HIGHER DIPLOMA IN ELECTRICAL AND ELECTRONICS ENGINEERING

“SMART GRID USING RENEWABLE ENERGY”

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DECLARATION

I declare that this thesis has been made based on my personal ideas of the whole topic (SMART GRID USING RENEWABLE ENERGY) as well as some extra referential help from other already presented related projects. However, this thesis is largely self-referential.

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ABSTRACT

Renewable energy resources hold great promise for meeting the energy and development needs of countries throughout the world. This promise is particularly strong for developing countries where many regions have not yet committed to fossil fuel dominance. Solar photovoltaic and solar thermal technologies are particularly advantageous for serving the two billion people in rural areas without grid electricity. Modern biomass energy is attractive because it uses locally available agricultural wastes. Wind energy and small hydroelectric resources also are mature technologies well suited to developing countries. Such renewable resources are far more economical than traditional energy resources, especially where the costs of acquiring, maintaining, and operating centralized power stations and remediating their pollution can be avoided. However, a host of economic, social, and legal barriers prevent these renewable resources from reaching their full potential. This Article explores the legal mechanisms for overcoming these barriers and provides examples of how they have been overcome in industrial, as well as developing countries.

ACKNOWLEDGEMENT

In the name of Allah, the most gracious and the most merciful. All praise is to Him. I thank Him for giving me the opportunity to terminate this thesis successfully.

I would like to give my sincere thank you to my supportive parents for guiding, supporting and parenting me throughout my whole educational journey. I would also like to give my special thank you to my supervisor for his satisfying and defective mentoring and more importantly his effort to ensure the successful completion of this thesis.

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CHAPTER 1

Introduction

In modern world the demand for energy has increased dramatically in the past century and it will grow. Even further in the near future than ever before. Renewable energy is that energy which comes from the natural energy flows on earth. Unlike conventional forms of energy, renewable energy will not getExhausted.
Renewable energy is also termed as „green energy , „clean energy , „sustainable energy and „alternative energy .

Different types of renewable energy are:
Solar energy
Wind energy
Biomass energy
Hydropower
Geothermal

Traditionally, the term "*grid*" is used for an electricity system that may support all or some of the following four operations: electricity generation, electricity transmission ,electricity distribution and electricity control.

A smart grid (SG), also called *smart electrical grid*, *intelligent grid*, *intelli grid*, *future grid*, *inter grid*, or *intra grid*, isan enhancement of the 20th century power grid. The traditional power grids are generally used to carry power from a few central generators to a large number of users or customers[[i]]. Smart Grid is a popular phase that in the last year has dominated the political landscape and therefore in some respects has lost relevance from a technical standpoint. In some circles, the electrical "grid" only refers to the interconnected transmission system. Clearly, when the term Smart Grid is used, it refers to the entire electrical system, including generation, transmission, distribution and into the home, building or industrial complex[[ii]].

The initial concept of SG started with the idea of advanced metering infrastructure (AMI) with the aim of improving demand-side management and energy efficiency, and constructing self-healing reliable grid protection against malicious sabotage and natural disasters[[iii]]. However, new requirements and demands drove the electricity industries, research organizations, and governments to re-think and expand the initially perceived scope of SG. The U.S. Energy Independence and Security Act of 2007 directed the *National Institute of Standards and Technology* (NIST) to coordinate the research and development of a framework to achieve interoperability of SG systems and devices.By utilizing modern information technologies, the SG is capable of delivering power in more efficient ways and responding to wide ranging conditions and events. Broadly stated, the SG could respond to events that occur anywhere in the grid, such as power generation, transmission, distribution, and consumption, and adopt the corresponding

strategies. For instance, once a medium voltage transformer failure event occurs in the distribution grid, the SG may automatically change the power flow and recover the power delivery service[1].

Fig.1. the 150 mw Anda sol solar power station

CHAPTER 2

2.1 Solar energy

Every hour the sun beams onto Earth more than enough energy to satisfy global energy needs for an Entire year. Solar energy is the technology used to harness the sun's energy and make it useable. Today, The technology produces less than one tenth of one percent of global energy demand.

Many people are familiar with so-called photovoltaic cells, or solar panels, found on things like Spacecraft, rooftops, and handheld calculators. The cells are made of semiconductor materials like those Found in computer chips. When sunlight hits the cells, it knocks electrons loose from their atoms. As the Electrons flow through the cell, they generate electricity.

2

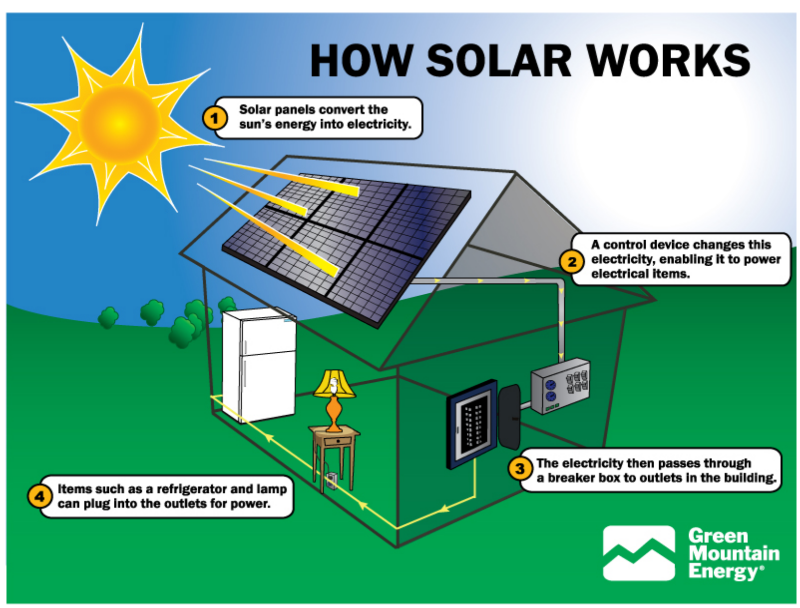
Solar energy is lauded as an inexhaustible fuel source that is pollution and often noise free. The Technology is also versatile. For example, solar cells generate energy for far-out places like satellites in Earth orbit and cabins deep in the Rocky Mountains as easily as they can power downtown buildings And futuristic cars.

But solar energy doesn't work at night without a storage device such as a battery, and cloudy weather, Can make the technology unreliable during the day. Solar technologies are also very expensive and Require a lot of land area to collect the sun's energy at rates useful to lots of people.

Despite the drawbacks, solar energy use has surged at about 20 percent a year over the past 15 years, Thanks to rapidly falling prices and gains in efficiency. Japan, Germany, and the United States are major Markets for solar cells. With tax incentives, solar electricity can often pay for itself in five to ten years.

2.2 how solar energy work

We can change sunlight directly to electricity using solar cells. Every day, light hits your roof's solarPanels with photons (particles of sunlight). The solar panel converts those photons into electrons of Direct current ("DC") electricity. The electrons flow out of the solar panel and into an inverter and otherElectrical safety devices. The inverter converts that "DC" power (commonly used in batteries) intoAlternating current or "AC" power. AC power is the kind of electrical that your television, computer, and Toasters use when plugged into the wall outlet. A net energy meter keeps track of the all the power your solar system produces. Any solar energy that You do not use simultaneous with production will go back into the electrical grid through the meter.



At Night or on cloudy days, when your system is not producing more than your building needs, you will Consume electricity from the grid as normal. Your utility will bill you for the "net" consumption for any Given billing period and provide you with a dollar credit for any excess during a given period. You can.

2.3 Photovoltaic (directly using) by solar energy

Photovoltaic (PV) is a method of generating electrical power by converting solar radiation into directCurrent electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic power Generation employs solar panels composed of a number of solar cells containing a photovoltaic material.
Solar photovoltaic power generation has long been seen as a clean sustainable [1] energy technology Which draws upon the planet's most plentiful and widely distributed renewable energy.

