POLITECNICO DI MILANO

School of Industrial and Information Engineering

Master of Science in Management Engineering

FINANCING OF RENEWABLES IN DEVELOPING COUNTRIES:

Financial models of Microgrid development in the South East Asia

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Master Thesis of:

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TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 2

CHAPTER 3

CHAPTER 4

CHAPTER 5

LIST OF TABLES

CHAPTER 2

CHAPTER 3

CHAPTER 4

CHAPTER 5

CHAPTER 6

ABSTRACT

Literature demonstrates that the development of Microgrid projects can be a cost-effective solution to the access of electricity in any countries. As evidenced in recent researches, this direction is mostly followed by developing countries, such as South East Asian countries, in which there are a lot of efforts in deploying Microgrids in order to power rural and isolated areas. Hence, the private sector and several developers are investing in this field with the goal to spread and develop these instruments, convinced of the fact that are the most efficient ways to power and connect those areas. The objective of this thesis is to access the impact of those instruments in developing areas, particularly in South East Asia, showing also the typical investment behaviour in such situations from the beginning to the end of the Microgrid project. The conducted study starts from a general overview on Microgrids, then financial data of the last years are reported with the aim to highlight that the amount of investments in this environment has increased a lot recently. This trend is positive and forecasts on future developments is cheering since the most innovative scenarios talk about Neural Grid, as the next step.

The analysis is carried out using four case studies of financing in Microgrids referring to the intervention of private assets in this sector. Once identified those actors, the work focuses on how Microgrid projects have grown from their participation onwards. Finally, the most significant points are reported in a table built with the aim to show some guidelines, drawn from these case studies, addressed at those interested in investing in this field.

ABSTRACT – ITALIAN VERSION

La letteratura dimostra che lo sviluppo dei progetti Microgrid può essere una soluzione economica per l'accesso all'elettricità in qualsiasi paese. Come evidenziato in recenti ricerche, questa direzione è per lo più seguita da paesi in via di sviluppo, come i paesi del Sud-est asiatico, in cui ci sono molti sforzi nell'implementazione di Microgrid al fine di alimentare aree rurali e isolate. Quindi, il settore privato e diversi sviluppatori stanno investendo in questo campo con l'obiettivo di diffondere e sviluppare questi strumenti, convinti del fatto che sono il modo più efficiente per alimentare e connettere quelle aree. L'obiettivo di questa tesi è quello di mostrare l'impatto di tali strumenti nelle aree in via di sviluppo, in particolare nel Sud-est asiatico, mostrando anche il tipico comportamento di investimento in tali situazioni dall'inizio alla fine del progetto Microgrid. Lo studio condotto inizia da una panoramica generale sulle Microgrid, quindi vengono riportati i dati finanziari degli ultimi anni allo scopo di evidenziare che recentemente la quantità di investimenti in questo campo è aumentata molto. Questo trend è positivo e le previsioni sugli sviluppi futuri sono incoraggianti dal momento che gli scenari più innovativi parlano di Neural Grid, come passo successivo.

L'analisi è condotta utilizzando quattro casi studio di finanziamento in Microgrid riferiti all'intervento di beni privati in questo settore. Una volta identificati questi attori, il lavoro si concentra su come i progetti di Microgrid sono cresciuti dalla loro ingresso in poi. Infine, i punti più significativi sono riportati in una tabella costruita con lo scopo di mostrare alcune linee guida, tratte da questi casi di studio, rivolte a coloro che sono interessati a investire in questo campo.

CHAPTER 1: INTRODUCTION

Energy has always been a very important element for human life and its evolution. This topic is becoming very crucial because the resources of fossil fuels are not infinite.

The continuous increase in electricity demand has highlighted the time limit imposed by fossil fuels and has focused attention on issues such as efficiency, energy saving and environmental pollution. In this reasoning renewable energy sources represent a major development point and a possible solution to the fossil fuels.

The priory is to replace the traditional production and management of electricity with new solutions that are able to decrease costs and solve the problem of efficiency of resources. This is possible only with cutting-edge technologies such as Microgrids. This work has the aim of analysing the projects of Microgrid in the South East Asia understanding how these projects are financed and their future development from the economic point of view.

In the Chapter 2, a brief overview about Microgrids will be made starting from the general definition of Microgrid. This concept represents a big step for the evolution of the electrical system and is a starting point for new technologies looking for better management of the available resources and an increase in the quality of service. Then, various typologies of Microgrids are highlighted focusing and their advantages and importance of their development. Not only technological advantages but also economic ones considering also the environmental sustainability. Moreover, on this new technology, an analysis will be made about the characteristics of the system control and operating strategies. Then, different application at national and international level are presented, highlighting how Italy is positioned in this field and the huge amount of investments that, nowadays, the renewable energy is attracting. Finally, will be made an excursus about what are the currently main storage methodologies in order to introduce the new interesting project of electric care exploited as storage system because this topic perfectly fits in this discussion.

After this, will be presented in deep the case of Microgrid in the South East Asia (S.E.A) because this technology has been developed with great success in this environment, focusing on production and distribution. As introduction of this paragraph, will be presented an overview of the most significative renewable plants in different countries in the South East Asia. There are important projects here and their development is essential due to the low cost and efficiency of these new instruments.

In the Chapter 3, instead, will be highlighted some financial data related to the development of Microgrids in S.E.A. After a brief introduction in order to present the topic, will be reported the most significant barriers distinguishing between financial, non-financial, and regulatory issues that the deployment of renewable energies and Microgrids are meeting. These obstacles refer to the whole case, not only about S.E.A but are the main one when we talk about the development of renewable energy power plants.

Then, will be presented the most effective policies in the South East Asia, going in deep in every member state of this area, showing also what are the main financial tools used for this type of investment.

Consequently, in the next paragraph will be presented the most effective financial and fiscal incentives that have the aim to support these policies, taking as case study some of the South East Asian countries that are more involved in the renewable energy projects, like Thailand, Indonesia, Vietnam and Philippines with the investment in the Microgrid projects.

After this, in order to conclude the Chapter 3, will be made an overview of the various possibility to reach the off-grid areas. In this part, are reported the main instruments used to support the development of renewable energy projects, in particular Microgrids, aimed at electrifying the off-grid areas in the South East Asia. Finally, it is made a recap, highlighting some of the most important companies that are investing in Microgrid projects.

Following this study, the next sections are: Chapter 4 and Chapter 5. In the Chapter 4, we will make an overview of the Microgrid development and future possible applications. Staring from the last years, specifically from 2016 we will follow all the steps that Microgrid met in its growth until 2018. As starting point, we have taken as reference only these last years because only recently these projects have been developed. After having presented several projects and applications, the goal is to try to predict future applications and innovative projects, and how this field is going to grow. Must be said that for the projects presented developed and developing countries are taken into consideration, even if we will go in detail only for those announced in developing countries, since South East Asia is part of this category.

While in the Chapter 5 will be reported real case of investments made in developing countries on Microgrid projects. These real cases have been categorized according to the typology of investments, according to the protagonist of the investment. in this way, we can distinguish between: private sector, impact investing, financial intermediaries, concessionary finance. From those examples we will extract some key lesson learned in order to show what are the best mechanisms and steps to follow for a potential investor in this emerging market.

Finally, the Chapter 6 will be composed by the conclusions on this conducted study about the financing of renewable in developing countries with particular attention to Microgrid projects, in which guidelines will be drawn thanks to the contribution of some specific real cases.

CHAPTER 2: ELECTRICAL ENERGY PRODUCTION AND DISTRIBUTION IN DEVELOPING AREAS: A REVIEW

This research starts with a macro outlook investigation about the development of renewable energy production, considering the thread of Microgrids and analysing implications due to the fast grow of certain world areas. After having clarified what a Microgrid is and how they work, the current situation in the South East Asia will be mapped entering in detail with the innovative project of the energy storage. The literature is full of these references and in particular about Microgrids because nowadays is becoming an important solution more efficient and less costly. In the same way, the environment of South East Asia is under the magnifying glass due to its peculiar morphology and meteorological conditions. Last but not least, the South East Asia is characterized by political instability and there are a lot of poor areas. So, for this reason, for the member states of S.E.A is crucial invest in this field in order to exploit their potential of renewable energy reaching as many citizens as possible.

Figure 2.1: focus of renewable energy sector

2.1 Microgrid overview

A Microgrid is an electrical system that interconnects loads and sources, generally in distributed generation. It has the ability to operate both in connection with the national electricity system and independently, in the so called “island” mode [1].

Hence, Microgrids also known as Smart Microgrid, are complete miniature electrical systems that exploit the use of digital meter technologies (Smart Meter) and the use of Smart technologies (Smart Grid, Smart Community, and Smart City). The fundamental elements to consider are:

- Electric Generation: Renewable and Distributed Energy, and also the Traditional one.
- The Loads: residential, commercial or industrial users.
- Accumulation systems: even if not always present.
- Electric network: it connects the various elements of them and with the medium voltage Macro Grid. These networks are locally governed and can operate in “electric island” or connected to the Macro Grid.

It is important to highlight that the Microgrids are designed to supply electricity but in some cases also heat and gas, with a quality and reliability (PQR *Power Quality & Reliability*) variable and different from that provided today by the Macro Grid designed to provide a universal service and homogeneous. Instead, the Microgrid PQR is customizable on the actual needs of any type of customer protecting loads with a quality of service proportional to the needs of customers. In this way the Microgrid improves the overall reliability of critical loads, reducing the costs of the system as a whole and in particular for those that do not require particular performances [2].

In other words, when we talk about Microgrid we refer to electrical users brought together under a single connection point (Point of Common Coupling or PCC) with the network electrical distribution.

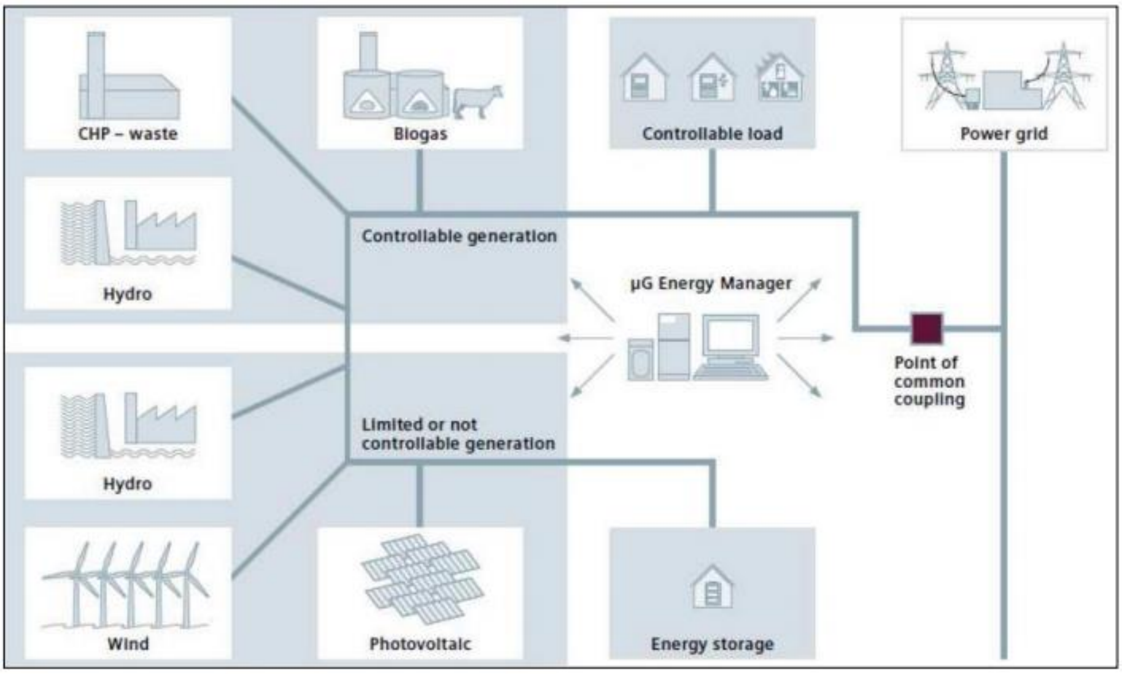

Figure 5.2: graphical representation of a Microgrid (source: Siemens)

As we can see, the various units of consumer production must be connected not only from the electrical point of view, but also through a communication system where, eventually, the Microgrid Energy Manager operates.

The maximization of self-consumption is pushed to the highest levels thanks to a software that allows not only short-medium term planning, but also the optimization of real time managements by minimizing the gap between current and optimal energy exchange with the external network [3].

There are different types of Microgrids that can vary for installed power (less than 250kW, between 250 and 1000kW, higher than 1MW):

- Institutional and campus microgrids: they aggregate the electricity generation in loco of different sources located in a close area that simplifies their management.
- Remote microgrids (off grid): they are never connected to the electricity grid and operate in “island” mode for economic reason.
- Microgrids of military bases: they are focused on the physical and computer security of military structures of which they represent reliable sources of electricity.

- Commercial and industrial microgrids: they are emerging in the North America and Asia. Their installation is due to the need for safe and reliable energy supply.

From a technical, scientific, economic and social point of view, the advantages offered by Microgrids are widely confirmed by the international technical literature and by the main researchers of the sector (conducted in the EPRI, Berkeley National Laboratory, DoE, Cigre, CIRED, CIRED, IEEC, TRI and DEMEPA). This is the solution for which the maximum development is expected in the next 15 to 20 years and that in terms of global investments will overcome the traditional solution “Bulk PowerPlants & Bulk EHV/HV infrastructures” (large concentrated power plants, very high voltage transmission and centralized management. The new delocalized approach has advantages not only for local micro-networks, but also for favourable impacts on macro geographic networks and consequently on the entire global electro-energy system.

From an extract of the online newspaper *Canale Energia* from 2012 [2] that elaborates the topics of energy, infrastructures, environmental impact and energy efficiency, we can pull out the advantages of Microgrids:

- Reduction of the tariffs compared to the Macro Grid solution through a high customization of supplies and the possibility of planning the meeting between supply and demand according to the production/consumption peaks. This opportunity is to be added to the advantages already described about the supply of energy with PQR.
- Local operations are easier and more efficient and require limited investments. Indeed:
    - No impact on the quality of the service during a “disturbance” as they can be separated and isolated from Macro Grid in Medium Voltage.
    - They automatically resynchronize, reconnecting to the Macro network without ad hoc interventions.
    - They are interconnected to the MV network and when convenient they can buy and sell energy and ancillary services.
- They have a favourable impact on the territory both:
    - Environmental promoting the development of Renewable Energies.

- Social with community participation to define the development of the territory.
- Employment because the management and maintenance activities are carried out locally, involving new employment at graduate level, experts and IT specialists.
- Quality of life thanks to the greater financial resources to solve local problems.

Now, after having highlighted what a Microgrid is, the various typologies and the advantages, it is the moment to make a step further understanding the control method of a Microgrid from the technological point of view.

The aim of the control mechanism is to regulate voltage and frequency, reactive and active power output to fit the setting. There are two types of control method [4]:

- Non-interactive control method
- Interactive control method

In the non-interactive control strategies, output power settings carried out independently while in the second type the output power setting performed as command from control unit. These two types of control methods are divided in:

- Grid following control
- Grid forming control

In the first, settings power output, including voltage and frequency, are determined by the microgrid. Mechanisms of active and reactive power dispatch by an energy management system to perform optimization strategy based on potential energy profile. While in the second, settings power output, including voltage and frequency, are followed by DER units. Droop control strategies made using voltage and frequency droop control.

Must be said that to ensure that the Microgrid operation mechanism works as expected it is necessary a supervisory control strategy that can be centralized or decentralized. In the first type of strategy the amount of power output from each Local Control is determined by the Microgrid Control Center, while in the decentralized strategy, each Local Control has the ability to determine operating autonomy of energy production.

Reading this preliminary overview about Microgrids, it is evident that it is a success in the field of energy and environmental sustainability. But, in concrete terms, what are the real application of this Microgrid?

Microgrids are riding the success of solar and wind energy, Smart Grid technologies and new automation and dispatching systems for electricity grids. In the 2010, the world market for Microgrids was about $ 4,2 billion with significant growth compared to 2009. The market expects growth to continue at least until 2020-2025 (Articolo, "*Micro Grid: tipologie, vantaggi e applicazioni*", Canale Energia, 2012).

In particular, according to a research of DeMEPA conducted in the 2012 [5], the countries in which Microgrids will grow a lot are: South America, Asia, Russia and Africa. The reference applications of the other geographical areas are:

- BT networks with a strong presence of renewable energies
- Peripheral locations
- Off-grid
- Applications for electrification and rural generation

Italy is among the world leaders in the Smart technologies and Renewable Energy sectors. In particular, the country is in fourth place in the world ranking, after China, Germany and United States in investments in renewable energy. It is the first for solar applications, but Italy has not yet seen the flourishing of this new business. The target applications for Microgrid business refer to small hamlets of about 1000-2000 inhabitants characterized by a user with about 200-350 users/consumers, small commercial and industrial businesses, public utilities and small distributed generation.

So, it is important that also Italy starts to invest in this new business starting from that regions in which there are sources already installed of wind, photovoltaic and water distribution (like Basilicata, Puglia e Sicilia).

From the figure below [6], we can see the Global investment trend from 2004 to 2017. It is evident how, year by year, the field of renewable energy is becoming crucial and the amount of investments is the proof of this. In fact, the Global clean energy investment was $333.5 billion in 2017, up 3% from 2016 and the second highest annual figure ever.

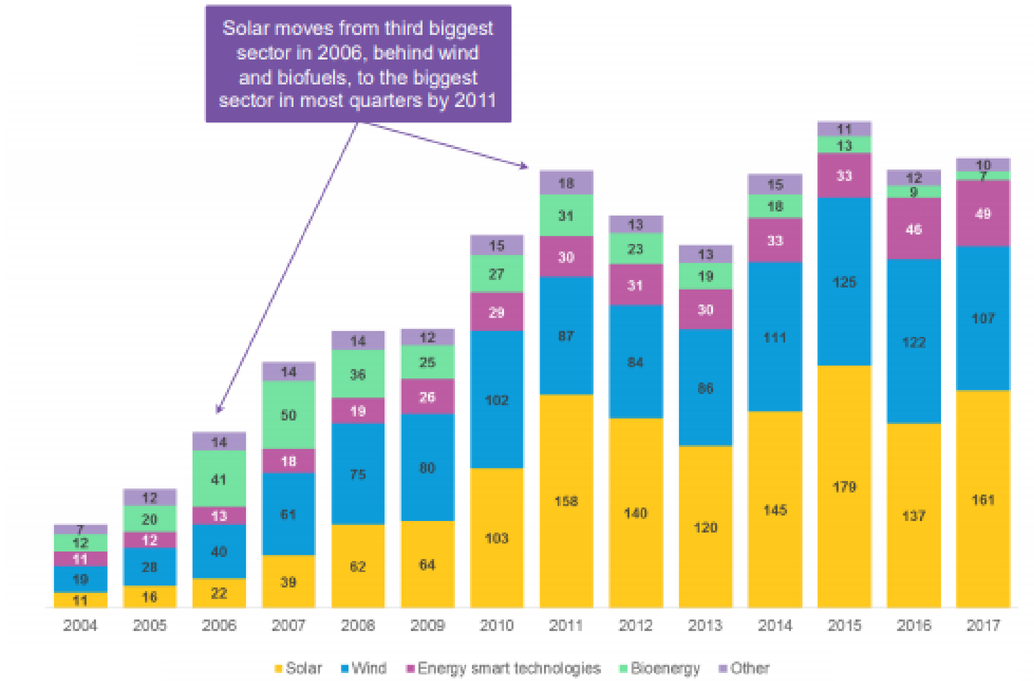

Figure 2.6: Global New Investment in Clean Energy by Sector, 2018 (source: Bloomberg New Energy Finance)

Different reasons are driving this development across different countries. In Europe, regulated tariffs have increased, and subsidies are offered for sales to national grids from renewable sources. Technology has also assisted, with solar, wind, and gas turbine generation becoming ever cheaper, as has battery/hydrogen storage. Microgrids' low voltage distribution reaches less losses than the transmission network, boosting efficiency further still.

For some users, cutting CO2 emissions is a primary goal, like the University of Genoa in Savona, Italy, where Siemens helped shape a microgrid based on solar power and micro-gas turbines. Following the work of Zanellini F., "*Un esempio di mirogrid: la Smart Polygeneration Grid di Savona*" [3], this microgrid delivers 250 kW of power and 300 kW of heating for its 40,000 students, and this is viewed as a pilot for an expanded version for the surrounding green-minded city.

In the US market, demand is driven more by reliability issues. Hurricane Sandy in 2012 left many citizens without power. This demonstrates that a big grid is not necessarily a safe one. Microgrids exploit the option to disconnect temporarily from the main grid if threatening interruptions or can remain permanently as separate "islands." Moreover, if its own generation fails, a connected microgrid has the option of drawing on the main grid as backup.

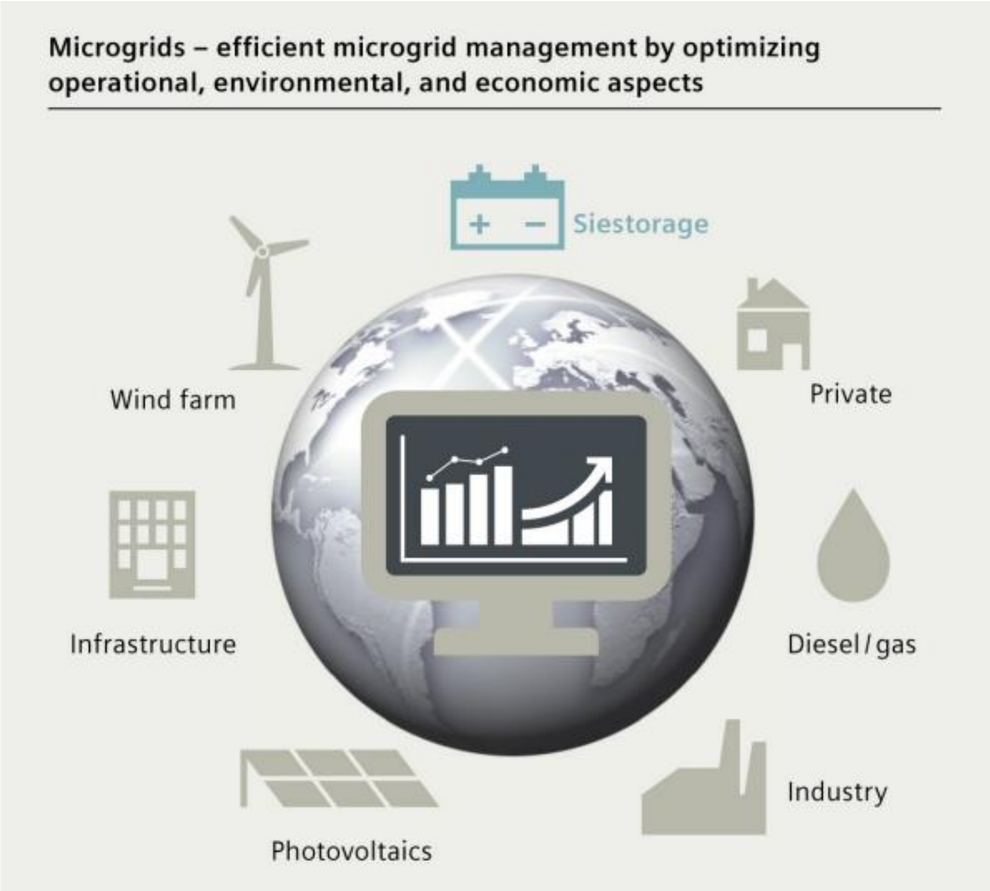

Figure 2.7: Microgrid management, 2016 (source: Siemens, The Magazine)

Siemens Digital Grid delivers a range of software and services to help microgrids achieve these benefits, according to customer needs. The SICAM Microgrid automated control system can check the status of local assets and the wider grid, using a rule-based algorithm to connect or disconnect. The more complex Spectrum SP7 MGMS management system can also take account of future load and weather forecasts to optimize in real time the energy dispatch and can interact with wholesale power markets to maximize economic return or minimize CO2 emission over a longer term [7].

The majority of Microgrids are not isolated but are regularly connected to the largest power grid. As such, however, as we said before, they can disconnect from it in the event of power failure and provide for their own electricity needs. So, until now, we are facing an emergency system or a little more.

