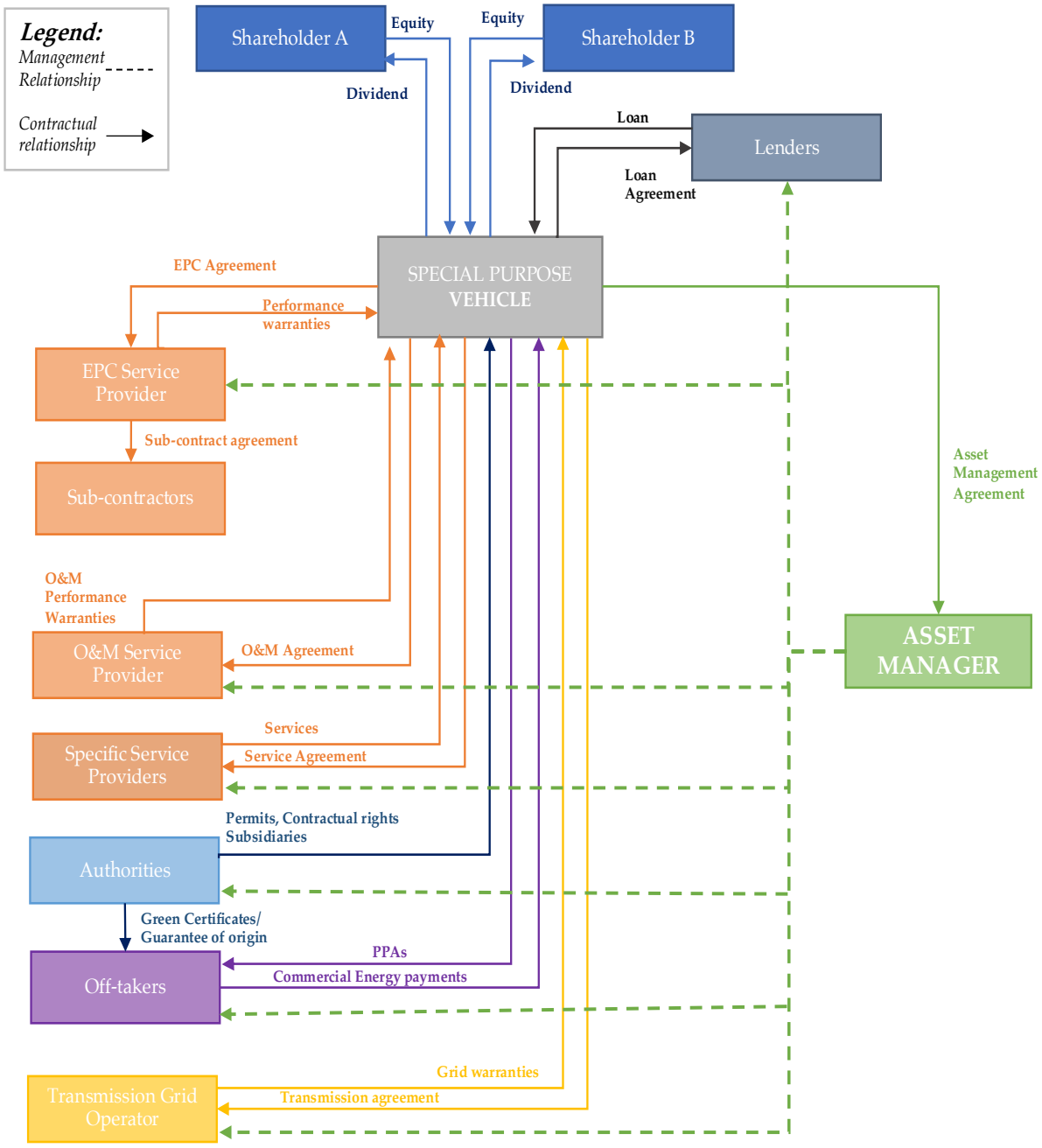

Figure 13 Renewable Asset Management 's Stakeholders

As described in the previous chapter, there could be different types of shareholders that participate in the financing and operation of the power plant. Usually, they are investors or a group of investors such as utilities, private individuals, investments funds, independent power purchased, insurances companies or banks.

The legal ownership of the asset, instead, is entrusted to a Special Vehicle Purpose (SPV), a subsidiary company with limited liability with the main purpose to build, own and operate the power plant to obtain a final economic return. If up to now many utilities had sufficient funds to finance the project itself and internalize the management and operation of all phases of the project, nowadays, with the participation of always more investors many companies are changing their business model trough a project finance structure as explained in the chapter 1.4.2.

Before to create a corporate, a long bureaucratic and technical feasibility study of the project is carried out by the *Project Developer*. It is a figure that usually gain access to the project in the early stages and whose role is to develop the feasibility study, participate in tenders for the assignment of the project, manage permits with third parties such as landowners or EPC contracts and relate with banks or other investors securing their funding. Although this figure is often vertically internalized within each company, it may also be carried out by external companies or performed as an extra service by asset management companies.

If a renewable energy project will be financed is decided by the *lenders.*

They are not owners of the power plant but play a fundamental role in raising capital to finance the project, collateralize the assets and be certain that the borrower will be able to repay its financial obligation. Commercial banks can be considered as the main stakeholders as they usually finance more than half of the project. Usually, the financing process is based on the bankability of the project. It determines the ability of the Project Company to repay the loan.

Typically, the requirements for lenders to ensure a project finance structure and, thus the bankability of the project are:

- Liquidated damages capable of fully covering the associated risks and restoring the lenders' base case (DSCR, LLCR...)
- EPC to be based on a lump-sum fee and through a turkey contract
- A fully wrapped asset management agreement without using multiple contractors

Moreover, another practice used in the renewables sector in order to make a project bankable is through power purchased agreement which set a fixed price of electricity for the buyer ensuring a stable flow of revenues for the Project

Company. Also, in considering the PPA, banks require specific requirements in order to be bankable. Within the main requirements, they usually require:

- A sufficient credit of off takers
- PPA term aligned with the debt tenor
- Termination amount at least equivalent to outstanding debt and breakage costs
- Limited spread between PPA and electricity market price

Although these stringent requirements, given the increasing demand for renewable investments and the creation of limited liability companies, banks are increasingly reluctant to grant loans and, thus, technical advisors are hired to monitor the annual performance of the plant and whether it meets the initial business case. In this case, an annual and quarterly reporting activity is required by the banks during the plant operation in order to ensure the compliance of the Project Company to its obligations.

Once the project has been defined, the *EPC Contractor* will be responsible for the engineering, procurement and construction phase of the renewable asset with the main purpose to deliver to the project company a renewable plant with certain specifications defined by the EPC agreement. Once the EPC contractor performs the tests on completion, also called Commercial Operation Date (COD), there are two-year evaluation periods within which the contractor warranty that the current performance shall not be less than the guaranteed ones. Often, it is only after these two years in which the Final Acceptance Certificate is released, the plant is turned over to the O&M service provider whose purpose is to perform scheduled and unscheduled maintenance and put in place all the actions necessary to guarantee plant performance.

The transition phase, also called handover, it is a delicate process in order to finalize the construction and deliver all the liabilities to the *O&M provider*. Thus, it is important to clearly define the clauses and responsibilities of each parties to avoid paying subsequent liquidated damages.

The continuous settlement of technology in all the sectors has led to digital service providers being of paramount importance for the operation of a power plant. Specifically, they are companies that offers software and hardware digital solutions such as ERP systems, Asset Management platforms, monitoring and

preventive systems to optimize and manage the plant. Considering the amount of data to be managed, there is a tendency in the market to centralize all the single systems in a common platform and try to develop digital competencies to internalize the service.

Finally, looking at the downstream of the value chain of a renewable asset the main players are:

- *Regulatory Authorities* who include any government, minister or official person aimed to guaranteeing any approval, authorization, consent, permit, certificate or registration of or any renewal or variation.
- *Transmission grid operators* who are national entities responsible for the transmission and dispatching of electricity on a national or regional level through the public infrastructure. The main object is to manage the electricity system ensuring a constantly monitor of the balance between demand and supply of energy.
- *Buyers or off-takers* who, by signing an off-taker agreement with the producer, establish the price and the portion at which the energy will be supplied ensuring to the producer a secure revenue stream and an increased likelihood of securing funding for the project.

Coordinating and managing all these different stakeholders involved during the lifecycle of the power plant is a responsibility of the *Asset Manager*. Delegated by the Project Company to act on behalf of the SPV, the Asset Manager shall ensure that all the parties fulfill their contractual obligations and the plant, or the entire portfolio, is efficiently managed from a technical, financial and commercial perspective.

From a technical point of view, the Asset Manager must supervise and monitor the O&M provider ensuring that all activities such as schedule maintenance, unscheduled maintenance, reporting activities and all the availability guarantees defined in the O&M contract are correctly fulfilled.

From a commercial and financial perspective, the Asset Manager shall ensure the negotiation, administration and preparation of contractual provisions, insurance policies, perform secretarial activities of the company, records payments, issue invoices and liaise with banks, auditors and tax advisors providing them all the necessary information and documents needed. It is a dynamic figure who, with

the increase of players in the renewable sector, is assuming significant importance in the market whose main role is to manage a portfolio of plants rather than a simple power plant.

The role of asset management within the renewables value chain is becoming so wide that many companies have started to offer asset management services, making the boundaries between one player and another very blurred.

2.3. THE ROLE OF THE ASSET MANAGER DURING THE RENEWABLE POWER PLANT LIFECYCLE

The Asset Manager is an interdisciplinary role which should be involved into the lifecycle of the plant since the beginning.

Usually, this figure joined in the lifecycle of the power plant mainly from the conclusion of COD. Nowadays, with the change of approach towards a portfolio management or rather a corporate one, the Asset Manager is increasingly taking part already from the establishment of the Project Company. Thus, although technical asset management only begins at the operational stage, the role of commercial and financial management are keys starting from the development and construction phase.

At each stage, different stakeholders are bound by contractual agreements with the SPV, and different liabilities and responsibilities are in place. The Asset Manager being the only one to have a long-term perspective must ensure that during the transition from one stage to another all the risks are managed, the contracts and relative documentations are stored, the contractual rights are enforced, the performance are certified, and, in the subsequent phase, all the parties have the information required to fulfill their obligations.

