CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

FACULTY OF TROPICAL AGRISCIENCES

Sustainable Renewable Energy Sources as Part of Emergency Energy System and its Effects on Environment: A case Study of Latakia, Syria

Thesis of dissertation for state doctoral exam

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In Prague, on: 14. 11. 2018

Content of thesis

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1. Preface

Electrical energy is one of the most urgent of our daily needs. Shortage of energy can be very dangerous for any society. This can affect the standard of living and quality of life of the people and even endanger the lives of those in hospitals, etc.

Developed countries do not face such risks in general because they have well organized electrical systems and high energy security. The developing countries are faced daily with electric system collapses, especially in the case of wars, where many parts of the electrical grid in the country can be damaged and fuel transmission lines for generators cut off. Every city in developing countries should have a strategic plan to deal with any unexpected occurrence of energy shortages using any available renewable energy sources.

Latakia city is located in a region which has been suffering from the consequences of war for more than six years. The fact that a high number of migrants from other cities have come to Latakia along with a lack of fuel makes the energy shortage in the city worse. An emergency system could use sustainable renewable energy to provide an acceptable energy supply for the minimum requirements of daily life.

2. Introduction

Getting continues and stable electric-power supply is one of the most important needs of human existence in the modern age, especially in cities where daily human activities are very active during the day and night hours [1]. Therefore, interruption of electricity supply for long hours significantly affects social economic life, causes financial loss, negatively affects a nation's economy, decrease the Gross Domestic Product (GDP), retards development and daily life activities, [2-4].

Using electrical energy in the cities does not result in any emissions because power plants are usually located far from cities so that their effects on human health and the environment in cities is reduced to the barest minimal. But due to poverty and weak infrastructure in developing countries, old ways of heating or cooking such as diesel and wood are being used, most especially in the suburbs of cities. Using such methods is very harmful to people's health and the surrounding environment since they emit a lot of emissions [5,6]. In the same vein, energy stored in fossil fuels that is released by human activity causes environmental pollution. Furthermore, fossil fuel energy resources are exhaustible, and alternatives will be needed in the near future [7]. The extensive exploitation of renewable energy sources in cities has become an essential and practical strategy for fostering sustainable development [8].

Renewable energy sources such as solar, wind and biomass energy has become an essential part of the modern grid owing to the fact that renewable energy resources are clean and cannot be depleted; other reasons are that this reduces global warming, there are limited levels of fossil fuel in the world, and that diversification of energy sources achieves high levels of energy security and…etc [7,9,10,11,12,13]. Renewables can play a major role in mitigating an energy crisis especially in the remote areas of developing countries. Considerable research has been done on the ability of renewable energy sources to solve the problems related to energy shortages. Some of these projects have been proposed to mitigate electric-power crises in Pakistan, China and Bangladesh [14-17] and others are about to be implemented in Africa and India [18-20].

Continuous electricity supply enhances energy security, as energy security is a very important aspects of the energy plans of countries, mostly in situations where it is essential to have many sources of energy supply and to also have alternative sources of power in case of armed conflicts, natural disasters etc. Power shortages and climate change are two great problems today. For this reason, the power sector must be rid of carbon emitting plants to create a pollution-free environment [20]. It is hoped that renewable energy sources will help to reduce energy crises and prevent further climate change. Renewable energy is one of the fundamental natural resources needed to help achieve the social, economic and environmental goals of mankind [21-23]. Access to clean energy is essential for well-being, poverty reduction and the sustainable development of cities [24]. Energy security plans can be locally or centrally organized. Local plans may be more efficient because each municipality can adopt a strategy according to its geographical location and the available energy sources.

The city of Latakia in Syria is discussed as a case study of a city which has faced an unexpected energy crisis and its related consequences. The methodology adopted in the study and the data sources used for the analysis are also discussed in order to achieve comprehensive fore-knowledge of the energy crises been faced by the city of Latakia.

3. Literature review

3.1 The Electric Power Distribution Grid

The principal function of an electrical power distribution scheme is to supply electricity to individual power consumer buildings, together with its outbuildings. Distribution of electricity to diverse power consumers is done with much low voltage level and it is executed by means of the distribution systems. The distribution systems are composed of the following dominant parts, that is; Distribution substation, Primary distribution feeder; Distribution Transformer; Distributors, and Service mains. Transmitted electricity is stepped down with the aid of step-down transformers in substations, for primary distribution. The stepped down electricity is conveyed to the distribution transformer via primary distribution feeders. Overhead primary distribution feeders are normally supported by iron pole, ideally rail pole. The conductors are strand aluminum conductors and they are installed onto the arms of the pole with the aid of pin insulators. Some times in overcrowded locations, underground cables may equally be utilized for primary distribution purposes. Distribution transformers are predominantly three-phase pole mounted type. The secondary of the transformer is linked to distributors. Different power consumers are fed electricity by means of the service main. These service mains are tapped from individual points of distributors. The distributors can equally be re-classified as distributors and sub distributors. Distributors are exactly joined to the secondary of distribution transformers in contrast with the sub distributors that are tapped from distributors. The service main of the power consumers may either be joined to distributors or sub distributors, this depends on the location and agreement with power consumers. Feeder and distributor convey electrical loads, but they have one fundamental difference. Feeder feeds electric-power from one point to another point without being tapped from any intermediary point. Since there is no tapping point in between, the current at the sending end is equal to the current at the receiving end of the conductor. The distributors are tapped at different points for feeding individual power consumers; and hence current differs throughout the whole length of the conductor. There is the radial and ring main electrical power distribution systems. Diagrams showing the electricity distribution networks can be seen in fig 3.1 and 3.2 [25], [26], [27] and [28].

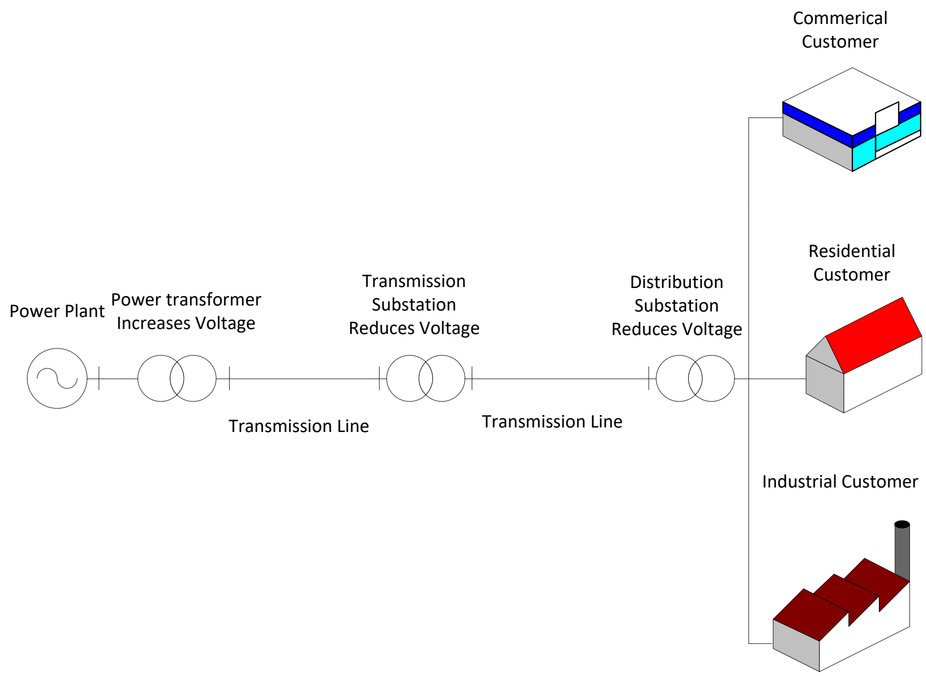

Fig 0.1 A typical electric-power distribution grid [28]

3.2 Dispersed Generation

Dispersed generation is decentralized electric-power plant, feeding into the electricity distribution power network and usually sized between 10 and 150 MW. Dispersed generation is strategically situated on the electricity transmission grid to deal with issues in the transmission and distribution network and to enhance the stability of the electricity network. In the world of decentralized power technologies, electricity is generated at or near the locality of consumption, comprises both distributed and dispersed kinds of electric-power generation. The main difference between these two types of electric-power generation, is that distributed generation is joined to the electric-power grid but dispersed generation is not. dispersed generators are planned to supply backup power and normally functions exclusively in the time of urgent situation or electric-power system outages [29] and [30].