Figure 2.8: Microgrids more sustainable (source: Green.it)

According to Andreatta N., "*Microgrid più sostenibili, ecco come dovrebbe essere il futuro delle reti elettriche*" [8], it is necessary to prepare and design more sustainable, more efficient Microgrids for those environments where national grid is not so well developed. This step will be favoured by the progressive decline in prices for small and medium-sized renewable energy plants, as well as for energy storage systems. All of this will be made more controllable thanks to new technologies base on AI with the aim to make the interaction between the most sustainable microgrids and the normal electrical network even more efficient.

The goal is to have a normal electricity grid consisting of a set of more sustainable Microgrids, in an integrated and connected set of zero-emission energy resources. The result would be the widespread availability of clean, renewable, economical and reliable electricity, with the various Microgrids inserted in a "give and take" mechanism.

2.2 Methods of electricity energy storage

Nowadays, the theme of electricity storage is becoming very important because the implications it has in Microgrids and autonomous production systems in general. There are a lot of researches with the aim to find the more efficient solution that can accumulate electricity and that can release it when we have the need, because the non-continuous production process in renewable systems due to rushes and non-continuity of wind and sun, makes necessary the development of new storage systems in order to compensate those moments in which there is a shortage of wind and solar energy.

But what are the current main electrical energy storage systems? [9]

- Chemical systems that exploit hydrogen.
- Electrochemical systems with batteries.
- Electrical systems with supercapacitors.
- Mechanical systems.

The **hydrogen** used as a storage system can be stored as compressed gas in different ways. The mainly used are:

- On-board vehicles in pressurized containers. This storage technology is the simplest in which the hydrogen is compressed to about 20,7 MPa and stored in cylinders for gas, at standard pressure or in spherical containers for quantities exceeding 15000 Nm^3. In general, the accumulation in the form of compressed gas, in high pressure pipes, is limited to systems below 14000 Nm^3 or even lower, due to their high cost.
- Underground systems. This method, however, is convenient for the treatment of large quantities or for long periods. Currently there are numerous underground storage facilities in Germany, France, Great Britain and Norway. This methodology is more or less convenient, in terms of costs, depending on whether pre-existing structures (salt mines, emptied gas wells, etc.) are used or their creation is necessary as in the case of artificial wells. The capacity of this storage system is very high (35 kWh per kg) but the problem is that in order to create hydrogen from water through electrolysis, electricity is required as well as for the compression of hydrogen itself.

The **Batteries** used as storage system differ according to the chemical combination used (sulphur-sodium, lead-acid, nickel-cadmium, ions-lithium, etc.) inside them. The most promising are the lithium-ion batteries used especially for laptops, mobile phones and smartphones. The advantages in using this type of batteries are different: the high energy density (energy per unit of mass: 150 Wh/kg), the low weight, the longevity, the very short total recharge times (about 3 hours), the possibility of partial refilling and the absence of toxic materials. Instead, the main disadvantage is the high cost around 400 €/kW, even if the widespread use of the last few years has led to a drastic reduction in costs which, will be further reduced. In general, the use of batteries, in a context of reducing the environmental impact of the latter, is a valid prospect for widespread installation and decentralized of many high capacity and efficiency systems that would overturn current energy utility business models. The storage batteries are fundamentals component for plants isolated from the electricity grid. The batteries have the task of accumulating the electricity produced in excess of the immediate needs of self-consumption, and then return it to the user when the solar system is inactive, for example in moments of low isolation or at night.

Instead, **supercapacitors** are composed of two polarizable electrodes, a separator and an electrolyte, where the electric field is stored in the interfaces between the electrolyte and the electrodes. Supercapacitors are characterized by high power density, long life (500000 charge-discharge cycles with a minimum lifespan of 10 years, without changing the capacity with time) and for simplicity and reversibility of energy storage compared to conventional batteries. The disadvantage is, instead, related to the amount of storable charge that is limited and depends on the surface of electrode-electrolyte interface. Carbon supercapacitors are currently being studied, which have an energy density and high-power density (respectively 76 Wh/kg and 506 kW/kg), more than 20 times greater than traditional supercapacitors.

Finally, regarding **mechanical systems** it is necessary to distinguish between:

- System of vertical axis flywheels located in sturdy cylindrical containers in which a certain degree of vacuum is maintained in order to reduce the noisiness and aerodynamic frictions of the rotor, also thanks to the adoption of magnetic bearings. Using a converter, the rotor transfers energy to the network on the form of variable high-frequency alternating current. These systems are suitable for powers up to 500 kW and can be used in parallel for higher powers. The flywheel costs are competitive with those of batteries considering the long life and the minimum maintenance, and they are characterized by high efficiency, high durability and can be recharged very quickly.

- Storage system of compressed air that is similar to those of hydrogen. These systems use compressors powered by low-cost electricity produced at night: compressed air is accumulated in hermetic underground cavities, at a pressure of 70-100 bar, then, the compressed air obtained and accumulated is generally used in a traditional turbo-gas plant or pneumatic drives in production lines. These are systems with a good storage capacity from 2 to 3 kWh/m^3 of tank (underground).
- Hydroelectric systems that are based on the pumping of water and use two reservoirs placed at different altitudes. In the hours when the energy produced is higher than the required energy, the water is pumped from the lower tank to the upper reservoir, while during peak of demand the water accumulated upstream is used to produce electricity. They are very useful for storing the energy produced by the thermoelectric power plants. Currently, more than 90GW of pumping plants are installed worldwide, corresponding to 3% of the global generation capacity. These systems are essential for the operations, regulation and rationalization of electricity transmission networks. The costs of the pumping plants currently installed are variable, from 150 €/kW in USA to more than 2000 €/kW in Japan.

A recent research conducted by McKinsey in 2016 [10] asserts that the attention to storage systems is very high and this involve a great number of utilities because the aim is very ambitious: to be able to storage energy efficiently with low costs. The mission of the storage is crucial, that is overcome the limits of clean technologies because their production is subject to the weather variability. These are reliable technologies, but it is necessary to have a solution that can support the renewable energies when, for example, there is not sun or wind.

As said before, there are a lot of studies that go in this direction of electric energy storage. One of the most recent and interesting research concerns the exploitation of electric cars as storage system for the own home.

Photovoltaic + storage + electric car would be the new combination that will evolve the energy system or the next years.

According to the study conducted by UBS, this triad could be a winner in Italy, even without the need for incentives, in just three years. this hypothesis even if provides a new orientation of the industrial policy, it is an unstoppable trend and will change deeply the world of electric production and also affect the car industry.

Figure 2.9: cars as storage systems (source: Velga.it)

The idea is to use the electric car, that is able to store energy, to feed houses. Hang up the socket and the electricity run in the opposite way and we are able to exploit our electric car as power supply during the night [11].

The experimentation is already underway. Enel is protagonist through its Spanish subsidiary Endesa. Together with the automotive giant Nissan, which puts the intelligence and technology of its electric cars. This suggestion goes in the direction of the binomial *Smart Grid – Smart City*: the biunivocal integration between electricity supply and demand in the name of distributed production and energy efficiency.

The solution developed by Enel and Nissan includes a bidirectional loader and a management system compatible with the generation of renewable energy through plants outside the network, such as solar panels and turbines and wind turbines. Thus, the electric car can create important technological and managerial synergies with the production of green energy [12].

2.3 The projects in the South East Asia

South East Asia is a geographic region of Asia that is located in the middle between China and Australia, between the Indian Ocean and Pacific Ocean. It involved 11 states:

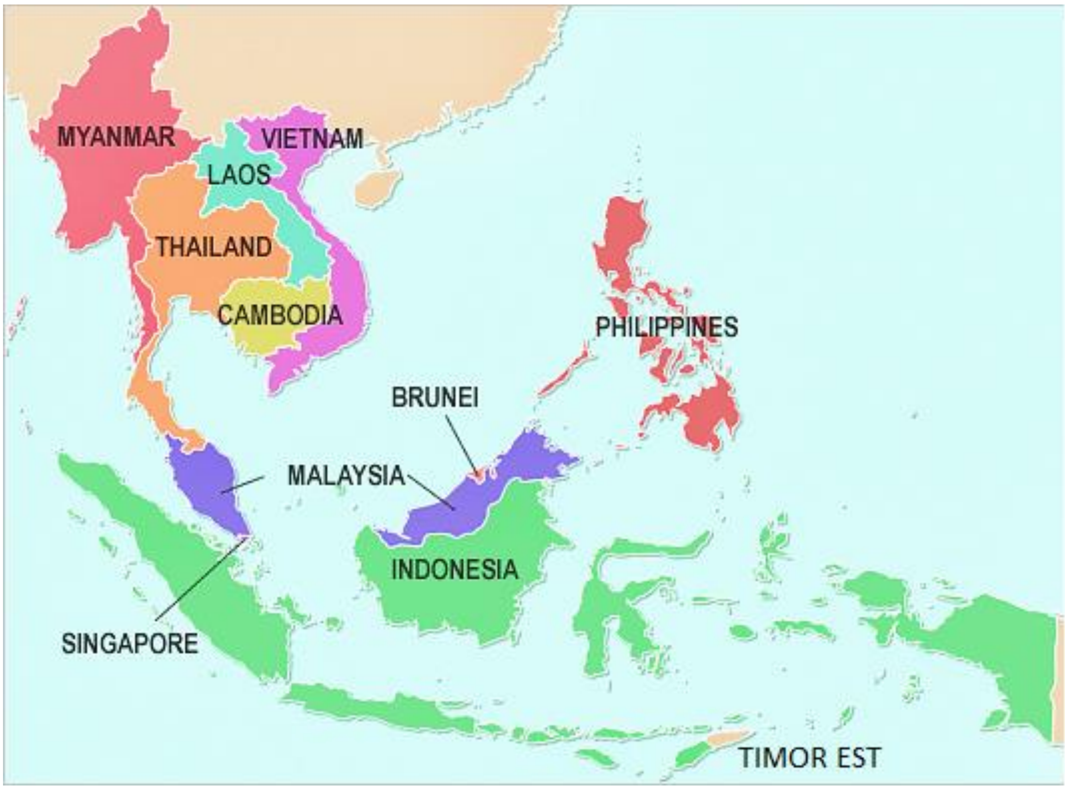

Figure 2.10: Map of the South East Asian countries

South East Asia has emerged as one of the most fastest growing economic regions in the world with an average rate of 4,9% for the period 2013-2017. This trend appears to be confirmed by the growth estimates for 2018 and 2019 of over 5%. A widespread crisis of democratic infrastructures with the progressive affirmation of authoritarian drifts and the relative shrinking of the spaces of civil liberty has been corresponded to this expansive period of the economy. In some cases, such as in Thailand, Philippines and Cambodia it is a question of discontinuity and trend reversals. In other contexts, such as in Laos and party in Vietnam, no significant reforms of the political system were made to economic growth, allowing for the perpetuation of existing regimes. The situation in Myanmar, which is facing a very difficult transition path, is not different from contradictions [13].

In any case, the current photography portrays a region in which to a substantially florid economy correspond more or less authoritarian political systems.

In this field, affordable and environmentally energy will be crucial to underpin the South East Asia's development over the coming years. Energy consumption is expected to more than double by 2040. For this reason, experts are trying to find new ways to meet this huge demand because through fossil fuels alone is very expensive [14].

The current situation of the electricity energy capacity in the South East Asia, considering both fossil fuel and renewable sources, is the following:

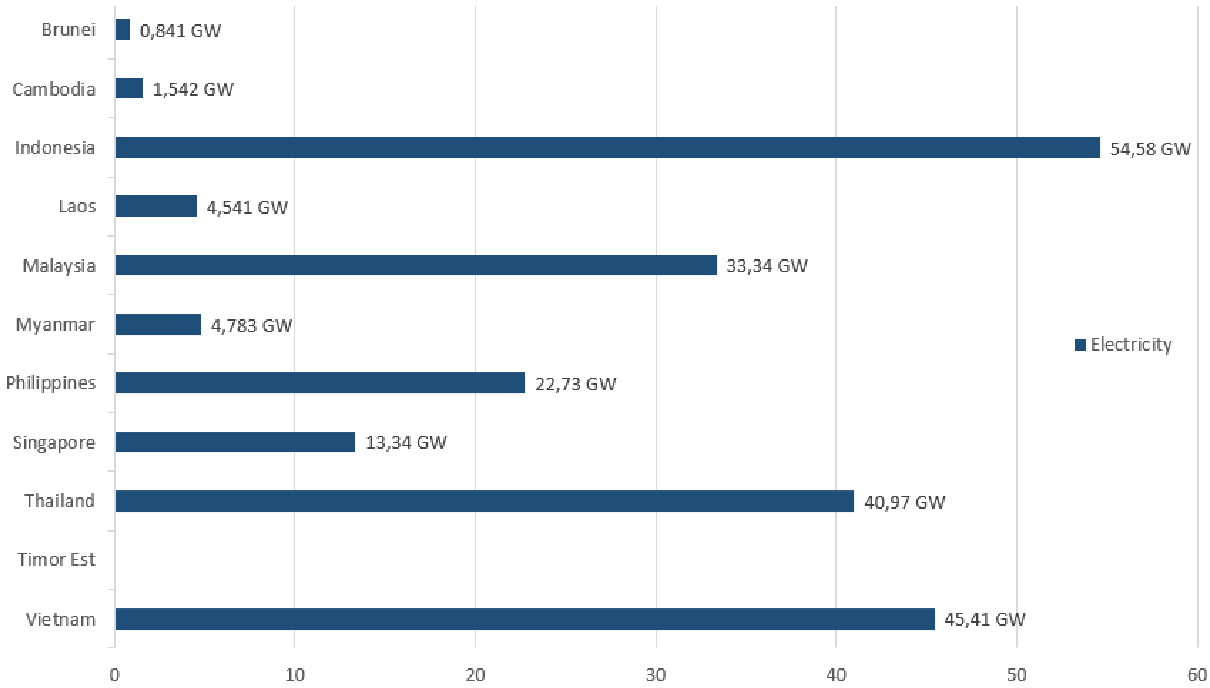

Figure 2.8: Electricity-installed generation capacity, 2017 (source: The World Factbook)

Entering in detail through the graph above, it is interesting to highlight the percentages of different energy sources from which it is produced that amount of electricity. In particular, we distinguish between fossil fuels, hydropower and other renewable energy sources as wind, solar and geothermal:

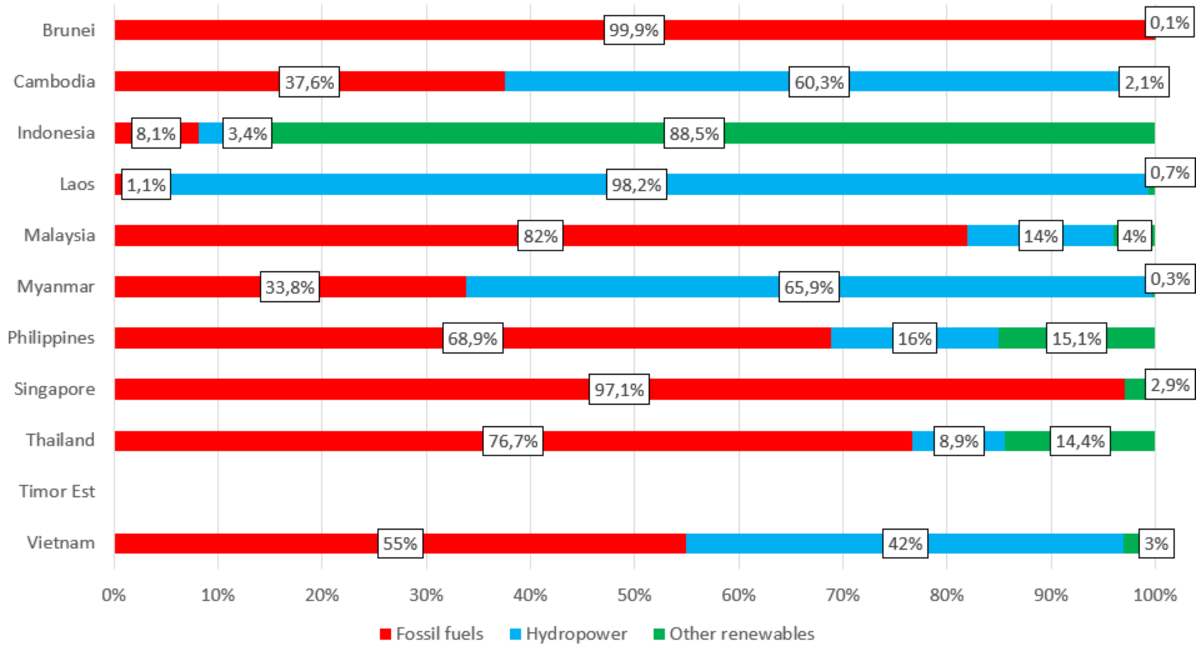

Figure 2.9: energy sources used for the electricity-installed generation capacity, 2017 (source: The World Factbook)

As we can see, in the South East Asia, the majority of the electricity energy capacity have been provided by fossil fuel, but this trend is going to change thanks to the efforts in promoting and developing the renewable energy sources as first source exploited for the production of electricity energy.

In fact, enlarging these percentages related to the renewable energy sources, it is evident how South East Asian countries are making efforts in this sense with the aim to reach the future prefixed targets. In the following graph it is taken into consideration all the range of renewables considering also the hydropower as the major renewable energy source exploited. The growth in renewables across the S.E.A has mainly been driven by the capacity deployment of hydro-based solutions:

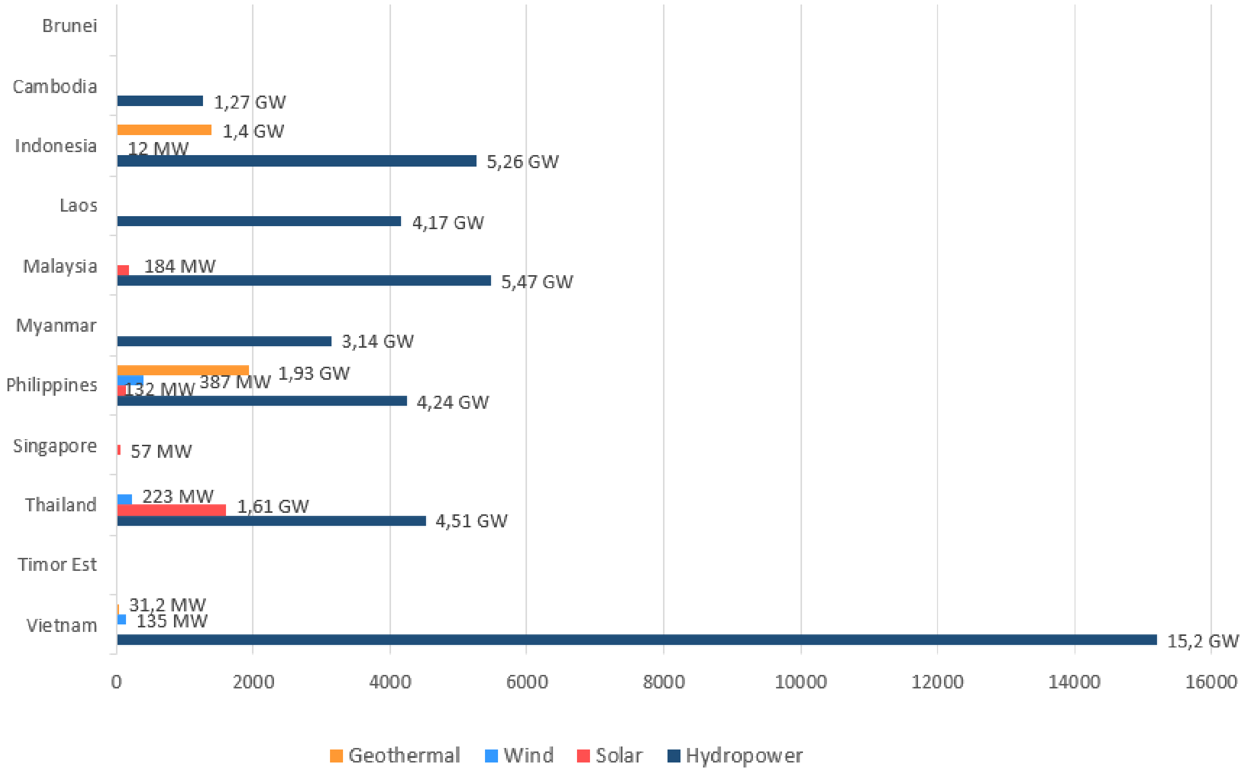

Figure 2.10: installed capacity of power plants in the S.E.A (source: World Energy)

The Figure above highlights the capacity of those plants that overcome a minimum level of 10 MW. In this sense, Timor Est and Brunei are behind compared to the other countries, while it is evident that in Vietnam the hydropower plants are the buttonhole of the country itself thanks to the delta of the Mekong river, one of the biggest rivers in Asia. Another important data regards Indonesia and Philippines that have great geothermal potential.

These numbers are the result of efforts started in 2015, when the Association of South East Asian Nations (ASEAN) decided a series of targets to increase regarding the region's share of renewables. The Members states set a renewables target of 23% of the region's fuel mix by 2025. This means that the region's ongoing energy demand is forecast to increase by 80% within 2035 [15].

But why the South East Asia has this renewable potential?

- the region has significant potential for **wind power** in Thailand, Philippines and Vietnam. Moreover, Vietnam's long coastline and good seasonal monsoon winds makes this country suitable for wind farm investment.

- Malaysia is the world's third largest producer of **PV cells and modules**, but Thailand is the first between the countries of the S.E.A in terms of capacity installed of photovoltaic plants.

EA Solar Lampang	128.0	Thailand
EA Solar Nakornsawan	126.0	Thailand
SSE1 Solar PV 1 – 10 Power Plant Project	104.7	Thailand
EA Solar Phitsanulok	90.0	Thailand
Nakhon Sawan solar PV	90.0	Thailand
Lopbuir PV Solar Power Plant	84.0	Thailand

Table 2.1: the 6 most important solar PV plants in Thailand (source: Unlocking Solar Capital)

In the first 25 top solar PV plants, Thailand has 11 operational projects and has the largest share of installed solar capacity in the region, which is a huge lead from its capacity in 2014 that was only 1,3 MW [16].

- Countries are developing **hydro power** projects of all sizes. As said before, some of the largest are being built along the Mekong River, which flows from China to the Mekong Delta in Vietnam. It has been calculated that hydroelectric power potential in the Greater Mekong basin is between 175 GW and 250 GW. Moreover, Indonesia plans to build new hydroelectric generating capacity by 2021.

Obviously if the S.E.A wants to develop renewable energy systems, it is necessary the financial support of different entities and companies. The diversification of South East Asia's energy supply through investments in renewables offers a viable option to support their expansion and also achieve wider benefits.

In this direction, all countries in this region have made important investments in this opportunity. This is a signal that the entire South East Asia has the aim to transform the energy sector reducing carbon emissions (under the 2015 Paris Agreement). The S.E.A has a lot of renewable energy resources, whose deployment is being supported at both the regional and national level. It has some of the best hydropower potential in the world as in Indonesia and Myanmar. Global horizontal irradiation in this region is very strong with an annual average of 1,5-2 MWh/m^3 annually. Wind resources are modest in Indonesia, Philippines, Thailand and Vietnam. Indonesia and Philippines have significant geothermal potential, and in particular, Indonesia hosts substantial potential for ocean energy.

Obviously cost continues to be a major deciding factor in the adoption of renewable energy technologies in the South East Asia. The latest trends in renewable energy costs are showed in the figure below:

Table 2.2: Investment costs of renewable energy technologies (sources: IRENA)

As we can see from the figure above, solar PV experienced the most significant cost reduction from 2012 to 2018. Overall, geothermal is the only technology that has seen a slight increase in weighted average investment costs.

Must be said that, following this development of renewable energy, it has some socio-economic benefits. On a global scale, the analysis of IRENA [14] reveals that there is direct proportionality between relatively high shares of renewable energy and economic growth.

We assist to this trend because of the negative effects of climate change that have a great impact on S.E.A, whose low-lying major cities and abundance of agricultural activity will make it vulnerable to rising sea levels, increased heat-related deaths, and extreme weather events. As a major source of climate-forcing greenhouse GHG emissions, the power sector is an important place to look for solutions to mitigate the effects of climate change. As said before, many countries of the South East Asia are focusing their efforts in the application of low or zero-carbon renewable energy [17].

