# H.R. 2774: The Solar Energy Research and Advancement Act of 2007

**Columbia University**
**School of International and Public Affairs**
**Program in Environmental Science and Policy**
**2008**

## TEAM SOLAR

Advisor, Andrea Schmitz

**MANAGEMENT TEAM**

Team Manager, Gabe Cowles
Deputy Manager, Diane Foy

**TEAM MEMBERS**

Dayna Adelman, Fletcher Beaudoin
William Covin, Betty Cremmins, Colin FitzGerald, Judith Harwood, Joe Katz, Lisa Nagy, Jonna Robins, and Julie Rowlett

Report compiled by
Lisa Nagy and Dayna Adelman

## EXECUTIVE SUMMARY

### The Problem with Electricity

The current US electricity profile is heavily reliant on fossil fuel combustion, specifically coal. In 2007, 49% of the country's electricity was produced by coal combustion, while only 2% of electricity generated came from renewable technology (EIA, 2007). While any fossil fuel combustion carries a variety of environmental consequences, coal is especially detrimental to both the environment and human health. The extraction and combustion of coal have significant negative environmental and human health impacts, including soil erosion, acid rain, smog and emissions of mercury and $CO_2$, a greenhouse gas. With population and electricity consumption expected to increase, the US must reduce reliance on coal to prevent further environmental degradation and to avoid adverse impacts on human health.

### The Solar Solution

In the ongoing search for cleaner, cost-competitive forms of energy, solar power has the potential to become a significant component of the US electricity profile as it is abundant and emissions free. While solar technology has emerged in the US energy market in recent years, it has not reached the point of widespread commercial viability. Through research programs and job training, the Solar Energy Research and Advancement Act of 2007 (H.R. 2774) aims to improve current solar technologies and develop the infrastructure necessary to make solar power a more substantial portion of the electricity profile.

H.R. 2774 seeks to reduce national reliance on fossil fuels by advocating further research into a variety of solar power technologies. Historically, political and financial support for solar power has focused on photovoltaic (PV) technologies. Photovoltaic cells absorb energy from the sun and instantly convert it into a direct current of electricity, also known as DC. Although PV cells can be successfully utilized for electricity in individual homes or buildings, PV technology faces two primary challenges. First, converting direct current to alternating current (AC) is necessary for residential and commercial use, but this causes a significant energy loss. Second, the batteries used to store the power generated by PV cells are often cumbersome to install and utilize and disposal releases harmful chemicals into the environment. This is

> **Direct Current (DC)** cannot be easily be changed to higher or lower voltages, requiring separate electrical transmission lines to be installed to power appliances of different voltages.
>
> **Alternating Current (AC)** can be transmitted over long distances at high voltage and stepped down to low voltage for residential and commercial use.

because semiconductor materials are often toxic but occur in amounts below levels regulated by the EPA. The 20-30 year lifespan of PV cells is causing disposal policy to lag behind the growing solar energy sector. The wide dispersal of photovoltaic use make a recycling program unrealistic at this time, but there is potential for the future.

By comparison, concentrated solar power (CSP) has the greatest potential to impact our electricity profile on a national scale. These systems utilize large mirrors to convert the sun's heat to generate base load utility-scale electricity. CSP operates like a traditional steam turbine power plant, so it can be easily incorporated into the current electric grid, with the added benefit of being renewable and emissions free.

**Issues with Concentrated Solar Power**

For concentrated solar power to be competitive with electricity, the issue of cost must be addressed. Currently, CSP costs $0.16-$0.17 per kilowatt hour (kWh), versus coal, which averages $0.05 per kWh. One key element is needed to solve the technical issues associated with cost: storage of heat produced from solar power. Storage systems must be capable of storing the heat from solar power for use when the sun is unavailable. Molten salt, the medium used to store harvested solar energy in a CSP system, has a storage capacity of approximately six hours using existing technology. Storage capacity will need to increase to 16 hours for CSP to become a base load electricity source that operates 24/7, 365 day per year[1].

In order for CSP to become commercially viable, investor confidence must also improve. Although CSP plants have low maintenance costs, large initial capital investments are required to build the plant. For example, Solar 1 in Nevada cost $4.1 million per megawatt to build, while Centralia Coal costs $0.86 million per megawatt (Powertechnology.com, 2008). CSP development is also hindered by weak political support, which affects the demand for this technology. In the first quarter of 2008, the solar lobby spent $75,000 promoting solar technology, compared with almost $5 million spent by the coal lobby in the same amount of time (Goodell, 2008). Increased investor and political support will pave the way for CSP to achieve cost parity and large-scale implementation.

**Program Design for Concentrated Solar Power**

To address these obstacles, H.R. 2774 allocates funding over five years in the form of grants to promote the research and development of concentrated solar power. Using the

---

[1] Typically, base load power plants produce most of the electricity, generated primarily by coal and nuclear because they are the least costly to run. Peaking plants, on the other hand, have to be built specifically for periods of high electricity consumption, or peak load times. When not in the peak load times, these plants remain idle. Increased demand for electricity at peak load times drives up the market price, and building many plants for that one purpose is inefficient.

$5 million allocated for the first year, our program design will administer $4.4 million in grants specifically for storage research. Remaining funds will be used for administrative purposes including salaries, and to create a private investor knowledge base where industry professionals can access a comprehensive list of current technology developments in CSP. A public and proprietary website and database will also be developed as a place for industry professionals to share progress and information, and will also serve as a public forum for CSP. A marketing campaign will also be launched to improve political support through increased media coverage and the initiation of an annual conference dedicated to large scale CSP. A small administrative staff will be housed in the Department of Energy's existing Renewable Energy Office in Golden, Colorado to administer the program.

**The Ultimate Goal**

By increasing solar thermal storage capacity, concentrated solar power can become competitive with other reliable, base load sources. Improving investor confidence will increase available funding for capital investment in solar energy and augment supply. Marketing and increased political lobbying can increase political support and increase consumer demand for solar energy. If the renewable portion of the US electricity profile can be increased, the US will be able to meet the growing demand for electricity and mitigate some of the negative impacts associated with continued fossil fuel combustion. While solar power is not the only answer to our energy needs, it must certainly be part of the solution.

**TABLE OF CONTENTS**

## THE POLITICS BEHIND SOLAR POWER AND H.R. 2774

H.R. 2774 represents a shift in the field of solar energy research and development. This landmark bill aims to meet the current shortcomings of solar energy technology and infrastructure. Currently, coal powered electricity costs $0.05 per kilowatt hour, while CSP costs $0.13 to $0.17 (EIA, 2007). Research and development (R&D) as designated by this bill will help solar powered electricity reach cost parity with current fuel sources, such as coal and natural gas. Goals for technological improvements in storage methods and water usage will also be achieved. Solar technology has made laudable strides; however, wide-scale solar implementation has largely been hindered due to relatively high costs and the intermittent supply of solar energy from the sun.

The potential for solar energy to play a role in a more diverse electricity profile was first realized in 1954 through the creation of the first photovoltaic (PV) cell. Over the next several decades technology became more widespread and costs were lowered, allowing for wider implementation. Early PV cells were used as power sources to satellites, and other "off-the-grid" sources, such as offshore oil rigs and railroad crossings (DOE, 2007).

During the latter portion of the twentieth century, solar energy was brought to public attention during times of energy crises. Financial investment into solar energy brought improvements in technology, and solar became part of the political agenda. As oil prices rose during the 1973 oil embargo crisis, PV technology began to achieve greater cost parity with other fuel sources used for electricity generation. This balance was achieved through various federal programs and research initiatives (Hart, 1983). "Nuclear destroys, solar employs" was a popular slogan during this time, when arguments in favor of solar also included reduced electricity costs and movement beyond the nation's dependence on foreign oil. However, arguments against solar energy similar to those of today (primarily regarding technology and cost) eventually took precedence and quelled the

**Photovoltaics** are best known as a method for generating solar power by using solar cells often electrically connected in multiples as solar arrays to convert energy from the sun into electricity. Within a solar panel, photons from sunlight knock electrons into a higher state of energy, creating electricity. A photovoltaic (PV) cell is a semiconductor diode that converts light into direct current electricity. Virtually all photovoltaic devices are some type of photodiode.

Electricity produced by solar cells can be used to power equipment or to recharge batteries. The first practical application of photovoltaics was to power orbiting satellites, but today the majority of photovoltaic modules are used for grid connected power generation. In this case an inverter is required to convert the DC to AC.

There is a smaller market for off grid power to remote buildings, roadside emergency telephones and remote sensing.

interest which had peaked through the mid 1980s.

The Solar Energy Research Institute began its operations in 1977 to support R&D initiatives (DOE, 2007). This organization eventually broadened its scope to include other renewable technology, and later became the US Department of Energy's National Renewable Energy Laboratory (NREL). In 1978 the Federal Photovoltaics Utilization Program was established as an effort to implement PV technology throughout the United States (Hart, 1983). This program, however, was largely unsuccessful due to lower than expected appropriated funds, mismanagement by the DOE, and improper focus on cost-efficiency, rather than technologically-efficient and innovative technologies. PV technology achieved further development during this period, but was unable to attain large-scale implementation and usage (Hart, 1983).

Now, in twenty-first century, the world is again sinking into an energy crisis. As energy prices fluctuate, the nation is looking for alternatives to conventional energy sources. Partnered with the current energy crisis is a new problem facing the world: global climate change. Current electricity sources are a large part of the problem. Harmful emissions from traditional fossil fuel power plants enter the atmosphere and cause adverse effects on human health and the environment. The realization of this problem has increased political, social, and environmental awareness that has resulted in the demand for a "green energy" revolution.

As a result of this green revolution, renewable energy has received noticeably more attention in the public and political arena. Solar energy is no exception. National leaders have made significant efforts to include solar power in the emerging renewable energy profile of the United States. Congresswoman Gabrielle Giffords (Arizona) is a solar energy leader for the southwest, and for the nation. Giffords is not alone in her promotion of solar energy. Along with Arizona, other states including New Mexico, California, and Nevada are installing solar energy systems and looking to increase their capacity. The current governor of California, Arnold Schwarzenegger, has proposed a statewide initiative to install PV on one million homes by 2018 (Mara, 2006). He has also passed legislation that would increase renewable technology in California to 20% by 2010 and 33% by 2020 (CA Energy Commission, 2008). This ambitious plan is being widely embraced by several organizations. The Interwest Energy Alliance, for instance, is a trade association that focuses on overcoming the barriers preventing solar power from becoming a viable energy option. The Western Governor's Association, along with many public utility commissions and local government also support the initiative (Western Governors, 2008).

The implementation of widespread solar power still faces opposition. Inadequacies and limitations must be addressed so that the technology can gain acceptance from a broad audience. Current opponents include members of the coal industry, who believe that coal can be a "green" part of the energy profile through "clean coal" technologies such as integrated gasification combined cycle (IGCC) and carbon capture and storage. These technologies, while innovative, still face challenges of high capital and operational costs, public skepticism, and a lack of regulatory framework. The issue also remains that coal is a finite resource and is predicted to reach peak supply by 2025, then experience terminal decline (Strahan, 2008). Carbon capture and storage technology is not developed sufficiently for implementation in the near future. Clean coal and carbon capture also fail to address the negative effects to the environment and society caused by coal mining. Given these facts, it becomes imperative to find an alternative energy source that will meet the demands of increasing energy requirements as well as prevent further harm to human health and the environment.

> **Clean Coal** is a term used to promote the use of coal as an energy source by emphasizing methods being developed to reduce its environmental impact. These efforts include chemically washing minerals and impurities from the coal, gasification, treating the flue gases with steam to remove sulfur dioxide, and carbon dioxide capture and storage technologies (Australian Coal Association, 2008).
>
> David Brockway, Chief of the Energy Technology Division at CSIRO, estimates that "commercial-scale, clean-coal power stations [coal-burning power stations with carbon capture and sequestration] cannot be commercially viable and widely adopted before 2020 or 2025".

Supporters of solar energy are actively committed to preserving resources for future generations. The United States must become an integral member of the growing global community currently engaged in innovation, technological advancement, and climate change awareness. A 2007 survey by Deloitte and Touche revealed that 86% of the US public would welcome solar energy in their communities, and a large portion of this sample population were willing to pay higher electricity bills to implement solar energy (Burnham, 2007).

With the current heightened public awareness and support, the time is right to take important steps that will lead us to energy independence and away from pollution and the depletion of finite resources. Currently, 26 states have mandatory renewable energy standards. As solar technologies become more viable these requirements will become more widespread. California has a Renewables Portfolio Standard (RPS) that offers the most ambitious alternative energy standard in the country. The RPS program requires electric corporations to increase eligible renewable energy resources by at least 1% of retail sales annually until they reach 20% by 2010. The California Solar Initiative program provides rebates and cash incentives to utilities in a push for 3,000 megawatts of new, grid-connected solar systems by 2016 (California Energy Commission, 2007).

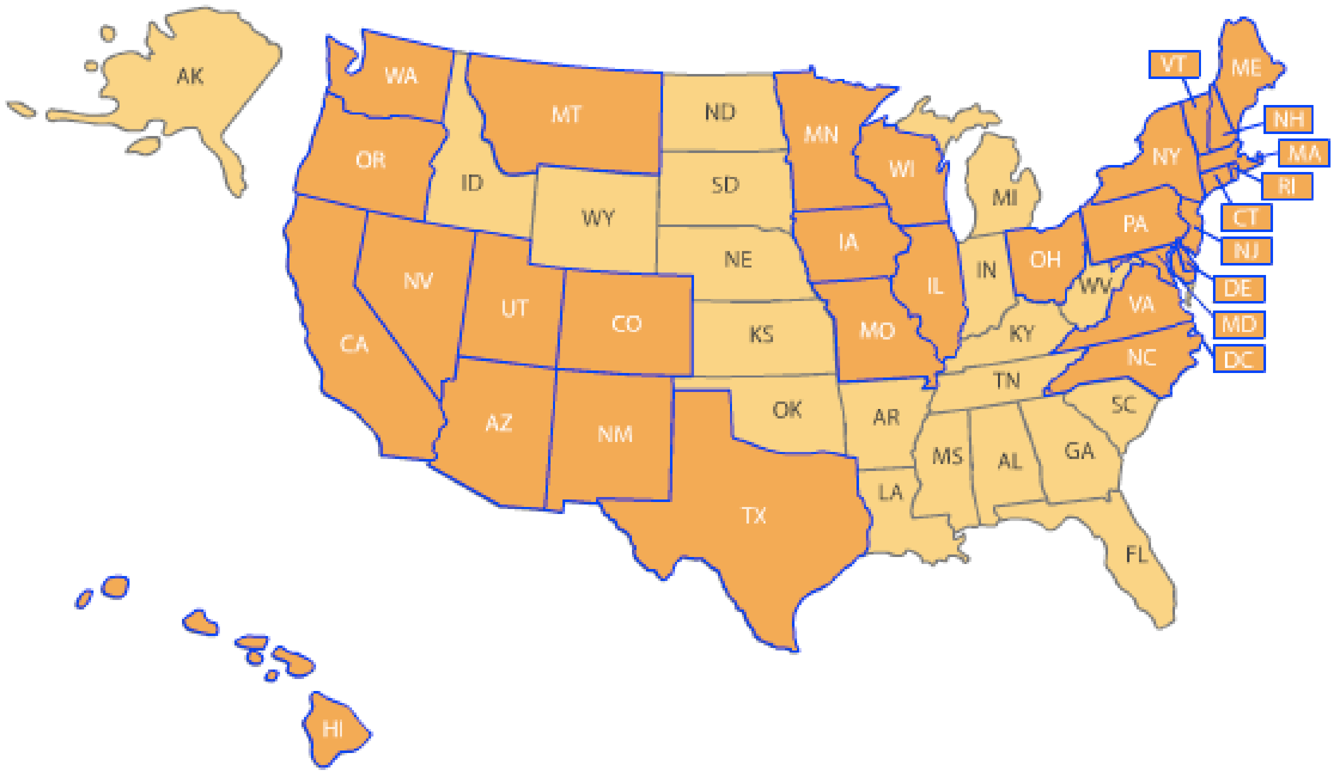



**Figure 1: States with renewable energy requirements are shaded above (EERE, 2008).**

**Legislative Summary: H.R. 2774**

H.R. 2774 was proposed by Congresswoman Gabrielle Giffords (D-AZ) in 2007 to address the need for alternative energy sources in the United States, as well as to serve as an effective solution to the problem of global climate change. On August 3, 2007, the Committee on Science and Technology described H.R. 2774 as a bill designed "to support the research, development, and commercial application of solar energy technologies" (United States Cong. House). H.R. 2774 is an important step in improving the technology and increasing the presence of solar energy in the United States. Primarily a research bill, this legislation will seek to find new storage methods for solar energy to counter the current problem of intermittent supply. It will also require the study of decreased water usage involved in solar energy systems. Other research components will include transmission, workforce training, and photovoltaic (PV) development.

