SUSTAINABLE LOUDOUN ENERGY SUMMIT

RENEWABLE ENERGY ALTERNATIVES FOR BUILDINGS

What can governments do to respond to local and global energy and resource challenges?

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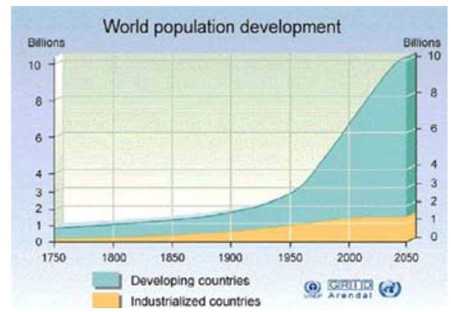
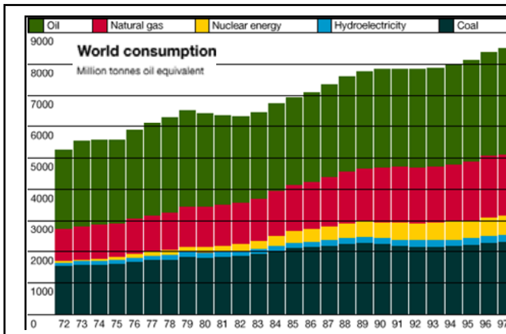
1. Population Growth

1.1 Population Growth [1]



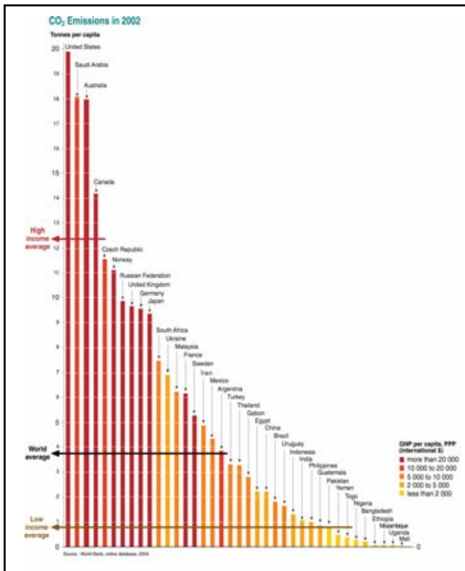
The size of the human population is one of the major factors which determine the total ecological impact of human activities.
Significant increases in human population are almost inevitable, with projections ranging from a high of almost 12 billion by 2050, to a low of just under 8 billion. Meeting the basic human needs of an additional 2 to 5.5 billion people over the next half century will place an increasing burden on the earth's ecosystems, especially if global per capita consumption levels remain constant, or worse, continue to increase.

1.2 Depletion of non-renewable fuels [2]



With the increase of human population, the energy consumption is also increasing. Because fossil fuels are non-renewable resources, their continued use is by definition unsustainable. Of more immediate concern is the fact that their emissions are overwhelming various ecosystems capacities to absorb them, resulting in elevated concentrations of greenhouse gases in the atmosphere. In turn, these atmospheric concentrations are contributing to climate change, thereby posing a serious threat to the environment and humanity. Reducing our reliance on fossil fuels and making a transition to renewable alternatives are essential to ensuring sustainable energy supplies.

1.3 Carbon Dioxide Emissions [3]

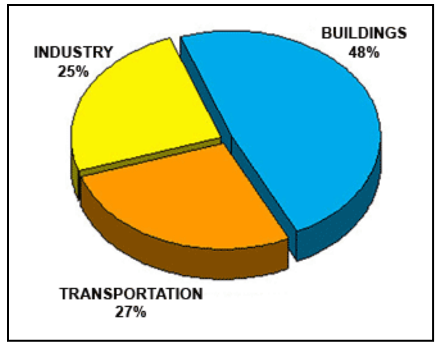


We know for a fact that CO_2 levels are rising and that human activity is the cause. We also know that carbon dioxide is a greenhouse gas that changes the thermal equilibrium temperature of the earth.
The diagram shows various countries and their levels of CO_2 emissions per capita. It also indicates the difference from high income to low income nations on CO_2 output.

CO_2 Emissions per Capita and Year:

- High income average	**12.5 Tons per capita**
- World average	**4 Tons per capita**
- USA	20 Tons per capita
- Canada	14.5 Tons per capita
- Germany	9.5 Tons per capita
- Switzerland	6 Tons per capita
- Low income average	0.8 Tons per capita
- Sustained CO_2 Emissions	**1 Tons per capita**

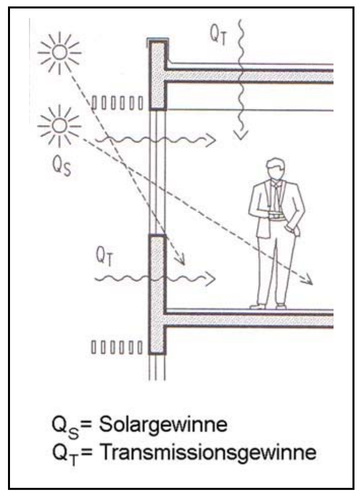
1.4 Reduce Greenhouse Gases from buildings [4]



Many people are surprised to learn that buildings are the single largest contributor to global warming. Data from the US Energy Information Administration illustrates that buildings are responsible for almost half (48%) of all energy consumption and greenhouse gas emissions annually.
Clearly, immediate actions in buildings are essential if we are to avoid hazardous climate change. Green building is the practice of increasing the efficiency with which buildings use resources (energy, water and materials).
New buildings can be constructed using passive solar building design, low-energy building, zero-energy building techniques, and renewable heating and cooling sources. Existing buildings can be made more efficient through the use of insulation, high-efficiency appliances, triple-glazed gas-filled windows and external window shades.

2. Loads in Summer and Winter [5]

2.1 Cooling Load



The calculation for the cooling load is the sum of the external cooling load and the internal cooling load

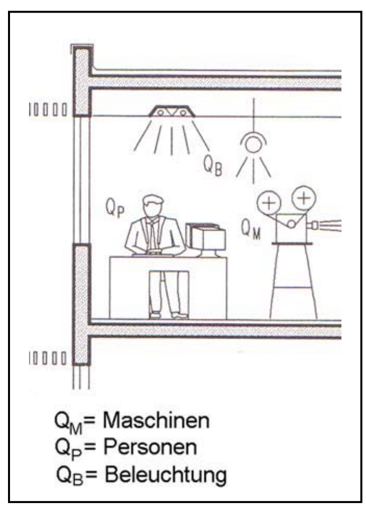
2.1.1 External Cooling Load

The heat gain from solar radiation is a function between location, orientation, natural light from the daytime, and season.

