Solar Thermal Systems

A new way of looking at energy.

RABCO SOLUTIONS

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Our effect on our world…

Winston Churchill once said, “We shape our dwellings and afterwards our dwellings shape our lives.” As humans, we tend to stay within a conduit, constructing, extending, and continuing the same practices that history has dealt us until something gives us reason to change. It can’t just be a reason of convenience or a simple distraction, but something that threatens the very path beneath our feet. The trend toward urban development has been increasing steadily throughout history, and this trend is affecting the climate around the world. As the climate is affected, the need to cool or heat our dwellings and buildings is also affected. This has caused a vicious cycle that must be altered if we are to control our energy future.

The wealthiest cities and urban areas on Earth consume a disproportionate amount of the world’s energy supply. An urban dweller in New York consumes approximately three times more water, and generates eight times more trash, than does a resident in Mumbai, India. The massive demand for energy in wealthy cities contributes a major share of the greenhouse gas emissions that fuel global warming. The number of urban dwellers around the world rose from 600 million in 1950, to 2 billion in 1986, and another 700 million migrated to urban development in the last decade of the 20th century. If these trends continue, more than half of the world’s population will live in urban areas by 2010. In the U.S., approximately 90% of the population is now considered urban dwellers.

Another effect on energy consumption in the U.S. is the increase of space requirements per person in our homes. Between the 1950 and 1990, the foor space requirement per person doubled. With the increase in space requirements, comes an increase in energy consumption per person. More heating and cooling is required per person as a result, which, again, adds to the environmental urban effect causing urban areas to be hotter in the summer and more polluted in the winter than in surrounding rural areas.

Increased urbanization and industrialization have caused the urban environment to deteriorate. The size of housing plots has been reduced, thus increasing both living and traffc densities. By increasing the number of buildings, we also crowd out vegetation and trees. It has been reported that New York City has lost 175,000 trees or 20% of its urban forest in the last ten years alone.

Building density and loss of vegetation creates a heat imbalance. Air temperatures in densely-built urban areas are higher than surrounding rural areas. This phenomenon is known as the ‘Heat Island’ effect and is caused by many factors related to the increased and concentrated use of energy The effect of buildings on airfow patterns is called the canyon effect. It is a concentration of greenhouse gases, plus the thermal properties of materials used in construction, and many more factors that add to this growing concern. Extensive studies of the heat-island intensity have shown that the temperatures are between 5° to 12°F higher worldwide than in surrounding rural areas. Peak electricity load will increase 1.5% to 2.0% for every 1° F increase in temperature. The heat-island effect alone can account for more than $1 billion a year in increased power consumption, and as urban areas grow in density and footprint (size), the effect will also increase.

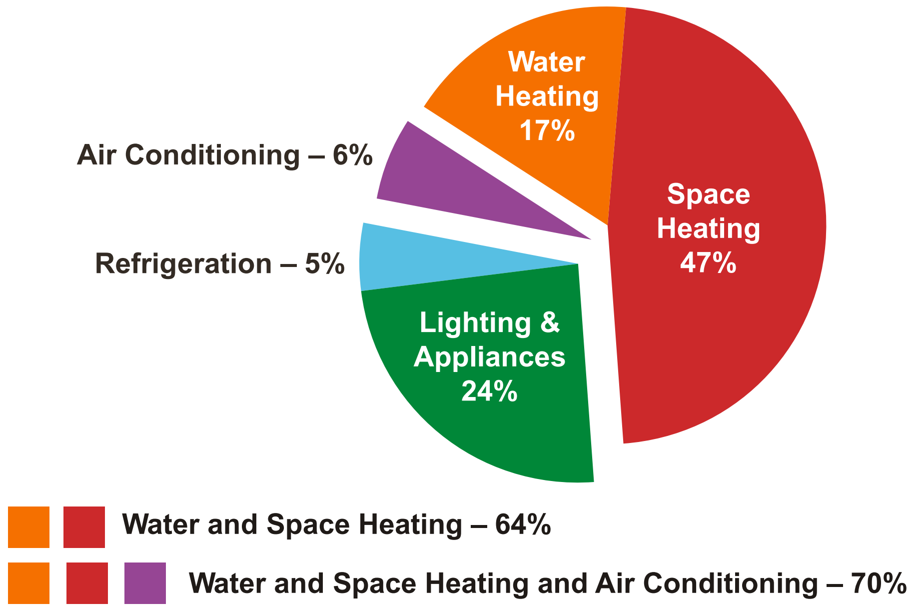
Buildings in U.S. cities consume close to 700 Million Tons of Oil Equivalent (MTOE) per year. One MTOE represents 7.4 million barrels of oil, or 42 gigajoules of electrical energy, and represents a cost of approximately $400 trillion dollars per year. Buildings account for approximately 40% of energy consumption in the U.S. and for 18% of all CO_2 emissions, as well as 7.5% of Chlorofuorocarbons (CFCs – another compound implicated in the accelerated depletion of the ozone layer).

