Geothermal heating were researched engineering essay

Engineering

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Abstract

This thesis is about energy plus houses technologies, renewable sources of energy and future of the power grid system. Renewable energy technologies such as wind turbines, solar systems – PVs, geothermal heating were researched.

Introduction

Energy and civilization

Energy technology plays big role in societal economic and social development. Fossil fuel-based technologies and innovations have improved people's quality of life, but at the same time, these advancements have come at a very high price. Fossil fuel sources of energy are primary cause of environmental pollution and degradation. Global warming is a result of world's fossil fuel consumption. The processing and use of fossil fuels has escalated public health cost. Our persistent search for fossil fuels and the need to control these valuable resources have promoted political strife and conflict between countries. We are now dependant on an energy source that is unsustainable and as our energy needs grow we deplete our limited resources. It will become increasingly urgent to find and use clean energy alternatives that are sustainable, safe and healthy for humanity and the environment.

Global warming

Greenhouse gases in the earth's atmosphere emit and absorb radiation. This radiation is within the thermal infrared range. Since the burning of fossil fuel and the start of the industrial revolution, the carbon dioxide in the atmosphere has substantially increased. The greenhouse gases are primarily water vapour, carbon dioxide, carbon monoxide, ozone, nitrous oxide, hydroflourocarbons, sulphur hexafluoride and perflourocarbons. Greenhouse gases are trapped within the atmosphere of the earth. http://www. pc. gc. ca/~/media/docs/v-g/ie-ei/cc/ghg_effect_sm_e. ashx [1]Figure : The greenhouse effectThe solar radiation incident energy emitted from the sun and its energy is approximated as 343 W/m². Some of the solar radiation is reflected from the earth's surface and the earth's atmosphere. The total reflected solar radiation is approximated as 103 W/m². Approximately 240 W/m² of solar radiation penetrates through the earth's atmosphere. About half of the solar radiation, approximately 168 W/m² is absorbed by the earth's surface. This radiation is converted into heat energy and this process generates infrared radiation in the form of the emission of a long wave to earth. A portion of the infrared radiation is absorbed. Then it is re-emitted by the greenhouse molecules trapped in the earth's atmosphere. Some of the infrared radiation passes through the atmosphere into space. As the use of fossil fuels is accelerated, so is carbon dioxide in the earth's atmosphere. [2]The World Meteorological Organization – MWO is the international body for the monitoring the climate change. The MWO has clearly stated the potential environmental and socioeconomic consequences for the world economy if the current trend continues. Observational records and climate projections provide abundant evidence that freshwater resources are vulnerable and have the potential to be strongly impacted by climate change, with wide-raging consequences for human societies and ecosystems. In this respect, the global warming is an engineering problem, not a morale crusade. Until we take serious steps to reduce our carbon footprints, pollution and the deterioration of environment will continue. As the ice glaciers continue to melt due to rising temperatures, over the next few centuries the sea level will also continue to rise. It is a direct consequence of trapped carbon dioxide in the atmosphere, causing temperature increase and is melting of the polar ice caps causing sea levels to rise that bring coastal flooding. Changes in water quantity and quality due to climate change are expected to affect food availability, stability, access and utilisation. Water supplies stored in glaciers and snow cover are projected to decline in the course of the century, reducing water availability during warm and dry periods in regions supplied by melt water from mountain ranges where more than one-sixth of the world's population currently live. This means that our patterns of life on earth will be changed forever. [3]

EU objectives of 2020 and roadmap of 2050

Energy plus houses and zero-emission houses is a concept of the future building technology standard, to meet ambitious climate and energy targets set by the EU commission. With set three key objectives for 2020: A reduction of 20% in EU greenhouse gas emissions from 1990 levelsRaising the share of EU energy consumption produced from renewable resources to 20%A 20% improvement in the EU's energy efficiency[4]With roadmap moving forward a competitive low-carbon economy in 2050. The roadmap suggests that by 2050 the EU should cut its emissions to 80% below 1990 level. It sets out milestones with form a cost effective pathway to this goal – reductions of the order 40% by 2030 and 60% by 2040. Around 40% of total energy consumptions contributes to the buildings, so energy plus and zero emission building technology will play a big role in achievement of the milestones. [5]

Building energy efficiency analysis

When designing buildings, energy analysis is typically done after the construction has been completed. Making design decisions, while having energy efficiency as a main factor is one way to make energy-efficient buildings. Using renewable sources of energy to fulfil the house needs and in case of energy plus houses generating more electricity than it uses, with excess power sold to the grid could save a lot of energy usage from households which would decrease the emissions of carbon dioxide substantially. As a result such houses are not reliant on external suppliers which energy prices depend on the market price of fuel used. Energy analysis for a building can be done manually, this approach is time consuming and expensive, or with optimization programs to automate this process.

