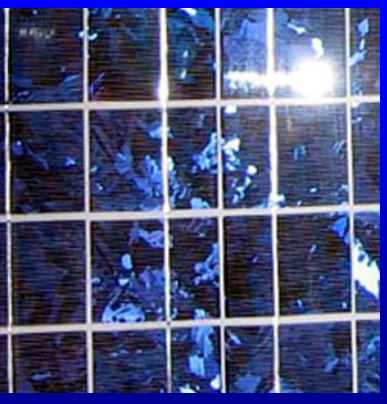
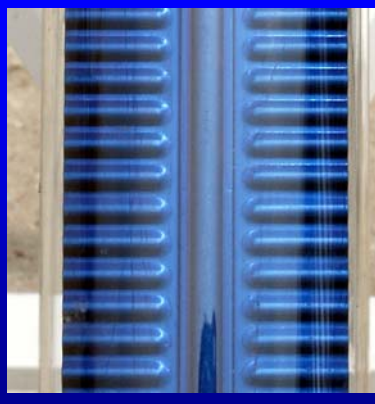
Renewable Energy in Development

Making The Case For Solar Energy In China



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Introduction

This guide is for anyone with an interest in learning about how renewable energy technologies, particularly solar energy, can be designed, supported, and implemented in order to address the pressing challenges of energy supply and demand.

Readers with little to no background in energy or solar technology should be able to grasp the basic principles by the time they finish reading this guide.

The specific focus on the People's Republic of China is to help policy-makers, funding institutions, public interest organizations and the private sector better understand the country's potential for solar energy development. While China's per capita demand for energy may remain low, with a growing population of approximately 1.4 billion people China may quickly become the world's largest gross energy consumer, requiring more innovative and effective energy solutions.

For Policy Makers

…this guide can provide a new way of understanding and examining energy demand and supply. Policies supporting the growth of renewable energy alternatives are still very important for nurturing their development and proliferation in society and the market.

For Funding Institutions

…this guide can clarify the potential impacts and explain the mechanics of projects seeking to implement renewable energy solutions. Better understanding the basics about renewable energy technology and its benefits will hopefully give rise to renewable energy projects receiving greater funding priority by institutions.

For Public Interest Organizations

…this guide can help these groups adapt renewable energy solutions to their existing or new programs and lobby funding institutions for the support necessary to make positive changes in real lives. There are thousands of small public interest organizations, NGOs, non-profits, and civil society groups around the world already helping communities reap the benefits of small- to medium- scale renewable energy solutions. There are also thousands more who can learn about and find ways to adopt these methods to help the communities they serve.

For The Private Sector.

…this guide should help companies already involved or seeking to be involved in renewable energy solutions think about the needs and requirements in underserved lower-income areas and countries. One of the most exciting changes in the renewable energy sector is the development of increasingly appropriate technologies for developing countries. Previously, renewable energy had been tagged as a high-tech, high-cost approach for high-income markets. With China and other developing nations increasing demand and supply for domestic markets, the private sector must re-think the way the renewable energy market is shaped.

Rethinking Energy

We need to change the way we think about energy. We too often think about ourselves as energy consumers. In reality, we are energy wasters.

"We too often think about ourselves as energy consumers. In reality, we are energy wasters."

Developed nations have the most intense energy demand and supply and have become the model for modern energy systems worldwide. The amount of energy being consumed by developing nations is growing rapidly and is following the model of developed nations. The problem is that the model is flawed.

The overwhelming majority of our energy comes from burning things. And the majority of what we find ourselves burning we can never use again nor replenish. Most of our energy sources come in the form of nonrenewable fossil fuels such as coal, natural gas, and oil. Most wood that is burned for energy is not done so in a sustainable fashion.

"Like eating a balanced diet, we should depend on a combination of nonrenewable and renewable sources to produce the most efficient, healthy and cost-effective energy supply."

We are burning up our nonrenewable fossil fuel resources inefficiently and at an unnecessary rate. We burn fossil fuels at a rate about 100,000 times faster than they are formed. The most efficient car engine wastes at least 1/3rd of the energy it produces. To get electricity from the power plant to homes and buildings requires transmission over long distances taking up energy in the process. Anytime we consume energy there is a large portion that is wasted or lost.

Another example is when we burn precious natural resources to create heat. This heat is used to make electricity in power plants in amounts more than we consume so as to be able to transport it to the places we want. When it gets there, we turn it back into heat. We lose and waste energy at every step of the process.

We have an over-reliance on mass-produced electricity as a main form of energy. We use electricity for applications that have more efficient and sustainable alternatives. Large-scale electricity grids provide convenience, but at an economic and environmental cost.

Rethinking Energy Solutions

All energy sources have advantages and disadvantages. Instead of seeking one solution to solve all of our energy needs, it is more advantageous to identify a combination of approaches for supplying and conserving the energy we use.

Like eating a balanced diet, we should depend on a combination of nonrenewable and renewable sources to produce the most efficient, healthy and cost-effective energy supply.

It is not necessary to separate our entire living or working environment from traditional energy systems, but it is possible to reduce the energy we draw from nonrenewable sources by a

significant amount and replace it with energy from renewable sources.

For example, pairing an electric or gas-fired water heater with a solar water heater can greatly reduce the amount of energy needed by providing water that has been partly heated by free energy from the sun!

Likewise, too many homes and buildings are designed as to be neither cool in the summer nor warm in the winter, requiring both heating and air conditioning in one calendar year. If not designed for both, they could at least be designed for one or the other. There are many proven and traditional "passive" building designs that utilize the free abundant energy available from the environment. Like the increasingly popular hybrid designed cars, systems that combine traditional energy systems with renewable solar, wind or hydropower energy sources can greatly reduce overall energy costs and consumption.

Innovative energy solutions first require a better understanding of the different types of energy demands and choices available.

Renewable Energy in Development

There is an increasing use and growing potential for renewable energy in rural and developing areas of the world. This is shaping the new generation of renewable energy technologies and changing the nature of renewable energy use.

Renewable energy technology manufactured for consumers in highly developed nations has traditionally been costly. The designs have high levels of efficiency, but are not cost-effective for many parts of the world. This has contributed to the widespread notion that renewable energy is not cost-effective and inappropriate for many applications. With communities in developing nations now making up a greater portion of the demand for renewable energy, new designs that are more cost-effective and appropriate are entering markets. There are many areas in developing nations with modest local markets for affordably priced and reliable renewable energy technology. Thus, renewable energy to assist in meeting development needs is a growing frontier for the renewable energy sector.

"Renewable energy technology manufactured for consumers in highly developed nations has traditionally been costly."

International organizations, public interest organizations, governments and even the private sector are witnessing the growing potential for renewable energy to address economic, environmental and social challenges in development. However, the overall support for, awareness of and implementation of renewable energy solutions is occurring at far too slow a pace.

Role of Public Participation

Effectively utilizing renewable energy sources requires including local communities in the processes of decision-making, planning, implementation, maintenance and long-term management. Because each renewable energy system must be tailored to the natural resources available in the local area and must try to meet the specific needs of each consumer group, the level of participation and investment by communities must be greater than with nonrenewable energy systems. But, the savings and benefits can also be greater.

Communities must also have a greater awareness of how their energy supply systems work, how much energy they can produce, how to properly use them and what to do in case of problems or breakdowns. In many cases, end users become owners of their energy supply creating better stewardship. This process powers and empowers the end users, making them more knowledgeable and in control of their energy demand and supply.

In contrast, the introduction of traditional energy sources is often a top-down decision involving only a few high-level government and private sector representatives. It usually requires very little consideration for the local users and is rarely tailored any differently to needs or circumstances of one set of users compared to another. In traditional energy systems, end users are seen primarily as customers who are charged for service. In remote or rural areas with limited profit potential this

often results in bad service and poor responsiveness to community needs.

While public interest organizations are not always the primary actors in developing renewable energy technology, they are often the initial implementers and field-testers of new technology via small-scale pilot projects and initiatives. This affords them a key role in advancing renewable energy technology from drawing boards and prototypes to real-world implementation, adoption, and proliferation. Public interest organizations are also uniquely positioned to draw upon funding available for development not generally directly available to the private sector. This is important because these funds and pilot projects can act as catalysts for introducing renewable energy technologies to local markets. Most importantly, many public interest organizations working in renewable energy are intensely fixed on bringing into balance comprehensive and sustainable economic, environmental and social goals.