H.R. 2774 promotes solar energy use through several different technologies including photovoltaic, daylighting systems, solar air conditioning and concentrated solar power (CSP). While each of these technologies has its merits, there is a significant emphasis in the bill on improving CSP storage technology. Targeted CSP funding is described in the bill under the Thermal Energy Storage provision.

R&D was first established for CSP through the Energy Policy Act of 2005. H.R. 2774 seeks to address some of the issues that continue to prevent large-scale use of CSP. First, thermal energy storage technology is a very important component of CSP, as its direct use is limited to daylight hours and further restricted during periods of cloudiness. Second, the bill addresses water usage in CSP systems. A CSP plant uses the same amount of water as a traditional coal-fired plant; however, CSP plants would naturally be located in the regions of highest solar activity (the southwest United States) which are also water-scarce regions. Finally, H.R. 2774 mandates research into the possibility of connecting CSP to the established infrastructure of regional and national electrical grids, and assigns the Secretary of Energy to make recommendations for transmission upgrades needed in order to bring electricity generated by CSP plants to areas of growing demand.

As described in figure 2, H.R. 2774 mandates that a majority of funding be allocated to photovoltaic systems. However, when the bill was introduced in its original form on June 19, 2007, it dealt solely with CSP technologies, shown in Figure 2 as Thermal Energy Storage. The sections dealing with the promotion of other solar energy technologies were added later in the version approved by the committee and reported to the full House. Likely, these amendments were added primarily to generate support for the bill by appealing to a wider audience of interested parties. Since being reported in the House on August 3, 2007, H.R. 2774 became incorporated into H.R. 3221: Housing and Economic Recovery Act of 2008, and later into H.R. 6: Energy Independence and Security Act of 2007. H.R. 6 has since been signed into law by the President (Public Law No: 110-140). The section summaries for H.R. 2774 can be found in Appendix C of this document.

| H.R. 2774 Solar Energy Research and Advancement Act of 2007 ($ in Millions) | | | | | | |
|---|---|---|---|---|---|---|
| | Thermal Energy storage | Solar Energy Curriculum | Daylight Systems | Solar A/C | Photovoltaic | Photovoltaic incl. Matching** |
| 2008 | $5.0 | $10.0 | $3.5 | $2.5 | $15.0 | $39.0 |
| 2009 | $7.0 | $10.0 | $3.5 | $2.5 | $30.0 | $78.0 |
| 2010 | $9.0 | $10.0 | $3.5 | $2.5 | $45.0 | $117.0 |
| 2011 | $10.0 | $10.0 | $3.5 | $2.5 | $60.0 | $156.0 |
| 2012 | $12.0 | $10.0 | $3.5 | $2.5 | $70.0 | $182.0 |
| **Total** | **$43.0** | **$50.0** | **$17.5** | **$12.5** | **$220.0** | **$572.0** |
| ** Grants require 60% matching source from State or Private source, minimum of 10% from State funds | | | | | | |

**Figure 2: Authorization of Appropriations; Thermal Energy Storage refers to concentrated solar power technologies.**

# WHY SOLAR?

## The Problem with Electricity Consumption in the United States

By the year 2030, an already excessive and unsustainable demand for electricity in the United States is projected to grow by 40% (EIA, 2007). Currently, renewable sources make up less than 10% of the total US energy profile, while fossil fuel combustion is responsible for 71% of all electricity generated in the US. Specifically 49% of the nation's electricity comes from coal combustion (EIA, 2007).

Both the extraction and combustion of coal have detrimental impacts on the health of our planet and its inhabitants. Coal mining processes destroy wildlife habitats and vegetation, erode soils, and lead to air, noise and water pollution.

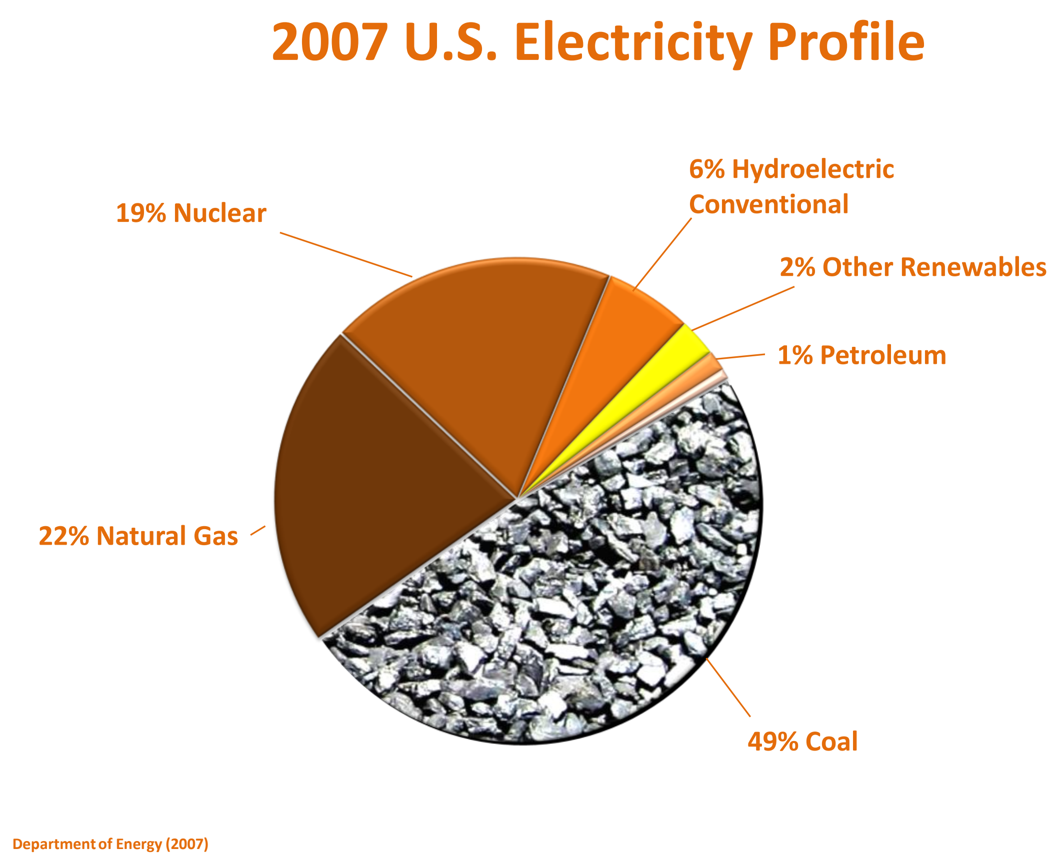



**Figure 3. Fuel sources used for total electric generation in the United States (EIA, 2007).**

**Coal Extraction**

Surface and underground mining techniques are used to extract coal from the earth. Surface mining, or strip mining, is typically used when coal reserves are close to the earth's surface. In this method, the land directly above the coal is removed by detonating explosives. This process destroys wildlife habitat, reduces vegetation, and leads to soil erosion and noise and water pollution. When coal reserves are located far beneath the surface of the earth, underground mining is utilized. In the most common methods of underground mining, large amounts of land are excavated from below the earth's surface to retrieve the coal deposits. These processes also have environmental consequences including soil erosion, changes to local water tables and subsidence. Subsidence occurs when surface land sinks as a result of rock strata collapsing into the space left by the mining operation. This consequence of coal mining can cause damage to buildings, roads, railroads and buried pipe lines that lay above the subsided earth.

Coal mining also exposes rocks and minerals that would not normally be open to the elements. When iron pyrite is exposed to water for instance, a chemical reaction occurs that creates sulfuric acid and iron. Heavy metals are then dissolved in the sulfuric acid, contaminating ground and surface water. Coal mining also disrupts water tables, which leads to flooding. Chemical runoff, or acid mine drainage, results from a combination of exposed minerals and excessive flooding. This mixture infiltrates ground and surface water, lowering pH levels and harming aquatic life.

**Coal Combustion**

After coal has been successfully extracted, it is washed in preparation for combustion. This process usually occurs at a power plant where the wastewater, known as slurry, is discharged into a sludge pond. This water tends to be highly acidic and laden with heavy metals, and dissolves into the ground and surface water.

During combustion, the coal is put into a boiler or furnace where it is burned. The heat generated is used to heat water that is housed in heat-exchanging pipes running through the boiler. High-pressure steam results and is piped into a turbine where its pressure rotates the blades of the turbine. As the turbine blades rotate, the steam is repeatedly recovered in a condenser, and is then cooled using water from a nearby source, such as a river or stream. The steam is then converted back to its liquid state and is either piped back to the boiler to carry out the process again (closed-loop system) or discharged into the water body from which it was taken (once-through process). The shaft of the turbine rotated by the steam is attached to a metallic coil suspended in a magnetic field. This configuration is the main component of a generator and is the mechanism for generating electricity. The movement of a metallic object within an electric field creates a flow of electrons, effectively generating an electric current. The generator is wired to a transformer, allowing the current to flow into the transformer where it is ramped up to a higher voltage. This high voltage current is now ready to be transmitted to the electric grid and supply electricity to those who need it.

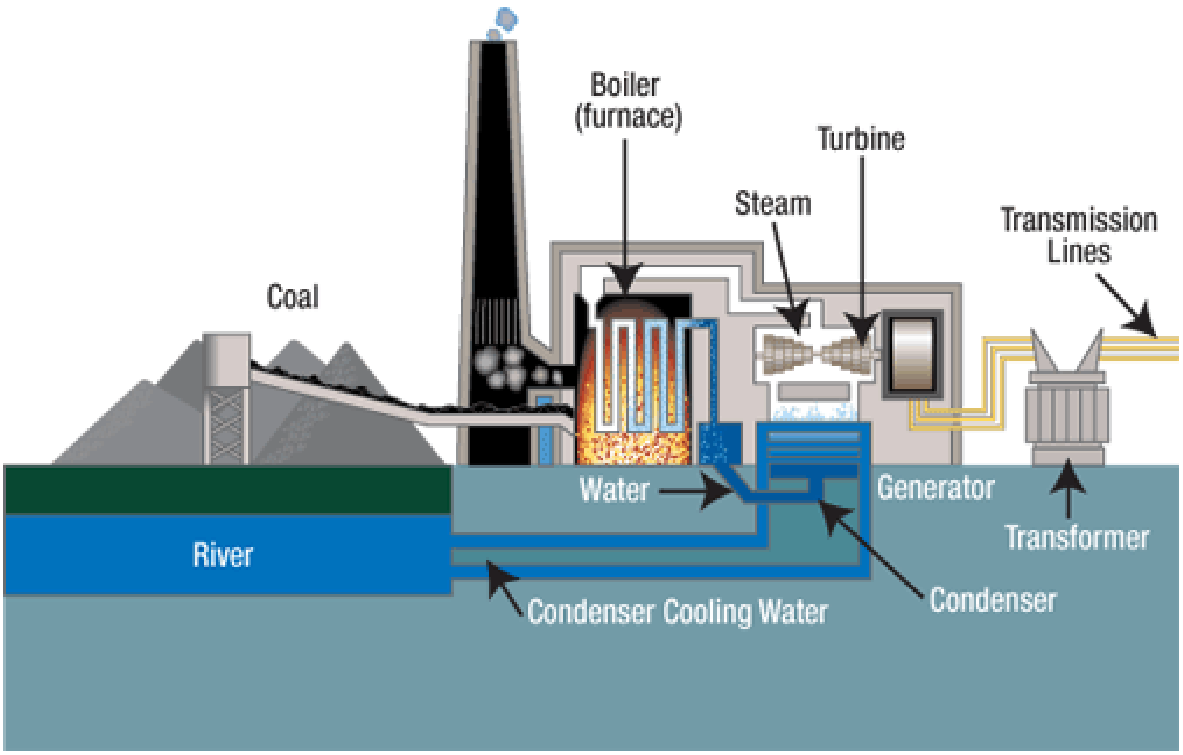



**Figure 4. A traditional, coal-fired power plant utilizing a steam-powered turbine to generate electricity. Heat released from combusting coal is used to make steam, which in turn spins the blades of a turbine. The turbine generates electricity which can be transmitted to the grid (www.cs.wright.edu).**

The process of generating electricity through the use of a steam-powered turbine is not an environmentally harmful process. The problem instead lies with the use of coal as a fuel source. When coal is burned, the chemical bonds within coal are broken resulting in the release of heat and the emission of several chemical compounds into the atmosphere. The emissions most problematic for the environment are sulfur Oxides, ($SO_x$), nitrogen oxides ($NO_x$), carbon dioxide ($CO_2$), and mercury (Hg).

## Acid Rain and Deposition

When $SO_x$ and $NO_x$ are released into the atmosphere, they combine with water vapor to create sulfuric acid ($H_2SO_4$) and nitric acid ($HNO_3$). These suspended acids eventually precipitate from the atmosphere, returning to earth in the form of acid rain. Acid rain then falls into surface waters such as lakes and streams, and can decrease the pH of the water, causing harm to aquatic organisms. The average pH of fresh water is 7, while acid rain has a pH ranging from 5.6 to 4.5. When water reaches a pH of 6, snails and rainbow trout begin to die. When it reaches a pH of 5, frogs, crayfish and mayflies die. When the pH reaches 3, all fish in the water will die (Aliff, 2003). Coal combustion plays a significant role in this process, as it is responsible for 59% of all $SO_x$ emissions and 18% of all $NO_x$ emissions in the U.S (Sierra Club, 2008).