Electricity utility infrastructure in many countries is usually founded on large electric-power plants system feeding electricity to consumers through an extensive power transmission and distribution network, collectively referred to as the electricity grid.

Dispersed generation is an idea where smaller, highly efficient electric-power plants would be built throughout the length of the existing grid, close to the power consumer. It is comparable in conceptualization to the move from the era of bulky central computers to desktop computers on an interconnected system. Nations with strong renewable power potentials such as wind energy, are preferably suited to embrace dispersed generation. Dispersed generation provides a range of advantages for many prospects. Electricity consumers, electric-power providers, and other stakeholders in the industry all have their own rationales for wanting greater acquisition of distributed generation. Distributed electric-power generators are small when compared with normal central station electric-power plants and gives distinctive advantages that are not obtainable from centralized electricity generation. Most of these advantages is as a result of the fact that power generating units are essential modular, which makes distributed electric-power highly accommodating. It can supply electric-power where it is required, and when it is required. Since they normally depend on natural gas or renewable power resources, the generators are usually associated with less noise and therefore less pollution than larger electric-power plants, this makes it appropriate for on-site installation at various locality [29] and [31].

3.2.1 Features of Dispersed Generation

Dispersed generation minimizes both power transfers between localities of electric-power systems and power imbalance in every single location. Dispersed generation equally enable uniform distribution of the general electric-power system by responding speedily to electricity demand variation. It gives more flexibility and can be dispatched in incremental blocks of electric-power as required. It brings about reliability and stability of the electric-power system. Complete failure of the network can be averted when the load centers are sustained by dispersed generation. A significant outage in the electric-power line can be forestalled with the aid of dispersed generation connected by reciprocating engines, thereby bringing electricity back onto the power line within minutes [29].

3.2.2 Benefits of Dispersed Generation

The drivers for dispersed generation are including of Low cost of electricity -. The fact that power consumers benefits from low cost of electricity could well be the main reasons for embracing dispersed generation; Geographical factors – Due to the overcrowding of power transmission lines and higher electricity price in mainly metropolitan localities, dispersed generation technology is being embraced; Saving on outage cost - The increasing demand for premium electric-power might have force most industrial and commercial power consumers to change to dispersed generation in order to secure consumers from the threat of power outages; Increasing demand in intermediate sector - Flexibility to meet up with intermediate electrical load increases the demand for dispersed generation; Low payback period - Electricity utility authorities are usually disturbed about investing on long-term bases. Hence, they are comfortable with dispersed generation, which is based on lesser investment and lower payback time [29].

3.2.3 limitations and Challenges of Dispersed Generation

Just as dispersed generation has its benefits, it equally goes with limitations and challenges, these are: Dispersed Generation Utility attitude - Electricity utility authorities are normally bothered about the recouping of stranded assets, therefore they provide resistance in terms of execution of dispersed generation; Consumer perception – For now, there are few successful stories of dispersed generation, so power consumers are afraid of the future of dispersed generation; Government regulations – The future growth of dispersed generation markets predominantly rely on the regulator’s policy and framework; Grid interconnection issues – Issues such as lack of uniform standards, safety, and the influence of grid tear affects dispersed generation [29].

3.2.4 The Future of Dispersed Generation

Although decentralized generation of electricity is not likely to absolutely take the place of central power generation, the share of decentralized power generation is hope to rise dramatically in the near future, with significant benefits to all electricity consumers and coupled with its environmental advantages. Dispersed generators are improbable to compare with central power station, consumers are attracted by the crave for reliable electric-power which would be the propelling factor for the future of dispersed generation. Since the quality of the entire centralized electric-power system and its capability to transmit electricity to the loads at where and when required is a concern to stakeholder's in the industry, a mixed portfolio together with dispersed and distributed electric-power generation will help to supplement and improve the reliability of the general electric-power system [29].

3.3. Most important renewable energy sources

3.3.1. Wind energy

The collective wind power production from 1999 to 2020 is shown in fig 3.2, from this diagram, it is observed that wind power has grown rapidly to a capacity of 283 GW with approximately 45 GW put in place only in 2012, this number is anticipated to reach 760 GW in 2020, that is on a moderate situation. Wind power generation has grown more notably than any other renewable power sources and it is becoming actually a significant player in the modern electricity supply system. Today, most countries have a high penetration of wind power, this is to say that electric power consumption is mostly covered by wind energy. Presently, some nations have even the ambition to achieve 100% non-fossil based power generation system in the near future [32], and [33].

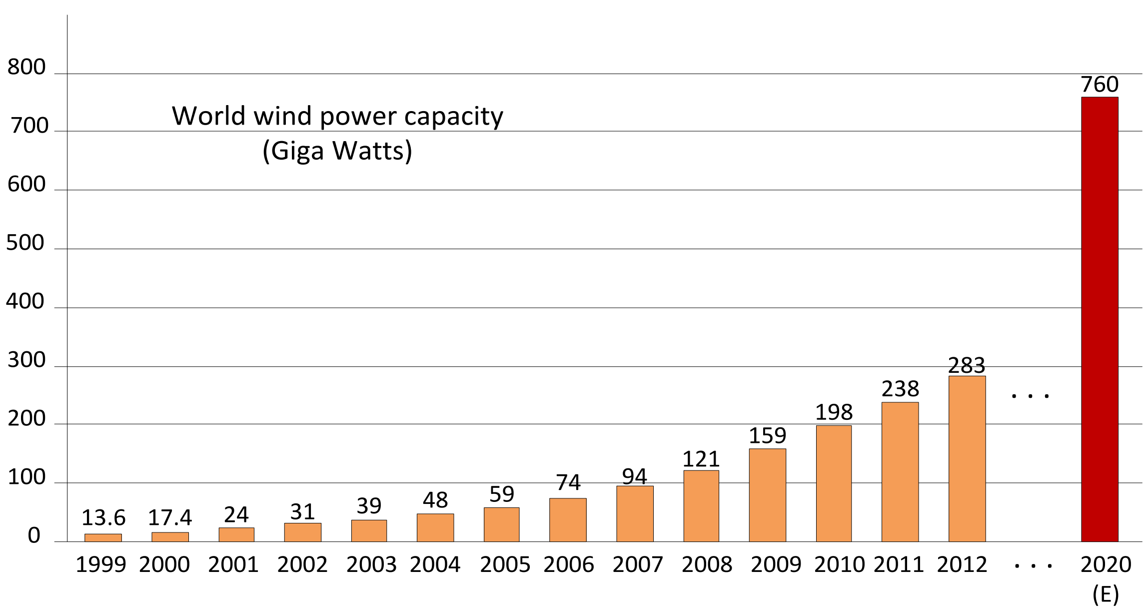

Fig 0.2 Global collective installed wind power production from 1999 to 2020 [34].

In inclusion to the quick development in the total installed production of wind power generation, the size of each wind turbine has equally increased dramatically to get a lower price per generated kilowatt hour. In the year 2012, the average turbine size brought into the market was 1.8 MW, out of which the average offshore turbine technology has realized a size of 4-MW. The increasing tendency of emerging wind turbine size between 1980 and 2018 can be vividly seen in fig 3.3, The growth of power electronics in wind turbine systems with its rating coverage and function role is as well shown. It is noticed that the cutting-edge 8-MW wind turbines having a diameter of 164 m have hitherto shown up in 2012. Today, many wind turbine manufacturers are initiating products in the power competence of 4.5–8 MW, and it is presumed that more and more huge wind turbines of multi-megawatt electric-power level, even as large as 10-MW will emerge in 2018, this will be in existence in the following decade driven mainly by the thoughts to bring down the cost of electric-power [32] and [35].

