Emerging Opportunities for Renewable Energy Development in California: Lessons from Europe

By Nicolas Chaset

The confluence of existing initiatives for increasing California's renewable energy portfolio[i], and Governor Schwarzenegger's proposed "Million Solar Roofs" initiative[ii] are helping California to build a globally significant renewable energy technology sector.

California has been at the forefront of the global information technology revolution for nearly fifty years, and much of the state's economic prosperity is either directly or indirectly linked to the global reach of Silicon Valley. A new technological revolution is coming, and California has an opportunity to once again be at the forefront of innovation.

Energy Technology

Let's first start from the idea that the world is now entering into the age of the energy technology revolution. As more and more energy is needed to sustain the growth of the global economy, resource scarcity is becoming a problem of the utmost significance. The time when the world could meet its energy demand by simply drilling holes in the ground is nearing an end. And much like information technology revolutionized the way people communicate and share ideas, energy technology is changing the way we use and produce energy.

Within the last year, the price of oil has nearly doubled, leading to increased costs for consumers and businesses; the effect has been a slowing of economic growth. One approach to dealing with the growth of demand and the diminishing supplies of crude oil is to make more efficient use of fossil-based fuels. This approach is being championed by companies like Toyota, which have started to mass-produce hybrid gasoline/electric cars. While fossil resources remain the key ingredient to the functioning of Toyota hybrid internal combustion engine, technology has been harnessed to make it possible to stretch more miles out of a tank of gas.

Another approach is to move away from crude oil and its derivatives and rely on other fossil fuels like coal and natural gas to meet global energy needs. In both of these sectors, technology is becoming an increasingly important part of the supply chain. Proponents of a move back to a greater reliance on coal-fired power plants to provide electricity champion ideas like the development of clean coal systems. Clean coal, also known by the process name Integrated Gasification Combined Cycle (IGCC)[iii], integrates the production of electricity with other systems that use the by-products of coal burning to produce synthetic engine fuels, while sequestering CO_2 to minimize greenhouse gas emissions.

Similarly, the uses of natural gas are also being redefined by technology. No longer is natural gas simply a resource that has to be piped in gaseous form from producer to consumer. Liquefaction of natural gas has made it possible to transport LNG from anywhere in the world to consumers. Refining processes have also created new and more efficient uses of natural gas and liquefied gas and expanded the scope of uses for natural gas into fuels for engines.

The application of technology to extend finite supplies of fossil fuels is valuable in the short-term, but does nothing to address the underlying problem of resource scarcity. There is another way. The abundance of the sun, of the wind and the ocean, if properly harnessed, can meet and surpass the energy needs of the world, today and into the future. The question is not whether or not there is enough sun or wind to create power, but rather: 'what systems need to be developed to harness these abundant and renewable resources?' The answer lays in technology-based solutions that can produce low-cost and efficient renewable energy systems. While the global economy is still defined by a fossil-based resource energy paradigm, these resources are beginning to dwindle. Within the next half-century, nations will either have to make the switch towards technology-based energy systems, or be left in the dark.

The potential for energy technology is two-fold. There is the research, manufacturing, and project development that go into creating energy systems. There is also the generation of power and the distribution of this power to consumers. What is most revolutionary about solar and wind-based energy systems is that once the capital investments have been made to build or install these systems, they generate power without any significant further need for inputs of capital. From an investor's perspective, wind and solar projects are smart, because they can become highly profitable once the amortization of their initial investment has been reached. Unlike fossil based energy where the cost of inputs is constantly fluctuating, both the cost and the revenue of solar and wind systems is predictable in the short and long-term. Wind resources can be mapped and modeled, as such the electrical output of a wind farm is predictable. Though wind resources are intermittent, proper modeling of wind can by-pass this problem through distributed generation. In linking sites with different wind profiles, a grouping of wind farms can be achieve near constant electrical generation. Similarly, the output of a solar system can be modeled based upon the solar radiation at the particular site. The main fluctuation in output in this model has to do with the change in the number of sun hours over the course of the year. The point is that these renewable resources provide an absolute predictability that fossil resources can never provide. As a result, these projects can be structured to offer solid and profitable investment opportunities.