Acid rain also causes damage as it falls over land. Soil acidification removes key nutrients from the soil, such as calcium and nitrogen. This can have deleterious effects on the health of vegetation. Acid rain has also caused damage to sculptures and buildings. Many of these structures are made from basic substances containing calcium carbonate, such as marble, which acid rain erodes over time.

$SO_x$ and $NO_x$ released into the atmosphere can also return to the earth in the form of dry particulates. These particulates can be inhaled at ground level, exacerbating asthma and other respiratory ailments.

**Smog**

Another problem created by $NO_x$ emissions at ground level is the creation of ground level ozone, also known as smog. When nitrogen dioxide ($NO_2$) absorbs sunlight it becomes photo-excited and unstable, causing disassociation to nitric oxide (NO) and oxygen (O) atoms. These O atoms combine with the nearby oxygen molecules ($O_2$) forming ozone ($O_3$), which is a main component of smog. Remaining NO molecules can react with these ozone molecules to restore the $NO_2$, which can then carry out the ozone forming processes again. While ozone in the atmosphere is beneficial, as it absorbs harmful UV rays from the sun, ground level ozone has several negative health impacts. Inhalation of ground level ozone can aggravate asthma, irritate the respiratory system and lead to permanent lung damage. This is problematic for humans, especially those living in more urbanized regions where an increased number of cars and buses emit large quantities of chemicals that react with sunlight and break apart compounds, leading to higher levels of smog (Spiro, 2003).

**Greenhouse Gas Emissions**

Many of the chemicals released during coal combustion are greenhouse gases. When these greenhouse gases are released, they help trap heat in the atmosphere that would otherwise be radiated back out into space, a process known as the greenhouse effect. The greenhouse effect is generally a positive feature of the atmosphere as it keeps our climate warm and inhabitable. However, by adding extra greenhouse gases to the atmosphere, this effect becomes magnified, leading to a warming of the planet commonly referred to as global warming. One of the primary compounds contributing to the greenhouse effect is $CO_2$, which is a common by-product of the coal combustion process. In fact, 38% of all $CO_2$ emissions in the atmosphere are from coal combustion (EIA, 2008). While it is not entirely clear what effects global warming may have on the planet, the International Panel on Climate Change has concluded that global warming will likely have a variety of negative impacts on the planet, including the rise of global sea levels, disturbance to ecosystems, and the increase of infectious diseases like malaria (IPCC, 2007).

**Mercury**

Another by-product of coal combustion is the release of mercury into the atmosphere. Mercury is a naturally occurring element, but some 2000 tons of it enter the environment each year from human-generated sources such as incinerators, chlorine-producing plants and coal-burning power plants (Science Daily, 9 Oct. 2008). It is estimated however, that coal combustion is responsible for 30% of all mercury emissions in the US (Sierra Club, 2008). Like $SO_x$ and $NO_x$, mercury can combine with water vapor in the atmosphere and precipitate back to earth where it is absorbed into waterways. Once in the water, bacterial conversion transforms the relatively stable mercury (Hg) into the water soluble and toxic methyl mercury ($CH_3Hg_+$). Once in this form, the methyl mercury can be ingested by aquatic organisms such as fish, where it has the ability to bioaccumulate in fatty tissue (Spiro, 2003). Methyl mercury is a fat soluble substance, so it can be stored in an organism's fat cells. For humans, this bioaccumulation pattern is most problematic in fish that are eaten. Small fish absorb methyl mercury and are eaten by larger fish which absorb the methyl mercury present in the small fish. Since methyl mercury is fat soluble, larger fish continually accumulate it in their tissues as they eat the smaller fish. By the time the mercury reaches the top of the food chain, it has accumulated in levels significant enough to affect human health. These larger, predatory fish tend to be the ones consumed by humans. If ingested in significant quantities, mercury can have significant impacts on the central nervous system. Some other physical effects of mercury poisoning include deafness, speech difficulties and visual impairment. Even more serious are the risks mercury poses to a developing fetus. Mercury consumed by pregnant mothers has been linked to deafness, blindness, mental retardation and cerebral palsy in fetuses (Spiro, 2003).

## SOLAR TECHNOLOGIES

### Photovoltaic (PV) Cells

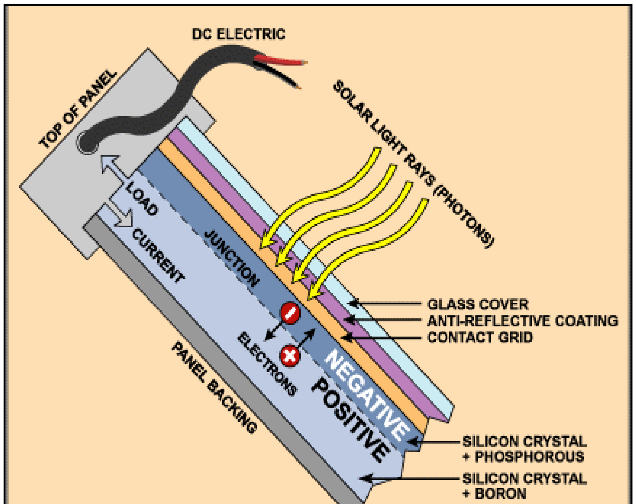



**Figure 5. A side view of a solar cell and its generation process.** **(http://www.hotpools.co.za/Solar_Electric_Power.htm)**

PV cells are one of the most common forms of solar power currently being used. The science behind PV can be seen in many applications from large arrays of rooftop panels to the small strips that power many calculators. PV cells absorb radiation from the sun and transform it into an electric current. This reaction is created by a semiconductor material, usually silicon crystal. The silicon crystal is chemically treated in such a way that one half of the crystal has an abundance of electrons, making it negatively charged, while the other half has an electron deficiency, making it positively charged (REUK, 2008). When photons of light from the sun reach the electron-rich half of the silicon crystal, some electrons are knocked loose and are free to move. These free electrons are naturally attracted to the electron-deficient portion of silicon, so they will move in that direction. The movement of these electrons in a particular direction is the basic formation of an electric current. This current is harnessed from the panel and is directed through lead wires to where electricity is needed. The electricity generated is a direct current (DC), which for most practical purposes needs to be converted with a transformer to an alternating current (AC) before it can be used. Once transformed into AC, the power generated from PV panels can be used to power any equipment that runs on AC, such as household appliances or electronics. The power also has the potential to be stored in batteries and used as needed. The generation capacity of a PV system is generally a function of how many PV panels are being used and where those panels are located. Areas that receive more sunlight, such as the southwestern US, can generate more electricity with PV panels throughout the year than can cloudier regions. While this doesn't relegate PV panels to a set area, they will be more efficient and cost effective in areas with more sun.

## Daylighting Systems and Light-Pipes

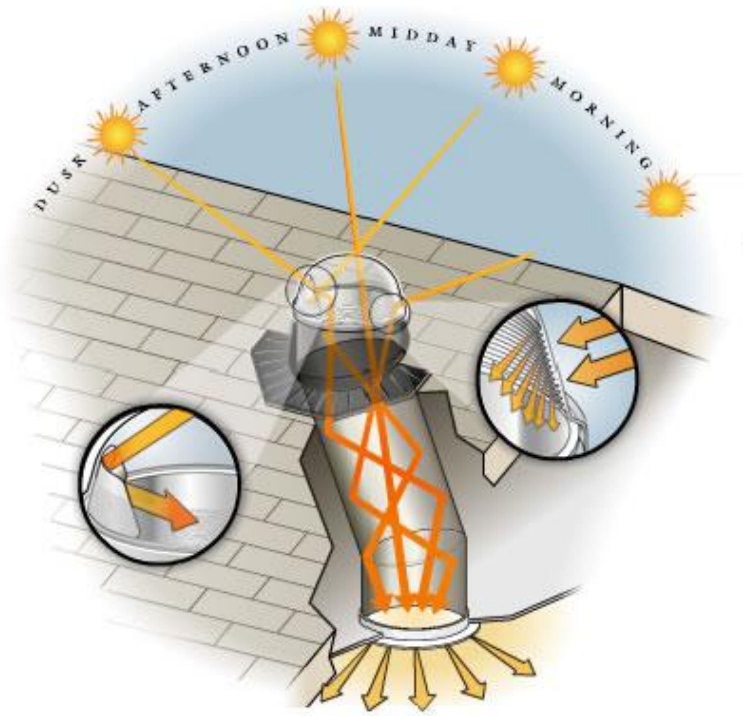



**Figure 6. A typical light pipe system installed in the roof of a home. The sun can be harvested throughout the day and used for interior lighting (source: www.solatube.com)**

These systems are a simple and effective way to provide lighting using direct sunlight. The technology utilizes a solar collector, usually dome shaped, which is mounted on the roof of a building. The collector absorbs and concentrates light from the sun using a series of mirrors or fiber optic cables. The concentrated light is piped down into the inhabited space, providing overhead light through what looks similar to a recessed lighting fixture. Due to the nature of the solar collector, light can be harvested throughout most of the day, though ultimately the fixture will stop providing light when the sun goes down. This system can be an effective alternative to traditional sources of overhead lighting but has limitations on where it can be used. For example, it would not be very effective for a large apartment building with several floors and limited roof space. Light pipe technology may be limited in scope but because interior lighting is a very common user of electricity, the widespread use of this technology may be able to noticeably reduce electricity consumption.

## Solar Air-Conditioning

There are several types of technologies encompassed within the solar air conditioning concept. In some applications, desiccants are used to remove moisture from the interior air. Desiccants are solid substances that are able to absorb moisture, effectively reducing the humidity in the surrounding air. A common desiccant is silica gel, which often comes pre-packaged and is included with products that need to be kept dry, such as sneakers. Since moist air tends to hold heat better than cold air, removing moisture from the air effectively removes heat as well. The desiccant, after being saturated with moisture, is dried out using heat collected from solar energy. This recharges the desiccant and restarts the cooling cycle. Other solar air conditioning technologies are as simple as using solar energy to power a traditional air conditioner, similar to one used in an automobile's cooling system. Since cooling demands generally tend to be higher during the day when there is ample solar energy, a solar air conditioner can effectively utilize the sun's peak power output. Further, the amount of air conditioning used in the US is projected to increase, which will make these technologies increasingly relevant in the coming years.

**Concentrated Solar Power (CSP)**

While all the solar technologies researched in H.R.2774 can help reduce our dependence on coal, CSP is the technology most likely to help mitigate the problems associated with our current energy consumption. There are several reasons why CSP will have the most significant impact in reducing our nationwide reliance on fossil fuels. First, it is important to understand how CSP works.

CSP uses mirrors to concentrate the sun's energy. These mirrors are of a parabolic shape, which allows the sun's energy to be concentrated onto a focal point. The parabolic shape is advantageous when considering the properties of reflected light. When a ray of light is reflected by a flat mirror, the angle of the incoming, or incident, ray is equal to the outgoing, or reflected, ray. Utilizing this property of light, a parabola can be curved on such an angle that all incident rays striking it will be reflected to a single focal point. This makes the parabolic mirror very efficient at collecting incoming solar rays and concentrating their energy on a set point.

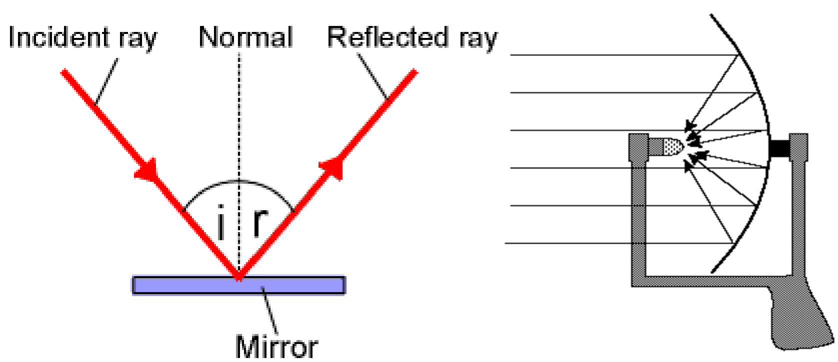



**Figure 7. On a flat mirror, the reflection angle of an incident ray is equal to the angle of the reflected ray. A parabolic mirror can reflect several rays on to a focal point. (www.library.thinkquest.org, www.scienceprog.com)**

The focal point onto which the sun's energy is concentrated contains some form of heat exchange liquid. The liquid used may be a mineral or synthetic oil with the characteristic of being easily heated to high temperatures. The efficiency of this process is dependent on the heat capacity of the liquid. The less solar radiation needed to super-heat the liquid, the more efficient this heat exchange process will be. Once this liquid becomes super-heated, it is pumped through a heat exchanger positioned in a tank of water. The heat is transferred from the super-heated fluid, such as oil or molten salt, to the water in the tanks, creating steam. The steam is routed to a turbine, where its high pressure is used to spin the turbine's blades. Like a coal plant, the turbine shaft is attached to a metallic coil suspended in a magnetic field, which creates an electric current as it spins. The electricity is then stepped up in voltage to be transmitted through the electric grid and to consumers across the country, just as it is in a coal plant. The entire electricity generation process for CSP is basically identical to the generation process for a coal plant. The important difference is that a CSP plant utilizes heat from the sun, while a coal plant relies on combustion as a source of heat.