2.4 concentrated solar power (indirect using) by solar energy

Concentrated solar power (also called concentrating solar power, concentrated solar thermal, and CSP) Systems use mirrors or lenses to concentrate a large area of sunlight, or solar thermal energy, onto a Small area. Electrical power is produced when the concentrated light is converted to heat, which drives A Heat engine (usually a steam turbine) connected to an electrical power generator or powers a Thermo chemical reaction If you like the thought of contributing to the efforts of making the earth a better place to live, or if you like money, you'll love solar energy. There are a myriad of great reasons to install a photovoltaic solar Power generation system in your home or commercial building, here are a few. A solar energy system adds to your property value without adding any tax liability.
Home based solar power is a quiet, nearly maintenance free, continuous source of electricity.
Solar electric systems reduce pollution and CO_2 emissions by generating electrical power using radiant Sun light that can replace electricity that comes from coal fired electrical plants.
Solar power systems generate electricity at peak power usage times (during the day) when the value And cost of electricity is the highest. Modern grid-tied home solar power systems can use the cheap rate Grid power at night and reduce or eliminate the need for the high rate electrical power during the day.
Home-owners can actually push power back into the electrical grid during the day and run their meters Backwards which is generates energy credits and even capital. Imagine your electric company sending You a check every month instead of a bill! Sounds too good to be true?

2.5 Energy wind hydraulic

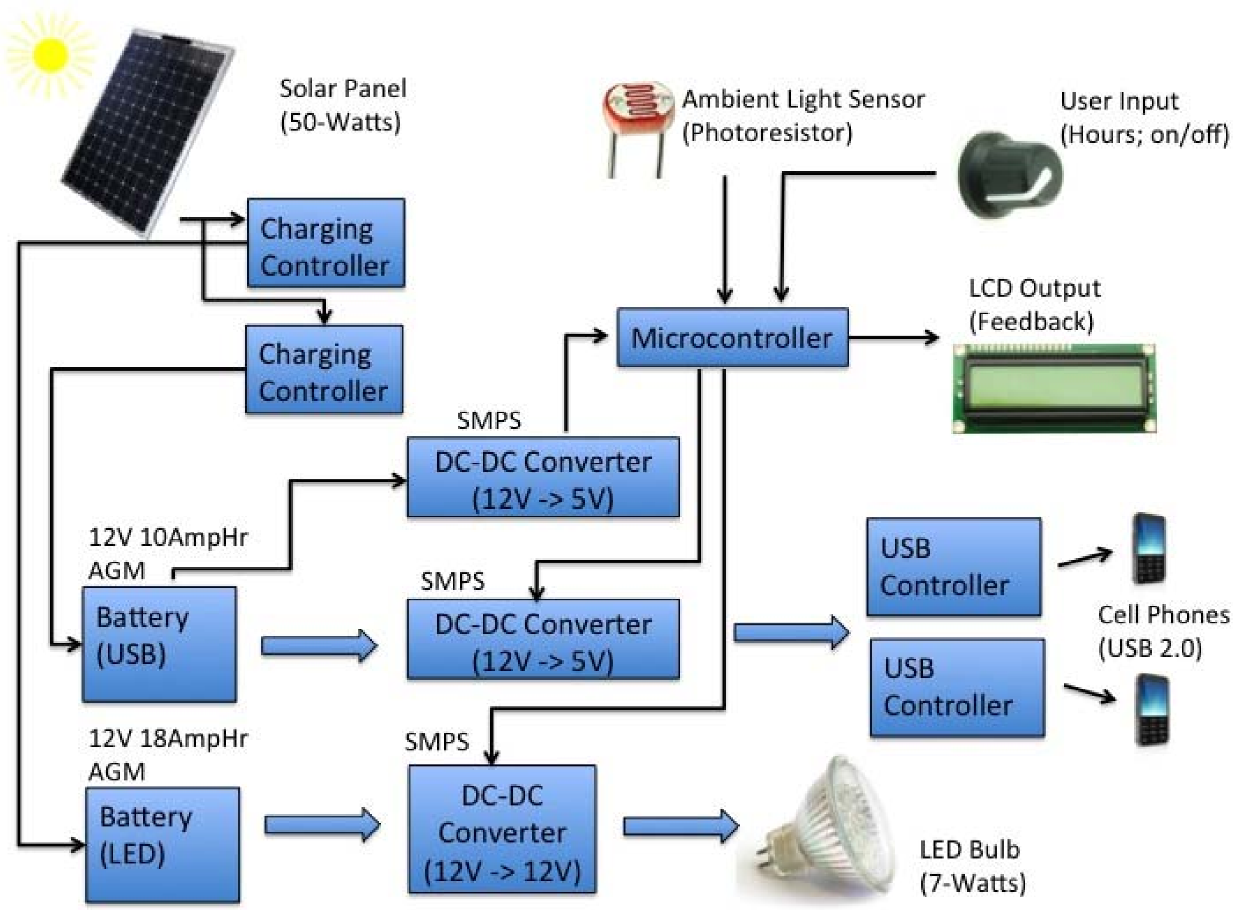
Hydro-power or water power is power derived from the energy of falling water and running water, Which may be harnessed for useful purposes. Since ancient times, hydro-power has been used for Irrigation and the operation of various mechanical devices, such as watermills, sawmills, textile mills, Dock cranes, domestic lifts, power houses and paint making.

Since the early 20th century, the term has been used almost exclusively in conjunction with the modern Development of hydro-electric power, which allowed use of distant energy sources. Another method Used to
transmit energy is by using a tromp, which produces compressed air from falling water.

Compressed air could then be piped to power other machinery at a distance from the waterfall. Hydro Power is a renewable energy source.

2.6 Solar-powered lamppost

A solar-powered lamppost that is able to provide light at night for the people of these communities, and Fitted with USB charging ports to enable charging of mobile phones. The system will consist of a 50-Watt Solar panel mounted on a 18 - 21 foot Schedule-40 galvanized steel pole, with an 8-Watt LED bulb Serving as the source of light. Power from the solar panels would be stored in two separate AGM Lead-Acid batteries - one to provide power for the light and the other to power the charging ports. The block Diagram below shows an overview of the system architecture:



General Facts:

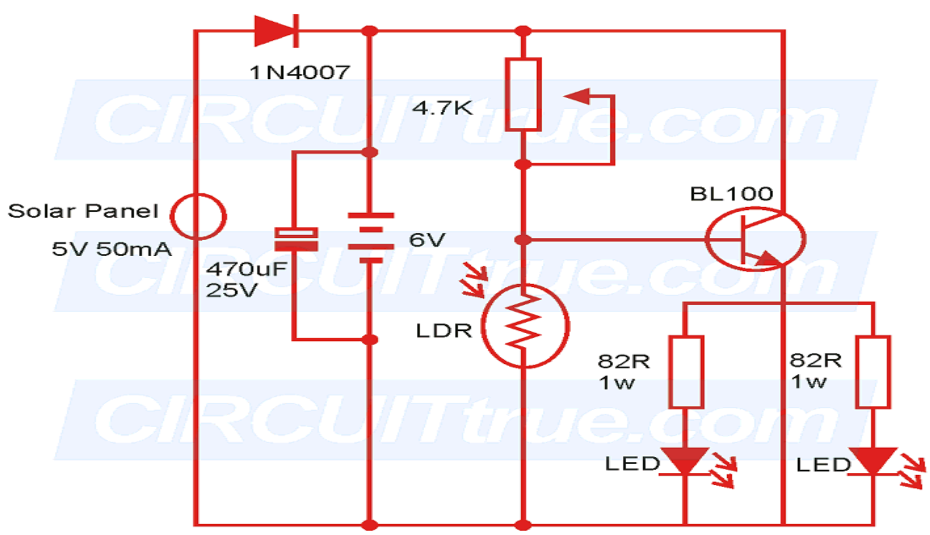
Operating temperature 0 - 130 F.
Power consumption of LED bulb 8 Watts.
Approximately 7 hours of direct sunlight will fully charge the system Up to 2 days of reserve power to allow of successive cloudy days. An ambient light sensor controls automatic on and off illumination
System feedback provided by LCD screen

Electrical System:

Operating voltage 12 V.
50 Watt polycrystalline solar panel.
Switched-mode power supplies with up to 80% efficiency.
Solar controllers with Maximum Power Point Tracking.
Universal USB charger.
Interactive user interface.

Mechanical Structure:

Completely weatherproof.
Withstand winds up to 60 mph
Entire structure (besides pole) is collapsible into 30" suitcase for shipping Can be assembled with basic hand tools in 2 hours.
Lockable enclosures for added security



2.7 Schematic diagram of Solar-powered lamppost

Simple Solar Night Lamp That Turns on Automatically at Sunset and Stays on Till Morning schematic Diagrams are used extensively in repair manuals to help users understand the interconnections of parts,And to provide graphical instruction to assist in dismantling and rebuilding electrical or mechanicalAssemblies.