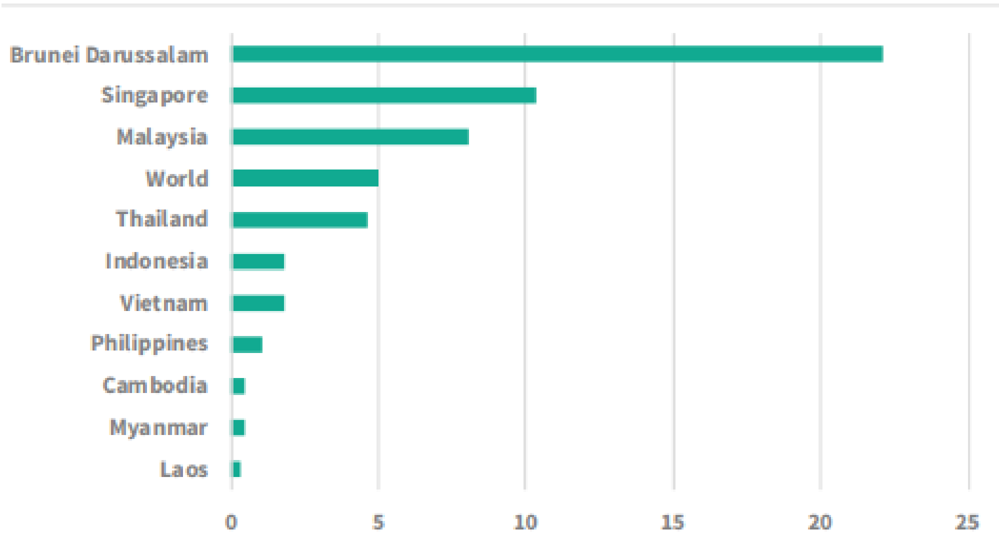

Figure 2.11: CO_2 emissions per capita, 2018 (source: World Bank)

As shown in Figure, carbon emissions per capita in most Southeast Asian countries are lower than the world average. However, every Southeast Asian country has submitted a Nationally Determined Contribution to the Paris Agreement.

However, there are several challenges to overcome if renewables are to take a greater share. One of these is the power of the established fossil fuel producers and exporters. For instance, both Malaysia and Indonesia are among the world’s top exporters of natural gas. Then, also the lobbying efforts of traditional energy suppliers must be considered that in order to maintain their status quo have hampered the adoption of suitable energy solutions.

Another important factor is the non-electrification rate because now it stands at 120 million people, out of a total amount of 639 million in the South East Asia.

In this sense, the member states of the ASEAN region are working jointly to link up national power networks with cross border power interconnection. Such integration of the grid network improves the economic viability of renewables at the expense of fossil fuels. Indeed, thanks to the completion in 2016 of the 275 kV inter-connector linking the island of Borneo in Malaysia with Indonesia, communities in Indonesia have been importing power from Malaysia's 944 MW Murum dam [17].

It is clear that if the South East Asia wants to be fully reliant on green energy, more than this must be done. In fact, nowadays we are assisting to a lot of projects about the so called Microgrid, explained in the previous chapters.

Access to sustainable and affordable energy is a requirement to eliminate poverty and create a cycle of market growth. However, products and services are often not customized for the low individual purchasing power of the poor today and thus leave attractive market potentials untapped. To leverage this opportunity, corporations need to start considering the poor as customers of the future and develop technologies and business models which fit the local conditions.

Microgrids are at the technological core of this development and are already commercially deployed in the world, as grid-connected systems. This type of technology is perfect for the South East Asia because of geographical factors that make difficult connecting communities with Macro-Grids. For locations served by the grid, total daily supply is about 18 hours, so electricity is a top priority. It is expected that the South East Asia will spend $14 billion to reach universal electricity access by 2030, with 75% of off-grid population mostly served through remote Microgrid systems.

The multi-million Microgrid effort is expected to facilitate the development and market penetration of the energy technologies, recognizing that remote Microgrids will become key to addressing the need for better energy access. A consortium of international corporations has partnered together to test and demonstrate a range of solution suitable for deployment in S.E.A. while, some countries like Thailand, Malaysia and Vietnam have seen more of a focus on grid extension, other countries like Myanmar, Indonesia and Philippines are looking to remote Microgrids as a key solution.

Some of the most relevant projects in S.E.A [18]:

- **Myanmar** has the highest percentage of communities without access to electricity. The government is prioritizing the provision of electrical infrastructure allowing up to 100% ownership on any remote Microgrid project. The need for increased mobile phone connectivity has been one of the key drivers for remote

Microgrid deployment. A push for cell tower deployment requires remote Microgrids to power the towers, which in turn act as anchor clients. In this direction, in Myanmar, Yoma Micro Power (a developer and operator of small-scale power plants and Microgrids in off-grid areas) is raising a lot of money in order to realize these projects.

- With more than 17500 remote islands, **Indonesia** faces distinctive geographic restraints when it comes to electrification. Two years ago, Indonesia adopted the "Accelerating Electrification in Rural Areas" policy, which outlined the framework for private sector investment and development of remote Microgrids. Any Microgrids at 10 MW or above are allowed up to 95% ownership but restricted to 50% on projects between 1 and 10 MW. Under 1 MW, the law forbids foreign ownership completely and almost all island Microgrids. Corporates such as Engie have entered the space, signing three partnership agreements to develop remote Microgrids for a total value of $q,25 billion over the next 5 years.

Figure 2.12: solution for rural electrification, 2018 (source: GE's infographic)

- The case of **Philippine** is similar to that of Indonesia, with its 7000 islands. Remote regions without electricity and those that are connected suffer from frequent power outages. Philippines has ambitious targets aiming to reach 100% electrification by 2022, up from 91%. What is different in Philippines with the rest of the countries of the S.E.A is a relatively open regulatory environment, with the government in support of establishing tender agreements to add renewables to remote islands, drawing in interest for new business opportunities. Organizations such as the Alliance for Rural Electrification are actively encouraging foreign companies to come helping the development of Microgrids. Solar Philippines, one of the country's largest solar providers, announced they will put $15 million towards developing remote Microgrids and has partnered with Tesla to deploy a 2MWh Tesla Powerpack battery system. In May 2018, Philapinas Shell Foundation announced they are advancing 20 Microgrids for rural communities.

- Instead, **Singapore** will become the first South East Asian country to have a hybrid Microgrid system that integrates solar, wind, diesel, tidal and power-to-gas technology. The Microgrid project is being built by Nanyang Technological University and will cover more than 64000 m^2. The project will integrate four hybrid Microgrids, energy storage systems, and more than 3000 m^2 of solar panel. The electricity produced from the site is able to provide electricity for the many islands and remote villages in Singapore [19].
- Concerning **Vietnam,** the government is trying to develop the national electrical system in both stability and capacity to ensure the supply in the country. With the majority of rural farms in Vietnam, there is a large potential for the application of renewable energy. This case is very suitable for applying the microgrid topology because it has great potential for distributed energy which can satisfy most of the electrical demand. The power demand id projected to increase 10-15% annually to 15kW in 2020. Another factor to take into account is that the price of energy in Vietnam is increasing in the last years. for example, one of the best solutions can be the Microgrid with the mail DC bus and an extra AC bus for household devices and gadgets, since many of the household devices nowadays have the AC socket as primary manufactory setting [20].

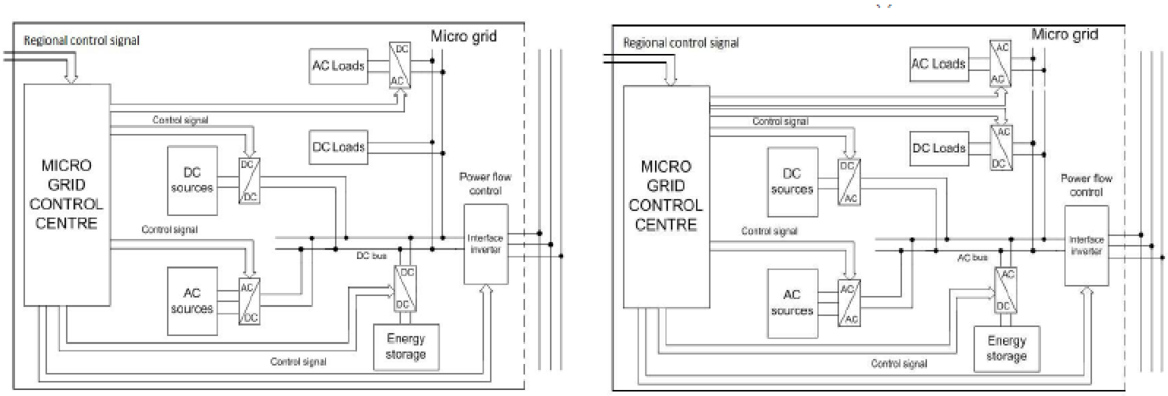

Figure 2.13: Microgrid Structure with DC common bus (figure on the left) and with AC common bus (figure on the right) (source: University of technology Sydney)

These are example of the current projects in S.E.A and it evident that are innovative solutions. Technologies like remote Microgrids monitoring and Microgrid maintenance are creating opportunities for the development of scaling requirements. These solutions provide reassurance for international donor organizations, like the World Bank, who are active participants looking to help end energy poverty in the South East Asia, providing reassurance that their contributions will service rural communities in the future.

- Okra Solar, a start-up based out of **Cambodia** works closely with local utilities to supply rural communities with energy. The company develops efficient Microgrid systems that connect assets together through a software solution, which can remotely monitor and control remote Microgrids as well as notify customers when action is required. Okra is an example of how opportunities are also possible for smaller players via disruptive technologies that can drive change across the industry [18].

For these new technologies, some challenges arise. In some countries theft attempts are still frequent, with people attempting to connect directly to power networks, skipping meter systems. There is also an underestimation of the frequent failure frequency for many Microgrid components. Components such as inverters can burn out due to adverse temperatures or moisture, and in remote locations, the replacement can require months.

In the next section, Chapter 3, we will discuss about how the financing of project focused on renewable energy works in the South East Asia. There will be an analysis of the most the most effective policies in S.E.A. Specifically, it addresses the way through which is possible mitigate the most prominent risks related to renewable energy investments and therefore facilitate the application of the most promising financial mechanism in the region.

CHAPTER 3: FINANCIAL DATA RELATED TO THE DEVELOPMENT OF MICROGRID IN S.E.A

To translate the targets and objectives, explained in the previous chapter, into deployment several countries of the South Est Asia have adopted policy and investment frameworks in order to allow the growth of all forms of renewables, including also the development of Microgrids. To reach the aspirational target of 23% renewables in the region's primary energy mix by 2025, South East Asia countries will have to scale-up their deployment of renewables.

Understanding what renewable resources are available, and where, is important for different stakeholders. Policy makers need data to inform national planning, target setting and policy design. The private sector to develop project proposals identify potential sites and conduct preliminary feasibility studies. In the same, way investors in order to access financial proposals and risks.

The continuous increase of the Microgrids' demand with high penetration of distributed energy generators, mainly renewable energy sources, is modifying the traditional structure of electric distribution grid. In developed countries where there is already a central grid, creating a Microgrid, that should be connected to the central one, is expensive. For this reason, this country is modifying its grid structure exploiting Microgrids projects with lower costs since there is not a central network to which Microgrids have to adapt. The South East Asian countries are looking for alternative energy sources to avoid the impact of higher fossil fuels consumption. Indeed, different policies have been adopted to promote renewable energy technologies (RET) and distributed energy resources (DER) deployment. The aim is to decrease the greenhouse gas (GHG) emissions and achieve energy security meeting the growing of the electricity demand. In the literature there are many researches about the successful integration of

RET and DER operation, protection and stability issues, all satisfactorily implemented thanks to the feasible Microgrid operation.

The Microgrid is gaining importance because of its flexibility and the trouble-free plug and play of distributed energy resources, both from renewable energy and fossil fuel power sources, into the larger electrical distribution system.

As production costs decline and technology performance improves, the renewable energy sector has witnessed a boom. Many countries have moved their focus on this market implementing projects deployment considering both financial and non-financial barriers [14].

3.1 Financial and non-financial Barriers

It is important to understand that there are different issues to consider when we talk about the distribution and development of these renewable solutions. From the economic point of view there are both financial and non-financial barriers that it is important to consider.

The non-financial barriers are related to factors that inhibit the deployment of these innovative solutions or lead to higher costs than the necessary prices. These barriers can be differentiated as:

- Obstacles to the regulatory and policy uncertainty that are related to bad policy design or discontinuity and insufficient transparency of legislation.
- Institutional and administrative barriers which include the lack of strong institutions, lack of clear responsibilities and slow and non-transparent permitting procedures.
- Obstacles to the market such as inconsistent pricing structures that disadvantage renewable energies, asymmetrical information. market power, subsidies for fossil fuels and the non-capacity to include social and environmental costs.
- Infrastructure barriers that are mainly focused on the flexibility of the energy system, for example the power grid to integrate or absorb renewable energy.
- Lack of awareness and skilled workers about insufficient knowledge related to the availability and performance of renewables.
- Social acceptance and environmental barriers related to experience with planning regulations of renewable energy.

These regulatory, economic and commercial challenges are becoming an obstacle to the distribution and development of renewable energy and Microgrid solutions.

Then, there are also financial barriers that works like an obstacle to the implementations of this market and are related to the absence of adequate funding opportunities and financing products for renewable energy. We can distinguish between:

- *Power Purchase Agreement PPA*. It is an instrument of project finance and it is a technical document developed with the support of experts in engineering, finance and law. Basically, PPAs are related to demonstration projects for long period over 15 years because the PPA contract agreement forecasts and anticipates future uncertainties.

- *High upfront costs*. Large-scale renewable energy power plants are expensive to build, and this is known, due to the high cost of renewable energy technologies (RET), and investors are worried about the payback time on the investment. Every region has to promulgate policies and regulations that can work like support including financial incentives for the deployment of renewable energies, like concessional import duties, exercise tax benefits, corporate income tax benefits, subsidies to investment costs, low-interest loans.
- *Grid connection costs or transmission expansion*. Due to the rapidly decreasing cost of generating units of renewable energy, grid connection costs are becoming an obstacle to the development of DERs. According to a World Bank research, for the developing countries, like the S.E.A, costs are typically 10000 $/km, plus 7000 $ for materials. There are not clear regulations in many developed and developing countries for remote area small-scale renewable energy system grid connection.

However regulatory barriers still exist at the federal and state levels, which inhibits the effort to deploy renewables. Administrative procedures for approval are very long and in many developing countries policy instability creates stop-and-go situations. Among regulatory issues we highlight:

- *Identifying renewable energy zones*. The site selection is a regulatory issue during the planning of large-scale wind, solar PV power plants projects. This because there are "environmental worries". These "worries" are related to relocation and devastation of habitats for animal and different species of threes, water supplies and waterways and cultural resources like areas of importance and scenic beauty. Moreover, it is necessary to consider that most of the land is owned by the government or local people and is being used for agriculture, wildlife habitat, livestock grazing, etc. so, careful and efficiency planning of projects can reduce land and wildlife impact.
- *Distributed generation integration*. Regardless the growing interest in the distributed generation, there is not clear policies or regulatory instruments related

to the repercussions of DGI into electric power systems. With these conditions it is improbable to believe that these systems can thrive. Current transmission and distribution generation systems were developed and are operated as passive networks. So, it is necessary to formulate policies and regulations to support the integration of DG into electricity grid. in doing so, it is possible to increase supply security and ensure economic competitiveness.

- *Transmission planning*. It is a DG project regulatory process which identifies routing issues and constraints. A project cannot begin until the transmission planning process is complete. The DG access to existing transmission lines is a problem because of multiple power generation sources, power flow time coordination, all bringing significant challenges for existing power grids and Microgrids.

Regardless the positive aspects of renewable energy, the reality is that the green power is not cheap in comparison with the conventional energy sources. For example, solar power plants are costly systems, but costs have fallen in the last years. Also, costs related to the wind power and to small hydropower plants are expensive. Due to higher costs of renewable energy electricity generation, a lot of countries are providing various forms of support and incentives to increase their share in energy production and consumption with the aim to achieve set targets [21].

3.2 Renewable energy policies in the S.E.A

It is important to identify the most effective policies in the South East Asian context in order to mitigate the most prominent risks related to renewable energy investments and facilitate the application of the most promising financial mechanism in the region. There are some steps to follow in order to understand how and where it is possible to invest in this type of field [22]:

- Market creation policies as the renewable portfolio standard and the renewable energy certificate.
- Reducing uncertainties of investment in renewable energy through regulations.
- Improving profitability of renewable energy projects through the provision of power purchase agreements PPA and even fiscal incentives.
- It is necessary the support of R&D, grid connection, data of renewable energy resources and capacity building for all stakeholders.
- Enlargement the sources of funds dedicated to renewable energy and lowering the financial costs for this kind of projects.

Regarding the Environment of South East Asian, the member states have to work among five policy dimensions with the following issues:

1. Renewable energy certificates should be implemented because in this market a weaker form of renewable energy exists.
2. Renewable energy acts should be established to promote the culture of renewable energy and to spread this kind of projects.
3. The technological factors are crucial for the development of these instruments, so they need much emphasis, such as the availability of accurate data of renewable energy resources, smart grid capability.
4. More stability and predictability are necessary in the region of South East Asia.

Specifically, for off-grid renewable energy especially regarding rural areas, since these areas are several in the S.E.A, there are different issues to consider:

1. A clear electrification plan should be provided to reduce the risk of investing in renewable energy off-grid systems.

2. Public financing is still necessary since the low-income levels of rural areas and the high cost of renewable energy systems.
3. For business models, which provide electricity from renewable energy, information technology tools for remote monitoring, fee collection and regulating consumption are needed.
4. Capacity building for local communities, installation, operations are key to the successful adoption of renewable energy systems.
5. Training of local engineers need to be developed with government support.
6. Governments can cut the cost of investment if measure are taken along the whole supply chain.

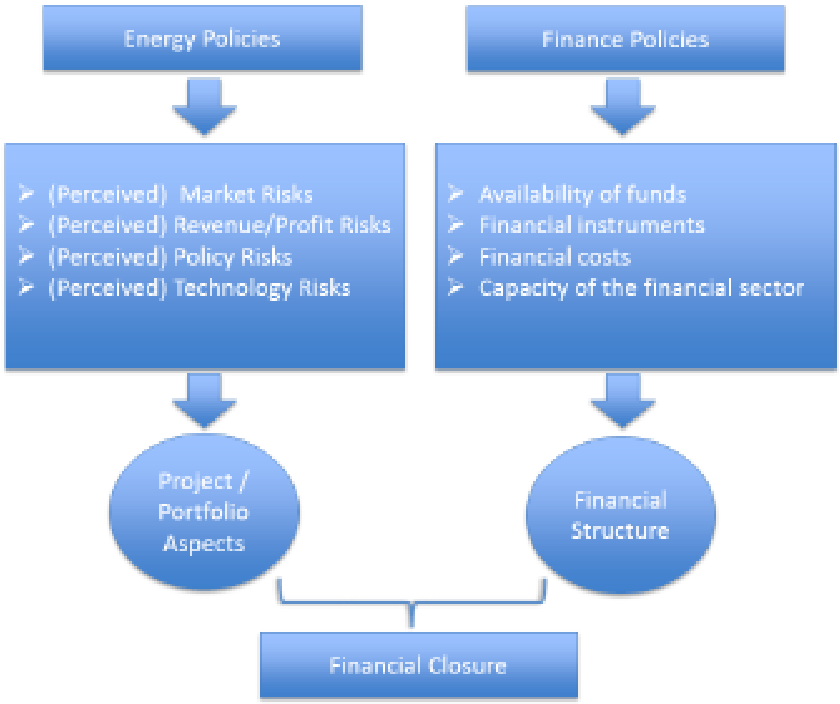

Figure 3.1: Supportive Policy Framework for renewable energy investment (source: IRENA, 2014)

Basically, investors make the final investment decision based on the risk-return prospects of a project or a portfolio of projects. On the other side, energy policies, by reducing the risks and improving the expected revenue, help improve such aspects to incentivise commercial and private investors.

Energy policies are concerned with the siting, planning, construction, grid access, pricing, sales and internalisation of environmental impacts of renewable energy projects. Finance policies ranges from providing public finance to incentivising private sector financing.

The key obstacle to financing is the reduction of sharing of risks involved in a renewable energy investment. the main financial tools are summarized in the figure below.

Private / Commercial	Public Financing
Equity / Balance sheet financing	R&D support
Debt / loans	Grants
Bonds	Soft loans
Credit facilities	Loan facilities
Insurance	Credit enhancement
Project finance	Credit lines
Lease finance	Guarantees
Refinancing	Incubators
Angel investor	Public VC funds
Venture capital	Public equity funds
Private equity	
Mezzanine finance (tax equity, passive equity, preferred equity, convertible debt)	
Development banks / Import-export banks	
Carbon financing	

Table 3.1: Financial Tools for renewable energy investment (source: ERIA)

The South East Asia countries face specific challenges due to their unique economic, demographic, geographical and technological characteristics. The need of electricity is the main challenge, especially those that have not been electrified and have no grid access. Other challenges take into consideration the lack of local capacity for installation and maintenance; the lack of experience with renewable energy projects; the lack of reliable data on renewable energy resources; the lack of mature financial markets and financial tools.

In particular, projects developers raise as much capital as possible form the cheapest source before moving up to the next. Capital subsidy is a kind of “free money”. Public loans, usually at low interest rates, could be used specifically for deployment of renewable energy projects. Venture capital or private equity investment facilitates the provision of funding to firms in the industry with unproven and high-risk technologies. Said this, new developments in investment channels emerge and are summarised in the following figure:

	Description
Project bonds	Debt securities issued on an individual project
Green bonds	Debt securities issued by corporations to support green investments
Yield companies	Listed investment companies with equities that pay dividends based on underlying assets
Asset-backed securities	Debt securities that pool assets such as mortgages or auto loans

Table 3.2: International Energy Agency, 2015 (source: ERIA)

But specifically, what are the renewable energy policies in the individual countries of the South East Asia? [22]

- **Brunei**: it is rich in oil and natural gas reserves, so it had little interest in the development of renewable energy. This is evident in the figure in the previous chapter about the installed capacity of power plants (Figure 2.10). However, due to worldwide focus on renewable energy and also to diversify its sources, also Brunei has to adapt itself to the new trends. In fact, it set a goal of generating 10% of electricity from renewable energy by 2035 and another goal of reaching 954 GWh of renewable energy power generation by 2035.
- **Cambodia**: it has many renewable energy resources such has hydropower and biomass. It is estimated that renewable energy has the potential to generate 67,388 GWh per annum. In this field, the lack of policies is one of the mail problems. Although the government has targeted to enable 70% of rural people to have reliable electricity services by 2030. Various policy measures to expand and improve grid accessibility should be taken simultaneously.
- **Indonesia**: due to its volcanic geology, it has a great geothermal potential which is estimated 40% of the world’s potential geothermal resources. Moreover, since Indonesia lies on the equator and has large coastal areas, it also has potential in wind and solar energy. However, regardless to its potential in renewable energy, these sources are not fully exploited due to the lack of fiscal and financial incentives and technological barriers. This must be the priority of the government. Recently the government has taken measures such as developing energy policy and regulations, targeting 17% renewable energy by 2025.
- **Laos**: it is a fiscally poor area, and as a result, there is little financial assistance to renewable energy investment. grid electrification is currently the most important energy strategy. Another off-grid electrification technology, pico-hydropower,

has been established but neglected. The Laos government targets to have 30% of renewable energy in the energy mix by 2025.

- **Malaysia**: renewable energy was targeted to be the major contributor to the electricity generation in 2001 but the goal to reach 500 MW of electricity to the grid was not achieved. Now, Malaysian government targets to generate total of 985 MW electricity from renewable energy during this period. there are many fiscal incentives implemented, like the "Pioneer Status" where companies are exempted from income tax on 100% of statutory income for 10 years.
- **Myanmar**: the electrification rate was 26% in 2010 and the renewable energy generation is virtually all from hydropower projects as we have seen in the figure in the previous chapter (Figure 2.10). Given its economic status, there are few renewable energy policies in place except a memorandum of agreement signed in 2014 which aimed to build two 150 MW solar facilities in the region of Myanmar.
- **Philippines**: it is characterised with a tropical climate, high rainfall and volcanic geography. So, it has a great potential in hydropower, wind and geothermal energy development (Figure 2.10). The government brought into effect the net metering policy that was established in 2008. Policies to support development of renewable energy technologies and facilities building are mostly missing in the country.
- **Singapore**: it has limited renewable energy options and the most viable renewable energy option is the solar energy as explained in the Figure 2.10 about the installed capacity of power plants that regards only the solar energy. This thanks to its average solar irradiance of 1150 kWh/m^2 per annum. Singapore is investing in renewable energy, amounting to $228 million, obviously with a focus on photovoltaic system. Singapore raised the cap on total power provided by variable renewable energy to 600 MW during peak demand. the government also provided funding to develop renewable technologies with the aim if prioritize them. Innovative financing and offsite PPA are being exploited to create business opportunities in this sector.
- **Thailand**: it has a great potential in solar energy (Figure 2.10). Furthermore, it extended subsidies for solar water heaters to 2021 and established a $121 million fund to encourage deployment of photovoltaic systems on buildings. The aim, according to the long-term alternative energy development plan, is to increase

renewable energy consumption to 25% by 2021. In 2030 20546 MW of electricity will be generated from renewable energy. Different policies have been comprehensive and contributed to private investment in the renewable energy sector. However, the market for renewable energy investment is yet to be expanded.