In the external cooling load are related tree heat flow rates:

- Solar radiation gain through transparent spaces (windows)
- Transmission heat gain through transparent spaces (windows) and opaque spaces (walls, floors and ceilings)
- Infiltration gain through air leakages (walls, doors and windows)

The external cooling load can be reduced if the window with a low solar heat gain coefficient (SHGC) is used, or if exterior shading exists.
The transmission heat gain through opaque spaces is low if the building surface is built with a low U-Factor [Btu/(h*ft^2*°F) or W/(m^2*K)].
Infiltration calculations are usually limited to doors and windows. The infiltration can be minimized if the inside of the building is over-pressured. The cooling load will decrease when the surface is airtight.



2.1.2 Internal Cooling Load

Internal heat gains from people, lights, motors, appliances and equipment can contribute to the majority of the cooling load in a modern building.
Using high-efficiency appliances should be considered to decrease the cooling load.

2.2 Heating Load

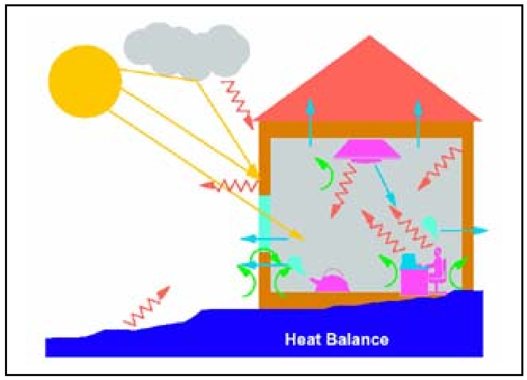
Calculating a heating load system involves estimating the maximum heat loss of each room, the space to be heated, and the simultaneous maximum heat loss for the building, while maintaining a selected indoor air temperature during periods of designed outdoor weather conditions.
The ideal solution to a basic heating system design is a plant with a maximum output capacity equal to the heating load that develops with the most severe local weather conditions. However, this solution is usually uneconomical.

In the heating load calculation the credits for solar heat gains and internal heat gains are not included. This simplified approach is justified because it evaluates worst case conditions that can reasonably occur during a heating season; then without solar heat gains and internal heat gains.

2.2.1 Heat Loss

The heat loss is divided into two groups:

- The heat transmission losses through transparent spaces (windows) and opaque spaces (walls, floors and ceilings)
- The infiltration losses through air leakages (walls, doors and windows)



2.2.2 Heat Gain

The heat gain is divided into two groups:

- The solar gain through transparent spaces (windows)
- The internal heat gain from several internal heat sources (people, lights and electrical equipment)

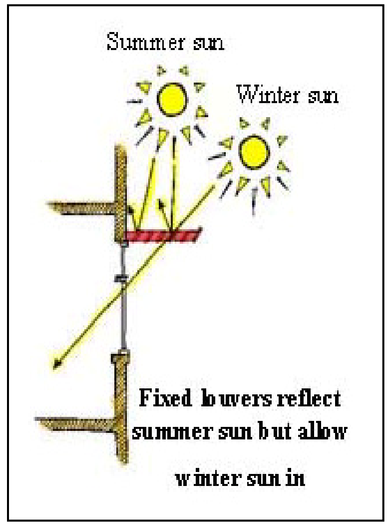
2.3 Decrease Heating and Cooling Load

2.3.1 Fenestration

Fenestration affects building energy use through four basic mechanisms:
- thermal heat transfer,
- solar heat gain,
- air leakage, and
- natural day lighting

The energy impacts of fenestration can be minimized by using daylight to offset lighting requirements, using appropriate glazing and shading strategies to control solar heat gain to supplement heating through passive solar gain, minimize cooling requirements using appropriate glazing to minimize conductive heat loss, and specifying low air leakage fenestration products. Today, designers, builders, energy codes, and energy-efficiency incentive programs (Energy Star www.energystar.com), and the LEED Green Building Program (www.usgbc.gom) are in high demand for fenestration systems.

2.3.2 Solar Radiation Gain



Solar control is a critical requirement for both cooling-load dominated and passively solar-heated buildings. High-performance glazing and external shading systems can significantly reduce solar radiation gain. The crucial design issue is to achieve a balance between solar control and day-lighting.

Awnings and overhangs are the most effective means of solar control since they prevent sunlight from striking the windows. Movable systems are adjustable according to season. Fixed overhangs are more dependable, but their design must account for daily and seasonal variation of the sun's path. A properly sized overhang on southwest and southeast oriented windows can reduce energy use by up to 6%. A further 20% can be gained by combining overhangs with daylight controls.

2.3.3 Internal Heating Gain

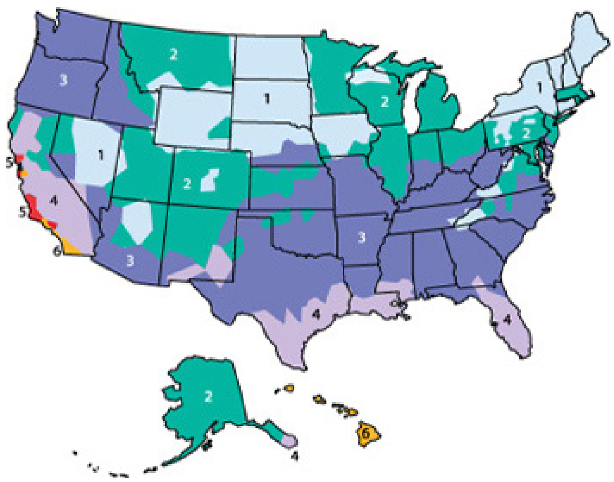
In a typical commercial building, electricity accounts for 60% to 95% of the total energy consumption. Thoughtful selection of transformers and motors can greatly reduce electricity consumption.
Small efficiency improvements are very effective. Typical efficiencies range from 95% to 99%; a 1% improvement can reduce waste by one-half. When selecting transformers, consider the load factor; with high load variation, transformers are mostly lightly loaded, and should be selected for low core losses. With higher load factors, transformers with low winding losses save more.

www.energystar.gov

ENERGY STAR is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy helping us all save money and protect the environment through energy efficient products and practices.