Most of the energy spent in the U.S. is for space heating: 46% of the total energy consumption for residential buildings and 55% for commercial and offce buildings. Water heating represents 17% of all energy consumption within the U.S.; and cooling represents approximately 6% of all energy consumed in the U.S.

According to the department of Energy, by averaging domestic and commercial consumption; heating, cooling, and heating water consumes 74% of total energy used in the U.S. each year. The vast majority of this energy is produced by burning fossil fuels (oil and coal), production of electricity through nuclear power plants, and the burning of gas reserves – all of which either add to the greenhouse effect or create other environmental concerns.

Another major factor and widely unknown outside the energy sector is that we lose 7 to 10% of electrical power produced in the transportation of the electric through grid loss. This does not take into account power lost during production and other ineffciencies throughout the system. It has been estimated that only 35% to 45% of electricity that is created in a power plant actually reaches the customer. Our dependency on foreign oil has created a national security threat and also threatens our economy as energy prices eat into the production and transportation cost of virtually every product and service we use or consume.

Energy Use By Sector



There is a better way…

"Solar energy is the light and radiant heat from the sun that infuences Earth's climate and weather and sustains life. Solar power is sometimes used as a synonym for solar energy or more specifcally to refer to electricity generated from solar radiation." – Source: Wikipedia

This statement is misleading, but an important insight to the way we think in the U.S. and how we approach problems and resolve issues in this arena. In the U.S., we tend to mentally attach measurements to items or products that interfere with problem solving. For example, when I say gallon, you might automatically think of milk, water or gasoline, but what you should think of is 128 ounces.

When I say Kilowatt, most would associate this with electricity automatically when they should think power (energy in general). We have too many ways to measure things: inches, miles, yards, ounces, watts, gallons, pounds, feet, horsepower, inches, tons, and so forth. None of these measurements are easily connected or converted to one another, and are used in most industries here, which in turn enter our learning of these industries and shapes the future problem solving and approaches to new technologies.

In Germany, as well as the rest of Europe and Asia, the metric system is used. Mercedes, a world leader in the auto industry reports for their customers in Germany, the power produced by their cars in Kilowatts, not horsepower. A Kilowatt is 1,000 watts, and a watt is defned as the rate at which work is done when an object is moving at one meter per second against a force of one newton.

To German's, power is power. This might seem a trivial point, but take a look at the Wikipedia defnition of solar energy again. Solar power is not a synonym for electricity generated by solar radiation; solar energy is simply solar power, or Kilowatts of power. The Earth receives, in solar energy each hour, 1.740x1017 Watts. In other words, a lot. Depending on where you are on the Earth's surface, and assuming areas in which 90% plus of people on the Earth live, you will receive approximately 600 to 1,000 watts per square meter. Even on a cloudy day, about 75% of this power hits the Earth's surface.

We need to begin thinking of Solar Energy in the form of Power, not in the form of electricity. This will help us grasp the true potential of all alternative sources of energy more easily.