How solar powered lamp postwork:

Solar-powered lighting consists of a solar panel or photovoltaic cell that collects the sun's energy during The day and stores it in a rechargeable gel cell battery. The intelligent controller senses when there is no Longer any energy from the sun and automatically turns the LED light on using a portion of the stored Energy in the rechargeable battery.

2.8 Solar panels

enables you to get the most from them, but your solar panels will still work even on cloudy days since the panels do not depend on direct sunlight.

2.9 GRID CONNECTED SOLAR POWER SYSTEMS

You can have solar energy powering your home, school, community building or business easily and economically using mains electricity supply integrated grid connect rooftop systems!

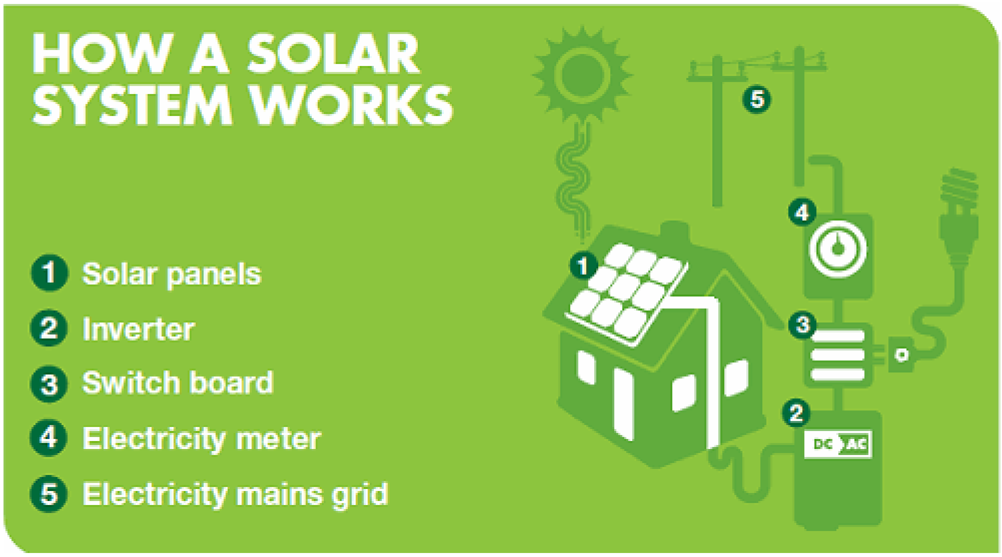
Grid connect solar electricity for your home

Off grid for home

In a remote location away from the mains grid and need a standalone power solution? We have an off grid solar power section for you – all the information you'll need regarding equipment, systems and rebates! as there are very few components! Here's how they work:

30 second guide to grid connect

Does the idea of generating electricity from the sun seem too complex? Grid connect solar power systems are really quite simple**.**



- Sun shines on the solar panels that then generate DC electricity.
- This DC current is routed into an inverter that converts it to 240 volts AC, the same as your mains supply
- Any surplus electricity generated by the system not used by your appliances is fed back into the mains electricity supply grid; for which you receive a credit that varies depending on the state in which systems are installed.

Aside from the components, Energy Matters also makes installing systems simple! Learn more – tips for choosing solar panels and estimating how many you'll need.

Reduce or wipe out your power bills altogether while helping to reduce energy related carbon emissions! Check out our specials, get an instant solar quote, contact us today toll free on 133SUN or email our friendly team for expert, obligation-free advice! Join the 15000+ Australian households saving money on their electricity bills with solar power systems from Energy Matters.

CHAPTER 3

3.1 Wind energy

Wind is a form of solar energy. Winds are caused by the uneven heating of the Atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth.
Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetative Cover. This wind flow, or motion energy, when "harvested" by modern wind turbines, can Be used to generate electricity.

3.2 How Wind Power Is Generated

The terms "wind energy" or "wind power" describe the process by which the wind is used To generate mechanical power or electricity. Wind turbines convert the kinetic energy in The wind into mechanical power. This mechanical power can be used for specific tasks Such as grinding grain or pumping water) or a generator can convert this mechanical power into Electricity to power homes, businesses, schools, and the like.

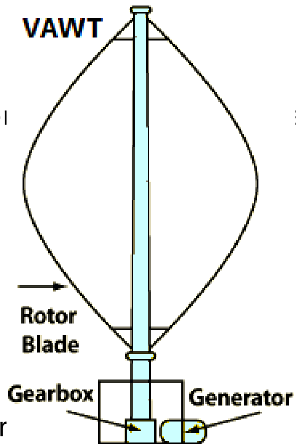
Wind turbine

Wind turbines, like aircraft propeller blades, turn in the moving air and power an electricGenerator that supplies an electric current. Simply stated, a wind turbine is the opposite of
A fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make Electricity. The wind turns the blades, which spin a shaft, which connects to a generator and Makes electricity.

3.3 Wind Turbine Types

Modern wind turbines fall into two basic groups; the horizontal-axis variety, like the Traditional farm windmills used for pumping water, and the vertical-axis design, like the Eggbeater-style Darrius model, named after its French inventor. Most large modern wind Turbines are horizontal-axis turbines.

Hoı ɘr-type")



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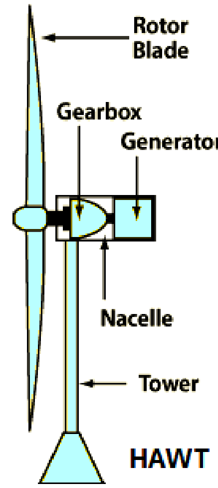


Both styles have their pros and cons and both are used in home wind generators. The main advantages of **horizontal axis** wind turbines (HAWT) are their higher efficiency and ability to self-start. Their main disadvantages are the requirement of tall towers, which are difficult to transport and install, and the necessity to constantly align in the direction of the airflow. Vertical-axis turbines (VAWT) do not have to be pointed into the wind, so their alternator and gearbox can be placed at the bottom of the tower. There are two brands of VAWT: Darrius ("egg-beater") and Savona's (S-type). Both are relatively low-efficient. In addition to this, the Darrius type is not self-starting. On the positive side, a small VAWT can be mounted on a home's flat rooftop, since the building generally redirects an air flow over the roof and this can increase its speed at the turbine. Nevertheless, because of lower efficiency of vertical systems, HAWTs are more common nowadays. You can find more details including pros and cons of each

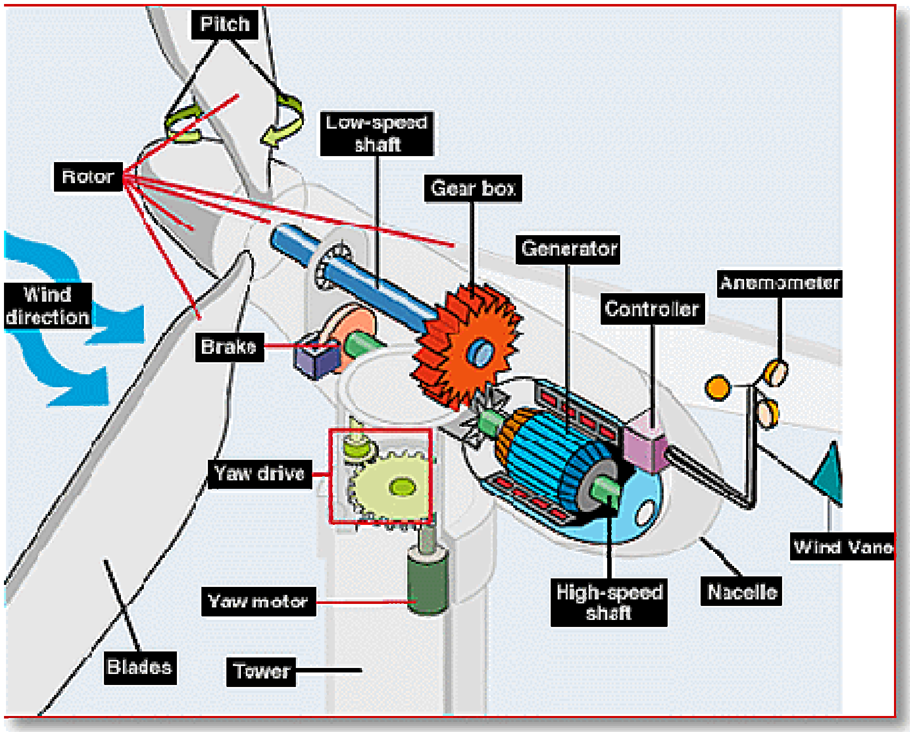
3.4 Turbine Components

Horizontal turbine components include:

- **blade** or **rotor**, which converts the energy in the wind to rotational shaft energy;
-
- a **drive train**, usually including a gearbox and a generator;
-
- a **tower** that supports the rotor and drive train; and
-
- other equipment, including controls, electrical cables, ground support equipment,
- And interconnection equipment.