With the development of technology and diffusion of sophisticated software, many asset management companies have internally developed Asset Management Portals able to aggregate all contractual, insurance and loan information, manage deadline and obligations and deals with the compliance of permits, licenses and authorizations.

There is still a lot of confusion in the marketplace about the importance of this figure during the overall lifetime of the asset so the following discussion will analyze the role of the Asset Manager in each single phase.

2.3.1. DEVELOPMENT PHASE

Usually in this stage the parties mainly involved are the asset owners, investors, lenders and technical advisors. The aim is to analyze the feasibility of the project from a geographical, economical and investment point of view, draw the layout of the plant and carry out tender offers to secure future EPC and construction works in order to finally obtain financing commitments.

In this phase the uncertainties are high and each single mistake in drafting the EPC or supplier contracts have huge implications in the future phases.

Thus, an Asset manager shall:

- prepare and review all the relevant documentation and liaise with the relevant authorities, buyers, insurance companies in order to maintain and renew any permits.
- liaise and negotiate with landowner or third party on behalf of the Project Company in order to obtain any other land agreement or contractual rights or make some amendments of contracts.

The involvement of Asset Manager in the design phase could be also relevant for the subsequent monitoring phase of the asset. In fact, the technological advancement and the possibility of remote control of the power plant might requires an electronic surveillance system and infrastructure connections which is better if defined already in the development phase of the project.

2.3.2. CONSTRUCTION PHASE

The construction of a wind or solar plant usually takes 2 or 3 years. During this period the Asset Manager shall provide a close monitoring of the main tasks performed, check completeness of, and achieve package documentation submitted by the parties.

Due to the relevant expenses carried out by the SPV, often the Asset Manager may be involved actively also in this phase assuring that the project company complies with its contractual, legal, tax and financial obligations and provide during the overall phase commercial asset management.

A critical phase for the Asset Manager is the so-called Take-Over or Commission Operation Date in which tests are performed in order to transfer the operation of the plant to the O&M Contractor. Although the EPC Contractor guarantee 2 years of guaranteed performance before to deliver the final Taking Over Certificate, the Asset Manager shall gather all the documentation relating to the commissioning and testing activities checking its completeness, analyze possible components defects and verify the correct installation of data acquisition systems provided by the EPC Contractor.

An additional service usually performed by an Asset Manager is to act as project management during the construction phase. In this case, general activities are related to administer the construction contracts on behalf of the owner, perform site visits inspections to check the completeness and the achievement of milestones, prepare construction budget, monitor the quality assurance documentation and health and safety conditions, and provide regulatory monthly reports. Moreover, a Project Manager or Site Manager can be hired in order to monitor the power plant construction.

In each specific phase of the construction, the main activities can be summarized in the figure below:

Figure 14 Asset Management support during Construction Phase

2.3.3. HANDOVER AND OPERATION AND MAINTAINANCE PHASE

The maintenance and operational phase might be divided in two different phases. As mentioned before, the first two years of operation the EPC Contractor is still liable for the achievement of the guaranteed performance ratio as contractually agree so that the contractor is not entirely relieved of its responsibilities. Precisely, it is in these two years and during the defect liability period of components that many of the disputes and claims between the EPC Contractor, O&M Provider and Asset Manager arise.

If contractual responsibilities are not clearly defined in the contract, and if there are no suitable high skilled resources able to calculate data on the SCADA System and calculate the performance ratio, there is a risk of incurring heavily liquidated damages requested by commercial banks. For instance, considering that all the defects that fall into the component's defect period shall be executed at the Contractor's risk and cost, save for those that result of damage or losses caused by inadequate or improper operations and maintenance, a correct definition of the latter would reduce the risk of incurring costly disputes.

In this framework, it is under the Asset manager scope of work to timely notify the EPC Provider of any defect it became aware, to request the Contractor to remedy of those defects on behalf of the owner, participate in any test, check the performance ratio guaranteed by the EPC Contractor, prepare all the necessary documentation required by the relative parties and manage all the performance warranty claims that could arise under the construction contract.

If after two years, tests after completion are successful achieved, the Contractor's obligations can be considered terminated. Starting from that phase, the technical operation and maintenance comes under the O&M Contractor and the asset management of the facility under the responsibility of the Asset Manager who has the main goal to supervise and monitor the O&M Contractor and perform commercial and financial activities.

As previously said, in the market always more Asset Managers have expanded their network of services by offering their clients support in the development and construction phase or by providing additional advisory services during the lifecycle of the project. The "pure" asset management agreement, usually, enters

into force when the asset becomes operational. If the Asset Manager is appointed to provide the service starting on the Commencement Date or subsequently, it requires the crucial so-called handover process in which the Asset Owner transfer to the Asset Manager the responsibility for ensure the supervision and management of the power plant.

Depending on the capacity of the asset or portfolio, it could require two or three weeks to compute the infrastructure and integrate services for the installation of new systems required to ensure the remote monitoring and control of the plant. Nowadays this process is completely digital, but the overwhelmed amount of data and information exchanged up to that moment require the Asset Manager a costly research activity aimed at acquiring site information (identification number of the key components, location, structure of the corporate, company's contacts…) and all the historical data of the plant (owner's variations, equipment warranties, contractual terms...).

Being the contract management one of the main services offered by an asset management provider, the collection and understanding of responsibility, warranties, milestones, service offered within each document is vital to manage the boundaries between different stakeholders and minimize the risks to incur in potential claims by the asset owner.

2.3.4. EXTENSION, REPOWERING AND DECOMMISSION

As the plant is approaching to 20 years, there are different possible choices within which the Asset Owner may decide. In fact, in this phase the Project Company may choose to extend the lifetime of the asset, repowering or dispose the renewable plant. Whatever the choice, the Asset Manager shall ensure an optimal investment's return providing to the owner all the information required to take the best decision by considering all the opportunities and risks.

As many contracts are getting closer to the end of their obligations, an extension of the life requires to the Asset Manager to ensure that all the permits, land lease contracts and maintenance agreements are still valid. In case, the main role will be to negotiate, prepare and revise the contracts with authorities, landowners or

each party involved and finally ensure a maintenance schedule optimizing the replacement of components.

Another challenging solution is the repowering. As the term suggest, the repowering is the process of replacing components or equipment with the aim of increasing the nominal power of the renewable system.

Notwithstanding repowering is one of the many optimization strategies, this activity usually is offered as additional service to the common asset management services since it might be considered as a quite completely new power plant.

Over the last few years, technology evolution has bought major advances in components dimensions, costs and efficiencies to solar and wind technologies, prompting an increased number of asset owner to repower its own assets. For instance, actually the turbines can reach enormous dimensions implying that a reblading, operation which allows larger blades to be installed to sweep more wind and produce more energy, is not always conceivable.

The choice between repowering, extend the life of the plant or simply follow the asset's disposes procedures it is the result of a carefully weighed assessment made by the Asset manager considering all the possible repowering and decommissioning solutions.

CHAPTER 3

After an introduction of the definition of asset management according to the ISO standard, the stakeholders that interact during the life cycle of a renewable asset and the growing importance of the Asset Manager from the development phase of a renewable asset up to the decommission phase, in this chapter we get to the heart of the matter by carrying out an analysis of the current market of Asset Managers in the renewable energy sector and the dynamics that are moving these players in contributing to the energy transition. Considering the forecasted renewable installed capacity and the unseen amount of third-parties' investments that are expected in the coming years, it is estimated a proportional growth of these figures in the market. Thus, through a comparative analysis of seven asset management companies, the aim of this chapter is to examine the value added offered by Asset Managers in driving this energy transition and the strategies used by these companies in positioning themselves in this unpredictable market.

3.1. METHODOLOGICAL ANALYSIS

The research carried out was born from the Enel Green Power's need to analyze how the renewable asset management market was evolving specifically to solar and wind technologies and in emerging countries such as Africa, India and Southeast Asian countries in order to provide an internal assessment identifying whether outsource or internalize asset management services.

In order to perform this work, the information collected were mainly based on two different sources:

- Desk analysis and collection of open-source information from website, reports and company's network.
- Dedicated interviews with Asset Managers aimed at knowing specific areas of interest.

The first step in order to start a suitable market analysis was to identify all asset management companies specializing in solar and wind technologies.

Starting from a scanning of 37 Asset Managers worldwide were possible to observe how in reality, in the market, there are different types of companies that offer renewable asset management services. Within these companies, it was possible to identify:

- **Utilities**: They are large vertically integrated companies which provide internal asset management services mainly on their own portfolio.
- **Independent power purchased companies:** They are companies focused on power generation where the direct performance of asset management depends on their size. Usually, they internalize the service if they are large companies and outsource it if they are small.
- **Original equipment manufacturer:** Companies producing equipment and providing related asset management activities.
- **Digital services providers:** Asset management companies focused on developing asset management solutions in order to optimize the asset management services.
- **Investment funds:** They are large enterprises whose objective is to collect investor's capital and invest it in renewable assets. They are starting to internalize asset management service for their own asset portfolios.
- **Asset Management Companies:** Companies that offers a full set of asset management services to third parties.

As showed in the figure below, in my analysis, 9 of these companies, representing the 23% of the total, were independent power purchasers who mainly invest, build and operate renewable assets asking for asset management services.

