KM3NeT INFRADEV – H2020 – 739560

Report on contacts/discussions with power companies/ local authorities /potential partners

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Abstract

The document reports on the identification of possible strategies which can be followed in the three countries hosting KM3NeT sites, in order to make KM3NeT a Zero Carbon footprint research infrastructure. We present a general overview of the Renewable energy generation technologies and market situation, and follow with reports on the possible solutions in each case. Possible synergies and collaborations are reported as appropriate.

I. COPYRIGHT NOTICE

II. DELIVERY SLIP

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IV. APPLICATON AREA

This document is a formal deliverable for the GA of the project, applicable to all members of the KM3NeT INFRADEV project, beneficiaries and third parties, as well as its collaborating projects.

V. TERMINOLOGY

A project glossary is provided below:

BIPV – Building Integrated PhotoVoltaic
CNRS – Centre National de la Recherche Scientifique

CSP – Concentrated Solar Power
DAQ – Data Acquisition
GSE - Gestore dei Sistemi Energetici
HAWT – Horizontal Axis Wind Turbine
KM3NeT/FR – The installation site of KM3NeT in France, south of Toulon
KM3NeT/IT- The installation site of KM3NeT in Italy, east of Capo Passero
Ktoe – Kilo tonne oil equivalent (~11,63 GWh)
IRENA – International Renewable Energy Agency
MRE – Marine Renewable Energy
OTEC – Ocean Thermal Energy Conversion
PV – Photovoltaic
RnE – Renewable Energy
REI – Renewable Energy Infrastructure
VAWT – Vertical Axis Wind Turbine

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VIII. PROJECT SUMMARY

KM3NeT is a large Research Infrastructure that will consist of a network of deep-sea neutrino telescopes in the Mediterranean Sea with user ports for Earth and Sea sciences. Following the appearance of KM3NeT 2.0 on the ESFRI roadmap 2016 and in line with the recommendations of the Assessment Expert Group in 2013, the KM3NeT-INFRADEV project addresses the Coordination and Support Actions (CSA) to prepare a legal entity and appropriate services for KM3NeT, thereby providing a sustainable solution for the operation of the research infrastructure during ten (or more) years. The KM3NeT-INFRADEV is funded by the European Commission's Horizon 2020 framework and its objectives comprise, amongst others, activities on the preparation for establishing KM3NeT as a Zero Carbon Footprint research infrastructure (work package 10).

IX. EXECUTIVE SUMMARY

The main goal of WP10 of the KM3NeT-INFRADEV project is to prepare for the establishment of KM3NeT as a Zero Carbon Footprint research infrastructure. The current first deliverable of WP10, establishes the framework in which our next steps will be made. In particular, after a brief overview of possible Renewable energy generation technologies, we report on the condition of the energy market in each of the three hosting countries, and on the possible synergies and collaborations that can be established.

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1. Introduction

Energy generation and consumption has evolved as one of the main global issues to be resolved within the coming years. It has been widely accepted that the use of fossil fuels as an energy source is not sustainable at the rate currently practiced. At the same time, issues related to climate change and global warming have contributed to the awareness that the energy production issue has to be solved respecting the fragile global environment. To this end, renewable energy sources have been identified and the relevant technologies to realise the exploitation of these sources, have been under development. Some of these are currently mature enough to guarantee realisation scales suitable for useful application, while others are more in the research and development stage.

Although scientific and research efforts, usually require medium to large quantities of electrical power, the funding agencies and/or management teams have been quite slow in realising the need to incorporate environmental friendly use of energy sources. It is only in the last few years that the realisation that the extended use of renewable energy sources and efficient use of the available energy can contribute not only to reduce the negative footprint of these infrastructures to the environment, but also, to contribute to a less costly mode of operation, even after accounting for the initial significant material investment.

KM3NeT, the large Research Infrastructure (RI) which will host the latest generation of deep-sea neutrino telescopes in the Mediterranean Sea with user ports for Earth and Sea sciences, will open a new window on our Universe, but also forward the research into the properties of neutrinos. KM3NeT will be a distributed infrastructure with deep-sea instrumentation east of the Sicilian Coast (Italy), south of Toulon (France) and off the South-West coast of Peloponnese (Greece) (fig.1). The main science objectives, a description of the technology and a summary of the costs are presented in the KM3NeT 2.0 Letter of Intent [1].

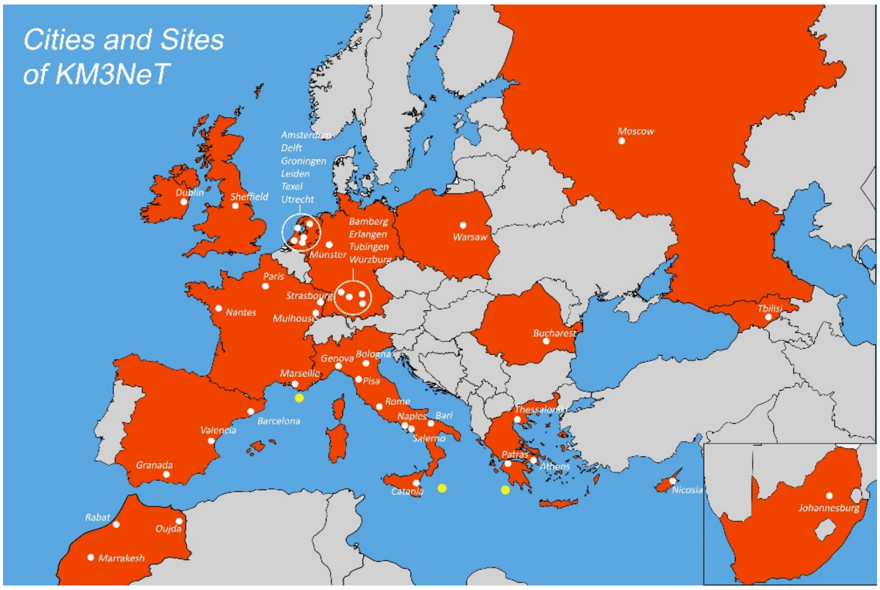

Figure 1: The 3 KM3NeT sites (yellow dots) in France, Italy and Greece

KM3NeT has been quite proactive in realising that by adopting strategies based on renewable energy sources, a significant window of opportunity exists towards reduced costs of operation, an environmentally friendly and sustainable way of satisfying the energy needs of the research infrastructure, while it is, at the same time, contributing to the general public awareness as well as supplying part of the energy needs of local communities.

This document describes the progress made in planning for the adoption of renewable and sustainable energy sources for the operation of the three KM3NeT sites. In particular, at this stage of the project, our goal has been to identify possible synergies and partners for the implementation of renewable energy production, and investigate the maturity of these collaborations. In section 2, the energy requirements of the KM3NeT sites are presented. In section 3 we present a brief overview of existing renewable energy production technologies. In section 4, the possible implementation methodologies are presented. In section 5, the main implementation policies relevant to the three countries of interest are presented, and in section 6 the plans for the future are discussed, to be followed by our conclusions.

2. The energy consumption of the KM3NeT sites.

As already mentioned above, KM3NeT is a distributed research infrastructure. Currently, the Italian and French sites are operational with the Greek site to become fully operational at a later stage. At each site, the infrastructure consists of the instrumentation located in the deep-sea which is linked to the on-shore station. The shore station hosts the power system for the sea instrumentation, the DAQ system and support equipment for the operation of the detector.

The energy requirements for the two operational sites are shown in table 1 below. These are estimates based on the current energy consumption, and the projected needs and design for the completed infrastructure. The difference between the two is attributed to differences in the implementation of cooling, heating, and DAQ system requirements. The building size (after the planned renovation) in Porto Palo will be much larger than the Toulon building, and will also host more amenities for the locally present personnel. In any case, the two estimates are within 20%, and are subject to revision and optimisation. It is reasonable to assume that the average consumption of the two can be used as a benchmark for the definition of our strategy. In what follows, the average of 615 kW/h will be the working hypothesis for the power required for each site.

Item	KM3NeT/IT (kW)	KM3NeT/FR (kW)
Power Feed equipment	100	100
Data Acquisition Center	240	130
Fan Coils	4	200
Refrigerating Unit	193	80
Air Handling Unit	15	0
Dehumidification system	15	0
Offices (lights, PC…)	20	20
Meeting rooms	2	2
Miscellaneous	91	18
Total	680	550
Average	615 (kW)	

Table 1: The projected energy consumption of the KM3NeT/IT and KM3NeT/FR sites

The above energy requirements are at such a scale that a small-to-medium size energy generation infrastructure can easily meet them. Although the above figures refer to a 24/7 continuous operation, it should be realised that there will be periods when the required energy will be much less due to periods of maintenance, dead time, etc. This will turn out to be an important issue when establishing partnerships and synergies, especially with local and regional authorities, as will be described later.

3. Renewable energy technologies

A general overview of the available renewable energy technologies is given in this section. Some of them are in a more mature level than others, while some of them may be more relevant to the installation sites than others.

3.1 Solar energy

Solar energy can be harnessed in the form of heat or light. When it is harnessed in the form of heat, it can be used as heat or converted to electricity while when it is harnessed in the form of light it is converted to electricity [2].

3.1.1 Solar thermal systems

Solar thermal systems are used to produce heat from the energy of the sun. The most common solar thermal systems are water heating panels and passive solar design. The water heating panels provide hot water for domestic or commercial use at moderate temperatures while the passive solar design uses the heat from the sun to provide the correct living temperature for a building (Figure 2) [2].

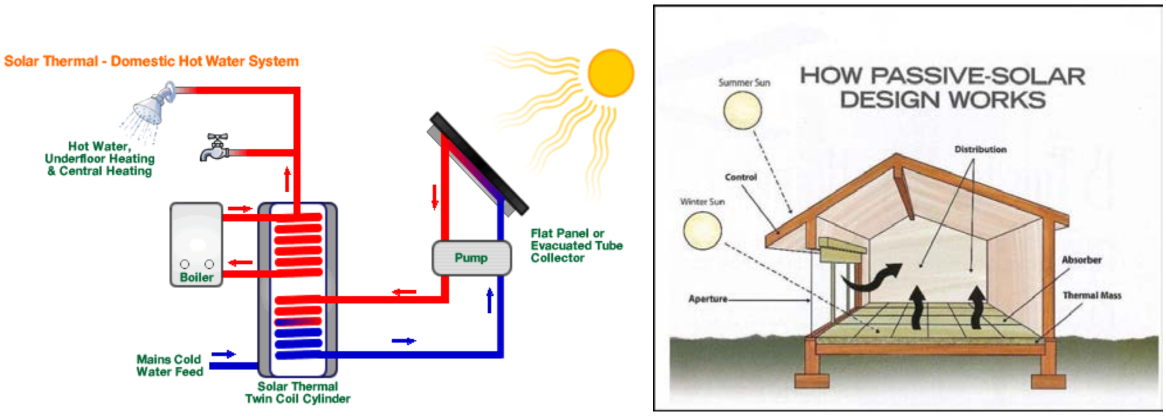

Figure 2: Water heating panel and passive solar design [3, 4]

3.1.2 Photovoltaic (PV) applications

The photovoltaics, or as otherwise known solar cells, are used for the direct conversion of light to electricity and are made of semiconducting materials. The most common semiconducting material used in fabrication of PV cells is silicon. PV cells are divided in two categories, crystalline and thin-film [5]. The best research cell efficiencies are shown in figure 3.

