SOLAR PHOTOVOLTAICS USAGE AMONG CALIFORNIA HOMEOWNERS 2006-2011

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ABSTRACT

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Aaron Litwak

During any brief perusal through the literature on solar photovoltaics (PV), one is sure to quickly encounter a reference to their "large up-front cost." But while the technology slowly becomes cheaper and more widespread, some governments, especially Germany, Japan, and the state of California, are not waiting for PV's price to fall below the price of fossil fuel-based electricity. Rebate programs have been used to encourage deployment of solar PV, and some have tried new financial innovations. The city of Berkeley in particular tried implementing its idea of tying the cost of a household PV unit to the home's property tax payment. The financial obligation is paid off over a period of twenty years, and it stays with the home if the present owner moves. California in general has adopted a large PV rebate program. Following President Clinton's 1997 Million Solar Roofs initiative, California Governor Arnold Schwarzenegger approved a similar initiative in 2006 to promote PV usage among California homes, businesses, and local government and non-profit entities.

This thesis looks at the people who participated in California's rebate program. In lieu of a questionnaire or survey, a regression test was performed with two large data sets. California Census data from 2000 and, in separate tests, data from the American Community Survey 2005-2009, were used as the explanatory variable. Go Solar California residential PV unit data were used as the response variable. In general, a portrait is painted of a middle-class, mostly white California resident who has adapted his or her lifestyle to avoid the harsh California metropolitan commutes.

While it is probably too early to brand the California rebate program a success or failure in the conventional economic sense of the word, it is strongly recommended that Washington State adopt similar measures, using rebates and high feed-in tariffs to encourage businesses and homeowners to generate their own power, and to feed excess power back into the grid using solar PV technology. This energy strategy has the potential for multiple long-term benefits: as a means to help slow down rising energy costs, a means to create local green energy jobs, and to help counteract the effects of global warming and climate change by preventing the release of greenhouse gases.

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CHAPTER ONE

A BRIEF HISTORY OF SOLAR PV FOR THE HOME

Some of the reasons homeowners turn to solar PV as an alternative source of electricity have remained consistent over the years: environmental concerns foremost, and economic concerns secondary, given its traditional high up-front cost. An energy efficiency audit for the home, therefore, has typically been a first step towards getting a home PV system.[1] It is also the first prerequisite of the Go Solar California rebate program,[2] since the paybacks of energy efficiency improvements are often realized more quickly than those for a PV system.

What has changed, since the 1990's, is the notion of PV as a complete alternative to, and escape from, the power grid, as opposed to its potential partner. Additionally, as PV technology has improved, reaching greater efficiencies and cheaper production costs, the idea of feeding power back into the grid and getting paid for it has taken hold. Even Clint Eastwood wanted some credit for the surplus power that his Tehama country club fed back to the grid.[3] In 2001 Eastwood visited then Governor of California Gray Davis to endorse a bill that would allow schools, nonprofits and businesses to receive credit for the wind and solar energy they've contributed to the state's power grid.[4]

Concerns raised in the national spotlight about the reliability of our domestic energy supply has tended to be favorable for solar, if only in theory. Tensions in the Middle East, especially high-profile events such as the OPEC oil embargo of 1973 and the Persian Gulf war of 1991, have led to short bursts of increased interest in solar PV usage. High-profile nuclear power-related disasters,[5] or even local concerns about

[1] Hinds, M. The New York Times: New York, NY. *An energy audit of a typical row house*. 08 Jan 1981.

[2] Step 1: Energy Efficiency Audit. (http://www.gosolarcalifornia.ca.gov/csi/step1.php)

[3] Associated Press. Telegraph-Herald: Dubuque, IA. *People*. 28 Mar 2001.

[4] Hochschild, D. The Los Angeles Times: Los Angeles, CA. *PUBLIC UTILITIES; Power Play: Big Energy vs. Solar*. 11 Aug 2002. AB 58, a net-metering bill sponsored by then Assemblyman Fred Keeley, was apparently watered down by the local utility companies, who were opposed to net-metering at the time. California at large, of course, was still recovering from the deregulation of the electric utilities in 1996, which culminated in rolling blackouts and the collapse of Enron in 2001.