Wind energy

Wind energy is one of the vital inputs for the social and economic development of any nation. It supplies affordable renewable energy to the economy. It is alternative clean energy source and has been the world's fastest growing renewable energy source. Technological improvements over the last years have placed wind energy in a position to compete with conventional power generation technologies. Fossil fuels are not infinite resource and cause pollution of the atmosphere, so it is crucial to develop clean wind energy as part of an alternative source of energy. Wind energy is eco-friendly and does not pollute the atmosphere like thermal power plants.

Solar and Photovoltaic

Solar and photovoltaic – PV energy are also important renewable energy sources. The sun, the earth's primary source of energy, emits electromagnetic waves. It has invisible infrared waves – heat, as well as light waves. Infrared – IR radiation has a wavelength between 0. 7 and 300 micrometres or a frequency range between approximately 1THz to the 430THz – Terra = 10^{12}. [6]

Geothermal heating

Earth energy systems – EESs are a renewable energy option. Like most renewable energy systems, EESs make use of the sun's energy. EESs are environmentally friendly because approximately two-thirds of the energy they deliver comes from the renewable energy within the ground. This indirect use of solar energy comes from the capability of the earth's crust to store solar energy. An earth energy system is heating and cooling technology which transfers heat from the earth or water source to provide space conditioning at greater efficiencies than conventional systems. Earth energy systems can also be used to heat domestic water. Natural heat from the earth or water source is absorbed into a refrigerant liquid, heat transfer medium and is carried through a system of buried pipes to building, where in heating mode, it is upgraded to the required temperature level via heat pump unit. The heat is then circulated via ductwork or through radiant heating. A ground-source heat pump is an air-conditioner that can also run in reverse during winter. Earth energy systems can maintain high efficiencies and capacities because the components of the system are not exposed to the outdoors. Many earth energy systems on the market have the ability to provide domestic hot water heating through a device called a desuperheater, further increasing their operating efficiency. Alternately, it may provide domestic hot water through a dedicated water to water heat pump.

Significant energy savings can be achieved compared to conventional systems, typical reductions in energy consumption of 30 to 70 per cent in the heating mode and 20 to 95 per cent in the cooling mode. [7]

Main text

Smart power grid systems

In a smart power grid system, power grid consists of interconnected microgrids. As an example, a photovoltaic residential system with an electrical storage system and load would be a small microgrid which would be interconnected in the smart power grid system. To understand the smart power grid design and operation, one needs to understand how electric power grid operates and costs of design. A basic understanding of a power grid's operation will facilitate how to design a microgrid to operate as a standalone system when it is separated from its local power grid. These concepts set the stage for the design of green energy microgrids.

Power grid operation

The operational objectives of a power grid are to provide continuous quality service at an acceptable voltage and frequency with adequate security, reliability and an acceptable impact upon the environment, without damage to power grid equipment – all at a minimum cost. Quality service that is environmentally acceptable, secure, and reliable and entails minimum cost is the main objective in power grid system operations. However during emergency conditions the system may be operated without regard for economy and environmental restrictions such as the use of a high polluting energy source, instead concentrating on the security and reliability of the service for the energy users, while maintaining power grid stability. To ensure security and reliability, facilities such as power plants and its resources must be planned ahead and managed effectively and efficiently. A power grid consist of many elements: generating units, transmission lines, transformers, circuit breakers, etc. As new renewable and clean energy sources are embraced and accepted to the power grid and implementation of smart grid is put in place, additional equipment such as DC/DC and DC/AC converters must be integrated and scheduled for power grid operation. Power grid need to plan and schedule of power generation to supply system loads. The power system energy resources consists of nuclear energy, hydropower, fossil fuel, renewable sources such as wind and solar energy, fuel cells, combined heat and power – CHP: also known as cogeneration, micro turbines, geothermal, etc. These available resources of energy must be managed closely and synchronized to be able to satisfy the load demand of the power grid. The load demand of power grid is cyclic and has a daily peak over the week, a weekly peak over a month and monthly peak over a year. Energy resources must be optimized to satisfy the peak demand, that the cost of the production and distribution is minimized.