Renewable Energy in California: Barriers to Entry

California was once the global leader in the development of renewable energy technology projects. During the energy crisis of the 1970's and into the 1980's, California installed more renewable energy capacity than anywhere else in the world. The momentum has slowed considerably, and Germany, Denmark and Japan have taken California's place. Yet, there remain considerable opportunities for California to tap into the emerging energy technology revolution, in terms of both renewable energy project development and technological innovation. However, before California can take any major steps forward, a number of important barriers to project development, finance, and grid access must be addressed.

In terms of the development of renewable energy projects, the regulatory framework in California is prohibitively expensive and overly complex. Generators are not guaranteed that they will be able to deliver their energy to load, and therefore are unable to offer the necessary investment security when seeking project financing. For those generators able to secure financing, lengthy licensing procedures and unclear jurisdictional issues between local, state and federal agencies further hinder project development. Even in the face of numerous barriers, the people of California have built some of the most significant renewable energy projects in the world, the Kramer Junction Solar Thermal fields being but one example. There is strong support for renewable energy, but what is lacking is the political will to get behind the necessary initiatives. Now is the time to harness the growing momentum and build a framework where access and opportunities lead the way.

Growth in the energy technology sector relies heavily upon the existence of a local demand for products as well as government support in the form of tax incentives and research and development funding. The California consumer market for renewable energy systems remains largely limited to those who can afford large up-front costs and have a particular interest in renewable energy and sustainability issues. While much good work is being done both in the private sector and in California's universities, California's progress is on a much smaller scale than in places like Japan and Europe.

Strong local demand coupled with more government support can increase access to capital for both renewable energy project development and renewable energy technology development. For an example of the success of this model, we need only look to Germany, where growth in the renewable energy technology sector relates to the growth in German demand for renewable energy. This growth in demand has increased revenues and has given German companies the opportunity to increase their research and development budgets. Larger research and development budgets and a strong home market for their products have pushed German companies to become global technological leaders in this sector. This has been further buoyed by government support for research and development and the creation of university research institutes focused on renewable energy technology (Freiburg Institute)

To put Germany's success in a context that Californian's can understand, let us consider the growth of the California IT industry during the second half of the 20th century. The existence of a strong local demand for both hardware and software allowed California companies to start out by servicing other California companies. As companies grew, they could increase their research and development budgets. This progress was further multiplied by work being done at California universities and government support. Growth in output led to job creation and a further strengthening of the human capital base. The best and brightest engineers and business people from around the world flocked to California to work in IT. This influx in it of itself has had a significant impact on the state’s economy. Furthermore, California's IT industry benefited from a public-private partnership that opened doors for entrepreneurs to expand their businesses globally, and what started out as the California information technology industry became the worlds.

There is a great opportunity for California to mirror its IT success in the Renewable Energy technology sector, but some important outside lessons need to be learned. It is therefore the purpose of this paper to present renewable energy support models that have worked in other countries with the idea that California can begin to implement new policies based on these experiences. To date, Germany has seen the greatest growth in the use of renewable energy to meet its domestic demand for electricity. For this reason, this paper will focus on the German model toward the end of gaining an understanding of how regulatory frameworks, financial mechanisms and grass roots organizing have put Germany in a position of global leadership in renewable energy, and examining how these lessons might be adopted in California.