[5] United Press International (UPI). *Energy Resources: Japan's nuclear disaster boosts*

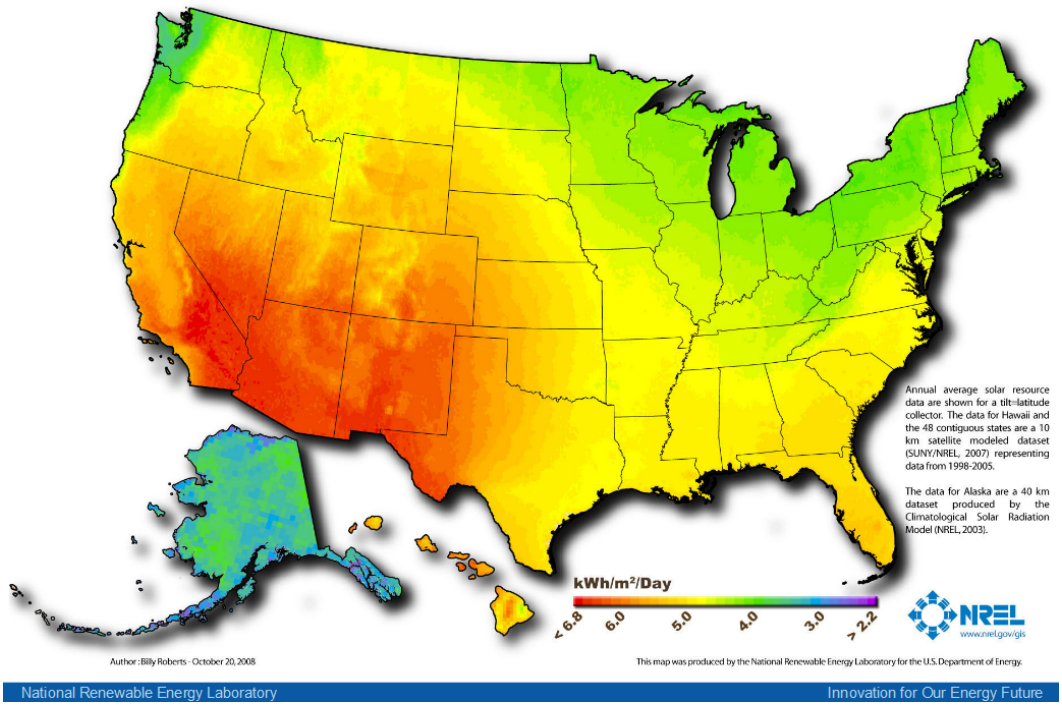

Figure 1. Insolation map of the United States. Courtesy of National Renewable Energy Lab.

storage of nuclear waste, have helped to raise awareness of solar as a cleaner, safer alternative. But despite the recent technological strides PV has made, the sheer numbers in terms of cost per kilowatt are still generally in nuclear's favor.[6]

What follows is a brief overview of how solar PV for the home has changed over the past thirty years. In general, solar PV has become cheaper, more powerful, more reliable and more technologically diverse, as have the secondary technologies involved with it, mostly inverters, or devices that convert the direct current (DC) produced by solar panels into the more commonly used alternating current (AC). Interest in, and usage of, solar PV over this time frame seems to be on an exponential rise.

1980s

Despite the OPEC oil embargo of 1973-74, the typical American home was not only still an energy hog, but also an energy sieve because of poor design, poor craftsmanship and inadequate materials. "There are people walking around today who still don't seem to believe there is an energy shortage," said Charles Schwing, president

renewables. 21 Mar 2011. (http://www.upi.com/Business_News/Energy-Resources/2011/03/21/Japans-nuclear-disaster-boosts-renewables/UPI-28501300714143/#ixzz1HJPwVWKa)

[6] Mansur, S. The Breakthrough Institute. *Doing the Math: Comparing Germany's Solar Industry to Japan's Fukushima Reactors*. 23 Mar 2011. (http://thebreakthrough.org/blog/2011/03/doing_the_math_comparing_germa.shtml)

of the American Institute of Architects, "and our homes reflect it."[7]