2.3.4 Transmission Heat Gain and Infiltration Gain

To increase the efficiency of the building envelope, we have to use high-efficiency windows and insulate the building envelope (walls, ceilings and floors). A good insulating system includes a combination of products and construction techniques that protect a home from the outside temperatures – hot and cool, as well as air leaks.
Insulation works best when air is not moving through or around it. So it is very important to seal air leaks before installing insulation to ensure that we get the best performance from the insulation.



Zone	Gas	Heat pump	Fuel oil	Electric furnace	Ceiling: Attic	Ceiling: Cathedral	Wall (A)	Floor	Crawl space (B)	Slab edge	Basement: Interior	Basement: Exterior
1	✔	✔	✔		R-49	R-38	R-18	R-25	R-19	R-8	R-11	R-10
1				✔	R-49	R-60	R-28	R-25	R-19	R-8	R-19	R-15
2	✔	✔	✔		R-49	R-38	R-18	R-25	R-19	R-8	R-11	R-10
2				✔	R-49	R-38	R-22	R-25	R-19	R-8	R-19	R-15
3	✔	✔	✔	✔	R-49	R-38	R-18	R-25	R-19	R-8	R-11	R-10
4	✔	✔	✔		R-38	R-38	R-13	R-13	R-19	R-4	R-11	R-4
4				✔	R-49	R-38	R-18	R-25	R-19	R-8	R-11	R-10
5	✔				R-38	R-30	R-13	R-11	R-13	R-4	R-11	R-4
5		✔	✔		R-38	R-38	R-13	R-13	R-19	R-4	R-11	R-4
5				✔	R-49	R-38	R-18	R-25	R-19	R-8	R-11	R-10
6	✔				R-22	R-22	R-11	R-11	R-11	(C)	R-11	R-4
6		✔	✔		R-38	R-30	R-13	R-11	R-13	R-4	R-11	R-4
6				✔	R-49	R-38	R-18	R-25	R-19	R-8	R-11	R-10

Figure: U.S. Department of Energy Recommended*) Total R-Values for New Houses in Six Climate Zones

*) These recommendations are cost-effective levels of insulation based on the best available information on local fuel and materials costs and weather conditions. Consequently, the levels may differ from current local building codes. In addition, the apparent fragmentation of the recommendations is an artifact of these data and should not be considered absolute minimum requirements.

A. R-18, R-22, and R-28 exterior wall systems can be achieved by either cavity insulation or cavity insulation with insulating sheathing.
For 2 in. x 4 in. walls, use either 3½ in. thick R-15 or 3½ in. thick R-13 fiber glass insulation with insulating sheathing.
For 2 in. x 6 in. walls, use either 5½ in. thick R-21 or 6¼ in. thick R-19 fiber glass insulation.
B. Insulate crawl space walls only if the crawl space is dry all year, the floor above is not insulated, and all ventilation to the crawl space is blocked.
A vapor retarder (e.g., 4- or 6-mil polyethylene film) should be installed on the ground to reduce moisture migration into the crawl space.
C. No slab edge insulation is recommended.

Water can condense on a non-insulated or poorly insulated exterior wall inside heated rooms (heat bridges are the reason for a cold inside surface wall temperature). A solid metal frame surrounding the panes in a window, for example, could conduct cold air into the heated area of the house and cause condensation to form on it.
The inside air then touches the cold surface, and the decrease in temperature robs the air of its ability to hold water, forming droplets on the surface. Mold can then be developed with those conditions.

Mold on a wall suffering from condensation

2.3.5 Building Ventilation

We usually think of air pollution as smog, odors, and loss of humidity outdoors, but the air in our houses and offices could also be polluted just as easily in the same way. Sources of indoor pollution or loss of humidity could be caused by:

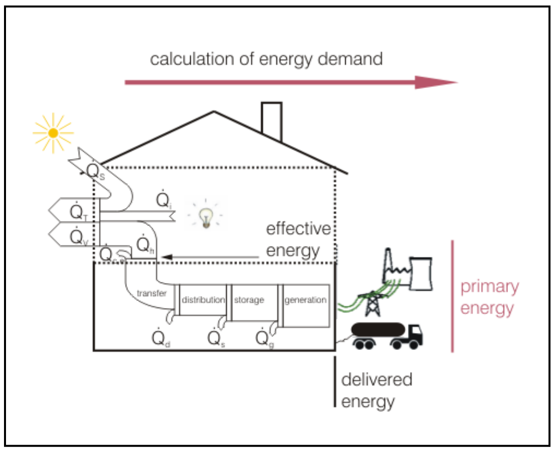
- Biological contaminants like mold and pollen
- Tobacco smoke
- Household products
- Materials used in the buildings
- Plants
- People

Indoor air quality problems usually only cause discomfort, and most people feel better as soon as they eliminate the source. With a well-ventilated building, we can improve the quality of the indoor air.
For less heating and cooling load, we should have an airtight surface so the pollution, odors and humidity cannot escape through air leaks in the building envelopes.
Because of the heat loss or the cooling load, we should not naturally ventilate by simply opening the windows. Instead, we should exchange the indoor air using a mechanical ventilation system.

3. Forms of Energy

3.1 Primary Energy (or Source Energy)

Primary energy is the energy embodied in natural resources prior to undergoing any human-made conversions or transformations. Examples of primary energy resources include coal, crude oil, sunlight, wind, running rivers, vegetation, and uranium.
Primary energy sources are transformed in energy conversion processes to more convenient forms of energy, such as electrical energy and cleaner fuels.