The German Model: creating markets and leading innovation

Introduction to German Model

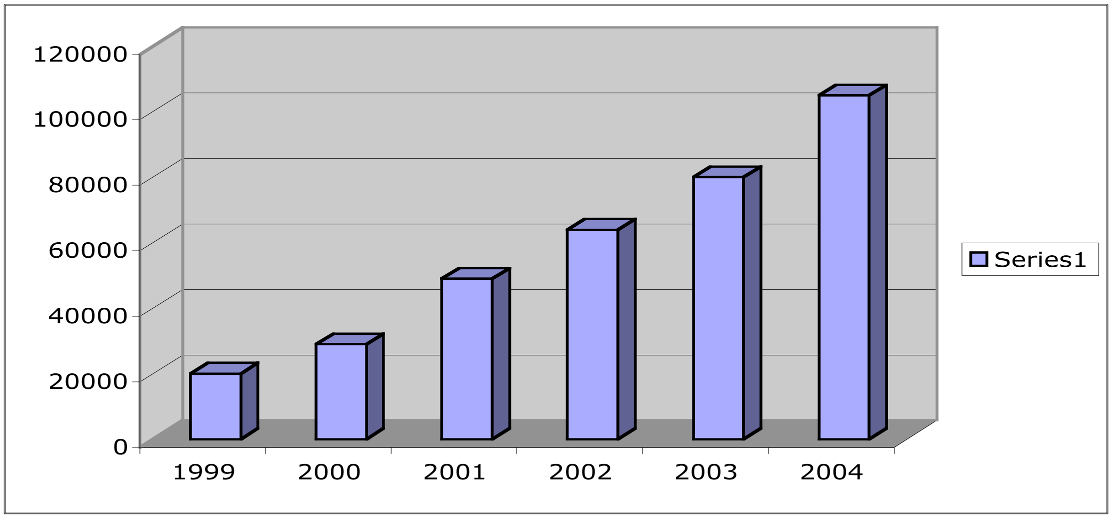
The first solar initiative in Germany was legislated in 1990. The 1000 solar roofs program provided low interest financing to individuals who installed solar systems on their roofs. Over the five-year life of the program, more than 2250 systems were installed[•]. This program, coupled with the 1991 renewable feed-in tariff law[iv], assured that all renewable energy providers would have assured grid access and would receive government subsidies.

In 1999, a new five-year program was launched to promote the installation of PV on 100,000 German roofs, with a budget of 460 million euros[•]. The aim was to develop a total generating capacity of 300 MW. The incentive came through a guaranteed 10-year low interest loan (1.9% per annum), with no repayments in the first two years. Such loans were considered a proven method of avoiding the currently high start-up investment costs of PVs. The Renewable Energy Law (EEG-Erneuerbare-Energien -Gesetz)[v] introduced in April 2000 has accelerated the market significantly.

• source: European Photovoltaic Industry Association.

• source: European Photovoltaic Industry Association

Installed Solar Units[•]



Under the EEG renewable energy law, any individual or group who installs a photovoltaic electrical generation system receives a buy-back rate ranging between .57 euros and .47 euros based upon the location and size of the project. This rate is subject to an annual regression of 5% that is tied to the falling costs of production for these systems. The notion behind this rate structure is that over a period of time, the growth of the renewable energy technology sector will cause costs to fall to a point where they are on par with conventional energy generation. As a result of the feed-in tariff, Germany has become the world's largest consumer of solar energy systems, while also pushing its solar technology and industrial base to a position of global leadership. Germany also has the most developed conventional finance mechanism for solar energy projects in the world, which primarily benefits from the security provided by the feed-in tariff. As Eric Hafter, General Manager of Powerlight Europe said,

"we are business people, not environmentalists. We are driven by profit margins, but if the consequence of building a solar power facility is greater economic and environmental sustainability then all the better."

A consequence of investment security and profitability is growth. In 2004, Germany installed more solar energy capacity than anywhere else in the world (more than 300 Mw according to the UVS) and since 1999, more than 80,000 solar units have been installed in Germany. This has led to the creation of nearly 20,000 jobs related to the development, manufacture, marketing and installation of solar systems. The German solar industry saw its revenue rise to an all-time high in 2004, topping 1.5 billion euros. Another consequence is greater competition and lowered prices. According to projections from the European Commission, the

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[•] source: Unternehmensvereinigung Solarwirtschaft e.V (UVS) *German Solar Industry Association* price of electricity generated from PV will drop from its current level of 45 eurocents to 25 eurocents by 2010 in areas of lower solar irradiation[vi] like northern Europe. The value of PV-generated electricity will be greater in sunnier countries where greater benefits can be drawn from the increased efficiency of PV cells. Again the European Commission estimates the price of PV generated electricity to drop to below 15 euro cents in Southern Europe where there is greater incidental solar radiation. As stated above, once the capital investments are made, solar power costs next to nothing. The long-term implication is that at some point in the near future, power generated from solar cells will allow for the spread of abundant, cheap electricity for everyone.