Basic concepts of the smart power grid

In a classical power grid, a fixed price is charged to energy users. However the cost of energy is highest during the daily peak load operation. The classical power system operations has no control over the loads except in an emergency situation, when a portion of loads can be dropped as needed to balance the power grid generation with its loads. Therefore much equipment is used for a short time during peak power demand, but remains idle during daily operations. For an efficient smart power grid system design and operation, substantial infrastructure investment in the form of a communication system, cyber network, sensors and smart meters must be installed to curtail the system peak loads when the cost of electric energy is highest. The smart power grid introduces the sensing, monitoring and control system that provides end users with the cost of energy at any moment through real-time pricing. In addition, the advanced control systems of smart metering provide the energy users with the ability to respond to real-time pricing. Furthermore, the smart power grid supplies the platform for the use of renewable green energy sources and adequate emergency power for major metropolitan load centres. It safeguards against a complete blackout of the interconnected power grids due to man-made events or environmental calamity. It also allows for the break-up of the interconnected power grid into smaller, regional clusters. In addition, the smart power grid enables every energy user to become an energy producer by giving the user the choice of PV or wind energy, fuel cells, and combined heat and power – CHP energy sources and to participate in the energy market by buying or selling energy through the smart meter connection. Two-way communication is a key characteristic of the smart power grid energy system. It enables end users to adjust the time of their energy usage for nonessential activities based on the expected real-time price of energy. The knowledge gained from smart meters permits the power grid operators to spot power outages more quickly and smooth demand in response to real-time pricing as the cost of power varies during the day. Historically, power grid companies have operated the power system as a public service. They have provided reliable electric power at a constant price regardless of changing conditions. Their systems used additional spinning reserve units to serve the unexpected loading and outages due to the loss of equipment. However, in the age of global climate change, this kind of service cannot be provided without severe environmental degradation. Power grid operators have to schedule generation sources based on the cost of energy. However, the weather-sensitive load component adds substantial uncertainties in planning load-generation balance. As can be expected, the least costly units are scheduled to satisfy the base loads. The more costly units are scheduled to satisfy the time-changing loads. Therefore, the price of electric energy is continuously changing as load demands are changing. If real-time pricing is implemented, the variable electric rates must be used for the privilege of reliable electrical service during high demand conditions.

Smart grid development

Global warming and the environmental impact of coal-based power generation are changing the design and operation of the power grid. The industry is experiencing a gradual transformation that will have a long-term effect on the development of the infrastructure for generating, transmitting and distributing of power. This change will incorporate renewable green energy sources in a new distributed generation program which is based on increased levels of distributed monitoring, automation, control as well as new sensors. Power grid control will rely on data and information collected on each microgrid for decentralized control. In return, the microgrids and interconnected power grid will be able to operate as a more reliable, efficient and secure energy supplier. The technology of the power grid and microgrids has a number of key elements: Adaptive and autonomous decentralized controls to respond to changing conditionsPredictive algorithms capture the power grid state for a wide area and are able to identify potential outagesThe system also provides market structure for real-time pricing and interaction between customers, grid networks and power marketsThe smart grid provides a platform to maximise reliability, availability, efficiency, economic performance and higher security from naturally occurring power disruptionsThe implementation of an advanced metering infrastructure provides real-time pricing to the energy end user. In parallel, the penetration of renewable energy sources is providing a platform for autonomous control or local control of connected microgrids to the local power grid. A distributed autonomous control will provide reliability through fault detection, isolation and restoration. The autonomous control and real-time pricing also delivers efficiency in feeder voltage to minimize feeder lasses and to reduce feeder peak demand of plug-in electric vehicles. The maturing storage technology will provide community energy storage, which becomes yet another important element for microgrid control and allows the energy user to become an energy producer. These interrelated technologies require a coordinated modelling, simulation and analysis system to achieve the benefits of a smart power grid. [8]

Wind turbines

Wind power

Wind energy as one of our most abundant resources, is the fastest growing renewable energy technology worldwide. Improved turbine and power converted designs have promoted a significant drop in wind energy generation cost making it the least-expensive source of electricity – from 37 cents/kWh in 1980 down to 4 cents/kWh in 2008 (currency USD). In 2008, wind energy systems worldwide generated 331, 600 million kWh, which was 1. 6% of total electricity generation. [9]

Understanding wind turbines

All residential wind turbines, large or small have the same three basic components: A blade assembly, commonly referred as rotor that turns in windA shaft that connects to the rotor and rotates when the blades turnA generator – a device that converts mechanical energy into electricityWind turbines exist in two basic varieties: Horizontal axis unitsVertical axis unitsHorizontal axis units are the most widely used in household-sized turbines. Vertical axis wind turbines are now making a comeback to the market. When wind blows, they turn around its vertical shaft.