3.2 Site Energy (or Delivered Energy)

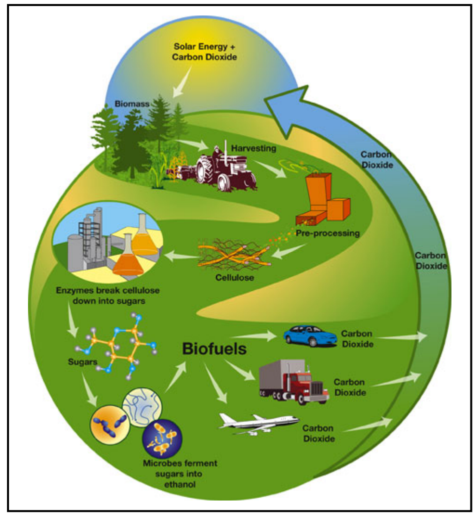
Most building managers are familiar with site energy, the amount of heat and electricity consumed by a building as reflected in utility bills. Site energy may be delivered to a facility in one of two forms: primary and / or secondary energy.
Site energy does not incorporate the energy used for storage, transport and delivery of fuel to the building.

3.3 Useful Energy (or Effective Energy)

By useful energy one means the energy available to the consumer after the last conversion is made in his own equipment. It is the final energy (energy supplied to the equipment) minus the conversion loses.

4. Renewable Energy [6]

4.1 Biofuels

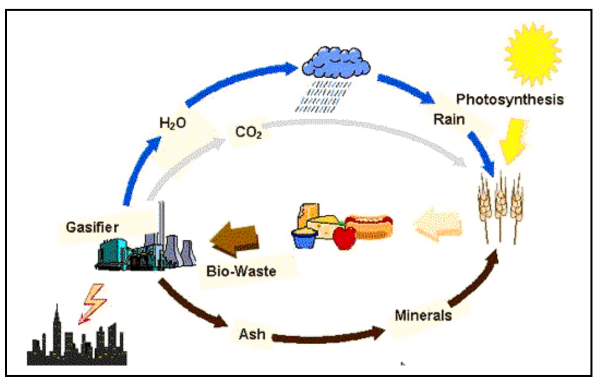


One source of alternative energy is biofuel. Biofuel can be in the form of a solid, liquid or gas and serve as a carbon neutral fuel and energy source that can reduce the world's dependence on petroleum usage and in hand, decrease greenhouse gases in the atmosphere. Biofuel can be produced from any carbon source derived from biological materials (such as photosynthetic plants) and help produce energy without an increase of carbon levels in the atmosphere.

Ethyl alcohol (ethanol) is a common biofuel that is produced from crops that are high in sugar or starch by using yeast fermentation. Another common biofuel is biodiesel, which is processed from crops that are high in vegetable oil with heat and viscosity manipulation.

However, we have to be careful with planting corn and sugar to produce biofuel. The Princeton study points out, clearing previously untouched land to grow biofuel crops releases long-sequestered carbon into the atmosphere. While planting corn and sugar cane in already tilled land is fine, a problem arises when farmers churn up new land to grow more fuel or the food and feed displaced by biofuel crops.

4.2 Biomass

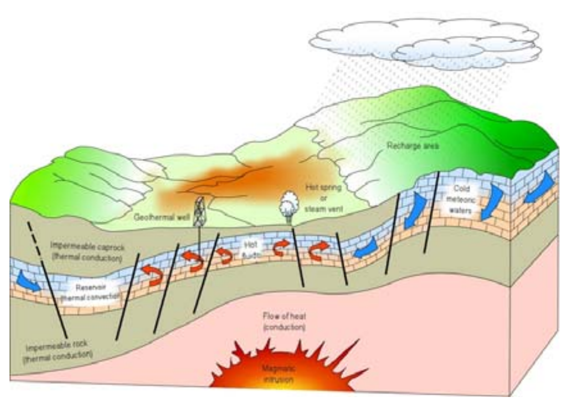


Biomass is an alternative energy source made from living organisms or their by-products based on the concept of the carbon cycle. Upon plant or by-product death or combustion, carbon goes back into the atmosphere in the form of carbon dioxide (CO_2), giving off a relatively stable level of atmospheric carbon as a result of its use as a fuel.

It is when biomass is used as an energy source that it is considered carbon neutral and a reduction of greenhouse gases due to the usage of methane (CH_4) that would have normally gone into the atmosphere. Biomass absorbs CO_2 and its carbon reverts to the atmosphere as a mix of CO_2 and CH_4, which the CH_4 will convert to CO_2 in the atmosphere to complete the carbon cycle.

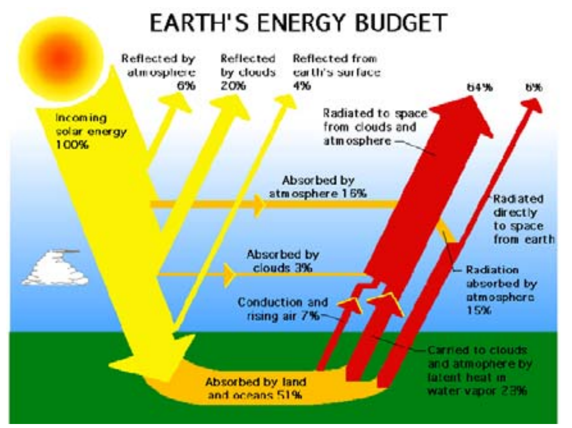
4.3 Geothermal

Geothermal refers to heating and cooling through the usage of water or steam from the Earth's surface. Geothermal heat pumps take advantage of the constant temperature of the earth. During the winter, the ground temperature is warmer than the air, while during the summer, the ground temperature is cooler than the air. Acting as a heat exchanger, a geothermal heat pump then recovers the earth's heat or its cool soil depending on the situation. Geothermal energy is one of the few renewable energies that can supply continuous base load power.

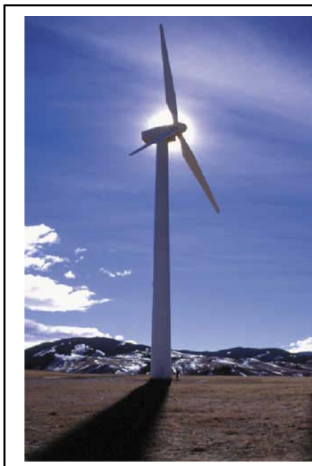


4.4 Solar Energy

Solar energy refers to energy or electricity generated from solar radiation and heat. Solar energy can be harnessed for several different types of use. Natural solar lighting is achieved through the use of windows, light shelves, sky lights and light tubes as well as optical fibers. Solar water heating is achieved through the use of solar collector panels that transfer heat from the sun to the water that runs in the panel veins. Other HVAC applications can use solar heat by storing or transferring heat from the sun in various materials. Electrical generation through the use of photovoltaic solar cells converts light into direct current, effectively collecting sunlight for electricity.