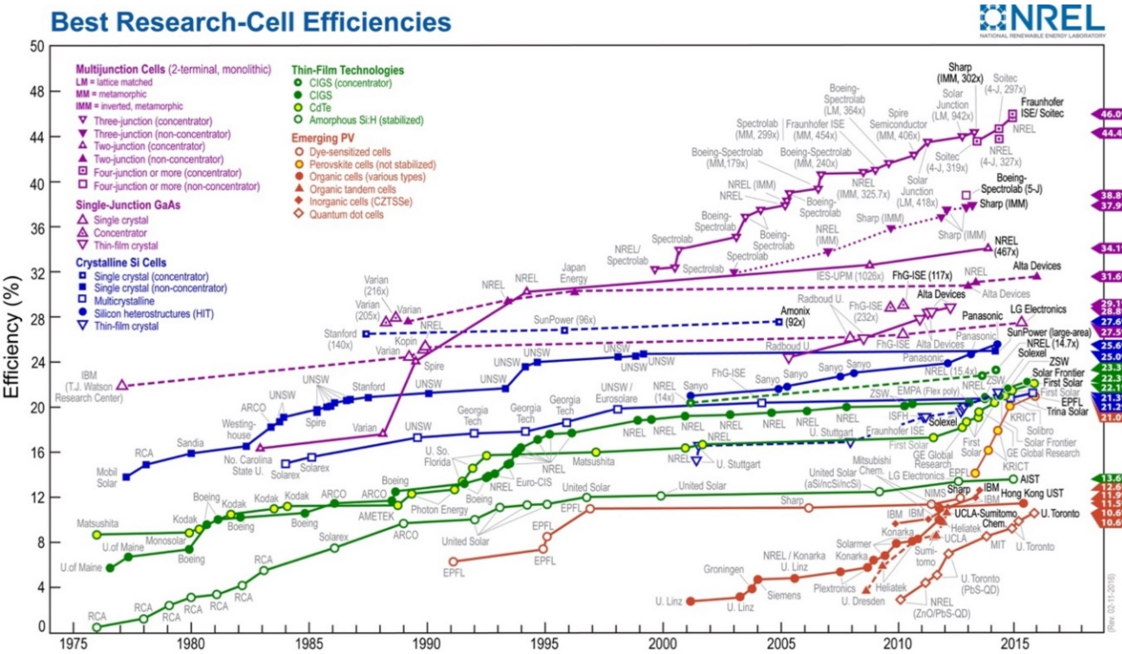

Figure 3: Historical evolution of the PV cell efficiencies [6]

Photovoltaics were invented in the United States in 1954 at Bell Telephone Laboratories. Currently, in the area of renewable energy, PV is one of the fastest-developing technologies and can have a significant role in the future of global electricity generation mix [7]. Their first commercial use was to power satellites but since 1970s various terrestrial applications have been developed [8]. The main categorisation in the terrestrial application is between off grid (stand-alone) and on grid-connected PV systems. However, a distinction can be also made for the consumer product applications and the concentrated PV systems. The consumer products are small PV modules integrated into products to meet the electrical supply requirements of the particular product [9] while the concentrated PV systems are presented in the following section. In addition, PV systems can be fixed mounted or tracking systems. The tracking systems track the position of the sun during the day, hence can produce more power, however they are costlier than the fixed and require more maintenance for the moving parts and the gears. They also need extra power supply for the motor and more time for installing. Figure 4 shows the different types of tracking systems according to their tracking axis.

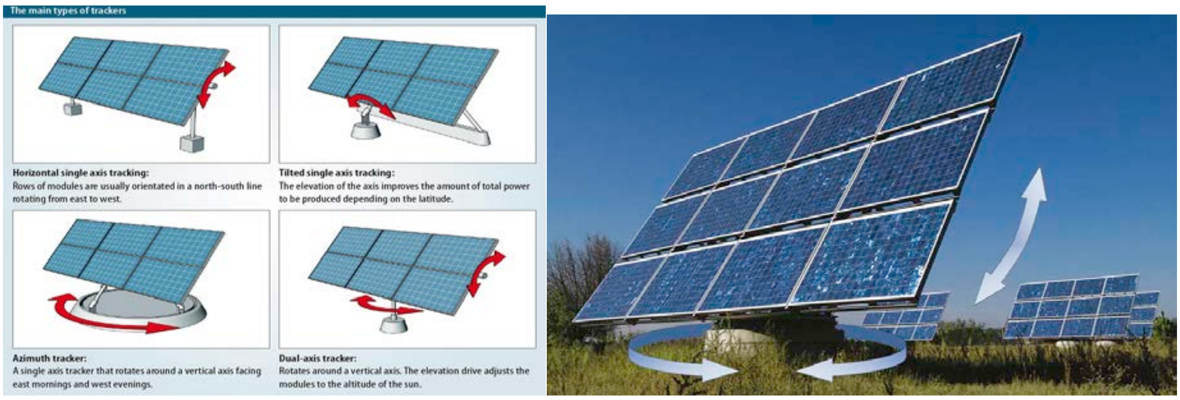

Figure 4: PV tracking systems [10, 11]

The standalone PV systems operate independently of the electricity grid. They are used for domestic and non-domestic applications. In remote areas they can power buildings such as farms, houses, hotels, education centres etc. or even a whole community when they are combined with a mini grid to distribute the produced electricity. The utilisation of solar PV for mini-grids is an outstanding mode to provide electricity access to individuals who do not reside close to power transmission lines, especially in developing countries with solar energy resources [7]. In such cases it is also likely to be combined with a diesel generator (Hybrid PV/diesel system) in order to ensure the availability of the energy delivered. Both wind and solar are considered as intermittent power sources, hence for a constant availability a hybrid system is preferable. Further, some of the non-domestic applications are telecommunications, water pumping, vaccine refrigerator, medical equipment, remote sensing, parking meters, bus stops etc. [12].

The grid connected PV systems are connected directly to the electrical grid and operate in parallel with it for supplying the load. They are used for commercial, domestic, power plants and building integrated PV (BIPV) installations (Figures 5 and 6). In the BIPV applications the PV modules are part of the building construction materials. Unlike the stand-alone systems, grid connected systems do not need to account for energy availability as they get the support from the electricity grid. Moreover, the produced PV energy by these systems can be consumed locally or exported into the grid. The annual average amount of energy that a solar PV system can produce in the southern parts of the Mediterranean area is around 1600 kWh per 1 KW installed rated power.

Figure 5: PV generation plant and commercial systems [13, 14]

Figure 6: PV domestic systems (roof mounted and BIPV) [15, 16]

3.1.3 Concentrated PV systems

At the end of the 19th century, heat collected from solar concentrators was utilised by numerous inventors and engineers to operate steam engines that pumped water and later to produce electricity through revolving mechanisms [17]. Concentrating PV systems or otherwise concentrated solar power (CSP) use lenses or mirrors to focus the sunlight onto a smaller area where high efficiency concentrator cells are located. The rays generate steam, by heating fluid, in order to drive a turbine and produce electricity. CSP is utilised to produce electricity in large scale power plants [7]. These systems require direct sunlight and the collector must track the sun. Hence, they are suitable only for locations with high percentage of direct radiation throughout the year [18]. One of the primary benefits of a CSP power plant in comparison to a solar PV power plant is its configuration with molten salts, which can store heat in order to generate electricity after the sun set [7]. There are four basic types of CSP electricity plants: a) Parabolic trough, b) Fresnel lens, c) parabolic dish and d) power tower (otherwise central receiver) [18]. Figures 7-9 present the main types of CSP and some basic configurations.

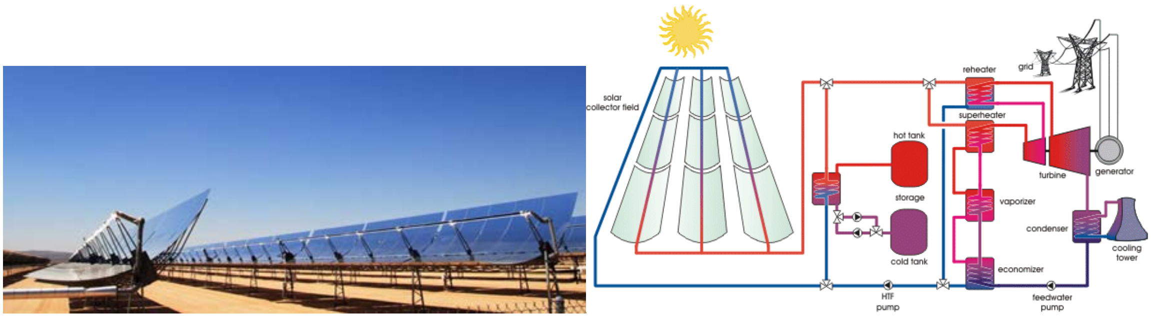

Figure 7: Parabolic trough [19, 20]