The vast majority of energy that comes from the sun is thermal, not proton energy (proton energy is converted to electricity using photovoltaic panels). But thermal energy should be our focus for the future as detailed further in this paper. Also remember that 65% of all electricity produced in the U.S. is lost as it travels through the grid and never reaches any consumer. We will compare the two types of alternative energy, photovoltaic and solar thermal, and you be the judge to which is a real solution.

Harnessing Solar Energy with Alternative Energy Technologies

With the use of photovoltaic solar cells or PV, sunlight can be converted to electricity. Unfortunately, only about 7% to 15% of the energy hitting a PV cell can be converted to watts or energy. This is the cell's effciency. This means that, at best, a PV cell can produce approximately 70 to 150 watts per square meter. The current average cost per watt using PV is as low as $6 per watt, but this does not include control and support systems, which when included will increase the cost per watt between $9 to $12 per watt.

Effciency goals for the PV industry have been projected to reach 42% by 2015. To obtain this goal, an increase in technology, such as tracking systems, will drive up the complexity and cost of the support systems, which in turn will keep cost per watt high. Mass production and new approaches coupled with new technologies are the best hope to make PV a real viable solution.

Another problem with PV is the footprint of the solar array. For every 1KWh (1,000 watts used in one hour) consumed in a home or business over a 24 hour day, the system needs to produce and store 24Kw of power (1Kw x 24 hours). Solar, of course, is only power producing during daylight hours, so you must produce enough power during the daytime production hours for use in the daytime, plus an additional amount to store for nighttime use. Production time of the array can vary depending on where it is installed geographically, but rule of thumb is between 4 and 8 hours. If you assume the average of 6 hours, a PV array must produce 4Kw per hour to handle each 1kw load over a 24-hour period (4Kw x 6 hours = 24Kw). Assuming an 110w per square meter average, this means that the PV solar array footprint would need to be 218 square meters or 2,181 square feet. This is almost twice the size of a standard American roof (1,200 square feet) and would cost $28,000 ($7 per watt x 4,000 watts on the array).

Since businesses generally consume even more power, this example gets even more impractical. If you look at the idea of very large PV arrays in the desserts of the Southwest or California, again remember that no matter if you take today's 12% to 18% effcient solar collectors and you ignore the price per watt for construction, you will lose 10% of the electricity that is produced in transmission.

Net…Net…Net, the consumer will see at best 4% to 8% of the power generated. Simply put, photovoltaic panel arrays do not produce enough energy to be economically viable and the footprint is too large for onsite production that works. Average return on investment with a PV solar installation on a home or business exceeds 30 years, with no real reduction in power production. Building large solar PV power plants is extremely expensive and, again remember, that 10% power loss of the grid for distribution to customers.

Solar thermal energy (STE) is a technology for harnessing solar energy to create thermal energy. This energy can be used for space-heating, heating water and through the use of absorption chillers, cooling – air conditioning buildings and homes.

These three categories of energy consumption make up 74% of the total energy consumption in the U.S. Unlike PV, Thermal Solar collectors are very effcient. Solar thermal systems, on average, are 92% effcienct, compared to the 12% seen in PV arrays. After taking into account system loss, Thermal Solar arrays produce 750 to 950 watts per square meter, ten times more per square meter than PV arrays.

Historical costs of solar thermal systems from the power industry, including all three power sectors – heating, cooling, and water heating – on average cost one-tenth the price of a photovoltaic system. When looking at cost per watt, remember that PV is $7 to $12 per watt. The cost of a nuclear power plant is $3.50 per watt.

A thermal solar system designed by Arctic Solar on average is as follows:

- For heating water, which makes up 17% of all energy consumed in the U.S., costs $0.30 per watt;

- For space heating, which makes up 46% of all energy consumed in the U.S., costs are $1.25 per watt; and
- For solar cooling or air conditioning, which makes up 6% of all energy consumed in the US, costs are $2.75 per watt.