3.5 turbine configuration

Wind turbines are often grouped together into a single wind power plant, also known as A **wind farm**, and generate bulk electrical power. Electricity from these turbines is fed into A utility grid and distributed to customers, just as with conventional power plants.



3.6 Advantages and Disadvantages of Wind-Generated Electricity

A Renewable Non-Polluting Resource

Wind energy is a free, renewable resource, so no matter how much is used today, there Will still be the same supply in the future? Wind energy is also a source of clean, non-Polluting, electricity. Unlike conventional power plants, wind plants emit no air pollutants Or greenhouse gases. According to the U.S. Department of Energy, in 1990, California's Wind power plants offset the emission of more than 2.5 billion pounds of carbon dioxide, And 15 million pounds of other pollutants that would have otherwise been produced. It Would take a forest of 90 million to 175 million trees to provide the same air quality.

Cost Issues

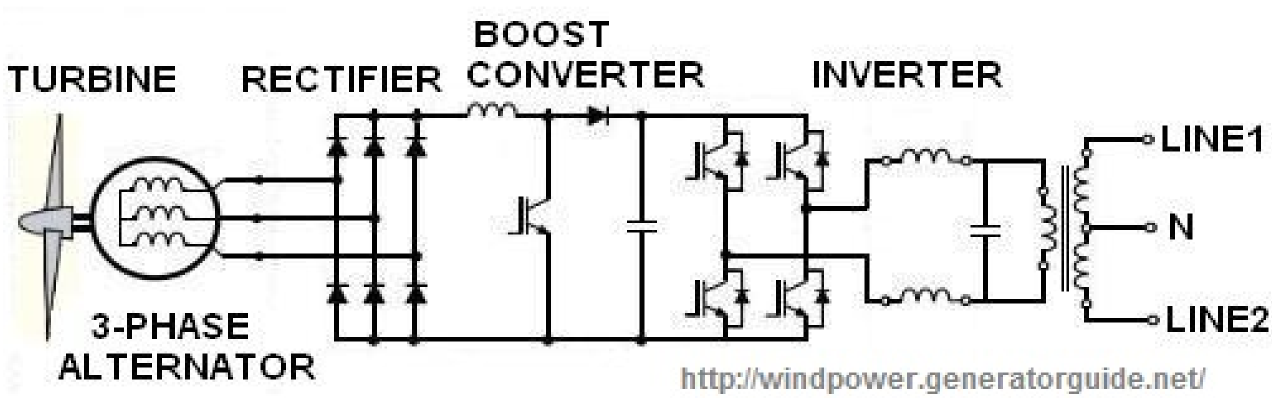
Even though the cost of wind power has decreased dramatically in the past 10 years, the Technology requires a higher initial investment than fossil-fueled generators. Roughly

80% of the cost is the machinery, with the balance being site preparation and installation. If Wind generating systems are compared with fossil-fueled systems on a "life-cycle" cost basis (Counting fuel and operating expenses for the life of the generator), however, wind costs Are much more competitive with other generating technologies because there is no fuel to Purchase and minimal operating expenses.

Environmental Concerns

Although wind power plants have relatively little impact on the environment compared to Fossil fuel power plants, there is some concern over the **noise** produced by the rotor Blades, **aesthetic (visual) impacts**, and birds and bats having been killed (**avian/bat mortality**) by flying into the rotors. Most of these problems have been resolved or greatly Reduced through technological development or by properly sitting wind plants.

Supply and Transport Issues



The major challenge to using wind as a source of power is that it is **intermittent** and does Not always blow when electricity is needed. Wind cannot be stored (although wind-Generated electricity can be stored, if batteries are used), and not all winds can be Harnessed to meet the timing of electricity demands. Further, good wind sites are often Located in **remote locations** far from areas of electric power demand (such as cities). Finally, wind resource development may compete with other uses for the land, and Those **alternative uses** may be more highly valued than electricity generation. However, Wind turbines can be located on land that is also used for grazing or even farming.

3.7 Wind generating for home using

We can use the wind energy when we have a speed of at least 8-10 mph, it is Realistically possible to use a small wind power generator to provide electricity to your House, lower the utility bills or supply an emergency backup power. This guide will tell How it works and things to know to make the right choice. Let's just start with a quick Technical reference.
Wind generators for home use range in size from several hundred watts to tens of Kilowatts with rotors typically up to 25 feet in diameter.
Most small wind turbines suitable for homes are **horizontal axis fixed-blade three-Phase permanent magnet** systems. The rotation of their rotor varies with air speeds And therefore produces AC voltage with variable amplitude and frequency.

This voltage Is not usable directly by conventional household electrical appliances. It has to be Rectified and then converted into a regulated constant-frequency AC compatible with the Utility power. The conversion is done by a solid-state inverter, which operates as a Switch mode power supply (**SMPS**). The reason wind systems usually use a 3-phase Alternator is because rectified 3-phase voltage has ten times lower ripple factor than That of a single-phase circuit. Therefore it requires much lower value of smoothing Capacitance to produce DC output with a given amount of ripple.
This is a diagram of a typical wind-powered generator with a transformer-isolated output. Such battery less configuration can be used if you are on grid or you have other sources of

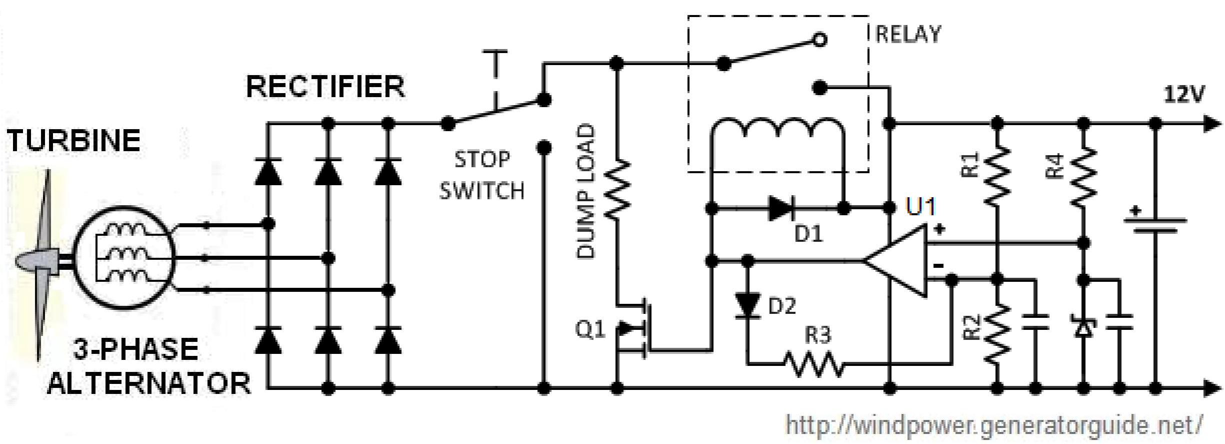
3.8Components of wind-powered generator with a transformer-isolated output

1 .turbine
2. 3phase alternator
3. Rectifier
4. Boost converter
5. Inverter

How it is works
It can works into two types
1 charger.
2. Regulator

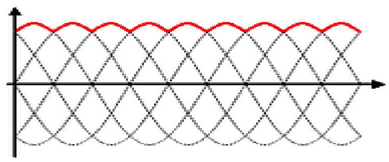
Charger

For a small hobbyist system one can connect the turbine through a rectifier directly to a battery. This is the simplest approach, although it is also the least efficient as we will see below. This schematic shows a design idea for such a **wind-powered charger**.