Horizontal-axis wind turbine

A horizontal-axis wind turbine is equipped with two or three blades, three being the most widely used and most desirable. The use of three blades results in less wear and tear on the generator in shifting winds and results in more reliable wind turbines. Blades are typically made of a highly durable plastic or fiberglass. The blades of a wind turbine and the central hub to which they are attached are called a rotor. The rotors of wind turbines capture kinetic energy from the wind and convert it into rotating mechanical energy – a spinning shaft. The spinning shaft is attached to the generator. It converts mechanical energy into electrical energy. Several types of generators are found in household-sized wind turbines. The most common is the permanent magnet alternator. When the shaft of a wind turbine with a permanent alternator spins, it causes a component called the armature inside the generator to spin. The armature consists of a mass of tightly coiled copper wire. It spins inside a magnetic field. Moving an electrical coil through a magnetic field creates an electrical current in the wires. DC current produced by a wind turbine is carried away by electrical wires. They deliver the electricity to a device known as an inverter. Inverter converts DC current to AC current. They also boost the voltage from 12, 24, 48 volts, typically produced by wind turbines to the required voltage for most household appliances and electronic devices.

Is wind energy appropriate to the site

Before investment of the time learning about wind generators and wind energy systems it is important to know that there is enough wind energy in the location of the site to make it worth the money.

Assessing wind resource

Wind is clean, free fuel that powers wind turbines. In order for a system to make sense economically, there is need for sufficient wind in the site. Most systems for homes require an average annual wind speed at ground level of at least 3-4 m/s, the faster the wind – more energy extraction is available. Although that sounds like a lot of wind, it doesn’t mean that the wind has to blow constantly at these speeds year-round, in order for this energy source to make sense. Wind turbines are not mounted at ground level. Wind turbines are typically mounted on sturdy poles or towers of various heights. The higher wind turbine is mounted, the higher wind speed. Wind also blows more smoothly – less turbulent. Slight increases in wind speed dramatically increase power generation. Before even considering installing wind system, sites need to be assessed very carefully. [10]

Wind regime characteristics

Characteristics of the wind regimes can be incorporated in assessing the wind energy potential as well as estimating the output from a wind energy conversion system. Global wind movement is predicated on the earth’s rotation, regional and seasonal variations of sun irradiance and heating. Local effects on wind include the differential heating of the land and the sea, and topography such as mountains and valleys. The average wind speed determines the wind energy potential at a particular site. Wind speed measurements are recorded for a 1-year period and then compared to a nearby site with available long-term data to forecast wind speed and the location’s potential for wind energy supply.

Boundary layer effect

The first factor to be considered while estimating the wind resource and wind turbine performance at a given site is the variations in wind velocity due to the boundary layer effect. Due to the frictional resistance offered by the earth surface to the wind flow, the wind velocity may vary significantly with the height above the ground. Ground resistance against the wind flow is represented by the roughness class or the roughness height – Zo. The roughness height of a surface may be close to 0 – surface of the sea or even as high as 2 – town centres. The effects of tower height – h are associated with vertical variation in the wind speed.

How much energy in the wind?

It is useful to begin by considering the amount of energy and power available and reviewing the difference between these two concepts. The volume of the element is the product of its area isLength normal to the disc isSo its mass isAnd its kinetic energy – KE isThe time taken for this element to cross the blade disc is and is given simply by: . The contribution of the element to the total amount of KE that passes in is symbolized as , and given by: Summing over all elements of area that make up the disc gives the KE passing the disk as: This equation can now be taken formally to the limit as , to giveP is the power. This equation suggests that the output power of any turbine depends of the cube of wind speed. This simple and fundamental fact must never be forgotten. The wind speed determines both the amount of energy, proportional to and the mass of air carrying that energy through the blade disk per unit time, which is proportional to. In practice the power output is never as great as suggested by the equation, because extraction of all the available KE would require the wind to be decelerated to rest. Furthermore, a turbine cannot capture all the wind that would otherwise pass through the disk. Including the finite efficiency drivetrain and the generator, and aerodynamic losses through the action of viscosity, is reasonable to assume that the power converted into electricity is about 40% of that given by the equation.

Examples of wind turbines

Wind turbine range in power output from a few watts to few megawatts. The IEC safety standard for small wind turbines, IEC 61400-2, defines a small turbine as having a rotor swept area less than 200m², which corresponds roughly to P <50kW. The basic operating principles are the same for turbines of all sizes. There are operational issues that do depend on size: starting performance and cut in speed – the lowest wind speed at which power is extracted. Both of these are more important for small machines because: Small wind turbines are often located where the power required or adjacent to the owner's home which may not be the windiest location, whereas wind farms containing large turbines are deliberately sited in windy areas. The generators of small turbines often have a significant resistive torque that must be overcome aerodynamically before the blades will start turning. Pitch control is rarely used on small wind turbines because of cost. Small wind turbine aerodynamics is influenced strongly by low values of the Reynolds number, Re. Virtually all large turbines are upwind machines – the blades are in front of the tower when viewed from the wind direction and have three blades. The main differences occur in the drivetrain and generator. The most common generator types are: Doubly fed induction generators (DFIGs)Permanent magnet generators (PMGs)DFIGs require a gearbox and are rarely used on small turbines. PMGs and less-used induction generators – IGs do not. There is a much greater diversity of small turbine types with the number of blades varying from two to seven, and the most popular turbines being downwind machines.