But the government was starting to respond to our dependence on foreign oil, if only slowly. Federal tax credits for solar PV and other alternative energy sources were enacted into law under the National Energy Act of 1978.[8] But at a cost of about $100 per watt-hour of energy produced, solar technology for terrestrial applications was still well within the realm of science fiction.[9] (By comparison, the cost of solar PV electricity in 2008 was estimated by Zweibel at 17 cents per kWh, or 0.017 cents per watt-hour.[10]) The tax credits were due to be phased out in 1985, and the Washington DC-based Solar Energy Industries Association supported this. "We don't want to be in the solar tax credit business," SEIA Executive Vice President David Gorin said. "We think the phase-out is the way to do it."[11] Most in the industry, however, wanted the credits extended, and for good reason. The price of oil dropped in the early 1980's and, consequently, so did interest in solar power.[12] Looking back, an article from the Los Angeles Times refers to "the solar massacre of 1985":[13]

> "Everybody and their brother was manufacturing or installing solar equipment," recalled Mike Gallant, owner of Generic Electric in Orange (California). "After tax credits ended, it was a matter of months and the entire industry had been shaken out."
>
> Gallant is a survivor of the solar massacre of 1985. Dozens of companies failed, big marketing firms washed their hands of the solar industry, and a once enthusiastic public ran back into the welcoming

[7] Hinds, M. The New York Times: New York, NY. *Despite a trend toward energy conservation, new houses are called energy sieves*. 28 Dec 1980.

[8] Wald, M.L. The New York Times: New York, N.Y. *Solar power's future unclear as tax credit faces end.* 30 Dec 1985.

[9] Scanlon, M. *Living off the grid: 1994 guide to solar power for home owners*. Mother Earth News: Dec. 1993.

[10] Zweibel, K., Institute for Analysis of Solar Energy, George Washington University. *PV Innovation.* (p.20, http://solar.gwu.edu/index_files/Resources_files/Innovation%20in%20PV_KZ.pdf)

[11] Rivera, N. The Los Angeles Times: Los Angeles, CA. *Solar Tax Credit extension sought: Industry fears that lapse would mean serious setback*. 12 Mar 1985.

[12] Rierden, A. The New York Times: New York, NY. *Homeowners revive interest in solar power*. 25 Aug 1991.

[13] Clark, S. The Los Angeles Times: Los Angeles, CA. *Solar Energy comeback: Companies hope to bring the sun back into homes.* 15 Sep 1990.

arms of the Southern California Gas Co. for its home heating needs. It seemed that the great solar experiment had gone into eclipse.

The Carter Administration did manage to make a small solar footprint with eight demonstration projects scattered around the country, designed to promote solar PV during the energy crisis. As the energy crisis waned, however, the projects were shut down, except for one at Beverly High School in Beverly, Massachusetts, which was saved by the city and volunteers.[14]

For homeowners during the 1980's, solar PV was seen more as a means to escape being connected to the grid entirely rather than as a complement to it. However, in 1989 one enterprising homeowner, Frank Poust, found that his PV system of 66 panels wasn't enough to make a complete break from the grid, so for power at night he added a battery backup consisting of 32 six-volt batteries. The return on investment for his complete system was estimated at 8.5 years.[15] Others were even more innovative, utilizing solar PV to power individual appliances. In 1986, in addition to using a solar cooker, solar-powered battery rechargers and solar panels to heat a hot tub, William Becker used solar panels to charge a battery for an electric bicycle.[16]

If a homeowner wanted to use conventional appliances in a PV-powered house, such as a refrigerator or a dishwasher, they would need an inverter, a device that turns the direct current generated by solar PV panels into alternating current that runs an appliance. The inverters of the time were ill-equipped to handle the power needs of large appliances, until Trace Engineering[17] developed a special surge-proof inverter in 1985, thereby revolutionizing the home-power industry.[18] Devices such as solar-powered attic fans,

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[14] Leighton, P. The Salem News: Salem, Mass. *Solar field at Beverly High due for major upgrade.* 15 May 2009. (http://www.salemnews.com/local/x1690076982/Solar-field-at-Beverly-High-due-for-major-upgrade)

[15] Beauge, J. The Patriot-News: Harrisburg, PA. *Gutsy home builder bets on sun, skips commercial power; No electric lines to this Lycoming house*. 29 Jan 1989.

[16] Ritter, J. The Chicago Sun-Times: Chicago, IL. *Solar man wants world to see the light on power.* 08 Jun 1986.

[17] Trace Engineering is now owned by Xantrex (http://www.xantrex.com).