Due to increasing international attention on China's environment, Chinese environmental organizations are receiving increased support and resources making it possible for them to introduce new renewable energy projects and technology at the local level. This is done outside the bureaucracy of government and the profit seeking objectives of the private sector. The best projects involving local communities seek to integrate positive impacts on the economic livelihoods, environmental conditions, and cultural traditions of their participants.

Organizations involved in helping poor and rural populations are now seeking to integrate sustainable energy technology as a part of their projects. Cleaner renewable energy technology can reduce human health hazards from conditions such as indoor air pollution. Chinese organizations are on the front line of developing tailored applications of sustainable energy technology for the most numerous and needy of household consumers. Their success and innovations could provide renewable energy alternatives that will become beneficial to communities around the world.

The Benefits of Renewable Energy Solutions in Development

Renewable Energy Solutions (RES) often provide the best way to address energy needs in rural or developing regions.

The benefits of Renewable Energy Solutions in rural or developing areas include:

- **RES** take advantage of existing and locally available energy resources;
- **RES** are tailored to meet the specific energy needs of the local users;
- **RES** when properly installed are reliable and durable;
- **RES** do not introduce environmental degradation or pollution;
- **RES** can develop local capacity for maintenance and management;
- **RES** are often cost-effective and affordable compared to other options;
- **RES** can be designed and implemented quickly;
- **RES** are sometimes the only viable solution for remote areas;
- **RES** do not rely on the costly import of fuel from outside areas; and
- **RES** reduce greenhouse gas emissions and minimize other contributions to global warming.

There are also disadvantages associated with RES, some of them include:

- Sometimes equal or greater initial costs at start-up;
- Variability in energy supply due to fluctuations in environmental conditions;
- Energy storage;
- Requires educating end users about new technologies; and
- Potential system breakdown if not properly maintained or installed.

Renewable energy options are often referred to as alternative energy sources – this is because of conscious choices in the past by industry and government to develop fossil fuel

How Renewable Energy can help achieve the Millennium Development Goals		
Millennium Development Goals		Impacts of Renewable Energy
Goal 1	Eradicate extreme poverty and hunger	Renewable energy helps people light their homes, increasing economic productivity. Indoor lighting can encourage micro enterprise and other business ventures. Using solar water pumps can free time from water collection, increasing productivity in other areas. Clean energy can also facilitate irrigation, increasing agricultural productivity and decreasing hunger.
Goal 2	Achieve universal primary education	Renewable energy increases access to education and communications materials. Lighting in schools facilitates education and allows for night classes. Clean energy can help heat or cool schools making it easier and safer to educate students.
Goal 3	Promote gender equality and empower women	Using solar energy to facilitate water collection can free time for women to undertake other activities. Having indoor lighting can allow women to study at home and can facilitate women starting micro enterprises in their homes.
Goal 4	Reduce child mortality	Renewable energy can make it easier to cook food, increase access to clean water, and reduce indoor and outdoor air pollution. All of these improvements can vastly improve health in young children. Clean energy is also vital for rural health clinics and can also increase access to vaccines and other medicines important for children.
Goal 5	Improve maternal health	Clean energy makes homes healthier, with clean water, cooked food, and lower air pollution, keeping mothers healthier while they are pregnant or have young children. Electricity can also increase access to medical services, including maternity care.
Goal 6	Combat HIV/AIDS, malaria and other diseases	Renewable energy can improve medical facilities and access to medicine, especially by providing critical refrigeration of vaccines. By enabling better communication through radio, television, and computers, clean energy can also facilitate education about AIDS and ways to prevent it.
Goal 7	Ensure environmental sustainability	Renewable energy can be used for cooking and to pump and purify water without contributing to air pollution. Renewable energy will reduce the negative impacts of the use of traditional sources of energy, like wood, which leads to erosion, reduced soil quality, and desertification. Renewable energy also reduces global carbon emissions, lessening the impacts of climate change.
Goal 8	A global partnership for development	Clean energy can facilitate communication, education, and job creation.

(Text modified from, "Power Failure" published by Friends of the Earth, October 2005.)

burning technologies for mainstream use. Even with only a fraction of the overall investment of fossil fuel burning technologies, renewable energy technologies are proving themselves as viable substitutes or supplements.

The current economically feasible and widely utilized forms of renewable energy around the world are: solar, wind power, hydropower, biogas and biomass. Other forms of renewable energy that are also found include geothermal and tidal power.

Types of Renewable Energy Sources

What makes energy sources renewable is the simple fact that, unlike fossil fuels, these resources can be utilized without risk of depletion. Obviously, in the case of wood as a source of biomass it is possible to chop down a whole forest for fuelwood at an unsustainable rate. However, it is also possible to selectively harvest fuelwood without depleting or reducing the producing capacity of the forest – this is untrue for fossil fuels.

When implemented properly, drawing energy from renewable energy sources can maintain a balance with natural ecosystems. The large-scale search for, extraction and commercial consumption of fossil fuels all contribute to massive degradation of the environment. Similarly, a large hydrodam can also have equally disruptive impacts on the environment by submerging land resources, destroying natural habitats and adversely affecting the ecological balance of an area. All energy choices require careful consideration and study to evaluate their environmental, social and economic impacts.

The basic renewable energy sources commonly found are:

Solar Energy
The energy from the sun can be used directly for traditional heating needs, it can also be absorbed by solar panels to generate electricity or be concentrated to create steam.

Wind Power
Wind farms use the natural power of the wind to operate motors to generate electricity. Examples of traditional uses of wind power that do not involve creating electricity include boats with sails for transportation and windmills for pumping water or grinding grain.

Hydropower
By harnessing the natural flow of water due to gravity, hydropower can be used to generate electricity as with large- or mini- hydroelectric dams. Hydropower can also be stored by pumping water into reservoirs for use when there is demand. There are many people across the globe that still rely on waterwheels and water currents in their daily lives.

Biogas
Largely composed of methane – also known as natural gas – biogas is formed from the natural decomposition of plant and animal waste by bacteria. As the breakdown of organic matter occurs, biogas is released and can be collected and used as fuel. The remaining matter can be used as fertilizer to grow more organic products. Biogas is also found in large quantities below ground where there are oil deposits.

Biomass
Burning wood is a simple example of biomass energy. Biomass refers to organic matter that can be burned directly – such as wood or agricultural waste – and includes organic matter that can be processed into energy sources like fuel pellets for more efficient use. Biomass includes biofuels such as ethanol and methanol – highly flammable alcohols made from plant sugar and fibre – that can be burned as liquid fuels.

Renewable energy can be found in everyday use in different places around the world. It is found in applications in rural areas, large industrial plants, schools, hospitals, homes, office buildings, parking lots and on roads and highways.

When implemented properly, drawing energy from renewable energy sources can maintain a balance with natural ecosystems.

China's Energy Sector: An Overview

China needs energy to develop. And once it reaches a stable level of development it will continue to require energy to sustain itself.

China consumes over 10% of the energy produced in the world each year. It is currently the second largest consumer of energy in the world and its overall energy consumption is on track to double in the next 15 years.

China's per capita energy use is below the world's average and only one-tenth that of the United States. Overall energy consumption is less than half that of the United States.

China currently meets well over 90% of its energy needs through domestic sources. However, that number is expected to drop to 80% in the year 2025.

Coal

Coal is by far the major resource consumed in China's energy sector. It accounts for approximately three-fourths of China's energy needs. It is used for electricity generation, industrial processes and at the household level in rural and urban areas.

However, despite having one of the largest domestic supplies of coal resources, much of China's coal supply is of low quality and much of it is located in remote areas. In fact, even with the low cost of labour in China, coal production in China is more costly than the global average. This is partly due to inefficient production and transportation costs.

Coal is used as a primary industrial and household energy source throughout the country, and is particularly important in the production of steel and electricity.

Coal is responsible for substantial portions of the nation's pollution. It is estimated that about 85% of China's carbon emissions are directly related to coal burning. This has resulted in massive emissions of carbon dioxide and sulfur dioxide into the atmosphere. Related to this is the fact that 9 of the top 10 most polluted cities in the world are in China, and the country is the second largest emitter of greenhouse gases – and likely to become the largest emitter in the very near future.

Oil

The second largest source of energy for China's development is oil. Twenty years ago China was a significant oil exporter in Asia, but since 1993 China has been a net importer of oil and is currently the second largest importer in the world. China has recently expanded its oil investments from traditional sources in the Middle East. It has been increasing investments and exploring oil opportunities in Africa, South America and in the rest of the developing world. China accounts for approximately 40% of the growth in global oil demand. Chinese oil demand is a part of increasing global demand for oil, rising prices, increasing greenhouse gas emissions and heightening international natural resource related conflicts.