At these costs, real power savings can be achieved. These systems are easy to install and have a 25 year life span. So in looking at our 24Kwh home used in the example above for PV, in a 6 hour solar day, a solar thermal system (800 watts per square meter) would need to be 5 square meters in size (800watts x 5 = 4000 watts per hour), (4000w x 6 hours = 24kwh). Compared with the 218 square meters of PV, there simply is no comparison. 5 square meters is 50 square feet and would easily ft on any standard 1,200 square foot U.S. roof.

Given that the Solar Thermal array produces more than 10 times the power, it can be many times smaller to produce the same power output of a PV array. We must begin thinking power, not electricity. Do we care how the water is heated? Or how the air that comes out of our vents is cooled or heated? No, we should only care in terms of costs and how it affects the environment.

Solar thermal has many more advantages. Not only is it taking the most abundant type of energy that we have from the sun (thermal), but it is also, when installed on a building or home, acts as a solar/thermal blanket, or sponge, that absorbs the thermal heat that would otherwise hit the roof of a the structure. This shading effect reduces the load of a structure and, therefore, reduces the cooling requirements for that structure. Estimates are that between 10% to 15% of the air conditioning load is reduced when a thermal solar collector is intalled on the roof of building because of the absorption of heat by the array that would otherwise be applied to the structure during daytime hours.

These systems have been, for the most part, forgotten by the main stream alternative energy sector whose sole focus is the production of electricity. The focus on semiconductor or PV and bio-technologies has given little time and development for thermal systems. It has created a welfare sector that can only survive with government grants or corporate donations – mainly because their products are not commercially viable. Arctic Solar believes that true gains in energy independence can only be realized by the use of thermal solar systems.

PV is too expensive and requires too much space or footprint to be practical in today's economy. We continue to try and drive a square peg in a round hole by our focus on electricity and oil to handle our energy needs. Remember, it is not important how the hot air for heating arrives, or the cold air for cooling arrives, or how hot water is obtained for our homes and businesses; it is the cost and effect on our planet which is important.

The real importance is that we reduce energy requirements that come from fossil fuels and non-replenishable resources. What we should focus on is the real and practical ways of achieving alternative energy goals by following a technology that can deliver today, not maybe in year 2015. PV has a place in alternative energy planning and the research should be continued, but not at the expense of today's energy needs or our climate for the next six years.

Out of 100% of the thermal solar systems installed over the past three years, which constitutes hundreds of thousands of systems worldwide, only 0.004% were installed in the U.S. — less than one half of one percent. The rest of the world is leaping ahead and harnessing the sun in cost effcient ways while we focus on a technology whose goal is still to be cost ineffcient in 2015. As in light-rail systems or mass transit, the U.S. is missing the goal as the world builds bigger and better transportation systems. Take a look at what is happening around the world in thermal solar.

Odeillo in the Pyrenees of France

A solar furnace is a structure used to harness the rays of the sun in order to produce high temperatures, usually for industry. This is achieved using a curved mirror (or an array of mirrors) that acts as a parabolic refector, concentrating light (Insolation) onto a focal point. The temperature at the focal point may reach 3,000° C (5,430° F), and this heat can be used to generate electricity, melt steel, or make hydrogen fuel.

The term “solar furnace” has also evolved to refer to solar concentrator heating systems using parabolic mirrors or heliostats where 538° C (1,000° F) is now commonly achieved. The largest solar furnace in the world is at Odeillo in the Pyrenees of France, opened in 1970. It employs an array of plane mirrors to gather the rays of light from the sun, refecting them on to a larger curved mirror. The rays are then focused onto an area the size of a cooking pot and can reach 3,000° C (5,430° F). In the deserts of the Southwest and in Florida and California, such furnaces could be used to drive steam turbines to create the electricity to add to the grid.

Madrid Spain, solar tower could eventually power an entire city

Recently we witnessed a gigantic skyscraper/solar tower hybrid that generates a whopping 390-kilowatts of energy, but even that looks like child’s play compared to the 40-story solar power plant that resides in Spain. The expansive system consists of a towering concrete building, a feld of 600 (and growing) sun-tracking mirrors that are each 120-square meters in size, and a receiver that converts concentrated solar energy from the heliostats into steam that eventually drives the turbines. Currently, only one feld of mirrors is up and running, but even that produces enough power to energize 6,000 homes or 11 megawatts, and when the reactor is fully operational, the creators are hoping to see the entire population of Seville (population: 600,000) taken care of solely from sunlight. This is truly the greenest power plant on Earth.