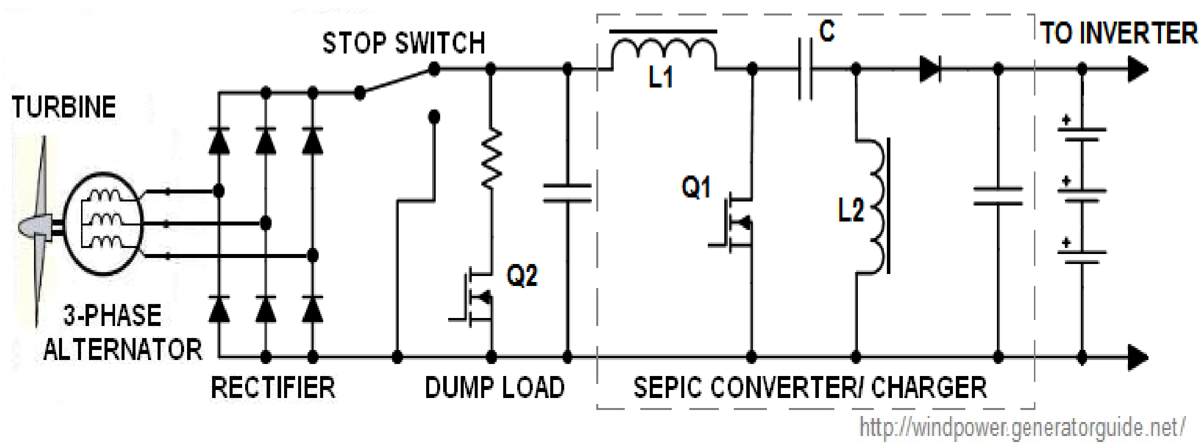
Here is how it works. The battery "clamps" the alternator voltage. The opamp monitors it via the divider R1, R2 and compares to a reference. Under normal conditions opamp U1 stays low, the relay is energized and Q1 is OFF. When the battery is fully charged and its voltage is approaching maximum permitted value, U1 switches to "high" state, the relay opens and terminates the charge.

At the same time Q1 turns ON and connects the turbine to a dump load. D2 and R3 provide a hysteresis to avoid a hiccup mode: when opamp is high, it increases the voltage at R1-R2 junction. As the result, the battery has to discharge to a certain level before it will be connected back to the turbine. D3 should be a temperature compensated precision reference, such as LM4040-2.5. For a 12V battery with 14V maximum charging voltage we can set for example R1=11.3k, R2=2.5k. This will provide 13.8V cut off. With R3=54k the relay will activate again when the battery discharges to approximately 12V (you may need to trim R3 for a desired threshold). Examples of other parts: Q1=STP80N70, D1,D2=1N4819, U1=LM6132 (it should have rail-rail output), R4=10k. The relay should be automotive type such as G8JN-1C7T-D-DC12.



Regulators

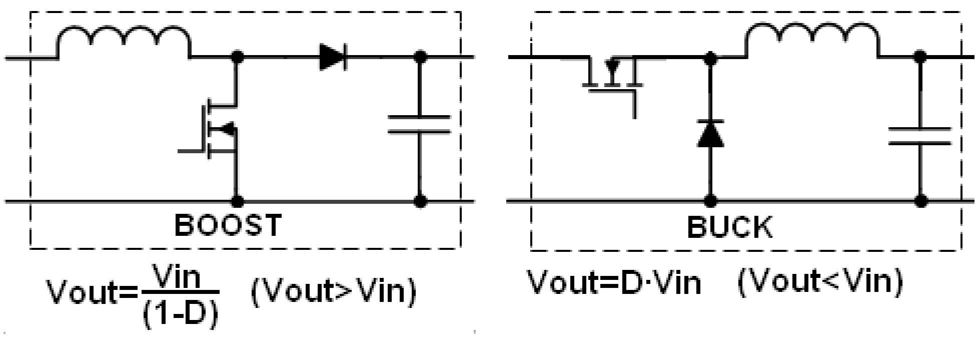
In the above circuit, available energy in the wind will often be lost. Also, the battery can easily be damaged because its rated charge voltage varies with the temperature. A much better approach is to use a PWM regulator, such as the one shown on this block diagram.



The rectifier bridge produces pulsating DC voltage- see the waveforms of an ideal 3-phase rectification. The resulting output is shown in red. Theoretically, with a resistive load the ripple are just 4.2% without any capacitors. In reality, of course, the alternator does not deliver a clean sinewave, especially because winds usually blow in gusts. Nevertheless, output ripple here are quite low even without any smoothing filter.

The switching regulator in this example is so-called **SEPIC converter**. Its main advantage is its output can be greater than, less than, or equal to the input. Therefore it can provide a charge in a wide range of winds. When Q1 is on, energy is being accumulated in L1. At the same time the coupling capacitor "C" transfers energy to L2.

When Q1 turns off, L1 current continues to flow through "C" and the diode to the load. For a steady state operation in a continuous conduction mode, output is given by **Vout=Vin×D/(1-D)**, where D-duty cycle of the switching MOSFET. You can see that for D=0.5 Vout=Vin, for D<0.5 Vout<Vin, for D>0.5 Vout>Vin. You can find more info on the operation of power electronics converters in smps.us site. Note two additional protection components in the above diagram. A solid state switch Q2 automatically connects "dump load" when turbine's output reaches dangerous levels. An optional manual "stop switch" disconnects regulator and shorts all alternator coils. Mechanical breaking however is more reliable.



The main disadvantage of SEPIC is the coupling capacitor "C" has to pass an entire load current. This makes this topology best suited to low-power applications. For mid-power wind generators "**boost**" and "**buck**" converters may be more suitable. Here are their basic conceptual diagrams. In boost converter output is always greater than input: Vout=Vin/(1-D). This topology is used when you want high DC-link (up to several hundreds volts). If DC-link is above peak of the desired sinewave, it can be fed directly into a transformerless inverter. For 115VAC this value would be around 200VDC. Conversely, buck is suitable for low-voltage designs, such as 12VDC, when the turbine output is normally higher than the battery voltage.

CHAPTER 4

OPTIMIZATION OF RENEWABLE ENERGY

4.1 How to Optimize Solar Panels

f you use **solar panels** on your home to provide electricity or heat your water, you probably have wondered if you need to change the angle of your panel during the year to make the most of the sunlight. The answer to that is a resounding *yes*. Optimizing the

Step 1 - Understand the Types of Sunlight

Before optimizing your solar panels, you should understand the three types of sunlight that hit your panels. The first is direct irradiation, which occurs when the sunlight hits the solar panel directly. (This happens on sunny days.) Diffuse irradiation happens when the sky is cloudy and no direct sunlight reaches the panels. Finally your solar panels can benefit from reflected light. Buildings and even trees can reflect light to the solar panels. This is a phenomenon we see frequently in snowy conditions.

Step 2 - Set the Panel Angles

Although your panels will still work without adjustments, you'll optimize them by changing the angle to give you the most energy. You'll need to make four different adjustments during the year. Unless you have an automatic tracker, you'll need to climb up on the roof to make adjustments. Use a protractor to establish the right angles. The generally accepted theory for

optimization is as follows:

- At the beginning of February switch the panel so the angle is the same as your latitude. Thus if your latitude is 49 degrees, set the solar panel at the same angle to be most effective.
- Three months later, at the start of May, change the angle to your latitude minus 15 degrees. At 49 degrees latitude that would be 34 degrees.
- At the beginning of August move the panel back so the angle is the same as your latitude.
- Once November arrives, reset the panel to your latitude plus 15 degrees. For 49 degrees latitude this would be 64 degrees.

If you want to be more exact, you need to discover exactly how the sun moves across the sky where you live. You can accomplish this with an Internet search for a solar radiation map. The map will show you how much sun any particular location receives at each time of the year. You can readily purchase automatic solar trackers. With these, your solar panels are put on a pathfinder that follows the sun across the sky. They are expensive, and you will need a professional installation unless you're very adept.

Step 3 - Use an Automatic Tracker (Optional)

Trackers do make a significant difference. Results have shown an increase in power of 35 percent in the summer and 15 percent in the winter.

Several different manufacturers produce these units, which all give around the same level of improvement.

Step 4 - Use Reflected Light

In winter, when the sun is low, you can increase the amount of reflected light on your solar panels by mounting mirrors on the sides of the panels. Although the method has not been scientifically proven, a number of solar panel users do this and have been pleased by the results.