- **Timor Est**: this area is the only of the South East Asia that is not in the same step with the others. The territory is at high seismic risk and earthquakes are very frequent and, as we can see from the Figure 2.10 in the previous chapter, it has not any noteworthy installed power plant.
- **Vietnam**: in the 2008 the government approved the National Energy Development Strategy which sets targets to improve the percentage of renewable energy reaching the specific target of 11% by 2050. To encourage the development of renewable energy, some of the main difficulties that the government need to overcome are lacking awareness and reliable data on renewable technologies as well as inadequate regulatory framework.

After having presented the current situation in every country of the South East Asia in detail, to conclude we can say that:

Basically, the energy market exists but could be developed further. Incentives such as tax reduction are prevalent, while power purchase agreements are less present. Moreover, policies that may advance technologies are less seen, while financing resources, especially traditional vehicles, are already in place.

3.3 Investment incentives and initiatives

The governments of the member states of the South East Asia have started to address those barriers explained before with several policies in order to allow the development of renewable energy projects. Governments do this with the aim to incentivize renewable energy investment giving them the possibility to overcome financial and non-financial barriers. Since the socio-economic situation is quite the same in all the countries of the S.E.A we can investigate what the main financial incentives are taking a close look in some of those countries. We take as example, the main developed South East Asian countries in the implementation of renewable energy projects: Thailand, Indonesia, Vietnam and Philippines. In fact, not by the chance, between the member states of the S.E.A, they are the firsts for installed capacity of renewable energy power plants (as we can see from the figure 2.10 in the chapter 2).

Before starting it is important clarify the definition of incentives. Investment incentives are classified in three categories:

- Financial incentives like outright grants and loans at concessionary rates.
- Fiscal incentives like tax holidays and reduced tax rates.
- Other types of incentives like subsidized infrastructures, market preferences, etc.

The figure below shows what the main incentives are in **Thailand** [23]:

INCENTIVE TYPE	REGULATION	SCHEME	DESCRIPTION	TYPE OF SUBSIDY
Financial incentives	Feed-in premium (Adder)	Feed-in tariff (FIT)	Additional payments to RE generators	Direct transfer of funds, market price support
	The ENCON Fund	Compulsory, voluntary and complementary program	Government Building Project; Project on Existing Designated Factories and Building; Project on Factories and Buildings under Designing or Construction; and Promotion of Small power producers	Direct transfer of funds
		Revolving fund	A fund used to provide low-interest loans to RE and energy businesses	Direct transfer of funds, provision of goods or services below market value
		Investment grant	Provision of investment grants for bio energy and energy from waste.	Provision of goods or services below market value
		Energy Service Company (ESCO) fund	Equity investment scheme, credit guarantee scheme and technical assistance	Direct transfer of funds or liabilities Government loans and loan guarantees
	Carbon Credit guarantee facility		Provision of support to develop CDM and provide access to carbon markets	Provision of goods or services below market rates
Fiscal Incentives	Investment Promotion Act	Import duty exemption	Exemption and reduction of import duties on machinery and raw materials for export production	Exemptions from excise taxes/special taxes
		Exemption on income tax and dividends	Up to eight years corporate income tax exemption for RE manufacture and consulting services. 50% reduction from years 9-13	Tax expenditures
		Other tax deductions	Tax deductions on transport, electricity, water supply and installation or construction	Tax expenditures
Other	Regional incentives and Special Economic Zones	Feed-in tariff	Higher FIT rates in some areas	Market price support
	The ENCON fund	Complementary program, voluntary and complementary program	Funding for human resources development, public awareness, industrial liaison, management and monitoring	Provision of goods or services below market rates

Table 3.3: summary of investment incentives (source: TKN REPORT)

Financial incentives:

- *Adder (Feed-in Premium) Scheme*. This program was introduced in order to permit to renewable energy investors to be eligible for an additional price on for electricity when selling to the Thai power utilities. In 2012, adder rates for renewable energy are differentiated by technology and installed capacity. Unfortunately, the Thai government suspended the purchase of solar energy through the adder program while the purchasing scheme rate and regulations were revised, due to the larger cost than the one expected. The adder rates programs for the other categories of renewable energy sources are still in place.

- *ENCON Fund*. It is Thailand's main source of public finance for renewable energy subsidies and incentives. The fund receives money transferred from the petroleum fund. Further funding comes from surcharges on power consumption. The fund provides working capital and grants for investment in energy efficiency and renewable energy for the public and private sector. The ENCON Fund reached an amount of 32000 million THB in the 2012.
- *Revolving Fund*. It is a low-interest loan scheme for energy conservation and renewable energy projects. The fund allocated money from the ENCON Fund through financial institutions to entrepreneurs. The aim is stimulating financial institutions to provide finance to energy conservation and renewable energy. The fund provides loans to banks at a 0% interest rate and then, banks give this money to renewable energy projects with a maximum interest rate of 4% for a maximum loan period of 7 years.
- *Investment Grants*. They have been promoted especially, to support the use of biogas and solar thermal. The ENCON Fund approved about 4000 million THB to support the use of biogas technology from wastes. The maximum investment grant is about 20-50% for capital investment.
- *ESCO Fund*. It is aimed to encourage investment in energy efficiency and renewable energy projects and to promote greater use of energy management services. it was created to target SMEs that demonstrate potential in energy saving but faced problems with project financing for investment. so, two fund managers from non-profit organization were assigned to implement this program.

Fiscal incentives:

- *Investment Promotion Act*. The Board of Investment is authorized to grant tax incentives and provide services. no restrictions are made on foreign equity manufacturing and protections are provided to mitigate risks to investors. Investment services include provision of information, contacts and coordination with other public agencies.
- *Renewable Energy Sector Tax Incentives*. The Thai government introduced tax incentives to encourage energy-efficiency improvements and renewable energy investment by the private sector. They provide corporate income tax exemptions

for 8 years for the manufacture of solar cells, the manufacturing of energy-saving or renewable energy equipment. Moreover, the Board if Investment will also provide 50% reduction of corporate income tax depending on the location of the project.

Other incentives:

- *Regional Incentives and Special Economic Zone*. The Thai government has provided additional rates to renewable energy projects in three provinces that have political unrest issues and in remote areas. This is to help investors operate renewable energy projects in those areas.

About **Indonesia,** this is the situation [24]:

INCENTIVE SCHEME	RELATED REGULATIONS	REMARK
Financial incentives		
Indonesia Infrastructure Guarantee Fund	MoF Regulation 260/2010	SOE providing guarantee to attract private capital investment in infrastructure development.
The Geothermal Fund	MoF Regulation 3/2012	Provides finance for exploration, only to be paid for if sites prove productive.
Development Credits for Biofuels and Plantation Revitalization	MoF Regulation 117/2006 MoF Regulation 79/2007	Low-cost loans for farmers and farmer groups that plant energy crops.
Government financial guarantee	MoF Regulation 139/2011	Government guarantee for geothermal and hydro power plant projects as part of FTP II of electricity development.
Fiscal Incentives		
Import duty and VAT exemption	MoF Regulation No. 21/2010	Import duty exemption on machinery and capital for development of power plants. Exemption from VAT on importation of taxable goods.
Income tax reduction	MoF Regulation No. 21/2010	Reduction and various facilities for income tax on energy development projects, including net income reduction, accelerated depreciation, dividends reduced for foreign investors and compensation for losses.
Provision of goods or services below market value		
The Geothermal Fund	MoF Regulation 3/2012	Survey and exploration services, only to be paid for if sites prove productive.
Guarantee on business viability of PLN	MoF Regulation 139/2011	Guarantee that PLN would perform its business activities and respect contracts with IPP.
Public competitive bidding	MEMR Regulation 1/2006	Agrees favourable tariffs with most competitive company bidding for tender.
Feed-in Tariffs	MEMR Regulation 4/2012 MEMR Regulation 22/2012	FIT for biomass and mini hydro power plant. FIT for geothermal power plants.
Mandatory utilization	MEMR Regulation 32/2008	Obligatory usage of biofuels for fuel mix. Mandatory usage of biofuels in mining industry.

Table 3.4: incentive scheme for renewable energy (source: TKN REPORT)

Financial incentives:

- *Geothermal Fund Facility*. The government allocated a revolving fund of 1236,5 billion Rp for geothermal development. One of the two services of the GFF is that, it will provide financial support for data collection and high-quality information about the new potential geothermal sites. The fund can be applied to by local governments where the site is located or by private investors.
- *Infrastructure Guarantee Fund*. It is created state-owned company which guarantees any contractual risks in order to facilitate the implementation of large infrastructure projects.
- *Loans at an interest rate lower than provided by national banks*. These loans are available to farmers for planting palm oil for biofuels. This was followed in order to enables SMEs to obtain low-cost finance from national banks for food and energy crops. The maximum period of these loans is 5 years.

Fiscal incentives:

- *Income tax reductions*. A renewable energy investor is eligible or net income reduction by 5% of the investment value each year, over a period of 6 year. There is a tax reduction also for foreign investors allowing them to pay a rate of 10% on dividends they receive.
- *Import duty and VAT facilities*. This is used for goods or machinery that are not available in Indonesia or that have an insufficient quality. This import duty exemption is also available for power plant development from all other sources of energy. It is valid for 2 years and can be extended. Investors have to request the facility following several procedures. Indonesia offered also a tax incentive for investors in renewable energy projects that would allow the government to pay for their income tax and VAT for the current year.

Other incentives:

- *Guarantee for PLN's business viability for power projects operated by IPPs (independent power producers)*. It is available for all renewable energy technologies, but since the program is related to big projects, only geothermal and hydro projects (Figure 2.10) get the facility. The government ensures that PLN (the Indonesian government-owned corporation) would have sufficient financial capacity to fulfil its payment obligation to IPPs under the purchasing power agreements.

- *Bidding processes for power projects*. They are used to choose which investors have to be awarded a tender to build new capacity and to agree and appropriate concessionary tariff. In the case of hydro and geothermal sites, tenders are awarded through a competitive evaluation of project development plans. While, for smaller electricity providers, PLN has the obligation to purchase the energy produced.
- *Feed-in tariff*. It sets a guaranteed purchasing price for renewable electricity generated by IPPs. It is set at the beginning of the project with the assurance that PLN will take all the electricity produced by the power plant. This price reduces the risk associated with the investment and operational costs.
- *Mandatory utilization*. Fuel distributors are obliged to mix some part of their products with biofuels in order to contain up to 10% fatty acid methyl ester and 10% bioethanol. This number is expected to increase reaching 20% of transportation fuels by 2025. Another form, introduced by the government, is the compulsory use of biofuels in certain industrial sectors.

Moving to **Vietnam,** we can distinguish between financial incentives, fiscal incentives and market price support and regulation which support market prices and demand for renewable energy [25]:

Financial incentives:

- *Financial incentives are focused on the provision and cost of project finance*. this is particularly true for renewable energy projects which require a large amount of capital and can involve several risks for investors. Financial incentives take the form of mechanisms such as investment grants, subsidies loans, loan guarantees and insurance.

  In 2006 was introduced investment and export credits in order to cover the cost to build small hydropower projects and wind farms. The loan size for each eligible project is up to 70% of the total capital of the project. In the moment in which projects require funds that are higher to the 70% of the total capital, it is necessary a bank loan that must be approved by the Ministry of Finance. the government can provide loan guarantees in cases where investors have to obtain loans from other financial institutions.

In Vietnam, it is also created the biogas program in order to develop biogas technology with the aim to provide sustainable energy source and improve the quality of life of rural farmers. This program consists of public-private partnership model aimed at enhancing the participation of the private sector in the commercialization of the technology and the development of credit structures provided by financial institutions for accessing finance.

Finally, biomass and biogas sources are promoted and supported by investment incentive schemes.

Fiscal incentives:

- They are provided through *tax provisions*. They are aimed to reduce costs related to investment and plant operation.

  Fiscal incentives for renewable energy are summarized in the table below:

	STANDARD GOVERNMENT RATES FOR ENTERPRISES	PREFERENTIAL TREATMENT FOR RENEWABLE ENERGY ENTERPRISES
Importation duties	There are three import duty rates in Viet Nam: ordinary rates, preferential rates and special preferential rates (PricewaterhouseCoopers [PwC], 2012) In calculating import duties, Viet Nam follows the WTO Valuation Agreement. Value of dutiable imported goods is based on the transaction value (PwC, 2012).	Exemption from import tax on machines, equipment, tools and materials imported for production activities. Available for the first four years of operation.
Value Added Tax (VAT)	Viet Nam has three VAT rates: 0%, 5%, and 10% a) 0% for exported goods such as those sold to firms without a permanent legal base in Viet Nam and goods at duty free shops. b) 5% is applied to enterprises that provide essential goods and services such as books, teaching aids, clean water, etc. c) 10% is applied to all other activities that are subject to VAT.	a) Purchase of investment equipment is exempted from VAT. b) 0% VAT for renewable energy projects.
Corporate Income Tax (CIT)	Standard corporate income tax for enterprises is 25%. However, enterprises in oil and gas industry have to pay tax ranging from 32% to 50% depending on the geographic location.	a) Tax rate: 10% for a period of 15 years for newly established renewable energy enterprises. If the project employs advanced technology or is a large-scale project, corporate income tax rates can be extended up to 30 years with a tax rate of 10%. b) Tax exemption and tax reduction: for the first four years, enterprises receive a tax exemption. For the next nine years, enterprises may also receive a tax reduction of up to 50% (Decree No. 124/2008/ND-CP, 2008).
Soft loans	Companies borrow from commercial sources based on market rates.	Investors are supplied with preferential loans of up to 80% of the investment cost of projects. In addition, Government Decree 75/2011/ND-CP (August 8, 2011) stressed wind power projects were eligible for government credit incentives.

Table 3.5: fiscal incentives for renewable energy projects in Vietnam (source: TKN REPORT)

Incentives related to market support and regulation:

- *Avoided Cost Tariff*. By definition, it is “the electricity tariff calculated by avoided costs of the national power grid when 1 kWh is generated to the distribution power grid rom a small renewable energy power plant”. Avoided cost means “the production cost per 1 kWh of the most expensive power generating unit in the national power grid, which would be avoided if the buyer purchases 1 kWh of electricity from a small renewable energy power plant instead”. This instrument is applied in the formulation of the purchasing price of electricity generated by small renewable energy power projects with an installed capacity of 30 MW or less, like some of the hydropower plants in Vietnam and plants that exploit the geothermal source. This tariff allows small renewable energy power projects to sell electricity at a price equal to other generation sources.

- *Wind power*. The Ministry of Finance of Vietnam has announced a price subsidy of 0,078 $/kWh for wind farms. The unit subsidy for buying the electrical output of grid-connected wind farms is calculated as subsidy per unit multiplied by the level of bought electrical output. the investment costs for wind power farms equipped with new technology, in line with the international standards, are paid at 2250 $/kW. The average electricity price is calculated at 0,1068 $/kWh equivalents.
- *Small-scale hydropower projects*. Investment incentives have been established based on an avoided cost tariff for electricity generated by small-scale hydropower plants.

To conclude, in Vietnam there are also other subsidies available for investors. For example, renewable energy projects are not involved in the fees related to the protection of the environment:

Environmental protection fees	a) Solid waste: With the ordinary solid waste from business: not exceeding VND40,000/tonne (nearly US$2/tonne). With hazardous solid wastes: not exceeding VND6,000,000 /tonne (nearly US$300/tonne) (Decree No. 174/2007 ND-CP, 2007) b) Liquid waste: + Chemical Oxygen demand from VND100/kg to VND300/kg +Suspended solids from VND200/kg to VND400/kg + Mercury from VND10,000,000/kg to VND20,000,000/kg +Cadmium from VND600,000/kg to VND1,000,000/kg (Decree No. 04/2007/ND-CP, 2007)	Exemption from environmental protection fees.
Land-use fee/rental	Dependent on location.	Dependent on location of the project; enterprises receive exemption/reduction of land use fees.

Table 3.6: other subsidies for renewable energy in Vietnam

Must be said that in Vietnam these investment incentives have little effect on investment decisions and are not considered critical variable by foreign investors. Moreover, Vietnam has not a clear legal framework on renewable energy projects. In many countries in Vietnam, laws and regulations are contradictory, hence, investors, that want to invest in the field of renewable energy, have to face a lot of challenges aside from investment incentives.

In **Philippines** [26], aside from the other renewable energy projects like hydropower, solar and wind power plant, there are important studies about the use of Microgrids that are worth investigating.

In terms of off-grid electrification, the efforts are focused on enabling the privatisation of some operations and the electrification of missionary areas and renewable energy development.

The privatisation of National Power Corporation (NPC) is intended to reduce the dependence on government resources for power generation in more viable areas and increase the availability of resources in order to reach also unelectrified areas. Nevertheless, was not sufficient to attract more private investors to venture into off-grid areas.

The program, called Renewable Energy Act, is aimed at giving the guidelines for power generation in the main grids with regard to measures as feed-in-tariffs and net metering. Renewable energy developers must respect specified contracts in order to have benefit from incentives.

According to these preconditions, in case of Philippines, instead of incentives, we talk about initiatives. So, the main initiatives are the following:

- *Renewable Portfolio Standards*. They are created in order to accelerate the development of renewable energy sources in off-grid areas by mandating that a minimum percentage of renewable energy generation and supply comes from renewable energy. Anyhow, this is not enough if the goal is to develop these sources in Philippines, but it is necessary other incentives and subsidies.
- *Amendment to the Quick Test Professional (QTP) guidelines*. After the failure of these QTP to take off despite the early issuance of the guidelines, the government reviewed and abrogated new regulatory frameworks for the entry of third parties on off-grid areas. The same rigorous process of registration and application is applied to all projects regardless of size and technology. It is necessary to revise the requirements for the renewable energy developers because they tend to deter rather than encourage the entry of private-sector actors. If those requirements are simplified, compliance costs, in terms of time and financial resources, are

reduced. In the recent years, the government of Philippines has abrogated the Energy Virtual One Shared System, a web-based application processing and monitoring system aimed at decreasing the time to obtain the necessary permits to start renewable energy projects.

- *Universal Charge for Missionary Electrification subsidy*. All electricity end-users are obliged to pay a universal charge to fund missionary electrification. The amount of subsidy for each area is based on the cost of production and on the production-tariff applied to electricity consumers. Missionary electrification is related to the provision of basic electricity to unviable areas, but there is confusion among which the unviable areas are. Moreover, only large islands are receiving funds while the remote islands remain substantially isolated, receiving less electricity service for limited hours.
- *Rate setting for off-grid rural electrification*. The proposal is to adopt a methodology for setting a benchmark tariff in which solar home system households are grouped together into cost areas. These areas are defined according to their distance to the nearest office of electricity service. It also provides adjustments in the incremental costs for personnel allowance and transportation, which are necessary for taking care of solar home system customers in isolated and far areas.
- *Proposed distributed generation and renewable energy deployment roadmap*. According to this program are been recommended the provision of mechanisms and incentives to new power providers to distribute renewable energy in off-grid areas. In this direction there are funds under the General Appropriations Act.

Form this overview of the situation in Philippines, it is evident that it is necessary something more. The government of Philippines is called to identify new ways with the aim to improve and attain sustainable energy access using renewable energy solutions. If those objectives will be reached will be possible reducing the use of fossil fuel in off-grid rural electrification.

In this direction, several organisations in the South East Asia, not only in Philippines, are trying to use renewable energy Minigrids for rural electrification. For this type of project, the first issue is to choose the specific area where a renewable installation is advisable and if it will result in a lower energy cost. It is important to give solutions to off-grid areas, but they are complex and heterogeneous so, specific renewable energy technologies for the installations of mini-grids are required.

The lack of economies of scale and other technical difficulties are the main challenges that off-grid renewable energy has to meet. Moreover, in off-grid areas there are few technical expertise that are able to deal with these technologies and these projects in order to be financed require a working model that investors can observe. Probably, they will be carried out by the government or implemented by the private sector. The government effort is necessary, it must be able to develop the right mix of regulatory framework and incentives in order to attract the private sector to invest in this field. In other word, entry barriers must be reduced to permit the development of these renewable energy projects.

3.4 Investment in Off-grid renewable energy projects

Off-grid renewable projects are the starting point of the development of electric grid in those areas where a strong demand brings to build a proper distributor generator without waiting the construction of the main grid. Microgrid is the answer to this issue because is the cost-effective solution to implement in the moment in which the main network is missing.

We have understood that in the South East Asia, one of the main challenges is to reach off-grid areas investing in off-grid renewable energy projects. After having presented some specific cases in some of the main promoters South East Asian countries, it is important to highlight how it is possible to facilitate the investment in off-grid renewable energy projects with specific instruments. This is a critical issue due to limited financing access low affordability for consumers and high transaction costs. Access to electricity is crucial to human development and it is essential for basic needs and improve the quality-life of everyone. Significant programs were launched in order to increase the population's access to electricity. For example, in 2011, was launched the Sustainable Energy for All initiative aimed at making sustainable energy for all a reality by 2030. In order to achieve this target, Minigrid and off-grid electricity supply systems are implemented.

As said before, off-grid solutions are crucial especially in remote and rural areas because they are more cost competitive than grid extension. Moreover, in these areas grid extension is not suitable due to transmission losses and maintenance. While, Minigrids are aimed to provide the solution when a central grid is absent, especially in small towns or large villages where the electricity should be generated in order to power the household use. It is estimated that about 60% of additional generation capacity for electricity access by 2030 will come from off-grid installations, both stand-alone and Minigrid.

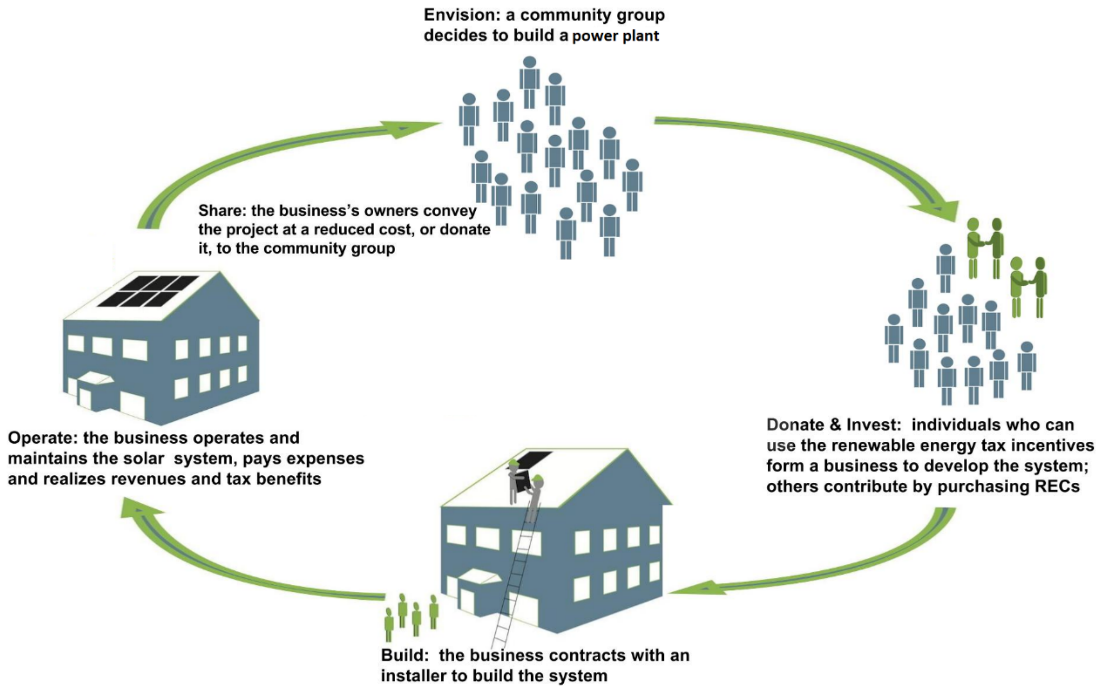

Figure 3.2: community renewable energy finance (source: AIRE)

In order to support these projects is necessary both financial and fiscal incentives. We have seen before, some examples in specific areas, but this is the situation in all counties of the South East Asia.