China currently meets well over 90% of its energy needs through domestic sources. However, that number is expected to drop to 80% in the year 2020.

Hydropower

Within China's borders flow some of the world's largest rivers. The now famous Three Gorges Project has brought great attention to China's capacity for harnessing hydropower. It also brought to light many questions about the impacts of large hydrodam

construction in China and around the world. China has a long history of hydropower projects. While there are many large-scale projects such as the Three Gorges Dam planned, small hydropower projects are among the largest and fastest growing renewable energy resources in the country providing electricity to over a quarter of China's population, mostly in rural areas.

Natural Gas

Natural gas accounts for 3% of China's energy needs. While overall a small percent, the country seeks to double that number in the next 25 years. Natural gas is a major source of energy for domestic cooking and heating as well as for industrial processes.

China's Projected Energy Supply in 2030

Coal	**62%**
Oil	**18%**
Natural Gas	**8%**
Hydropower	**9%**
Nuclear	**3%**

Nuclear Power

China has 9 nuclear power plants that are currently in commercial operation, but they account for barely 1% of China's overall energy supply. The country plans to expand nuclear energy production, but it is a relatively costly path to meeting the nation's energy needs.

Comments

On a national scale, renewable energy sources comprise a limited portion of China's energy sector. The current and future energy picture includes a continued heavy reliance on coal, oil, natural gas and hydropower. Projections for the next quarter of a century include reductions in the percentage of coal used for energy production, but an overall increase in coal consumption.

The country is already facing severe environmental pollution directly related to its energy consumption. Acid rain as a result of dirty emissions is causing widespread contamination of water bodies, environmental degradation and public health problems.

Though China has signed the Kyoto Protocol - a global agreement on greenhouse gas emission reductions - it is a non-Annex I country which means that it is not bound to specific reduction targets. It is becoming increasingly clear that China has not been able to entirely leapfrog the negative environmental impacts related to the patterns of industrialization in developed nations. Today there are new alternatives available that did not exist in the past; there are cleaner more environmentally friendly technologies, renewable energy sources, more efficient mechanisms for production, and a new awareness of sustainability and development. So, there is still hope that China can take a side step towards a more balanced ecological, social and harmonious path to development.

A typical gasoline-powered generator used to provide electricity in rural areas.

China's Energy Demand

China's energy demand is on its way to doubling and domestic supply of traditional energy resources are not sufficient to meet its growing needs.

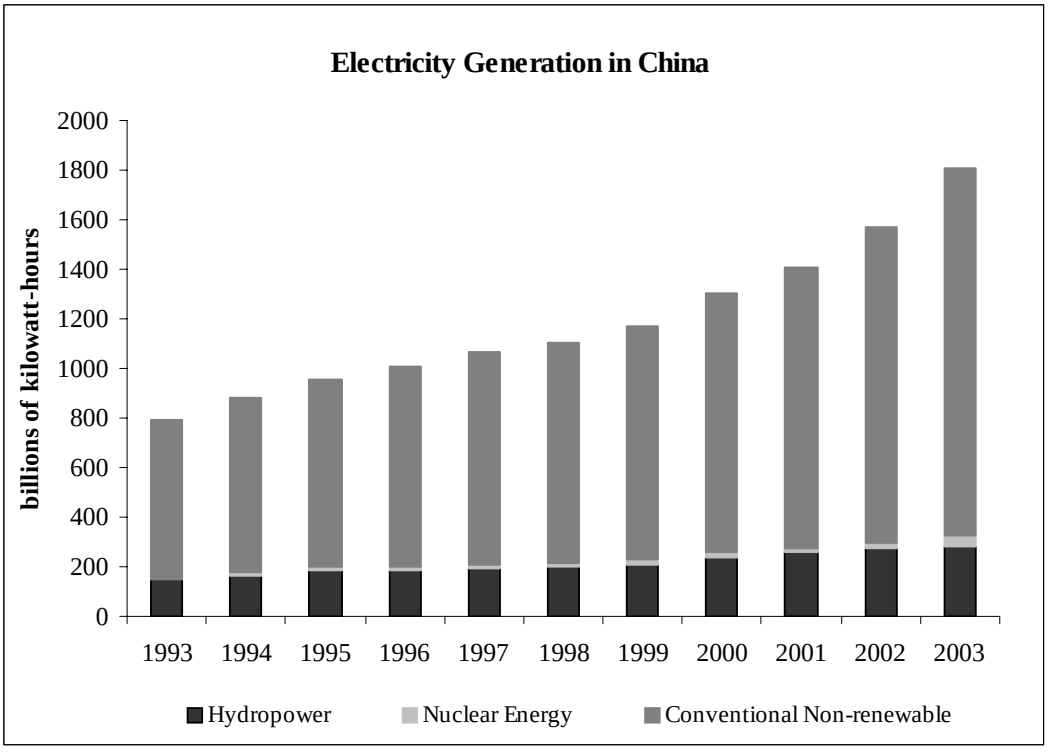
Coal is probably the one fossil fuel resource that the country will not have to resort to importing anytime soon. Coal demand is projected to grow at an average annual rate of 3.6% over the next decade and a half. Oil demand is projected to grow at an average annual rate of 3.3% until the year 2020. And natural gas is projected to grow at an average annual rate of 11.7% during the same period.

China ranks second in both electricity generation and consumption in the world and accounts for 11% of the world's electricity consumption each year. Even so, domestic sources report that there are an estimated 70 million households that lack electricity and most are located in rural areas far from the electricity grid. Many of these households also fall within the estimated 200 million people in China – or roughly 15% of China's population - who live on less than a dollar per day. Currently, electricity generation is almost entirely produced through conventional nonrenewable energy sources, hydropower and a small amount of nuclear energy production.

It has been estimated that in the five northern and western provinces and autonomous regions of Qinghai, Tibet, Inner Mongolia, Xinjiang, and Gansu there are 2.2 million households without electricity and without access to the electricity grid. China also has some 300 inhabited islands along its coast, most without access to grid power from the mainland.

Electricity is only one of the types of energy demands of these populations and others like them. Energy is also needed in alternative forms that can be used for heating, cooking and mechanical labour. Lack of energy has a direct impact on local development and livelihoods. Renewable energy is one way to meet the energy needs for these communities.

There are an estimated 70 million households in China that lack electricity and most are located in rural areas far from the electricity grid.



China's Renewable Energy Resources

China will continue to look outward toward foreign sources for traditional energy supplies to meet its growing needs, but there are also abundant yet to be tapped energy resources located well within the country's borders. Namely, sources of renewable energy that the country has barely begun to harness. There are ample solar and wind resources in areas all across China. China is also reported to have the largest untapped hydropower potential left in the world. Biomass and biogas are viable energy solutions for many local communities that carry with them environmental and public health benefits as well.

"A closer look at the renewable energy potential in China shows that these resources are readily available and able to offset nonrenewable sources in substantial quantities."

Rapid development of renewable energy sources in China could alleviate energy demand pressures. It could also help as part of the strategy to address rural development and poverty in remote areas where traditional energy systems are economically unattractive. China's renewable energy sector has grown by 25% each year for the past several years. This is still only a modest expansion given the limited size of the renewable sector compared to the overall nonrenewable energy generation and consumption.

A closer look at the renewable energy potential in China shows that these resources are readily available and able to offset nonrenewable sources in substantial quantities.

Solar Power

China has a potential annual solar energy reserve equal to 1,700 billion tons of coal a year. Two-thirds of the country receives approximately 2,000 hours of sunlight annually, more than many other regions of similar latitude. In 2005, China had a total cumulative amount of installed solar power capacity of 70 MW – the total electricity capacity in China is 6,000 times larger.

One of the main areas of expansion for solar energy applications is in underdeveloped rural areas that lack electricity. These areas are mainly in the North and West of China. Fortunately, due to higher average levels of sunlight, these areas are relatively well-suited for harnessing solar energy.

There is potential for wide application of solar photovoltaic (PV) panels which collect sunlight and transform it into electricity. Solar thermal collectors (i.e. solar water heaters) that absorb the heat of the sun are another large growth market. In some more remote areas such as Tibet, there are daily applications of solar energy for cooking – mainly boiling water – already in widespread use.

A typical household PV system can be as small as 5 watts (used for lighting) to 150 watts (used to power several appliances such as a TV, radio, etc.). Prices for such systems range from roughly about 2,000 yuan (~ $250 US Dollars) to 4,000 yuan (~ $500 US Dollars). Systems can be expanded by adding additional PV panels.