4.5 Wind Energy

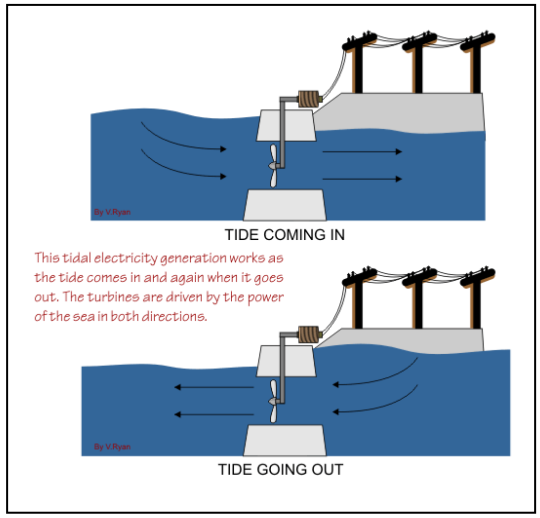


Wind power is the conversion of wind energy into a useful form, such as electricity, using wind turbines.

The principle application of wind power is to generate electricity. Large scale wind farms are connected to electrical grids. Individual turbines can provide electricity to isolated locations. In the case of windmills, wind energy is used directly as mechanical energy for pumping water or grinding grain.

Wind energy is plentiful, renewable, widely distributed, clean, and reduces greenhouse gas emissions when it displaces fossil-fuel-derived electricity.

4.6 Tidal Power

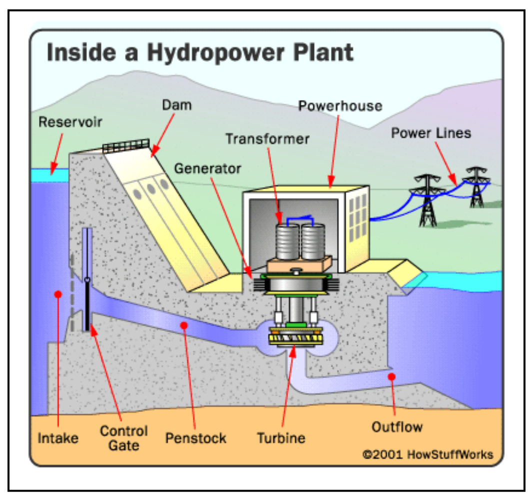


Tidal power, sometimes called tidal energy, is a form of hydropower that converts the energy of tides into electricity or other useful forms of power.
Although not yet widely used, tidal power has potential for future electricity generation. Tides are more predictable than wind energy and solar power.
Tidal power is the only form of energy which derives directly from the relative motions of the Earth-Moon system, and to a lesser extent from the Earth-Sun system. The tidal forces produced by the Moon and Sun, in combination with Earth's rotation, are responsible for the generation of the tides. Other sources of energy originate directly or indirectly from the Sun, including fossil fuels, conventional hydroelectric, wind, biofuels, wave power and solar. Nuclear is derived using radioactive material from the Earth, geothermal power uses the heat of magma below the Earth's crust, which comes from radioactive decay.

4.7 Wave Power

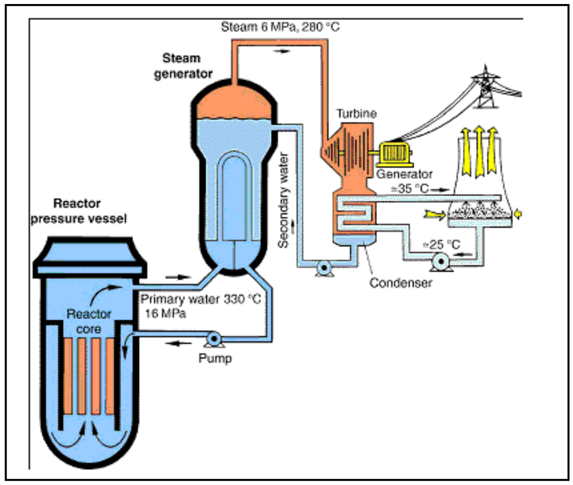
Wave power is the transport of energy by ocean surface waves, and the capture of that energy to do useful work - for example for electricity generation, desalination, or the pumping of water (into reservoirs). Wave power is a renewable energy source.

4.8 Hydro Power



Hydroelectricity is electricity generated by Hydro Power (the production of power through use of the gravitational force of falling or flowing water). It is the most widely used form of renewable energy.
Most hydroelectric power comes from the potential energy of dammed water driving a water turbine and generator. In this case the energy extracted from the water depends on the volume and on the difference in height between the source and the water's outflow. This height difference is called the head. The amount of potential energy in water is proportional to the head. To obtain very high head, water for a hydraulic turbine may be run through a large pipe called a penstock.
Pumped storage hydroelectricity produces electricity to supply high peak demands by moving water between reservoirs at different elevations.

4.9 Nuclear Power



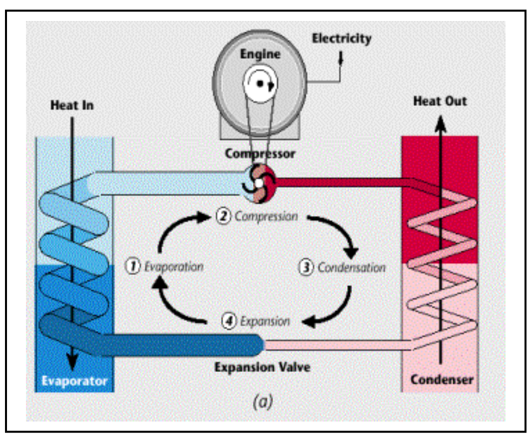
Nuclear power is any nuclear technology designed to extract usable energy from atomic nuclei via controlled nuclear reactions. The most common method today is through nuclear fission, though other methods include nuclear fusion and radioactive decay. All utility-scale reactors heat water to produce steam, which is then converted into mechanical work for the purpose of generating electricity or propulsion. Today, more than 15% of the world's electricity comes from nuclear power, more than 150 nuclear-powered naval vessels have been built, and a few radioisotope rockets have been produced.