4.2 Optimized Wind Energy Harvesting System Using Resistance Emulator and Active Rectifier for Wireless Sensor Nodes

This paper presents an optimized wind energy harvesting (WEH) system that uses a specially designed ultra-low-power-management circuit for sustaining the operation of a wireless sensor node. The proposed power management circuit has two distinct features: 1) an active rectifier using MOSFETs for rectifying the low amplitude ac voltage generated by the wind turbine generator under low wind speed condition efficiently and 2) a dc-dc boost converter with resistor emulation algorithm to perform maximum power point tracking (MPPT) under varying wind-speed conditions. As compared to the conventional diode-bridge rectifier, it is shown that the efficiency of the active rectifier with a low input voltage of 1.2 V has been increased from 40% to 70% due to the significant reduction in the ON-state voltage drop (from 0.6 to 0.15 V) across each pair of MOSFETs used. The proposed robust low-power microcontroller-based resistance emulator is implemented with closed-loop resistance feedback control to ensure close impedance matching between the source and the load, resulting in an efficient power conversion. From the experimental test results obtained, an average electrical power of 7.86 mW is harvested by the optimized WEH system at an average wind speed of 3.62 m/s, which is almost four times higher than the conventional energy harvesting method without using the MPPT.

CHAPTER 5

Smart grid system

5.1 WHAT IS SMART GRID?

A smart grid is an electrical grid that uses information and communications technology to gather and act on information, such as information about the behaviors of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity.[iv]

According to *National Institute of Standards and Technology*, the term “Smart Grid” refers to a modernization of the electricity delivery system so it monitors, protects and automatically optimizes the operation of its interconnected elements – from the central and distributed generator through the high-voltage transmission network and the distribution system, to industrial users and building automation systems, to energy storage installations and to end-use consumers and their thermostats, electric vehicles, appliances and other household devices.[v]

There are three major systems in Smart Grid from technical perspective:

Smart infrastructure system: The smart infrastructure system is the energy, information, and communication infrastructure underlying of the SG that supports

- Advanced electricity generation, delivery, and consumption;
- Advanced information metering, monitoring, and management;
- Advanced communication technologies.

Smart management system: The smart management system is the subsystem in SG that provides advanced management and control services.

Smart protection system: The smart protection system is the subsystem in SG that provides advanced grid reliability analysis, failure protection, and security and privacy protection services.

5.2 OPERATING PRINCIPLE

The Smart Grid uses two-way information, cyber-secure communication technologies, and computational intelligence in an integrated fashion across electricity generation, transmission, substations, distribution and consumption to achieve a system that is clean, safe, secure, reliable, resilient, efficient, and sustainable. This description covers the entire spectrum of the energy system from the generation to the end points of consumption of the electricity. [vi]

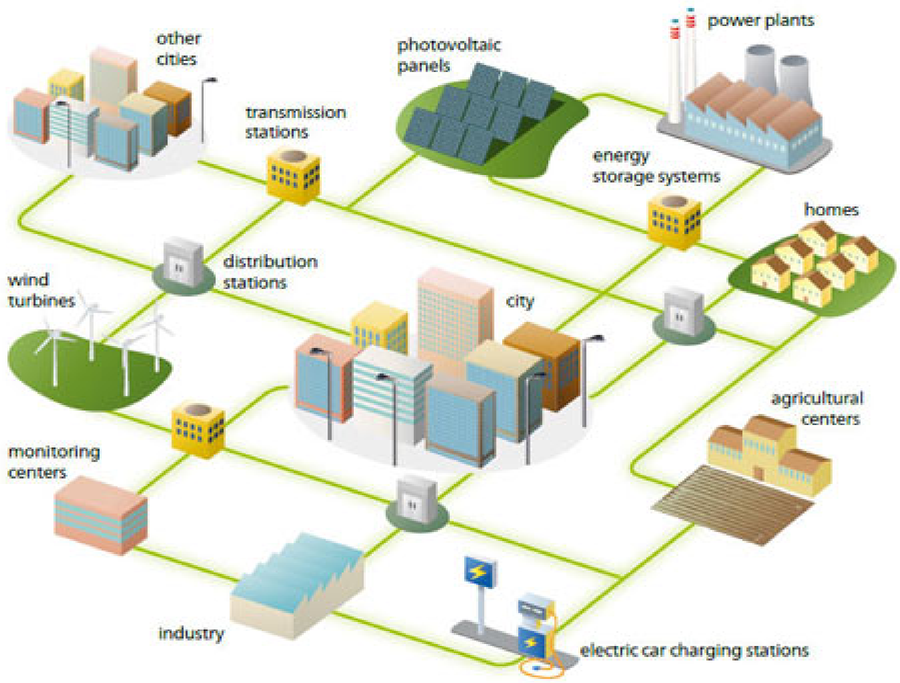


FIGURE 1: SMART GRID OVERVIEW

5.3 advantages

According to the report from NIST, [5] the anticipated benefits/advantages and requirements of Smart Grid are:

1. Improving power reliability and quality;
2. Optimizing facility utilization and averting construction of back-up (peak load) power plants;
3. Enhancing capacity and efficiency of existing electric power networks; 20
4. Improving resilience to disruption;
5. Enabling predictive maintenance and self-healing responses to system disturbances;
6. Facilitating expanded deployment of renewable energy sources;
7. Accommodating distributed power sources;
8. Automating maintenance and operation;
9. Reducing greenhouse gas emissions by enabling electric vehicles and new power sources;

10. Reducing oil consumption by reducing the need for inefficient generation during peak usage periods;
11. Presenting opportunities to improve grid security;
12. Enabling transition to plug-in electric vehicles and new energy storage options;
13. Increasing consumer choice;
14. Enabling new products, services, and markets.

In the recent report on National Institute of Standard and Technology (NIST) framework and roadmap for smart grid interoperability standards,[vii]several wired and wireless communication technologies are identified for smart grid. Advanced wireless systems offer the benefits of inexpensive products, rapid deployment, low cost installations, widespread access, and mobile communications which wired technologies and even the older wireless technologies often cannot provide. [viii],[ix]

5.3 Disadvantages

Biggest concern about SG is the consumer security and privacy; the use of automated meters, two-way communications: between a power consumer and provider and advanced sensors; some types of meters can be hacked. Hacker can gain control of thousands, even millions, of meters. To avoid that Consumer has to install Smart Meter and this requires additional expenses.

In addition, it consists of various technology components: software, the power generators, system integrators, etc. This made the system too complicated.

5.4 Locations

The Map below shows the world locations of the current existing SG projects, the key of each term is given blow.

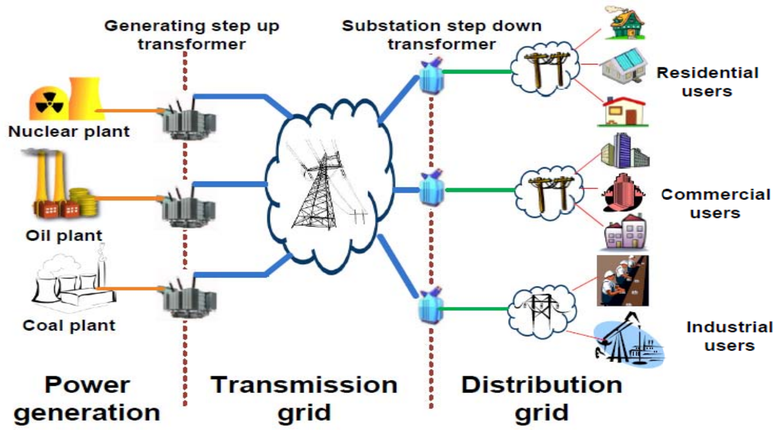
Source: *Smart Grid Information Clearinghouse. http://www.sgiclearinghouse.org*

FIGURE 2: SMART GRID PROJECT MAP

5.5Comparison Between Traditional Grid And Smart Grid

Electricity is often generated at a few central power plants by electromechanical generators, primarily driven by the force of flowing water or heat engines fueled by chemical combustion or nuclear power. In order to take advantage of the economies of scale, the generating plants are usually quite large and located away from heavily populated areas. The generated electric power is stepped up to a higher voltage for transmission on the *transmission grid*. The transmission grid moves the power over long distances to substations. Upon arrival at a substation, the power will be stepped down from the transmission level voltage to a distribution level voltage. As the power exits the substation, it enters the *distribution grid*. Finally, upon arrival at the service location, the power is stepped down again from the distribution voltage to the required service voltage(s).