Government grants are necessary because the cost of these technologies is high, and it is difficult to be financed by rural population. While donor funding can play an important role in supporting those projects. In addition, specific electricity tariff mechanisms and subsidies could be incorporated to address the issue of setting up a special fund to spread the finance channels, providing preferential interest rates for the loan, thinking of a tariff that can cover the initial costs or levying low import duties. For example, in case of Philippines, the government has provided lower interest loans with the support of various funds.

Moreover, the importation of machinery and equipment for Minigrid projects is exempted from the payment of tariff duties within 7 years from the date of assigning the contract. Tax credit is given to developers who purchase machinery and materials.

Following the development of the entire project, it is useful distinguishing between various types of investment considering the different phases of the project itself.

According to the study of Kimura S., et al. (2015) [22] we consider three phases of the project lifecycle:

- Plan and development phase
- Operation and maintenance phase
- Energy use phase

1. **Plan and development phase:**

   During this phase, called also pre-investment phase, grants or subsidies can be designed for feasibility requests, business plan development, technical planning, capacity building as well as transaction costs. In developing countries, like South East Asia, rural electrification investment cannot totally rely on customer revenue in the short and medium term. It needs subsidies that should be designed to support rather than obstruct Minigrid roll-outs. Capital subsidy is one of the most adopted policy instruments to assist off-grid projects to overcome the obstacle of the initial investment.

   Other fiscal incentives can help to promote the development of renewable energy decreasing the investment costs such as accelerated depreciation. Accelerated depreciation is widely used to support investors of renewable energy projects in order to cut the equipment costs and to increase the profit, reducing taxes.

   Crowdfunding is a new mechanism of financing where investment funds, for example in solar systems, are raised from individual investors through internet. Companies that manage crowdfunding platforms for these types of investments, pool many small investments from several individual investors and these individual investors receive interests and are paid back in full over a specified number of years. Through crowdfunding, people are able to provide zero-interest loans to organisation and products that they support. Basically, this instrument increases the financial channel for these projects. In addition, it is also given easy access for investors or donors that try to approach to these projects.

   Finally, in remote rural areas, the most effective way of delivering energy is through small-scale systems and with distributed clean energy.

2. **Operation and maintenance phase:**

In the operation and maintenance phase, incentives related to the energy generation or to a fixed subsidy per connection can help to cover maintenance and operational costs and finally to cover profit gaps. Some subsidies of operation and maintenance are crucial in order to support project activities over a long period, particularly in the case of extremely remote areas with a poor ability to pay. For example, in Thailand, as said in the previous paragraph, the government has abrogated a pricing subsidy for the capacity generated by renewable energy from small power producers.

Moreover, subsidies can also be available to the Minigrid operator achieving certain targets. Also, the training and capacity development should be considered, since the human resources are the key for promoting the distribution of renewable energy projects.

Must be said that, the local involvement of operation and maintenance could save costs and create opportunities for income generation.

3. **Energy use phase:**

The appropriate tariff scheme is complex, and it must consider the following three aspects:

- To ensure energy affordability of low-income consumers.
- To be cost-effective for private renewable energy developers.
- To encourage consumers to manage their energy consumption in a different way.

Form the developers' point of view, tariffs must be cost-reflective. In the opposite case, Minigrids cannot be managed profitably and this situation hinder potential customers in rural areas from receiving high quality electricity.

From a regulatory point of view, the critical problem of tariff directly affects the deployment of Minigrid and their sustainability in the long-term. There is not a valid solution for all the tariffs, so it is necessary reaching an equilibrium among these aspects. In order to overcome the challenges created by high initial cost of renewable energy projects and low affordability of consumers, governments and developers are trying to transform the system in which there is a high initial cost into a new one in which there is a long-term energy service. The World Bank Group has implemented the so-called Long-term Consumer Credit to overcome the first cost barrier, and it has forecasted that consumers will be able to continue to pay what is equivalent to their conventional energy purchases. Demand-side subsidies incorporate the off-grid electricity tariff settings to support consumers of those projects.

The use of tiered electricity tariffs can be an effective way to address energy poverty, improve energy viability, because the Tier 1 tariff could be lowered so that low-income consumers can also have access to electricity, whereas the tariff could increase at higher tiers to reach higher efficiency.

The tariff design must consider the feasibility and costs of tariff collection. Microfinance to rural households has been successfully implemented. For example, in Laos, interest free loans were provided to poor families to be paid back in a 3-year period.

In practise, consumer credit can be provided through:

- Local development finance institutions
- Microfinance organisations
- Equipment dealers

It seems that result-based subsidies, which aim to subsidies connection fees for consumers are more efficient than operational or investment subsidies to investors. Moreover, in different institutions, also in banks, the presence of an implementing organisation and direct access to loans for costumers are the strength points of the microcredit financial model.

To conclude this topic, various business models can be used to support the creation of those projects and improve their financial sustainability (Kimura S., et al., 2015):

- Utility model
- Community model
- Private model
- Hybrid model

Utilities has more experience, financial resources and technical capabilities in order to realise rural electrification projects. Instead, the private model works in a more effective way, but it requires higher rate of returns.

Local communities have the best knowledge of the local conditions and they can operate more efficiently after an appropriate training and capacity development. Moreover, the cooperation with local governments can be also better than cooperate with the central government.

The hybrid model combines different players so that they can make different roles during the lifecycle of the project, i.e. introducing the utility as investors, combining the community as the operator as operator with the private organisation's technical and financial support.

Private operator models, where private investors build and manage the off-grid system, have the potential to attract private investments. Various forms of assistance should be offered in order to promote their development, creating a publicly backed debt or credit enhancement facility that can provide low interest loans that commercial lenders are not able to give. Loan guarantees provided by national banks may compensate the lender in the case of default, and the loan guarantee can cover 50% of the loan itself.

There are also instruments that are able to face issues related to the credit risk. It is not easy to extend credit to rural consumers with little credit history. It is possible to adopt three methods in order to mitigate the risk:

- Credit guarantee schemes
- Microfinance lending
- Partnering primes via models

Another way that can be exploited, with the aim to promote these projects, could also be the joint development of other industrial activities in the same areas that could increase the interest of investing in such zones.

The project of Powerhive is set in this direction, perfectly in line with the characteristics explained above.

Figure 3.3: Powerhive, American company specialized in the storage projects (source: Rinnovabili.it)

This project is focused on the storage capacity and telecommunications network in a community of Minigrids. This company has spent the last 3 years testing the effectiveness of this solution in a series of isolated villages in rural areas. In fact, it plans to expand the project also in the South East Asia.

The choice of these locations is certainly not left to chance. In fact, it has many advantages: not only for the more isolated villages, where the national network does not arrive or does not guarantee the continuity of electricity supply, but also in order to increase the resilience of local communities in areas where the risk of catastrophic natural events is high. It seems evident that those areas are perfectly suitable for the development of these projects, this is a necessity. Nevertheless, since in the South East Asia there are several rural and poor areas, it is indispensable a specific support from the governments and incentives that can help the development of renewable energy projects.

Alternatively, it can be thought of as a transitory solution in a post-disaster situation, covering the period necessary to rebuild the basic infrastructure [27].

The area of the South East Asia is characterised by strong economic growth and it will face a constantly increasing energy demand. As the economies of the South East Asian countries depend on imports of fossil fuels, they have started to consider renewable energy sources as a viable solution to meet the growth of energy demand.

For example, the importance of solar energy is destined to increase in these countries, given the abundance of solar exposure and thanks to the new state incentives. Now, as said in the previous paragraph, Thailand seems to be the country that has been able to exploit in the best way the solar energy. However, even the surrounding countries have started investment projects for the construction of solar panels, they have proposed incentives and attracted solar panel manufacturers.

In addition, South East Asian countries host annual events with the aim of attracting local and foreign investors in the solar energy sector, as well as in every renewable energy source [28].

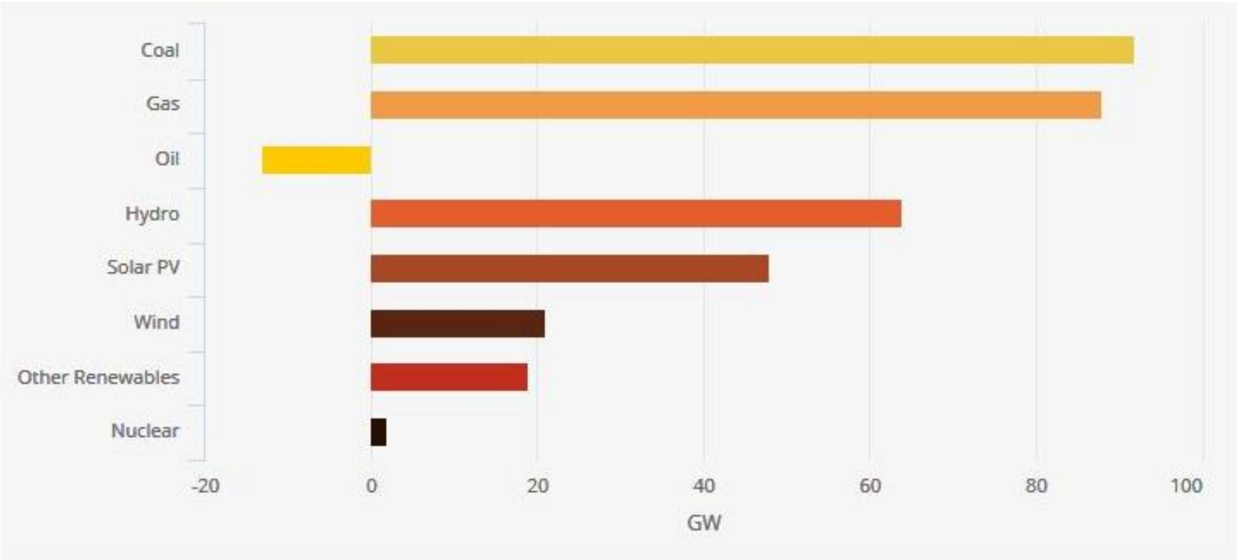

Figure 3.4: installed generation capacity by type to 2040, outlook 2017 (source: IEA)

According to the IEA, International Energy Association (2017) [29], electricity will represent the largest share of the increase in final consumption, as the increase in income in the region will result in a greater ownership of household’s appliances and cooling appliances. 2/3 of the growth in electricity demand will come from the residential and service sectors, due to the increase in the urban middle class. The demand for industrial electricity will also double, while for transport, in the absence of support policies for the moment, electric mobility will not give significant results.

To meet the increase in electricity demand, it will require a huge expansion of the region's energy system, with renewable energy that will account for almost 70% of the new capacity.

Finally, regarding the development of Microgrids, between the protagonists, some of the major investors are Elon Mask with Tesla, Schneider Electric, Engie, Microsoft and Facebook, that have the aim to develop network infrastructures in the under-electrify areas, like the South East Asia [30]. This is reported by Bloomberg New Energy Finance (BNEF) highlighting that the last years are crucial for the development of new Microgrids, powered by wind and solar plants with integrated systems of electrochemical storage. Several island communities will act as "technological test bed" for this sector in full and constant evolution.

Starting from Minigrid networks seems the most logical and profitable choice because in the small island the cost of electricity is much higher than in mainland. Replacing diesel generators with renewable sources and storage devices, therefore, offers several advantages, like security of supply, energy independence and lower electricity prices, while companies can test their technologies and then supply them in large projects, exploiting the economies of scale and skills acquired in the field.

Of all Tesla's installed capacity in network storage between 2016 and 2017 (not only in S.E.A), we are talking about 174 MWh in which the 36% is for the island Microgrid that replaces and supports conventional generation with fossil fuels.

Among the projects, we find the agreement signed by Schneider Electric, Engie Lab and Nanyang Technological University to improve access to energy in the off-grid areas in Singapore and in the South East Asia through a series of renewable Micro-networks combined with energy storage systems.

The French company Engie, in partnership with Electric Vine Industries, also plans to electrify about 3000 villages in Indonesia with photovoltaic smart grids. Moreover, always in Indonesia (but not only), a group of companies such as Facebook, Microsoft and Allotrope Partners, has launched a fund with the idea of mobilising $50 million of Micro-network investments in 2018-2020.

More generally, these companies intend to develop energy and telecommunications infrastructures in various emerging countries.

CHAPTER 4: PREDICTION OF MICROGRID DEVELOPMENT

These two last years have been fundamental for the Micro-power grids development.

Whether they are intended for rural regions or non-electrified areas, Microgrids have finally created a solid basis of development. The market is in the hands of big-tech companies and the energy storage industry, focused on investing in small-scale projects. However, also island communities have taken a piece of the market, because they are perfect test beds for new pilot systems.

In this context, India has one of the leading roles. In the first quarter of 2017, New Delhi announced the allocation of 740 million dollars for the electrification of all the villages of the nation by the end of next year, including almost 3000 communities in which, for economic issues, it is not possible to bring the electricity grid in a conventional manner. In the Asian giant, as in many developing countries, small plants power by renewables find a fertile filed. Photovoltaics, especially the Chinese one, is one of the fastest growing solutions in the field of distributed generation.

As previously announced, the role of technological laboratories rests on the islands. In the last years at least more than a dozen projects have been presented or commissioned, employing Micro-power grids and multiple energy storage systems. It ranges from the commitment of the International Agency for Renewable Energy (IRENA) to install 30 MW of clean energy in the Pacific Islands, to the project conducted by Tesla for the Hawaiian Kauai and Honolulu.

As said at the end of the previous chapter, other technology giants have also recently appeared on the global scene with Microgrid projects. These include Schneider Electric and Engie, aimed at improving access to energy in South East Asia, and Microsoft and Facebook, among the founding members of a “Microgrid Investment Accelerator”, a new financing mechanism that aims to raise $500 million [31].

4.1 The current Microgrid scenarios

Financing rural Microgrids is a different task from a traditional utility power plant because they operate without the cost of raw materials. Except from the development cost (generally covered by a proper financing operations), the operational costs are equally divided within the customers because they are independent from the amount of the energy consumed. In this way, the management of Microgrid is significantly different from that of traditional utilities and use of energy metering is highly reduced or completed avoided. Data shows that, where the power is consistent, rural consumption is unequally distributed. The financial success of a rural Microgrid relies on the wealth distribution between the customers in the compound in the village. In most Microgrids, four out of 5 customers had a zero or negative account balance for at least six days. Pricing models should allow for such flexibility. So, the richest of Microgrid consumers buy most of the power.

Said this, in frontier markets, like this, it is important to reach the last mile. In order to exploit this market several partnerships have been created aimed at seeking to power all the people. In the last years a lot of companies are emerged and wants to overcome the boundaries of this market with new and innovative solution that can reach isolated and rural areas with low costs:

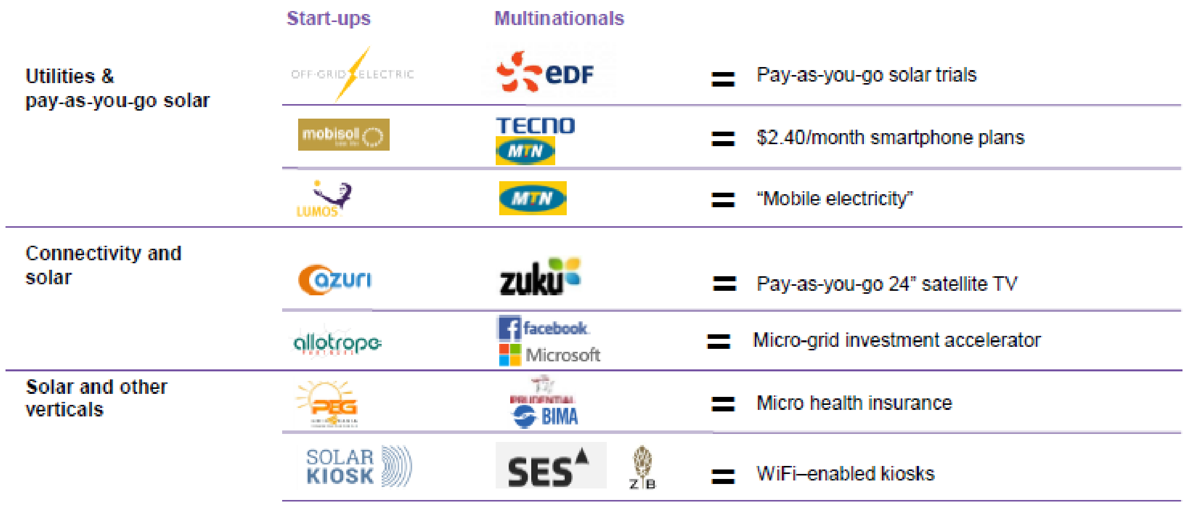

Figure 4.1: connectivity partnerships, 2017 (source: Bloomberg New Energy Finance)

As we can see, the market for Microgrids and hybrid generation in emerging economies is getting bigger, with a strong focus on islands, remote zones, and rural areas. The projects of Microgrid are the new frontier, and since there are just few projects, project developers are growing more comfortable with the role that these instruments play in serving remote regions [32].

In this perspective, we will consider only the last years because only the recent period has known a great development of Microgrid projects.

Considering the 2017, at least 20 MW of renewables-based commercial or industrial Microgrid projects were announced in developing countries like Africa. In 2017, the market leader for rental power, the English company Aggreko, has introduced a solar-diesel hybrid product and bought an energy storage company to better control those projects. In fact, the aim of these company that are emerging in this market is to find a low-cost solution that can store energy, exploiting renewables even when the source is missing because, as said in the previous chapter, renewable energy sources suffer from non-continuity of power. This is the precondition.

In general, the popularity of renewable is growing across emerging markets. Non-OECD countries bought $722 million worth of PV equipment from China in March 2017. India was the biggest buyer while total spend on PV from China has installed in South East Asia and Africa [33].

Specifically, residential Microgrids saw $386 million in program and loan announcements, by governments and development banks. The commercial and industrial sector benefits from favourable economies and projects on islands and in the mining-sector are common because those sites offer the necessary lands for renewables development. The most noteworthy new hybrid renewables/diesel or renewable/storage projects in developing countries since April 2017 are [34]:

- Rental power giant Aggreko will supply the Nevsun copper and zinc mine with 29,5 MW, including 7,5 MW of solar.
- Tata Power Solar 3 MW PV plant at an iron or mine. This site is grid-connected and benefits from net-metering arrangement but can be isolated and function as a Microgrid in case of an outage.
- Enel Green Power Chile and Electro Power Systems' solar + storage Microgrid in the Atacama Desert, consisting of 125 kW PV, along with a lithium-ion battery

and hydrogen storage system. The total hybrid storage capacity exceeds 580 kWh and the installation requires no diesel generator for backup.

- Italian smart energy company Terni Energia's $10 million engineering contract with Juice Power Group as part of a solar-powered Microgrid project in India. It wants to implement three Microgrids of 3,5 MW solar for $3 million and adding additional 8,5 MW to complete the project.
- Sungrow's five solar + storage projects on five islands in Maldives. A total of 2,7 MW of PV and 700 kW/333 kWh of Li-ion batteries sourced from a joint venture with Samsung SDI were installed.
- Australia's Advanced Energy Resources 3 MW solar and wind project. It includes a storage component to be commissioned in 2019.

Renewable energy can represent an independent energy supply. particularly, several island projects employing Microgrids have been announced and completed in 2017. Before we have seen an overview of different projects announced in April 2017, while the following list is related to island projects declared in a period that cover 2016 until the early 2017 and it takes into consideration developing and also developed countries:

Location	Project description	Developers and investors	Capacity (generation in kW / storage in kWh)	Announcement
Monolo island, Fiji	Micro-grid combining 1MW solar array and 20 Telsa Powerpacks, totalling 4MWh or energy storage.	Tesla, PowerSmart	1,000 / 4,000	December 2016
Ocracoke island, North Carolina, US	The micro-grid includes a 15kW PV array, 10 first generation Tesla Powerpacks and 150 Ecobee smart thermostats to enable demand response.	North Carolina Electric Membership Corp, Tideland Electric Membership Corporation, Tesla	1,000 / 1,000	December 2016
Kauai island, Hawaii, US	13MW solar PV and 52MWh energy storage project powering the island, with 272 Tesla Powerpack 2 battery systems.	Tesla	13,000 / 52,000	December 2016 (announced in March 2017)
Marshall Islands	4.6MW hybrid micro-grid, combining solar PV assets and lithium-ion batteries.	IRENA, ADFD	4,600 / NA	15 January 2017
Seychelles	5MW solar PV plant integration into existing wind farm.	IRENA, ADFD, Seychelles government	5,000 / NA	15 January 2017
Solomon Islands	20MW reservoir dam and hydropower facility.	IRENA, ADFD, Solomon Islands government	20,000 / NA	15 January 2017
Misool Eco Resort, Raja Ampat Islands, Indonesia	Microgrid combining 125kW PV array, diesel generators and lithium-ion energy storage. The project will be commissioned in Q2 2017.	Micool Eco Resort, Canopy Power, Qinous	125 / NA	24 January 2017
Sekunyit Island, Indonesia	Solar and storage micro-grid including 15kW PV array and zinc-air storage.	Fluidic Energy	15 / NA	February 2017
Anchorage, Alaska, US	Micro-grid using ABB's Powerstore micro-grid solution, combining battery and flywheel technology. The micro-grid will integrate wind power from a 17MW wind farm on Fire Island.	Chugach Electric Association, ABB	NA / 500	01 February 2017
Elivathu Island, Jaffna, Sri Lanka	Sri Lanka's first hybrid power plant, with a 46kW PV array, six 3.5kW wind turbines and a 100kWh lithium-ion battery. The project cost LKR 187m (USD 993k).	Asian Development Bank, Ceylon Electricity Board	60 / 100	10 February 2017
Karampuang Island, Indonesia	Portfolio of PV plants with total capacity 598kW.	Sky Energy	598 / NA	10 February 2017
East Kalimantan, Borneo, Indonesia	Portfolio of PV plants with total capacity 1.2MW.	PT Akuo Energy Indonesia	1,200 / NA	10 February 2017
Flinders island, Tasmania, Australia	Micro-grid combining 0.5MW, 0.5MWh of energy storage assets and 2 MVA diesel generators.	Electro Power Systems, Hydro Tasmania, Australian Renewable Energy Agency, Tasmanian Government	2,500 / 500	15 February 2017
Sardinia, Italy	Micro-grid connecting lithium-ion energy storage system to Ottana Experimental Solar Farm. The 1.2MW mini-grid was hybridized with 0.6MW of CPV, and 0.6MW CSP and 0.5MWh of energy storage capacity.	Electro Power Systems, FZSoNick, University of Cagliari and Sardegna Ricerche	1,200 / 500	22 February 2017
Honolulu, Oahu island, Hawaii, US	Ainamalu micro-grid, a 410 home project, which will include solar systems and Blue Planet Energy's Blue Ion energy storage systems.	JPL, Koloa Energy, Blue Planet Energy	NA / NA	13 March 2017
Honolulu, Oahu island Hawaii, US	Private community eight-home project, off-grid.	GreeneWaters Hauiki Hui LLC, Tesla	NA / NA	30 March 2017

Table 4.1: island projects announced in 4Q 2016- 1Q 2017 (source: Bloomberg NEF)

During 2016, energy storage players Fluidic Energy and Electro Power Systems (EPS) continued to deploy new Microgrid projects but since that moment a big player as Tesla had not yet entered in the game. As we have presented at the end of the previous chapter, Tesla has created a market for its grid-scale storage Powerpacks on five islands in the Pacific. Only in the first quarter of 2017, Tesla has installed storage capacity by 17 MWh.

The recent projects suggest that MW sized island Microgrids represent an important component of the company's grid-scale storage strategy.

In 2017 several governments and technology giants have made a lot of efforts for Microgrid projects and most of these efforts involved the South East Asia. We have just introduced some projects in the previous chapter but now it is necessary to go in deep, since we are dealing with the topic of Microgrid development.

In that year, Schneider Electric, Nanyang Technological University, and the Engie Lab signed an agreement to improve energy access in off-grid areas in Singapore and the other countries of the South East Asia Engie's contribution was on operations and planning, whereas Schneider provided the energy management equipment. Engie also signed an agreement with Electric Vine Industries to develop, finance and operate PV Microgrids for 3000 villages reaching 2,5 million people in Indonesia. The investment is going to achieve $240 million in the next five years. Moreover, Facebook, Microsoft, Allotrope Partners have created a partnership in order to create a facility to fund Microgrids in emerging markets. The partners seek to mobilise $50 million between 2018-2020 with seed financing currently provided by Facebook [35].