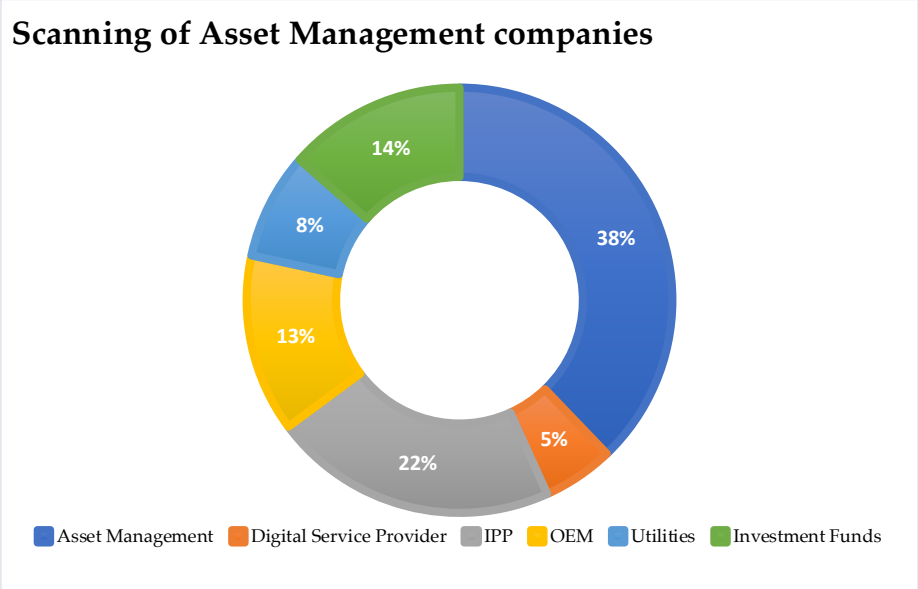

Figure 15 Scanning of 37 Asset Management Companies

Moreover, 13% were original equipment manufacturers and only 5% provided asset management software.

Interesting is the case of utilities and investment funds, which accounted respectively for 14% and 8% of the total share. Indeed, it emerged that in the market these two new players are starting to insource asset management activities to benefit from scale effect, thus, reducing Asset Management need.

Considering that the final interest of the research carried out was to analyze asset management companies, the analysis was restricted to focus only on 14 of these companies, respectively 38% of the total share.

Furthermore, by consulting company's gatekeepers in order to understand the most popular asset management companies in the market and considering that two of them only offered commercial and financial services due to their specialization on tax and legal advisors and, that other companies only operated in certain countries such as England or Italy, it was possible to narrow the field to a final number of 8 Asset Managers.

Finally, looking at the services offered by these 8 companies, one of them was focused on many different sectors and the renewables asset management service was just an ancillary business offered to third parties. However, being a company that offered certifications, a specific interview was carried out to understand the importance of the ISO 55000 certification in the renewable asset management market.

Thus, through an initial desk analysis of these 7 companies, a technical sheet for each company was made in order to identify:

- Technology
- Plant Managed
- GW Managed
- Geographical footprint
- People
- ERP Systems
- Service Offered

A summary of the characteristics identified are given in the table below. As the team have signed non-disclosure agreements, the names of these companies cannot be disclosed.

	Technologies	Plants managed (n°)	GW managed	Geography	People (n°) –People/GW	Systems
Company A		+190	0,5	Italy, Spain, Jordan, Kazakhstan, Hungary, Malaysia, Vietnam, Thailand, UK, Greece, Chile, Canada, India, US. (14 Countries)	50 100 P/GW	ERP system internally developed. Product commercially offered
Company B		+250	0,7	Spain, Portugal, Italy, Poland, Netherland, UK, Greece, Ireland, Germany, Czech Republic (10 Countries)	+60 85 P /GW	Multiple Systems internally developed
Company C		+35	1,0	Italy, Spain, Mexico, Chile, Colombia, France, UK, US (8 Countries)	32 32 P/GW	System commercially available in the market
Company D		1380	2,1	Italy, UK, India, Portugal, Chile, Namibia, US. (7 Countries)	+120 57 P/GW	Asset management platform internally developed
Company E		+400	3,0	Spain, Italy, UK, France, USA, Australia, Ireland and Portugal (8 Countries)	+170 56 P/GW	Asset Management Platform internally developed.
Company F		+540	3,8	Italy, Germany, Spain, USA, Mexico, Chile, Australia, Japan, Jordan, Saudi Arabia, Philippines, South Africa (more than 40 Countries)	+200 52P/GW	Asset Management Platform internally developed. Product commercially offered
Company G		n/a	8,3	France, Italy, Spain, US, Malaysia, Japan, Australia, Mexico, Thailand, Vietnam, Philippines, Zambia (27 Countries)	2.750 331 P/GW	Software internally developed. Product commercially offered

Figure 16 Selected Asset Management Companies

A first comparison showed that all the companies selected were built on solar technologies while only 4 of them were also focused on wind. However, even where companies were focused on solar and wind technology, the wind installed capacity under management were in any case lower than solar PV assets. This is mainly due to the greater complexity of managing a wind farm compared to solar. Furthermore, based on the number of plants operated and the size of the company, it was possible to see that as the company growth, usually, they start acquiring expertise also in other technologies such as batteries. In fact, today, with the diffusion of batteries, Asset Managers that are approaching this new technology and acquiring know-how in this field are growing.

In addition, analyzing the foundation year, the results showed that all these companies were established in the last two decades. Three of them started out as technical service providers and then expanded their services to include also administrative services, while all the other companies were specialized in offering commercial, financial and advisory renewable asset management services from the outset.

Moreover, comparing the number of plants and GW managed, was possible to note as they were all small companies that mostly operated many different plants but with an average size very small in terms of GW managed.

Looking at geography, all of them had a wide geographical footprint in Europe, America, the UK, South America such as Chile, Colombia and Mexico but many of them were approaching new markets in the so-called APAC countries such as India, Africa, Australia and many Southeast Asian countries.

Finally, through the number of people and GW managed it was possible to identify a fundamental KPI to identify the average number of people per GW managed and consequently understand the company's organization. In fact, as showed in the table above, the average number of resources per GW managed is between 30 and 57 people. Company A and B showed that they have few GW under management, but they provide also advisory and digital service. Therefore, they could appear inefficient in terms of resources allocated per MW, bit actually they act not only as asset managers.

Another driver influencing the number of resources employed concerns the management systems and software used in managing a renewable asset. As showed in the table above, all the Asset Managers selected, had developed digital skills and internal systems to make their services more efficient and effective, thus reducing the number of staff needed. Moreover, only company C had an IT system commercially bought in the market while four of them could even offer to the market the digital asset management system independently of their asset management service.

After an initial comparative analysis based on information gathered from open source and desk analysis, the second step was to find the contacts of the selected companies and proceed with a detailed analysis mainly based on dedicated interviews.

Once the contacts had been identified, at each company was sent a presentation explaining the research carried out and an invitation for an interview.

In order to standardize the survey and to be objective in the final results, at each respondent the main topics of interest were:

- Strengths and technologies on which the company is built

- Asset under management and geographical area of interest
- Type of services that the asset management company may offer
- Additional advisory service offered by the company
- Level of commitments and responsibility that the company is able to take on
- Possible modular services packages and relative fees charged to the service
- Organizational structure
- Advanced O&M tools, data science and innovative solutions

The time period in which interviews were carried out was from the beginning of May until mid-June but due to the great availability of many of them further exchanges of information were carried out by email.

During the interviews I was able to speak directly with global manager directors, heads of asset management or country managers and gain important insights from the market. At the end of each interview, a document was sent to the interviewees inviting them to provide a relative range of prices of the services offered and send it within two weeks. The prices, depending on many different factors such as the country, the GW managed and the services offered, were difficult to gathered for each company. In fact, only few of them responded to this request.

Once the interviews were over and all the data had been collected, it was possible to explore the results and understand how the market of Asset Managers is evolving.

The following paragraphs provide an assessment of the key topics asked to Asset Managers during the interviews and the outcomes obtained from the analyses carried out.

3.2 SERVICES PROVIDED BY RENEWABLE ASSET MANAGEMENT COMPANIES

Depending on the stage at which the asset management agreement begins its effectiveness and whether the project is in development, construction or

operational phase, different services may be provided by an asset management company.

Based on the results of the interviews, it was possible to differentiate the main services offered by Asset Managers in the market as reported in the table below.

	Development Support	Construction Support	Asset Management	O&M Service	Advisory	Systems provider
Company A		✕	✕	✕	✕	✕
Company B	✕	✕	✕	✕	✕	
Company C	✕		✕		✕	
Company D	✕	✕	✕		✕	
Company E	✕	✕	✕		✕	
Company F	✕	✕	✕		✕	✕
Company G		✕	✕	✕	✕	✕

Figure 17 Services offered by the selected Asset Management Companies

While asset management services are those related to the day-by-day full management of the assets and refer to technical, commercial and financial services described in the following paragraphs, the latest trends show as Asset Managers are always more acquiring additional know-how and competencies outside the "pure" asset management service specializing their self in offering additional or advisory services whose purpose is to find a solution to specific problems in the short term. These advisory services being divided into technical and financial advisory according to the specific expertise of each individual company, it resulted that all the selected companies, in addition to offering asset management services, also offer advisory services.

Moreover, as they are increasingly involved in all phases of the project, most of them offer as additional service the development and construction support. For development support, it refers to:

- Engineering design services aimed at carrying basic, detailed and specific engineering studies

- Commercial and financial activities aimed at managing and collecting permits, authorizations and liaise with third parties for the development of the project.

For the construction support, instead, it refers to periodic site visits to monitor the progress of the works according to the schedule, supervise EPC contract, guarantee compliance with quality standards and applicable regulation, provide all the key construction role such as Project Manager, Site Visits and/or H&S Coordinator and finally provide all the related activities regarding the Commissioning and Final Acceptance as described in the previous chapter.

Regarding the O&M service, the result showed that only three Asset Managers offered this service. This is mainly due because, in reality, the two roles are completely different and performing at the same time asset management and O&M service can give rise to conflicts of interest as the main role of the Asset Manager is to supervise the O&M contractor. Only in case of small plants the two roles may coincide.

In some cases, based on the type of company and their history, they can be more expert in technical services and optimization process offering in exceptional cases also O&M services.

Regarding digital systems, some companies have acquired enough digital skills to sell also their internally developed digital system to the market, thus, becoming a hybrid between digital service providers and asset management companies. In our case, company A offered an ERP system able to manage processes in a more efficient way from a technical, commercial and financial perspective, company F offered an asset management platform able to perform advanced technical analysis, financial management, documental repository and reporting activities, while the company G, offered different software capable of performing different tasks including monitoring the plant, managing the resources or viewing the performance through a customized customer portal.