Solar thermal systems, particularly solar water heaters, have a possibly much greater potential for expansion throughout the country than solar PV. If looking at the application of solar water heating, solar energy is perhaps the most widely used renewable resource in China at the household level – the country ranks first in the world in terms of the manufacture and use of solar water heaters. Solar water heaters at the household level are competitively priced and can operate below the cost of electric and gas-powered water heaters.

Rooftop solar water heaters produced in China for the domestic market.

Compared to other renewable energy sources, solar power provides practically instant returns given the proper weather conditions. While the electricity generated by PV systems is more expensive than traditional energy provided by the grid, many of the most important PV applications in China are in areas that have little to no access to grid power.

Wind Power

China has first-class wind resources. There is no exact estimate of the amount of wind resources available in the country, but the majority of wind resources reside in Inner Mongolia, Xinjiang and Qinghai provinces. These areas are prime locations to develop wind energy due to available land and low population density. However, they are also considered fairly remote from the rest of China's economic and urban centers making transmission of produced energy difficult and costly. The development of wind energy in these areas to supply demand for local energy needs is still highly desirable.

Wind is being harnessed at large-scale industrial wind farms and on small-scale community and household levels. In 2005, China's installed capacity for wind power production amounted to 1,300 MWs. Predictions are that China's capacity may grow to 4,000 megawatts by 2010, 6,000-8,000 megawatts by 2020 and 50,000-100,000 megawatts by 2050.

China has invested in a number of large wind energy facilities around the country and is seeking to build more.

Wind power generators range from small 50-watt to 20-kilowatt generators. The most basic components of a wind power system generally consist of a windmill or fan type apparatus, a turbine (motor) and a battery. The wind turns the fan which in turn rotates the turbine generating electricity that can be used directly or stored in the battery for later use.

Prices for such systems can vary due to components and regional markets. An average price for a medium-sized 200-watt generating household system is approximately 2,000 yuan (~ $250 US Dollars). These types of systems are particularly desirable in areas where households are too far from the grid and have few alternatives for electricity generation. A wind power generating system can provide a practically instant source of electricity. Common household uses of wind power generators include powering light fixtures, radios, televisions, and in some cases refrigerators and washing machines.

Solar water heaters at the household level are competitively priced and can operate below the cost of electric and gas-powered water heaters.

Hydropower

China is also rich in hydropower. Hydropower potential is rated as high as 676,000 MW, however the economically exploitable potential is closer to just less than half of that amount. It was reported that hydropower produced 400 billion kilowatt-hours of energy in 2005 – 16% of the country's electricity – of which 48.6 billion kilowatt-hours was produced by the Three Gorges Dam. When the dam is completed, electricity production is expected to rise to 84.7 billion kilowatt-hours annually.

Large hydropower projects in China have received international attention and criticism. While their achievements and implications are significant, it is reported that the small-to-medium hydropower plants are the larger and faster growing hydropower source. It is reported that small hydropower supplies up to 300 million people with electricity in China. Small hydropower projects generally produce electricity on a scale of 25,000 megawatts.

Large hydropower projects can be considered a traditional and mainstream form of energy production in China and around the world. There is a long-standing debate on their environmental and economic implications. Small to medium hydropower plants are a less mature industry and continue to require assistance and support.

Biogas

Biogas is a gaseous fuel composed primarily of methane (MH_4) and carbon dioxide (CO_2). Biogas is a byproduct of the process of breaking down human and animal waste by micro-organisms. It is a relatively simple system requiring very basic technology and management. China's 2003-2010 National Biogas Construction Plan included the goal of increasing the number of households using biogas from under 10 million to 20 million households in 2005 and 50 million households in 2010.

Biogas is an effective fuel source for cooking and heat. It burns much more cleanly than coal or oil. A useful byproduct of biogas production is fertilizer for agricultural use.

Biomass

Biomass has been in use throughout thousands of years of Chinese history. Biomass is the use of organic material as a fuel source (i.e. wood and agricultural waste). Estimates of China's biomass potential register at about 700 million tons of coal per year.

It can be a sustainable and cheap source of energy at the household level in areas with sufficient supplies of biomass. Commercialization of biomass and industrial farming of biomass for fuels is being explored in China. These types of processes usually process normal organic material into fuel pellets or bricks using a mixture of materials for maximum efficiency in burning. Challenges to the growth of biomass include the lack of arable land and widespread water shortages. Also, energy produced by biomass fuels must still undergo combustion processes releasing greenhouse gases into the atmosphere.

A Closer Look at Solar Energy

Solar energy, particularly photovoltaic (PV) installations, is a major component of plans for rural electrification in China. While close to 97% of households have some form of access to electricity, the majority of the remaining 3% are among the poorest of the poor. Household or village level electrification schemes are among the most practical ways to assist households in remote locations and those with nomadic lifestyles.

Solar Electricity

Solar energy can enhance household standards of living. When used to produce electricity it can provide families with various benefits, including:

- Light
- Communication
- Water pumping
- Refrigeration
- Kitchen appliances
- Washing machines

These small life enhancements can make long-term contributions to rural families. They can reduce the health risks associated with indoor air pollution caused by burning oil, coal & firewood. They can extend the working day by providing light after hours and by reducing time spent on labour intensive activities such as collecting fuelwood and manually transporting water. They can provide improvements in nutrition and hygiene through better food storage alternatives.

At the village level, the generation of solar electricity is regularly used to improve access to better education and community health facilities. Solar electricity can be used in rural schools to run computers, TVs and DVD machines. It can also be used to provide refrigeration for medical supplies and for other equipment in rural clinics.

Solar Thermal

In addition to the use of PV installations, there are other applications for solar energy. At present, China ranks first in the world in manufacturing and use of solar water heating systems which are a form of solar thermal energy use. Solar water heating is the simple process of using the sun's radiant heat to either directly or indirectly heat water for daily household or industrial use.

Applications of solar thermal energy include:

- Heating water for cooking or bathing
- Boiling water for consumption
- Distilling water for consumption
- Solar space heating
- Solar cookers

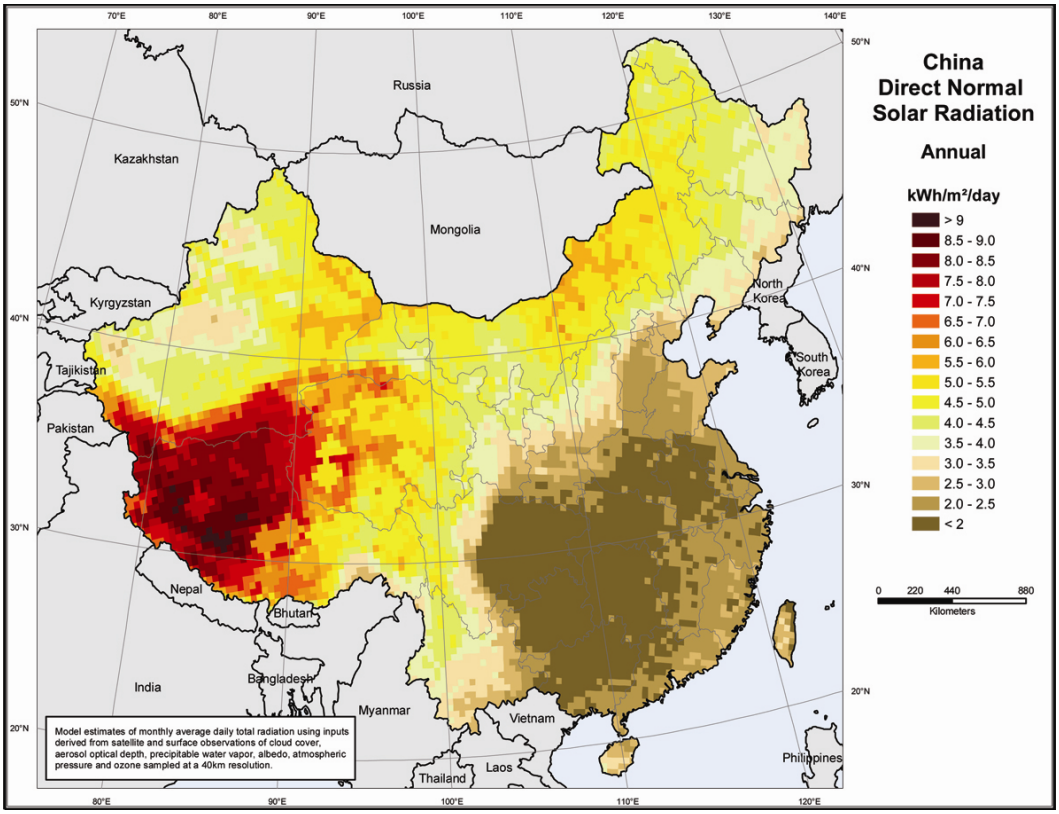
A very basic example of solar thermal energy is placing wet clothes in the sun to dry. More efficient, yet low tech and affordable methods for using solar thermal energy can make it a practical alternative for daily needs.