One of the main risks of investing in rural Microgrids is the exposure to retail risk. a developer that starts a micro-utility cannot rely on a long-term power purchase agreement but should sell energy and receive payments from local residents. The reliability of this cash flow is an important consideration when we talk about financial risk, so also the developers and operators of Microgrids must learn about the typical consumer usage habits and revenue flows.

Data from the community of Microgrids showed that a small group of clients represented the majority of project revenue. In addition, clients that consumed more than 20%, have generated 50-77% of total revenue. We are saying in other word what we have said before, that is that a significant proportion of the local population cannot afford or is unwilling to pay for full-time service.

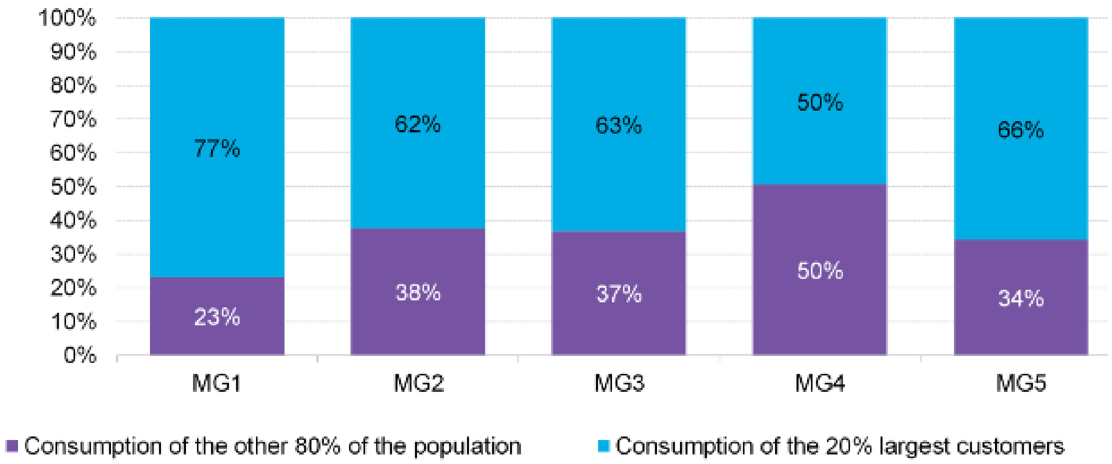

Figure 4.2: share of total consumption, 2017 (source: Bloomberg New Energy Finance)

This figure summarizes what we have explained, and from a sample of five Microgrids, it is evident that only the 20% of customers consumes more than the other portion, and finally the other portion, that is the largest, has problems to pay this service. This is perfectly showed in the figure below:

Item	Micro-Grid 1	Micro-Grid 2	Micro-Grid 3	Micro-Grid 4	Micro-Grid 5
Average consumption/customer (kWh)	36.11	25.87	54.37	27.09	6.81
Average number of days of zero or negative balance per month	12.43	8.37	2.99	6.02	9.58

Table 4.2: KPI for five Microgrids, 2017 (source: Bloomberg New Energy Finance)

Close to 69% of the customers consume less than 5kWh per month. On average, customers had no credit on their meters for three to 12 days per month [34].

Passing from 2017 to 2018, Microgrids and decentralized renewables are slowly moving to the mainstream markets with new emerging projects in developing countries. For example, India and he South East Asia are making progresses to expand the electricity access in order to reach their targets. This is the situation in the early 2018:

- *Microgrids*. The projects started in 2018 cover a wide range of applications. It is not just remote areas and islands like in 2017 but there are also projects aimed to boost the efficiency of gas-fired power plants or to integrate power from utility-scale wind and solar farms. Both Aggreko and Sterling & Wilson have introduced new turnkey Microgrid offerings combining solar, storage and fossil fuels.

- *Fuel cells*. This market has seen an injection, thanks to Bloom Energy's filing for an IPO. There was record deployment in 2017, mostly in North America and Asia.
- *Energy access*. It is expected that the world will spend around $162 billion on building new power lines, Microgrids and solar home systems for energy access by 2030. Must be said that, since this is a great effort, it represents only the half of the amount needed for universal access.

Until now, the grid is still the preferred solution for those that live near it or where power demand is high. However, the decentralized energy from community-levels grids and small solar kits will bring electricity to more people than the grid every year for the first time from 2020.

This is a matter of economics, because Microgrids and solar home systems seems to be more expensive than the power from the grid. Since expanding the grid to connect new families has a cost between $266-2100 per family and this makes sense only if those users can afford large appliances. Nevertheless, most households are able to remain under the threshold of 200 kWh per year, so for this large proportion such a large upfront investment can bring the cost of electricity to 1 $/kWh. At this point, both Microgrids and solar home systems are cheaper than extending the grid.

Forecasting what we have just said, both solar home systems and solar Microgrids will be less costly because solar modules and lithium ion batteries will drop 37% and 54% by 2025. The current trends show some opportunities:

- Additional day-time load can reduce the average cost of electricity in a rural Microgrid by 18% because it allows to capture more solar energy. Midday loads like water pumping, cooling, agricultural processing is more likely to be income-generating than residential evening loads.
- Small solar home systems provide a limited range of services, but they are affordable with costumers. For example, in East Africa, the kits formed by several lights and basic appliances have achieved a market penetration of 10%.

In these developing countries such as Africa and South East Asia, Microgrid are expected to play a larger role because governments are developing ambitious roll-out plans.

The figure below highlights the household electrification capital spend starting from 2018 and it is interesting to have, in most of developing countries, a positive evaluation in term of numbers, of what we have explained previously:

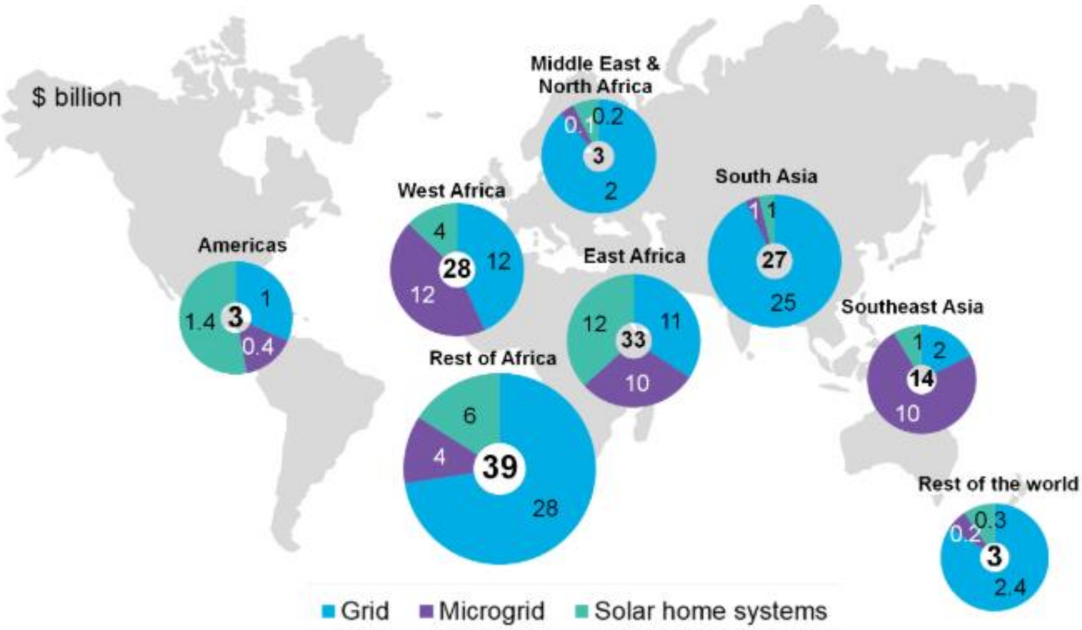

Figure 4.3: projected household electrification capital spends from 2018 to 2030 (source: Bloomberg NEF)

Development banks have approved $2,8 billion in loans, funds, grants and guarantees in 2Q 2018. This amount is lower than $0,5 billion in comparison to the previous quarter. Power generation has represented two thirds of the funds thanks to several big-ticket loans for the construction of natural gas and solar generation facilities. Less than 10% of the total was allocated to grid extensions, in contrast with the first quarter. Moreover, $134 million was directed towards off-grid energy access, an increase of about 350% in comparison with the first quarter of 2018. All of this is summarized in the figure below that is useful in order to make a comparison between 2017 and the firsts 2Q of 2018:

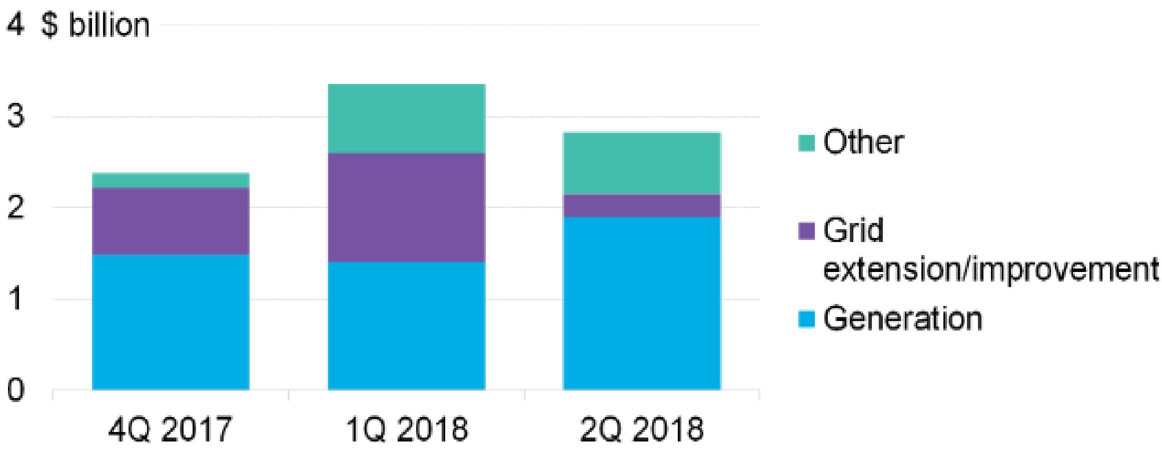

Figure 4.4: Development bank financial commitments (source: Bloomberg NEF)

Between the developing countries, one of the most innovative area is the South East Asia. Specifically, Indonesia and Philippines inaugurated renewables based on Microgrids last quarter. ABB, Siemens and Aggreko are protagonists in this direction with innovative approaches for Microgrid technologies to boost gas-fired power generation, new business models and pilot project for grid-embedded Microgrids. We moved form 16 new projects in the first quarter of 2018 to 11 in the second one, totalling 104 MW in power generation capacity. In this environment, Australia is the leader in the second quarter with four projects that have several applications like the gas-fired power plant optimization and island power.

The following figure summarizes some relevant Microgrid projects announced or completed in the 2Q 2018, considering developing and also developed countries:

Country	Project description	Involved parties	Capacity	Status, date, and source
India	A 1.2MW grid-tied microgrid installed at ABB's Vadodara manufacturing site in Gujarat to cut power outages and integrate more renewables during early evening hours.	ABB	PV, lithium ion battery	Commissioned, April 26, 2018
India	A 1MW grid-connected microgrid at a facility of Central Electronics Limited in Sahibadad, Uttar Pradesh.	Dynapower, Raychem	PV, diesel generators, energy storage	Completed, May 17, 2018
China	China's first island microgrid was commissioned on Youngxing Island or Woody Islandin South China Sea	Hainan Power Grid	PV, diesel generators	Completed, May 27, 2018
Philippines	Pilipinas Shell Foundation is advancing 20 microgrids for rural communities on Palawan Island.	Shell	PV, hydro, diesel generators	Announced, May 27, 2018
Western Africa	Sterling and Wilson launched microgrid project to power behind-the-meter clients in the educational sector at three sites. This involves 30MWh batteries installation including Africa's single largest one of 17MWh.	Sterling and Wilson	PV, diesel generator, battery storage	Announced, May 30, 2018
Australia	A microgrid will add 5.6MW of PV to supply electricity to 17 remote communities on the Tiwi Islands to the South Australian border.	Australian Renewable Energy Agency	5.6MW PV, diesel generators	Announced, May 31, 2018
Australia	ABB will build a grid-connected microgrid as a part of the Energy Storage for Commercial Renewable Integration (ESCRI) to support renewable energy integration to the main grid.	ABB, ElectraNet, AGL, Australian Renewable Energy Agency	30MW lithium ion battery storage, 90MW wind, rooftop PV	Announced, June 11, 2018
Philippines	Solar Philippines will develop isolated microgrids at ten locations across the country.	Solar Philippines	PV, battery storage, diesel generator	Announced, June 14, 2018
Indonesia	Akuo Energy inaugurated three microgrids on remote islands on remote islands with a total of 460 homes in East Kalimantan region.	Akuo Energy	1.2MW PV, 2.1MWh battery storage, diesel generators	Completed, June 14, 2018
Finland	Siemens and Lempäälän Energia will develop a grid-connected microgrid combining six gas motors, fuel cells, PV. It will also manage district heating.	Siemens, Lempäälän Energia	Gas, fuel cells, PV	Announced, June 19, 2018
Senegal	A 800kW microgrid was built on four new ministerial buildings and carports in Dakar.	BayWa r.e., OneShore Energy, Dieng & Co Engineering	PV, diesel generator	Completed, June 20, 2018
US	Honda commissioned a DC microgrid at its parts distribution center in Chino.	Honda, Bosch Building Grid Technology	300kW PV, 546kWh lithium ion battery	Completed, June 20, 2018
US	Honda commissioned a grid-connected microgrid installed at its Torrance campus in California. It also integrates 60 EV charging stations which will be managed by a cloud-based energy system to manage EV charging demand and PV production.	Honda	2MW PV, 500kW/1,000kWh, Two 100kW/ 200kW lithium ion batteries	Completed, June 21, 2018

Table 4.3: relevant Microgrid projects in 2Q 2018 (source: Bloomberg NEF)

In order to be coherent with our research, in the table above, we analyse in detail the situation in Indonesia and Philippines since they are located in the area of our interest. These two countries are the most populous of the S.E.A and they have the objective to reach respectively the 100% of electrification by 2020 and 2022. In this environment, Microgrids are the best solution to provide isolated island communities. In 2018, Akuo Energy inaugurated three renewables-based Microgrids on remote islands that are able to electrify 460 homes. With these new instruments installed, the cost of electricity is decreased, and the operating hours are extended combining 1,2 MW of PV, 2,1 MWh of battery storage and diesel generators.

In Philippines, Solar Philippines, the major solar company in this region, has announced that it will spend $15 million to develop isolated Microgrids at 10 locations across the country. In 2018, this company has inaugurated a utility-scale Microgrid formed by 2 MW PV, 2 MW diesel generator and 2 MWh lithium ion batteries. Shell, the global energy company, is also spreading 20 rural Microgrids for island communities. Shell is a new entry in this market and has created partnerships with Microgrid companies like Husk Power and GI Energy.

These new emerging projects and the positive trend about the development of Microgrid, can be a support to convince governments to undertake the necessary reforms to allow private IPPs to serve, since these new sources can save energy costs and can improve the reliability. For example, it is expected that the South East Asia will spend $14 billion to reach almost universal electricity access by 2030, and specifically, Indonesia and Philippines will reach about 75% of their off-grid population with mostly Microgrids.

We have also examples of PV projects in the South East Asia. This is true also about Africa where it is starting to receive more specialized debt financing.

Then, for completeness, it is important to mention also the market trend of fuel cells, which has seen an unexpected level of new flows in 2Q 2018 on capital markets and in deployment. Fuel cell have had a strong presence in remote power systems, but the growth has been slow. In 2017 650 MW were deployed globally, mostly in North America and Asia but this trend is decreased this year before picking up in 2019 [36].

As we can see, in the last years the topic of Micro-networks has had particular attention for reasons like the access to energy in remote areas of developing countries. The main issues in micro-networks development are focused on modelling and design technologies to build a secure and reliable infrastructure. The research areas are divided into three functional areas [37]:

- Creation of models: development of models of components and control strategies with the creation of test functions for the detection of the main behaviours in certain dynamics.
- Development of technologies: development of reliable test and measurement systems, expansion of transmission and communication bands, development of methods for controlling distributed generation sources, in particular on power electronics for energy conversion and storage.

- Demonstration and evaluation: verification of the performance of micro networks, storage of analysis and modelling data, construction of processes and infrastructures for testing and support.

4.2 The grids of the third millennium

It is evident that the market for Microgrids is growing, business opportunities are emerging, and regulatory condition are improving. By 2020, the financing requirement could climb to over $100 million.

The dimension of the global Microgrid market was valued at $3,76 billion in 2016 and this number is grown over years and it is destined to grow again in the future because the power demand in developing countries is expected to be a driving force. Microgrid is a local electric system that can provide power either in parallel or isolation from electric grids, and the inclination from remote central station power plants to more distribute generation is expected to have a substantial impact. Moreover, the central role of renewable resources for power generation is expected to upscale the requirements of Microgrid in the future. In this sense, more awareness towards power generation through the utilization of alternative renewable sources such as wind, solar and hydrogen is forecasted to have a positive impact on the Microgrid development.

All the steps and efforts that have been made in these projects are also the response to the population growth and urbanization in emerging markets. This has brought national governments to increase the investments in infrastructure development. Furthermore, increasing the construction expenditure in developing countries is a way to support the growth of Microgrid market over years. For example, rising spending on the developments of new prototypes of smart Microgrids thanks to the Galvin Project Inc. should open new markets [38].

Considering the 2017, the Microgrid market has known a capital expenditure CAPEX of $9,645 billion. This happens because Microgrids are one of the most advanced projects in the power generation sector and it can be used as a source of electricity during emergencies, bad weather conditions or power outages. The amount of money spent confirms what we stated before, i.e. to re-equilibrate the unbalanced supply of electricity among customers, due to the growth of the population. The implementation of Microgrid technology, will not only decrease the burden on existing utilities, but will also contribute to reduce greenhouse gases thanks to renewable sources [39].

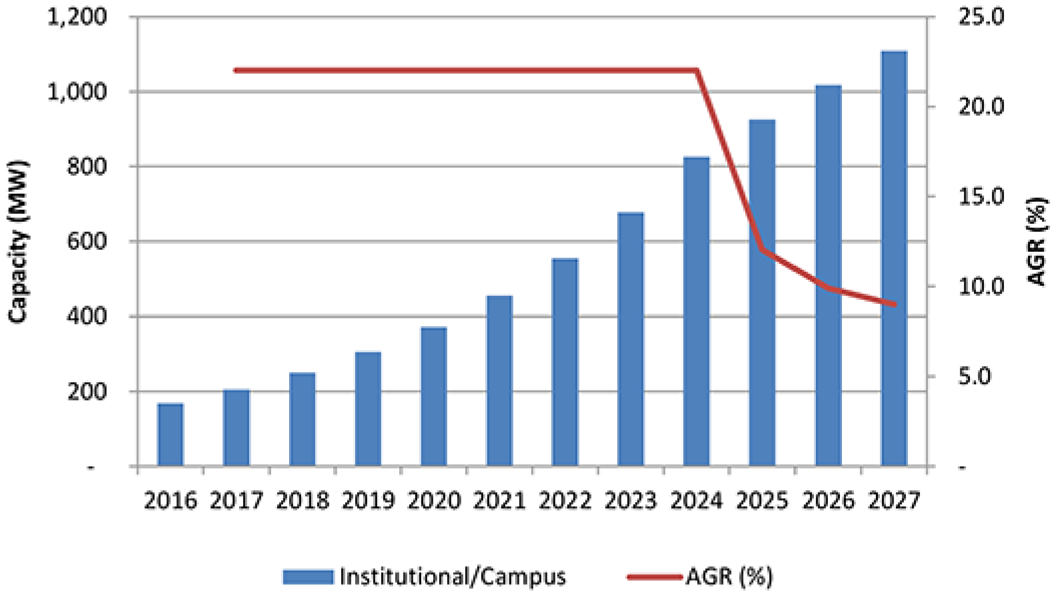

Figure 4.5: Global Microgrid Institutional/campus Application capacity forecast 2017-2027 (source: VISIONGAIN)

The figure above shows the forecasted evolution of the Microgrid market starting from 2017, considering also the Adjusted Gross Revenue (AGR) that is related to revenues from interests and other fees.

What developers want for the future is a smart energy system with Microgrid compact design and high reliability during emergency conditions. It is expected that the Microgrid market will be in line with the current trend presented previously, i.e. reaching remote areas and islands. Increasing government measures to facilitate efficient and reliable advantages will increase the demand for Microgrid in the world [40].

In fact, in 2018 is increased reaching $22,22 billion and it is expected to grow to $39,1 billion by 2023, at a CAGR of 11,97% between 2018 and 2023. This thanks to the characteristics of Microgrid:

- Reliability
- Secure power supply
- Cheat and clean energy storage

Remote/Island Microgrids are used to provide different power sources for geographically remote communities and developing countries. With the expansion of electricity structure in those areas, many remote Microgrids are been thought to be self-sufficient in order to reach distant villages where the traditional electric utility players are not available. The main reason of their growth is due to the decline in PV prices and wind power sources in comparison with centralized power grids.

The highest growth rate of the Microgrid market for software can be attributed to the adoption of several software in different universities, industrial sites and utilities. Software-as-a-service platform permits to Microgrid operators to dynamically manage and control energy resources with integrated forecasting. Thanks to the software management service, owners of Microgrids have a single point of accountability and a lower risk of project failures.

Microgrids have also other application like in the healthcare sector. in fact, the market for healthcare is expected to increase at the highest CAGR between 2018 and 2023. this because there is a constant demand for uninterrupted power supply as key factor of the healthcare market. Next-generation Microgrids offer healthcare facilities the ideal power source for maintaining user experience while optimizing energy consumption [41].

According to the Microgrid Enabling Technologies report (2018) [42], combined heat and power was the leading DER choice in terms of capacity for microgrids on a global basis in 2017 with 655 MW deployed, followed by PV (392 MW) and then diesel (385 MW).

Implementation spending takes into account this capacity growth and all the DER are profiled in the report. This market forecast represented just over $4 billion in investment in 2017. That annual spending increases to about $23.6 billion by 2026, a 21.7% CAGR. Solar PV ranks as the top DER investment target for Microgrids, with annual spending reaching virtually half of all DER investment by 2026 at $6.7 billion. Energy storage spending follows at $4.5 billion annually in 2026.

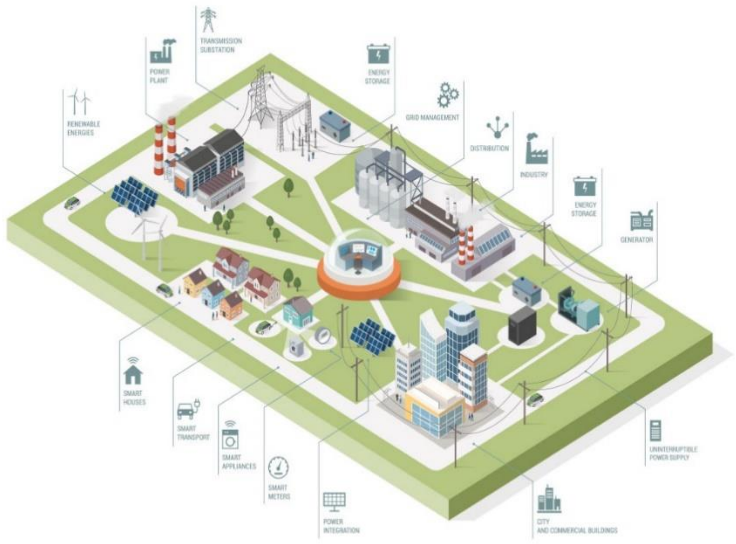

Figure 4.6: example of Microgrid as the future of power (source: National Energy Control)

Of course, the energy service approach to microgrids is still in incubation. The Microgrid of the future will be more sustainable, ultra-resilient, plug-and-play, financed under an energy as a service business model with private capital, and will include both solar and energy storage. For sure, one of the most innovative way for the electricity market is to bet on the generation distributed by renewable sources. A greater opening of the market for alternative electric services, such as intelligent aggregators, able to coordinate many consumers, and consumption in a more efficient way can be the right way to guarantee a more competitive future.

Proceeding step by step, going back to the present, the current and contingent demand is to adapt the electricity grids to the new energy needs, in a reality that sees the customer no longer just as a traditional consumer, but also as an active player in the production chain. One of the feasible answers is the development of pilot projects that can verify the resistance and reliability of intelligent energy distribution networks, as Microgrids or Smart Grids.