Wind turbine noise

In siting a wind turbine, the first and often far from minor task is to determine the wind resource, which may vary significantly over short distances because of the surface roughness, the topography and proximity to buildings, trees and the like. There remain at least three further important issues: NoiseVisual impactPossible restrictions on tower heightThe first two are often addressed for large wind farms using sophisticated software that optimises the layout of the turbines to maximise power extraction and minimise the visual impact of the turbines. Well-designed wind turbines are extremely quiet. One simple data correlation for the sound power level (Lp), gives: That is one-ten millionth of the turbine's power is output as noise. For this reason, a well-designed small wind turbine is almost guaranteed to be quiet. Another correlation that is more accurate in some cases is: Where Lp is measured in the more common unit: A-weighted decibels – dBA. Ω is the blade angular velocity in rad/s, so ΩR is the circumferential velocity of the blade tips in m/s and R is measured in meters – m. Lp is the strength of the source of the sound as a multiple of the standard base level of Watts. It is used, in combination with an equation for the propagation of the sound, to determine the noise level at any point around the turbine or turbines. The most common spreading equation is: It gives the noise level on the ground at distance – d from the turbine with a tower of height – h. The second term is the hemispherical spreading term which is strictly valid only when h>> d and the ground is flat. The third term represents the atmospheric absorption of sound with the coefficient – α typically in the range 0. 002-0. 005dB/m. For a small wind turbine purposes, this term is usually negligible. Turbines whose blades flex to unload the turbine in high winds, has a correspondingly high noise level during the resulting flutter.

Turbine operating parameters

As with any fluid machine, it is often useful to discuss wind turbine operation in term of parameter groupings that can be obtained from dimensional analysis. The most important parameter, the power coefficient – Cp, should be defined as: Cp the ration of the actual power produced to the power in the wind that would otherwise pass the blade disk. Cp is dimensionlessBy convention, it includes the factor of ½ to relate power to the kinetic energy flux through the blade diskCp is not exactly efficiency, even though it is often treated as one. It is possible to increase Cp by increasing the velocity of the wind through the blade by surrounding the blades by a diffuser. Cp can be interpreted as efficiency when comparing turbines of the same type. [11]

Solar energy systems

Solar electric system

Sunlight is defined by irradiance, meaning radiant energy of light. One sun is defined as the brightness to provide an irradiance of about 1 kW/m^2 at sea level. One sun's energy has 523W of IR light, 445W of visible light and 32W of UV light. This can be used to compute the area in square meters needed to generate required amount of power. As the thermal IR radiation from the sun reaches the earth, some of the heat is absorbed by earth's surface and some heat is reflected back into space. Highly reflective mirrors can be used to direct thermal radiation from the sun to provide a source of heat energy. The heat energy from the sun – solar thermal energy can be used to heat water to a high temperature and pressurize in in a conventional manner to run a turbine generator. [12]A photovoltaic cell is a solid state device that absorbs visible light and converts its energy to electricity. As sunlight strike a PV cell it free electrons from silicon atoms. Due to boron and phosphorus added to different layers of PV cell, these electrons are forced to migrate from one side of the cell to the other, where they are drawn away by the metal contacts on the cell's surface. Flowing electrons form an electrical current. Because silicon reflects about 35 per cent of the light striking it, the cells are coated with a thin, anti-reflecting layer of silicon monoxide or titanium dioxide. It is applied after the metal contacts have been put in place. The back of the cell is made of a thin layer of metal that completes electrical circuit. Silicon cells are mounted in the metal-backed modulus casing and wired in series to boost the voltage. The unit is sealed by a clear layer of glass or durable sun-resistant plastic. Glass and plastic prevent moisture from reaching the cells and also resist the force of hail stones and strong winds. PV modules are typically mounted on a durable metal rack. The rack maybe located on the roof of a home or on the ground in a sunny location with good access to the sun year round. In some installations, the modules are mounted on a rack attached to the pole. In others the racks are part of a tracking device that enables the panels to follow the sun from sunrise to sunset thus increasing energy yields. Solar arrays produce direct current DC electricity when cells are struck by light. Direct current electricity consists of electrons flowing in wires in a single, fixed direction. The DC electricity produce by a solar array is carried away by wires that lead into the home. Virtually all of households today use another type of electricity, known as alternating current – AC. AC electricity consists of electrons that cycle very rapidly back and forth through the wire. In order for the DC current produced by PV cells to power household, it must be converted to AC. This task is done by the inverter. [13]