The German role as leader in innovation applies to both future development/growth of solar energy industry and existing plans to install solar capacity. Germany's fully integrated, vertical solar industry has the capacity to supply everything needed to develop and implement a solar energy project from the necessary technological know-how to turnkey systems. This full integration means that German companies are the leaders both domestically and internationally. An example of the relationship between German dynamism and legislative frameworks is illustrated by the fact that since 2001, Germany has been a net exporter of photovoltaic modules and silicon wafers.

The strength of the German model is illustrated both by robust growth and by the fact that German companies are leading the field in applied and theoretical research into energy technology systems. This proprietary research is creating benefits at all levels of solar system manufacturing (silicon wafers, converters, solar cells etc). The solar energy sector has seen a mean growth of 33% per annum• over the course of the last 10 years, which only underscores the future expectation for growth as the cost of solar systems fall and the price of fossil fuels rise.

One example is Solon AG, which was founded in 1997 and in 1998 became the first solar technology company listed on the German Stock Exchange. Solon is now Germany's largest producer of solar modules. Solon is also active in project develop and is currently working on building a 12 Mw Solar field. Solon's expansion into this type of speculative investment has been buoyed by the feed-in tariff and is an example of how solar system producers can find multiple revenue streams. These successes are not limited to the domestic market. Germany has also started to become one of the primary exporters of solar energy technology to the rest of the world. Currently, a German company, Solar Millenium, is developing the world's largest solar sites with its multiple 50 MW solar thermal power plants in Spain.

The Political Impact

The solar energy question has become one of the main economic issues in the German elections. While the Christian Democrats and the Social Democrats are at

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• [2] source UVS and BSI *German Solar Industry Association* odds over the length of feed-in tariff incentives, they both have made the promotion of the German renewable energy industry a priority. The more conservative CDU believes that the statutory buy-back rates legislated into the REL should be limited to shorter time periods. However, the CDU understands the impact that the renewable energy sector is having on the German economy and has stated that there will be continued support and promotion of the German renewable energy industry as a locus for exports in the coming decades. The CDU believes that Germany should become a global leader in the energy technology sector, and use its dominance over this particular area of the knowledge economy to become to energy technology what Silicon Valley is to information technology, although there is less willingness on the part of the CDU to continue to bear the costs of the feed in-tariff.

The SPD, led by Chancellor Schroeder, have firmly stated their belief that all existing renewable energy laws and subsidies should remain in place. Their argument follows the logic of staying the path that has already been so successful in promoting growth for the German renewable energy sector. Over the course of the German electoral season, the renewable energy lobby has pushed hard for all existing statutes to be maintained. With the inconclusive results of the September 2005 election for the CDU, it is highly likely that existing renewable energy statutes will be renewed and the buy back rates will be preserved or increased[vii]. Thus, the result of the election should be a continuation of current progress and an expansion of already pervasive solar and renewable energy initiatives.

Community Involvement

One of the reasons Germany has seen its renewable energy sector grow so quickly is grass roots support for the promotion of solar and wind power. Germany's renewable energy legislative framework was pioneered by local groups and community-based initiatives that promoted the installation of PV on roofs. This grass roots effort worked to raise awareness about the benefits of PV as a way to defray the cost of energy, and helped to build support for the legislation of the feed-in tariff, which economically legitimized further investment and installation of PV.

On the community level, many small PV installations are financed by groups of residents who share the investment cost of buying and installing PV panels. (The average installed on-roof system in Germany is 3.5 Kw peak capacity = 15,000-18,000 euro)• The existence of the feed-in tariff encourages community involvement. These types of community-based initiatives have played a significant role in building a popular base of support for the German governments renewable energy programs. Universal access to the electrical grid coupled with mandated feed-in rates has made both individuals and communities into stake holders in the renewable electricity market. One of the reasons the German people have been willing to bear the costs of the feed-in tariff is that if they so choose, they can invest and benefit from installed renewable capacity.