In the following paragraphs a better definition of all the services offered will be carried out in order to have a wider range of possible solutions performed. While for asset management services aimed at optimizing the plant, the services offered by all Asset Managers are the same and provide technical, commercial and financial services, the additional and advisor services depend on the company

itself, thus, to include in the next chapter only those services common to all Asset Managers.

3.2.1 TECHNICAL SERVICES

Technical services are the most important services for a good asset management company. Since investors are usually non-industrial partners, Asset Managers are the only ones who have specific technical know-how in the fields of performance optimization, data analysis, maintenance of a plant and all those skills usually needed by an O&M contractor to provide schedule and unscheduled maintenance.

The main difference is that the two roles are completely different and if not well defined can lead to conflicts of interest. In fact, while the O&M contractor has to provide technical availability warranties to the final Project Company, otherwise it could resort to liquidated damage, the Asset Manager does not provide any contractual warranties. However, the technical Asset Manager has to supervise the work of the O&M Contractor and perform the service in accordance with all laws, authorization and good industry practices and standards.

Within the technical services provided by an Asset Manager there are:

Contract Management

The Asset Manager represents the Principal in respect of the O&M Agreement and other sub-contracts. In performing this task, the technical Asset Manager shall monitor the operating activities provided by all contractors and maintain records. Being a supervisor of the O&M service provider, the Asset Manager shall identify any potential dispute, performance deficiencies and gaps respect to contractor's obligations, verify maintenance works at the site and provide monitoring of preventive and reactive maintenance work identifying possible development solutions with relevant parties encouraging flexibility of them in achieving optimization process and ensuring proper saving or extra allocation. The attendance at relevant and/or emergency meeting with contractors, advisors, sub-contractors or third parties is essential in order to carried out an optimal contract management service.

O&M Monitoring and Supervision

As previously said, the O&M Contractor is the only one to provide technical warranties. However, the Asset Manager shall monitor that the power plant is operated, maintained, tested and inspected efficiently and safely. Specifically, a full monitoring of compliance shall be performed with regard to:

- Operating and maintenance manual
- Design documents versus built and hand-over report in case of
- Technical schedules
- Health and Safety process

In supervising the solar or wind farm, the Asset Manager shall supervise O&M Contractor in preventive maintenance works, corrective maintenance works and any additional environmental and improvements works performed by the contractors and pro-actively contact them in case of incident. A supervision of personnel qualification and training system shall be checked in order to identify if they are adequate to the activities to be performed by the O&M service provider.

Health, Safety and Environment compliance

In this field, the Asset Manager shall make an assessment and implement strategic action plans in order to comply with Health, Safety and Environmental standards such as the ISO 140001 and OHSAS18001 and identify KPIs, policies and targets to be applied. In defining a strategic plan, the Asset Manager shall check whether procedures are correctly applied by contractors and implement health and safety training programs in the workplace.

Visits on Site

Usually, asset management companies do not have a permanent staff on site, but their flexibility and worldwide brunch presence allows them to offer a full service from a fixed operator on site to two or three site visits per year. It depends on the client's needs.

In performing site's inspections, the recommended tasks should be performed by a diligent Asset Manager:

- Check of the performance of the O&M Contractor's obligations

- Check the security systems (visual control of cameras and microwave barriers and testing alarms, access of personnel on site),
- Identification of any potential improvement and analysis of cost-benefit opportunities,
- Visual vegetation's inspection,
- Visual inspections and checking of the main components (inverters, blades, gearboxes, panels, electrical components…).
- Final report in which highlight potential improvements and recommendations.

Performance optimization and data management

An Asset Manager shall constantly monitor the performance of the power plant against forecasted through performance data acquisition systems and checks any possible improvement or action aimed at optimizing the plant.

A thermographic inspection, root cause analysis, yield monitoring and I-V curve analysis are necessary in order to check any losses and technical availability of the power plant. In case of any incident or underperformance, the Asset Manager shall maintain a proactive contact with the O&M Contractor or any other suppliers in order to maintain an incident log and develop technical solutions.

Usually, an annual detailed optimization process is carried out by the Asset Manager in order to verify the productivity of the plant and identify possible improvements. In doing this, as showed in the table below, different levels of analysis are needed.

Overall analysis	
Step 1	Statistical analysis of the operational data: ▪ Final Energy Production ▪ Irradiation/ Speed wind ▪ Breakdowns due to external factors
Step 2	Examination of the past performance in each period
Step 3	Review of all technical reports: ▪ Assessment of mechanical components (gearbox, panels, inverters…) ▪ Assessment of substation and electrical equipment
Step 4	Final description of possible improvements

Component analysis	
Step 1	Detailed performance analysis at inverters and/or wind turbine level: ▪ Calculation of the yield and identification of possible low-yielding at component level ▪ Assessment of the past performance
Step 2	Cause analysis of underperformances and final description of possible improvements

On Site analysis	
Step 1	Specialized inspection and test performance of the main components
Step 2	Final analysis, valuations and final detailed description of improvements

Figure 18 Optimization process

The first assessment is a general analysis of the current and previous technical performance of the plant and an examination of all technical, electrical and civil documents of the renewable assets. In this phase possible improvements could be checked at a higher level.

After an overall analysis, the Asset Manager shall perform a detailed verification of the performance at component level in order to verify the availability of each inverter or wind turbine and possible solutions to implement in order to optimize the overall power plant.

Finally, through a site visit inspection, the Asset Manager is able to perform a detailed examination of the blades and gearbox components, provide a thermographic inspection and other on-site analysis in order to release a final paperwork of possible improvement opportunities.

Reporting

Reporting is one of the main activities performed by an Asset Manager as it allows to keep track of the tasks performed.

Depending on the customer's expectation, the Asset Manager usually shall provide to the owner, technical advisors and/or lenders a monthly report in which the following information usually are given:

- Electricity produced by each meter or wind turbine and the electricity produced by the facility at whole,
- The annual availability warranties defined in the O&M agreements
- Any events happened during the operation of the plant (accidents, error codes, environmental actions, disputes between contractors and any incident)
- An executive report of the main KPIs such as availability warranties, capacity factor, production, revenues, expenses, EBITDA and net income respected to the budget.

Moreover, a semi-annual Operating Report must be provided by the Asset Manager to the Project Company.

Typical information to be required in the Operating Report can be summarized in the following table:

Documents	Description
Financial Report	Comparison of historical, current, and forecasted financial data
Yield Analysis	Current energy produced vs energy forecasted.
Health, Safety and Environmental Report	▪ Health, Safety and Environmental events happened during the operation (accidents, incidents, activities performed, special waste events…), ▪ Lesson learned, possible actions and an update of past HSE report's actions.
Key Figures	Summary of the actual revenues, energy production, availability, and possible variations.
Renewables Source	Summary of the wind turbine and/or solar panels (Irradiation, wind speed, operating hours, actual production vs forecasted production…).
Facility Performance	▪ Performance of O&M Contractor and/or any subcontractor, ▪ Project performance KPIs vs Expected KPIs, ▪ Performance of the Balance of Plant components, ▪ Lesson learned and possible improvements.
Administrative Reports	▪ Contractor's claims or disputes, ▪ Permits or authorization issued, ▪ Grid transmission and distribution, events, ▪ Procurements and spare parts used and/or to be replaced, ▪ Personnel training and key events happened during the operation of the power plant, ▪ Surveillance and alarm monitoring, ▪ Detailed description of Scheduled and Unscheduled maintenance performed.

Figure 19 Documentations provided in the Operating Report

3.2.2. COMMERCIAL SERVICES

While technical services start from the signing of COD, commercial services take place throughout the lifecycle of the plant, from the development phase to the operational and finally decommissioning phase.

These set of services are related to all bureaucratic tasks in order to be compliant to Project's obligations towards third parties such as banks, off-takers, insurance companies, technical advisory, Responsible Authorities, Data Providers, Local communities or non-governmental organizations.

Within these services an Asset Management company provides:

Contract Management

The Asset Manager acting on behalf of the Owner shall manage compliance and administer all the contracts entered by the Principal in relation to the project. This means to monitor the performance of any contractors hired by the company, manage interface between them and prepare all permits, authorizations and all necessary documentation, certifications and payments to Responsible Authorities or any other any third-party.

In commercial services, the Asset Manager shall manage the Power Purchase Agreement counterparty by checking production measurements, issues invoices and reconcile possible disputes and claims with off-takers, O&M provider, sub-contractors or other stakeholders involved in the value chain of the renewable asset.

Actually, the digitalization process has speed up also the contract management activity which is usually managed through an Asset Management Portal. Thus, one of the first activity to be performed by the Asset Manager is to review, prepare and input all the required contract information to Asset Management Portal or any other digital support. Once contract's input has been entered into the platform, the Asset Manager can manage and monitor all obligations that the Project Company has towards third parties, supervising buyers, suppliers or other third parties in complying with their obligations and provide notices in case of violations.

Insurance and Insurance Claims

The Asset Manager acting on behalf of the Owner shall:

- Supervise the quality assurance and quality control procedures for the project
- Prepare, submit and negotiate with insurance companies, lenders or technical advisors in order to obtain Construction and/or Operational insurances.
- Prepare, submit, maintain and/or renew any insurance document and manage insurance claims.
- Provide that all the insurances are placed and maintenance in full force and effect providing payments and contractual obligations

External Relations and Sustainability

When a plant is installed in a geographical area, the landscape is impacted, sometimes causing protests and discussions among the local population. In this framework, the Asset Manager shall reduce this risk by implementing a communication network with local organizations, citizens and foreign governments and maintain relations with authorities important for the needed authorizations for the power plant.

Moreover, sustainability is becoming an increasingly topic within the population. Thus, an Asset Manager shall participate and create social initiatives for the promotion of renewable installations and collaborate with local communities to implement ESG targets and UN Sustainable Development Goals. Typical examples applied is to support biodiversity through the establishment of animals and vegetation in solar PV or Wind farm or involve the community as schools or non-profit organizations in activities aimed to promote the territory. Establishing sheep on the land not only prevent the destruction of the landscape but also allows lower maintenance costs for cutting the grass.