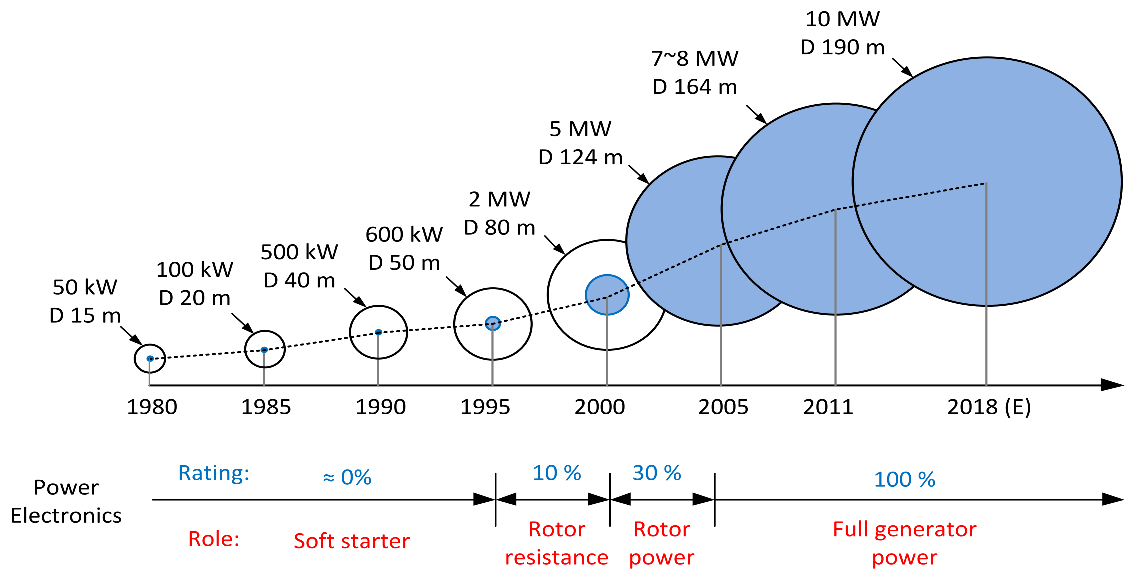

Fig 0.3 Evolution of wind turbine size and the power electronics seen from 1980 to 2018 (estimated). Blue circle: the power coverage by power electronics [34].

Synchronous generators, whether externally excited or with permanent magnets, are now becoming the favored technology in the wind power industry. Multipole permanent magnet synchronous generator (PMSG) having a full power back-to-back converter hope to become the predominantly embraced generator in the near future due to its lowered losses and lower weight as compared to the externally excited synchronous generator that has been manufactured successfully by wind turbine manufacturers. In some cases, the generator can be annular generator, and the rotor current is utilized to regulate the direct current link voltage. The change appears to be mainly valid for larger wind turbines from 3–6 MW. Nonetheless, the increment in the prices of rare-earth magnets might transform the philosophy of wind turbine drive trains to keep away from high risk in terms of expenses [36], [37] – [40].

Permanent magnet synchronous generators occupy an important part in direct-drive wind power generation systems for changing mechanical power into electrical power. The dynamic configuration of the permanent magnet synchronous generator is obtained from the two-phase synchronous reference frame, in which the q-axis is 90 (°) degree leading of the d-axis in conformance with the orientation of rotation. The harmonization connecting the (d-q) revolving reference structure and the abc three-phase structure is sustained by utilizing a phase locked loop. A detailed mathematical modelling of the permanent magnet synchronous generator is a necessary condition for the design of the machine control algorithms and the examination of the steady-state and dynamic features of the wind power transformation scheme. Direct drive wind turbine generators, distinguished as highly effective or efficient and requires low maintenance procedures, provides favorable possibilities for future implementations, particularly offshore applications. In order to do away with the gearbox, the generator is constructed for low speed performance maximally between 15-20 (rpm). This characteristic has made synchronous generators the only choice for low speed wind turbine utilizations. Synchronous generators magnetic field is provided with rotor excitation, but in the instance of the permanent magnet synchronous generator the direct current excitation scheme can be removed, which necessitate minimizing losses and exclusion of slip rings and consequently the maintenance requirements of the system. To realize independent control strategy of the active and reactive power, the d-axis and q-axis equivalent circuits is utilized in the drive converter arrangements [41], [42], [43] – [48].

3.3.2. Solar energy

The Sun is the central star of our solar system. Hydrogen and helium are main components of it. Some basic facts are summarised in table 1 and its structure is sketched in Fig. 3.4. The mass of the Sun is so large that it contributes to 99.68% of the total mass of the solar system. In the center of the Sun the pressure-temperature conditions are such that nuclear fusion can take place. In the major nuclear reaction, the proton-proton reaction, via a number of steps four protons react into

• a helium core (two protons and two neutrons),

• 2 positrons (the anti-particles of electrons),

• 2 neutrinos,

• electromagnetic radiation.

The positrons annihilate with electrons leading to additional radiation. The mass of the helium core is 0.635% less than that of four protons, the energy difference is converted into energy according to Einstein's equation (1):

$$E = mc^2 \tag{1}$$

Every second thus, approx, 4 million tons of mass are converted into energy. However, the power density at the center of the Sun is estimated by theoretical assumptions only to be about 275 W/m3 . The converted energy will go throght the space to reach the Earth as light. The spectrum of the solar light coming from sun covers from about 250 nm to about 2500 nm in wavelength, as can be seen in the figure 3.5. By the way visible light of human beings covers from 400 to 700 nm, at which band the light is very dense, about 1.5 W/m2/nm at 400 nm, going up to about 1.75 W/m2/nm at about 550 nm and then comes back to 1.5 W/m2/nm at 700 nm as can be deduced from the figure [49], [50].

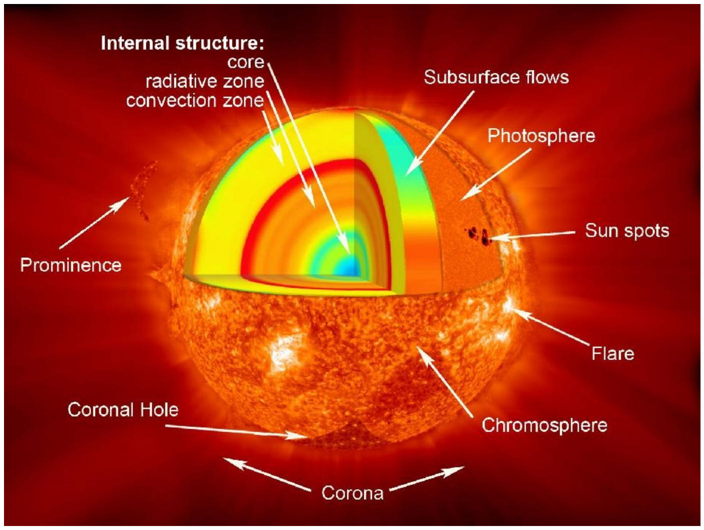

Figure 3.4: The Sun with its layer structure depicted [51].