Photovoltaic materials

The manufacture of PV cells is based on two different types of material: A semiconductor material that absorbs light and converts it into electron-hole pairsA semiconductor material with junctions that separate photo-generated carriers into electron and electron holes. The contacts on the front and back of the cells allow the current to the external circuit. Crystalline silicon cells – c-Si are used for absorbing light energy in most semiconductors used in solar cells. Crystalline silicon cells are poor absorbers of light energy. They have efficiency in the range of 11 to 18% of that of solar cells. The most-efficient monocrystalline – C-Si uses laser grooved, buried grid contacts, which allow for maximum light absorption and current collection. Each of the c-Si cells produces approximately 0. 5V. When 36 cells are connected in series, it creates an 18V module. In the thin film solar cell, the crystalline silicon wafer has a very high cost. Other common materials are amorphous silicon – a-Si, and cadmium telluride and gallium. These are another class of polycrystalline materials. The thin-film solar cell technology uses a-Si and a p-i-n single-sequence layer where: P is positiveN is negativeI is the interface of a corresponding p-type and n-type semiconductorThin-film solar cells are constructed using lamination techniques, which promote their use under harsh weather conditions. They are environmentally robust modules. Due to the basic properties of c-Si devices, they may stay as the dominant PV technology for years to come. However thin-film technologies are making rapid progress and a new materials or process may replace the use of c-Si cells.

Photovoltaic characteristics

As sun irradiance energy is captured by a PV module, the open-circuit voltage of the module increases. If the module is short-circuited, the maximum short-circuit can be measured. PV module selection criteria are based on a number of factors: The performance warrantyModule replacement easeCompliance with natural electrical and building codesA typical silicon module has a power of 123. 5W/m² surface area. A typical thin film has a power of 96W/m². Hence the land required by a silicon module is almost 35% less. Typical electrical data apply to standard test considerations –STC. Under STC, the irradiance is defined for a module with a typical value such as 1000W/m², spectrum air mass – AM = 1. 5, and a cell temperature of 25° Celsius. The PV fill factor – FF is defined as a measure of how much solar energy is captured. This term is defined by PV module open circuit voltage – Voc and PV module short-circuit current – Isc. AndSome PV modules have a high fill factor. In the design of PV system a PV module with high FF would be used. For high-quality PV modules, FF's can be over 0. 85. For typical commercial PV modules, the value lies around 0. 60. A typical PV module characteristic is not only a function of irradiance energy, but it is also a function of temperature.

Photovoltaic efficiency

The PV module efficiency, η is defined as: where = maximum power output and is the surface area of the module. The PV efficiency can also be defined as: P(λ) is the solar power density at wavelength λ. [14]

Geothermal heating

Heat pump fundamentals

Heat naturally flows from higher to a lower temperature. A heat pump is a device that causes heat to flow in the opposite direction. Because work must be done to accomplish this, the heat pump is used. The heat pumps that are in earth energy systems operate following the same basic principles as refrigerating equipment. Most of these systems are based on two physical phenomena: When a liquid evaporates, it absorbs energy and when it condenses it releases energyAny liquid will evaporate or condense at a lower temperature when the pressure decreases and will condense or evaporate at a high temperature when the pressure increasesThese two principles are the basis of the mechanical vapour compression cycle. This cycle uses the two principles to transfer energy from a colder source to a warmer sink. Therefore, a heat pump is the same as a refrigeration unit. The only differences between a heat pump and a refrigeration unit are the temperature levels at which they operate and that heat pumps are reversible – can be used for heating or cooling.

How earth energy system work

Energy in the form of heat is present even at very low temperatures. Provided the temperature of an object is above absolute zero point -273. 15°C, there is some heat energy present in the object. The temperature of the ground is too low to heat a building directly, but the ground still holds a vast store of heat. A heat pump is required to upgrade this energy extracted from the ground to a convenient level for heating, or to reject heat to the ground effectively. This ground heat source and sink has a near constant temperature, which is well suited for a heat pump, giving predictable performance and lower thermal and mechanical stress.