Regulatory Compliance

As the management of tax, also the regulatory framework is very specific to the country in which the plant is operating and it is often outsourced to local agencies or entrusted to consultants or advisory. In case this service is internalized by the asset management companies, the Asset Manager shall monitor the evolution of

local regulations, inform the owner of any relevant law and regulatory changes, perform an assessment and take all the commercially reasonable steps to ensure that the Project is be able to operate in the country without resorting to potential legal violations, including those related to safety, health and environmental protection.

IT and cybersecurity systems

As the number of plants under management increases and the amount of data continues to grow, IT and communication systems are becoming increasingly important for an Asset Manager to have greater control over the plant. Thus, currently, whether internally or externally developed, all asset management companies have their own data management and communication systems. These can be a plant monitoring systems, security or cybersecurity system, simple platform in order to visualize the acquired data. In doing this, an Asset Manager shall implement the overall infrastructure usually connecting it to the SCADA System and integrate software and hardware in order to provide the remote and local monitoring of the renewable plant.

Revenues and invoices management

Commercial services include those activities related to the sale of energy produced and the respective management of all payments made by PPAs or other customers and the related issuing of all invoices.

In managing revenues on behalf of the Project Company, the Asset Manager shall negotiate and have contact with buyers and release all the documentation or green certificates requested by customers.

Regarding cash management, the Asset Manager should provide monthly revenues reports identifying imbalance of cash during the operation of the renewable power plant, provide revenues and volume forecast and reports regarding all the activities related to the renewable energy in the wholesale market.

Procurement of services

In the procurement process, Asset Manager have an important role in identify the best O&M Contractor, EPC service provider, Balance of Plant Operator, Data provider or any contractor involved in the surveillance, cleaning and

environmental control of the power plant ensuring the quality of services and/or components' reliabilities. Recently, there is a trend to have few contractors and entrust them the management of non-core services through sub-contracts in order to reduce the coordinated activities needed to manage all different operators.

In managing different asset portfolios and suppliers worldwide, the Asset Manager can take advantage of the scale effect in order to ensure an optimal cost-quality tender process. Different KPIs might be used in order to make an assessment of the different contractors. However, Project Company, technical advisors, and insurance companies have the final role to validate the procurement process used by the Asset Manager and the final operator selected.

Moreover, during the operation of the solar or wind power plant, the procurement of spare parts and the management of warehouse is another task performed by the Asset Manager. In this case, the Asset Management platform identifies the level of components used and an alarm alert the Asset Manager the replenisher's need.

Depending on the experience in managing procurement process and tenders, some Asset Manager provide the negotiation and selection of contractors as an additional service or simply acting as advisor.

3.2.3. FINANCIAL SERVICES

Financial services are those related to the management of the Project company itself and the fulfillment of all legal and financial activities that the establishment of a corporate requires.

Within these services there are:

Payments and Revenues management

The Asset Manager shall process all the accounts payable due by the SPV to contractors and any suppliers and ensure that those are delivered within the timeframe delineated on the contract. Moreover, an accounting system should be maintained by the Asset Manager in order to collect all the payment invoices of component and services acquired or to be acquired during the lifecycle of the

project and to manage all the invoice to be delivered as outstanding accounts to contractors, suppliers or any other third party. In payments and revenues management, the Asset Manager should prepare a payment list and perform bank transactions, check all the cash-in and cash-out, review potential defaulter or collector and manage any potential claims, liaise with any suppliers and off takers and provide an assignment of credits and financial obligations to be performed by the Project Company.

Corporate Affairs and Secretarial Activities

In managing the solar or wind power plant, the Asset Manager shall coordinate all the corporate policies and procedures which fall in the sphere of the SPV. In doing this activity, the Asset Manager participate in the board performing typical secretarial activities such as:

- Review and manage correspondence
- Participate and draft minutes of boards making possible shareholder's recommendations
- Maintain statutory accounts and liaise with technical and tax, authorities and lenders in order to comply with the specific country's law and corporate's obligations.
- Draft the powers of attorney on behalf of the owner in order to operate
- Handle and solve any claims made against the corporation

Treasury and Bookkeeping Management

In offering this service, the Asset Manager acts as treasury of the SPV, managing the inflow and outflow of cash towards banks and third parties guaranteeing a certain level of liquidity of the company. Moreover, the Asset Manager shall keep records of all the company's transactions and corporate books, evaluate the balance between active, liabilities and stakeholder's equity in the balance sheet and prepare a periodical closing account.

Financial accounts and audit process

Based on the company ledger, the Asset Manager shall prepare and deliver on behalf of the Owner any annual or quarterly financial statements, notes and/or others mandatory financial documents as required by the country's law.

Before to deliver the financial statements and audit process should be implemented by the Project Company. In doing this task, the Asset Manager shall manage and prepare all the audit process collaborating with tax and audit advisors and participating in audit meetings.

Corporate taxation

In managing the tax system, the Asset Manager shall determine and prepare all documentations regarding the annual tax burden including any calculation of corporate tax, project tax credits, potential deferred or accrual taxes, preparation of VAT and any other document necessary to comply with the tax obligations and required by the authorities.

Being the fiscal policy extremely specific to the legislation of the country, often this service is subcontracted to other local agencies or tax advisors who provide the management of tax burden and assistance in performing these activities.

However, an Asset Manager shall liaise with authorities and these tax consultants in case of financial and tax issues or disputes, coordinate all the tax activities, support tax advisors in the fulfillment of their obligations and finally suggest them potential tax improvements.

Loan Management

The project financing and the relations with technical advisors and commercial banks is one of the key features in the management of an asset. As in the technical management of the plant, they require stringent conditions during the lifecycle of the plant and a periodical financial report in order to ensure the loan compliance. Thus, an Asset Manager shall prepare all documentations required by banks in order to not put the Owner in a position to breach the project's obligations, liaise with banks and technical advisors and provide possible refinancing process.

Typical documentation needed by the commercial banks and technical advisor include:

- A quarterly financial statement*:* an operating report regarding all the activities during that quarter and a report with the main financial covenants

- An annual financial statement including the audited version and an audit description made by the auditors in which they comment the financial position of the corporate
- An annual report regarding the compliance with the environmental and social performance which summarize the main aspects occurred during the period such as the working conditions, security and safety actions taken on site, a detailed risks assessments, potential community's feedback or environmental target achieved, and other requirements based on banks' needs.
- A quarterly and annual operating report which should contain a comparison between the actual operating costs and revenues against the forecasted and with and explanation with the possible variations, the cashflow of the power plant, possible incidents and health and safety condition of the power plant, the organizational structure and strategy of the corporate and possible on-going disputes and/or litigations.

Moreover, technical performance availability should be included in the operating report in order to specify the status of the renewable power plant.

Ordinary information to be incorporated are:

- Performance Ratio and Availability of the power plant and cumulated curves
- Hours of operating/outage, monthly production and performance curves
- Speed of wind and/or Irradiance and temperature of panels with relative cumulative curves during the operating period
- Average sales prices and revenues generated
- Spare part status, number of outages, explanation of the status warranty claims
- Curtailed Hours and Deemed Energy Curtailed
- Report of warranty claims

Reporting

Depending on the client, an annual or semi-annual financial budget, short and long-term forecasts and any variation respected the actual budget should be delivered by the Asset Manager to the Project Company. Moreover, during the operating year, monthly and semi-annual reports should be delivered to the

Project Company in order to inform them of the operating performance of the renewable power plant or the entire portfolio.

Typical information to be included are the analysis of cashflow and liquidity of the project, losses or earnings respect to the budget, profits, net project value and any other document required to the banks, insurance company and any third party. Moreover, the Project Company shall be constantly kept informed of any disputes, incidents, social and environmental KPIs.

Thereby, a customized platform based on the client's needs is offered to the client in which monitoring the technical and financial performance of the plant and supervise the entire portfolio.

Following the description provided above, the asset management services might be summarized as reported in the table below:

Figure 20 Overview of Asset Management Services

3.2.4. ADDITIONAL AND ADVISORY SERVICES

As already point out, with the climb of non-industrial investors in the renewable energy market, new expectations are placed on an asset manager to perform its activities. Thus, involving Asset Managers in all phases of the project and mostly

in the management of entire portfolio has led asset management companies to become technical experts in renewables energy and to increasingly have a wide range of services, all with the aim of adding value to the client and customizing them according to their needs.

Base on the phase of the power plant, additional specific services are:

Site and Yield Assessment

In the project development phase, a careful analysis of the site and an analysis of the technical characteristics of the ground, such as irradiance or wind speed, are essential to identify the possible layout of the power plant, decide the appropriate technologies and configurations, select the most suitable EPC Contractor and make strategic investment decisions. Moreover, a yield assessment is crucial in order to obtain the requirement funds by lenders and the acceptance of project finance structure. Thus, an Asset Manager through technical site visit inspections and more sophisticated technologies as drones could provide the best strategic decisions with the purpose of optimize the renewable power plant, study historical wind speed or light exposure in order to predict possible performance ratio, capacity factor and a clear analysis of strengths and weakness of the terrain.

Support during development

Starting from the initial assessment, different technical services could be offered by an Asset Manager during the development phase. Within these, typical services offered are the initial feasibility study from a technical and financial point of view, basic and detailed engineering studies and final design of the plant's layout.

From a management perspective, instead, the Asset Manager could coordinate and supervise all the parties involved in the development process, liaise with authorities and local entities and deliver all the documentation required to start the plant's construction.

The network of contact provided by an asset management company could be useful in order to speed up the obstructing renewable authorization process which in some countries is the bottleneck of the diffusion of the renewable power plant.

Another typical service often provided in this phase is the support during the tender procedures which through their detailed description of technical specifications and their impartiality in suggesting alternatives in the market can be crucial in ensuring the quality of the project and in actualizing EPC, O&M or other suppliers' agreements.

Technical due diligence and technical consultants

Throughout the project phase disputes may arise as a result of mistakes made by the operators or external events so that technical consultancy and due diligence services made by an external party may be a remedy to ensure the proper construction and operation of the plant. Thus, an evaluation of technical performance through field investigations, an assessment of performance, warranties and risks and a final report with optimization strategies could be of value added for the client.