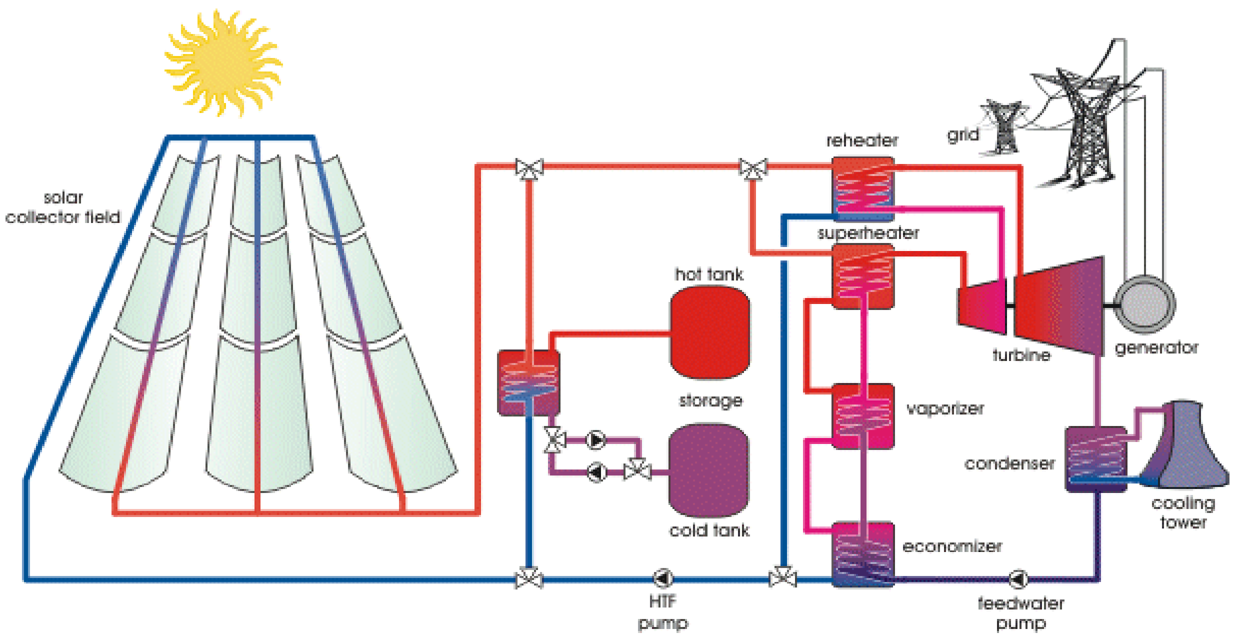



**Figure 8. A schematic of a parabolic trough concentrated solar power plant. (source: www.volker-quaschning.de)**

## Limitations

### *Water Usage*

Electric power plants that use steam-powered turbines for generating electricity are inherently water intensive. CSP plants are no different from coal plants in this way and use just about the same amount of water (Mancini, 2008). The real problem is the issue of water scarcity in regions where CSP plants are most effective. As evidenced before, CSP plants will only be commercially viable in the southwestern U.S. at present. This hot, arid region already contends with issues of water scarcity. Nearly all power plants built in the Southwest today use closed-loop cooling systems which are very water efficient compared to single use, or 'once-trough', systems. A re-circulating system uses about 23 gallons per MWh for cooling and generation, thus a 300 MW CSP plant would consume about 69,000 gallons per hour. This is considerably less water than a traditional, 'once-through' plant which would require 7,500–2,000 gallons per MWh (Baum, 2003). However, even in a closed-loop system water usage is an issue as about 5% of the total water used will be lost to evaporation (NETL, 2007). This is problematic for the water scarce regions that CSP plants need to be built in, such as the southwestern U.S. The annual precipitation in this region is exceptionally low, as evidenced in Figure 15. Compare these rates of precipitation to that of the New York City region, which receives around 40" of precipitation per year (Hypertextbook, 2005). In areas with such serious water scarcity issues, addressing the water usage associated with CSP will be crucial to making it a viable energy solution.

*Land Usage*

CSP plants will have to be significantly scaled up in order to provide enough electricity output to meet future demands. However, there are many limiting factors to where CSP plants can be built. CSP is most efficient when built on land with a 1 percent or lower grade and where constant solar input is most intense. This means that regions with extensive cloud cover are not acceptable for construction, nor are areas with significant pitches. Furthermore, habitats or sacred land sites must be protected, adding to the challenge of selecting an adequate location for a CSP plant.

**Renewable and Free**

The fuel for a CSP plant comes directly from the sun, a renewable energy source that is completely free to harvest. Earth receives about 198 watts of energy per square meter at its surface. This is a significant amount of energy that is consistently available for harvest. The sun is also accessible in many parts of the country, albeit in varied intensities, with the southwest United States receiving the most intense sunlight. Currently, CSP technology is the most applicable in this region, which makes it a viable option for growing electricity demand in the southwest.

**Clean Power Plant Technology**

Electricity generated through CSP has limited impacts on human health and the environment. The energy source comes directly from the sun so there is no destructive extraction process. There is also no combustion process which eliminates the issue of hazardous air emissions. In most electric generation systems, the fuel must be combusted to release heat for use in generation. With CSP, energy from the sun is directly utilized for the heat used in the electricity generation process. This lack of a conversion step is a key component in what makes CSP such a clean energy source.

**Grid-Ready**

The majority of power plants in the US utilize steam-powered turbines to generate electricity. Since CSP is designed to power these types of turbines, existing power plants can be retrofitted with CSP systems. Much of the electric infrastructure currently in place, such as power plants and transmission lines, would be compatible with CSP systems, making it easier to tie CSP into the existing electric grid. This will avoid the costs associated with a dramatic overhaul of the grid. Further, CSP can be used in conjunction with other traditional fuels, such as natural gas, at a power plant. In this scenario, CSP would be used to generate electricity during hours with abundant sunlight. When the sun goes down, natural gas can be used to generate electricity. This type of combined fuel system may be a good stepping stone on the path to plants that run entirely on CSP.

**Storage Potential**

One of the most problematic aspects of current solar technology is its inability to provide energy when the sun goes down. While power storage systems do exist, such as batteries in PV systems, their capabilities are limited. CSP has shown potential in storing significant amounts of heat through the use of molten salts. These salts are used as the system's heat exchange fluid but they can also be stored and later used to generate electricity. If a CSP plant is producing more electricity than the grid demands, some of the molten salt can be diverted from the electricity generation process and placed into a storage tank. The tank essentially acts as a giant thermos, allowing the molten salt to retain the heat it has absorbed from the sun. When this reserve heat is needed, for instance if cloud cover reduces the plant's ability to generate electricity directly from the sun, the stored molten salts can be piped back into the generation process to produce electricity. Currently, molten salts used in this capacity have a demonstrated storage capability of about six hours.

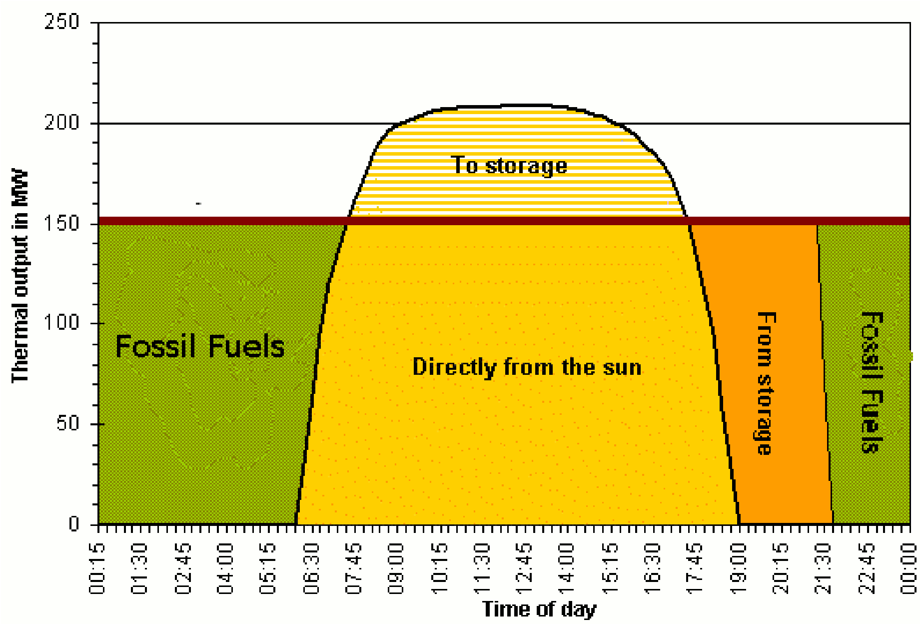



**Figure 9. The load pattern of a power plant utilizing both CSP and a fossil fuel source to generate electricity. During daytime hours, sunlight directly generates all electricity demanded with any excess heat stored for later use. When the sun goes down, either stored heat or fossil fuel combustion can be used to generate electricity. (source: www.volker-quaschning.de)**

Now that it is clear how solar technologies work, the rationale for a focus on CSP in this program design will be explained. The methods of implementation for H.R. 2774 through the program design and budget requirements, and measurement of success will also be discussed.

## PROGRAM DESIGN

Implementation of H.R. 2774 will center around two major areas of concern: finding the solution to the key technical issue of storage, as well as increasing public awareness and investor confidence in solar power. The conversion of solar energy to electricity can be achieved through several different technologies, as presented in H.R. 2774. However, CSP in particular has two main advantages which merit a focus on this technology during implementation of the bill. First, CSP has the most potential for efficient and inexpensive storage which can allow it to become competitive with other conventional forms of energy. Second, it has real potential for integration with the existing infrastructure. With a focus on improvement in these technologies, H.R. 2774 will work to create a strategic alliance between public and private technology supporters, aimed at gaining a substantial amount of capital to invest in CSP. In the first quarter of 2008, coal lobbyists spent $5 million to promote the continued use of coal as an energy resource. By contrast, the solar lobby spent only $75 thousand. There is a great need for a mechanism to create political and financial momentum in the push for solar power in the United States.

CSP is a maturing technology and therefore several issues must be dealt with before it will be considered completely viable as an energy alternative. Therefore, the first year of implementation is aimed at combining the resources and the right people to make successful strides in technological advances. The main obstacle to overcome is storage. As the sun's energy is only available during daylight hours and is restricted during periods of cloudiness, energy must be stored for use outside of peak supply periods. Current technology allows approximately six hours of storage which is insufficient for an uninterrupted power supply. Storage capacity will need to reach sixteen hours in order for continuous twenty four hour use, seven days per week.

The program outlined here will provide the funds and resources necessary for R&D aimed at extending the operating time of CSP facilities, and supplying electricity on demand. If thermal storage capabilities are increased, CSP will provide a continuous supply of electricity; further control over storage will allow thermal energy to be released as necessary to satisfy electricity demand. Operating with these capabilities would make CSP facilities reliable and truly cost-effective. With a foundation of advanced thermal storage technology, CSP can expand on a large scale. Therefore, the program design options discussed here will focus on thermal storage capacity as the priority R&D goal. A secondary goal is to increase the market share of CSP by improving investor confidence. The plan is to give potential investors the technical information they need to feel comfortable investing in concentrated solar power. To help spur the demand for CSP, a marketing initiative has also been included in this program design that targets audiences such as utilities, state governments and Public Utility Commissions. This broader marketing initiative will help generate demand for this technology as states and local governments look to modify their mix of energy sources.

H.R. 2774 appropriates $5 million during the first year of implementation. In this program design for CSP, The Department of Energy (DOE) will distribute funds to grant recipients to use toward research and development aimed at effectively addressing the issue of storage. Several options were considered for the program design; however, the following considerations were incorporated into the final program design.

- ***Program focus***- A concentration on improved storage capacity in CSP systems will lead to the increase in technology necessary to reach cost parity with traditional energy sources, and thereby lead to investor confidence and support.
- ***Eligibility/ Research Path***- Grants will be awarded to research facilities with the potential for commercial application studies. Recipients may be private, non-profit or public sector organizations.
- ***Funding Levels***- Recipients will be guaranteed funding for five years, removing the burden of re-application and allowing researchers to focus on their work. Opportunities for additional funds in the amount of $18 million over five years will be provided through incentive programs based upon performance and progress. Recipients will be required to match funds in order to maximize the potential for technological advancement
- ***Information and Marketing***- Marketing will be conducted by an outside contractor but coordinated by a DOE public relations associate. A centralized database will retain up to date information on CSP and document progress made by grant recipients. Quarterly newsletters, an annual report and an annual conference will facilitate the sharing of information and open lines of communication between all interested parties.

**Organization, Staffing Plan and Budget**

The project will run within the Department of Energy's Golden Field Office, under the direction of the Solar Branch Chief in the Renewable Energy Projects Division. The Department of Energy's Golden Field Office already houses the Solar Branch Chief in the Renewable Energy Projects Division. Several staff members will be borrowed from related departments and therefore it is most efficient to locate the office in Golden. Figure 10 represents the staffing plan of the first year budget.

These positions were chosen based upon a need to keep costs low, while employing the most efficient and well suited individuals for specific tasks. A full-time, permanent project manager along with one full-time project assistant will be hired. Two existing grants specialists from within the DOE will be hired to devote approximately 20% of their productive hours to the project. An Internet technology specialist will also be hired on a full-time, one-year contract. An existing communications specialist within the DOE will also commit 20% of his or her working hours to the project, acting as liaison between the public relations and event planning organization contracted for this project. Although this program design accounts for only the first year of implementation, it should be noted that in year-two a full-time program analyst will be hired to oversee the work of grant recipients through on-site inspections and reporting to the project manager. This analyst will have a science background, be familiar with the technology of CSP, and will continue over the remaining four years to ensure that the highest quality R&D is being carried out as intended by this legislation and program design.

The focal point of the staffing plan involves the multi-stakeholder Advisory Board, comprised of industry professionals from universities, organizations or research facilities within the sector. The project manager will recruit the Board Chair, who will then work to fill the remaining seats. These members will participate on a volunteer basis to supervise all operations and counsel grant administrators regarding the selection and distribution of funds. Members will also work very closely with the project manager to ensure that funds are utilized efficiently and in the manner intended by the legislation.

The project manager hired to administer this program will ideally have experience in each area of the design. The applicant should have experience with grant proposal and dispersal procedures, knowledge of the science behind CSP technologies (and storage issues in particular), as well as experience with performance management. Each of the support positions will reinforce these strata of operations. For a complete description of positions and responsibilities, please see Appendix A.

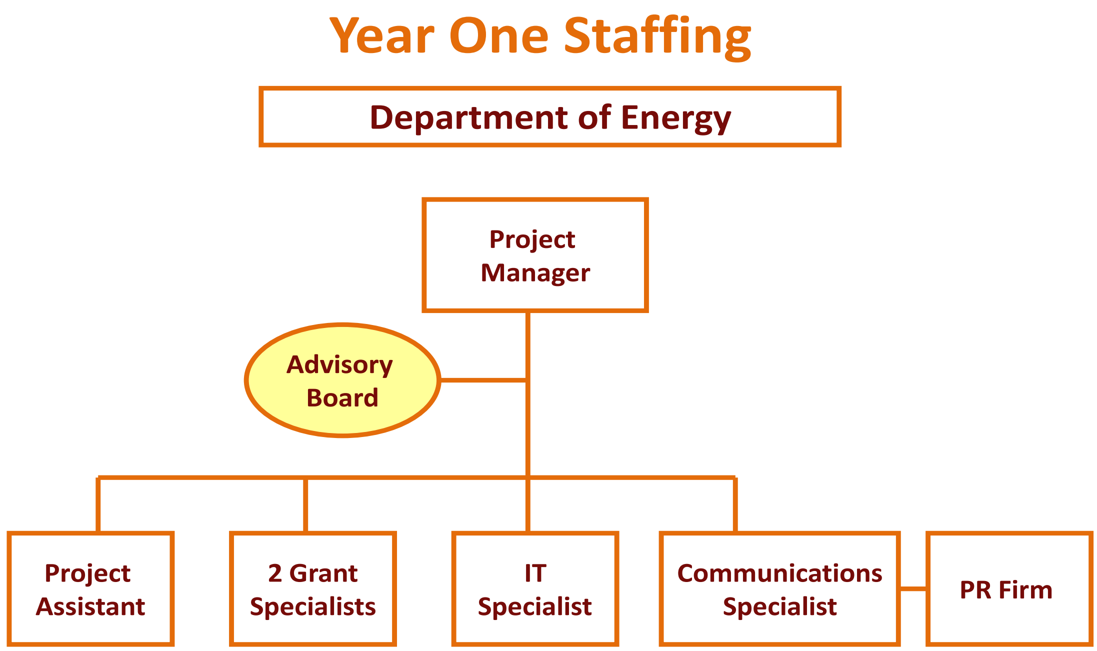



**Figure 10: Organizational Structure of the HR 2774 Program within the Department of Energy's Renewable Energy Field Office.**

## Budget

In the first year of the five-year budget, H.R. 2774 allocates $5 million for R&D. Seven percent, or $350,000 of these funds will be allocated for salary and benefits for staff. Salary and benefit amounts are based on the standard government grade scale for Denver, Colorado and take into consideration the amount of productive time each employee will devote to the project. Three percent, or $150,000, will be used for operational expenses. The remaining $4.4 million will be distributed in the form of storage-focused research grants. Our program design requires grant recipients to provide matching funds. By supplementing researchers who have secured other funding pathways, the program will be more effective and will be able to commence more quickly. Many federal grant programs institute this matching funds concept. The DOE's National Industrial Competitiveness through Energy, Environment, and Economics grants program has a similar requirement. This program is designed to "reduce the use of energy and energy intensive feed-stocks and reduce the generation of wastes in industry," and states that, "federal funds will be awarded to States and industry applicants that can match DOE federal funds at 50 percent" (National Industrial, 2008). For the complete break-down of allocated funds see Appendix C.