[18] Scanlon, M. *Living off the grid: 1994 guide to solar power for home owners*. Mother Earth News: Dec. 1993.

outdoor lighting, and solar water heating technology started to experience a resurgence by the end of the '80s.[19]

Mostly dominating the "headlines" during this period, however, were tales of passive and active solar heating, with greenhouses attached to some homes to help lower winter heating bills.[20] During the 1980-1981 school year, students at Shawsheen Valley Technical Vocational High School[21] helped to build a house in North Tewksbury, Massachusetts that incorporated solar heating technology provided by a local company, which the students helped install. The prospective owners made this atypical choice of housing because it saved them money compared to a conventional contractor, and because the students' work came highly recommended by other recipients of the students' work.[22]

1990s

Germany and Japan started PV incentive programs in the early 1990's. Most of Japan's capacity was the result of a residential buy-down program, while Germany used a number of approaches, including rebates, low-interest loans, and a feed-in tariff program (FiT) with high incentive levels and mandatory purchase requirements by utilities. By the end of 2000, nearly 320 megawatts (MW) of PV were installed and operational in Japan, while Germany had 110 MW, making them the first and third largest PV markets in the world, respectively.[23]

In the U.S., Berta Nelson of Norwich, Connecticut wanted to "get off the grid for good" and had solar panels installed with battery backup in June 1991. Among her reasons for going solar were concerns about air pollution, storage of the state's low-level

[19] Brooks, A. The Star Tribune: Minneapolis, MN. *Use of solar energy devices in homes is back on the rise*. 08 Aug 1992.

[20] Stocker, C. The Boston Globe: Boston, Mass. *Life in Solar Space*. 05 Nov 1982.

[21] Now named Shawsheen Valley Technical High School and/or Shawsheen Regional Technical High School, information on their carpentry program is available at http://www.shawsheentech.org/vocational-programs/carpentry.html.

[22] Pave, M. The Boston Globe: Boston, Mass. *High school students building solar house*. 25 Dec 1980.

[23] Bolinger, M., and Wiser, R. *Case Studies of State support for renewable energy: Support for PV in Japan and Germany*. Berkeley Lab and the Clean Energy Group, September 2002. (http://eetd.lbl.gov/ea/emp/cases/PV_in_Japan_Germany.pdf)

nuclear waste and the conflict in the Persian Gulf. Said Nelson, "…[w]hen you think about what we are paying in terms of air pollution and nuclear waste, deciding to go solar is really out of the domain of money." Before doing this, she made an informal energy efficiency audit, cutting her energy bill by 80 percent after buying a low-voltage refrigerator and conserving energy as much as possible.[24]

Judi Friedman of People's Action for Clean Energy[25] noticed that the group had been receiving more inquiries about solar since January 1991, around the time of the first big bombing campaign of the Persian Gulf War, than they did following the 1970's oil shortages. "In the last several years fuel has remained so cheap that the public has been lulled into not thinking about alternative energy," she said. "Now, however, many people are seriously considering if our dependence on fossil fuels and nuclear power is really worth all of the risk." Friedman herself has used a PV panel to operate a pump that moves water from a pond to an uphill vegetable garden.[26]

Strides were also being made towards mainstreaming eco-friendly home design. In 1993 the National Association of Home Builders built the "Resource Conservation House." Located in the NAHB National Research Home Park, it was made with 80% recycled materials, and featured a solar hot water heater, supplying 80 to 90 percent of home hot water needs. It also had a photovoltaic system to power the landscape lighting.[27]

If PV providers had trouble finding customers in tough times, they could at least look closer to home for business. John Patterson, president of Mr. Sun Solar[28] in Portland, Oregon, installed a solar PV system and a solar hot water system on his Johns Landing-area home. The home also featured an exercise bicycle as a stopgap measure in case of cloudy weather. A 20-minute aerobic workout can produce about 70 watt-hours - enough power to watch television for an hour or operate lights for five hours.[29]

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[24] Rierden, A. The New York Times: New York, NY. *Homeowners revive interest in solar power*. 25 Aug 1991.

[25] http://www.pace-cleanenergy.org

[26] Ibid.

[27] Anonymous. *Recycled house is builders' model*. BioCycle, June 1993.

[28] http://www.mrsunsolar.com

[29] Potter, C. The Oregonian: Portland, OR. *Solar systems*. 26 Feb 1995.