Table 1: Some facts on the Sun [49]

Mean distance from the Earth	149 600 000 km (the astronomic unit, AU)
Diameter	1 392 000 km (109 x that of the Earth)
Volume	1 300 000 _x that of the Earth
Mass	1.993 x1027 kg (332 000 times that of the Earth)
Density (at its center)	>105 kg m-3 (over 100 times that of water)
Pressure (at its center)	over 1 billion atmospheres
Temperature (at its center)	about 15 000 000 K
Temperature (at the surface)	6 000 K
Energy radiation	3.8 x1026 W
The Earth receives	1.7 x1018 W

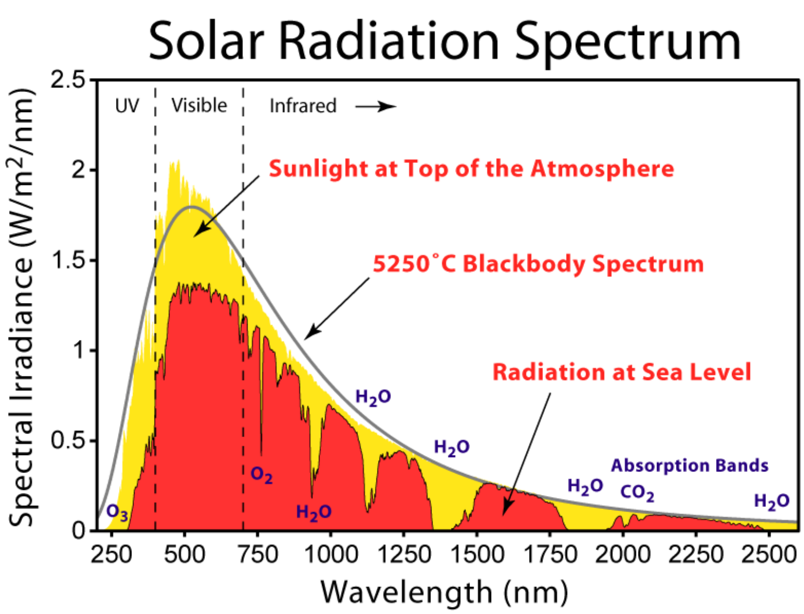

Figure 3.5: solar radiation spectrum [52]

3.3.2.1. Concentrated solar power and Solar PV Technology:

There are two types of solar energy systems accoding to the technology of energy generation .

A. Concentrated solar power:

Concentrating solar power (CSP) is an emerging controllable renewable generation technique that utilizes solar thermal power to generate electricity. The operational dispatchability of CSP would contribute to the power system transition toward high renewable penetration. Concentrated solar power (CSP) could be categorized as indirect systmes. The first type of CSP converts the solar energy first to heat and after that to electricity, which is the thermal CSP. This technology uses lenses or mirrors and tracking systems to concentrate solar irradiance to heat a solid, liquid, or gas. It directs the large area of sunlight into a small area (focal point) to produce heat and/or electricity. The block diagram of a CSP system is presented in Fig.3.6. Examples of concentrating technologies include parabolic trough and power tower, dish stirling, concentrating linear fresnel reflector, and solar chimney. Over 60% of the applications use long parabolic trough systems. Such plants may achieve at least 25% efficiency. Power-tower-based plants may have a capacity factor around 40%. The second type of CSP systems is the photovoltaic. Concentrating photovoltaic (CPV) systems concentrate the sunlight into PV surfaces to produce electricity. Therfore, it is an indirect method because sunlight is first concentrated, and then converted into electricity. A hybrid method is a combination (photovoltaics and thermal) that is used to produce electricity in addition to thermal heat [53], [54].

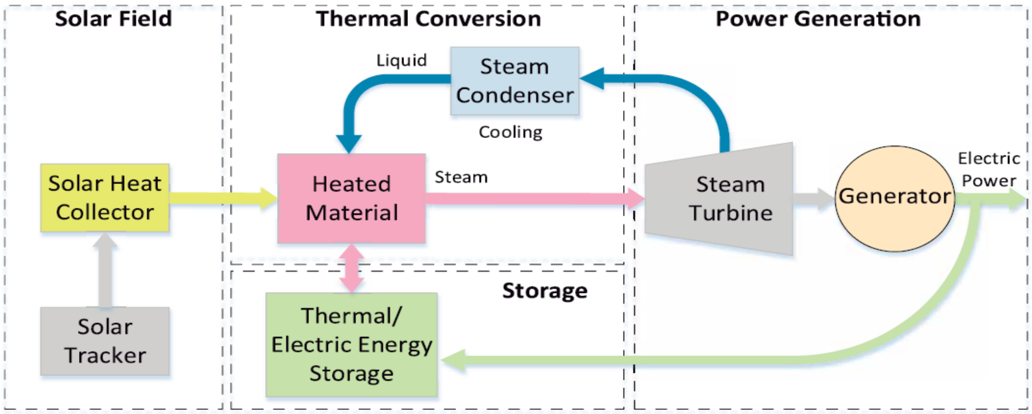

Fig. 3.6: Block diagram of a concentrated solar power system [54].

B. Solar PV Technology

Photovoltaic power generation system (PV system) is a device which changes the solar power into the electricity by solar cells and the principle of the solar cells is the use of semiconductor materials electronics characteristics of P-V conversion. PV system and its application is a profound research project, facing the 21st century, which gathers the utilization of green renewable energy, improve the ecological environment, ameliorate people's living conditions as integral whole will be of great benefits to economy, politics, coupled with society. [55] All type solar cells require a sunlight absorbing material which is present within the structure PV cell. The material absorbs the photons from the Sun and generated the free electrons within cell called as photovoltaic effect. This phenomenon converted the photons energies into electricity. These impacted photons on the PV cell raise their energy level and built the potential difference in the circuit and produced voltage for running the circuit. Generally semiconductor material like silicon used for manufacturing of PV cells [56]

A system of photovoltaic cells comprises PV cells only; this system of cells is called panels or arrays . Very simply, it can easily be used to operate a light bulb or a DC motor. In order to operate more complicated electrical devices using PV cells, an electronic converter is required. The same electronic converter can be used to regulate the voltage and current produced by the PV cells; this is helpful in controlling the power flowing into grid-connected systems. Another use of electronic converters is to be able to use maximum power point tracking; which changes the voltage of the cells accordingly to keep the power at the maximum level [57].

Ambient temperature and solar irradiation decide the characteristic of PV module. So it is crucial to figure out the maximum power point (MPP). Fig.3.7. is the plot of PV power output versus voltage at different irradiation level at a constant ambient temperature. Fig.3.8. is the plot of PV power output versus voltage at different ambient temperature at a constant irradiation. [55]

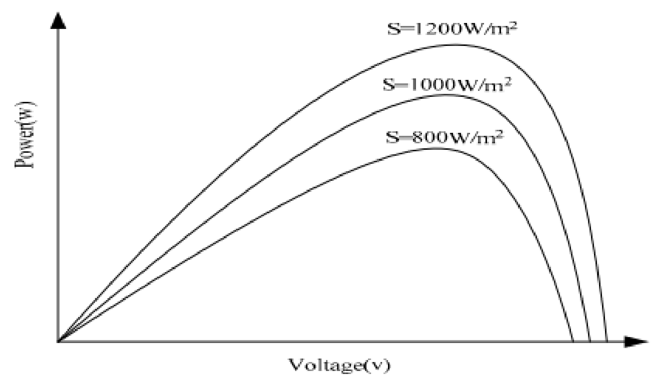

Fig.3.7: PV power characteristic for different irradiation level [55]

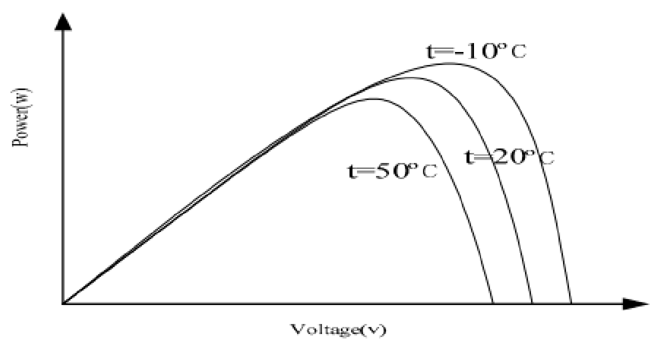

Fig.3.8: PV power characteristic for different ambient temperature level [55]

3.3.2.1. Grid connected and stand alone solar systems:

Also solar systems can be catorgized to grid connected or stand alone depending on applications. In grid connected systems, the generated electricity is passed to the utility grid and there is no need for storage. Stand alone systems must be complimented with batteries and backup (e.g. diesel or wind) to ensure enough energy supply for loads when the sun is not available [58].