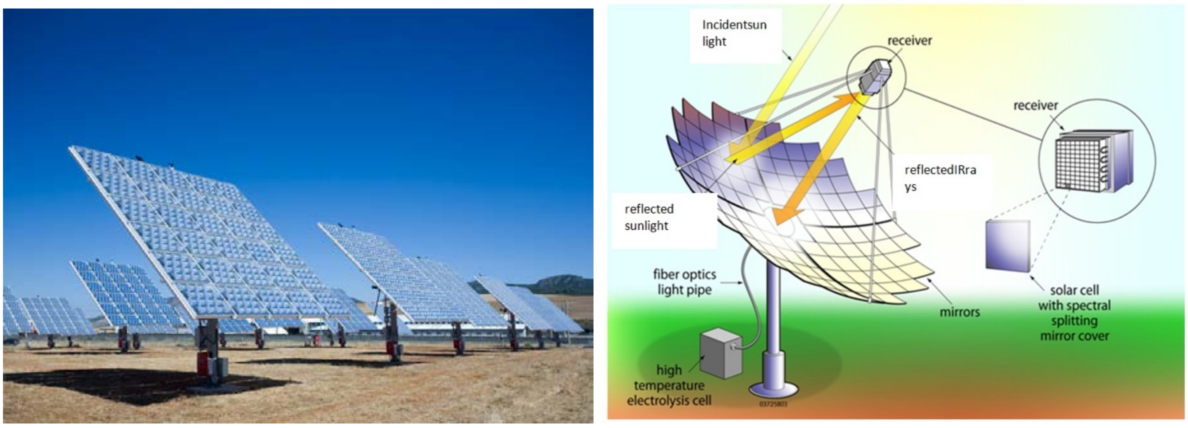

Figure 8: Fresnel lens and parabolic dish [21, 17]

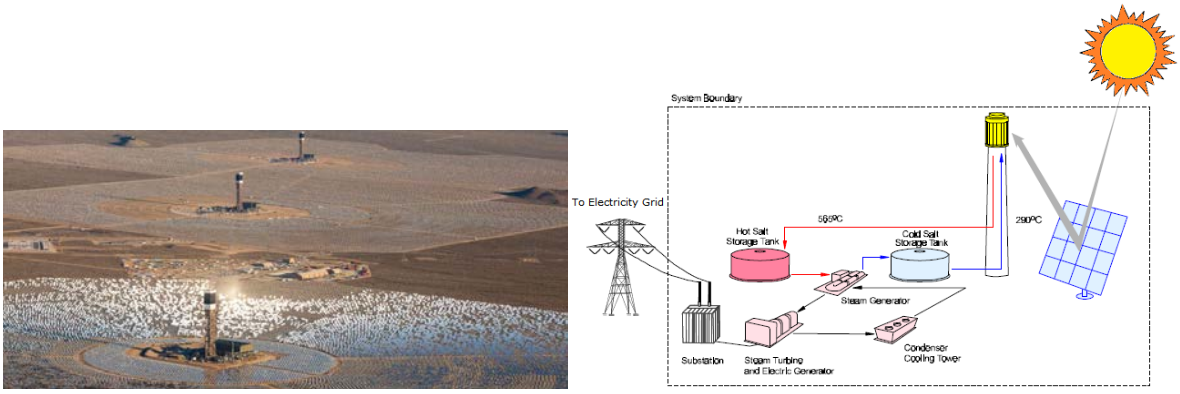

Figure 9: Power tower [19, 22]

3.2 Wind energy

"Wind is a form of solar energy. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth" [23]. Wind turbines or wind energy conversion systems harness the kinetic energy of the wind and convert it to mechanical or electrical energy. Mechanical energy can be used for water pumping, grain grinding etc. while in the case of the wind turbines, the mechanical energy (rotational energy of the turbine blades) is transformed to electrical energy trough a generator [23, 24].

3.2.1 Wind turbines

Wind turbines were first developed more than hundred years ago. After the invention of the electric generator in the 1830s, engineers began their efforts to control wind energy in order to generate electricity. The production of wind power occurred in the United Kingdom and the United States in 1887 and 1888 respectively. However, the current wind power is regarded to have been initially created in Denmark, where horizontal-axis turbines were constructed in 1891 while in 1897 a 22.8-metre wind turbine started to operate [24].

The amount of power that a wind turbine can capture from wind relies on its size and blades length. Generally, the output power of the turbine is proportional to the rotor's swept area and to the cube of the wind speed [24, 25]. However, there is a theoretical upper limit of the kinetic energy in the wind that a wind turbine can capture according to Betz's law. This limit in percentage is around 59% of wind's kinetic energy. In practice it has not been reached but 85% of the theoretical 59% has been achieved [25].

Wind turbines can be installed onshore or offshore. Offshore wind turbines are considered as a category of marine renewable energy technologies hence they are presented later in this report in the respective section. The main advantages of the onshore wind turbines compared to the offshore ones are that they need cheaper foundations and are also cheaper to install. Moreover, they are more accessible due to their installed location, hence they can be operated and maintained easier. Finally, their connection to the electric grid could be easier than from offshore wind turbines. On the other hand, offshore wind turbines might capture more wind energy than the onshore as in the sea there are not surrounding obstacles preventing or reducing the wind speed.

The rated capacity of the modern wind turbines has increased during the years. In 1985, it was around 50 kW with a rotor diameter of 15 meters while nowadays it has reached 8 MW "with rotor diameters of up to 164 metres" [24]. Generally, small scale wind turbines are up to 10 kW and are used in urban areas, farms and remote applications. Medium scale wind turbines are between 10 to 500 kW and are used to power villages (distribute power) and in hybrid systems. Large scale wind turbines are between 500 kW to 6 MW and are used for onshore or offshore wind farms (power distribution) [25].

3.2.2 Onshore wind turbines

According to their design wind turbines are divided in two main categories; the horizontal axis (HAWT) and vertical axis (VAWT) design wind turbines [23]. The horizontal axis turbines are subdivided according to their number of blades. Their main designs are with one, two or three rotor blades (Figure 10). The most efficient design would have been with multiple thin blades but this design is not cost-effective. Generally, the fewer the blades, the less the cost (due to manufacturing materials used) and the complexity [26].

Figure 10: Horizontal axis wind turbines (HAWT) [27-29]

The vertical axis wind turbines are subdivided in two main categories according to their blades design; the Savonius and the Darrieus VAWT. Figure 11 presents various types of Darrieus VAWT (helical, H-type and Darrieus classic) and of Savonius VAWT, which has an S-shaped rotor when viewed from above [30].

Figure 11: Vertical axis wind turbines (VAWT) [31]

In general, the horizontal axis turbines can capture more wind than the vertical axis, hence they have a higher power output. However, their rotor blades design has to be better than VAWT and they require a much higher tower to support the turbine. On the other hand, the vertical wind turbines have simpler blade design and are easier to maintain [26]. Moreover, they are omnidirectional and more suitable for urban areas where the wind speed is usually lower than rural areas [30].

3.3 Solar and wind markets deployment

The renewable energy and waste sources in 2015 constituted the 33.1%, namely 945.7 GW of the OECD generating capacity. This was an improvement in comparison to 2014 since the total electricity generation capacity was enhanced by 31.5 GW. The biggest increase occurred in solar PV (28.6 GW) and wind (24.6 GW) that counterbalanced the decreases in nuclear (-2.5 GW) and combustible fuels (-27.6 GW). Japan provided the biggest increase in solar PV by adding 10.8 GW while the US and the UK followed with 6.8 GW and 3.8 GW respectively. These three countries provided a total of 74.6% increase. Moreover, the US showed the largest increase in wind capacity with 8.3 GW while Germany followed with 5.5 GW increment. The total generating capacity is composed of 483.4 GW of hydroelectric plants (16.7%), 238.5 GW of wind (8.2%), 161.7 GW of solar photovoltaic (5.6%), and 62.1 GW of biofuels and waste (2.1%) [32]. Figure 12 below presents the cumulative installed capacity worldwide for all the renewable energy technologies.

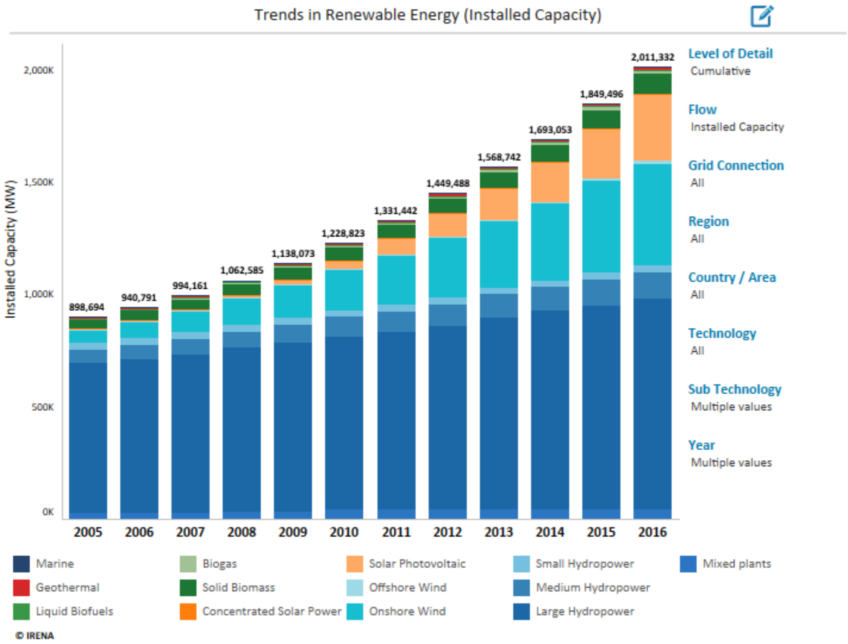

Figure 12: Total installed capacity of the various renewable energy technologies [33]

The global solar photovoltaic market increased by 50% in 2016 while the European market decreased, as its additional capacity reached 6.1 GW falling below the 7.9 GW of the previous year. The EurObserv'ER data, collected for the less structured markets based on estimates of the solar photovoltaic energy industry, show that the European Union connected up 6.1 GW in 2016 bringing its installed base over the 100 GW mark (100.9 GW). The annual connected capacity decreased to 22.7% in comparison to 2015. The reason for this decline is the British market, whose connection capacity decreased. Regarding the energy output of the European Union in 2016, the weather was not supportive to solar electricity. Decrease in production was detected in various countries such as Germany, Spain, Italy, Belgium and the Czech Republic while increase was seen in the UK and France. Approximately the 3.2% of the electricity production of the European Union is based on solar power. This percentage is higher in countries most engaged in photovoltaic technology such as Germany (5.9%), Italy (7.9%) and Greece (7.4%) [34].