• [3] source: UVS

Valuing Renewables: the Solar Example

One of the most important issues to consider when looking at renewable energy technologies is how they are valued. This is especially important when utilities or governments are performing cost comparisons between renewable energy and conventional fossil energy systems. Unlike a coal or nuclear power plant, renewable energy systems create both direct and indirect benefits. One factor that is particularly important has to do with the fixed costs of renewable energy systems. Both PV and wind have low long-term fixed costs because other than low-cost basic maintenance, the expense of these systems is primarily an initial capital investment. As such, the value of the power they generate is a function of the time it takes to amortize initial costs. By contrast, it costs nearly as much to maintain a nuclear power facility when active as it does when closed.

Another issue when considering valuation is efficiency. This is particularly important for PV and Solar Thermal, because in sunnier places they generate more power. By generating more power, these systems are creating more value and are lessening the time it takes to amortize initial capital investments. Given that the price of solar generated electricity directly relates to number of kilowatts each unit generates, divided by the cost of the unit, increased efficiency means lower costs.

The next issue to consider when valuing a renewable project is scale. When considering solar projects, there is essentially no limit to scale if there exists a valuation system that secures long-term investment. Any number of PV cells or solar thermal collectors can be set up into an integrated system. If anything, building bigger means taking advantage of economies of scale and cutting up-front investment costs. As the cost per panel drops, the value of the electricity produced rises. Currently, the main limiting factor for building PV has been a silicon shortage, which has cut world PV production. However, as more production comes on-line and ever more efficient panels are produced, this problem should disappear.

There are no effective limits to scale for PV other than access to building materials and transmission. Models have been created that project the capacity of a one hundred square mile PV site in the Arizona desert as being able to meet all demand for electricity in the US. The problem for the US is that this kind of scaling is generally more feasible in Europe, where markets exist that will give any solar project access to the grid and thus have access to liquid capital that meets the project's risk-return ratio.

The true value of renewable energy may not always be included in the balance sheet of a particular project, and as such any valuation scheme must also take into account external benefits. Let us start by considering the fact that a move to renewable energy systems means job creation in both project management and construction. This is an immediate benefit to the community where the system is being built. A second level of value is created in the opportunities for local assembly and manufacturing facilities. The German model is an example because of the significant growth in revenue generated by German companies who have been able to start manufacturing renewable energy systems. The third level of value is the creation of a knowledge base that can be exported. As global competition for jobs and investment capital grows, a fully integrated renewable energy industry can become a new avenue for exports and competitiveness. A fourth level of value is the security that renewable energy systems provide. They can be an avenue towards a lessening of the reliance on imported fuel sources, while also providing communities the chance to generate their own power when disaster or conflict knock out a centralized electrical system.

Applying the German Experience to California

Germany's success directly correlates to the simplicity of their renewable energy program. Through the implementation of a flat feed tariff that provides universal access to the grid, a functioning free market has developed. In guaranteeing remuneration to operators of solar systems, the necessary capital investments to build solar capacity have been secured.

In comparison, the ad-hoc subsidies that project developers may receive in California do little to protect long-term investments. Instead, the vast majority of installed PV capacity in California is either not grid connected or only functions as a way to defray the cost of a consumer's energy consumption. This is problematic because of the nature of the renewable energy revenue stream. Projects necessitate upfront investment and become profitable after these costs have been amortized. As a cost defrayer, the value of consumer renewable energy systems are linked to fluctuations in the costs of other energy sources, and as such, are hard to quantify over the long term. In this system, only those wealthy enough to afford large up front investments can afford to participate. The electricity that a PV system is producing is not a direct source of revenue, and its value is limited to the consumers own energy consumption. By contrast, when a system exists that gives renewable energy a fixed value over time, costs and benefits can be analyzed and value can be created. Furthermore by quantifying the value of electricity generated from renewable energy systems atop people’s homes or businesses as a source of revenue, many more investors will be attracted into the market.

California has a highly developed technology industry and has an incredible human capital resource to build on. The people of California are also aware of the need for energy self-sufficiency after the electricity crisis in 2000 and 2001. California has both the infrastructure and the necessary popular support to begin to follow the German renewable energy support system. Given California's history of economic dynamism, it follows that if the proper measures are taken, this state could become a global leader in both the usage and export of renewable energy technology.