Local Director

The flexibility to move from one country to another and the guaranteed support and reliability of the technology have led Asset Managers to manage facilities almost entirely remotely except for a few site visits during the year. Depending on the client's needs, however, an additional service offered to the client is to have a fixed person present on site, especially during the construction phase as this is the phase during the majority of the problems may arise. This manager acting as owner will be responsible for ensuring the quality required by the project and act as an asset manager on site.

Moreover, many non-industrial investors finance a renewables project mainly for two reasons:

1. To have an economic return

2. To meet sustainable development objectives

During my analysis emerged that among financial investors, many of them entrust the complete management to asset management companies, receiving only final financial outcomes of the project.

Financial advisory

By managing several financed projects and interacting with different lenders, insurance agencies and banks, the Asset Manager has acquired enough know-

how to be a perfect financial advisor and guide the client from the search for private and public funding to the construction of the loan agreement and the description of all the requirements needed to obtain the financing. In acting as financial advisor, the scale effect and the advantage for asset management companies to manage multiple portfolios and different clients, is evident. This allows them to know the best cost of capital in the market, negotiate with banks and advise the client on the most suitable period to refinance the project.

PPA Advisory

While asset management companies know what the banks need to finance a project, they also know how to ensure bankability by ensuring a continuous flow of revenue and driving the client in choosing the perfect buyer. In this framework, the Asset Manager not only coordinate all the parties involved but design and monitor the structuring process from the inception until the final signature.

Typical service offered in PPA advisory include:

- Understand the client's needs and align buyers and lenders requirements in order to achieve the bankability required by the banks.
- Provide an assessment of project performance to identify possible strategic solutions
- Identify possible buyers in the renewable market
- Support the final customer in negotiate, structure and close the final agreement

M&A Advisory

In creating the joint venture by two or more partners, several financial and commercial aspects shall be considered to avoid disputes between the parties.

Thus, several Asset Managers act as consultants in managing the merger and acquisition process of partners into the SPV and all the following financial aspects such as due the due diligence process between the parties, the definition of the legal structure, liabilities and tax burden of the final corporate.

Legal advisory

Similar to tax management, also legal service, being a very country-specific service with specific expertise, not all asset management companies provide this

service. Usually, they rely on third parties, thus having only a coordinating role for lawyers.

Only few of the larger Asset Managers specialized on financial service offer a comphensive legal service from different perspective.

From a corporate point of view, an Asset Manager can provide legal services related to the creation of the SPV and all the legal requirements involved in:

- Restructuring the company
- Corporate governance and attending corporate's meetings
- Drafting shareholder agreement
- Management of the capital share and accounting books
- Due diligence process in the merger phase

From a commercial perspective, the Asset Manager shall support the SPV in study the legal cases, drafting and structuring PPAs, O&M and EPC agreements and all other contracts between the Project Company and any third party. Other legal services include the management and resolution of claims or legal issues that could emerge between parties and finally determine the greatest insurances policy.

Being the renewable energy sector a specific and innovative framework, specific country law should be monitored in order to advise the Project Company on strategic legal choice and prevent any infringement.

3.3. LEVEL OF COMMITMENTS AND RESPONSIBILITY OF AN ASSET MANAGER

There is still some confusion in the market about the position of the Asset Manager in the renewable market and most of the time this figure is associated to the O&M contractor.

One of the reasons is mainly due to the previous management of fossil fuel plant in which, considering the few stakeholders involved, the only person responsible for the operational phase of an electricity or nuclear plant has always been the O&M provider.

Currently, even though O&M provider falls under the asset management branch, the two functions are completely different. In fact, while the O&M service provider deals with the day-to-day operation of the plant providing schedule and unscheduled maintenance, the Asset Manager has the main role in supervising the operations and maintenance activities provided by the O&M contractors, overseeing the performance of overall renewable plant and taking care of commercial and financial aspects as seen in previous paragraphs. Therefore, also the responsibilities and liabilities diverge.

In providing their service, the O&M contractors shall guarantee to the Project Company a constant amount of energy throughout the plant's operation, also called technical availability guarantee. This indicator, usually defined at the negotiation phase of the contract between 95% and 99,5%, determines the percentage of energy that the solar or wind plant is able to generate during the warranty period, i.e., the period from the signing of the COD until the closing of the agreement.

Calculated through an annual average of performance throughout the year and considering an annual degradation factor, if those technical availabilities are lower than the guaranteed, the O&M will be forced to pay liquidated damages.

From here comes the main difference between the Asset Manager and the O&M provider. In fact, contrary to this latter, the Asset Manager do not provide any contractual guarantees but will be responsible for overseeing the O&M contractor and performing the contractual services with due diligence and in full compliance with the regulations.

In our analysis, all respondents stated that they take no responsibility for the technical availability of the facility. Only three companies that occasionally offered O&M services in small-scale plants had responsibility for ensuring plant performance.

A different situation will be the case in which there should be several contractors managing the construction and the operation and maintenance phase of the

plant. For instance, the case of a wind power plant in which there are a turbine supplier, an Electric Balance of Plant [4] and Civil Balance of Plant [5]contractor.

In that event, the Asset Manager, having to coordinate the operation of several contractors, should guarantee an "additional availability" defined in the agreement. This means that excluding all the events attributable to the service providers and all force majeure events, the Asset Manager will be liable in case of underperformance of the power plant and pay a portion of the liquidated damages.

In a renewable power plant in which there are different parties involved, understanding who is responsible for the technical performance of the plant is of paramount importance in order to not resort to expensive liquidated damages.

Moreover, carefully attention should be paid to distinguish the role of O&M service provider and the Asset Manager because if identified in the same contractor, conflicts of interest between the two parties may arise.

Looking at the level of commitments that an Asset Manager takes during the overall lifecycle we can divide it, as made in the asset management services, between technical, commercial and financial responsibility.

Within the main technical duty, the Asset Manager shall be responsible for:

- **Operator responsibility** which means to planning, organize and supervise the day-to day business activities provided by the operators ensuring their obligations' compliance.
- **Plant responsibility** which means to overseeing the overall performance of the plants ensuring that it works efficiently in accordance with the technical availability guarantees defined in the contract and in compliance with the health, safety and environmental procedures.

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4 Electrical Balance of Plant Contractor is the dedicated supplier of electrical components except the wind turbines.

5 Civil Balance of Plant Contractor is the dedicated supplier of all the civil part of the plant except for the electrical components and wind turbines.

- **Traffic safety obligation** which means coordinating all transport activities on site and beyond the boundaries of the renewable power plant.

Within the commercial management, which represent the administration of the daily operations, the Asset Manager shall be responsible for:

- Managing daily business end-to-end
- Managing all stakeholders including all third-part contractors
- Reporting activities to the customers
- Contract management
- Main interface to the Project Company

Finally, within the finance management commitments, the Asset Manager shall be responsible for:

- Daily accounting
- Secretarial activities
- Interface to tax advisor and audit advisor
- Preparation of report to authorities and SPV
- Business controlling

In case of local director, owner engineer or other key manager on site or with a higher level of interface with customers, obviously, the responsibilities and the subsequent fees are different.

3.4. ORGANIZATIONAL STRUCTURE

Mainly due to the variety of services they offer, asset management companies need to have a multi-disciplinary team with specific expertise in certain areas and at the same time provide cross-functional areas for the coordination of the different units of a plant or the entire portfolio.

In fact, additionally to an Asset Manager for the single plant, with the latest trend of the market, even more asset management companies are structured with the presence of a Portfolio Manager with the distinct competence to have an entire overview of the investment made by the Owner and providing an added value in coordinating and optimizing the entire set of assets.

Although each unit is sector-specific and has peculiar competencies, cross-functionality and coordination of each activity is essential to optimize the whole asset. In addition, with the introduction of technology and the huge amount of data generated by a plant even more digital skills are required to each unit to fill the high-tech skills gap.

Despite the large number of units and the complex internal structure according to services, an interesting point to highlight is the total number of staff within an asset management organization. In fact, even in this case a scale effect can be seen based on the number of GW managed. The more renewable installed capacity is managed, the more active they are in the market through a worldwide portfolio, and the fewer resources are needed for each installed capacity.

Looking at the eight Asset Managers interviewed, it was seen that the largest companies had on average number of resources around 50-60 people per GW managed while for the smallest asset management companies the number of resources could go up until to 100 people.

This range should not be taken as an absolute reference but is influenced by two main factors:

Firstly, the service offered. As previously mentioned, many Asset Managers entering in the market are becoming more specialized in offering commercial, financial and ancillary services so requiring few resources involved and mainly by remotely. One possible reason why Company A and B resulted inefficient was mainly due to the fact that they are two small companies specialized mainly in technical services including O&M services, thus requiring a higher number of technicians and experts. They were born as O&M Contractors and only during the years they began to expand their services by offering administrative one.

The second factor is related to the technology. In order to increase the efficiency, all companies base their organization on the use of centralized asset management platforms that allow them to speed up the reporting and planning activities and have direct contact with the owner through the use of a dashboard where they can monitor all the performance of their assets.

As the number of renewable assets to be managed increases and the complexity of the entire business in terms of geographic presence, client portfolio and services offered increases, largest asset management companies are starting to

acquire digital asset management companies or developing in-house platform making of technology their core business and in turn optimizing the overall number of resources per each renewable installed capacity.

At an organizational level, technology has not only optimized the processes but has led asset management companies to focus their service on the remote monitoring and control of solar or wind plants reducing the need to have resources on site.

Any Asset Managers interviewed, unless explicitly requested by the customer, they had no people on site. Plant visits are usually carried out quarterly, annually or in case of specific performance tests, thus, leading a great advantage in terms of costs and resources. In fact, this structure allows them to manage a plant completely from their main headquarters without the need to open a new branch in a new place and at the same time manage installed capacity worldwide. In case of specific technical services, they can always rely on local third parties or subcontractors passing to the final customer a high-quality service and at lower cost.

Due to their limited liability, the law in term of foreign settlement does not necessarily require them to open a brunch in every country where they manage the assets, but simply operating remotely and opening it only once the country is consolidated and it is economically viable.

Based on the Asset Manager interviews, the global delivery model of an asset management company can be summarized by:

- An **in-country team** composed by locally branches opened when the asset portfolio becomes wider and more complex to manage remotely and local partners or subcontractors to ensure timely intervention on site
- **A remote technical**, commercial and financial team to guarantee the services offered worldwide
- **Additional teams** of specialists designated to provide additional services such as support during the development or construction phase of the plant, debt management, engineers design or others.