Proponents of nuclear energy contend that nuclear power is a sustainable energy source that reduces carbon emissions and increases energy security by decreasing dependence on foreign oil. Proponents also claim that the risks of storing waste are small and can be further reduced by the technology in the new reactors and the operational safety record is already good when compared to the other major kinds of power plants.

Critics believe that nuclear power is a potentially dangerous and declining energy source, with decreasing proportion of nuclear energy in power production, and dispute whether the risks can be reduced through new technology. Critics also point to the problem of storing radioactive waste, the potential for possibly severe radioactive contamination by accident or sabotage, the possibility of nuclear proliferation and the disadvantages of centralized electrical production. Arguments of economics and safety are used by both sides of the debate.

5. Smart Solutions

5.1 Heat Pump

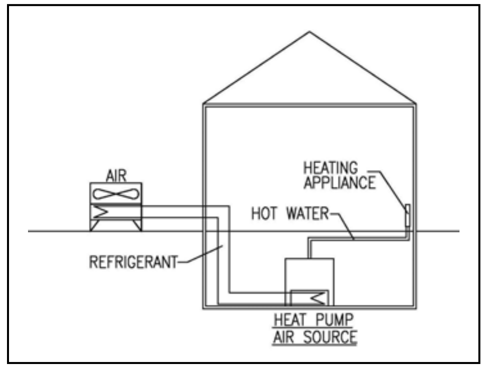


A heat pump is a machine or device that moves heat from one location (the 'source') to another location (the 'sink' or 'heat sink') using the physical concept of mechanical work. Most heat pump technology moves heat from a low temperature heat source to a higher temperature heat sink. Common examples are food refrigerators and freezers, air conditioners, and reversible-cycle heat pumps for providing thermal comfort. Heat pumps can also operate in reverse, producing heat.

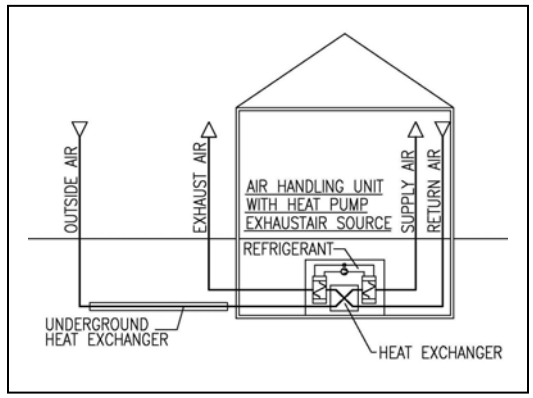
Heat pumps can be thought of as a heat engine which is operating in reverse. One common type of heat pump works by exploiting the physical properties of an evaporating and condensing fluid known as a refrigerant. In heating, ventilation, and cooling (HVAC) applications, a heat pump normally refers to a vapor-compression refrigeration device that includes a reversing valve and optimized heat exchangers so that the direction of heat flow may be reversed. Most commonly, heat pumps draw heat from the air or from the ground.

5.1.1 Air Source Heat Pump

Air source heat pumps are relatively easy (and inexpensive) to install and have therefore historically been the most widely used heat pump type. However, they suffer limitations due to their use of the outside air as a heat source or sink. The higher temperature differential during periods of extreme cold or heat leads to a lower efficiency, as explained above. In mild weather, COP may be around 3.5, while at temperatures below around −5°C (23°F) an air-source heat pump's COP will drop below 2. The average COP over seasonal variation is typically 2.5-3.0.

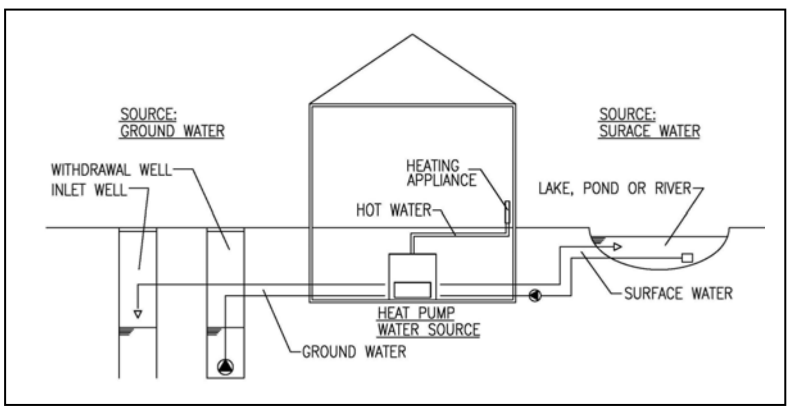


An Exhaust Air Heat Pump makes the COP more efficient. The basic principle behind these Heat Pumps is to reuse the heat in the exhaust air, which would otherwise leave a house, to heat the house and / or provide hot water. So we can use this type of Heat Pump for the system air-air or air-water.
For this solution we need an Underground Heat Exchanger and a Heat Exchanger for heating the Outside Air. Otherwise we take too much energy from the Exhaust Air and then the evaporation coil will freeze.

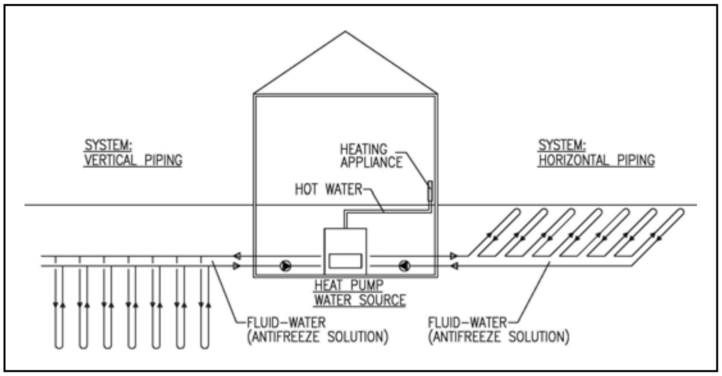


5.1.2 Surface Water / Underground Water Source Heat Pump

This type of system uses water to treat the outdoor coil and water or air is treaded by the indoor coil. There are several sources of water for the outdoor coil. Some of these are wastewater, single or double well, lake, pond or river. These systems are generally referred to as open-loop systems.
These types of heat pump use less electricity than the heat pump with the source air.
The average COP is typically between 3.0-5.0.