**Personnel**

This request includes $232,500 for personnel services. The total includes three new hires: the project manager, the project assistant, and the IT specialist. It also includes partial funding for three legacy employees at the Golden Field Office who will be dedicating approximately 20% of their time and resources for the Solar Energy Research and Development Program. The public relations and event planning firm will be a contracted organization.

The project manager will be hired by the manager of the Golden Field Office at the Department of Energy's Energy Efficiency and Renewable Energy division, prior to the January 1st authorization date. The Project Manager will start on January 1st and will be involved with the Solar Energy Research and Advancement Act from the start. The manager will have hiring authority for the rest of the program staff. Figure 11 shows the distribution of funding.

**Communication**

The request for funding for communication, utilities, and miscellaneous is $500. This is to cover various costs such as three additional phone lines for the newly hired staff members added to the Golden Field Office of the DOE.

**Printing**

The request for funding for printing cost is $50,500. This includes $500 for additional internal printing cost for the three additional staff members added to the Golden Field Office of the DOE, and $50,000 for the cost of printing and mailing Solar Energy Research and Development Program promotions.

**Travel**

The request for travel is $64,200; this includes $34,200 for staff travel, including expected cost of the hiring process and research needs of the staff. The request also includes $30,000 for travel costs of the voluntary board, including expected costs of travel stipends and one meeting in fiscal year 1. The request also includes $5,000 in travel expenses for the annual conference, including keynote speaker.

**Rental Payments for OSA**

The request includes $77,000 for payments to the Office of the State Actuary; this is to account for the increased headcount at the Boulder Field Office.

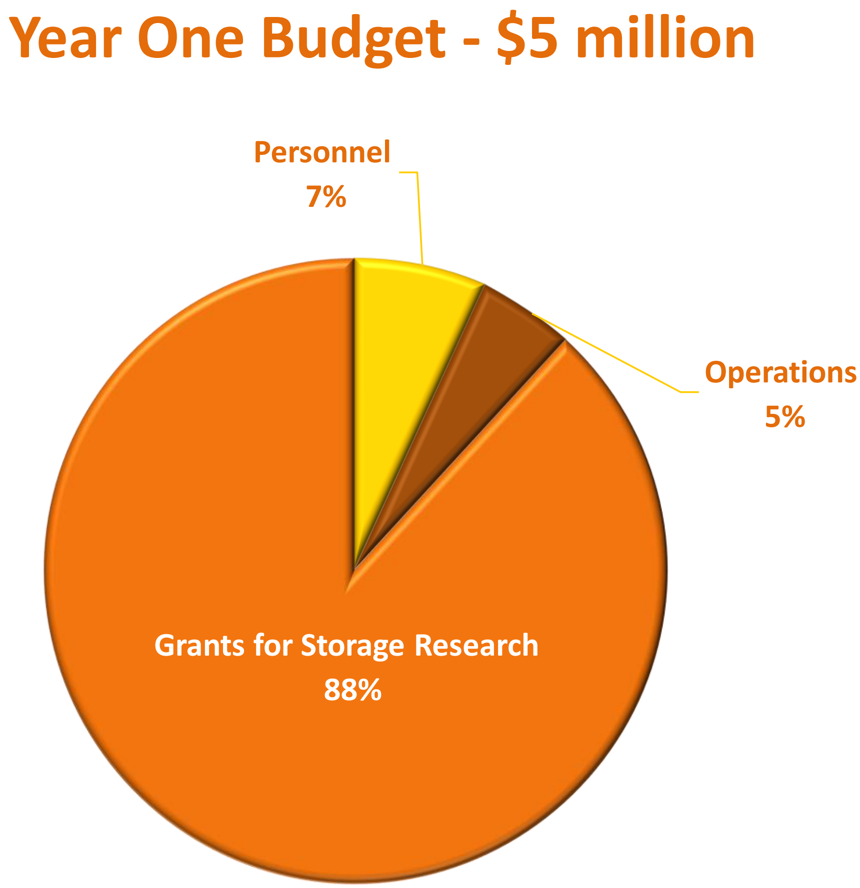



**Figure 11: The distribution of H.R. 2774 funding in the first year.**

**Measures of Success**

Measures of success of the implementation of H.R. 2774 will stem from three categories. First, a competitive grant program will provide the mechanism for research and development in the area of increased thermal storage. Funds will be distributed among recipients who will match the amount awarded as a stipulation to participation. By combining DOE funds of $4.4 million with matching funds, a total of $8.8 million combined will be applied toward this research in the first year.

Successful grants distribution will be determined from data collection and reporting of data. Grant recipients will be required to provide quarterly and annual progress reports and will be visited by the program analyst regularly. The following outputs are projected for this task during fiscal year 1:

- Solicitation of 25-50 applicants by July 31
- Distribute $4.4 million to grant recipients by October 1
- 1 progress report from each grantee by December 1
- 1- year and 5-year strategic plans from each grantee by December 31

Through the second component of the program, a centralized database will be available to interested parties so that progress can be monitored at all times. This database will be created and maintained by the IT specialist in conjunction with the project manager and Advisory Board. Information will be collected from grant applicants and recipients, marketing associates, current CSP facilitators, businesses and partnerships and public utilities. Information stored within it will include data regarding storage capability increases, budget allocation, partnerships, technology, and correspondence with project-related personnel. Feedback from users will provide measures of success for both research and marketing outputs, and the expected result will be improved communication between researchers, utilities, investors and other interested parties. While the majority of information stored in this database will be available to the public, certain areas involving research findings or material directly related to grant recipients and the DOE will remain in a restricted access domain. The following outputs are projected for this task in fiscal year 1:

- Website complete by February 15
- Comprehensive Project database complete by July 31
- Extensive research on top 5-10 CSP programs globally by July 31

Finally, the marketing campaign will be monitored through the number of relevant advertisements, website hits, news stories and similar public awareness indicators identified. In order to ascertain the effectiveness of this campaign, 25-30 surveys will be administered bi-annually, information will be collected weekly from the project database, and subscriptions to 10-15 renewables and/or technology news services publications will be collected. The following outputs are projected for this task in fiscal year 1:

- 50 advertisements for RFP's submitted by February 15
- 10% increase in the mention of CSP in clippings between February and December
- 11,000 website hits beginning March 1
- Initial newsletter sent by November 1
- 5,000 annual conference invitations by December 1
- Development of solar blog with 1,000 RSS subscribers

It is projected that these indicators will translate into increased investor confidence and support, and the ultimate realization of the program's main goals. Reducing the costs of CSP will render the technology competitive with other traditional base load sources. Marketing and increased political support will motivate a new demand for solar energy. If the renewable portion of the US electricity profile increases to 15% by 2020, the US will be able to meet its electricity needs and reduce the negative impacts of fossil fuel combustion.

## Master Calendar: Year One

The program was designed so that the first year of implementation would lay the groundwork for subsequent years when the most significant findings are expected in R&D. As it has been established here, the three focal points of this program are the grant program, to research CSP technologies and increase the amount of storage capacity, the CSP database, to increase the knowledge base of stakeholders and the general public, and finally the marketing and public relations strategy geared toward political support and investment, and increasing the demand for solar technology.

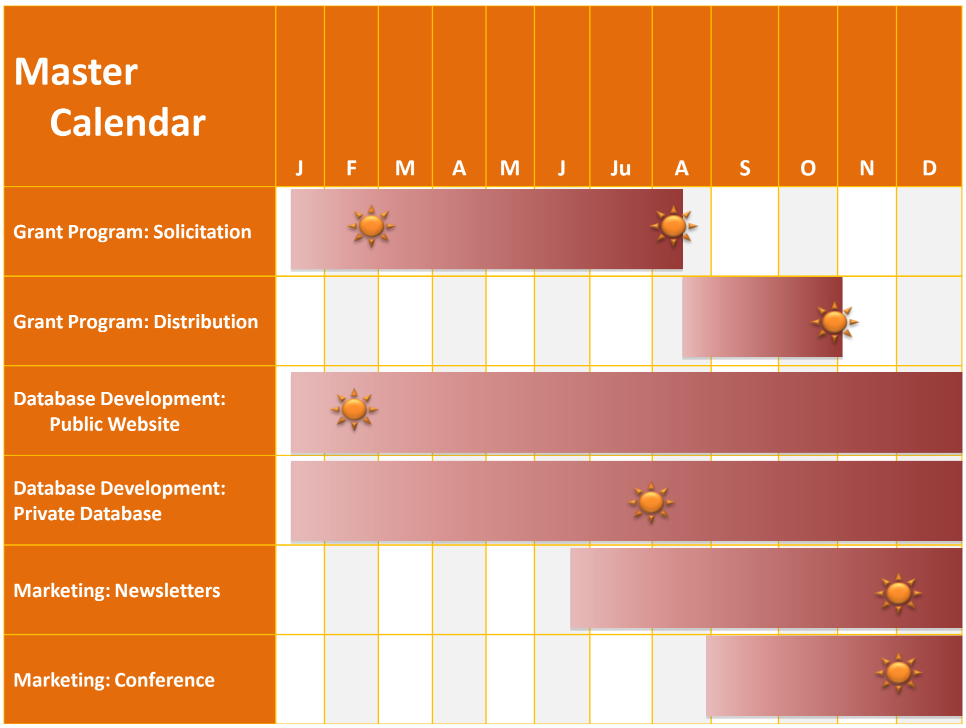



**Figure 12. Illustrates at which times during the first fiscal year various objectives will be met. For a further breakdown of the first year timeline, please see Appendix C.**

Within the first year, the following tasks will be fulfilled:

- Hire the full staff
- Distribution of research grants
- Establish online knowledge database
- Program evaluations
- Establish marketing strategy
    - Printed and online newsletters
    - Annual conference

See Appendix D for the full, year-one master calendar.

## CONCLUSION

Reliance on coal to meet the demand for its energy needs has caused the United States to unwittingly contribute to a decline in environmental quality, while placing health burdens on its citizens. Enough is known today about the harmful effects of coal extraction and combustion to warrant significant measures aimed at reducing this reliance on coal, and incorporating renewable, clean energy technologies into the US energy profile.

Solar power is potentially one of the most cost-effective and environmentally safe types of renewable energy. With R&D, investment and political support CSP in particular can reach commercial viability. H.R. 2774 is the mechanism which will allow this to happen.

The current problems with CSP can be addressed given proper time and investment. Storage capacity must be increased to sixteen hours, providing energy during the evening and low sunlight periods. Although CSP plants would be located within the southwest region of the United States, transmission throughout the national grid would not be an issue. The proportion of the energy profile replaced by CSP would still be significant enough to see substantial decreases in the harmful effects of coal-fired energy.

Solar energy is not the only answer to the problem of traditional energy, but it is certainly one answer. The program design in this report provides the framework for achieving great strides in R&D for CSP. Much work is needed beyond the scope of this outline for year one. However, once a solid base of personnel, funding and measurements of success are firmly established, this program will develop into the vehicle necessary for real change in the alternative energy arena.

## FREQUENTLY ASKED QUESTIONS

Q: Can CSP be feasibly integrated with the current grid?
A: Power plants in the US primarily use steam-powered turbines to generate electricity. CSP is designed to power these types of turbines as well; therefore existing power plants can be retrofitted with CSP systems.

Q: Will research be conducted in-house or through grant dispersal?
A: Grants will be awarded to universities, already existing CSP companies, etc, and administered through DOE. Reporting will be required to bring the knowledge back in-house and compiled into a central database.

Q: What will the primary goal of the communications specialist be?
A: The communications specialist will work with the public relations firm to ensure that up-to-date information is being presented to the public and to stakeholders on time, and regularly. The CSP conference, newsletter and database will be the main medium for this information.

Q: From where would members of the Advisory Board come?
A: Volunteer members will be recruited from research facilities, universities and industry.

Q: Will grant recipients be required to attend solar conferences?
A: Yes. It is imperative that grant recipients keep up-to-date on the research and findings of other recipients and of the CSP industry in general.

Q: Is the $5 million for the entire bill, or just the first year?
A: $5 million will be authorized for fiscal year 1; $7 million for fiscal year 2009, $9 million for fiscal year 2010, $10 million for fiscal year 2011, and $12 million for fiscal year 2012.

Q: Who will these newsletters be sent to, and how will they be distributed?
A: Newsletters will be distributed to all interested parties from a mailing list compiled through the centralized database and maintained by the program assistant.

Q: Why is the office located in Golden CO?
A: The Department of Energy's Golden Field Office already houses the Solar Branch Chief in the Renewable Energy Projects Division. Several staff members will be borrowed from related departments and therefore it is most efficient to locate the office in Golden.

Q: How efficient is CSP compared with coal-fired energy?
A: Approximately 25% of the energy captured by the sun is transformed into electricity through the power tower system, compared with 38% relative efficiency of coal.

Q: How many CSP plants are currently in use or under construction in the United States?
A: There are now 18 CSP systems within the US, either planned, under construction or running.

Q: What types of CSP plants are running? How many megawatts do they provide?
A: There nine functioning CSP plants in the US today; these are a combination of power tower, trough and dish systems. According to Scientific American, as of September 19th, 2007, these plants supply 350 MW yearly. One MW of solar energy can power about 250 homes, or 87500 homes a year (SEIA.org)

Q: What is molten salt?
A: Molten salt is raised to a temperature above its melting point. In this form, it has the ability to store thermal energy. The salt used in the process is mixture of sodium and potassium nitrate, the same ingredients used in garden fertilizer.

Q: Is it environmentally safe?
A: According to the material data safety sheet molten salt is believed to have essentially no impact on the environment.

Q: How much does it cost?
A: Molten salt used for thermal storage costs $40 to $50 per kilowatt-hour with an energy return rate of more than 90 percent.