With respect to the concentrated solar power, the global market has not shown great improvement after the installation peak of 1267 MW in 2013. This occurred because of the competition it faced from the PV, which attracted countries that aimed to improve quickly their efficiency levels at a reduced cost. The number of CSP installations is expected to increase from 2018 onwards due to the various projects that are developed in Morocco, South Africa, China and the Middle East. The EurObserv'ER measurements that are partly based on work completed by the International Renewable Energy Agency (IRENA) and SolarPACES, which is an International Energy Agency programme, identified that the installed CSP global capacity was approximately 4889 MW until 2016 while an additional 273 MW of connected capacity was installed during that year. Installed capacity remained the same in Europe (2313.7 MW including pilot facilities), North America (1758 MW) and the Middle East (123 MW) while the majority of the new capacity was installed in Africa, which increased from 169 MW in 2015 to 429 MW in 2016. Moreover, 10 MW of capacity was connected in Asia and slightly less than 3 MW in

Australia, which brought the on-grid capacity in Australia and Oceania to 6 MW [35]. The cumulative installed capacity of solar PV and CSP technologies is shown in Figure 13.

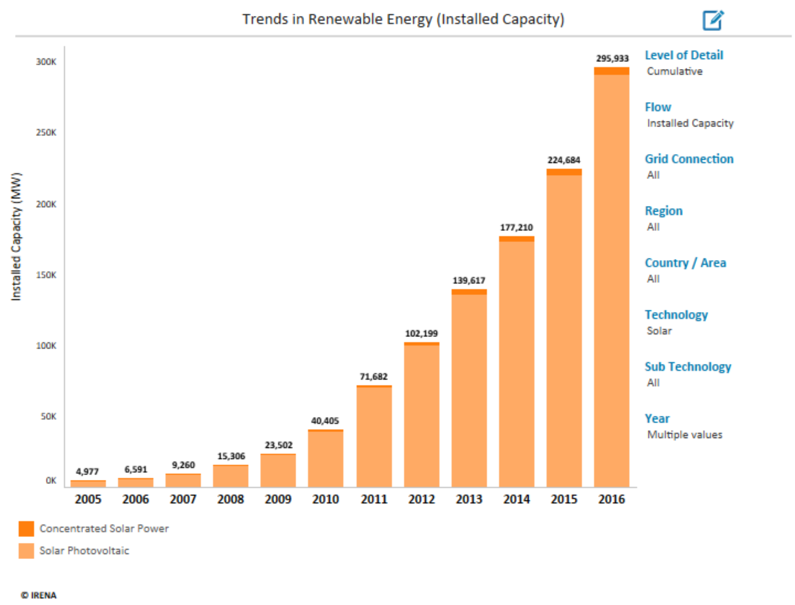

Figure 13: Cumulative installed capacity of solar PV and CSP technologies [33]

Concerning the wind energy, the global market continued to grow since early 2000s and reached 64.4 GW in 2015. Initial estimates for 2016 identified sales of 54.2 GW, which is a decline in comparison to the previous year. Despite this, the results were sufficiently good to provide a 12.4% improvement, which enhanced the global installed base up to 486.7 GW. Based on the EurObserv'ER, in 2016 the European Union wind energy market remained above the 12 GW threshold (12068 MW), and brought its total installed capacity base to 153.6 GW. These results can be attributed to Germany, which amounted 45.1% (5443 MW) of the EU market. Moreover, France reached a new installation record by passing the one GW installed capacity mark (1346 MW). In addition, the Netherlands entered into the global wind energy top 10 (788.5 MW) by connecting up the second biggest offshore wind farm (the 600 MW Gemini project), Finland reached a new installation record by adding 570 MW and by increasing its wind turbine base by more than 50% within twelve months, and Sweden added 493 MW. Despite these positive developments, there were 8 countries that did not show any improvement. For example, Spain, although it is the second European country for installed capacity, has only installed 38.2 MW in 2016. Also, Italy has only added 713 MW of capacity (282.6 MW in 2016) since 2013 [36]. The cumulative installed capacity of onshore and offshore wind technologies is shown in Figure 14.

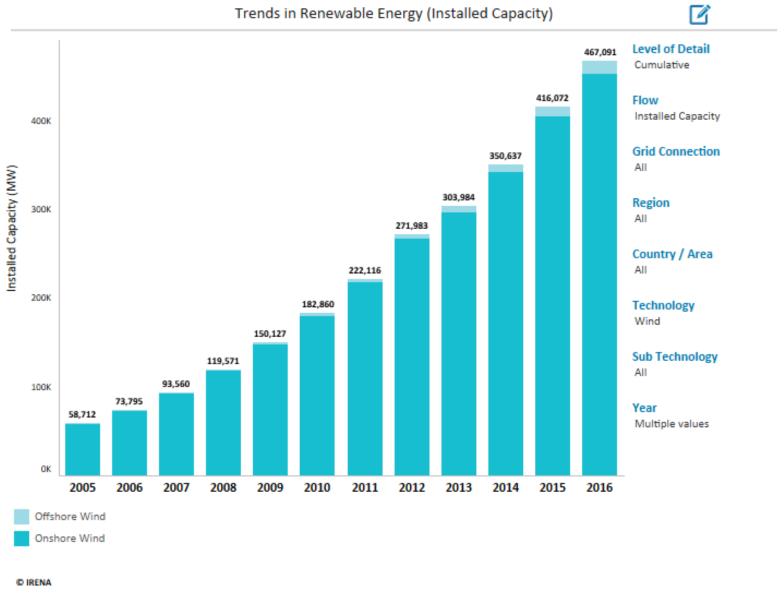

Figure 14: Cumulative installed capacity of onshore and offshore wind technologies [33]

3.4 Marine Renewable Energies (MRE)

The global emerging Offshore Renewable Energy industries are fixed offshore wind, floating wind, tidal wave and Ocean Thermal Energy Conversion (OTEC). Figure 15 summarizes the resource and installed capacity within the MRE sector.

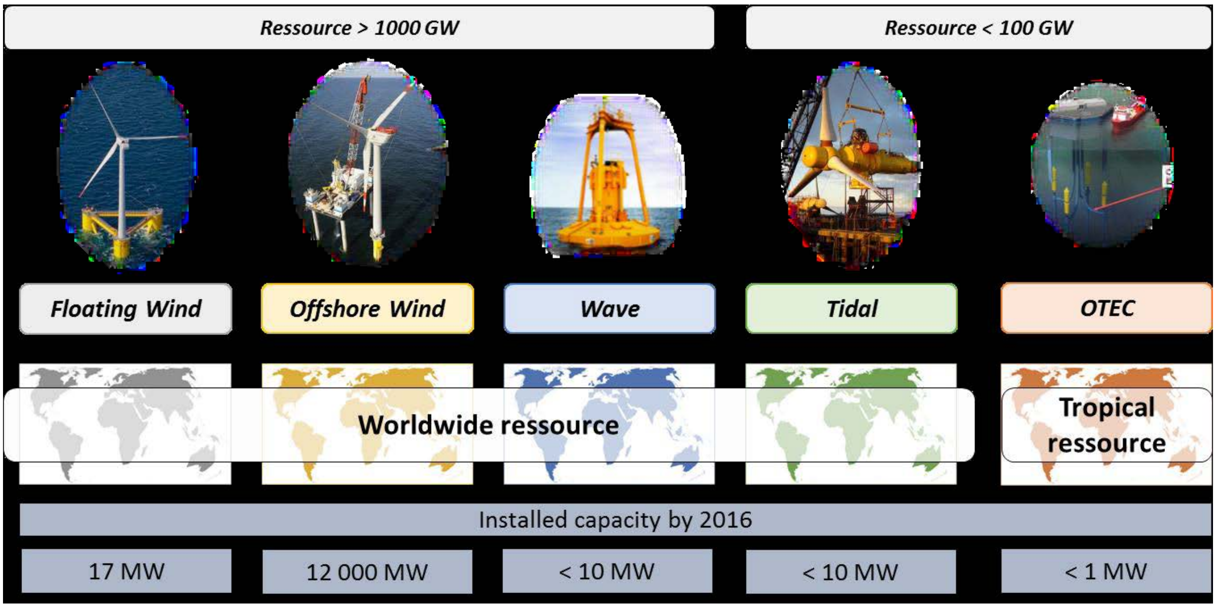

Figure 15: Status of each emerging MRE sector in terms of installed capacity

The success of the onshore wind sector has allowed to support the offshore wind industry, fixed and then floating. The technology transfer to tidal turbines is also pushing forward the tidal industry. On the other hand, the wave and OTEC industries are showing slower and more uncertain progress.

3.4.1 Fixed offshore wind

Fixed offshore wind power is the use of wind farms (figure 16) constructed offshore, on the continental shelf, to generate electricity from wind. Offshore wind power includes inshore water areas such as lakes, fjords and sheltered coastal areas utilizing traditional fixed-bottom wind turbine technologies.

To date, the installed fixed offshore wind turbine farms are the only renewable marine technology at the commercial stage. With average new installations of 3.1 GW/year, offshore wind will represent about one quarter of the total new wind installations (offshore + onshore). The offshore market will concentrate mainly in the UK with 5.2 GW, representing 42% new grid-connected capacity. Another 4 countries will see offshore installations: Germany (3.5 GW), Belgium (1.5 GW), the Netherlands (1.4 GW) and Denmark (1.0 GW). In 2019, annual installations in offshore will reach to over 4 GW.

Figure 16: Wind turbines and electrical substation of Alpha Ventus supplied by Adwen in the North Sea

3.4.2 Floating wind

Floating wind turbine is an offshore wind turbine mounted on a floating structure that allows the turbine to generate electricity from wind in water depths where bottom-mounted towers (fixed wind turbine) are not feasible (Figure 17). Locating wind farms out at sea can reduce visual pollution while providing better accommodation for fishing and shipping lanes. In addition, the wind is typically more consistent and stronger over the sea, due to the absence of topographic features that disrupt wind flow.

Floating wind parks are wind farms that site several floating wind turbines closely together to take advantage of common infrastructure such as power transmission facilities.

Figure 17: Floating wind turbine. Portugal's WindFloat demonstrator concept and location

At this stage, technologies are at a proof of concept stage. The most advanced technologies have been tried at sea for a few years (single units). The feedback from these sea trials allows for design evolution to be implemented in pilot farms, composed of three to six units (20-30 MW). These are to stay in place for about 20 years. The objective of these pilot farms is to demonstrate cost reduction and long term economic viability. It will also allow developing Operation & Maintenance (O&M) strategy on a farm scale.

If successful, these pilot farms are to be followed by commercial farms exploiting the proven technology within the following 5-10 years. These farms aim at reaching 100 to 1000 MW capacity, and can be expected for 2025 onwards.

3.4.3 Tidal

Tidal Farms utilize tidal stream generators that are grouped together to produce electricity (Figure 18). These generators use the moving tides to turn turbines that are very similar to the wind turbines used on land. Compared to other intermittent renewable energies, a considerable advantage of tidal energy lies in its predictability (tidal currents' speed can be calculated with perfect accuracy even in the distant future).