Solar water heaters are used in areas all over China to provide low-cost, reliable warm water. In Tibet, parabolic mirrors are used to focus sunlight in order to bring kettles of water to boil for safe drinking.

If implemented effectively, solar electricity is a low-cost, high-return method for assisting local communities. It can empower local populations by allowing them greater choices in their daily lives.

Diesel lamps used in rural areas in China are a source of indoor air pollution and are a health risk.

Rechargeable solar lanterns can be used to replace diesel lamps.



China's Solar Energy Supply

Official estimates report that 70,000 kW of solar power facilities were operational nationwide in 2005. As the map above indicates, China's solar energy supply is concentrated in the North, Northeast and Southwest regions of the country. These areas include the provinces and autonomous regions of Tibet, Gansu, Qinghai, Szechuan, Xinjiang and Inner Mongolia.

Average direct solar radiation per square meter in these areas ranges from 4.5 – 7.5 kWh per day. If fairly constant, this amount of solar radiation is sufficient to operate household size and even larger solar energy installations. While most of the areas in these regions also have poor water resources, some have substantial wind power potential. This makes hybrid solar-wind installations attractive alternatives in these areas.

In some of these areas there are already locally developed markets for solar energy technology. These markets commonly consist of items such as solar PV panels, storage batteries, AC/DC converters, solar thermal water heaters, parabolic water heaters, and DC appliances.

Annual salaries in these areas range from a low of several hundred RMB to several thousand. Even the cheapest solar PV installation can easily cost over half a year's wages. This makes the up-front cost of renewable solar energy technology one of the greatest barriers to adoption.

A simple solar setup can cost around a couple thousand RMB which is twice the average annual salary in some areas of Gansu province. It is true that while renewable energy can sometimes be most helpful to the poor, they are the least able to access it.

Solar 101: The Basics

Each day the amount of energy received by the Earth from the Sun is 600 times greater than the amount of energy produced by all other energy sources combined. The Sun is the planet's greatest energy source. It already accounts for the majority of energy consumed if you add up the daily heat transferred to the planet, photosynthesis in plants, and light provided during the daytime.

"The Sun is the planet's greatest energy source."

There are three primary ways that solar energy is harnessed:

1. Passive Heating
2. Active Heating
3. Photovoltaic

This section will focus mostly on discussing photovoltaic energy.

Passive Heating

Passive solar systems use the direct energy provided by the sun as a source of heat at the site where the energy is collected. Examples of this are solar ovens, drying processes using direct sunlight and parabolic reflectors for heating water.

A parabolic solar water heating device used in Southwestern China.

Passive heating for buildings is a method of construction based on the different position of the sun that optimizes a building's ability to take advantage of the sun's energy for heating in the winter and to deflect sunlight in the summer. Passive heating is also used in practical daily applications such as drying clothes or foodstuffs in the sun, operating a solar oven or evaporating sea water to produce salt.

Active Heating

Active heating operates on many of the same basic principles of passive heating, but involves the transfer of energy or heat from where it is collected to where it will be used.

The most common example of active heating is solar water heaters. Solar water heaters are commonly installed in a location to maximize the amount of sun energy able to be collected. However, solar water heaters are usually combined with a system of heat transfer, pumping and storage components to allow the heat collected to be transferred to the water that will then be transferred to its point of use.

Photovoltaic

A photovoltaic (PV), or solar-electric, system uses PV cells to convert sunlight into electricity. The PV cell is made up of at least two layers of a semi conducting material. When light shines on the cell it creates an electric field across the layers causing electricity to flow in a direct current (DC). The greater the intensity of the light, the greater the flow of electricity.

The basic components of a photovoltaic system are:

1. PV Cells
2. Battery
3. Charge Controller
4. Inverter
5. Load

It is important to note that any properly designed and installed PV system must have components that are chosen to best match for use and safety.

PV Cells

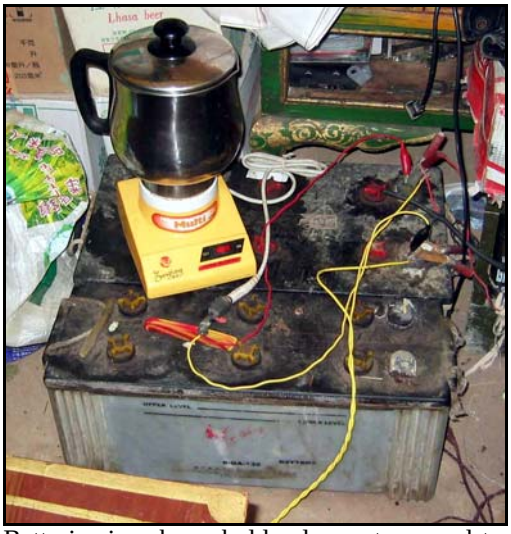
There are many different types of cells and designs. The majority of cells are made from some form of silicone. A PV cell can be designed in different sizes and to output different amounts of current. Generally, groups of identical types of cells are mounted together and sealed into the more traditionally recognizable PV or solar panel. Solar panels are generally designed and categorized by capacity to produce direct current and, for example, come in sizes such as 4-volt, 6-volt and 12-volt units. Similar to batteries, solar panels can be wired together in series or parallel configurations to increase the current and/or voltage output.

Examples of domestically produced solar panels.

Traditionally, solar panels have been produced for use in developed economies for high-end home-owners or industrial installations. This has affected their construction and pricing making them relatively robust with 20-25 year lifetimes and warranties and expensive. Newer technology and markets for less robust and more inexpensive designs are changing the face of the solar panel market and industry.

Battery

One of the characteristics of solar energy is that it can only be produced when there is daylight. This requires that energy produced during daylight hours be stored for use at night or when there is no sun. Some form of battery is usually used for this purpose. The battery is charged when there is an abundance of electricity being produced and discharged, or used, when sunlight is not available or insufficient.



Batteries in a household solar system used to run a hot water kettle.

There are many high-end batteries designed specifically for solar power installations. These batteries are designed for multiple deep discharges over long lifetimes. However, in many developing countries, such batteries are costly and in short supply. In household solar installations, it is common to find systems using old car batteries. While less efficient, car

batteries are cheaper and far more available.

Charge Controller

Anytime a solar panel is exposed to sufficient sunlight and attached to a closed circuit, it will produce electricity. When that closed circuit includes a battery, it is necessary to ensure that the battery is not overcharged or discharged too deeply. A charge controller operates to prevent both of these things.

A charge controller will sense the battery charge and control the flow of energy to the battery when it is charging. It will also prevent the over discharging of a battery by stopping the flow of energy from the battery to the system and/or allowing the flow of energy from elsewhere to enter the circuit.

A Chinese manufactured charge controller with integrated clock and radio.

Charge controllers can carry out their functions with several options which include turning off loads, signaling when a battery charge is too low (called load management), activating external power sources to replace the battery energy flow to a system, acting as a load circuit breaker or fuse, showing system voltage or current, and acting as a system timer for pre-set activation.

A charge controller must be used that can operate at the maximum voltage the system it is being used in is designed for (i.e. a 12-volt controller must be used for a 12-volt system).

Inverter

There are generally two types of electrical current that are available. The first, Direct Current (DC), is the form that is provided by most batteries and travels in a single direction from negative to positive poles. The second, Alternating Current (AC), is what is available in most homes when plugging into an electric socket where the electricity travels back and forth in cycles due to alternating polarity. Appliances can be designed for either DC or AC currents or both.

The electric current produced by a PV panel is DC. This current can be used to charge a battery. As long as the voltage is sufficient, it can also be used to power any DC electrical appliance or load.

However, to provide AC power or to upload power to a power grid, an inverter is needed to change the DC current to AC current.

Inverters are not very complex, but they do have different specifications. There are three basic waveforms (type of alternating current) that an inverter can be designed to output: Square Wave, Modified Square Wave and Sine Wave. Square wave is the least expensive, but best only for basic applications such as lighting or simple heating. Sine Wave is most expensive, but can be used to run all types of AC appliances in which well-moderated AC current is important (i.e. computers, telecommunications, etc.). A Sine Wave inverter is also necessary if the user is planning to feed electricity generated back into the power grid.