Q: How hot does it get?
A: The molten salt is a mixture of 60 percent sodium nitrate and 40 percent potassium-nitrate, commonly called saltpeter; the salt melts at 430 deg. F and is kept liquid at 550 deg. F in an insulated cold storage tank. The salt is them pumped to the top of the tower, where concentrated sunlight heats it in a receiver to 1050 deg F.

Q: What are the storage tanks like?
A: The tanks are well insulated and can store energy for up to a week. As an example of their size, tanks that provide enough thermal storage to power a 100-megawatt turbine for four hours would be about 30 feet tall and 80 feet in diameter. Studies show that the two-tank storage system could have an annual efficiency of about 99 percent.

## GLOSSARY

**Acid mine drainage:** This refers to water pollution that results when sulfur-bearing minerals associated with coal are exposed to air and water forming sulfuric acid and ferrous sulfate. The ferrous sulfate can further react to form ferric hydroxide, or yellowboy, a yellow-orange iron precipitate found in streams and rivers polluted by acid mine drainage.

**Acid Rain:** Also called acid precipitation or acid deposition, acid rain is precipitation containing harmful amounts of nitric and sulfuric acids formed primarily by nitrogen oxides and sulfur oxides released into the atmosphere when fossil fuels are burned. It can be wet precipitation (rain, snow, or fog) or dry precipitation (absorbed gaseous and particulate matter, aerosol particles or dust). Acid rain has a pH below 5.6. Normal rain has a pH of about 5.6, which is slightly acidic. The term pH is a measure of acidity or alkalinity and ranges from 0 to 14. A pH measurement of 7 is regarded as neutral. Measurements below 7 indicate increased acidity, while those above indicate increased alkalinity.

**Baseload:** The minimum amount of electric power delivered or required over a given period of time at a steady rate.

**Baseload Capacity:** The generating equipment operated during normal demand to serve loads on an around-the-clock basis

**Baseload Plant:** A plant, usually housing high-efficiency steam-electric units, which is normally operated to take all or part of the minimum load of a system, and which consequently produces electricity at an essentially constant rate and runs continuously. These units are operated to maximize system mechanical and thermal efficiency and minimize system operating costs.

**Bioaccumulation:** Occurs when an organism absorbs a toxic substance at a rate greater than that at which the substance is lost; hence the toxin accumulates in the body.

**Biomagnification:** also known as bioamplification or biological magnification, it is the increase in the concentration of a substance that occurs in a food chain.

**Btu (British Thermal Unit):** A standard unit for measuring the quantity of heat energy equal to the quantity of heat required to raise the temperature of 1 pound of water by 1 degree Fahrenheit.

**Capacity:** The amount of electric power delivered or required for which a generator, turbine, transformer, transmission circuit, station, or system is rated by the manufacturer.

**Carbon dioxide ($CO_2$):** A colorless, odorless, non-poisonous gas that is a normal part of Earth's atmosphere. Carbon dioxide is a product of fossil-fuel combustion as well as other processes. It is considered a greenhouse gas as it traps heat (infrared energy) radiated by the Earth into the atmosphere and thereby contributes to the potential for global warming. The global warming potential (GWP) of other greenhouse gases is measured in relation to that of carbon dioxide, which by international scientific convention is assigned a value of one (1). Also see Global warming potential (GWP) and Greenhouse gases.

**Clean Coal:** a term used to describe methods and technologies intended to reduce the environmental impact of using coal as an energy source. These efforts can include chemically washing minerals and impurities from the coal, gasification, treating the flue gases with steam to remove sulfur dioxide, and other proposed technologies to capture the carbon dioxide from the flue gas. The coal industry uses the term "clean coal" to describe technologies designed to enhance both the efficiency and the environmental acceptability of coal extraction, preparation and use, with no specific quantitative limits on any emissions, particularly carbon dioxide.

**Coal:** A readily combustible black or brownish-black rock whose composition, including inherent moisture, consists of more than 50 percent by weight and more than 70 percent by volume of carbonaceous material. It is formed from plant remains that have been compacted, hardened, chemically altered, and metamorphosed by heat and pressure over geologic time.

**Cogenerator:** A generating facility that produces electricity and another form of useful thermal energy (such as heat or steam), used for industrial, commercial, heating, or cooling purposes. To receive status as a qualifying facility (QF) under the Public Utility Regulatory Policies Act (PURPA), the facility must produce electric energy and "another form of useful thermal energy through the sequential use of energy," and meet certain ownership, operating, and efficiency criteria established by the Federal Energy Regulatory Commission (FERC). (See the Code of Federal Regulations, Title 18, Part 292.)

**Collection tower**: A tall "thermos" located at the focus of a field of flat mirrors arranged in a parabolic array (CSP power tower) that collects and concentrates solar radiation in a thermal heat transfer fluid. Depending on the fluid used, the thermal energy can be concentrated up to 600 times in an efficient system.

**Commercial:** The commercial sector is generally defined as nonmanufacturing business establishments, including hotels, motels, restaurants, wholesale businesses, retail stores, and health, social, and educational institutions. The utility may classify commercial service as all consumers whose demand or annual use exceeds some specified limit. The limit may be set by the utility based on the rate schedule of the utility.

**Concentrated Solar Power**: Any solar technology that uses mirrors to concentrate solar energy and convert it into thermal or heat energy; this thermal energy is then used to generate electricity.

**Consumption (Fuel):** The amount of fuel used for gross generation, providing standby service, start-up and/or flame stabilization.

**Current (Electric):** A flow of electrons in an electrical conductor. The strength or rate of movement of the electricity is measured in amperes

**Demand (Electric):** The rate at which electric energy is delivered to or by a system, part of a system, or piece of equipment, at a given instant or averaged over any designated period of time.

**Dish engine systems:** Similar to how a satellite dish concentrates a signal, these dishes instead concentrate sunlight with a heat engine located at the focal point to collect thermal energy and generate electricity. These power generators are small, mobile units that can be operated individually or in clusters, in urban or remote locations.

**Desiccant:** Any substance that removes moisture.

**Energy:** The capacity for doing work as measured by the capability of doing work (potential energy) or the conversion of this capability to motion (kinetic energy). Energy has several forms, some of which are easily convertible and can be changed to another form useful for work. Most of the world's convertible energy comes from fossil fuels that are burned to produce heat that is then used as a transfer medium to mechanical or other means in order to accomplish tasks. Electrical energy is usually measured in kilowatt hours, while heat energy is usually measured in British thermal units.

**Energy Efficiency:** Refers to programs that are aimed at reducing the energy used by specific end-use devices and systems, typically without affecting the services provided.

These programs reduce overall electricity consumption (reported in megawatt hours), often without explicit consideration for the timing of program-induced savings. Such savings are generally achieved by substituting technically more advanced equipment to produce the same level of end-use services (e.g. lighting, heating, motor drive) with less electricity. Examples include high-efficiency appliances, efficient lighting programs, high-efficiency heating, ventilating and air conditioning (HVAC) systems or control modifications, efficient building design, advanced electric motor drives, and heat recovery systems.

**Fossil Fuel:** Any naturally occurring organic fuel found in the Earth's surface, such as petroleum, coal, and natural gas. Fossil fuels are formed from long-buried plants and animals.

**Fuel:** Any substance that can be burned to produce heat; also, materials that can be fissioned in a chain reaction to produce heat.

**Gas:** A gaseous-phase fuel burned under boilers and by internal combustion engines for electric generation. These include natural, manufactured and waste gas.

**Gas Turbine Plant:** A plant in which the prime mover is a gas turbine. A gas turbine consists typically of an axial-flow air compressor, one or more combustion chambers, where liquid or gaseous fuel is burned and the hot gases are passed to the turbine and where the hot gases expand to drive the generator and are then used to run the compressor.

**Generator:** A machine that converts mechanical energy into electrical energy.

**Gigawatt (GW):** One billion watts.

**Gigawatt hour (GWh):** One billion watthours.

**Greenhouse gas (GHGs):** the gases present in the earth's atmosphere which warm near-surface global temperatures through the greenhouse effect.

**Greenhouse Effect:** The increasing mean global surface temperature of the earth caused by gases in the atmosphere (including carbon dioxide, methane, nitrous oxide, ozone, and chlorofluorocarbon). The greenhouse effect allows solar radiation to penetrate but absorbs the infrared radiation returning to space.

**Grid:** The layout of an electrical distribution system.

**Hydroelectric Plant:** A plant in which the turbine generators are driven by falling water.

**Industrial:** The industrial sector is generally defined as manufacturing, construction, mining agriculture, fishing and forestry establishments Standard Industrial Classification (SIC) codes 01-39. The utility may classify industrial service using the SIC codes, or based on demand or annual usage exceeding some specified limit. The limit may be set by the utility based on the rate schedule of the utility.

**Kilowatt (kW):** One thousand watts.

**Kilowatt hour (kWh):** One thousand watt hours.

**Load (Electric):** The amount of electric power delivered or required at any specific point or points on a system. The load requirement originates at the energy-consuming equipment of the consumers.

**Longwall mining**: A form of underground coal mining where a long wall (typically about 250-400 m long) of coal is mined in a single slice (typically 1-2 m thick).

**Megawatt (MW):** One million watts.

**Megawatt hour (MWh):** One million watt hours.

**Methyl Mercury ($CH_3Hg^+$):** an organometallic cation and a bioaccumulative environmental toxin. Its anthropogenic sources are the burning of wastes containing inorganic mercury and the burning of fossil fuels, particularly coal.

**Net Metering:** An electricity policy that allows consumers who own wind or solar generation facilities to tie into the electricity grid. This eliminates the need for large battery backup systems and inputs energy into the grid during bright, sunny days (when energy demand is high) for a profit and purchases it back at night and during cloudy or windless days (when electricity demand is generally lower). Although this has potential to supplement the power grid during times of maximum load, it puts the burden of implementation and maintenance on fragmented consumers and can have dangerous consequences when utilities need to shut down the grid locally for maintenance.

**Nitric Oxide (NO):** A colorless, poisonous gas, NO is formed by the oxidation of nitrogen or ammonia.

**Nitrogen Dioxide ($NO_2$):** A highly poisonous brown gas often present in smog and automobile exhaust.

**Nitrous Oxide ($N_2O$):** A major greenhouse gas, $N_2O$ is emitted by bacteria in soils and oceans. Agriculture is the main anthropogenic source.

**Nuclear Fuel:** Fissionable materials that have been enriched to such a composition that, when placed in a nuclear reactor, will support a self-sustaining fission chain reaction, producing heat in a controlled manner for process use.

**Nuclear Power Plant:** A facility in which heat produced in a reactor by the fissioning of nuclear fuel is used to drive a steam turbine.

**Ozone ($O_3$):** An almost colorless gaseous form of oxygen that is abundant in the stratosphere. Ozone can also occur at ground level (see Smog).

**Parabolic mirror:** A reflective symmetrically curved object designed to capture incoming radiation and concentrates the sunlight onto a pipe located at the focus (single central point). A fluid circulating inside the pipe collects the energy and transfers it to a heat exchanger which, in turn, produces steam to drive a conventional turbine.

**Peak Demand:** The maximum load during a specified period of time.

**Peak Load Plant:** A plant usually housing old, low-efficiency steam units, gas turbines, diesels or pumped-storage hydroelectric equipment normally used during the peak-load periods.

**Petroleum:** A mixture of hydrocarbons existing in the liquid state found in natural underground reservoirs, often associated with gas. Petroleum includes fuel oil No. 2, No. 4, No. 5, No. 6, topped crude, Kerosene and jet fuel.

**Petroleum (Crude Oil):** A naturally occurring, flammable liquid composed principally of hydrocarbons. Crude oil is occasionally found in springs or pools but usually is drilled from wells beneath the earth's surface.

**pH:** The measure of the acidity or alkalinity of a solution.

**Photovoltaics (PV):** A field of technology and research related to the use of solar cells or semiconductors for the conversion of sunlight directly into electricity.

**Plant:** A facility at which are located prime movers, electric generators, and auxiliary equipment for converting mechanical, chemical, and/or nuclear energy into electric energy. A plant may contain more than one type of prime mover. Electric utility plants exclude facilities that satisfy the definition of a qualifying facility under the Public Utility Regulatory Policies Act of 1978.

**Power:** The rate at which energy is transferred. Electrical energy is usually measured in watts. Also, used for a measurement of capacity.

**Power tower systems:** A CSP system that uses a large field of rotating mirrors to track the sun and focus the sunlight onto a heat-receiving panel on top of a tall tower. The fluid in the panel collects the heat and either uses it to generate electricity or stores it for future use.

**Redundancy:** The national electricity transmission grid is a network of power stations and transmission circuits that allow areas of high demand to purchase power from areas of cheapest production, often located far away. The web of interconnections between power producers and consumers allows for multiple distribution paths to insure that inoperative links can be bypassed.

**Residential:** The residential sector is defined as private household establishments which consume energy primarily for space heating, water heating, air conditioning, lighting, refrigeration, cooking and clothes drying. The classification of an individual consumer's account, where the use is both residential and commercial, is based on principal use.

**Retail**: Sales covering electrical energy supplied for residential, commercial, and industrial end-use purposes. Other small classes, such as agriculture and street lighting, also are included in this category.

**Room and pillar mining:** a mining system in which the mined material is extracted across a horizontal plane while leaving "pillars" of untouched material to support the overburden and, in turn, creating open areas or "rooms" underground. It is usually used for relatively flat-lying deposits, such as those that follow a particular stratum.

**Silica Gel:** Gelatinous silica in a form that readily absorbs water from the air.

**Smog:** A kind of air pollution; the word "smog" is a blending of the words "smoke" and "fog;" smog is comprised mostly of ground level ozone and can have detrimental effects on human health.

**Solar Air Conditioning**: Any system that uses solar energy to cool the air.
Solar daylighting technology: any system which brings natural light into a building. One example is solar tubes which have an aperture and a reflective inner surface to direct sunlight. Another example is optical fiber which is simply a small cable that can carry focused sunlight and direct it where needed throughout a building.

**Stirling Engine:** A closed-cycle regenerative heat engine with a gaseous working fluid. "Closed-cycle" means the working fluid, the gas which pushes on the piston, is permanently contained within the engine's system. This also categorizes it as an external heat engine which means it can be driven by any convenient source of heat. "Regenerative" refers to the use of an internal heat exchanger called a 'regenerator' which increases the engine's thermal efficiency compared to the similar but simpler hot air engine.

**Steam-Electric Plant (Conventional)**: A plant in which the prime mover is a steam turbine.

**Subsidence**: The motion of a surface (usually, the Earth's surface) as it shifts downward.

**Sulfur**: One of the elements present in varying quantities in coal which contributes to environmental degradation when coal is burned. In terms of sulfur content by weight, coal is generally classified as low (less than or equal to 1 percent), medium (greater than 1 percent and less than or equal to 3 percent), and high (greater than 3 percent). Sulfur content is measured as a percent by weight of coal on an "as received" or a "dry" (moisture-free, usually part of a laboratory analysis) basis.

**Sulfur Dioxide ($SO_2$)**: A heavy, pungent toxic gas that is a major air pollutant emission released from the burning of fossil fuels.