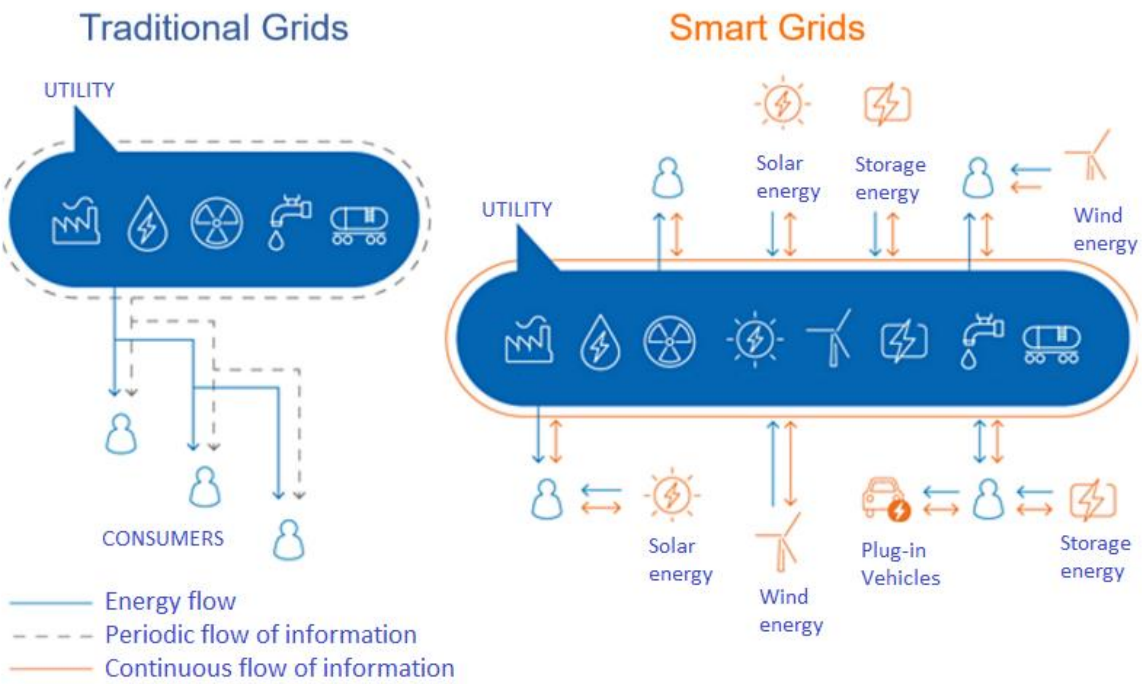

Figure 4.7: comparison between Traditional and Microgrids or Smart Grids (source: MAPS)

These new systems combine electronics and digital technologies to enable two-way communication between the various points in the network. This allows monitoring, analysis, control and exchange of information in real time between the parties involved, to improve network efficiency, reduce consumption and energy costs, and maximize reliability and transparency along the whole energy supply chain. This is the future because the advantages that it is possible to exploit are crucial for the future world. Indeed, the integration with digital technologies, makes the network:

- able to respond promptly to the request for more or less consumption of one or more users.
- Resilient to the variability of the load of electricity produced in power stations that exploit renewable energy with characteristics of randomness, such as wind and photovoltaic.
- easily integrated, for a constant dispatching of energy, to traditional production power plants and to the energy balancing service of the national distribution network.

Parallel to Microgrids, a fundamental role for the efficient management of renewable energy is given by energy storage systems. These, in fact, allow the storage of any over-production of energy, typical of sources such as solar and wind, or to buy energy from the network when the price is convenient, in order to make it available in periods when consumption exceed production.

In addition to traditional storage systems, as we introduced in the Chapter 2, growing interest is developing around electric vehicles (VEPs) and their impact on the energy distribution system.

Therefore, new energy models based on the integration of renewable sources, storage systems and smart technologies for network management are going to emerge. Their consequent adoption will introduce, in cascade, new stakeholders and related business models, very different from those traditionally adopted in the electricity market, that will advantageously involve not only the big energy, but also small businesses, consortia and finally private.

Faced with systems operating on these different levels of needs, resources, suppliers and users, soon specific user interfaces will be indispensable to support Demand Response, a model that encourages the participation of consumers in the efficiency of system, which requires a proactive response to any requests for limitation or remodulation of consumption by the operator. Incentives that can also be implemented through the adoption of a pricing mechanism that:

- will, to a large extent, be proportional to the overall demand on the network.
- Can be based on incentives offered to consumers with the aim to reduce their energy consumption in times of peak demand or when the system is under stress.
- Will involve the use of automated solutions (such as domotic systems), able to move loads of energy by balancing them between the various moments of the day.

It is therefore increasingly clear, how the Demand Response dynamics require a very high level of coordination and responsiveness among the various subjects involved. The ability to meet the commitments taken, such as the limitation of the maximum power absorbed in each period of the day (Peak Shaving), the deferral to the evening band of certain consumption by one or more users, is in fact essential to ensure an optimal network management and limit the risk of congestion or over-production.

To ensure this coordination, it is essential that the new Microgrid management systems will be able to:

- accurately forecast energy consumption on the one hand and production capacity of the various renewable sources on the other.
- Optimally manage the available energy storage systems.
- Adapt quickly to any deviations from the forecasts, notify the new planning to the operator and, if necessary, activate a new contract.

In other word, the new technologies for the utilization of renewable energy and the storage systems will be the main challenging sectors in the near future. The common goal is to implement Microgrids that, on the one hand, combine high levels of technology with a shared distribution of electricity (in a view both of reduction and rationalization of consumption and of Sharing Economy), and on the other, to minimize at the same time the losses, the network load, the overloads and the variations in the electric voltage.

These instruments, in this new market scenario, both competitive and quality, will be able to facilitate national governments to meet the parameters set at Community level for the reduction of CO2 production, minimizing the environmental impact due to production and supply of energy.

It is not by chance that, all analysts agree that a strong growth for the sector at global level will be expected in the coming years. Hence, according to Bloomberg New Energy Finance, the market for digital technologies for the energy sector will increase from the current 52 billion dollars to the 64 billion dollars expected for 2025. Growth is mostly concentrated in developing countries and in the most innovative segments, such as distribution automation systems (from $4bn to $10bn), domestic energy management (from $1bn to $11bn) and flexibility (such as Demand Response) which will be worth $4 billion in 2025 [43].

As we said, the future development of Microgrids will significantly involve developing countries. All entities, from governments to privates, will be part of this market as investors and with subsidies because Microgrids represent the next innovative step in order to exploit renewable energy sources. But what will be the general goal? The aim is to create, in a nearly future, the so-called Smart cities.

The creation of smart cities will allow a gradual transition to urbanization in which technological advances will help administrations to optimize resources in order to provide maximum value to the population, both as a financial value and as a savings in terms of time or improvement of the quality of life. Smart cities are therefore a necessity, considering the data forecasted which highlight that within the 2050, in fact, over 80% of the population will live in cities in developed countries; in developing countries, urban population will exceed 60% of the total population.

Smart cities will be able to [44]:

- create huge business opportunities with a market value of over $ 2 trillion by 2025.
- The Asia-Pacific region will record the fastest growth in the smart energy sector by 2025.
- In Asia over 50% of smart cities will be in China. The related projects will generate 320 billion dollars for the Chinese economy by 2025.
- Europe will record the largest number of investments in smart cities projects, given the commitment shown by the European Commission to promote these initiatives.
- In Latin America, several cities are actively developing initiatives for the emergence of Smart cities.

Following this direction and incorporating with the Microgrids technologies we will talk about, not only Smart cities, but Smart self-sufficient cities. The advantage of installing a Microgrid is, therefore, to be more independent from the public network, pushing maximum energy self-sufficiency from renewable sources. The technology exists and there is also know-how, but there are no regulations to implement this. Basically, there is no regulatory framework that allows energy management downstream of the meter. We have to solve problems related to the management [45].

There are just futuristic scenarios that sooner or later will become the reality. This will be the next step that researcher and developers of Microgrids should compute in order to achieve the top level of innovation. Imaging a perfect combination of cloud, artificial intelligence, robotics, edge computing, IoT. These are the main ingredients of the so-called Neural grid, the electricity grid of the future. It will be neural networks that disperse energy, in a way so ubiquitous, quick and connected. It is difficult to image this now because we are still at the step of Microgrids but for sure Neural grid will be the future evolution of the actual Microgrids.

Neural networks represent much more than a 2.0 version of Microgrids. Neural grids imply a much more powerful platform of hardware and software resources that exploit ubiquitous connectivity, cloud, robotics, artificial intelligence, edge computing and pervasive detection to run a wide range of energy and non-energy applications. It is the latest act of network modernization, able to transform the existing infrastructure into a platform that will support a fully mature Energy Cloud environment. In the neural grid, a reconfiguration of the resources of the distribution network allows new functions and eliminates activities now obsolete by the widespread diffusion offered by solar energy plants, community microgrids or virtual electric plants (VPP).

In practice, the neural network allows a deep involvement of the final customer and prefigures a panorama of the offer consisting of a variety of different actors, ranging from telecommunications companies to giants hi-tech up to start-ups. But the end user himself will become an active part of the game.

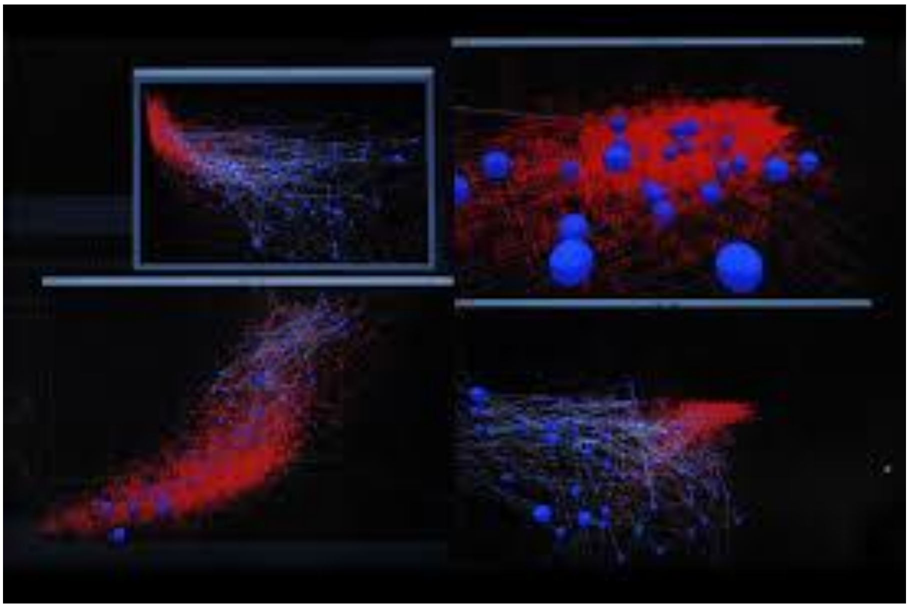

Figure 4.8: from Microgrid to Neural grid

Forecasts indicate that distributed energy resources such as photovoltaics, energy storage, but also Microgrids and VPPs could provide sufficient energy capacity to meet global demand by 2035. The previous network will no longer be needed from here or a little further. Now the challenge for the owners of the current networks will be to update them, putting more and more into practice the concept of energy digitization.

And the possibilities for investing in this transition are a lot. The International Energy Agency (IEA) is planning investments in transmission and distribution networks in the period 2012-2035 for 7.2 trillion dollars, where 40% is of for the replacement of existing infrastructures and 60% to build new ones. If even a third of the new one will not be needed within 20 years, it means that about $ 1.4 trillion will be available to optimize the transition efforts from today's Microgrids to tomorrow's neural grid platform.

According to what we said, there would also be five major growth markets that will benefit from the moment in which today's smart grid investments will turn into the neural grid market of the future. First of all, all the solutions concerning connectivity will be fundamental for its formation. Providing connectivity to billions of energy and network resources around the world ensures significant and growing market opportunities for decades. The detection and measurement technologies will be also important ad they will have several benefits: low-cost sensors integrated into each element of the network infrastructure, including the energy one, will provide data that allow analysis and artificial intelligence to manage each layer of the neural grid.

Then, drones and cloud robotics come into play. When autonomous drones and robots will be able to learn through vast data archives in the cloud and interact seamlessly with humans thanks to the natural processing of the language, they can perform maintenance and monitoring tasks. They will also have the necessary intelligence to face new problems and reduce human error.

Each of these technological areas is full of opportunities for the growth of the short-term market represented by Microgrids. All these segments are ready for market expansion leading to the transition to the neural grid platform.

Estimation on products, services and technologies identified in the neural network ecosystem will experience an annual growth of almost 6% up to 2025 of half a trillion dollars. On a cumulative basis, there is talk of almost 4 trillion dollars of opportunity. But the real market expansion is expected after 2025 and includes smart devices, applications, services and infrastructures that are currently at a very early stage or even have not yet been invented.

But already today the four key elements of the neural grid ecosystem / infrastructure exist and are represented by end-user devices, enabling technologies, apps and services. When they will work together harmoniously, the transformation of the sector could occur rapidly [46].

CHAPTER 5: MODEL ANALYSIS AND FINANCIAL SUPPORT: THE ROLE OF PRIVATE ASSETS

Access to electricity is an important factor for the development of rural and remote areas. This is particularly true for developing areas like sub-Saharan Africa, South Asia and South East Asia. This precondition has led governments and private investors to set ambitious goals to expand the electricity access. Decentralized solutions, as Microgrids are the most effective solution due to their low cost and capability to achieve communities located far from central grid infrastructure.

These innovative solutions, nowadays, are meeting some barriers for their development, in particular we are referring to financial barriers. Lack of capital from public sources is the major problem for the achievement of targeted goals, leading to calls for grater private sector participation. For this reason, there are different private actors that are entering in this emerging market with the aim to have a return in term of money or to impact economies of developing areas in order to leave an important footprint.

Principally, we will talk about three most important actors, that are emerging in this Microgrid market:

- Private sector, with private equity funds, that invests in order to have a financial return.
- Impact investing funds that develop initiatives to mainly impact the economic fabric of the country
- Financial intermediaries that participate in order to give a financial support to the who wants to invest in this emerging market.
- The mechanism of Concessionary Finance with the ecosystem approach to finance.

There is growing interest in understanding how to involve the private sector in this segment. One of the main motivations of the involvement of the private sector in these projects is to tap into the large amount of capital available. The activity of electrification is capital intensive and since the public sector has no sufficient resources the participation of the private one is fundamental.

Moreover, privately-operated Microgrids, often benefit from technical skills, management capabilities and efficiency that are lacking in publicly-owned utilities. So, the participation of the private sector in electrification projects could lead to both an increase in the availability of capital as well as improved technical and managerial performance.

Moreover, the success of a Microgrid also depends on the collaboration between consumers concerning their individual levels of consumption and timely payment of their electricity bills. Penalties are frequently incorporated into Microgrid rules in order to discourage customers from consuming more power than what is permitted and from making late payments. In fact, tariff levels are especially important factors for the determination of the Microgrid success because it depends also on the revenues from users that are necessary to cover the operational costs. The tariff design is influenced by the business model of every project considering the plan to cover all the costs. Subsidies are linked to tariff levels and payment and play an important role in this field.

Regardless of whether a Microgrid operator tries to recover costs, tariff levels imply a trade-off between the financial need of the system and the customer’s willingness to pay. So, one of the main aspects for the success of a project is to fix appropriate tariffs and subsidies.

5.1 The private sector: Private Equity financing

Private equity is a financial asset through which an entity (generally an institutional investor) takes over shares in a defined target company either by acquiring existing shares from third parties or by underwriting newly issued shares by bringing new capital into the target. PE typically refers to investment funds organized as limited partnerships that are not publicly traded and whose investors are typically large institutional investors, university endowments, or wealthy individuals.

In the renewable energy sector, we have different examples of PE investments especially in Microgrid market.

An important example to take into account for the efforts put in the Microgrid projects, is one of Powerhive. It is a Microgrid solution provider in emerging markets with a proprietary technology platform that simplifies the Microgrid development and customer management. This case study in Kenia offers a great reference point for identifying mechanisms that the private sector can use to incentivise and stimulate the development of Microgrids in those markets.

With over than two years of experience, Powerhive's four pilot projects offer 100% renewable energy to customers that purchase electricity on a pay-as-you-go basis using mobile money applications on their mobile phone. In order to test the business model, the first pilot project of 1,5 kW per unit was launched to a small group of residential customers. These users use electricity for indoor and outdoor security lighting, mobile phone charging, and to power small appliances. The next three sites serve about 1500 people and their capacity is about 10, 20 and 50 kW per unit. They are able to support greater number of users.

To scale its solution more broadly in Kenya, the company began the process of searching concessions. Concessions are an important instrument for the companies in the private sector that offer a public good and, in this case, provide the holder with the exclusive right to supply power in a certain area for a specific period. In this way, concessions increase the capacity of the provider to attract financing, while being regulated as a utility allows the eligibility for government-sponsored incentives.

Powerhive used its technology platform to collect data from its pilot projects when it applied for concessions. This data is used in order to demonstrate costs and revenues of electricity provision in remote areas. In addition, data are used to highlight also the Microgrids' reliability, acceptance by local governing bodies, financial solvency, and safety.

In this way the company was able to demonstrate that its Microgrids offer a grid-quality service at a reasonable cost in off-grid areas. As a result, Powerhive has been recognized as the first privately held utility company in Kenia. This concession will allow Powerhive to generate and sell renewable electricity from Microgrids. Moreover, as a result, the company will be able to scale its off-grid utility service over the next years, building 100 Microgrids, powered by First Solar's solar PV technology and operated with Powerhive's control technology. In this way, more than 100000 residential customers will be served.

As we can see this private company, in order to operate and develop its projects in a specified area, was not only necessary to have a lot of funds, but also the concession of the government.

> *"…Powerhive has demonstrated that its microgrids are capable of operating in compliance with the prescribed standards for residential and commercial electricity service provision".*

Written by the Director of Economic Regulation for the Kenyan ERC.

With Microgrid access, clients of Powerhive have been able to save money increasing their usage of energy services. Now, they are able to light their homes for a longer time allowing them working or studying. Moreover, another benefit impacts on the possibility to access to entertainment and connection via television. Also, the customers increased their incomes by operating new businesses thanks to butcheries, chicken hatcheries and hair salons.

From this case study, the experience of Powerhive has leaved the regulatory best practises in order to encourage financing and construction of Microgrid by the private sector across un-electrified markets worldwide. These best practises are showed as following:

- *Seek electricity distribution concessions*. Concessions are usually grant to private companies that offer a public service that use regional scale grid infrastructure.

However, regulators have to appreciate the role that Microgrid service provider can play using affordable access to energy in areas where grid expansion is an expensive undertaking. So, with concessions, these projects are more possible to the cost point of view.

- *Establish cost-reflective tariffs*. Usually there are fixed tariffs based on the cost of providing electricity to urban areas through the national grid. these tariffs prevent the development of rural electrification projects, because those tariffs are not sufficient to recover the capital costs of electrification in rural areas. So, regulators should allow energy service providers to set tariff considering the high capital cost of rural electrification. Following the Powerhive data, customers are able to pay for electricity if only if it has a price below the cost of polluting alternatives like Diesel.
- *Encourage risk-reflective rates of return*. In the last years, the private sector financing has been crucial by enabling new off-grid solutions to reach scale. Governments that try to reach high rates of electrification should allow providers to offer investors risk-reflective rates of return in order to attract the necessary private sector financing.
- *Plan the future growth*. Regulators should privilege compatible systems that can power income-generating activities, and to modular systems that can grow easily over time. the success of Powerhive is also due to that fact that is Microgrids offer appliance-compatible AC electricity in enough quantities to allow usage growth over time.

The example of Powerhive in Kenya has opened a path for Microgrid regulation in emerging markets. If these guidelines for regulators will be followed, Microgrid projects will be effective in unelectrified areas around the world [47].

Another example that can be perfectly fit into this paragraph is the one offered by the US private company NantEnergy with its project to make long duration stage profitable exploiting the technology of Microgrids. This company is known as Fluidic and it has a great advantage respect the others because it can count on thousands of systems spread and financial security.

The company has investing for a long period in zinc-air batteries for remote deployments overseas, while those making flow batteries, saltwater batteries and miniaturized compressed air batteries ran out of money.

Then, in the 2018, the company found a strong partner: Patrick Soon-Shiong, the billionaire who acquired the Los Angeles Times. He bought a majority stake for an undisclosed amount and the company had raised a total of $220 million to date. This has been a strategic partnership because with the entrance of Patrick Soon-Shiong, not only the capital increased, but also the influence increased thanks to his direction and vision.

With this financial sustainability, the private company has built a full-scale manufacturing facility of at least 1 GWh production capacity. The company states that it can reach the price of 100 $/kWh once it scales up production to 100 MW.

Instead of investing in lithium-ion like the trend in this market, NantEnergy has installed 3000 systems of zin-air battery in nine different countries. This amount equals to about 55 MWh of installed capacity. Rather than follow pilot projects, this company chose an overseas market where it could compete on cost: the remote Microgrid. In fact, its factory in Indonesia supplied the region, not to mention also the 1000 units in Latin America. In this way about 110 communities, of 200000 people, obtain 100% renewable-based electricity with Microgrids supported by NantEnergy batteries.

NantEnergy expanded its offer including also hybrid systems that pair long duration zinc-air with technologies for shorter-term power delivery, including ultracapacitors and lithium-ion.

For example, Duke Energy chose this company for its remote Microgrid to power an outpost.

Must be said that the long-duration storage sector has generated a series of bankruptcies and little success. So, the aim of NantEnergy is to demonstrate that its product is different from the mass. The first task is to build a product that can beat lithium-ion on price, considering the reaction of incumbents. In the opinion of Krishnan, the CTO of the company, the solution can be investing on zinco-air. This also because other companies have failed trying to invest in other sources of batteries. For example, Aquion tried to do that with saltwater batteries, but ran out of money. Also, LightSail, after sinking $80 million into tanks for compressed air storage, fails. Flow batteries hold the potential for cheap, long lasting storage, but they haven't reached large-scale commercial deployment.

The company has produced several implementations by going to extreme settings where it could beat the incumbent technology on cost. Zinc-air battery Microgrids are better than imported diesel for powering remote islands; they are better than old-school lead acid batteries for telecom backup.

The most important challenge of NantEnergy is to convince people and governments that its new product is better than other, that its new product is an innovation, and this will be a challenge because, as Krishnan said, *"no one wants to be the first one to buy a brand-new technology or product"* [48].

5.2 Impact Investing

For investments with a social impact we mean a wide range of investments based on the assumption that private capital can intentionally contribute to creating positive social impacts and, at the same time, economic returns. The proactive intentionality with which the investor pursues the social purpose, together with the economic return, distinguishes this new generation of investments.

In this direction we put the example of Decentralized Energy Systems of India, or DESI Power, a non-profit company that designs and builds biomass gasification microgrid systems, primarily in Bihar, India. The company has installed biomass gasifiers in five villages. System size varies between 30 - 150 kW. DESI greatly emphasizes the empowering aspects of electrification. They explicitly set out to create opportunities the lowest income villagers.

Town	State	Total Residential Customers	Total Commercial Customers	Status
Bara	Bihar	370	7	Functional
Baharbari	Bihar	75	1	Functional
Bhebra	Bihar	0	17	Functional
Gaiyari	Bihar	0	9	Functional
Orja	M Pradesh	N/A	N/A	Functional

Table 5.1: DESI Power Microgrid customers (source: United Nations Foundation)

Entering in detail onto the project od DESI, tariffs are very high because of:

- it serves a small number of customers on each of its Microgrids
- it sells power on a metered energy basis
- the company is highly diligent about tariff collection, sending out collectors on a daily basis to be available for residential customers to make their payments.

DESI Power, an independent rural power producer, invests into the installation of Microgrid to develop markets and ensure a reliable presence for commercial customers. DESI focuses solely on the market development, in fact, before the second installation, it surveyed 100 villages in order to decide the most suitable market. A careful selection of the company about the process and market development have also likely contributed to its successful also regarding the tariff collection at the Microgrid sites.

Another reason for the DESI Power success is caused by the poor competition of the central grid. The impression of the central grid held by potential customers in the remote towns where DESI operates its Microgrids is negative, and they are enthusiastic about becoming Microgrid customers. This means that this private company has installed Microgrids in areas where the central grid has already arrived so, this means that DESI has involved customers offering a more reliable service.

A rigorous discipline marks DESI's projects because the installation is only the last step after having undergoes all the process. DESI has a small number of Microgrids and it monitors them carefully making site visits. Thanks to this, electricity expands economic opportunities for villages by enabling processing of agricultural products.

Obviously, as in any environment, there are also disadvantages. Managing personally and carefully its few Microgrids, DESI has scaled up slowly. It could be an excessive due diligence or a goal of setting an example for others to replicate rather than electrifying thousands of people.