While we have certainly seen the benefits of the German model, it is also important to take into account initiatives in other places that could positively influence the direction California takes. Spain and Portugal are the next major European countries that are going to implement significant feed-in tariff measures. Both of their tariff formulas are a function of time of use. That is, the value of energy supplied under these tariffs corresponds to the time of day the power is generated. Such an approach values power generated during peak demand times more highly than off-peak generation. This differs from the German model, which is based on a flat rate all the time. The Spanish and Portuguese model is also based on a tax-funded peak premium given to renewable producers, whereas in Germany, the consumers pay a monthly surcharge on their power bill that funds the feed-in tariff.

The time of use system has its pros and cons. The benefit is that it values energy within an existing marketplace, where peak electricity already costs considerably more than off-peak. As such, the cost of PV-generated power is closer to the cost of conventional power[viii]. A time of use tariff can also be effective because during periods of peak demand, the market rate of electricity is closer to the amortization-corrected cost of PV power, and as such promotes greater investment in PV systems. While this saves money both for the government and the consumer who pay the tariff fees, it also gives less value to other renewables (like wind) that don't necessarily produce electricity during peak times. The problem is therefore that this time of use rate system gives less value to renewables that do not closely follow the peak demand curve. Another problem with the Spanish model is that where the Germans have a statutory framework that guarantees the feed-in tariff for the life of the project (20 years), the fact that the Spanish fund their tariff through taxation means that the government can cut funding and limit the long term viability of PV projects.

Though in the end, what is most important is statutory support for feed-in tariffs. Without this, feed-in tariffs can be endangered by political maneuvering and the influence of conventional energy generators. This has been one of the greatest problems in the U.S., where the support schemes for renewable energy are ad-hoc subsidies and regulations that are never secure for more than a single election cycle. Given that many renewable projects have amortization periods over ten years, this fact has severely limited renewable project development in the U.S.

The most important element is the creation of a system where investments in renewable energy technology are protected. However, a progressive policy framework can also be a key to continued market development for renewable energy. The current initiative to legislate "a million solar roofs" is a step in the right direction, but is not enough to create a fully functioning market for renewable energy or renewable energy technology.

Steps for California to Take

Based on the European experience, California needs to seriously consider the adoption and implementation six relatively straightforward policy changes that will allow it to succeed in becoming a world leader in the expansion of renewable energy technologies:

1. Create a System That Promotes Investment Security and Access to Financing

The German feed-in tariff is significant because of the success it has had in pushing the development of PV and wind projects that are attractive to investors. However, for California, the time of use model should also be considered because it fits into existing electrical market frameworks in the state. What both systems have in common is a guaranteed buy-back rate over time. Thus, such tariffs can create value within a marketplace, and unlike pure subsidies, promote competition and a progressive lessening of the tariff rate as the cost of renewable energy falls. A marketplace for renewable energy not only promotes demand, but favors those companies that work most efficiently. Competition with for business and investment will only hasten technological progress and falling costs. The spill-over being growth in the local energy technology industry to meet demand and associated job creation. One dollar in renewable energy project financing might create five dollars in associated revenue for the state. California must adopt some version of the feed-in tariff if it is going

2. People Need to Be Stakeholders

If the people cannot see the benefits for themselves of supporting renewable energy, then they will not push their representatives to pass the necessary legislation. These benefits can take multiple forms: job creation, greater energy security, lowered energy costs, or investment opportunities. Environmental benefits and long-term sustainability are just not enough to convince most people that there should be a shift towards renewable energy sources.

3. Universal Access to Grid

A complex interconnection system that limits access to the grid or makes permitting costly and time consuming will kill development. The system should focus on simplicity and provide incentives for building transmission lines between renewable energy systems and the electrical grid: something along the lines of "if you build it and connect it, then you get access to the consumers." This is particularly important in California, where the RPS standard has mandated that utilities increase the percentage of electricity they buy from renewables. However, for the achievement of this standard to become a reality, the various state and federal agencies that deal with transmission issues need to start working together more collaboratively toward the goal of facilitating the interconnection of all types of renewable energy sources, wind and biomass as well as solar energy. Utilities alone do not have an incentive to begin to give free access to renewable energy sources, because this electricity is in competition with power generated by their power plants. For this reason, the government and the regulatory agencies have to take a hands on role in mandated access and then enforcing their mandates.