A. standalone systems

The Fig.3.9. shows the conventional power flow for a standalone PV system. The configuration generally has two converters one for boosting PV voltage and other interfaces battery backup to maintain the DC link voltage at desired value. [59]

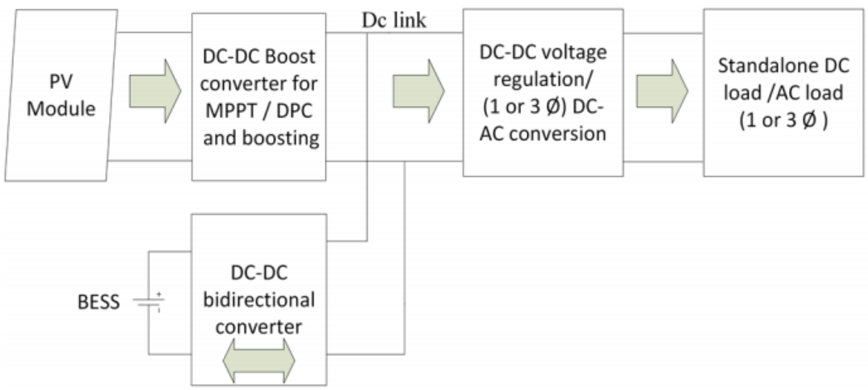

Fig.3.9: General Block Diagram of PV Standalone System [59]

B. Grid-connected systems

The configuration of a grid-connected PV generation system is depicted in Fig.3.10. The system connected with a utility power is mainly composed of PV modules, an active sun tracker, a high step-up converter, a full-bridge inverter, and a system controller. Due to the photovoltaic effect, the voltage of a PV cell is not very high. Because PV panels in a series string are constrained to all conduct the same current, the least efficient cell sets this string current, which may spell failure when one cell of a string is inactive. The overall efficiency of the PV array is reduced to the efficiency of this least efficient cell. It means that PV panels in a series string must be given the same orientation and be of identical size for obtaining a higher output voltage. Besides, the corresponding output voltage V_{pv} is varied easily with respect to the variation of loads. In order to satisfy the requirement of high-voltage demand, a dc–dc converter with high voltage gain is one of the essential mechanisms in the grid-connected PV generation system [60]

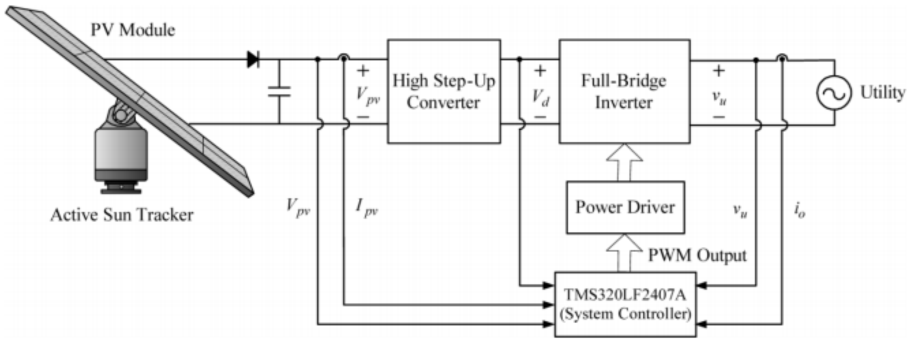

Fig.3.10: Configuration of grid-connected PV generation system [60]

3.3.3. Biomass energy

Biomass is plant matter such as trees, grasses, agricultural crops or other biological material that can be used as a solid fuel, or converted into liquid or gaseous forms, for the production of electric power, heat, chemicals or fuels. Fig.3.11. clarifies the bio-energy chain from biomass origin to energy usage. [61]

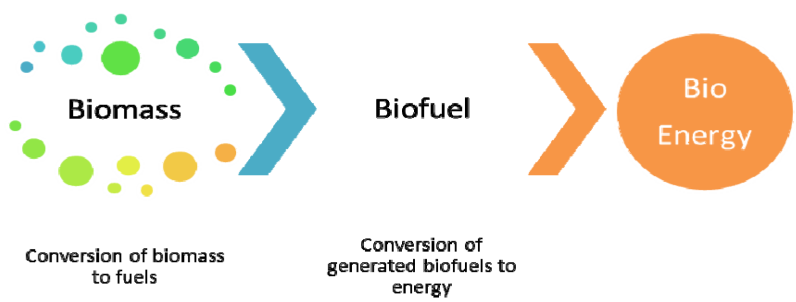

Figure 3.11: Energy chain of bio energy. [61]

Biomass energy is derived from five distinct energy sources: garbage, wood, waste, landfill gases, and alcohol fuels. Unlike fossil fuels, biomass is renewable in the sense that only a short period of time is needed to replace what is used as an energy resource. Biomass also is the only renewable energy source that releases carbon dioxide in use. However the release is compensated by the fact that the biomass grown uses the carbon dioxide from the atmosphere to store energy during photosynthesis. If the biomass resource is being used sustainably, there are no net carbon emissions over the time frame of a cycle of biomass production. Fig.3.12. shows a biomass energy cycle and the way biomass is utilized for energy generation in an environmentally friendly scheme [62].

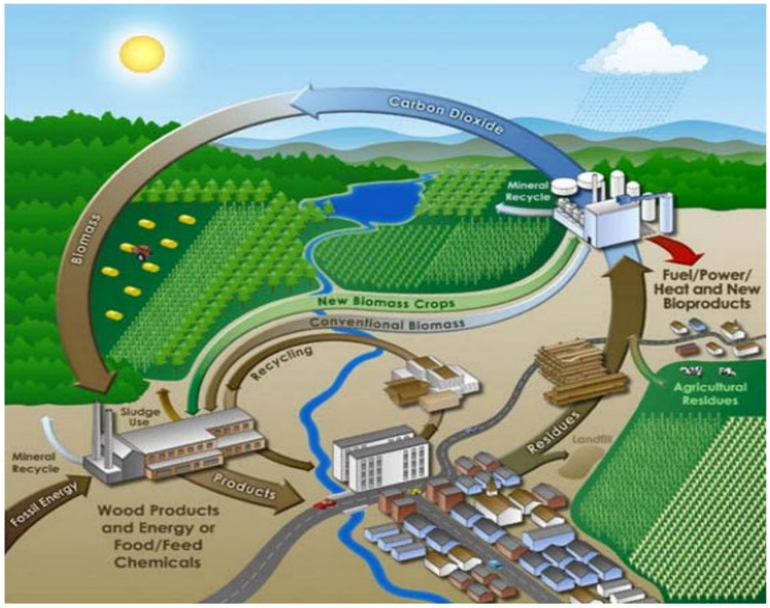

Fig.3.12: Biomass Energy Cycle [62]

Fig.3.13 shows that there are several pathways by which energy products and synthetic fuels can be manufactured.