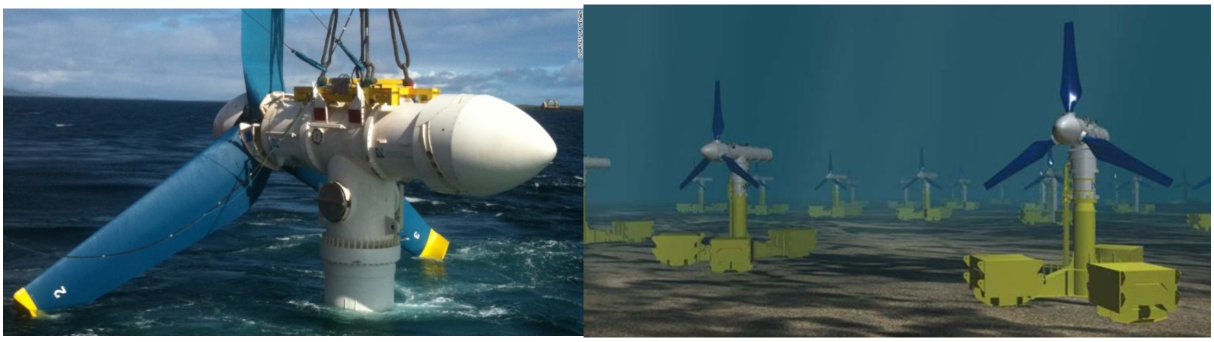

Figure 18: Overview of the MeyGen Project

The first plant at commercial scale is currently being built and the global potential market for tidal energy is evaluated as important as 120 GW (Source: Oxford University).
In terms of market development, Europe and more particularly the UK are well ahead, but commercial farms are also planned in France. It remains unclear whether North America or Asia will take the lead behind Europe in terms of installed power in the years to come. In any case, the tidal energy market is currently in the process of reaching commercial maturation.

Between 2018 and 2020, the first pilot farms are expected to expand towards real commercial farms of more than 5 units in Europe. From 2020 and onwards, project developers aim at developing bigger farms of 100 MW+ within Europe and start commercial farms in North America and Asia as well.

3.4.4 Wave

Wave power is the transport of energy by wind waves, and the capture of that energy to do electricity generation with a wave energyconverter - WEC. The first such installation in the world, the Agucadoura Wave Farm, which exploited the Pelamus WEC device, was installed offshore Portugal in 2008. (Figure 19).

Scenarios suggest that the deployment of wave energy worldwide could be substantial by 2050 (up to 189GW - base on IEA scenario). This depends on significant technological developments (no proof of concept in real condition and real scale up to now). Hence, there is considerable uncertainty around ultimate levels of deployment and risk of much smaller levels of deployment.

Figure 19: The Agucadoura Wave Farm offshore Portugal.

3.4.5 OTEC

Ocean thermal energy conversion (**OTEC**) uses the temperature difference between cooler deep and warmer shallow or surface seawaters to run a heat engine and produce useful work, usually in the form of electricity (Figure 20). Among ocean energy sources, OTEC is one of the continuously available renewable energy resources that could contribute to base-load power supply.

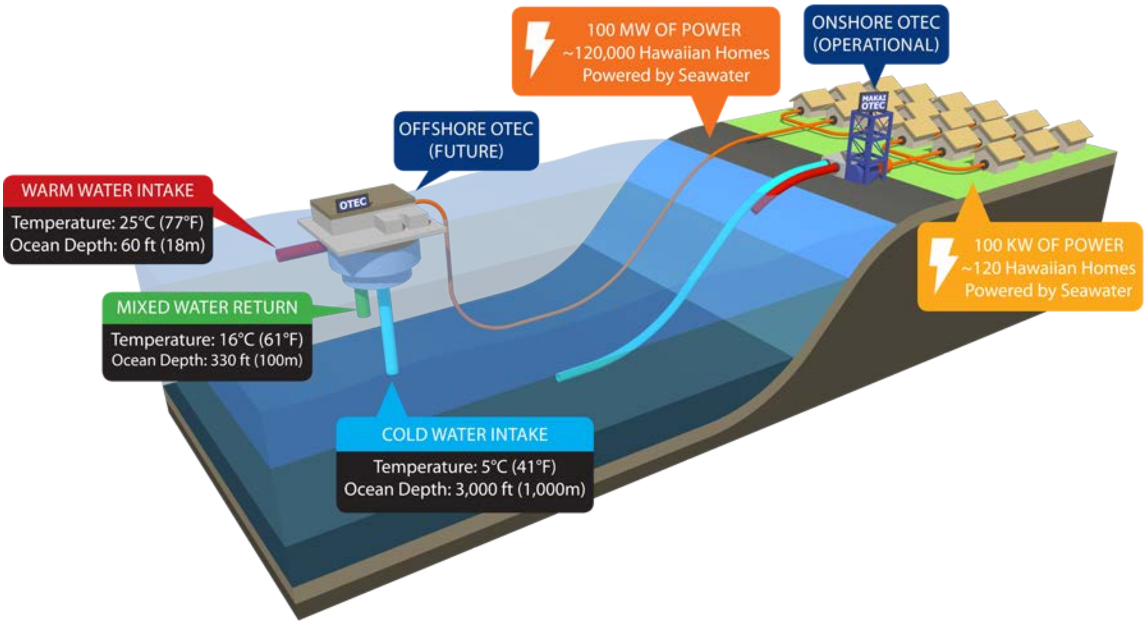

Figure 20: OTEC - .Mahaï Ocean Energy

The resource potential for OTEC is considered to be much larger than for other ocean energy forms. Up to 88,000 TWh/yr of power could be generated from OTEC without affecting the ocean's thermal structure.

As with wave energy, the scenarios suggest that the deployment of OTEC worldwide could be substantial by 2050. This depends on important technological developments.

It should also be noted that this technology is suitable for tropical regions where the temperature difference between the bottom and sea surface is high.

3.5 Relevance to KM3NeT

In addition to the above technologies, other possibilities like biofuel, geothermal, hydropower, etc. are available, but are not listed as they are considered quite outside the scope, needs and capabilities of our study due to complexity, scale and specificity.

The desired configuration for the three sites may be a different combination of these, depending on the environmental conditions, the economic constraints and budgeting issues, as well as the local synergies and collaborations. A detailed analysis of these factors will be the subject of feasibility study with the corresponding deliverable due on Month 30 of the project. At this stage however, we are interested in establishing possible strategies and synergies with other potential partners, and thus we had to make an ad-hoc – although quite reasonable – set of choices**. The benchmark system which we would eventually like to establish would (most likely) consist of a combination of wind and solar electric energy generation infrastructure.** Although the details will have to be adjusted separately for each site, the basic philosophy will be what we have outlined above.

4. Methodologies for establishing the Renewable Energy infrastructure

Depending on the constraints in each case, different methodologies can be adopted for satisfying the requirement of "Zero Carbon Footprint" of KM3NeT.

A dedicated renewable energy infrastructure is the most obvious approach, where each site establishes the REI which will satisfy the local energy requirements. This, depending on the site environmental characteristics, national and local constraints, legal issues, budgeting issues, real estate limitations, possible synergies and partnerships, etc., can be implemented in one of various ways.

The REI can be either established "de novo", either with the creation of a new independent infrastructure, or the collaboration with existing energy suppliers, or the collaboration with local or regional authorities or even the purchase/renting of existing facilities (at least in one of the countries of interest).

At this stage, it should be mentioned that all these solutions are based on the assumption that the generated power is fed to the local power grid, under an appropriate agreement with an energy provider, while the sites are fed by the normal power grid. This, although a matter to be debated and evaluated in detail in the future, seems to be the most straightforward, simple and cost effective way to proceed. In this scheme, we are avoiding the need of storing energy to accommodate for the temporal variation of the renewable energy generation methods.

Each of these possibilities present advantages and disadvantages which are briefly outlined below:

The creation of an independent dedicated REI requires the acquisition of real estate to accommodate the facilities, and implies the establishment of an entity to manage and support the operation of the infrastructure. In the same context, buying or renting an existing infrastructure means that some of the complexities of establishing the REI from “scratch” are overcome, at the expense of a, possibly, larger initial investment cost. Of course, in every case, the maintenance and operation costs have to be factored in. This possibility exists in France, but not in the other two countries, at least at the time of writing of this report.

Synergy with an established private sector renewable energy provider may be a solution with several pros: the KM3NeT REI could become an addition to an existing private facility, where KM3NeT benefits from the existing infrastructure in exchange of part of the produced energy. The private partner will also benefit from an increased visibility and positive public exposure which will be the result of such a synergy. The obvious disadvantage in this case is the fact that persuading an industrial partner to accept the added complexity of such a collaboration may turn out to be the limiting factor of such a solution. Indeed as it will be mentioned below, at least in one of the countries, this has been a significant limiting factor in pursuing this approach.

Collaboration with local and/or regional authorities may be an attractive solution, at least in Italy and Greece. The basic assumption is that these legal entities own a significant amount of real estate, part of which could be used for the establishment of the KM3NeT REI. In these cases, there are several key elements which may prove to be extremely important in realising such a collaboration: the highly positive public image of this effort; the possibility of installing, at least part, of the REI within the limits of urban environment, in the form of an infrastructure of high aesthetic value; the donation of the surplus energy generated to the local community (schools, hospitals, etc.). Finally, this could represent an appealing opportunity in terms of final ownership of the infrastructure after the end of KM3NeT.

Alternatively, “green energy” can, at least in France, be purchased from certified RE industrial suppliers. Although this appears as a less “visible” solution in terms of added positive image for KM3NeT, appropriate publicity can compensate for this. It is an interesting solution as it does not require any significant investment in the beginning as well as maintenance and operation costs.

As will be detailed below, having different market conditions, local and regional authorities’ capabilities, constraints and policies in the three countries will lead in the adoption of different strategies for implementing the REI for KM3NeT.

5 Italy

To achieve the targets of the Kyoto protocol on Climate Changes and to implement the EU directive 2001/77/EC, Italy has adopted several financial incentives and programs, which have pushed the development of Renewable Energy (RnE) plants (home and industrial) in the last 7 years.

The EU Directive on “RnE” requires Italy to increase renewable energy up to 17% of gross final energy consumption. The National Renewable Energy Action Plan (NREAP) of June 2010 shared the related burden among the electricity, heating & cooling and transport sectors.