FIGURE 3: EXAMPLE OF THE TRADITIONAL POWER GRID



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While the Smart Grid uses two-way flows of electricity and information to create an automated and distributed advanced energy delivery network as shown in ***Figure 4***[x].Smart Grid includes integrated communication systems, advanced Sensing, metering, measurement infrastructure, complete decision support and human interfaces.

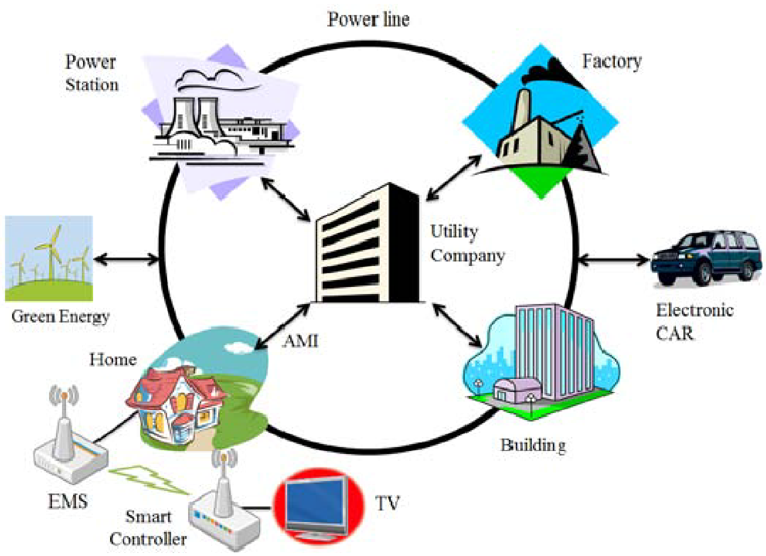


FIGURE 4: EXAMPLE OF SMART GRID SYSTEM

In contrast with the traditional power grid, the electric energy generation and the flow pattern in Smart Grid are more flexible. For example, the distribution grid may also be capable of generating electricity by using solar panels or wind turbines. **Table I** gives a summary or brief comparison between the existing grid and the Smart Grid. [xi]

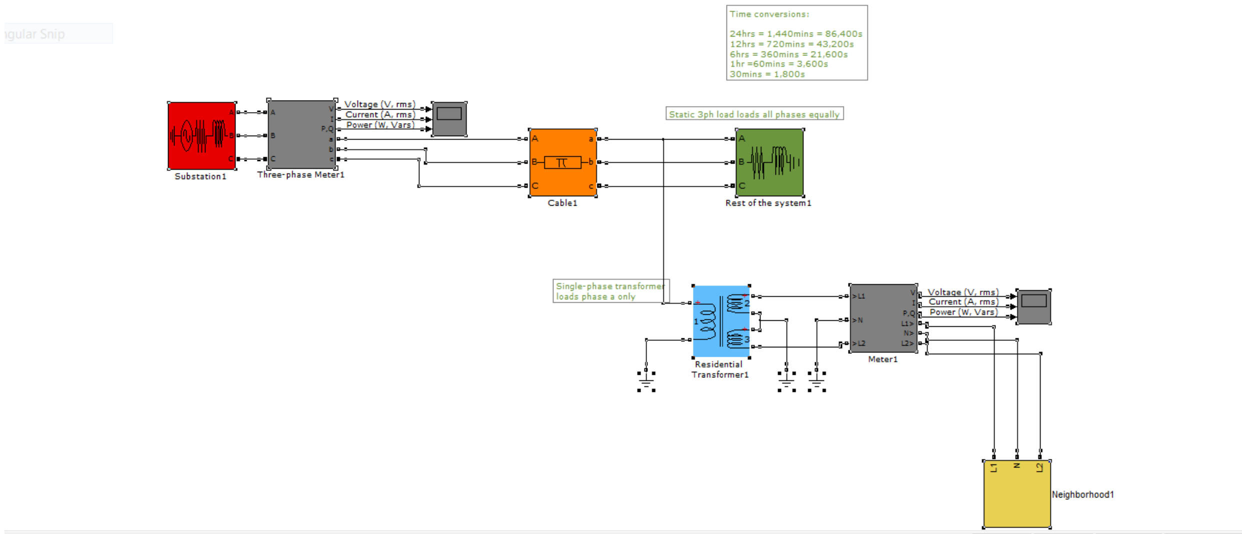
TABLE 1: COMPARISON BETWEEN TRADITIONAL GRID AND SMART GRID

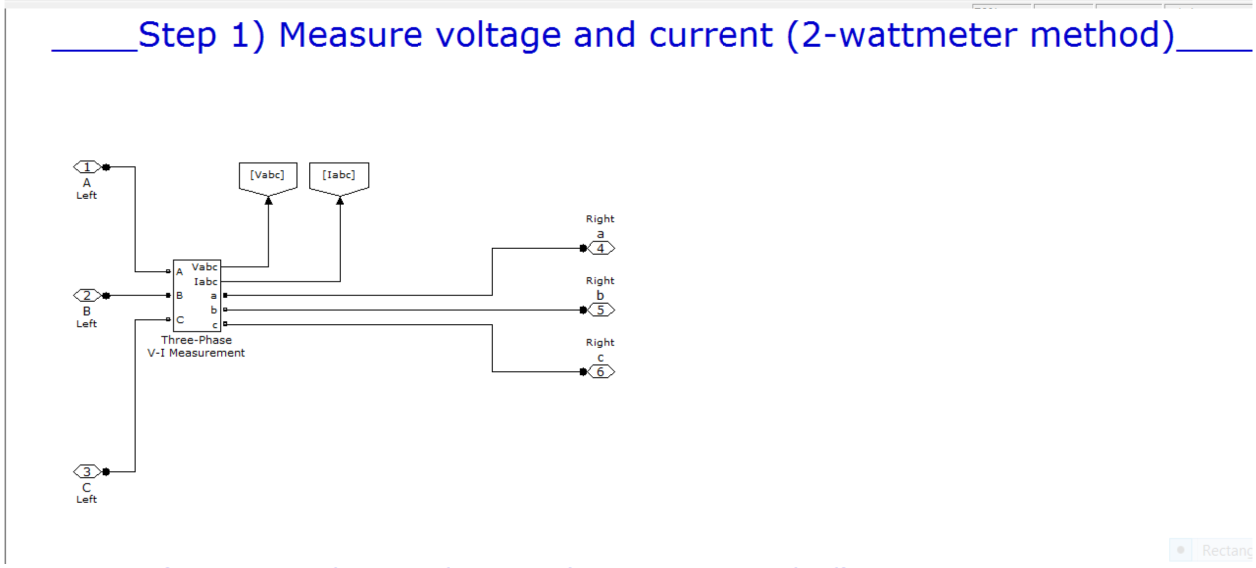
Traditional Grid	Smart Grid
Electromechanical	Digital
One-way communication	Two-way communication
Centralized generation	Distributed generation
Few sensors	Sensors throughout
Manual monitoring	Self-monitoring
Manual restoration	Self-healing
Failures and blackouts	Adaptive and islanding
Limited control	Pervasive control
Few customer choices	Many customer choices

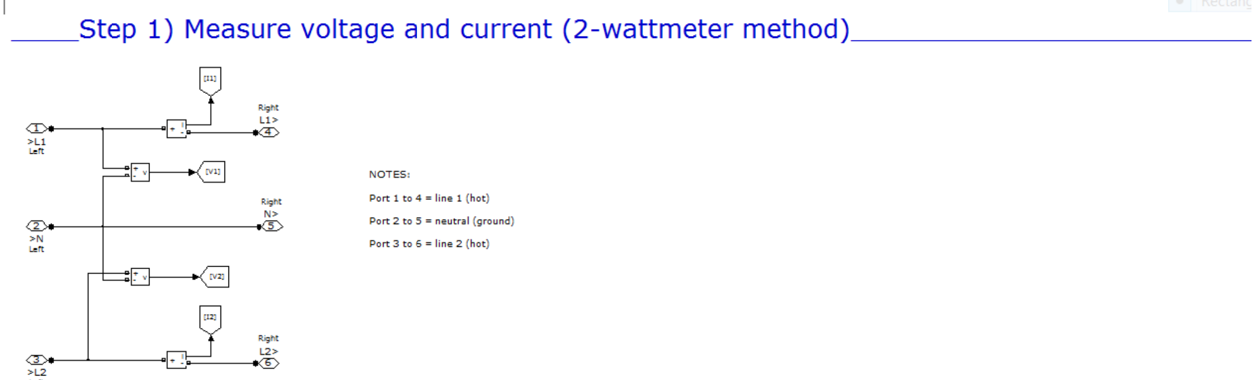
5.6 Stability Issues Related To Smart Grid