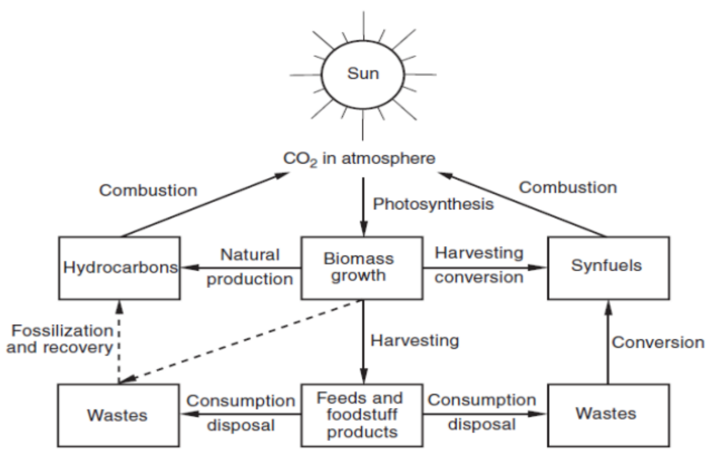

Fig 3.13: Main features of biomass energy technology [63]

Biomass Conversion Technologies: In general, biomass-to-energy conversion technologies have to deal with a feedstock which can be highly variable in mass and energy density, size, moisture content, and intermittent supply. Therefore, modern industrial technologies are often hybrid fossil-fuel/biomass technologies which use the fossil fuel for drying, preheating and maintaining fuel supply when the biomass supply is interrupted [64]. These technologies can be categorized into the following according to [64]:

1. Thermochemical Processes.

- Pyrolysis
- Carbonisation
- Gasification
- Catalytic Liquefaction

2. Biochemical Processes

- Anaerobic Fermentation
- Methane Production in Landfills
- Fermentation

3.4. Energy security

The continuity of energy supplies depends on the performance of a complex supply chain which spans different countries and continents and is subject to a variety of interdependent human, technical and natural risk sources that may cause interruptions at different places within the supply chain. In the electricity sector this is further complicated by the high inelasticity of demand and the non-storability of supplies, which leads to a complicated system behavior [65].

Fig.3.14. shows the expanded definition of energy security increasingly used in more recent years, where environmental sustainability has emerged as one of the three key dimensions. With this development, the main goals of energy security can be summarized as ensuring continuity and maintaining the affordability of energy services and at the same time reducing the environmental impacts of the energy system [66].

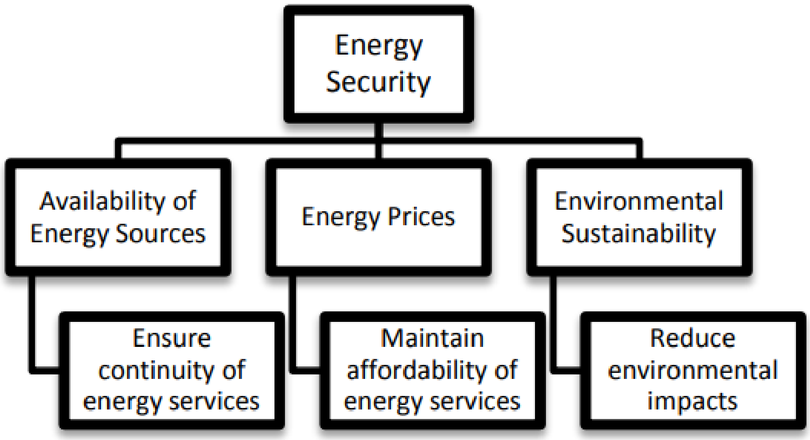

Fig. 3.14: Dimensions of Energy Security [66]

4. Methodology

The aim of the dissertation is: To gives a guide for any city or governate all needed parameters to start designing emergency energy system. Which will be able to cover most of the daily energy needs in the unexpected situations that may cause energy crisis. This system will depend on sustainable renewable energy sources as an important part of it to reduce the environmental pollution which could be occurred during energy crisis. Therefore, this dissertation will give the basics for designing an emergency security system in the current world with insecure fuel lines, wars and disasters.

Main objectives:

1. To determine the main factors which i must take into account during the design of emergency energy system period.
2. To design an emergency energy system which will cover most or all daily energy needs in case of crisis.
3. To determine all scenarios which could face the energy situation which will make the system more effective under any unexpected circumstances.
4. To set the sustainable renewable energy as important source in the emergency energy system.
5. To determine the effect of proposed emergency energy system on pollution.
6. To apply the proposed emergency system on Latakia city, Syria as a case study.

3.1.Basic assumptions of work

Designing the emergency energy system and figuring out its capacity depend on two important factors which can arise when any city, in particular, faces an unexpected situation. These two factors are:

1. Energy shortage (electricity): I can consider 6 emergency levels according to the electricity cut off hours per day as shown in Table 2.

Table 2: Emergency levels and the corresponded electricity cut off hours

Emergency level	Cut off hours per day
1	2
2	4
3	6
4	8
5	10
6	12

And for our methodology i will assume an average case where rationing hours are 6 daily, corresponding to emergency level 3, which implies a 25% decrease in the energy supply; i will also take into account the expected demand for energy for this city in the future for the next 2 years where the total system will be updated every 2 years.

2. Migration: where in case of war or natural disasters, people migrate to other safe cities or areas and this causes an increase in residential energy consumption. I will consider 4 emergency levels according to the population increase percentage as Table 3 shows:

Table 3: Emergency levels and the corresponded population increase

Emergency level	Population increase %
1	12.5%
2	25%
3	37.5%
4	50%

Here i will also consider the average case where the percentage of population increase is 25% corresponding to emergency level 2. Any expected increase in the demand for energy due to the native population increases will not be considered because they are included in the previous factor.

Using these two factors i can define an emergency energy function according to the following equation (2):

$$E_{em} = 0.25[E_T(1 + E_{ex}\%)] + 0.25E_{res} \quad (2)$$

Where:

E_{em} emergency energy.

E_T total energy demand for the city in 1 year.

$E_{ex}\%$ the percentage of expected energy demand for the next 2 years.

E_{res} residential energy demand in the city.

This emergency energy will come from different sources:

1. Power plants: if there is a power plant close to the city and the fuel supply for this plant is secure and stable.
2. Installed renewable sources: if any renewable sources are installed in city and the expected energy can be produced from them.
3. Uninstalled renewable energy: the cheapest and most available renewable energy sources in the city which could be shared to solve the energy shortage problem.
4. Portable generators energy: these generators can share the load with the previous sources whenever energy produced from renewable sources can-not be expected or is not stable, as we have to use alternative stable sources of electricity when renewable energy sources supply a city alone. These portable generators could be such as are used for industrial and commercial activities inside and outside the city and when any unexpected situationarises, they can be moved to residential areas where special rooms and filters should be used to reduce the noise and pollution inevitable with them.

We can use the following algorithm to express the methodology and how we can get the required values as shown in Fig.4.1.

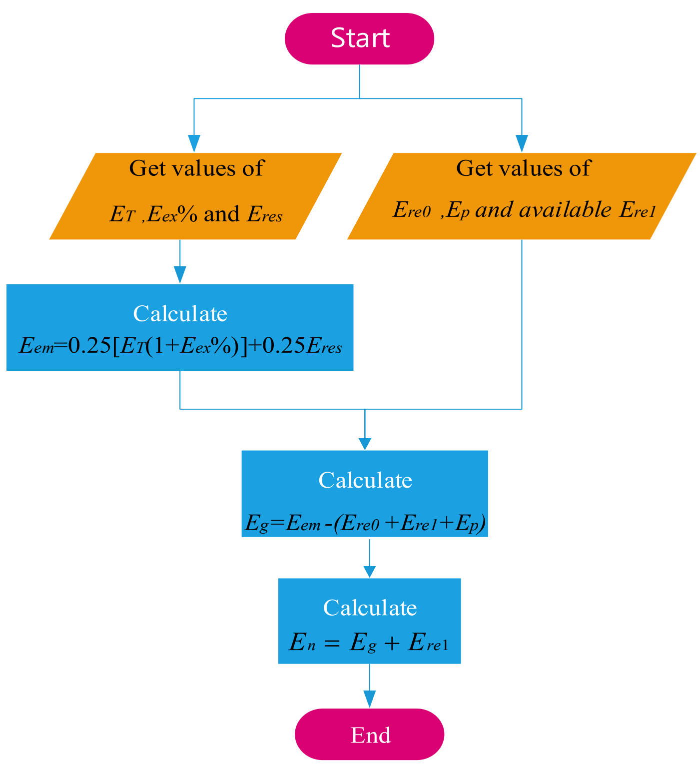

Fig.4.1: Proposed algorithm for the emergency system

3.2. Used materials and methods

1. The data of the case study, Latakia, Syria has been collected by assistance of several volunteers. In addition to views, surveys, follow ups, and contact with the responsible governmental institutions during the period 2011-2016.