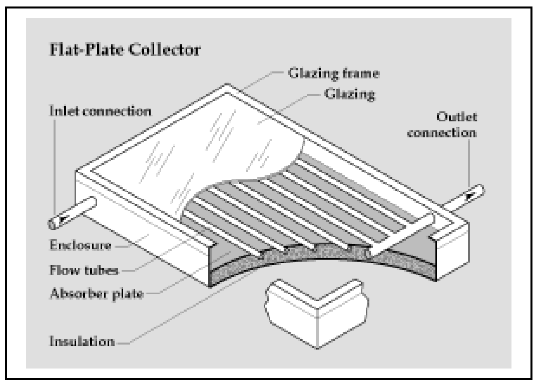
5.1.3 Earth-Coupled Heat Pump



An Earth-Coupled Heat Pump uses that available heat in the winter and puts heat back into the ground in the summer. These systems operate based on the stability of underground temperatures: the ground a few feet below surface has a very stable temperature throughout the whole year.
Earth-Coupled Heat Pump systems use either vertical or horizontal tubing buried in the ground and are referred to as closed-loop systems.
The vertical system is the most popular solution. The water (with antifreeze) is circulated through special piping. For the vertical solution it is possible to have a geothermal report for well field compatibility and information for calculations.
A disadvantage point of the horizontal solution may be a delay of growth from the flora because of lower ground temperature.
The average COP is typically between 4.0 -7.0.

5.2 Direct Solar Energy

5.2.1 Solar Collector Panel

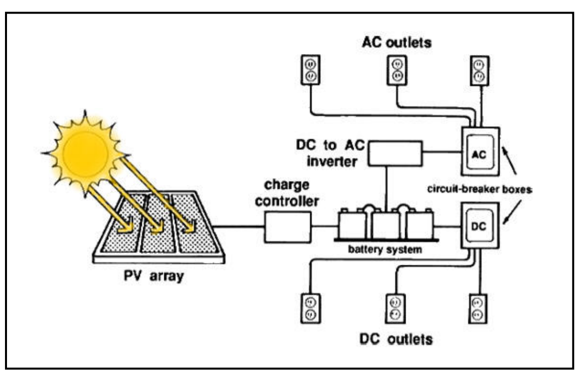


Solar collectors are the key component of active solar-heating systems. Solar collectors gather the sun's energy, transform its radiation into heat, then transfer that heat to water. There are two popular types of solar collectors:

- Flat-plate collectors
- Evacuated-tube collectors

Residential and commercial building applications that require temperatures below 200°F typically use flat-plate collectors, whereas those requiring temperatures higher than 200°F use evacuated-tube collectors.

5.2.2 Photovoltaic



Photovoltaic (PV) systems use solar electric panels to directly convert the sun's energy int electricity. The solar electricity fed through electronic equipment is converted to utility grade electricity for use directly in the home. The solar electricity can be used to offset the need for purchased utility electricity or, if the PV electricity exceeds the home's requirements, the excess electricity can be sent back to the utility, typically for credit.
The efficiency may be between 10% - 20%.

5.3 Wood Burning

Wood Boilers are an excellent use of a renewable energy source. Wood is a form of biomass and is a very efficient fuel.

5.3.1 Wood Pellet

Wood pellets are a type of wood fuel, generally made from compacted sawdust. They are usually produced as a byproduct of sawmilling and other wood transformation activities. The pellets are extremely dense and can be produced with a low humidity content (below 10%) that allows them to be burned with a very high combustion efficiency. Further, their regular geometry and small size allow automatic feeding with very fine calibration. They can be fed to a burner by auger feeding or by pneumatic conveying.
A wood pellet boiler is a fully automatic appliance akin to a gas boiler. Not only is it a very efficient system for a heating and hot water requirements, but it also produces very low emissions. A wood pellet boiler will need cleaning about once a month but is otherwise low maintenance. They are well suited to variable demand and can also be operated on a timer.

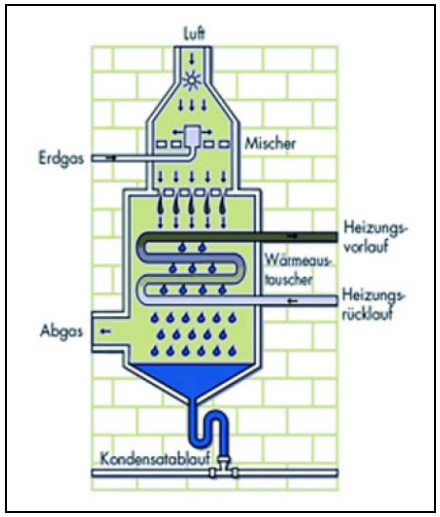
5.3.2 Wood Chips / Log

Woodchips and logs are a solid fuel made from woody biomass. Woodchips are made in the process of woodchipping with a woodchipper. The use of woodchips in automated heating systems, is based on an relatively new technology. Log burning boilers are an older and a mature technology.