The refrigeration cycle

The majority of heat pumps work on the principle of the vapour compression cycle. The main components in such a heat pump system are the compressor, the expansion valve and two heat exchangers referred to as evaporator and the condenser. The components are connected to form a closed circuit or closed system. A fluid, known as the working fluid or refrigerant, circulates through the four components. In the evaporator, refrigerant enters in a cool, mostly liquid state. The temperature of the liquid is lower than the temperature of the heat source, such as the surrounding ground in heating mode of a ground-coupled heat pump or the room air in cooling mode. The warmer ground or air then causes the liquid refrigerant to evaporate, thus absorbing heat. Refrigerant vapour from the evaporator travels to the compressor where it is compressed to a higher pressure and temperature. Once it passes through compressor, the refrigerant is said to be on the " high" side of the system. The hot vapour then enters the condenser, where it condenses and gives off heat, heating up the building when in heating mode. Finally, the pressure of the warm liquid refrigerant exiting the condenser is reduced through the expansion valve. The expansion process also reduces the refrigerant temperature before it re-enters the evaporator. The whole process can be reversed to cool the building.

Earth energy system components

The basic function of an earth energy system is to provide heating and cooling for a building. In addition, it may provide water heating, sometimes supplemented by a conventional water heater. To perform these functions, earth energy systems are made up of the following three primary sub-systems. An earth connection also known as ground or ground-water loops that extracts heat from the earth or discharges heat to the earthA heat pump that transfers heat between the distribution system and the ground or ground-water loopsA distribution system to deliver the heating or cooling of the building

Constant ground temperature

At a depth of eight to nine metres or more, ground temperatures is virtually constant throughout the year, having a value close to that of the average annual air temperature. This constant temperature environment is well suited to earth energy heat pumps, giving them consistent performance, regardless of the outdoor temperature.

Flexibility of Earth energy systems

Users of EESs can control comfort levels, and the thermostat control is simple to use. The heat pumps can be located out of occupied space. This permits flexibility in partitioning and layout of the occupied space and easily allows for space expansions. Careful planning and design will provide inherent flexibility and cost efficiency.

Space and cost savings

EESs can be all-electric, which eliminates the need for multiple utility service entrances, fuel storage tanks, etc. The system requires less mechanical room space, than central heating and cooling systems. There is much less outdoor equipment, which results in lower maintenance and security costs. Exterior noise is significantly reduced and building aesthetics are excellent. EESs also last longer, with buried piping lasting more than 30 years and the heat pumps themselves lasting typically 20 years. [15]

Hybrid systems, batteries and additional equipment

Hybrid systems

Because winds don't blow all of the time, even in windy locations, many homeowners who want to be off the grid or want to produce more energy turn to hybrid systems. A hybrid system is a renewable energy system that combines a wind turbine with solar electricity PVs or some other renewable energy technology. PVs and wind work particularly well together in many parts of the world. In many locations, during November through March winds blow frequently and fiercely. Because of this wind can supply a large portion of electrical needs. During this time, the PV arrays supplements wind-generated electricity. During the rest of the year, winds continue to blow, but they are often less frequent and milder than winter winds. However, because sunshine is now more abundant, it provides the bulk of electrical power and wind-generated electricity serves as a back-up. Although wind and solar electricity work well together and can provide nearly all of your electricity, you may still need to install a back-up generator if stand-alone system is used. It will supply electrical energy in periods of low winds and low sunshine.

Sizing a hybrid system

Because PVs supplement wind power in the winter and wind supplements PVs the remainder of the year, it is very likely to be able to pare both systems down a bit. That is because PVs will be main source of electricity in the summer and wind will be generally main source of electricity in the winter. [16]

Additional components of solar and wind systems

All code-compliant solar systems include two additional components: meters and disconnect switches. Meters are used to measure electrical production and consumption. The meters that measure electrical production by a PV system and energy consumption of household at any given time – providing an instantaneous picture of energy production and consumption. They are typically located on the inverter itself or in a separate location, situated in a convenient place for ease of monitoring. Short-term meters track electrical production or consumption in amps or amperes. More sophisticated meters measure long-term electrical productions – that is the total energy produced and consumed over long periods of time. As a result they keep track of production and consumption in kilowatt hours – kWh. Grid-connected renewable systems also require one, sometimes two standard utility electrical meters. These large, tamper-proof glass encased meters are installed by utility company, to keep track of monthly energy production and consumption so the utility can bill you at the end of each month. Solar electric systems also contain a couple of safety switches called disconnects. Disconnects enable homeowners or service personnel to shut power down to prevent electrical shock for safety reasons when working on the system. [17]