2. MATLAB Simulink model will be used to transform the mathematical equations which describe the emergency system to model in MATLAB which will make it possible to input, analyze, processing and output data.

3. Using the needed programs to calculate the available energy from the different renewable energy sources such as solar irradiation for solar energy and wind speed for wind energy…etc.

5. Preliminary results

4.1 The energy situation and sources in Latakia,Syria before the war

The supply of electricity and energy in Latakia before the war in 2010 was very effective where electricity was available 24/7 as shown in Fig4.2. and was used in all industrial, commercial, agriculture and residential sectors. Energy sources used was typically diesel or electricity for heating and gas for cooking.

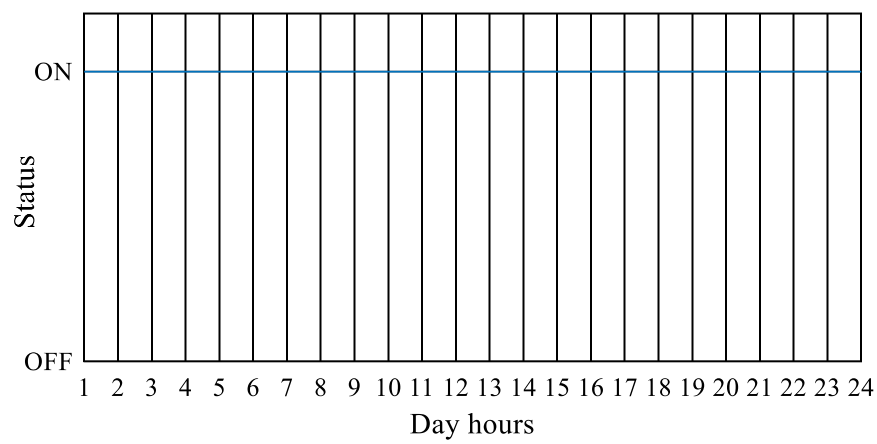

Fig4.2: Electricity supply in 2010

Latakia city gets electricity through three 230/66 kV distribution stations which are connected to the national power system which works on various sources as shown in Fig.4.3.

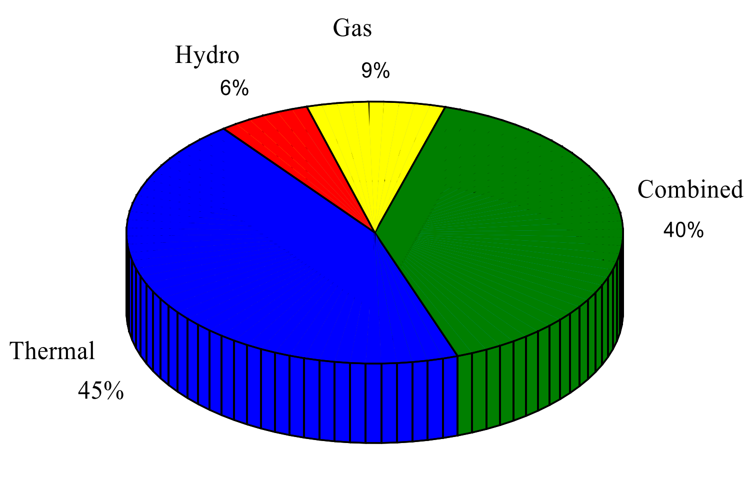

Fig4.3: Power plant in Syria

Most of these energy resources were available locally from oil and gas wells where oil production was 380,000 barrels per day and gas production was 21 million m3 per day in 2010. Syria also has two refineries which produce diesel, fuel and other products.

4.2. The energy shortage in Latakia during the war

I can summarize the energy situation since 2011 till 2016 with the following:

1. Rationing hours

Since the start of the war in Syria in 2011 the electricity hours started to decrease using a power rationing system where the rationing hours are as shown in Fig4.4.

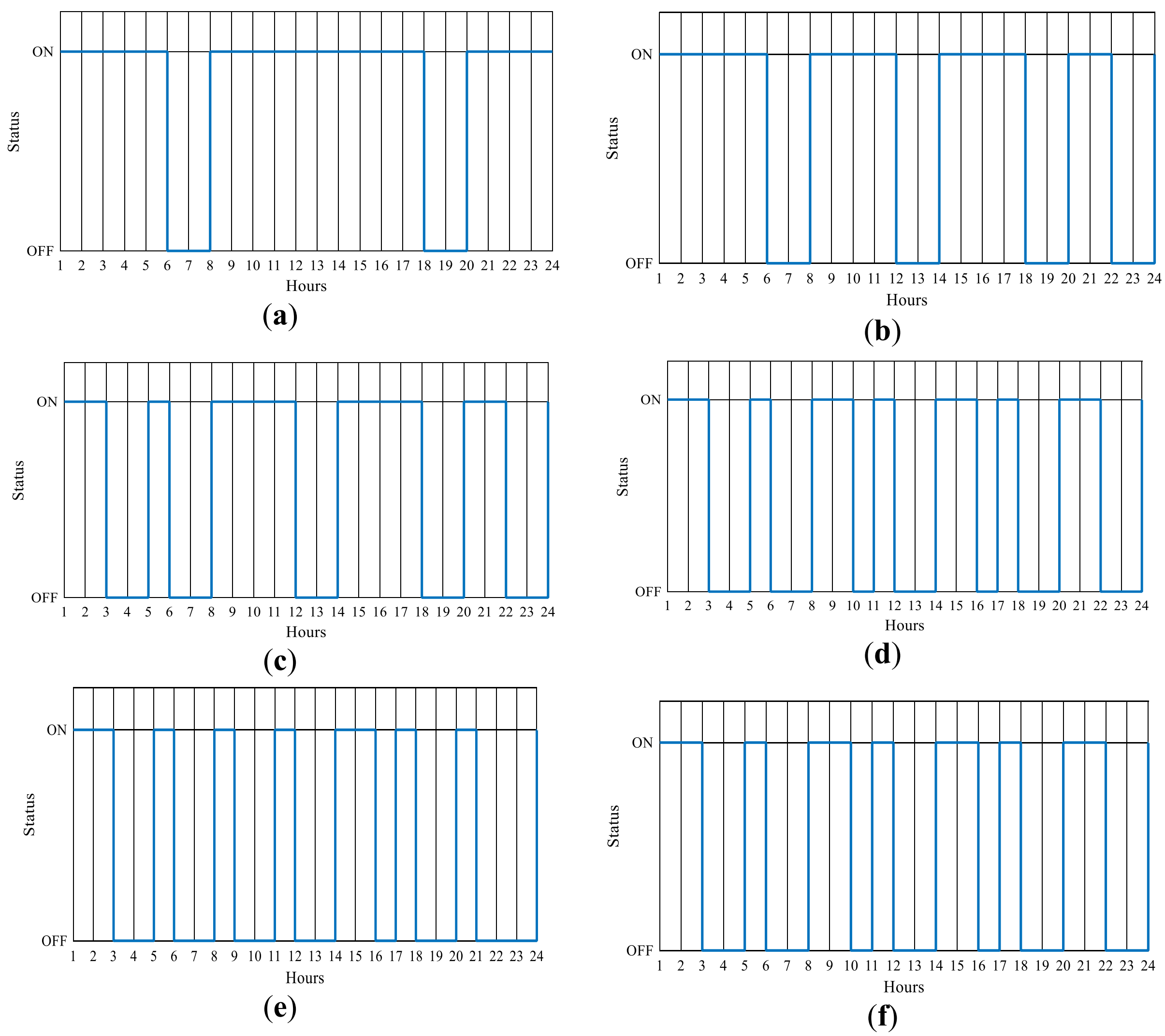

Fig.4.4: Electricity supply: (a) Year 2011; (b) Year 2012; (c) Year 2013; (d) Year 2014; (e) Year 2015; (f) Year 2016.