**Sulfuric Acid ($H_2SO_4$):** A strong mineral acid that is soluble in water at all concentrations. Sulfuric acid is a component of acid rain, which is formed by atmospheric oxidation of sulfur dioxide in the presence of water. Sulfur dioxide is produced when sulfur-containing fuels such as coal or oil are burnt. Sulfuric acid is formed naturally by the oxidation of sulfide minerals, such as iron sulfide. The resulting water can be highly acidic and is called Acid Mine Drainage (AMD).

**Super-heated:** Superheating is when a liquid is heated to a temperature higher than its standard boiling point, without actually boiling. Superheated liquids can be stable above their usual boiling point if their pressure is higher than atmospheric pressure.

**Thermal Energy Storage Systems**: Any system that stores thermal energy for future use.

**Transformer**: An electrical device for changing the voltage of alternating current.

**Transmission**: The movement or transfer of electric energy over an interconnected group of lines and associated equipment between points of supply and points at which it is transformed for delivery to consumers, or is delivered to other electric systems. Transmission is considered to end when the energy is transformed for distribution to the consumer.

**Transmission System (Electric)**: An interconnected group of electric transmission lines and associated equipment for moving or transferring electric energy in bulk between points of supply and points at which it is transformed for delivery over the distribution system lines to consumers, or is delivered to other electric systems.

**Turbine**: A machine for generating rotary mechanical power from the energy of a stream of fluid (such as water, steam, or hot gas). Turbines convert the kinetic energy of fluids to mechanical energy through the principles of impulse and reaction, or a mixture of the two.

**Watt**: The electrical unit of power. The rate of energy transfer equivalent to 1 ampere flowing under a pressure of 1 volt at unity power factor.

**Watthour (Wh)**: An electrical energy unit of measure equal to 1 watt of power supplied to, or taken from, an electric circuit steadily for 1 hour.

## APPENDIX A: JOB DESCRIPTIONS

**Advisory Board**
Ten member volunteer board: Each member will hold the following responsibilities:

- Be fully versed in the goals and objectives of H.R. 2774
- Serve as an initial point of contact for program related inquiries in his/her state or province, agency or institution.
- Actively participate in all program activities and events, including regular attendance at advisory board meetings
- Serve on one or more advisory board strategic planning groups (when requested or consistent with his/her area of expertise) to promote specific aspects of program marketing or development
- Adhere to program partner guidelines and educate other state/provincial agencies, as well as public and private organizations, about what it means to be a program partner
- Be accessible to program staff for periodic inquiries concerning related business
- Work within his/her state or organization to secure in-kind services or related resources that may be required to address program priorities
- Maintain a proactive role in program operations, including provision of advice, support and feedback on all aspects of activity, including content development, marketing and the research, development and application of new technologies
- Oversee the grant approval and disbursement process
- Make suggestions to program staff regarding ideas for grant proposals and/or collaborations; identify potential supporters for the program
- Identify potential supporters of the program

**Project Manager**
New hire, permanent

- Review project proposal or plan to determine time frame, funding limitations, procedures for accomplishing project, staffing requirements, and allotment of available departmental resources to various phases of program
- Establish work plan and staffing for each phase of project, and arrange for recruitment or assignment of program personnel
- Formulate and define technical scope and objectives of program
- Define program objectives, scope, and level of effort
- Develop program strategies and plans; identify the methods and tools required for the program

- Get tasks off the ground, keep them on track and on budget, and resolve issues with customers
- Monitor progress against plan objectives
- Confer with project staff to outline work plan
- Identify and schedule project deliverables, milestones, and required tasks
- Assign duties, responsibilities, and scope of authority to project personnel
- Direct and coordinate activities of project personnel to ensure project progresses on schedule and within budget
- Review status reports prepared by program personnel and modify schedules or plans as required
- Ensure standards and procedures for project reporting and documentation
- Prepare project reports for management, client, or others
- Confer with project personnel to provide technical advice and to resolved problems
- Coordinate project activities with activities of business unit(s)
- Coordinate and respond to requests for changes from original specifications
- Develop quality assurance test plans
- Direct quality assurance testing
- Ensure easy access to information that is useful to users
- Keep close contact with key end-user representatives directly to ensure technologies are providing valuable information-sharing capabilities to partners
- Work closely with the end users, technologists, scientists and others to understand and prioritize goals and information needs, then develop system requirements and design specifications
- Directly supervise and advise Project Assistant

**Project Assistant**
**New hire, permanent**

- General support functions for all areas of program
- Maintain logs to assure that the required submittals (contracts, grant proposals) are current.
- Data entry
- Other duties as regularly assigned

**Grants Specialists (2)**
Part-time, inter-departmental

- Pre and Post award functions
- Develop and manage matching grant proposal

- Compile and analyze project, grant, and financial data
- Develop, monitor, and review grant applications
- Perform month-end reconciliations
- Establish, modify, and implement grant and accounting procedures
- Establish financial controls and systems for new grants/programs
- Make recommendations for corrections or budget transfers when needed
- Maintain data files
- Perform related duties as assigned

**IT Specialist**
One-year, full time contract

- Designs, prepares, edits and tests centralized computer database to maintain new and pre-existing CSP information
- Identifies computer-user problems and coordinates to resolve them
- Installs, configures and monitors local and wide-area networks, hardware and software
- Compiles, enters and processes information
- Provides customer and network administration services such as passwords, electronic mail accounts, security and troubleshooting
- Constructs, edits and tests computer system programs
- Conducts data system studies and prepares documentation and specifications for proposals

**Communications Specialist**
Part-time, inter-departmental

- Serves as advocate for the program by building and maintaining positive relationships with stakeholders and the public; offer advice on the strategy and policy of implementation
- Organizes media, community, consumer, industry, and governmental relations; political campaigns; interest-group representation; conflict mediation; and employee and investor relations
- Understands the attitudes and concerns of community, consumer, employee, and public interest groups to establish and maintain cooperative relationships with them and with representatives from print and broadcast journalism
- Drafts press releases and contacts people in the media who might print or broadcast the material

- Arranges and conducts programs to keep up contact between organization representatives and the public, for example speaking engagements; often prepares speeches for company officials
- Represents DOE at community projects
- Keeps the public informed about the activities of the agency and its officials

**P.R. Firm**

Contract hire, marketing firm

- Develops and implements a plan to publicize program in print, online and through personal contacts
- Submits program information to appropriate search engines on a regular basis
- Designs newsletter and maintains regular contact with partners
- Writes press releases and distributes them
- Researches and lists appropriate potential partners
- Acts as liaison between the program and partners
- Plans, coordinates and carries out annual conference

## APPENDIX B: LEGISLATIVE SECTION SUMMARY

**Section Summaries**

**Section 1- Short title**

- Solar Energy Research and Advancement Act of 2007

**Section 2- Definitions**

- Defines “Department” as the Department of Energy and “Secretary” as the Secretary of Energy

**Section 3- Thermal Energy Storage Research and Development Program**

- Establishes a program of research and development for low cost viable thermal energy storage technologies
- Authorization of Appropriations (See Figure 3)

**Section 4- Concentrating Solar Power Commercial Application Studies**

- Requires study on integration of CSP into regional electricity transmission systems, and transmission of CSP from high solar resource areas to other regional centers throughout the US
- Requires study of methods to reduce the amount of water used in CSP systems

**Section 5- Solar Energy Curriculum Development and Certification**

- Establishes a competitive grant program to strengthen the solar industry workforce
- Grants are awarded for up to three years and will be reported publicly

**Section 6- Daylight Systems and Direct Solar Light Pipe Technology**

- Establishes a program of research and development for demonstration assistance and commercial use of direct solar energy sources
- Mandates annual report for each project that includes energy savings
- Defines “direct solar renewable energy” and “light pipe”

**Section 7- Solar Air Conditioning Research and Development Program**

- Establishes a research, development, and demonstration program for solar powered air conditioning and establishes criteria to receive grants
- Requires at least 20% of the funding for research and development, and at least 50% of the funding for demonstration, come from non-Federal sources

**Section 8- Photovoltaic Demonstration Program**

- Establishes a program of grants to states to demonstrate advanced photovoltaic technology; Funding will be allocated based on the proportion of US population in each state
- If funding exceeds $25 million in any given year 25% of this funding will be awarded through a competitive grant program
- The state will provide competitive awards for the demonstration and advancement of photovoltaic technology; Grants require a minimum of 10% funding from state and 60% from non-federal sources
- Unexpended funds will be returned to the treasury
- Five years after the funds are allocated there will be a report to Congress

# APPENDIX C: BUDGET SPREADSHEETS

| Expanded Line Items | | Baseline* | Expense |
|---|---|---|---|
| Travel for Staff | New staff visiting new locations increase cost for first year | 683,000.00 | 34,150.00 |
| Travel for Board | Board members reimbursed for travel to Golden and site visits | 5,000.00 | 30,000.00 |
| **TOTAL Travel** | | | **64,150.00** |
| Printing | Full color brochures and investor guides 4 times annually | 50,000.00 | 50,000.00 |
| Misc. Printing | 3 new employees out of 141 existing employees | 25,000.00 | 500.00 |
| **TOTAL Printing** | | | **50,500.00** |
| Rental payments for GSA | 3 new employees out of 141 existing employees | 3,654,000.00 | 77,744.68 |
| **TOTAL GSA Payments** | | | **77,744.68** |
| Misc. Comm./Utilities | 3 new employees out of 141 existing employees | 25,000.00 | 500.00 |
| **TOTAL Communication** | | | **500.00** |
| Operations | 3 new employees out of 141 existing employees | 500,000.00 | 10,000.00 |
| **TOTAL Operations** | | | 10,000.00 |
| Advisory/Assistance | 3 new employees out of 141 existing employees | 2,574,000.00 | 51,480.00 |
| **TOTAL Advisory** | | | **51,480.00** |

* Golden Field Office

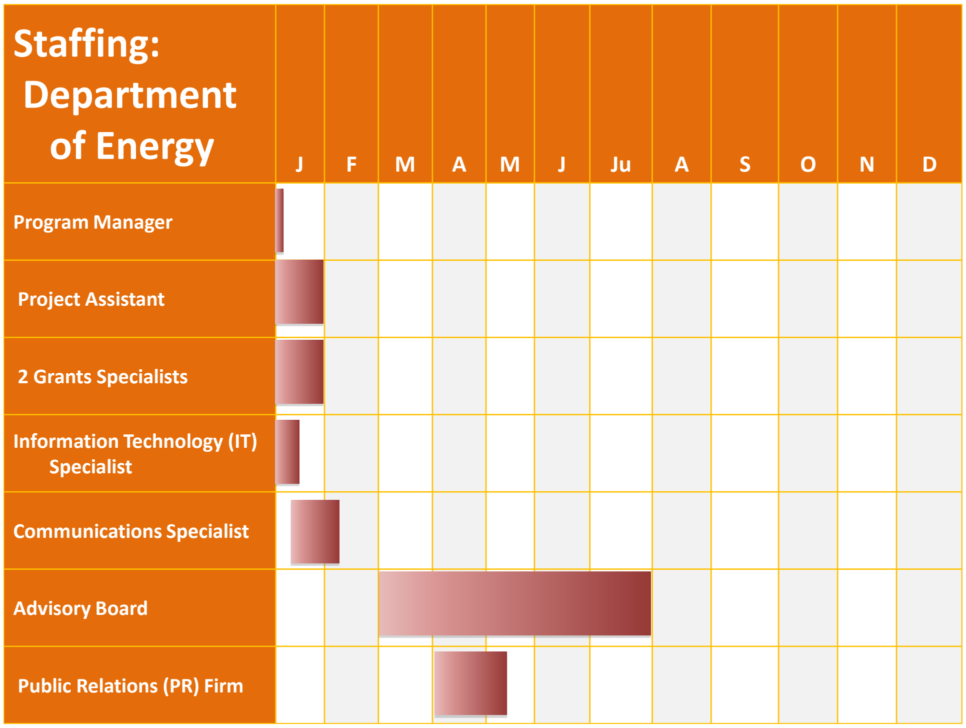
| Department of Energy Line Item Description | GFO* Fiscal Year Current | SERDA* Fiscal Year Next | GFO+SREDA Fiscal Year Next |
|---|---|---|---|
| Full Time Permanent | 14,771,400.00 | 297,500.00 | 15,068,900.00 |
| Personnel Benefits | 2,813,600.00 | 48,125.00 | 2,861,725.00 |
| Travel | 683,000.00 | 64,150.00 | 747,150.00 |
| Rental Payments to GSA | 3,654,000.00 | 77,744.68 | 3,731,744.68 |
| Communication, Utilities, and Misc. | 10,000.00 | 500.00 | 10,500.00 |
| Printing/Media | 25,000.00 | 50,500.00 | 75,500.00 |
| Advisory and assstance services | 2,574,000.00 | 51,480.00 | 2,625,480.00 |
| Operations | 500,000.00 | 10,000.00 | 510,000.00 |
| **TOTAL** | **25,031,000.00** | **599,999.68** | **25,630,999.68** |