The Modified Square Wave provides an AC current between the square and sine wave qualities. It can be used to operate various types of loads, but can cause 'humming' in audio equipment and may affect the performance of loads like clocks and microwave ovens.

Load

Appliances that use electrical power are often referred to as "loads" and will influence the type and size of photovoltaic system that is required.

There are many different types of loads that can be run on a solar energy system. However, some types are more efficient and easier to power than others. For example, common appliances that are run on energy supplied from PV cells include, radios, televisions, lighting, small pumps, table fans, battery chargers and CD players. The power required by these types of appliances are generally low – though running numerous devices at once over a long-period of time can significantly increase the energy demand.

Household appliances powered by batteries charged by PV panels.

Loads that require much larger PV installations and are often considered less compatible with solar energy installations include, electric space heaters, electric water heaters, clothes dryers, dishwashers, conventional refrigerators, many power tools, electric stoves and air conditioners.

A PV system should be designed around a model for the types of loads it will have to support. Depending on the number of appliances, their time of usage, and their energy requirements, a PV system can be effectively designed to provide the necessary power supply. It is important to note that many appliances require a surge load (i.e. initial energy required to start or turn-on an appliance) when first turned on which must be taken into account when calculating a systems maximum required load capacity.

Typical Watt Requirements for Common Appliances	
Appliance	**# of Watts**
Clock Radio	5
Incandescent Bulb (100W)	100
Fluorescent Bulb (100W)	30
DC Water Pump (2 hours)	60
CD Player	35
Stereo	15
19" Color TV	60
VCR	40
Sm. Freezer (13 hrs/day)	475
Blender	350
Electric Coffee Pot	1200
Large Electric Burner	2100
Microwave	1400
Desktop Computer	80-150
Laptop Computer	20-50
Satellite System	45
Toaster	1200
Clothes Washer	1450
Air Conditioner (1 ton)	1500
Hair Dryer	1000
Cellular Telephone	24
CB Radio	10
Ceiling Fan	10-50
Incandescent Bulb (40W)	40
Fluorescent Bulb (40W)	11

China's Solar Energy Future

There are various factors that will continue to encourage and hinder China's future development of solar energy.

Encouraging Factors

China has made policy commitments to developing its renewable energy sector. The passage of the 2005 Renewable Energy Law demonstrates that renewable energy solutions are among the priorities of the government when considering future development. During the same period that the Renewable Energy Law was passed, the country's leadership also pledged to increase the overall share of energy derived from renewable energy resources to 10 percent. However, hydropower, not solar, makes up the majority of the renewable energy resources planned for future development.

"In recent years, 90% of photovoltaic products produced in China have been for export markets – mostly to developed nations."

The new renewable energy targets and policies are in-line with a growing consciousness by China's leadership about the need for environmentally sustainable development. This consciousness influenced the country's bid for the 2008 Olympic Games, making their proposed theme the "Green Olympics." This has raised the profile of the need to adopt renewable energy solutions in the country for the Games and afterwards.

China is on the path to becoming a center for the world's solar energy sector. China is already a world leader in production and adoption of solar heating systems – mostly in the form of solar water heating installations. It will continue to expand its lead in this area as increased economic development continues and the domestic market for solar thermal systems grows.

A primary factor traditionally hindering the growth of the solar energy industry on a worldwide level has been the high-cost of manufacturing solar system components. China has evolved to become the *workshop of the world* with production lines across all industries relocated to Chinese factories in order to take advantage of cheap labour, low overheads, and a stable investment environment. The solar industry is no exception.

Some conservative estimates show that China's solar cell production has grown 50% per annum for the past few years with national sector estimates for manufacturing module capacity in 2008 at 1200 MW, solar cell manufacturing at 1200 MW and wafer capacity at 800 MW. From the manufacturing side, China will be a low-cost engine creating a source of cheaply mass produced solar components along the entire supply chain.

With the growth of a more integrated manufacturing chain, more products will be available for lower-priced markets and developing economies. This will likely drive the continued growth of the solar manufacturing industry in China.

In recent years, 90% of photovoltaic products produced in China have been

for export markets – mostly to developed nations. China's domestic solar energy market is still in its infancy. But, it is poised to grow due to higher energy prices, increased home ownership, economic growth in rural areas, development of appropriate technology, government policy priorities, and overall decreasing costs of solar technology. Of the small percentage of Chinese who do not have grid access to electricity, the majority of them live in areas with PV applications that range from good to excellent. Approximately 7 million Chinese do not have access to grid power. These communities are targets for the nation's rural electrification program which aims to electrify 20,000 villages with PV power by 2010.

Global climate change is another factor firing China's shift towards renewable energy sources, including solar energy. China is, or is soon to be, the largest gross emitter of greenhouse gases. The country's response is often that on a per capita basis its emissions are below the world average and that many of the emissions come as a result of manufacturing goods for consumption in other countries. However, it is undeniable that industrial activity from within China's borders is contributing to global warming.

In 2007, China announced a new *National Climate Change Programme* which included further support for the *Renewable Energy Law* and also stated that the country should, "*actively develop solar power and solar heating, including popularizing family-use photovoltaic power system[s] or small-scale photovoltaic power plants in remote areas; disseminating integrated solar energy building, solar energy based hot water supply, space heating and cooling pilot projects in urban areas and popularizing household solar water heater, solar greenhouse and solar stove in rural areas…*" Thus, expansion of solar energy is one of China's responses in combating climate change.

International aid and technical assistance for development projects will continue to be a driving factor for the growth of rural PV energy. Funding from bilateral aid agencies and public and private foundations is also an important impetus for the expansion of rural solar energy.

Limiting Factors

While there is a growth in capacity for manufacturing and constructing solar panels, the supply of polysilicon (the raw material used to produce the individual solar cells) continues to be a worldwide bottleneck in solar cell and panel production. It is standard industry practice for solar companies to use a mix of scrap and virgin polysilicon to keep material prices low and maintain a supply. China has several major private sector plans for increasing manufacturing capacity of polysilicon that should be in operation in 2008. It is estimated that raw material costs of polysilicon are responsible for about 40% of the cost of producing solar panels. In the short term there will continue to be a limited supply of polysilicon keeping the price for solar energy from dropping too dramatically.

Approximately 7 million Chinese do not have access to grid power.

Without substantial government subsidies or assistance, most areas underserved in energy supply will continue to lack adequate power.

Solar system component compatibility and reliability will continue to be a problem for small systems. With a

variety of manufacturers and no single standard for components or compatibility, solar systems suffer from non-standard system design and quality control. The various components of a household solar energy system must be paired according to their operating specifications. Incorrectly paired components are prone to malfunctioning or damage. Also, incorrect installation of components can severely hamper their performance and expected lifetime.

A battery produced specifically for use with solar systems.

Batteries used for energy storage are an important example. Cheap car or motorcycle batteries are used in many household PV systems because they are widely available. These batteries are not specifically designed for long-term deep discharging (they are usually designed for providing short energy surges to start an engine). In the short-term the systems will work, but over a longer period the battery will need to be replaced and it can be hazardous if the battery is not well maintained.


The panels in this system are connected directly to a battery, without a charge controller it is not possible to properly monitor the charging of the battery.

Out of necessity, China subsidizes and controls the price of energy resources to ensure affordability for its citizens. If there is existing access to cheaper subsidized fossil fuel based energy sources, consumers may not be motivated to switch to solar or other renewable energy sources.

Solar Energy Development Projects in China

Below is a list of examples of solar energy development projects in China.

Gansu Solar Electric Light Fund
Solar Electric Light Fund
This project was founded in 1993 in Gansu Province by the Solar Electric Light Fund and with support from the Rockefeller Foundation. It began with a pilot project that included the installation of 100 solar home systems. Based on the success of the pilot project, the Gansu Solar Electric Fund was awarded a contract by the National Renewable Energy Laboratory (USA) to supply 500 solar electric home lighting systems to farmers and herdsmen in Gansu.
(For more information contact the Solar Electric Light Fund.)

Various Solar Projects
The Shambala Connection
Over the past two years, the Shambala Connection has worked with local groups to distribute and put into operation over 450 solar cookers in villages within Gansu, Qinghai and the Tibetan Autonomous Region. In many cases local funding is supplemented by funds from The Shambala Connection. In 2007, The Shambala Connection also supported the Shem Women's Group in Gansu Province by supporting the distribution of 50 household solar panel sets to 50 households in Qiake Township.
(For more information contact: The Shambala Connection.)