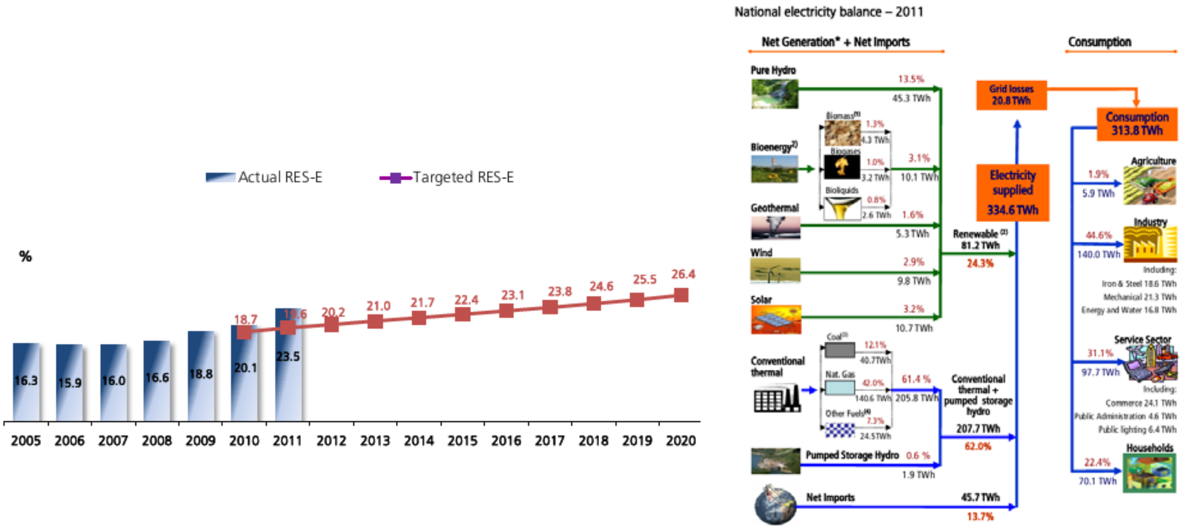

Figure 21: GSE annual report 2011

For the electricity sector, the target to be achieved by 2020 is 26.4% of electricity consumption from renewables. In 2011, Italy recorded 23.5%, surpassing by wide margins the 2011 intermediate target of 19.6% (Figure 21). This trend is confirmed, in the REN21 report, where Italy is on the top 5 countries worldwide for PV deployment and investment (Figure 22).

REN21

TOP FIVE COUNTRIES

Annual Investment / Net Capacity Additions / Production in 2016

	1	2	3	4	5
Investment in renewable power and fuels (not including hydro > 50 MW)	**China**	United States	United Kingdom	Japan	Germany
Investment in renewable power and fuels per unit GDP[1]	**Bolivia**	Senegal	Jordan	Honduras	Iceland
Geothermal power capacity	**Indonesia**	Turkey	Kenya	Mexico	Japan
Hydropower capacity	**China**	Brazil	Ecuador	Ethiopia	Vietnam
Solar PV capacity	**China**	United States	Japan	India	United Kingdom
Concentrating solar thermal power (CSP) capacity[2]	**South Africa**	China	–	–	–
Wind power capacity	**China**	United States	Germany	India	Brazil
Solar water heating capacity	**China**	Turkey	Brazil	India	United States
Biodiesel production	**United States**	Brazil	Argentina/Germany/Indonesia		
Fuel ethanol production	**United States**	Brazil	China	Canada	Thailand

Total Capacity or Generation as of End-2016

	1	2	3	4	5
POWER					
Renewable power (incl. hydro)	**China**	United States	Brazil	Germany	Canada
Renewable power (not incl. hydro)	**China**	United States	Germany	Japan	India
Renewable power capacity *per capita* (not including hydro[3])	**Iceland**	Denmark	Sweden/Germany		Spain/Finland
Bio-power generation	**United States**	China	Germany	Brazil	Japan
Geothermal power capacity	**United States**	Philippines	Indonesia	New Zealand	Mexico
Hydropower capacity[4]	**China**	Brazil	United States	Canada	Russian Federat.
Hydropower generation[4]	**China**	Brazil	Canada	United States	Russian Federat.
CSP capacity	**Spain**	United States	India	South Africa	Morocco
Solar PV capacity	**China**	Japan	Germany	United States	Italy
Solar PV capacity *per capita*	**Germany**	Japan	Italy	Belgium	Australia/Greece
Wind power capacity	**China**	United States	Germany	India	Spain
Wind power capacity *per capita*	**Denmark**	Sweden	Germany	Ireland	Portugal
HEAT					
Solar water heating collector capacity[5]	**China**	United States	Turkey	Germany	Brazil
Solar water heating collector capacity *per capita*[5]	**Barbados**	Austria	Cyprus	Israel	Greece
Geothermal heat capacity[6]	**China**	Turkey	Japan	Iceland	India
Geothermal heat capacity *per capita*[6]	**Iceland**	New Zealand	Hungary	Turkey	Japan

[1] Countries considered include only those covered by Bloomberg New Energy Finance (BNEF); GDP (at purchasers' prices) data for 2015 from World Bank. BNEF data include the following: all biomass, geothermal and wind power projects of more than 1 MW; all hydropower projects of between 1 and 50 MW; all solar power projects, with those less than 1 MW (small-scale capacity) estimated separately; all ocean energy projects; and all biofuel projects with an annual production capacity of 1 million litres or more. Small-scale capacity data used to help calculate investment per unit of GDP cover only those countries investing USD 200 million or more.

[2] Only two countries brought CSP plants online in 2016, which is why no countries are listed in places 3, 4 and 5.

[3] Per capita renewable power capacity (not including hydropower) ranking based on data gathered from various sources for more than 70 countries and on 2015 population data from World Bank.

[4] Country rankings for hydropower capacity and generation differ because some countries rely on hydropower for baseload supply whereas others use it more to follow the electric load and to match peaks in demand.

[5] Solar water heating collector rankings for total capacity and per capita are for year-end 2015 and are based on capacity of water (glazed and unglazed) collectors only. Data from International Energy Agency Solar Heating and Cooling Programme. Total capacity rankings are estimated to remain unchanged for year-end 2016.

[6] Not including heat pumps.

Note: Most rankings are based on absolute amounts of investment, power generation capacity or output, or biofuels production; if done on a basis of per capita, national GDP or other, the rankings would be different for many categories (as seen with per capita rankings for renewable power not including hydropower, solar PV, wind power, solar water collector and geothermal heat capacity).

Figure 22: REN21 report

Sicily is the largest and the sunniest among Italy's regions. For comparison, the global horizontal irradiation yearly total of the second largest region (Lombardia) is 1100 kWh/m^2 whereas Sicily has an average value of 1800 kWh/m^2.

While photovoltaic (PV) power generation was negligible till 2008–2009, the deployment of the feed-in-Tariff (FiT) incentive scheme in Italy between 2006 and 2013 caused an impressive surge in the PV installed power nationwide including Sicily, jumping from few tenths of MW to 1270 MW during 3 years (2011–2013). In 2014 Sicily saw the installation of another 130 MW bringing the overall power to 1400 MW.

This accelerated deployment of solar electricity took place almost concomitantly to the massive adoption of wind energy as Sicily is also the windiest region of Italy, so that the installed wind power rose from zero in 2005 to about 2.000 MW at the end of 2014. In Italy, at the end of 2015, more than 1.800 wind turbines have been installed with a total capacity of around 8.900 MW (Figures 23, 24).

The rapid change, along with significant economic interests behind the incentives that reward only the electricity produced and actually fed into the grid, pushed the State owner of the Italian grid to deploy massive investments to widen and improve Sicily's high voltage grid.
The significant PV and wind power generation has changed the electricity price formation in Sicily affecting the national price (PUN) to such an extent to cause a significant decrease in the national electricity price. In other words, the Sicily zone is substantially a one-way feeder into the Italian electricity market, not only on the side of locally generated power but also as a price steering element, since the zonal price affects the PUN in the weighted average leading to its formation.

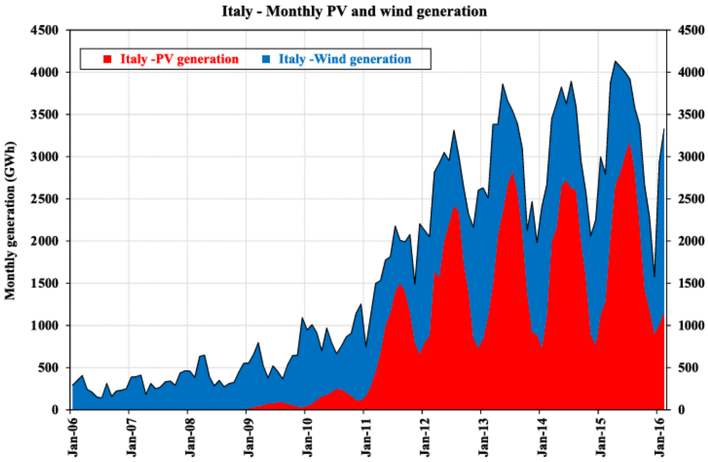

Figure 23: PV and Wind power generation - TERNA

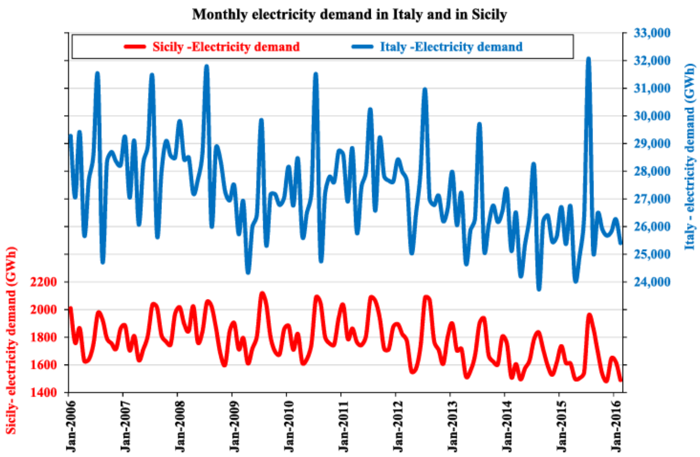

Figure 24 : Monthly electricity demand in Italy and Sicily (TERNA)

Renewable energy market in Italy and Sicily

The Italian market stands 4th in the European electricity market ranking, and 3rd in the European gas market ranking. The national electricity demand in 2016 is roughly at the same level as in 2014, with a reduction of -2.1% per year (Figure 25).