This innovative and flexible business model demonstrate the capacity of asset management companies to provide service anywhere without the need to raise

costs. Thus, affecting the end-customer who will reward with a high-quality service at relative lower price.

3.5. DATA-DRIVEN COMPANIES

Technology has brought about profound changes in various industries, including the renewable asset management.

With the introduction of many investors in the renewable market, the creation of entire asset portfolios and consequently the management of an increasingly amount of data processing, has led asset management companies to review all its internal processes, finding in technology the way to simplify and automate all those operations previously carried out by long spreadsheets, simplify the most complex operations and finally use artificial intelligence, data and machine learning to optimize the whole portfolio through predictive and preventive maintenance process. Thus, bringing a very paradigm shift in the management of a renewable asset.

With the last technology trend, many Asset Managers have started to acquire digital skills up to become awfully data driven companies and streamline their processes through asset management platforms.

These are integrated digital tools able to centralize and standardize all the data and different type of information towards a single platform able to perform different activities and deliver to the Owner, Asset Manager e O&M Contractor a single point of true with which to interact and extrapolate and/or view the data of a plant or a portfolio of plants.

These platforms are based on three main elements: the collection of data from multiple facilities, algorithms capable of cleaning the data and finally a decision-making system capable of obtaining real-time data and helping the asset manager to plan, coordinate and make strategic decisions to increase return on investment and reduce risks.

Although there is the possibility of using different tools such as a customer-portals, monitoring and ticketing software or ERP System, in the market there is a tendency to bring all these systems together in a single platform capable of forming a higher quality service.

Within the main benefit of these platform there is the possibility to:

- Create customizable dashboard and produce flexible and automatic technical, commercial and financial reports based on customers need.
- Provide a full remote service and a 24/7 monitoring of the plant looking for improvement and strategic decision-making
- Provide preventive and predictive maintenance and new technological solutions
- Obtain reliable and transparent power plant performance analysis (availability, performance ratio, temperature, wind speed…)

Moreover, while the use of digital systems has led to an efficiency boost in all asset management process, on the other hand, with the creation of multiple portfolios, the exchange of information between different plants in different areas and the use of cloud database or systems to store operational data, it has also created the need for Asset Managers to protect clients from external cyber-attacks and prevent a chain diffusion to all other power plants. Thus, it has become essential for Asset Managers to offer a secure service and implement a safe cybersecurity software in order to avoid short out and preserve the client's portfolio.

Recognizing in technology a key instrument for maximizing customer value, reducing operational costs and having a flexible business model, all asset management companies rely on digital platforms making of this their key strengths.

Depending on the complexity and size of the assets to be managed, Asset Managers are becoming always more data driven companies basing their core business digital services, developing software in-house and not only using it for their own purpose but commercially selling it as a separate service to third parties. Recognizing the importance to have digital skills, among 8 Asset Managers interviewed, only one company used software commercially available in the market.

Furthermore, many software companies, recognizing renewable asset management software as an attractive future business in driving this energy transition, are starting to enter in the market offering solar or wind asset management software, thus, increasing competitiveness in the market.

The installation of an asset management platform usually requires between two and three weeks depending on the time to collect all the information required. Usually, three steps have to be done in order to install an asset management platform:

- Set up a separate database for each customer
- Integration with the Monitoring Systems
- Basic configuration which includes the number of meters, location data, contract information…

In an asset management platform, each service or activity is composed by an independent module with is characterized by an internal process but at the same time connected with others module in order to guarantee the interoperability between all the functions and activities performed by all stakeholders.

After studying different internally and externally development platforms, the main modules common to all of them could be summarized as followed:

Real Time Monitoring

Integrating the software to the asset's infrastructure, it provides real-time monitoring of all data alerting the operator in case of incident or some components are not correctly working causing energy losses. If it is the entire system that is losing performance, a root analysis can be used to find the cause of the fault and repair it as soon as possible. Furthermore, in the case of decision-making, through data intelligence, different solutions can be provided by the operator so that they can make his own choices and provide the final solution.

Work Order and Ticketing Systems

Once detected the error, a work order can be opened in order to inform the O&M Contractor to go to the site to repair the damage. Usually, they are made through mobile applications which are able to monitor the operator's repairmen time, identify the type of fault, allocate the correct liabilities and warranties among the parties and supervise the correct operation of technicians.

Once the system identifies an error, an alert is sent to the platform dispatching the information to different place: health and safety, O&M Contract compliance, technical training management, subcontractor, Spare Part management, warranty management and all the task involved in this phase. Thus, the work

order is opened. Once the technician is on site, the error is identified, repaired and, if necessary, a new spare part used. Here, response time and lead time are two important parameters for assessing the efficiency of the contractor and supervise the task performed. After the component has been repaired and the order has been closed, the Asset Manager identifies the cause and associates the various costs and responsibilities. Each downtime is energy lost and a cost impact in the final balance. Once the analysis is performed, a final report with the activities performed, the reaction time and the causes are stored in the platform and the customer dashboard updated.

Usually there are two ways in which an Asset Manager can monitor the contractor. The first is through a mobile app incorporated by a GPS able to supervise the contractor's mobility. The second is through electronic email at the end of the day.

Financial Management

Within the main benefits of the platform is to provide a monitoring recording of all financial transactions, provide quick financial ratio such as DSCR, net working capital and liquidity performance ratios to create finally and customized financial statements and documents to deliver to banks, authorities and insurance companies.

Contract and Warranties Management

Once contractual terms, warranties and contractual performance have been collected and stored in an asset management platform, an alert system can be set up in order to check compliance, prices, accomplishments and manage all claims and activities made by all parties involved: from the EPC Contractors to banks, PPAs, insurance companies, authorities and grid operators.

Portfolio management

Based on the level of detail of the information, and asset management system allows the client to analyze the performance of a single assets or, at a higher level, the combination of multiple assets. This is essential for both, for clients to evaluate the return of investment of the entire portfolio and for Asset Managers to individuate optimization process due to the combination of multiple plants.

Customer Portal

In renewables market, the investors, being non-industrial partners such as private equity, pension funds or institutional investors, are used to managing large investments aimed at obtaining an economic return. Thus, a customized customer portal based on their needs allow them to constantly view and monitor all the technical and financial performance of the portfolio and provide a transparency process in all the activities carried out. Being the investors more involved in the renewable assets, a customer portal is become a must that all the Asset Managers must provide to the client. Usually, only strictly authorized persons have access to the portal.

Communication management

An asset management platform provides a unique and efficient way of communication and information exchange between stakeholders. Usually connected with mobile apps, they allow to create tasks, comment on them, and have an imminent exchange of communication.

Site Visit Report

Each time a technical operator carries out a site visit, a report is issued to communicate the activities carried out, checks compliances with Health, Safety and Environmental conditions and subcontractor's obligations. All the information is stored in the asset management platform; thus, all parties can have access on it providing comments and possible solutions.

Reporting management

Reporting is one of the crucial and time requiring activity carried out by an Asset Manager. Through an asset management platform, the Asset Manager can speed up the process creating customizable and automatic reports based on the customer's necessity.

Revenues and Cost management

Asset management platform allows you to automatically manage all incoming cash flows, check if the energy sold corresponds to the energy contracted, schedule payments and finally issue invoices. It keeps all costs on track against the budget and a series of reports can be automatically created to see all commercial data such as monthly income, expenditures and possible deviations.

Project Management

In case of repowering, construction support or in any activity in which there is a project that requires a scheduling of activities, set of milestones and responsibilities by several parties, the asset management platform can provide to the Asset Manager an instrument to plan, schedule activities and finally keep track of all tasks to be performed. It acts as a project management software able to monitor the project budgets and risks providing the optimal solutions in case of delays.

Technology is not only driving Asset Managers to become more efficient in their processes of managing a renewable plant.

With the acquisition of digital skills, their business is shifting to offering additional technical services through the use of the latest technologies creating added value for the end customer while at the same time increasing profitability by offering added services at an extra cost to the asset management service.

These include thermo-inspections and monitoring through drones, plant design through 3D software or AutoCAD, constantly research for predictive maintenance's algorithms and a continuous investment in R&D and new technological solutions.

3.6. RENEWABLE ASSET MANAGEMENT FEES

The large number of services offered and the flexibility in which resources are allocated makes it difficult to define the fee of an asset management agreement.

As defined in the table below, in our analysis only tree Asset Managers provided specific fees related to the technical and administrative services which include commercial and financial services.

All figures €/MW	Germany			France			Africa			S. Korea			India			Australia		
Installed MWp:	50	100	150	50	100	150	50	100	150	50	100	150	50	100	150	50	100	150
Technical & Operational *(lower - higher range)*	*930*	*540*	*400*	*980*	*570*	*420*	*470*	*260*	*190*	*800*	*510*	*390*	*260*	*180*	*130*	*1.200*	*760*	*580*
	1.080	*630*	*460*	*1.140*	*660*	*490*	*540*	*310*	*220*	*930*	*590*	*450*	*310*	*200*	*150*	*1.400*	*880*	*670*
Administrative Services *(lower - higher range)*	*1.240*	*720*	*530*	*1310*	*760*	*550*	*620*	*350*	*250*	*1060*	*670*	*510*	*420*	*230*	*170*	*1.600*	*1.010*	*760*
	1.440	*830*	*610*	*1.510*	*870*	*650*	*720*	*400*	*290*	*1.230*	*780*	*590*	*480*	*270*	*190*	*1.860*	*1.160*	*890*
Total (lower - higher range) - A	**2.170**	**1.260**	**930**	**2.290**	**1.330**	**970**	**1.090**	**610**	**440**	**1.860**	**1.370**	**900**	**730**	**410**	**300**	**2.800**	**1.770**	**1.340**
	2.520	**1.460**	**1.070**	**2.650**	**1.530**	**1.140**	**1.260**	**710**	**510**	**2.160**	**1.180**	**1.040**	**740**	**470**	**340**	**3.260**	**2.040**	**1.560**
Technical & Operational	*1.200*			*1.200*														
Administrative Services	*1.100*			*1.100*														
Total - B	**2.300**			**2.300**														
Technical & Operational	*800*			*800*			*900*											
Administrative Services	*400*			*400*			*400*											
Total - C	**1.200**			**1.200**			**1.300**											

Figure 21 Fees of Asset Management Companies selected

Only one of the Asset Manager provided a price in relation to the number of power plants and the contract duration: 35K€/y for single solar power plant, for a portfolio of 10 solar power plants, 10 years contract.