Solar Stoves
Heifer International China
HPI China has included the distribution of solar cookers to some of the communities it serves in Qinghai Province. HPI China's main focus is on capacity building for rural communities in raising and managing various livestock as a form of livelihood.
(For more information, contact HPI China.)

Rural School Renovation Sino-German Cooperation Project
German Embassy, Beijing
As part of a rural school renovation project in Hebei province which included construction of a new building and general upgrades and renovations, the project included a combined solar power and clean coal combustion heating system.

Promoting Solar PV development in western China
World Wildlife Fund (China)
As part of WWF's Climate & Energy Conservation Program Area it is encouraging the spread of solar PV systems in rural areas in western China. WWF is also promoting the growth of solar and other renewable energy sources through its Green Electricity Market Development program which involves market investigation in green electricity power production.
(For more information contact WWF China.)

The Dharma Sagara Clinic
The Surmang Foundation
TSF is building a model for rural healthcare in remote areas of China, their core project is the design and creation of a primary care clinic. Due to the remote location of the clinic, the building is solar powered and heated and has served over 60,000 patients in the surrounding area over the past 10 years.
(For more information, contact the Surmang Foundation.)

Protecting Forests in China's Yunnan Province

The Nature Conservancy, China

To date, TNC has installed over 2,500 household biogas, solar heating, micro-hydropower and biogas-greenhouse units to encourage alternatives to the use of firewood. The goal of this project is to reduce the demand for wood and address the serious threats to health and biodiversity of household fuelwood use.

(For more information contact TNC China.)

China's Renewable Energy Law

The following are excerpts from the Renewable Energy Law of the People's Republic of China adopted at the 14th meeting of the Standing Committee of the 10th National People's Congress on February 28, 2005.

General Principles

Article 1
The purpose of this law is to promote the development and utilization of renewable energy, increase energy supply, improve the energy structure, safeguard energy security, protect the environment, and realize the sustainable development of the economy and society.

Article 2
Renewable energy in this law refers to wind energy, solar energy, hydro energy, biomass energy, geothermal energy, ocean energy, and other non-fossil fuel energy sources.

The application of this law to hydropower shall be stipulated by the energy department in charge in the State Council and be submitted to the State Council for approval. This law does not apply to utilization of crop stalks and straw, fuel wood and manure by direct burning in low-efficiency stoves.

Article 4
The Government prioritizes the development and utilization of renewable energy in its energy development, and promotes the establishment and development of renewable energy market by setting the renewable energy target in terms of total volume and taking relevant measures.

An Overview of China's Modern Renewable Energy Policy

1983	Suggestions to Reinforce the Development of Rural Energy
1992	China Agenda 21
1992	Ten Strategies on China's Environment and Development
1994	Brightness Program and Ride the Wind Program
1995	State Science and Technology Commission Blue Paper No. 4: China Energy Technology Policy
1995	Outline on New and Renewable Energy Development in China
1995	Electric Power Law
1995	New and Renewable Energy Projects in Priority (1996-2010) China
1996	Guidelines for the Ninth Five-Year Plan and 2010: Long-Term Objective on Economic and Social Development
1996	State Energy Technology Policy
1996	Ninth Five-Year Plan and 2010 Plan of Energy Conservation and New Energy Development by the State Power Corporation
1996	Ninth Five-Year Plan of Industrialization and Renewable Energy by SETC
1997	Energy Saving Law
1997	Circular of the Communication and Energy Department of SPC on Issuing the Provisional Regulations on the Management of New Energy Capital Construction Projects
1998	Incentive Policies for Renewable Energy Technology
1999	Circular of MOST and SDPC on Further Supporting the Development of Renewable Energy
2001	Tenth Five-Year Plan for New and Renewable Energy Commercialization Development by SETC
2001	Adjustment of VAT for Some Resource Comprehensive Utilization Products by MOF and State Tax Administration
2001	Electricity Facility Construction in Non-Electrification Townships in Western Provinces of China or Township Electrification Program by SDPC and MOF
2003	Renewable Energy Promotion Law
2003	Rural Energy Development Plan to 2020 for Western Areas
2005	National Renewable Energy Law

(Information from National Renewable Energy Laboratory)

The Government encourages enterprises with various kinds of ownership to participate in the development and utilization of renewable energy, and protects the legal rights of the developers of renewable energy in accordance with the law.

Promotion and Application

Article 13
The Government encourages and supports grid-connected renewable energy power generation.

Article 14
Power grid enterprises should sign the grid connection agreement with renewable energy generation enterprises that have received administrative approval or have been submitted for record, purchase all the power that is generated from grid-connected renewable energy generation projects covered by their grid network, and provide grid connection services and support for renewable power generation projects.

Article 15
The Government supports the construction of off-grid renewable power generation systems to provide electricity services for production and domestic uses in areas not covered by electric grid.

Article 16
The Government encourages clean and high-efficiency development and utilization of biomass fuels, and encourages development of energy crops.

Article 17
The Government encourages enterprises and individuals to use solar hot water systems, solar heating and cooling systems, solar photovoltaic power generation system and other solar utilization systems.

Real estate developers must, in designing and constructing buildings, provide necessary conditions for solar energy utilization in accordance with the technical standards mentioned in the above paragraph.

For buildings already built, residents may, on the condition that its quality and safety is not affected, install solar energy utilization system that conform to technical standards and product standards, unless agreement has been otherwise reached between relevant parties.

Article 18
The Government encourages the development and utilization of renewable energy in rural areas…

Economic Incentives and Supervision Measures

Article 25
For renewable energy development and utilization projects that are listed in the national guidance directory for renewable energy industry and comply with the requirements for bank credit, financial institutions may provide preferential loans with interest subsidies**.**

Article 26
The Government offers tax benefits for renewable energy development and utilization projects that are listed in the national guidance directory for renewable energy industry. Detailed measures shall be provided by the State Council.

Discussion
The passing of the *Renewable Energy Law* demonstrates a clear recognition by the government of the increasing

need to support the further development of renewable energy sources in China.

The inclusion of financial incentives and economic guidelines for adopting renewable energy sources and even integrating them into the pre-existing power grid systems indicates that this new policy has a great potential for encouraging the expansion of renewable energy.

As stated in Article 14, this new law stipulates that state power grid enterprises should, “purchase all the power that is generated from grid-connected renewable energy generation projects…”

Overall, the *Renewable Energy Law* sets the stage for the continued development and adoption of renewable energy strategies in China. It encourages urban and rural implementation, grid-connected and off-grid projects, small-scale individual and industrial commercial installations and was passed along with the clear understanding of government representatives with the goal of increasing the share of national energy demand supplied through renewable energy by the year 2020.

Glossary

Alternating Current (AC) – Electric current in which the direction of flow oscillates at frequent, regular intervals.

Altitude – The angle between the horizon and the sun, measured in degrees.

Ambient Temperature – The temperature of the surrounding area.

Ampere (Amp) – Unit of electric current measuring the flow of electrons per unit time.

Ampere-Hour (Ah) – The quantity of electrical energy equal to the flow of current of one ampere for one hour.

Angle of Incidence – Angle which references the sun's radiation striking a surface. A "normal" angle of incidence refers to the sun striking a surface at a 90 degree angle.

Base Load – The average amount of electric power that a utility must supply in any period.

Battery – Two or more "cells" electrically connected for storing electrical energy.

Battery Capacity – Generally, the total number of ampere-hours that can be withdrawn from a fully charged battery.

Battery Cycle Life – The number of cycles, to a specified depth of discharge, that a cell or battery can undergo before failing to meet its specified capacity or performance.

Battery Self Discharge - Self-discharge is the loss of otherwise usable chemical energy by spontaneous currents within the cell or battery.

Btu – The quantity of heat required to raise the temperature of one pound of water from 60 degrees Fahrenheit to 61 degrees Fahrenheit at a constant pressure of one atmosphere.

Charge Controller – A device that controls the charging rate and/or state of charge for batteries.

Charge Rate – The current applied to a cell or battery to restore its available capacity.

Conduction – A transfer of heat through matter by transfer of kinetic energy.

Concentrator – An optical component of a photovoltaic array used to direct and increase the amount of sunlight on a solar cell.

Conversion Efficiency – The ratio of the electricity energy produced by a photovoltaic cell (under full sun conditions) to the energy from incident sunlight on the cell.

Crystalline Silicone – A type of PV cell made from a single crystal or polycrystalline slice of silicone.

Current – The flow of electric charge in a conductor between two points having a difference in potential (voltage).

Days of Storage – The number of consecutive days the stand-alone system will meet a defined load without solar energy input.