Imagine multiple solar towers in the deserts of the Southwest or in California, in the vacant areas of the swamps of Florida or the plains of Texas. All of these plants feeding pure, green electricity to the power grid while thermal solar tubes are being installed directly onto buildings and homes to reduce power draw from the grid.

Solar Heat Neckarsulm, Germany (Community Solar Engineering)

Since the beginning of the 1990s, the solar heating market in urban areas of Europe has been constantly growing, thanks mostly to large improvements in the quality and effciency of the equipment available, as well as to the support policies that many countries are copying from Greece, Germany, and Austria. Subsequently, in the city of Neckarsulm (Baden-Württemberg), a new concept in heat procurement, based on distribution networks powered by solar energy, has been developed for the residential neighborhoods, Amorbach.

THE CITY

Situated along the banks of the Neckar River, among forest and vineyards, the city of Neckarsulm is the main city in Baden-Württemberg's Heilbronn district, with 27,000 inhabitants. The arrival of the railway (1866) and the creation of a river port (1867) developed industrial activities (spinning, shipyards, production of pistons and two-wheelers) and economic growth in the city during the 20th century. Along with world-renowned industries such as Audi and Kolbenschmidt, many small and middle-sized companies were set up employing more than 20,000 people.

CONTEXT

Convinced that it is impossible to reach holistic goals (such as reducing CO_2 emissions) without a strong commitment by the various players on a local level, at the end of the 1980s Neckarsulm Town Hall committed to a widespread campaign to promote and raise awareness of solar energy. Since July 1996, Neckarsulm has been offering fnancing to individuals who wish to invest in photovoltaic and solar heat facilities. This aid program was extended in February 2000 and now supports all measures aiming to improve energy effciency in buildings – installing insulation and double glazing windows, as well as heat pumps or biomass boilers.

Note also: Since September 1999, owners of electric vehicles can recharge their batteries for free at the frst solar public service station in Germany. Eight photovoltaic panels produce the electricity, which also powers the Stadtwerke buildings outside charging periods (2 to 3 hours per vehicle). The municipality and the Stadtwerke fnanced the 20,450€ investment for 50% each.

THE NECKARSULM EXPERIENCE

In 1992, faced with a growing demand for housing, the municipality decided to enlarge the Amorbach district with a 51 hectare housing development, which would eventually house an extra 4,000 people in single-family homes or apartment blocks. Apart from the efforts made with respect to urban ecology, the new quarter was to provide the ideal site for experimenting and demonstrating a new concept in energy supply based on heating networks powered by solar energy. The project started in 1995 to connect 115 homes to the solar energy system with an estimated 800 homes by 2010, and is currently supplying 50% of the energy in the built out area.

There are many cities and urban areas throughout Europe and China that install solar systems each year. 75% of all current installations in thermal solar is in China and they are now the world leader in production of the technology. It is the easiest and quickest way to supply a larger percentage of environmentally friendly energy that works within an economic model.

Thermal Solar works, and more importantly it works now! Arctic Solar, through design and partnerships throughout the world, has lowered the cost and improved the effciency of thermal systems to a point that it is practical and cost effective today.

Going green, at this point in time, often means saying that I spent more money than I will effectively save, but I am helping the environment and reducing dependency on fossil fuels. With Arctic Solar, we can say going green not only helps the environment and gives us a reduction of fossil fuel use, but saves real money now and is economically justifable. It works on a building, school, hospital, hotel, home, etc. – anything that has a roof or a space that has sky above it. Solar thermal not only works in sunny California, but also in wintery Chicago. It simply works and it works today.

Pictures of Solar Thermal Installations


70% Cloud 130F Water