The appearance of ISIS in Syria has made people abandon their houses and go to safe areas and Latakia city is one of the safest cities in Syria as i mentioned before. And this has caused an increase of the population of Latakia city as shown in Table. 4 and Fig4.5. according to estimates, there being no formal statistics for the population. The numbers and percentages shown in the table relate to the population change only in the city center of Latakia because most of the migrants lives in the center of the city in its neighborhoods. The change in the percentage in 2016 due to the safety back as a result of the liberation of Aleppo and the Homs city from radical Islamic groups, which contributed to the return back of people from those cities to their homes.

Table 4: Population changes in Latakia and causes of migration 2011-2016.

Year	Population	Change %	Cause of the increase
2011	570000	-	No migration
2012	675000	18,42%	Migration from Idlib, Hama and Homs
2013	810000	42,1%	Migration from Aleppo
2014	980000	71,93%	Migration from Aleppo and Latakia rural
2015	1190000	108,77%	Migration from Aleppo and Latakia rural
2016	1085000	90.35%	Going back to Aleppo and Homs

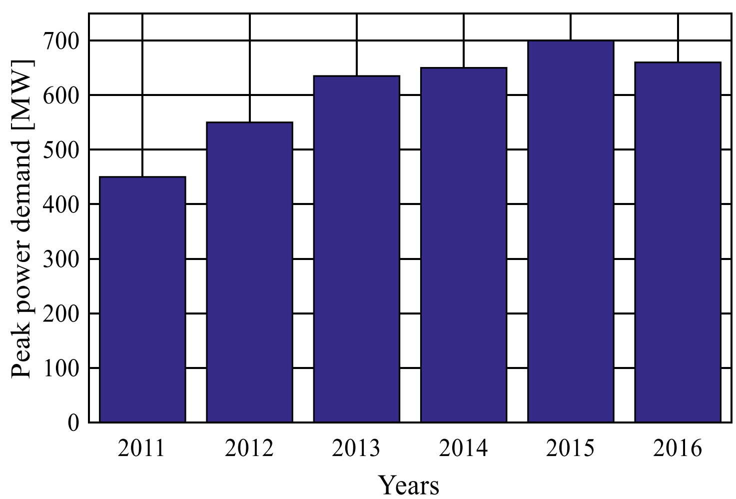

Fig.4.5: Population changes in Latakia 2011-2016.

4.3. Renewable energy sources in Latakia city as an alternative solution

I have given an overview of the electrical situation and energy crisis in Latakia city in Syria. Now i will figure out the ability of renewable sources in Latakia to face the energy crisis as an emergency system if applied in 2010 and i will see the advantages of such a system.

I can use the following renewable energy sources:

1. Biomass energy

There is a large area of landfill near Latakia in Al-Bassa which receives about 1100 ton/ day. Therefore, if i build a power plant to produce electricity from this waste, the generated electrical energy will be about 660 MWh per day and 240.9 GWh.

2. Solar energy

In Latakia city there are only a limited number of solar panel applications such as the solar panels in Tishreen University, and also some panels installed for the communications tower in addition to some domestic solar applications with an estimated produced energy by these of about 0.671 GWh.

I have high solar radiation in Latakia where the average daily sum of global irradiation per square meter is G0=5,9 kWh/m2.day.

Numbered lists can be added as follows:
Buildings rooves such as on schools, universities, residential buildings,…etc as shown in Table 5.

Table 5: Area of building roofs in Latakia city.

Buildings	**Area ($m2$)**
Schools	54000
Faculties and university buildings	21600
Government buildings	23100
Residential buildings	46000

So, the area is S= 144700 m2

The unused lands around the city which can not be used for agriculture or buildings. The area of these lands is about 214000 m2.

So, the total area would be about 358700 m2

6. Conclusion

Lack of planning for secure energy sources and depending on one source to generate electricity can lead to energy crises in the case of unexpected situations such as armed conflicts. Renewable energy sources are secure because they can work as local energy sources so they can play a major role in the emergency system for any city or country. This research could be used to design a local emergency system depending on many factors such as population, energy demand, available renewables sources,…..etc which will be very useful for energy security in any city or country. But i can notice also that i can not depend on renewable energy sources as the only source of energy in the propsed energy system because i need stable source of energy which could be big portable generators.

7. Author's Publications

6.1. Publications in the Framework of the Thesis

1. Designing of an Emergency Energy System for a City Assisted by Renewable Energy. Energies, 2018;11(11), 3138, IF:2.676.

2. Voltage Regulation and Power Loss Minimization in Radial Distribution Systems via Reactive Power Injection and Distributed Generation Unit Placement. Energies. 2018;11(6):1-7. IF:2.676.

6.2. Other Publications

1. Voltage regulation and power losses reduction in a wind farm integrated MV distribution network. Journal of Electrical Engineering. 2018 Jan 1;69(1):85-92. IF:0.524.

2. Improvement of voltage profile and mitigation of power losses in case of faults using DG units, IEEE EPE, ISBN: 978-1-5386-4612-0, 2018.

3. Reactive power producing capability of wind turbine systems with IGBT power electronics converters. Indian Journal of Engineering, 2018, 15, 198-208. (Scopus IF=0.543).

4. Progressive usage of the synchronous machine in electrical power systems, 2018, 15, 117-126. (Scopus IF=0.543).

5. Modeling and simulation of a gearless variable speed wind turbine system with PMSG, IEEE PES PowerAfrica, ISBN: 978-1-5090-4746-8, 2017.

6. Contribution to control strategies for converter connected to unbalanced grid, IEEE SETIT, ISBN: 978-1-5090-4712-3, 2017.

7. Effect of improved electricity product development on the business performance of a public electricity transmission company, IEEE PES PowerAfrica, ISBN: 978-1-5090-4746-8, 2017

8. Advantageous positioning of wind turbine generating system in MV distribution network, IEEE EPE, ISBN: 978-1-5090-0908-4, 2016.

9. Cost implication and reactive power generating potential of the synchronous condenser, IEEE IGBSG, ISBN: 978-1-4673-8473-5, 2016.

10. Optimal location of the synchronous condenser in electric-power system networks, IEEE EPE, ISBN: 978-1-5090-0908-4, 2015.

11. A review of electric vehicles emissions and its smart charging techniques influence on power distribution grid Journal of Engineering Science and Technology Review. 2016, 9(3), 80-85. ISSN 1791-9320. (Scopus IF=0,16).

12. Using renewable MV wind energy resource to supply reactive power in MV distribution network, IEEE EPE, ISBN: 978-1-4673-6788-2, 2015.

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14. Comparison of the Operational Theory and Features of SVC and STATCOM, Poster 2015, ISBN: 978-80-01-05728-5, 2015.

15. Analysis of the Synchronous Machine in its Operational Modes: Motor, Generator and Compensator In: Poster 2015, ISBN: 978-80-01-05728-5, 2015.

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17. FACTS devices influence on power losses in transmission systems, IEEE EPE, ISBN: 978-1- 4799-3807-0, 2014.

18. Study of MV Renewable Wind Energy Sources in Integrated MV Distribution Networks, ELEN 2014, ISBN: 978-80-01-05654-7, 2014.

19. Comparison of Simulation and Standard Method for Computation of Inductance, POSTER 2014, ISBN 978-80-01-05499-4, 2014.

20. The Converter Choice and its Control Circuit Design for Synchronous Generators, EPE, ISBN: 978-80-248-2988-3, 2013.

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