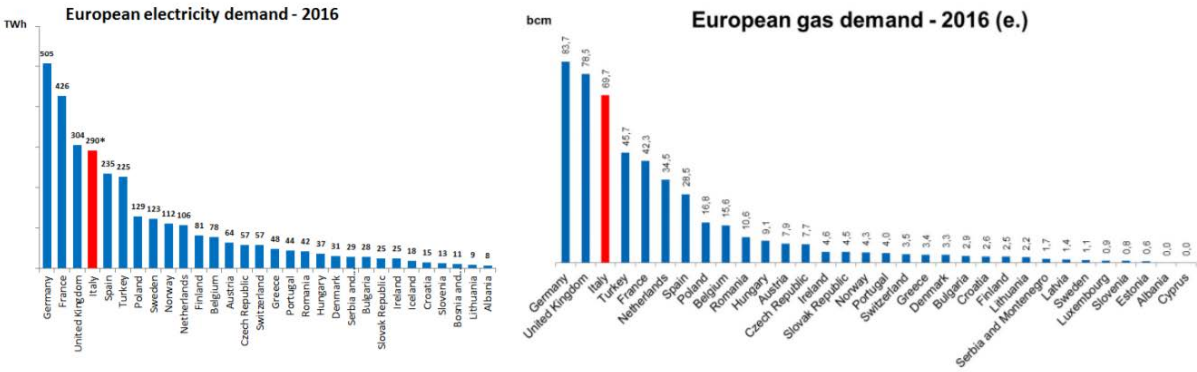

Figure 25: European electricity and gas demand in 2016

In Italy there are several energy distributor players as reported in figure 26.

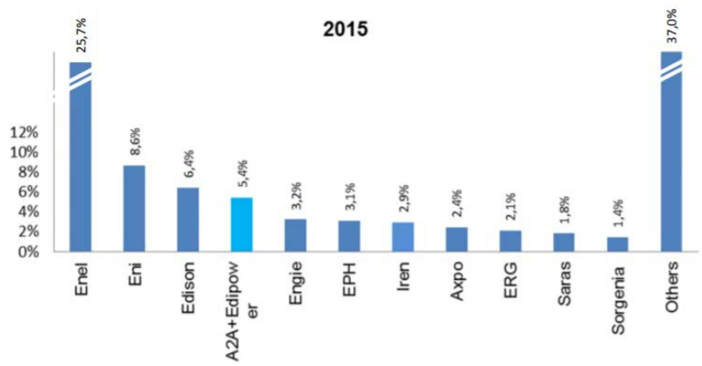

Figure 26: Italian energy distributors

The national incumbent is still the main player, with 25.7% market share, rather stable (27% in 2014). The first 6 operators produce nearly 50% of the Italian power generation (Figure 26). The drop in electricity consumption and the simultaneous investment in new renewable energy production plants caused the recent system overcapacity. A reversion in this trend arose in 2016 and at the beginning of 2017, when the French nuclear outages (combined to high French demand) caused a reduction in Italian imports, with a need for strong domestic production.

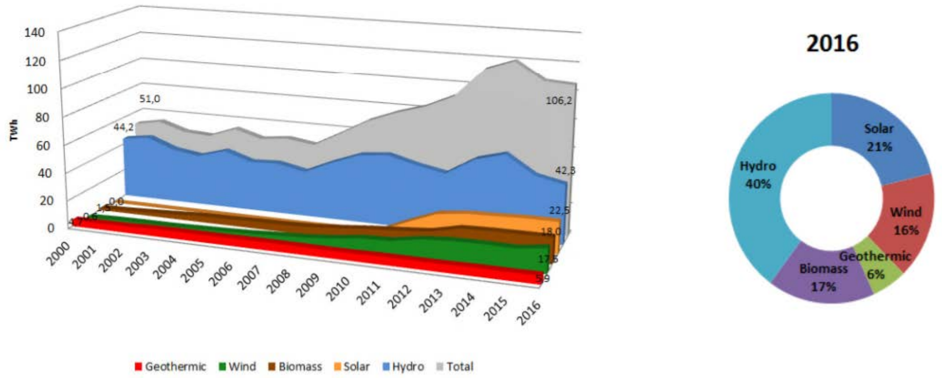

Figure 27: Energy production in Italy in 2016

In Italy the hydroelectric production share among renewable production has decreased, due to the increase in other sources of production, mainly PV and wind. The increase in PV and wind production has slowed down, due to the lower incentives provided by Italian country. Despite this, in 2016, the sum of PV and wind production accounted for nearly 40% of the whole renewables production and nearly 15% of the total Italian production (Figure 27).

In 2014 the energy gross production RnE of distributed generation (total amount of power plants connected to the distribution system) amounted to 64.3 TWh, about 23% of national production through around 657,000 plants. Nearly 40% of the energy comes from new renewable sources (solar and wind).

In December 2016, the latest auctions were held for the creation of incentives for renewable production from plants with power higher than 5 MW. The results show a strong competition in the on-shore wind sector, where the MW offered were nearly 250% the MW auctioned.

Sicily is the biggest region of Italy and the biggest island of Mediterranean with 5 million people. Beside the main island, there are several small islands, most of them living on tourism and local agriculture with very valued typical products. Some islands (Eolie) have been declared Human Heritage by UNESCO and on most islands there are several integral natural reserves. Under the renewable energy point of view, there are lot of natural resources such as wind, sun and also significant sea currents.

In Sicily one of the main issues on renewable energy sources is connected to environment protection, especially close to wildlife restricted areas. Often the most economically convenient locations for wind farms are very close to wildlife reserves and usually into wild landscapes.

Although generally there is a strong support to renewable energy, there is an even stronger concern whether wind farms might damage landscape or endanger fauna, especially migrating species which find in Sicily an important stage.

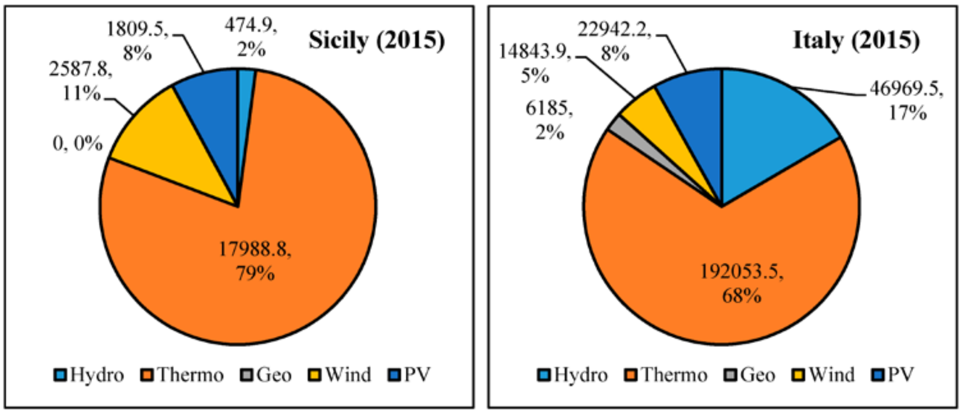

Figure 28: Sicily and Italy RnE status 2015

Local administrators are divided as well, with some supporting REIs for their economic and environmental benefits, other frightened that landscape damage could take tourism away.

The RnE market in Sicily has grown very rapidly in the last decade. According to studies of Ricerca Sistema Energetico-RSE (GSE) in the medium term the potential generation from:

- hydropower for Sicily is over 30 ktoe;
- solar sources is close to 231 ktoe;
- wind power it is 360 ktoe;
- biomass 292 ktoe;
- biogas and bio-liquids 63.5 ktoe;
- geothermal 185.1 ktoe.

From 2006 to 2012 the Sicilian energy system has shown a growing trend of the REI plants, especially for the power production. In 2012, the supply of energy from renewable sources was 4709.3GWh, equal to 404.9 ktoe (3079 MW installed), respectively:

- 1098.8MW from photovoltaic (1206.7 MW until 31 December 2013);
- 1747.9 MW (1828.5 MW till 30 June 2013) from wind power;
- 151.3 MW from hydropower;
- 80.8 MW from Bioenergy.

In terms of energy produced GSE has estimated that the generation of energy in 2012 from PV systems was 1492.3 GWh (128.3 ktoe), 2975.7 GWh (225.9 ktoe) from wind power, 171.7 GWh (14.8 ktoe) from hydroelectric plants and the production from bioenergy was around 69.6 GWh (5.98 ktoe). More recent data are compiled in Figure 28.

Opportunities and strategies

Taking into account the Italian RnE market and status, we think that the methodologies described in chapter 4 are all feasible. We have decided to contact local authorities and institutions but not companies, due to the type of Italian market.

A first opportunity could be to purchase electricity generated from renewable energy sources, by using approved distributor. As seen before, several RnE plants, especially big wind farms, are available in the Region.

Other opportunity could be the current ERDF Sicily program (2014-2020) where some funds could be available in order to improve the energy efficiency of the building and infrastructure.

Local authority of Porto Palo di Capo Passero, where the on-shore infrastructure of the KM3NeT telescope is located, has demonstrated a high interest to cooperate with KM3NeT community in order to develop carbon zero facilities.

The construction of a new farm could be a viable solution. The social and political context are favorable from this point of view and it could be possible to obtain funds and permission within the framework of the realization of the underwater telescope.

We think it is much more difficult, due to the reduction of national incentives, to find external investors interested to develop a new RnE farm dedicated to the KM3NeT research infrastructure.

6 France

The analysis of the various possible strategies to use RnE thus reducing CO_2 emissions from the detector presented in Chapters 3 and 4 must be carried out with an understanding of the market's policy, opportunities, functionality features and realization particularities. From the opportunities offered by the market, it is then necessary to confront them with the economic reality and general policy of an institute such as the CNRS.

Renewable energy market in France

French RnE politics

When France signed the European Union's "Energy and Climate 2020 Package" adopted in January 2008, it established its roadmap with a target of 23% renewable energy consumption in the country. This objective had been included in the Grenelle 1 and 2 laws and its application by sector in the multiannual investment program.

It is also necessary to add the promise made by President Macron in 2017 to reduce the share of nuclear power in French electricity production to 50% by 2025 (against 77% in 2014). Although a debate is currently under way on the credibility of the deadline, this also means accelerating the development of renewable energies.

In addition to the objectives, the law includes several key measures: a single authorization for the commissioning of plants and the encouragement of the participative financing of renewable energy production projects.