Inverter

The inverter is the key equipment for converting DC electricity into AC suitable for feeding into a power grid. Inventers use advanced electronics to produce AC power at the right frequency and voltage to match grid supply. A single inverter may well be sufficient for a domestic installation, but multiple units become the norm when power scale is increased and their efficiency, reliability and safety are major concerns of the system design. Inventers must be able to handle the power output over a wide range of climate conditions. Normally they do this using maximum power point tracking – MPTT to optimise the energy yield. DC to AC conversion efficiencies up to 98 per cent can be achieved over much of the range, although efficiencies tend to fall off if an inverter is operated below 25 per cent of its maximum power rating. Inverter system design can be a challenge if it is expected to maintain high efficiencies. From technical point of view, there are two main classes of inverter: Self-commutated – inverter's intrinsic electronics lock its output to the gridLine-commutated – grid signal is sensed and used to achieve synchronisationInventers are also classified according to their mode of use: Central – the complete output of array is converted to AC and fed to the gridString – this inverter is connected to a single string of modules, typical power range 1-3kWpMulti-string – these inverters can accept power from a number of strings with different peak powers and orientations, allowing each string to operate at its own MPPIndividual – Inventers attached to the equipment, making its own AC power source [18]

Grid-connected and stand-alone systems

Renewable energy systems fall in three basic categories: Grid-connectedGrid-connected with battery storageStand-alone

Grid- connected & Grid-connected with battery storage systems

A grid-connected system consists of three main components: A renewable energy sourceAn inverterA main service panelDC electricity produced by renewable source of energy is converted to AC by the inverter and travels to the main service panel. From here it travels to various open circuits – loads. Excess power goes on to the grid. If there is want to store electricity for emergency use – to protect household from an occasional grid failure, a battery bank can be installed for back-up power. In these systems, the wind turbine and/or solar panels supplies electricity to active circuits in the house. Excess electricity is fed into the batteries and when batteries are full, excess electricity is diverted to the grid. If a blackout occurs, the batteries kick in, supplying electricity to the household.

Stand-alone systems

A stand-alone system provides all of household electricity needs. Stand-alone systems are not connected to the electrical grid. Because of this, it cannot send surplus to the grid in times of excess production, nor can it draw from the grid in times of need. In stand-alone systems, surplus electricity is stored in a bank of batteries. When batteries are full, it shuts down the renewable energy system to protect the battery, not to fry it. The battery bank is much larger than in grid-connected system with a battery back-up. Electrical demand during windless and/or sunless periods is satisfied by electricity stored in the batteries. A back-up electrical generator may also be required. [19]

Discussion

Green and renewable energy sources

To meet carbon reduction targets it is important to use sources of energy that are renewable and sustainable. The need for environmentally friendly methods of transportation and stationary power is urgent. We need to replace traditional fossil-fuel-based vehicles with electric cars, and the stationary power from traditional fuels , coal, gas and oil with green sources for sustainable energy fuel for the future.

Conclusion

Society benefit of Renewable Energy

EESs involve the transfer of natural heat an no combustive process occurs, the only harmful environmental emissions attributable to their use is related to the electricity required for the system’s operation, if the source of electrical generation is from fossil fuels. EESs are also energy efficient because for every unit of electricity energy required to operate the system, the system transfers three to four times amount of heat energy. The use of EESs can contribute significantly to the reduction of GHG emissions, impacting on climate change, because there are little or no carbon dioxide emissions associated with the operation of EESs. Using earth energy systems has a positive impact on society as a whole as they use a significant portion of renewable energy in their operation, have long lives and are comprised of equipment that can be recycled. The resource is plentiful and readily available from one's own land. The use of earth energy systems should always be a part of taking into account when designing a building. For most efficient way of earth energy systems, the ground loops should be buried in the ground at the depth where temperature of the soil contains a constant temperature of at least 10° Celsius. The higher the temperature the better it is. Heating of the house should be done through the pipes in the floor at the temperature of 35°-45° Celsius to achieve high heating coefficient of performance. If using earth energy system to heat household, the electricity used should be from renewable sources of energy to reduce the pollution of the atmosphere. 0306-geodynamicsgraph1large. gifThere are a lot of benefits associated with wind turbines. The life expectation of wind turbines is around 20 years if maintenance and supervision is in place. Depending on wind speed, the power extraction varies. It is more economical to build wind turbines in more windy places, but there are benefits of wind turbines in less windy areas as well. When investing in wind turbines, the investment has a payback period of 5 to 8 years. A person can become free from energy suppliers and even producer of clean renewable energy to the grid and generate the revenue. Use of renewable energy also reduces the carbon emissions and pollution of the atmosphere caused by burning of fuels. As it is clean and has only small environmental impact of visual and noise, the use of renewable energy technologies will gain its movement of clean energy and reduced carbon emission society. Materials of wind turbines can be recycled and reused for building new wind turbine. No waste and no pollution is the future of energy production. PVs systems can generate a lot of electricity if there is sufficient sun light. The efficiency of the PVs is still low and the cost of it is high, it is still a good investment. Furthermore, the energy supplied by the PVs is renewable and clean and cause no pollution for producing the energy. The PV systems are advancing and the prices of it get lower each year.

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