Deep Cycle Battery – Type of battery that can be discharged to a large fraction o f capacity many times without damaging the battery.

Deep Discharge – Discharging a battery to 20% or less of its full charge capacity.

Depth of Discharge (DOD) – The amount of ampere-hours removed from a fully charged cell or battery, expressed as a percentage of rated capacity.

Design Month – The month having the combination of insolation and load that requires the maximum energy from the photovoltaic array.

Diffuse Radiation – Refers to solar radiation that reaches the earth directly due to reflection and scattering.

Diode – Electronic component that allows current flow in one direction only.

Direct Gain – A term used in passive solar design relating to solar heat collecting within the same space as where the collected heat will be utilized or stored.

Direct Current (DC) – Electric current flowing in one direction.

Discharge Rate – The current removed over a specific period of time from a cell or battery.

Disconnect – Switch gear used to connect of disconnect components in a photovoltaic system.

Double Glazed –
A term referring to the application of two panels of glass within a single window frame for the purpose of additional insulation.

Dry Cell – A cell (battery) with a captive electrolyte. A primary battery that cannot be recharged.

Duty Cycle – The ration of active time to total time. Used to describe the operating of appliances or loads in PV systems.

Efficiency – The ration of output power to input power - expressed in percent.

Electric Circuit – A complete path followed by electrons from a power source to a load and back to the source.

Electric Current – Magnitude of the flow of electrons.

Electrolyte – A conducting medium in which the flow of electric current takes place by migration of ions.

Energy – The capability of doing work; different forms of energy can be converted to other forms, but the total amount of energy remains the same.

Energy Audit – A survey that shows how much energy is used in a home, which helps find ways to use less energy.

Energy Payback Time – The time required for any energy producing system or device to produce as much energy as was required in its manufacture.

Flat Plate Collector – A collector of solar heat designed to be flat.

Full Sun – The amount of power density in sunlight received at the earth's surface at noon on a clear day (about 1,000 Watts/square meter).

Grid – The network of transmission lines, distribution lines, and transformers used in central power systems.

Grid-Connected System – A solar electric or PV system in which the PV array acts like a central generating plant, supplying power to the grid.

Hybrid System - A solar electric or photovoltaic system that includes other sources of electricity generation, such as wind or diesel generators.

Incident Light – Light that shines onto the face of a solar cell.

Indirect Gain – a term used in passive solar design relating to solar heat collecting devices that collect solar heat in a space adjacent to where the heat will be utilized or stored.

Insolation – The solar radiation incident on an area. Usually expressed in watts per square meter or Btu's per hour.

Insulation – A material with properties that prevent the free passage of heat or electricity.

Inverter – A solid state device which changes a DC input to an AC output.

Isolated Gain – A term used in passive solar design relating to solar heat collecting devices with a remote position from where the collected heat will be utilized or stored.

Kilowatt (kW) – One thousand watts.

Kilowatt Hour (kWh) – One thousand watt hours.

Latitude – The angular distance north or south of the Earth's equator, measured in degrees along a parallel, as on a map or a globe.

Life-Cycle Cost – An estimate of the cost of owning and operating a system for the period of its useful life; usually expressed in terms of the present value of all lifetime costs.

Load – The amount of electrical power being consumed at any given moment. Also, any device or appliance that is using power.

Longitude – Angular distance on the Earth's surface, measured east or west from the prime meridian at Greenwich, England, to the meridian passing through a position, expressed in degrees (or hours), minutes and seconds.

Maximum Power – For a photovoltaic cell module or array, this refers to the power at the point on the current-voltage curve where the current voltage product is maximized.

Module – A predetermined electrical configuration of solar cells laminated into a protected assembly or panel.

Nominal Voltage – A reference voltage used to describe batteries, modules, or systems (i.e. a 12-volt or 24-volt battery)

Ohm – A unit of electrical resistance measurement.

Open Circuit Voltage – The maximum possible voltage across a photovoltaic array. Open circuit voltage occurs in sunlight when no current is flowing.

Orientation – Placement according to the directions, N, S, E, W; azimuth is the measure in degrees from true south.

Panel – A configuration of solar cells or modules fastened together and designed as a field installable unit.

Parabolic Trough – A square or rectangular reflective surface curved to form a point of focus along one if its axis

Parallel Connection – The method of interconnecting electricity-producing devices or power consuming devices, so that the voltage is constant but the current is additive.

Passive Solar – A construction design referring to the practice of siting a home or building and constructing its various elements so as to take advantage of the ability of available sunlight to provide heat.

Peak Load – The maximum load or electrical power consumption occurring in a given period of time.

Peak Sun Hours – The equivalent number of hours per day when solar irradiance averages 1000 watts/m^2.

Peak Watt – The amount of power a photovoltaic device will produce during peak insolation periods when the cell is directly facing the sun.

Photovoltaic – Capable of producing a voltage when exposed to radiant energy, especially light.

Photovoltaic Cell (PV Cell) – A cell that generates electrical energy when incident solar radiation falls on it. This term distinguishes it from a photoconductive cell which changes its electrical resistance when light falls on it.

Photovoltaic System – An installed system of solar arrays, power conditioning and other subsystems providing electrical power.

Polysilicon – Term referring to polycrystalline silicon which is silicone with a crystalline structure which acts as a conductor of electricity. It is an essential raw material for producing solar cells.

Reflector- A polished surface for reflecting light or other radiation.

Resistance (R) – The property of a conductor which opposes the flow of an electric current resulting in the generation of heat in the conducting material. The unit of resistance is Ohms.

Semiconductor – Any material between an insulator and conductor which has a limited capacity for conducting electricity.

Series Connection – A method of interconnecting electricity producing devices or power-using devices so that the current remains constant and the voltage is additive.

Silicon – Semiconductor material commonly used in photovoltaic cells.

Sine Wave – A waveform corresponding to a single-frequency periodic oscillation that can be mathematically represented as a function of amplitude versus angle in which the value of the curve at any point is equal to the sine of that angle.

Solar Cell – Photovoltaic cell.

Solar Constant – The average amount of solar radiation that reaches the earth's upper atmosphere on a surface perpendicular to the sun's rays; equal to 1353 Watts/square meter or 492 Btu per square foot.

Solar Cooling – The use of solar thermal energy or solar electricity to power a cooling appliance.

Solar Thermal – Heat obtained from the Sun.

Solar Thermal Electricity – Method of producing electricity from solar energy by concentrating sunlight on a working fluid

which changes phase to drive a turbine generator.

Square Wave – A waveform that has only two states, (i.e. positive or negative). A square wave contains a large number of harmonics.

Stand-Alone System – A photovoltaic system that operates independently of the utility lines. It may draw supplementary power from the utility but is not capable of providing power to the utility.

Surge Load – A sharp spike in power demand usually associated with additional energy required to power-up an appliance.

Thin Film – A layer of semiconductor material, such as copper indium diselenide or gallium arsenide, a few microns or less in thickness, used to make photovoltaic cells.

Tilt Angle – Angle of inclination of collector as measured in degrees from the horizontal.

Trombe Wall – A passive solar heating device that uses massive walls, vents and glass covering to achieve a heating effect.

Uninterruptible Power Supply (UPS) – The designation of a power supply providing continuous uninterruptible service.

Volt, Voltage (V) – A unit of measurement of the force given to electrons in an electric circuit; electrical potential.

Wafer – A thin slice of semiconductor material used in photovoltaic cell manufacture.

Watt, Wattage (W) – A measure of electrical power. Watts = Volts x Amps

Watt Hour (Wh) – A quantity of electrical energy when one watt is used for one hour.

Additional Resources

National Renewable Energy Laboratory (NREL)
www.nrel.gov/china

National Development and Reform Commission (NDRC)
www.spdc.gov.cn

Solar Electric Light Fund (SELF)
www.self.org/china.asp

Beijing Energy Efficiency Center
www.beonchina.org

US Energy Information Administration
www.eia.doe.gov

The Energy Group at Lawrence Berkeley National Laboratory
china.lbl.gov

Energy Foundation
www.efchina.org

Solar Cookers International
solarcooking.org

UNDP China
www.undp.org.cn

ITDG Technical Briefs
itdg.org

World Bank Quality Programme for Photovoltaics
www.worldbank.org/astae/qpp/

South-North Institute for Sustainable Development
www.snisd.org.cn

China Energy Group
china.lbl.gov

China Environment Forum
www.wilsoncenter.org/index.cfm?fuseaction=topics.home&topic_id=1421

China Rural Energy Enterprise Development
www.c-reed.org

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