In defining the range of countries to be analyzed, our interest was mainly in knowing the fees of developing countries such as Africa, India, Australia and South Korea. Thus, the team explicitly asked to different Asset Managers which countries to include.

In defining a price different factors should be considered:

- The service offered
- The geographical area
- The capacity under management

Referring to the first point, an asset management agreement can be easily customized base on the client's needs. In fact, it can be defined as a full asset management service including technical, commercial and financial services described in the paragraph 3.2 or based on different pre-defined packages chosen by the client in accordance with their portfolio's size and the level of Asset Manager's support in performing the activities.

Moreover, a razor and blazed model is performed by the Asset Managers in considering all the additional services. In fact, each auxiliary service such as PPA structuring, technical or financial advisory is often offered at a higher extra-price even outside of the conclusion of the contract compensating the low cost of asset management services.

In addition, respect to solar management, for wind asset management the price increase of around 10% to 20% respect to the solar. This reflect the fact that there

are few asset management companies specializing in wind energy technology compared to solar, mainly due to the greater complexity in the operation and maintenance of a wind plant.

Concerning the country, the price may differ depending on the geographical location where the Asset Manager has to provide the service. Among the regions with the lowest price, there are developing countries including India and Africa. For instance, in India, the services provide in a solar plant with an installed capacity of around 150MW may cost around 300 to 340 €/MW per year compared to the same plant in Australia which the price can range between 1.340 to 1.560 €/MW, four time higher than the same service in India.

There are different ways to define the fee of an asset management service. It can be defined based on the capacity installed in which due to the scale effect increasing the MW under management the price tends to decrease or, sometimes set with an annual lumpsum based on the number of plants in the portfolio and the contractual years.

Due to their business model defined by remote monitor, annual or semi-annual site visits, subcontracted local technicians, the achievement of greater efficiency through the technology and asset management platforms has led these companies to be very competitive in the market compared to Utilities, Industrial Power Producers or Original Equipment Manufacturer that offer the same service but a higher price.

Moreover, due to their low running costs and few resources involved, not only the price is lower but also their marginality, thus, increasing competitiveness in the renewable market.

3.7. THE VALUE CREATION PROVIDED BY ASSET MANAGEMENT COMPANIES

The results of the interviews carried out showed that one of the main added values achieved by asset management companies, in this dynamic energy transition framework, is the ability to achieve a scale effect.

Their great experience in managing different client's portfolio in different geographic areas and interacting with different stakeholders as commercial

banks, suppliers or service providers have given them the required competences to speed up the processes and discover the right opportunities in the market driving the investor in doing the right choice. With the achievement of scale effect at multiple level, they are able to runs competitive power purchased agreements, identify the best cost of capital in the market to attract investors, refinance the project at a lower interest rate and interact with responsible authorities in order to obtain authorizations, permits or licenses.

Having a worldwide footprint and coordinating different O&M contractors, EPC contractors or subcontractors, they can exploit their international expertise in find the best high quality and reliable components, thus, guaranteeing a long component lifetime and consequently providing less maintenance operations.

Moreover, with their involvement in all phases of the project starting from its inception to the decommission, they are the only actors to have an overview of the entire plant, monitor the performance and promptly take actions in order to prevent a contractor's negligence. Through an active supervision of O&M and EPC contractors and all subcontractors involved, an Asset Manager is able to coordinate all the tasks to be performed and provide site visit inspections, guaranteeing a high level of energy availability to the owner, usually settled around 99,5%.

Furthermore, the spread of technology and the growing flow of data generated, Asset Managers have restructured their entire process becoming effective IT-driven company.

They are innovative companies always looking for technological solutions to optimize processes through drones, artificial intelligence and data analysts and opening to new technologies such as batteries for energy storage. Currently, only the larger companies offer battery solutions, but the evolving market is leading them even more to acquire technical expertise in that direction in order to satisfy the final customer and provide a value added to renewable power plants.

Moreover, real-time monitoring and the latest innovative software solutions are allowing Asset Managers to provide very technical experience in preventive maintenance, predicting failures and identifying reasons and solutions in case the performance fall below a certain threshold. For instance, a strategic solution

could be to repair the components in a phase of downtime in order to optimize the performance or simple provide new performing inverters or gearboxes.

In order to reduce cost, Asset Managers through specialized operating site visits and software able to identify root-cause analysis can timely notify the O&M contractor and provide effective maintenance. In doing this, the latest solutions offered by Asset Managers in the market are related to web apps in order to monitor in real time the operating activity of the O&M contractor through GPS systems, or applying specific video cameras in order to verify the correct operator's site visits.

They are innovative companies making constantly commitments in investing in R&D and in finding always new solutions in order to optimize the plant and give to the owner the best value. Moreover, the Asset Manager's experience in monitoring the plant can be extended to other assets providing an optimization of the entire portfolio and exploit scale effect.

As the sustainability is becoming always more relevant in driving institutional capital in renewable investments, always more Asset Managers are implementing ESG targets and United Nations Sustainability Objective in their procedures and process delivering to the client sustainable and environmental principles.

Finally, the main and perhaps the most valuable characteristic that have in common all the asset management company is their ability to standardize their services and customize them base on client's necessity and objectives. Their client-approach focused on the clients' needs and their satisfaction offering a wide range of services is the main characteristic that distinguishes an asset management company from all those that provide asset management services outside their core business.

CONCLUSIONS

The renewable energy sector is undergoing profound changes leading incumbents to adapt accordingly. New players are entering in the market and new expectations are placed on Asset Managers to perform not only technical but also financial and commercial asset management services with the final purpose of optimizing the entire portfolio rather than a single renewable asset.

In this framework, the objective of this work was to carry out a market analysis related to renewable asset management companies specifically to solar and wind technologies in order to identify the framework of this emerging market and to gather information for Enel Green Power on whether to internalize or outsource asset management services for the growing renewable installed capacity.

Based on the parameter selected, the analysis and interviews conducted revealed that all the Asset Managers follow a common approach to offer asset management services, with only few differences between them. Although they were all small companies, the main characteristics that differentiated the various asset management companies were mainly based on the size of the company, the installed capacity managed, and the company's history of offering more technical services such as O&M services and support during construction or, from the other side, specialized more in offering legal, financial and commercial advisory services. Despite these few differences, there are many key elements common to all asset management companies.

From the analyses carried out, it emerged that these innovative actors, specialized in the commercial and financial management of an investment and in the supervision and control of technical activities, are all new entrants in the renewable energy market. The increased accessibility of renewables and the push by political forces to reduce climate change has led non-industrial investors to find in renewable assets a profitable form of investment and consequently the need of technical expert capable of managing and optimizing entire asset portfolios. Indeed, all asset management companies examined had started their activities in the last two decades.

Basing their business model on a continuous improvement of investment's return through maximization processes, with the exponential growth and spread of installed capacity worldwide, these Asset Managers have gained enough

technical and commercial experience to be able to achieve scale effects and discover the right opportunities in the market with the final objective of creating value for the end customer. Furthermore, with the spread of technology and artificial intelligence, Asset Managers have become data driven companies offering a high skilled service such as corrective, preventive and predictive maintenance, automated data analysis and sophisticated performance analysis.

From the interviews conducted, the majority of them had developed in-house asset management systems to optimize internal process and manage wide client's portfolios worldwide efficiently and effectively.

In addition, due to the intrinsic characteristics of the service offered, their limited responsibilities and providing annual or semiannual site visits without the need of resources on site, has led asset management companies to operate in emerging countries without the need to open a branch as long as the presence in the country is not consolidated or economically convenient. All these affecting the asset management fees for the final customer who therefore receives a quality service at a very reasonable cost.

In fact, although prices depend on installed capacity, geographic area and service offered, the results showed that these companies are characterized by low margins and a relatively low price compared to the service offered, thus increasing competitiveness in the market. In addition, prices of wind technologies are 10%-20% higher than for solar, mainly due to the complexity of managing large wind plants.

To date, it is not possible to identify whether to internalize or outsource asset management service, but a careful internal assessment must be carried out by Enel to understand the company's ability to perform this service according to the partner's needs. In my opinion, for future installations and in countries where Enel does not have a strong presence, the company might consider to outsourcing asset management services and take advantage of the scale effect that these Asset Managers have in managing multiple portfolios and the low cost of the service offered. In case of insourcing, the company should align itself to the market standard and thus be more competitive in offering this service and attracting investors. In that event, the company might also consider acquiring an asset management services company and speed up the internalization process.

Whilst on the one hand, internalizing this service could create an opportunity for the company to attract investment, valorize the entire company's value chain and improve efficiency process not only for projects in partnership but also for project in ownership, the latest market trends have showed as utilities players and large funds are starting to insource these activities and digital systems, thus, reducing the need for Asset Management.

Nevertheless, given the carbon neutrality targets imposed by governments and the forecasted renewable energy demand over the next 30 years there will be an increasing involvement of private investors in the renewables. And thereby leading a proportional increase of Asset Managers able to maximize the return for these investors and a potential wide market for these new players. Being a sector in development phase, an interesting possible future research could be to estimate the market size for these new players and their relative share in the renewables sector. This would enhance the analysis in the decision-making process whether to enter the market and the opportunities offered.

Moreover, although this thesis has been designated to be a guideline for all those players who are approaching this evolving market, considering the volatility of renewable sector, a constant monitoring and improvement process must be in place by the companies involved in order to be constantly updated on the market's dynamism.

Considering the limited literature regarding this topic and being one of the few pioneers in tackling the issue of Asset Managers in the renewable market, with this work my objective was to raise awareness regarding the importance of asset management companies in catalyzing third-party investments and their contribution in driving this energy transition.

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