4. Past Successes Will Have a Multiplier Effect

Support progressive projects on a small scale. If the cost of one million solar roofs is too great, start with ten thousand. If a full on feed-in tariff is not feasible, create a system where there is guaranteed buy-back up to a certain installed capacity. The success of these initiatives will pave the way towards growth. Local installation and engineering companies will benefit, as will the manufacturers of the systems, all of whom will create jobs and help to educate the public about the benefits of renewables. If investor groups begin to see the benefits from small-scale feed-in projects, they will be more willing to consider bigger ones. If one person has a PV-system of their roof and is receiving a monthly check for the power generated, they are likely to share their positive experiences with their neighbors and friends. Progress builds upon itself.

5. Grass Roots Groups Need to Work with Vested Interests

The Green movement may start things, but if the economists catch on, then a good idea with long-term societal benefits may start to become a reality. Renewable energy is not simply an environmental or sustainability issue, rather it is an opportunity to create knowledge and lead innovation. More to the point, renewable energy technologies are going to provide the fuels to run the world. A robust renewable energy industry will create jobs and give California a competitive edge. Gaining political support starts with the people pushing their representatives, so grass roots groups need to build campaigns that reach the people. However, to be successful, such campaigns will need a mix of messages focusing both on the economic benefits and on stewardship of the environment. There is no reason why Greenpeace and Merrill Lynch can't work together.

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Endnotes:

[i] California Renewables Portfolio Standard Program (SB 1078, Statutes 2002) obligates all Load Serving Entities (LSEs) to increase the share of electricity they procure from renewable generation resources until the goal of 20% is reached, by no later than 2017

[ii] SB-1 Solar Homes Initiative: The Million Solar Roofs Initiative, administered by the Energy Commission, with the goals of placing 1,000,000 solar energy systems, as defined or designated by the Energy Commission, on new and existing residential and commercial customer sites, or its

generation capacity equivalent of 3,000 megawatts, establishing a self-sufficient solar industry in 10 years, and placing solar energy systems on 50% of new home developments in 13 years. The bill would establish the Million Solar Roofs Initiative Trust Fund and would provide that, upon appropriation by the Legislature, moneys deposited into the fund may be expended by the Energy Commission for purposes of carrying out the Million Solar Roofs Initiative. The bill would provide that up to 2% of the money in the fund may be expended for the state's costs of administration.
(source: Ca. SB-1 September, 2005, p.3-5)

[iii] [iii] IGCC: Carbon-based raw material reacts with steam and oxygen at high temperature and pressure. Mostly hydrogen is produced in the gasifier, along with carbon monoxide, methane, and carbon dioxide. The gasifier's high temperature vitrifies inorganic materials into a course, sandlike material, or slag. The synthetic fuel leaves the gasifier and is further cleaned of impurities. It is used in the system to run primary and secondary gas and steam turbines, similar to a natural gas combined-cycle generating system. The primary environmental benefit is increased efficiency and nearly zero air pollution. Most pollutants are removed before combustion and are not created when the fuel is burned. Or, in the case of sulfur, it is collected in a form that can be used. This is a big change for coal plants, where even clean ones produce a lake-sized impoundment of sulfuric slurry by pulling sulfur compounds from the stack flue gas.
(source: Los Alamos National Laboratory)

[iv] 1991 Feed-In Tariff guaranteed solar and wind energy producers 90% of the retail consumer price for electricity and provided low-interest loans for project developers.

[v] 2000 German Renewable Energy Law: http://www.fnr-server.de/cms35/index.php?id=401

[vi] European Commission, Directorate General for Energy and Transport, 2003

[vii] Taken from discussions with members of the German Bundestag and their Aides

[viii] The production curve of solar energy systems is very similar to the demand curve for electricity (mid day peak) because these systems produce more electricity during mid-day. If the valuation of electricity is higher during this peak time, say from .08 cents to .15 cents a kilowatt hour, then the difference between the cost of PV generated electricity and the market value of electricity is smaller.