STABILITY is characterized by the ability of the grid towithstand disturbances. Hence stability related problemshave been classified by the nature of the correspondinginitiating disturbance. Accordingly power system stabilityproblems have been classified into voltage, dynamic (or smallperturbation)and transient (or large perturbation) stabilityproblems.
Historically, assuring stability of the grid required complex and time consuming computations as well as very fast controlresponses. These two conflicting requirements were reconciled by performing extensive analyses of potentially severe contingencies and producing lists of operating limits subject toper-specified initial conditions, disturbance events andremedial measures. The remedial measures have been hard wired to meet the fast response times required. However, in the context of the smart grid, it is possible to obtain measurements from throughout the grid and identify and implement the necessary control actions in sub-second time frames. This paper proposes a methodology for assuring transient stability in the smart grid using such quasi-continuous control capability.
With unprecedented capabilities for monitoring system operating conditions based on synchronized sub-second measurements and providing quasi-continuous control capabilities throughout the grid, the smart grid offers the potential to increase all voltage, transient and dynamic (small signal) stability limits to a level above the relevant thermal limits. With stability thus assured, the smart grid can ultimately become as flexible as the internet[[xii]].

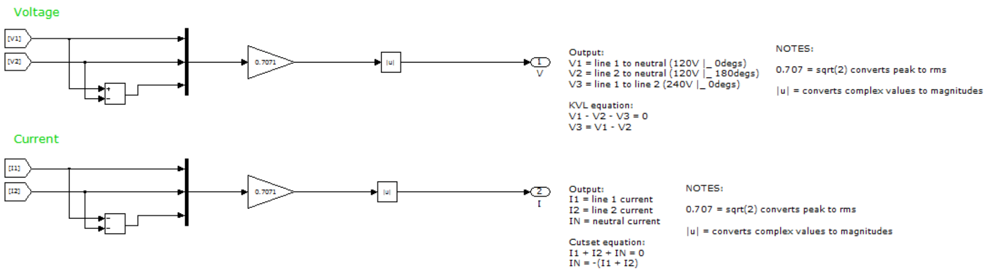
Simulation of smart grid in matlab

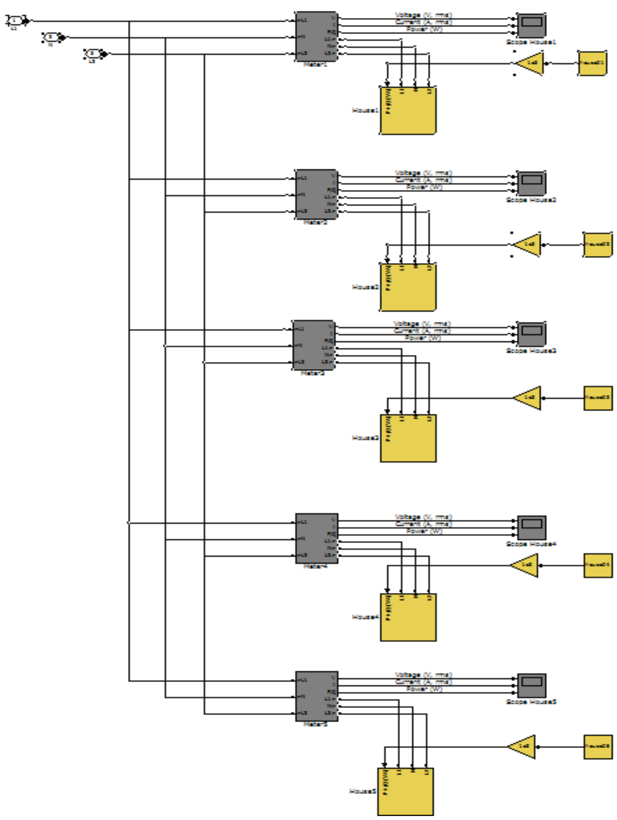




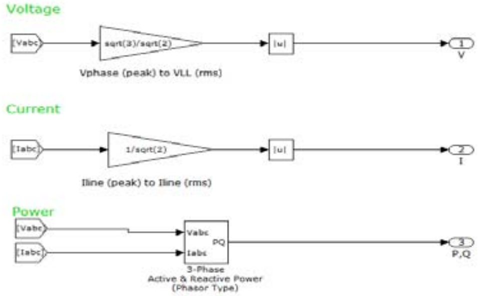


Step 2) Output desired measurements





Step 2) Output desired measurements



Output:
V1 = line 1 to neutral (120V |_ 0degs)
V2 = line 2 to neutral (120V |_ 180degs)
V3 = line 1 to line 2 (240V |_ 0degs)

KVL equation:
V1 - V2 - V3 = 0
V3 = V1 - V2

NOTES:

0.707 = sqrt(2) converts peak to rms

|u| = converts complex values to magnitudes

Output:
I1 = line 1 current
I2 = line 2 current
IN = neutral current

Cutset equation:
I1 + I2 + IN = 0
IN = -(I1 + I2)

NOTES:

0.707 = sqrt(2) converts peak to rms

|u| = converts complex values to magnitudes

Output:
P1 = 1/2 * (V1 * I1)
P2 = 1/2 * (V2 * I2)
Ptot = P1 + P2

NOTES:

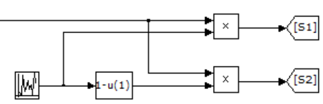
1/2 converts peak phasors to rms

Step 1) Compute per-phase power

1
P + jQ (VA)

This input is the total *complex* power entering the home. The input can be a complex number (S in VA), just real power (P in Watts), or just reactive power (Q in Vars).

Both approaches work well, however only real power is commonly available.



NOTES:

The total power consumed by split-phase load is

Stot = S1 + S2

where the power in each leg is

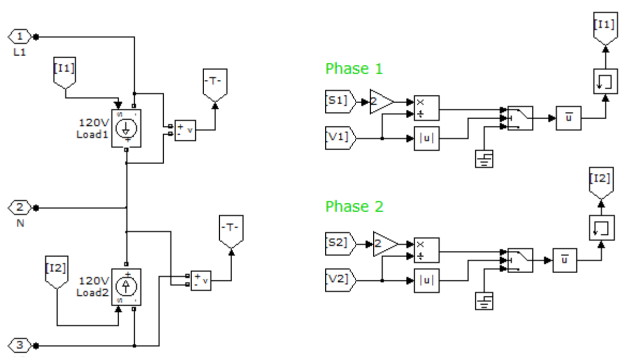
S1 = power from leg 1
S2 = power from leg 2

Since only Stot is known, we randomly distribute the total power to each leg as follows.

r = rand()
S1 = Stot * r
S2 = Stot * (1 - r)

This is how S1 and S2 are computed.

Step 2) Calculate phase currents



NOTES:

The current in each phase is computed as follows. Since there is no reactive power (Q=0), the total apparent power (S) is equal to the real power (P).

From
S1 = P1 = 1/2 * (V1pk * I1pk ')

compute the current as

I1pk = (2 * P1 / V1pk) '

(NOTE: division by 0 is avoided with ground terminator blocK)

where
['] = complex conjugate
Vpk = voltage phasor (peak value)
Ipk = current phasor (peak value)

SimPowerSystems uses peak quantities in its phasor simulation.

CHAPTER 6

Conclusion:

Renewable energy holds the potential to solve the energy problem. As we explored the options we realized that having more renewable energy sources implemented in a system will increase the efficiency.

The objective of our project was to study the sources of renewable energy separately and find the most effective combination in terms of efficiency as an attempt to optimize the overall system. We discussed the principle and operation of a smart grid as a suggested solution and how the world is adopting it. Historically, assuring stability of the grid required complex and time consuming computations.However, in the context of the smart grid, it is possible to obtain measurements from throughout the grid and identify and implement the necessary control actions in sub-second time frames.

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