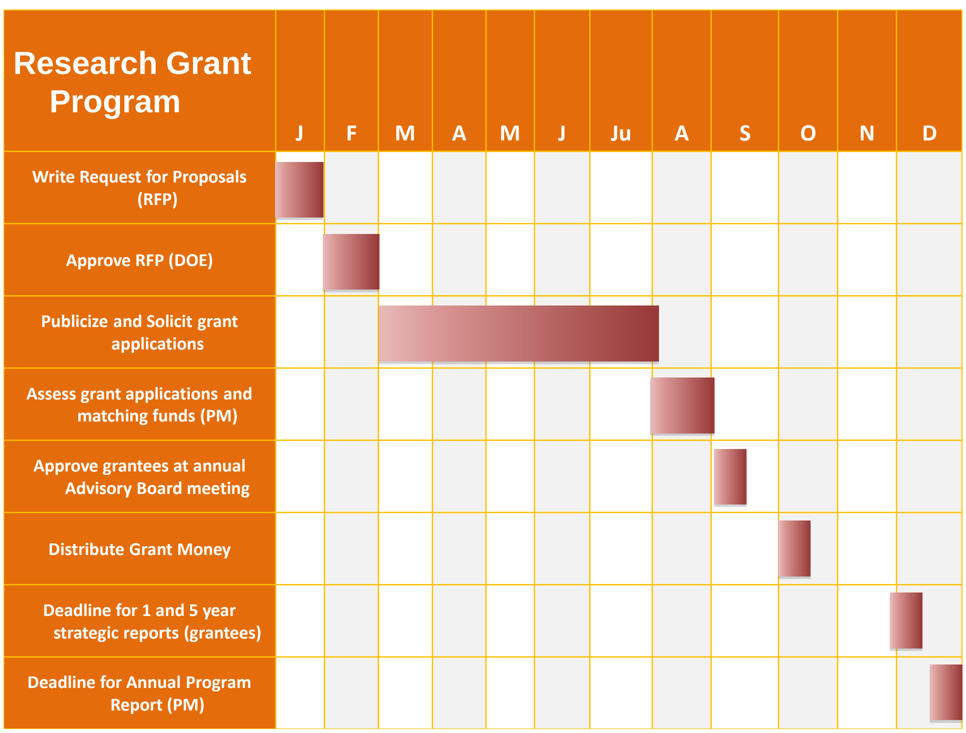
* Golden Field Office, Golden Colorado

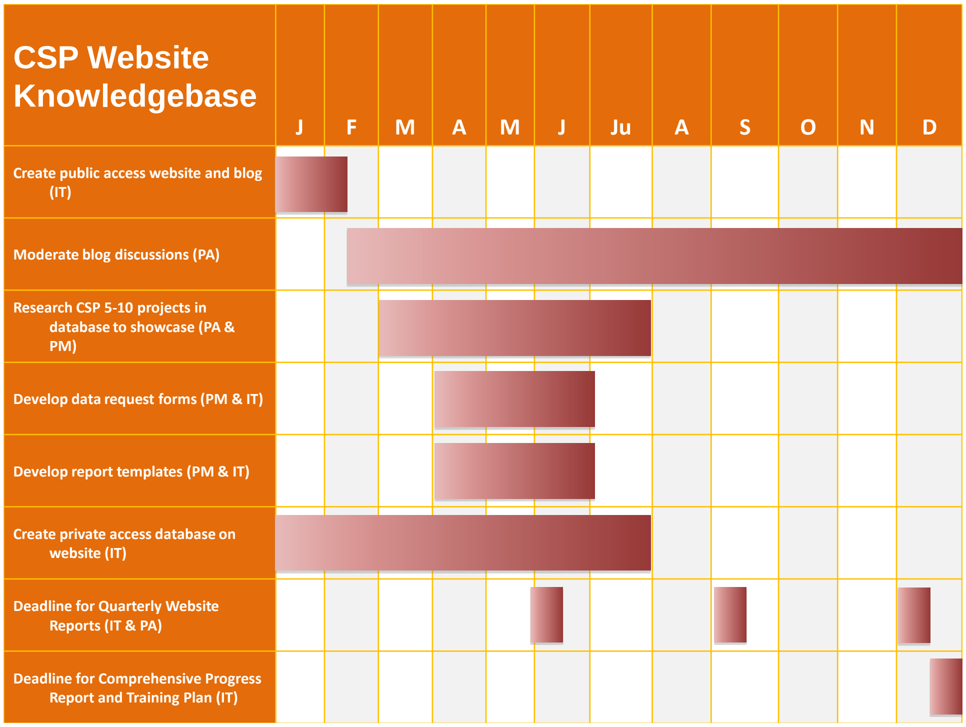
* Solar Energy Research and Development Act

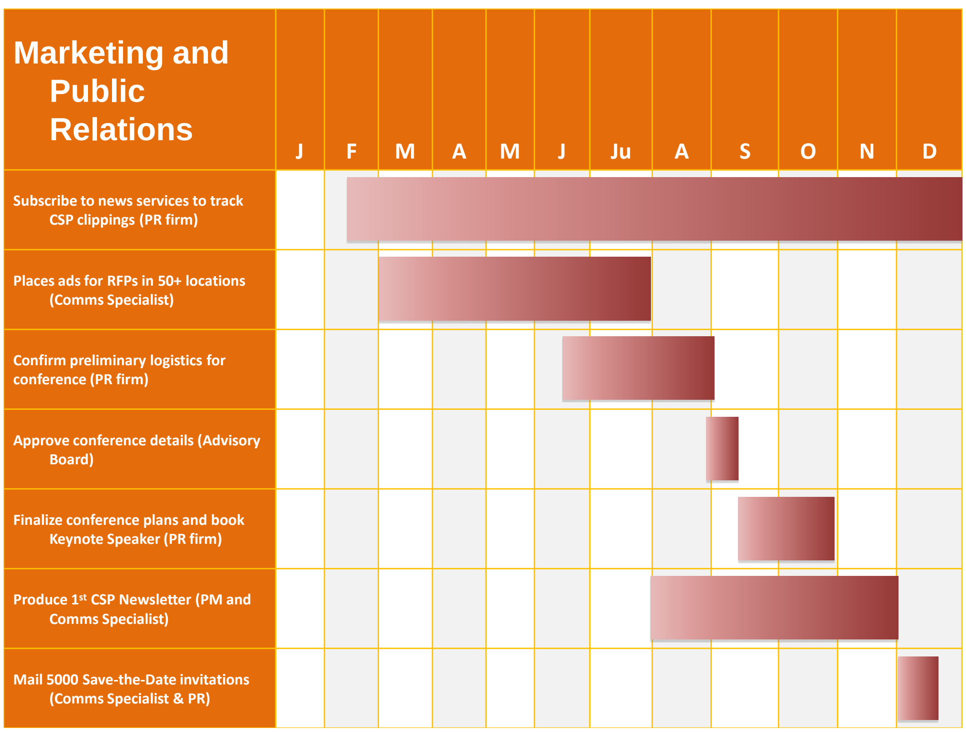
| **PERSONNEL** | | | **GOLDEN FIELD OFFICE** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **% of Total** | **Positions** | **Description** | **Grade** | **Salary** | **Total Salary** | **SERDA Total Paid** | **Benefits** | **Total** |
| Project Manager | 100% | 1 | Project Manager | GS-12:5 | 79,100.00 | 79,100.00 | 79,100.00 | 19,775.00 | 98,875.00 |
| Grants Specialist | 20% | 2 | Grants Specialist | GS-9:4 | 52,900.00 | 105,800.00 | 21,160.00 | 5,290.00 | 26,450.00 |
| Project Assistant | 100% | 1 | Project Assistant | GS-5:1 | 31,700.00 | 31,700.00 | 31,700.00 | 7,925.00 | 39,625.00 |
| IT Specialist | 100% | 1 | One-year contract | GS-9:1 | 48,100.00 | 48,100.00 | 48,100.00 | 12,025.00 | 60,125.00 |
| PR specialist | 20% | 1 | Media Contact | GS -11:3 | 62,200.00 | 62,200.00 | 12,440.00 | 3,110.00 | 15,550.00 |
| PR/Event Planning | 40% | 1 | Contract | Contracted | 262,500.00 | 262,500.00 | 105,000.00 | 0.00 | 105,000.00 |
| | | | **TOTAL** | | | | **297,500.00** | **48,125.00** | **345,625.00** |

# APPENDIX D: MASTER CALENDAR




CSP Website Knowledgebase
J
F
M
A
M
J
Ju
A
S
O
N
D
Create public access website and blog (IT)
Moderate blog discussions (PA)
Research CSP 5-10 projects in database to showcase (PA & PM)
Develop data request forms (PM & IT)
Develop report templates (PM & IT)
Create private access database on website (IT)
Deadline for Quarterly Website Reports (IT & PA)
Deadline for Comprehensive Progress Report and Training Plan (IT)


Marketing and Public Relations
J
F
M
A
M
J
Ju
A
S
O
N
D
Subscribe to news services to track CSP clippings (PR firm)
Places ads for RFPs in 50+ locations (Comms Specialist)
Confirm preliminary logistics for conference (PR firm)
Approve conference details (Advisory Board)
Finalize conference plans and book Keynote Speaker (PR firm)
Produce 1st CSP Newsletter (PM and Comms Specialist)
Mail 5000 Save-the-Date invitations (Comms Specialist & PR)

## REFERENCES:


Aabakken, J. 2006. "Power Technologies Energy Data Book." National Renewable Energy Laboratory. 2 Aug. 2008. http://www.nrel.gov/docs/fy06osti/39728.pdf

Baum, Eric. Miller, Bart. 2003. "The Last Straw Water Use by Power Plants in the Arid West." The Clean Air Task Force and the Land and Water Fund of the Rockies.

Bennett, Michelle. "Solar Power goes to Extremes for 5 cents per kWh." CleanTechnica.com 10 May 2008. 8 Sep. 2008. http://cleantechnica.com/2008/05/10/solar-power-goes-to-extremes-for-5cents-per-watt/

Broehl, Jesse. "A New Chapter Begins for Concentrated Solar Power." 11 Feb. 2006. 8 Sep. 2008. <http://www.renewableenergyworld.com/rea/news/story?id=43336>

Burnham, Michael. RENEWABLE ENERGY: Most Americans willing to pay more for clean power -- survey." E&E News PM 17 May 2007

California Public Utilities Commission. "The California Solar Initiative." 28 August 2008. http://www.cpuc.ca.gov/puc/Energy/solar/

California Energy Commission. "Go Solar California." 2007. http://www.gosolarcalifornia.org/

Congressional Budget Office. Cost Estimate: H.R. 2774 Solar Research and Advancement Act of 2007. 27 June 2008. 9 Sep. 2008. http://www.cbo.gov/ftpdocs/82xx/doc8293/hr2774.pdf

Dahl, Carol A. International Energy Markets: Understanding Pricing, Policies, and Profits. PennWell Books, 2004.

Denholm, P. Margolis, R. 2007. "The Regional Per Capita Solar Electric Footprint for the US." National Renewable Energy Laboratory. http://www.nrel.gov/docs/fy08osti/42463.pdf

Department of Energy. FY 2007 Congressional Budget Request. Feb. 2006. 6 Sep. 2008. < http://www.energy.gov/media/FY2007Budget/Highlights.pdf>

Department of Energy, Energy Efficiency and Renewable Energy. "Golden Field Office". 2007. 19 September 2008. http://www.eere.energy.gov/golden/Default.aspx

Department of Energy. "Federal Definitions of Basic Research, Applied Research, and Development". 2008. 20 September 2008. http://www.er.doe.gov/bes/definitions.html

Department of Energy. "Solar". 2007. (19 October 2007). 18 September 2008. http://www.doe.gov/energysources/solar.htm

Energy Information Administration (EIA), Official Energy Statistics from the US Government. VarioUSDocuments. 2008. 7 Sep. 2008. http://www.eia.doe.gov/fuelelectric.html

Energy Independence and Security Act of 2007. H.R. 6: 110th Congress. GovTrack.US9 Sep. 2008. < http://www.govtrack.us/congress/bill.xpd?bill=h110-6&tab=summary>

European Commission of Energy Research (ECER). 2008. European Commission Website. 12 Aug. 2008. http://ec.europa.eu/research/energy/index_en.htm

Friedman, Thomas. "Eight Strikes and You're Out." Editorial. New York Times 12 Aug. 2008. http://www.nytimes.com/2008/08/13/opinion/13friedman.html?em

Goodman, Al. All About: CSP "Spain's New Solar Power Tower." Cnn.com 12 Nov. 2007. 8 Sep. 2008. http://www.cnn.com/2007/WORLD/asiapcf/11/12/eco.about.csp/index.html

Hart, Stuart L. "The Federal Photovoltaics Utilization Program: An evaluation and learning framework." Policy Sciences 15.4 (1983): 325 - 343 http://www.springerlink.com/content/r5628635723g3544/

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Synthesis Report, Summary for Policymakers. Intergovernmental Panel on Climate Change, 2007.

Kanellos, Michael. "Shrinking the Cost for Solar Power." CNET News.com 4 Aug. 2008 http://news.cnet.com/Shrinking-the-cost-for-solar-power/2100-11392_3-6182947.html

Kulish, Nicholas. "German City Wonders How Green is too Green". New York Times 6 Aug. 2008. 9 Sep. 2008. http://www.nytimes.com/2008/08/07/world/europe/07solar.html?_r=2&hp&oref=slogin&oref=slogin

Mara. Janis. "Arnold Pumps Up Solar Power." Oakland Tribune 22 August 2006. http://findarticles.com/p/articles/mi_qn4176/is_/ai_n16689118

National Industrial Competitiveness through Energy, Environment and Economics. (2008). Retrieved November 10, 2008 from: http://www.federalgrantswire.com/national-industrial-competitiveness-through-energy-environment-and-economics.html

National Public Radio (NPR). 2008. "Vermont's Unique Approach to Curbing Energy Use." NPR.org Website. 2 Aug. 2008. http://www.npr.org/templates/story/story.php?storyId=92987505

National Public Radio. "The Potential of Solar Power." Talk of the Nation 12 March 2008. 8 Sep. 2008. http://www.npr.org/templates/story/story.php?storyId=88239836&sc=emaf

National Renewable Energy Laboratory. "2007 Parabolic Trough Technology Workshop." 25 July, 2007. 8 Sep. 2008. http://www.nrel.gov/csp/troughnet/wkshp_2007.html

National Renewable Energy Laboratory. "Solar Research". 2007. (25 October 2007). 18 September 2008. http://www.nrel.gov/solar/

Patz, J.A. Campbell-Lendrum, D. Holloway, T. Foley, JA. "Impact of Regional Climate Change on Human Health." Nature 438 (2005): 310-317.

Price, Hank, et al. "Advances in Parabolic Trough Solar Power Technology." Journal of Solar Energy Engineering 124.2 (2002): 109-125. 8 Sep. 2008. http://scitation.aip.org/getabs/servlet/GetabsServlet?prog=normal&id=JSEEDO000124000002000109000001&idtype=cvips&gifs=yes

Solar Energy Research and Advancement Act of 2007. H.R. 2774: 110th Congress. GovTrack.US4 Sep. 2008 http://www.govtrack.us/congress/billtext.xpd?bill=h110-2774

"SolarReserve Announces Appointment of Leading Financier; Michael Whalen Joins SolarReserve as Chief Financial Officer." Business Wire. 9 Sep. 2008. http://www.marketwatch.com/news/story/solarreserve-announces-appointment-leading-financier/story.aspx?guid={984C44D0-CF3D-422C-B484-AE508EFD2CA0}&dist=hppr

Strahan, David "Lump Sums." The Guardian 5 March 2008. http://www.guardian.co.uk/environment/2008/mar/05/fossilfuels.energy

Sunlight Electric. "Implementation." Sunlightelectric.com 2007. 9 Sep. 2008. http://www.sunlightelectric.com/implementation.php

The California Energy Commission. "California's Renewable Energy Programs." The California Energy Commission. 01 JULY 2008. 16 Sep 2008 http://www.energy.ca.gov/renewables/index.html

United States Cong. House. 110th Congress, 1st Session. H.R. 2774, A bill to support the research, development, and commercial application of solar energy technologies, and for other purposes. [reported US House; 8/03/2007) GPO Access Congressional Bills Database, 110th Congress.

Wald, Matthew. "Wind Energy Bumps into Power Grid's Limits." New York Times 26 Aug. 2008. 6 Sep. 2008. http://www.nytimes.com/2008/08/27/business/27grid.html?_r=1&oref=slogin&pagewanted=all

Wang, Ucilia. "Funding Roundup: Wind Power Finds Funding a Breeze." GreenTechMedia. 8 Sep 2008 http://www.greentechmedia.com/articles/funding-roundup-wind-power-finds-funding-a-breeze-1367.html

Western Governors' Association. "Clean and Diversified Energy Initiative." Solar Task Force Report. Jan. 2006. 9 Sep. 2008. http://www.westgov.org/wga/initiatives/cdeac/Solar-full.pdf