French RnE market

At the current rate, the share of renewable energies could only reach 17% against the 23% to which France has committed itself. At the end of 2016, renewable energies accounted for 16% of the energy mix. 100,000 people work in the sector. Table 2 gives the French installed power of renewable electricity according to sectors as well as forecasts for 2023. The total installed capacity in 2016 is 45 GW for a production of 100 TWh. This capacity is set to grow strongly in the coming years.

Sector	2023 objectives	Situation in September 2016
Ground wind turbine	21 800 to 26 000 MW	11 166MW
Hydraulics	25 800 to 26 050 MW	25 479 MW
Solar energy	18 200 to 20 200 MW	7 017 MW
Biomass	790 to1040 MW	365 MW
Marine energy	3 100 MW	241 MW

Table 2: Production in 2016 and targets for 2023 of renewable electricity in France (source ADEME)

A significant market for electricity production from renewable energy sources has been developing for the past ten years or so. It then becomes possible to buy green energy for companies from retailers (see for instance : https://entreprises-collectivites.engie.fr/electricite/option-alpenergie/, https://www.direct-energie.com). It is also possible to buy a plant or part of a plant that produces "green" electricity. Web sites are specialized in these transactions (http://www.envinergy.com or https://enerfip.fr)

How does the renewable energy market work in France?

First, there is a complex administrative environment and complex national regulations. Energy transition is also synonymous with cultural change. While it has become a passion for citizens, it is also closely followed by politicians. These factors, combined with private financing which is still limited, are an undeniable obstacle to the development of the sector. In France, it takes between 6 to 8 years for a wind farm to become operational.

The development of renewable energy production in France has been entrusted to private initiative. Thus, throughout the country, professional and private producers are developing photovoltaic or wind energy projects. The latter carry out all the steps necessary for the construction of production plants. These are generally the following:

- Obtaining the necessary planning permission (building permit, prior declaration of works)
- Seeking financing to acquire the necessary equipment, such as photovoltaic panels.
- Construction, installation and connection (to the electricity grid or to the place of consumption in case of self-consumption)
- Resale of energy through a long-term purchase contract

Long-term purchase contract

In order to encourage the production of renewable energy in France by private actors, the State has set up a financial incentive system based on an energy purchase contract. It is based on two stages:

- Collect a tax from the final consumer that will be used to finance the development of the sector.
- Designate obligated purchasers, who will commit themselves to renewable energy producers to buy back the electricity produced over a period of 20 years, with a fixed rate for the entire period.

Subsidy mechanism

In addition to this purchasing contract mechanism, which works very well in France, the country is also very committed to a subsidy policy, notably via the ADEME (Agence de l' Environnement et de la Maîtrise de l' Energie - Environment and Energy Management Agency). Such aid can often be very attractive, particularly for large-scale projects, for which it can sometimes represent up to 50% of the total amount of the operation.

Opportunity analysis – Contacts

In the light of the previous chapter, it clearly appears that all methodologies defined in chapter 4 are feasible. To guide our choice, we have contacted some companies, local authority and institutions.

One first remark that appears during our discussions: there is a well-established ecosystem with a market clearly defined, and well-marked procedures. We contacted the main French company, EDF EN (Electricité de France – Energie Renouvelable), which pay back green electricity and put it on the grid. They asked from us a very advanced technical and administrative report. When we told them that we were in a preliminary phase and that we did not have such document, they advised us to contact a firm specializing in these studies. We then discovered that the market was already sufficiently structured to allow the emergence of a constellation of competing companies doing studies for RnE installations. They are all listed (at least those labelled) on the site https://www.opqibi.com.

We found a similar response from the local authorities of CR PACA (Conseil Régional Provence-Alpes-Côte d'Azur) and ADEME. They are of course ready to listen and support us, but our project is too preliminary for them to be of any help.

For the past ten years, France has set up institutions dedicated to growth and employment: competitive clusters. By supporting the innovation and R&D efforts of companies, they are therefore mostly, more or less directly, associated with projects with a high technological content. They are therefore perfectly familiar with the market of RnE and its impasses. We contacted the specialist in energy, the competitiveness cluster CAP ENERGY.

For CAP ENERGY, investment in an RnE farm, whether through equity investments or construction, can only be considered as an investment to generate return on investment. In other words, it is a capital-intensive operation. Moreover, since the development of renewable energies is entrusted to private companies, setting up collaboration with a local public authority does not seem realistic. The role of the public sphere is obviously to help the actors in the field but not to invest for them. On the other hand, they pointed out that the reduction of the ecological footprint of companies is already considerably developed and that the solution generally used was the direct purchase of green energy from approved distributors. As an example, the airport of Nice has recently changed its electricity supplier to purchase electricity generated from renewable energy sources.

Proposed strategy

We are able to see through a brief overview of the green energy market in France that many solutions to reduce the carbon footprint are available. From the construction of a farm to the purchase of electricity on the distribution grid and the acquisition of a stake in an existing installation, the possibilities are varied.

Nevertheless, the environmental, political and social context makes obtaining permits extremely long (several years). It is not uncommon to see the project succeed after 10 years of hard fighting.

Although there are a large number of grants and private investors are encouraged, setting up a financial project is complex and requires extensive financial engineering.

We should also keep in mind that all acquisitions are made, in the context of the French market, as part of a capital investment that must be profitable. Since the market offers the opportunity to buy green electricity directly, reducing the carbon footprint does not require becoming an investor or businessman.

Finally, the CNRS is an institute primarily dedicated to research. It therefore seems obvious that it is not a commercial company that should invest to generate profits.

Taking into account the above points, we consider that the strategy to meet our objective of reducing KM3NeT's carbon footprint while preserving the primary missions of the CNRS and minimizing the risks is the purchase of electricity from renewable energy sources from an approved distributor.

7 Greece

Greece is adopting renewable energy generation at an increasing pace. The technologies involved are dominated by wind and solar energy generation, with a smaller scale hydro power generation. Other technologies have been implemented at a small scale which makes them irrelevant to our discussion.

According to the latest statistics published by Greece's electricity market operator (Lagie) in early August 2016, the country has installed 2.604 GW of solar PV, 2.283 GW of wind, 224 MW of small hydro plants and 53 MW of biomass and biogas capacity.

Wind Energy Capacity (MW)																		
1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
39	112	189	272	297	383	473	573	746	871	985	1,087	1,208	1,634	1,749	1,865	1,980	2,135	2,374

Table 3: Wind energy production in Greece [36], [37]

PV in Greece (MW_{peak})										
2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
5	7	9	19	55	205	631	1,543	2,585	2,603	2,613

Table 4: PV energy production in Greece [38], [39], [40]

In August 2016, a new renewable energy law was approved that aims to further stimulate renewable energy investments by introducing feed-in premiums, competitive tenders and virtual net metering. Under the new law, the compensation for renewable energy producers will consist of what they receive in the electricity market plus a variable feed-in premium. The latter is the difference between a price depending on market variables (e.g., the system’s marginal price) and a set price decided via a competitive tender. Furthermore, from the beginning of 2017, the new scheme to approve new renewable energy capacity is based on competitive tenders, where the Energy Ministry is able to call on a tender for specific capacities and technologies. Interestingly, there are exceptions to this, as wind power plants smaller than 3 MW, projects using all other renewable types of technology that are smaller than 500 kW and innovative projects that use a new type of technology configuration (e.g. a university-based innovation) can still apply for a set Feed-in-Tariff (FIT). For our purposes, the scale is small enough to fall in this category, which in turn means that an independent REI could be the most cost effective solution in the long term.

In Greece the Power Grid is controlled by ADMIE SA, an Independent Power Transmission operator, which undertakes responsibility and performs all duties as Main Operator of the Hellenic Electricity Transmission System (HETS) as described in the Directive, according to Law 4001/2011. Policies and regulatory affairs are the responsibility of the above company with whom any energy generation facility has to liaise with.

Opportunity analysis – Contacts

In order to define the best strategy to pursue, we have initiated a series of contacts with the private sector energy generation companies. These are medium scale operators with definite business plans and models. As such, we have found that there was no real interest to discuss in detail the possibility of collaboration with KM3NeT. The main problem lies in the fact that our scale is far too small to justify the added complexity to their system. In addition, being in the preliminary phase of our investigation, means that we could not provide a concrete business plan for the funding of this infrastructure which in turn meant that specific, detailed discussion was not an option.

In the same spirit, we have approached the Municipality of Kalamata, the main town in South-West Peloponnese. Kalamata is a medium sized town with a population of around 65,000 inhabitants. It hosts an Annex of NCSR Demokritos, and is the base of operations concerning the Greek KM3NeT site. The Municipality of Kalamata owns a significant amount of land in and around the city. Our proposal was to collaborate with them in establishing this REI. The basic idea is to split the REI into two main parts: one will be the main energy producing facility, to be established in the country around Kalamata at a suitable piece of land, while a second part will be installed inside the city, around the harbor, and/or in public areas like parks and on the river banks. The second smaller part will consist of a combination of vertical axis wind turbines, suitable for the urban environment, and solar panels designed to add in an aesthetically pleasing way to the cityscape. In addition to the added value in the urban landscape, the surplus energy not used by KM3NeT can be used in public sector buildings (schools, hospital, etc.).

The Municipality of Kalamata has embraced this proposal with enthusiasm. We have submitted a letter describing the general ideas as outlined above to their Technical department, and we are currently waiting for their response. At the stage of writing this report, all indications are that for the Greek site, this approach may be the most favorable.

Proposed strategy

We propose to pursue the collaboration with the Municipality of Kalamata for the establishment of a REI for the Greek KM3NeT site. We expect to have the opinion of the Technical department within the next few months, concerning the feasibility of different options. We will collaborate with them in the context of the feasibility study of WP10 which aims at assessing the environmental conditions coupled with the technical options. In collaboration with the officers of the Municipality, we will investigate the possibilities for financing this endeavor through regional or national funds, as well as use the mechanisms available to the Kalamata Municipality to attract additional funding.

8 Conclusions

KM3NeT could become an experimental infrastructure with Zero Carbon Footprint in the near future. Being a distributed infrastructure in three countries means that different constraints, market conditions, legal frameworks and limitations, funding schemes and synergies have to be taken into account. At present, the indications are that at least in Italy and Greece, collaboration with the local authorities may be a viable solution. In France, the proposed strategy is to purchase the electricity necessary for the KM3NeT local infrastructure to an approved provider of renewable energy sources. The next steps for us will be to identify the legal issues as they may be relevant in each country, follow up with a techno-economic feasibility study and pursue the synergies which we can establish in each case.

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