6. Other Energy Efficiency Systems

6.1 High Efficiency Condensing Gas Boilers [7]

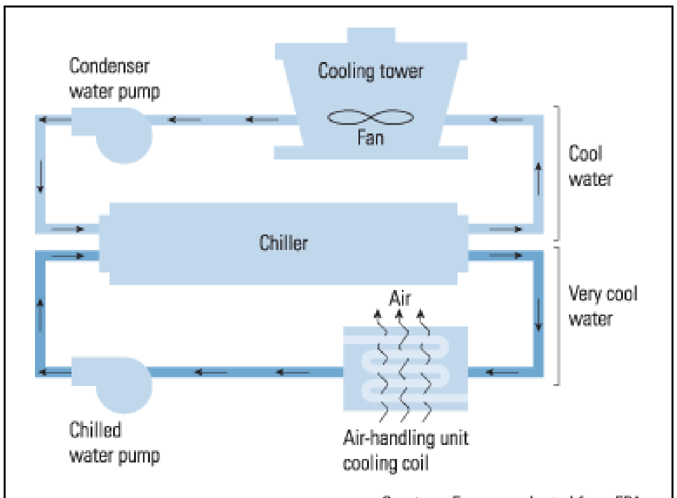
A condensing boiler is a water heating device designed to recover energy normally discharged to the atmosphere through the flue. When a condensing boiler is working at peak efficiency, the water vapor produced by the burning of gas or oil in the boiler condenses back into liquid water - hence the name “condensing boiler.” The boiler uses a heat exchanger so that incoming water cools the exhaust, condensing the vapor to water. This then heats the incoming water (if an air-to-water heat exchanger is used). A small proportion of the extra efficiency of the condensing boiler is due to the cooling of the exhaust gases, but the majority of the energy recovered is from the condensation of the water vapor in the exhaust gases. This releases the latent heat of vaporization of the water – 2260 kJ/kg (970 btu/lb) of condensation (the water vapor released whenever one burns fuels containing hydrogen).



Condensing boiler manufacturers claim that up to 98% thermal efficiency can be achieved compared to 70%-80% with conventional designs (based on the higher heating value of fuels). Typical models offer efficiencies around 90%, which brings most brands of condensing gas boiler in to the highest available categories for energy efficiency.
In North America, they typically receive an Eco Logo and/or Energy Star Certification.
When installed in real houses, the performance of condensing boilers is typically 4-5% lower than in laboratory tests by groups.

6.2 High Efficiency Water Cooled Chillers [8]

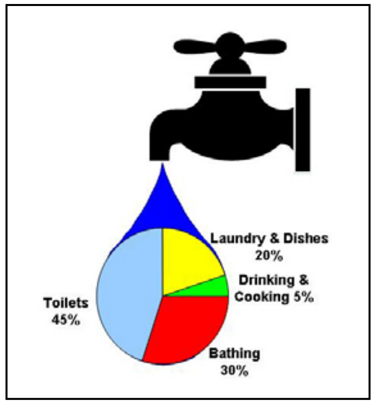
A chiller is a machine that removes heat from a liquid via a vapor-compression or absorption refrigeration cycle.
Water-cooled chillers incorporate the use of cooling towers which improve the chiller’s thermodynamic effectiveness as compared to air-cooled chillers.
Water cooled chillers are typically intended for indoor installation and operation, and are cooled by a separate condenser water loop and connected to outdoor cooling towers to expel heat to the atmosphere. A water cooled chiller makes the machine more than 15% efficient and also allows a significant reduction in the size of the chiller than a traditional air cooled machine.



Courtesy: E SOURCE; adapted from EPA

7. Saving Water

With the expected rise in the population by 50% in the next fifty years water conservation is something we need to start to worry about now. We all know the basics of turning off the water when you are brushing your teeth, take shorter showers, and watering your lawn early in the morning or late at night. But there is more that can be done and it has become a lot more easy to conserve water with new low flow fixtures, and also by collection and storage of rain water.



7.1 Dual-Flash Toilets

Did you know almost half of all water is wasted through old high flow toilets? There are many ways we can fix this problem. The best way to cut back on the water that is wasted is by using dual flush toilets. By using the dual flush system the average toilet can reduce its water usage by over 5,000gal per year. These fixtures look the same as your standard toilet but you have the option to use more or less water depending on what needs to be flushed down the system. For flushing of solids the system does a full flush using 1.6gal, and for liquids it only uses 0.8gal. These toilets are great for home and commercial use but would not be recommended for educational use. In schools where fixtures have to be able to stand up to the high usage and also be solid enough to handle any abuse, low flow fixtures are recommended. These toilets use only 1.6gal per flush compared to older 3.5gal per flush toilets. Just by switching to these low flow toilets we are saving over half of the water that use to be consumed by high flow toilets.

7.2 Waterless Urinal

Your standard urinal uses 1gal per flush. With the latest design and advancements in plumbing manufactures have come up with ways to now completely eliminate the use of water and have designed waterless urinals. This will truly help to conserve water in the future but as of now the design hasn't been updated enough for most building to install these. As of now the biggest complaint from the consumers is the odor left behind with these fixtures. Due to this many that have been installed have been removed and replaced by standard urinals until this technology has been updated.

7.3 Low-Flow Showers

High Performance Green Shower Heads with Ultra Low Flow. These Ultility Savers Showerheads need only 1.0 to 1.5 GPM.
Aerating - mixes air into the water stream. This maintains steady pressure so the flow has an even, full shower spray. Because air is mixed in with the water, the water temperature can cool down a bit towards the floor of the shower. Aerating shower heads are the most popular type of low-flow shower head.

7.4 Electronic Sensored Faucet

When you walk in to a public restroom the first thing everyone always see's is a leaking/dripping faucet. This is a definite waste of water that everyone has seen or experienced. The other normal think we see is where people just leave the water running. With your standard faucet when left running we are wasting between 2-3gal per minute. This is a complete waste of water that is no longer a problem. Thanks to the design of electronic sensor operated faucets, these faucets have become very popular these days in many commercial and educational projects. These faucets save water by setting a timer for how long the water will run before shutting its self off. These faucets are normally set to run for 30-45sec which will cut the normal water usage in half.

7.5 Gray Water System

Anywhere from 50-75% of the water that is wasted could be re-collected and re-used in a gray water system. A gray water system takes all water from sinks, lavatories, showers, and laundry for its re-use of this water for toilets so that water is used to its full potential prior to being send to the main sanitary system. This gray water could also be used for site irrigation and or plant watering.

7.6 Rain Water System

Did you know you can actually get some of the water you use for free? Well it's true. By harvesting rain water you can cut back on your water demand for any project. One of the major uses for harvesting rain water is for irrigation around the project site. But this water is also able to be used just like the gray water so it could also be used for use in toilets and urinals.

8. Reference:

[1] + [2] "The sustainable Scale Project"; www.sustainablescale.org

[2] "The sustainable Scale Project"; www.sustainablescale.org

[3] "World Bank, online database, 2004"

[4] "US Energy Information Administration"; www.eia.doe.gov

[5] Ashrae; 2005 FUNDAMENTALS; Chapter 28 – 30

[6], [7], [8] Wikipedia; www.wikipedia.org