Another important fact to take into consideration is the residential customer overuse. DESI has estimated that as much as 3 kWh/day are stolen by residential customers. The main point is that the residential consumption is difficult to monitor because most of it occurs in the evening. What is missing is the installed technological capability to prevent or monitor overuse at the individual customer level.

Moreover, the collaboration of the government is necessary, because DESI would like to create a Microgrid using the central grid infrastructure which would enable speedy project development and access to many customers. However, they cannot do so without the government's cooperation.

To sum up from this real case:

Specifies policies, investment funds and special mechanisms are needed for load development. Since Microgrids are an emerging market, it doesn't require a lot of effort in finding investors and even government capital subsidies. A big challenge is in the load side, as the market for electricity is very undeveloped and demand is low. In most villages, electricity is not linked to productive activities in the minds of villagers, only to lighting.

In the DESI opinion, the client creation is essential for the operational sustainability, as a small number of such loads can provide a significant and reliable revenue stream. It is crucial to have skilled employees in order to support the client and to increase electrical load [49].

The operational design of DESI Power's tariff collection resolves two challenges with tariff collection:

- customers are not self-motivated to make payments
- customers are sometimes unable to make a payment when the opportunity is presented to them.

In the category of impact investing, there is also another example, similar to the previous, but located in the South East Asia. We are talking about Green Empowerment with partner organizations such as Tonibung and Partners of Community Organizations Trust (PACOS), that has installed several micro hydroelectric powered Microgrids in villages located in Malaysia.

The most important aspect of these projects is the dedication to community empowerment. First of all, GE/T recognized that the community ownership is the key of the success in the long-term of micro-hydro facility. Without a private sector or a government agency behind, the community ownership was the only possible starting point. So, developers have invested time and efforts in community organizing. As such, since technical engineering was a GE/T strength point, for the community organizing they deferred to organizations like PACOS that help with the behaviour change aspect of the project. With these projects of micro-hydro, they enter in communities to support them also from the other points of view. Since the Microgrid is a positive project that requires community organization, PACOS has found the referral point around which the village can converge.

Hence, in this sense, the Microgrid is not an end unto itself, but a means to achieve community empowerment and cohesion.

In doing this, the partnership has met different challenges because the support of an external monetary entity was missed. Collected tariffs can cover a small payroll for operators but villages often need external support for expensive repairs. Since every community has the role to maintain the system, there is a lot of variability between them in comparison to how well each community has been able to minimize service interruptions. Financial and technical constraints are an obstacle to this self-maintenance. While community empowerment has been shown to be possible through the Microgrid projects, it is still proving difficult for communities to be fully cooperative around their usage. Moreover since, most management activities of every Microgrid is shared among different people, this can bring to sub-optimal performances because people do not have complete task or incentive to complete their work.

Green Empowerment and Tonibung develop and raise capital for Microgrid installation and training. The organizations act as conduits for donor funds to the community Microgrid, being the entities that apply for funding and execute agreements. PACOS has supported the leadership building and community organization around the Microgrids.

Town	Generation Source	Capacity (kW)	Year Installed	Description of Capital Contribuitons
Bario Asal, Arul Layun	Micro-Hydro	45	2009	GEF SGP/Seacology
Babalitan	Micro-Hydro	5	2012	Ranhill Powertron
Bantul	Micro-Hydro	5	2005	GEF SGP
Buayan	Micro-Hydro	14	2009	GEF SGP/DANIDA (Danish International Development Agency)
Inakaak	Micro-Hydro	3	2010	GEF SGP
Long Lawen	Micro-Hydro	15	2000	Green Empowerment/ Seacology/Energreen/ Borneo Project
Lumpagas	Micro-Hydro	1.5	2009	Digi
Mudung Abun	Micro-Hydro	20	2011	GEF SGP/Finnish Embassy/Seacology
Saliman	Micro-Hydro	3	2010	CIMB
Sungai Rellang	Hydro/PV Hybrid	1.5	2012	GEF SGP
Terian	Micro-Hydro	5	2005	Green Empowerment/ Seacology/Borneo Project
Tanjung Rambai	Micro-Hydro	5	2011	GEF SGP/Shell/Selangor Government

Table 5.2: GE/T/P Microgrids development in Malaysia (source: United Nations Foundation)

Usually, the community contributes 10000 hours to the project and in between 20-30% of the total cost of the facility through material, labour and other services. Tonibung has coordinated the development of 15 microgrids since 2000. Green Empowerment has collaborated with Tonibung in applying for financing for 3 of those 15 microgrids. For the 15 Microgrids, the majority of funding has come from international donor agencies, while the remaining part comes from the community itself in the form of in-kind contributions.

Tonibung finds that the transaction costs are too high for their small organizations to try to qualify for a Certified Emissions Reduction (CER) credit under the Clean Development Mechanism (CDM). It is beginning to utilize Corporate Social Responsibility (CSR) funds, in fact, the GE/T/P will depend on CSR program grants or revolving funds in the future since international donor agencies reduce their funding to Malaysia over the next years.

Regarding the Microgrid costs, capital costs are approximately 8000 $/kW, but the capital equipment alone is 2600 $/kW. The average cost per project is $ 50000, and project sizes vary between 1,5 kW and 45 kW, with most projects in the 3-5 kW range.

We can take this case study as reference case in the South East Asia, since it covers the Malaysia area. In particular, from this experience, we can say that it is important investing in community training. GE/T/P has learned that the community dynamics were the grater factor in determining the longevity and performances of a Microgrid. So, they prudently invest many resources in equipping the village with the appropriate tools they need. Another important aspect is defining clear rules and enforcement mechanisms focused on the customer usage. The operation of a Microgrid depends entirely in community cooperation and coordination. All of this is useful in order to create mutual understanding within the community.

The experience of GE/T/P shows that communities have innovative ways of managing their resources and solving problems. Solutions that are unique and can be thought only from communities that day by day have to keep themselves.

The next step is to share a single experience of a community through technology and hands-on assistance among villages. Sharing experiences and single operations and maintenance with each other can improve practices and this inter-village cooperation is integrated into all projects with the aim to improve the internal management.

Obviously, this is impossible to realize without the community commitment. Residents and GE/T/P employees alike credit this up-front community work for creating a degree of familiarity with the Microgrid system. In doing this, it is also important to incentivize labour community to insure consistent maintenance and operations.

A compensation and continuing education scheme were implemented to incentivize people of communities to stay and continue their duties. Moreover, government recognition provides protection and recourse channels. GE/T/P Microgrids are at risk due to the non-clear legal status of Microgrids that are not formally recognize by the government. So, the communities own Microgrids but these instruments are not registered in any way with the government with the aim to not pay taxes and to not be subject to regulations. Unlikely, this situation doesn’t allow for recourse in the event of damage caused by other entities. Therefore, this aspect should be improved because Microgrid would benefit from a special arrangement of legal recognition without financial penalties from the government [49].

5.3 Financial intermediaries

Another important example that is included in this category of financing is offered by the experience of SunFunder. It is founded in 2012, aimed at driving a global energy transformation to provide universal access to energy and to mitigate the environmental impacts of energy production and distribution in order to limit the climate change. In line with the philosophy of the impact investing, SunFunder wants to transform the economies and modify the structure of countries investing in renewable energy.

SunFunder is a financial intermediary in the off-grid solar industry with specialized skills and the most extensive lending track record in the sector. It is entered in this sector starting with the provision of structured debt notes issued by the Solar Empowerment Fund, and in 2017 they launched a fund called Beyond the Grid of about $47 million, with the aim to offer different types of investors with exposure to the market and large-scale funding solutions. Since in the market there is a lack of access to finance, this fund launched by the SunFunder wants to cover the gap and provide to specialized companies with tailored debt capital financing in order to scale up.

The fund is structured to meet the needs of specialized companies and debt investors across three tranches: Senior debt, Mezzanine Debt and Junior Debt. In this way different types of investors' needs are satisfied.

Assets Under Management (AUM)	USD 47 Million
Inception Year	First close: 2016
Geographic Focus	Sub-Saharan Africa, India, and the Pacific
Term	5-Year Fund
SDGs Targeted	#7: Affordable and Clean Energy #8: Decent work and economic growth #11: Sustainable cities and communities #13: Climate action #17: Partnerships for the Goals
Fund Capitalization	Three tranches - Senior Debt: DFIs, Foundations, Private Investors Mezzanine Debt: Foundations, HNWIs, Private Investor Junior Debt: Foundations, Private Investors
Underlying Assets	Loans to solar companies (see below for more)
Size of Investments	Range: $100k to $5m
Return Expectations	Range of 4-7%

Table 5.3: structure of the Beyond the Grid Fund (source: Global Impact Investing Network)

Before the creation of the Fund, SunFunder's blending was done purely with different private investors based on risk tolerance and return expectations of those investors, but now the situation is different because the offering is opened to all the investors and foundations.

The end beneficiaries of the Beyond the Grid fund are individuals that have access to clean energy through investments in solar companies. There are about 1,2 billion of people that live without access to power grids, 97% of which are in Sub-Saharan Africa, Asia and the Pacific. It Targets three customer types:

- *Pico-Solar Distributors and Suppliers (0-10 W Solar).* These companies are providing customers with power for lighting and charging. SunFunder offers corporate loans for working capital and inventory to support these companies.
- *Pay-as-you-go Solar Home Systems (0-1 kW Solar).* Solar home systems allow customers to generate enough energy to power several lights, televisions and other appliances. SunFunder provides PAYG receivables and structured finance to these companies to support the consumer-financing of products.
- *Commercial and Industrial and Microgrids (1 kW-1 MW Solar).* Commercial and industrial generation through Microgrids provides energy to more homes and businesses. SunFunder offers project and construction finance in order to finalise the development of these projects in markets where the access to the scale of capital is difficult.

This last type of target is the case of our interest because it is focused on Microgrids, so it is useful to go in detail with an investment example. It is the case of Quest Works, an engineering, procurement and construction firm focused on turn-key delivery of real-estate and renewable energy projects in Nairobi. Their customers are typically private, light industry and hospitality business.

The SunFunder's approach is to concentrate on the impact that can be directly linked to their loans. This means that they don't count their customers' wider impact enabled by other sources of financing.

From this experience of SunFunder, we can identify some key learnings. The lessons that we extract are related to the Fund structure and to the energy access market and they can be summarized as follow:

- The strategy must reflect the investors' needs. Since the demand of investors is not uniform, funds should be divided appropriately for different risk-return profiles and investor types. Concessionary or risk-tolerant capital providers can be essential to de-risking senior tranches for risk-averse investor types.
- The principal obstacle to the expansion of SunFunder has been a relatively lack of first-loss capital at necessary pricing levels to deliver an overall risk-profile attractive to more senior investors.

- Crucial is to match need of energy companies. Indeed, SunFunder has acquired a lot of knowledge about the capital needs and challenges of different solar companies operating in this market. Specialised skills allowed SunFunder to access a high-quality portfolio of investments.
- SunFunder has created lending and credit teams in Africa in order to spread in the countries local teams and investment officers.
- The lack of competences is a big problem. The experience of SunFunder allows to make deals more efficiently and make better decision on the risk.
- The speediness is a key element because the long due diligence processes can operate as an obstacle to the development of the project. SunFunder's shorter and more targeted process meets the need for a more agile finance.
- It is necessary the provision of flexible financing from junior debt to short term and local currency options is necessary.
- It is important to have structured capacity. In-house counsel and a lending team with a range of structuring backgrounds (including syndications, ABS, lease and project finance) allows SunFunder to tailor loans to borrower needs. An example of this can be the SAFI product that offers an SPV structure for receivables financing.
- Creating the possibility for a long-term loan is fundamental and can be a solution for this type of business. Regarding SunFunder, it is relationship-oriented company and it doesn't try to enter into loans on a single transaction-only basis.

This case study represents a type of educational resources offered to climate investors. Obviously, also the role of public institutions, like governments, is essential to support the development and diffusion of these projects. In this peculiar case, the case of SunFunder was made possible by the support of the UK Government through the Department for International Development's Impact Programme [50].

We want to report also another important example where the intervention of a great bank, the classical financial intermediator, intervened in order to allow the development of these types of projects. We are in Africa, specifically in Rwanda, a country with a good power sector. Nevertheless, there are a lot of challenges due to the inadequate physical infrastructures that need to be developed, poor institutional capacity and lack of enough financial means deriving from the immaturity of the country's private sector, that, in theory, should be the one that drives the development. investing in renewable energy is a prerogative of the governments regardless form the challenges, so the Government of Rwanda recognizes that availability of efficient electricity supply is a pre-condition for the social prosperity and economic growth. That's why and aggressive action plan is launched in order to increase electricity access from 16% in 2013 to 70% in 2017.

In order to achieve this target goals, the support of the African Development Bank was fundamental. Fortunately, Rwanda has lots of untapped energy resources. For example, micro-hydro potential sites have been estimated to about 333 spread out around the country, which means Microgrids with micro-hydro are promising options.

The aim of this plan is that more the 1 million of households, health clinics, schools and public sectors are expected to be connected though grid connection or reliable off-grid systems [51].

5.4 Concessionary Finance

With concessionary financing we mean loans extended on terms substantially more generous than market loans. The concessionary is achieved through interest rates below those available on the market or by grace periods or a combination of these. Concessional loans typically have long grace periods.

We will reference also to the so-called ecosystem approach that, in general, is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. It recognised that humans are an integral component of many ecosystems.

But in our case, we take into account the ecosystem approach to finance, that in particular combines the latest science with effective government policies, sustainable livelihood strategies for local communities, and innovative financing mechanisms, like concessionary finance, to protect the planet and benefit humanity for generations to come.

In line with this paragraph a very suitable example is offered by the experience of Microgrid Investment Accelerator (MIA).

Facebook and Microsoft have joined with the investment firm Allotrope Partners to launch a "first-of-its-kind" finance facility in order to put investments in reenable energy Microgrids in off-grid areas around the world.

The Microgrid Investment Accelerator will mobilize about $50 million between 2018 and 2020 in order to expand energy access in India, Indonesia and East Africa. The facility was launched in April 2017 at the U.N. Sustainable Energy For All Forum.

The CEO of the MIA facility in that occasion said:

> *"MIA will test the commercial opportunity for Microgrids and demonstrate how concessionary finance can unlock progressively larger proportions of private capital as risks are discovered, priced and mitigated"*.

The access to financing with affordable prices has been a great obstacle to the development of Microgrid solutions, especially in frontier markets. Few start-ups have been forging ahead, but with limited funds and relatively small projects. This is an important constraint because since there ideas and projects to be developed, it is difficult to go ahead without the participation or support of private funds or private companies that can put a lot of money into these projects.

In this way every company or even start-up specialized in Microgrid projects, or in general in renewable energy, has the possibility to realise its project and then, deploy it in specific areas.

Figure 5.1: Facebook and Microsoft mobilize $50 Million for Renewable Energy Microgrids (source: Foundation Rural Energy Services FRES)

MIA planned to accelerate the Microgrid market through an "ecosystem approach to finance" that exploits grants and loans from foundations and development institutions in order to attract private capital. The aim of MIA is to distribute projects with a tolerant risk and corporate debt and equity, both independently and with co-investment partners. This to help and inform the investment community with a rigorous data collection and analysis.

Founding partners Facebook, Microsoft and California-based Allotrope have joined with other several partners and observers to form the Microgrid Investment Accelerator. In MIA there are also other partners such as cKers Finance in India, CrossBoundary Energy in Africa, California Clean Energy Fund, Electric Capital Management, Morrison & Foerster LLP and GivePower. This to say that is a big entity formed by the most important private companies and specialized companies, all aimed at creating a referral point for the investor's community. The MIA is expected to accept pilot project applications and it will start to distribute funds to selected projects in the next years.

This because the scope of the energy access challenge is immense and year by year, more and more people remain without energy access. A research of the Global Tracking Framework shows that while between 2012 and 2014, hundreds of millions of people have had the access to clean cooking, electricity and renewable energy, today more than 1 billion people still live without access to power. It is incredible, the trend is increasing following the years, and for this reason it is crucial to develop projects focused on renewable energy, like the Microgrid projects. So, the trend is not positive and if this will not change, will be impossible to reach the Sustainable Development Goals (SDGs), which include universal access to modern energy services, doubling energy-efficiency improvements and doubling the share of renewable energy in the global energy mix. Moreover, the Renewable Energy Agency estimates off-grid solutions, such as Microgrids, will provide the 55% of the new generation needed to reach the universal electricity access goal by 2030.

In the occasion of the Sustainable Energy For All Forum also Enel signed an agreement to launch the SEforALL Electrification Accelerator, as well as putting efforts to support SEforALL and the SDGs. Enel agreed to offer its experience in the elaboration of a development plan for electrification through the digitalization of mini networks, mini-grids and electric mobility.

The reason why there a lot of private companies interested in this emerging market is that, besides expanding energy access provides significant social and health benefits for communities, it also represents a meaningful business opportunity.

Not by the chance, a spokesperson wrote this in an email:

> *"Facebook's mission is to connect the world, and we're exploring different ways to engage with partners to support energy-efficient systems that drive sustainable connectivity -- including our support of the Microgrid Investment Accelerator to help spur investment in affordable and clean distributed generation"*

What we can learn from this example is that partnerships will assist in broadening access to the own connectivity efforts. Finally, improving access to modern electricity systems could open the way to a multibillion market for appliances and for social networks [52].

CHAPTER 6: CONCLUSIONS

The Microgrid market is an emerging market through which different investors and companies are investing in. We are assisting to the development of several projects on renewable energy, especially focused on Microgrids since they are instruments that can be a big innovation in this field from different point of view.

Microgrids allow remote areas and islands of developing countries to access electricity through low-cost and efficient technologies. The priority is to replace the traditional way to product and consume electricity with new instruments that can make the same things solving the problem of efficiency resources.

We took as reference case the South East Asia as one of the most active areas in this emerging market. Exploring all the countries of the South East Asia we have learned that there are a lot of projects addressed to the deployment of such instruments as Microgrids in order to permit rural areas and island to be integrated with a grid connection.

The first three chapters are aimed at presenting what Microgrids are and their advantages in comparison with the traditional instruments. It is also important to understand the financial and non-financial constraints, some types of investments and challenges that the Microgrid development is meeting nowadays, focusing on the real practises in the S.E.A.

After this overview that has been useful in order to enter in this topic with all the necessary information, in the Chapter 4 there is a sort of forecast of what the Microgrid market evolution will be. We have started taking as reference the last two years because that is the period in which we can assist to a substantial progress in this environment. Starting from the early 2017 the big giants of technologies have put the interest in this market, investing and creating partnership. We are talking about important companies like Facebook, Microsoft, Tesla and so on, companies that put billions of dollars in the Microgrid projects with the goal to spread them in developing countries. This because, in these zones there is the possibility to exploit the natural environment through renewable energy in the best way as possible and then because there is the possibility to change the structure of some areas that, regardless to the evolution of the progress, they have remained behind.

After this recap of the big investments in the 2017 and 2018, as said before we have reported a sort of prediction of the future Microgrids. What we have learned is that there already is the willingness to make step further to the Microgrid even if we are only at the beginning of these instruments. From Microgrids or Smart grid to the futuristic scenarios of the Neural grid aimed at building the topic of smart and intelligent cities. The top level of innovation that implies a much more powerful platform of hardware and software resources that exploit ubiquitous connectivity, cloud, robotics, artificial intelligence, edge computing and pervasive detection to run a wide range of energy and non-energy applications. It is the latest act of network modernization, able to transform the existing infrastructure into a platform that will support a fully mature Energy Cloud environment.

Finally, in the Chapter 5 we reported some real cases of investment in Microgrids and renewable projects with the aim to show what the best practises and ways to reach the final result are. How to behave and approach with the public institutions as governments, how to identify with the rural communities, in such a way to overcome all obstacles in the best way possible and develop these projects in the shortest possible time. As stated before, different protagonists have entered in this market such as the private sector, but also banks and other actors aimed at creating a different world.

Hence, we divided the Chapter 5 according to who is made the investment and realized the projects. In this way we have seen that a big protagonist, as expected, is the private sector in which different private companies put a lot of money through the private equity fund, creating partnerships in order to have the necessary skills to develop those projects. Going in deep, not only private companies are interested in this field but also entities that work as financial intermediaries play an important role. They work as support in order to permit the rise of projects putting money and mitigating the risk.

Other forms of private assets that intervene in this field are the so-called impact of investing so companies like no-profit entities that invest with the aim to change the economy structure leaving a footprint or the form of concessionary finance that is a way to soften the terms and conditions of the financing.

Passing through these real cases, in the Chapter 5, in which there was the contribution of private assets, we highlighted step by step how a project like these begins and how it evolves overcoming constraints and obstacles. The aim is to exhibit examples to follow, the appropriate behaviour to hold in order to reach the final positive result of having a financial return or to leave a permanent footprint.

The lessons that we have learned from these cases study, are summarized in the table below:

	KEY POINTS	BUSINESS MODEL	DEMONSTRATION	IMPACTS
Powerhive	• 4 pilot projects in Kenya • Electricity through pay-as- you -go basis • Technology platform to collect data to highlight costs, revenues and Microgrid reliability	• First pilot project launched in a small group of residential as a test for the other • Searching concessions as instruments of private sector that offers a public good to attract financing and be regulated • Establish cost reflective tariffs • Encourage risk-reflective rates of return	• Microgrid offers a grid-quality service with reasonable cost • Powerhive as the first privately held utility company in Kenya • The company was able to scale its off- grid utility service	• Households save money and increase the usage of energy service • Possibility to access to entertainment and connection via Television • Increasing income by operating new businesses
NantEnergy	• Investment in zinc-air batteries for remote areas in opposition to the market trend • Hybrid system that pair long duration zinc-air with technologies for shorter-term power delivery	• Strategic partnership to increase capital, vision and influence • No pilot projects but overseas market (like Indonesia) to compete on costs: the remote Microgrid • Beating incumbents on technology costs	• Factory in Indonesia supplied the region • Convince people and governments of the new product	• 110 communities obtain 100% of renewable based electricity with Microgrid supported by its batteries
DESI	• No profit company that builds biomass gasification Microgrid systems in India • Invest to ensure a reliable presence for commercial customers • Rigorous process and monitoring activities	• Tariffs high due to small number of customers, sell power on a metered energy basis • Emphasizes the creation of opportunities for the lowest income villagers	• Poor competition of the central grid • Client creation is essential for the operational sustainability • Tariffs collection can solve the non- motivation of customers to pay	• Expanding economic opportunities for villages • Involve customers offering a more reliable service • Collaboration with the government
Green Empowerment /Tonibung/PACOS	• Several Microgrids installed in Malaysia • Micro-hydro facilities • No support of external monetary entitites • Development of 15 Microgrid since 2000 • Most of the fund came from international donor agencies	• Community ownership a starting point • Supporting communities from all the points of view • Developing and raising for Microgrid installation and training • Tonibung utilizes Corporate Social Responsibility funds	• Villages need external support for expensive repairs • Role of the community to maintain the system • Community dynamics as the biggest factor in the performance of Microgrids • Sharing experience to improve practices	• The community contributes 10000 hours to the project • Communities learned to find unique solution for repairs • Assistance among villages
SunFunder	• Launched a fund called Beyond the Grid of $47 million • Tailor debt capital financing • Construction finance to commercial and industrial Microgrid	• Senior debt, Mezzanine debt and Junior debt to meet needs of investors • Offering opened to every investor and foundation • The end beneficiaries of the fund are individuals that have the access to clean energy through investments in solar companies	• The strategy must reflect investors needs • Matching needs of energy companies • Specialized skills allowed SunFunder to access a high- quality portoflio of investments • Speedness is a key element • Need of flexible financing • The support of the government is crucial	• Expansion of credit teams in africa to spread local teams and investment officiers • Long- term loans can be the solution
Microgrid Investment Accelerator (MIA)	• Facebook and Microsoft and other important companies joined with Allotrope Partners to launch a first-of-its-kind finance facility • MIA mobilises $50 million • Also Enel launched the SEforALL Electrification Accelerator	• Concessionary finance can unlock larger proportions of private capital • Access to financing with affordable prices • Accelerate the Microgrid market through an ecosystem approach to finance	• MIA as referral point for the investor's community • Projects of renewable energy are necessary to reach the SDGs • Microgrid market as meaningful business opportunity since there are a lot of private investors • Partnerships assist in broadening access to the	• Microgrids will provide the 55% of the new generation needed by 2030 • Connect the world • Energy efficient systems to drive sustainable connectivity • Modern electricity systems could open the way to a multibillion market

Table 6.1: Recap of the main points of the real cases

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