In 1997, piggybacking on President Clinton's "million solar roofs" initiative, Governor Roy Romer of Colorado encouraged his fellow citizens to install solar panels on their homes. Romer declared a goal of 1,000 rooftop systems by the year 2000. To set an example, an 800-watt system was added to the roof of a carriage house adjacent to the Governor's mansion. The system was donated by Solarex of Frederick, Maryland, a company trying to develop markets in Colorado.[30] Meanwhile, Greenpeace campaigned for solar power in 1997. They collaborated with a housing association to set up three PV systems on homes in Silvertown in London's Docklands.[31] Recognizing the large up-front cost of PV, they also called for government grants to help offset this cost. Marcus Rand, a Greenpeace campaigner, said: "We are calling on the Government to start a nation-wide solar programme immediately … Just by re-directing the pounds 17m currently spent on oil, coal and gas industries Britain could have a minimum of 50,000 solar homes by 2010. The Silvertown project shows it's possible."[32]

Catering to Arizona's off-grid customers, Arizona Public Service[33] began using PV to help them provide off-grid power support. For $270 a month (1999 dollars), APS installed backyard units for customers consisting of solar panels that produced enough power for most domestic uses, a generator that automatically kicked in on cloudy days, and a propane tank to back up the generator. The company guaranteed the equipment, promising to keep power flowing around the clock. This was cheaper compared to the cost of hooking the customers up to the grid, about $50,000 per mile (1999 dollars). However, the Arizona plan does raise concerns that the state's most pristine locations will become just another suburb, populated by off-grid consumers.[34]

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[30] Frank, T. The Denver Post: Denver, CO. *Gov. Sunbeam: Romer launches state solar-energy drive*. 19 Nov 1997.

[31] Anonymous. The Independent: London, UK. *Solar power comes home.* 07 June 1997.

[32] Peabody News. (London-based housing association) *2011 to see solar electricity roll out.* 06 Jan 2011. The installation of solar panels on selected Peabody blocks and houses is set to begin this summer. The programme will cost around £23m, funded by energy suppliers through the government's clean energy cash back system, which offers incentives for energy producers to make use of renewable resources. (http://www.peabody.org.uk/news/2011-to-see-solar-electricity-roll-out.aspx)

[33] http://www.aps.com

[34] Bernstein, F. The New York Times: New York, NY. *O Spacious Skies, With Nary a Power Pole in Sight*. 23 Sep 1999.

2000s

While the Bush Administration emphasized a continued reliance on coal and nuclear for domestic energy production, Bush himself would eventually have three small solar systems installed on the White House grounds, and one at his Texas ranch.[35] The outlook for PV globally was much greater in the early 2000s. According to Hoffman,[36] the global PV industry grew by 27% per year since 1996, with projections of being an industry worth 100 billion euros by 2030.[37]

In 2002 the first Solar Decathlon[38] was held at the National Mall in Washington, D.C. Teams of college students from around the world compete to build the best solar-powered house, which also employ banks of batteries for nighttime power needs. The contest was created by the Department of Energy's Richard King, saying "There are two myths about solar energy for homes … One is that it doesn't work, the other is that it doesn't look good. We're here to prove the opposite."[39]

More than 100,000 people visited the event at the National Mall. In addition to the main award, many other awards were given, and each co-sponsor of the event handed out their own awards. The top three winners of the "People's Choice" awards were Crowder College, the University of Puerto Rico, and the University of Virginia, respectively. The University of Colorado won the Decathlon proper with their entry powered by 63 Astropower AP-120 panels (7.68 kW total). The Colorado team built their house out of mass-produced materials, yet went against many of the standard solar house "requirements." In particular, its roof was slanted almost 20 degrees flatter than

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[35] Nugent, T. The Chicago Tribune: Chicago, IL. *Midwesterners plug into trend to solar power; As many as 50,000 American homes are living `off the grid,' enabling users to snub utility bills.* 03 Mar 2003.

[36] Hoffman, W. *PV Solar Electricity: One among the new millennium industries.* Delivered at the 17th European Photovoltaic Solar Energy Conference, Munich, Germany, 22-26 October 2001. (http://www.nrel.gov/pv/thin_film/docs/pv_overview_21st_century_hoffmann_oca01720.pdf)

[37] According to online currency calculators (http://xe.com/ucc/ and http://www.x-rates.com/calculator.html), 100 billion euros is worth $143 billion in 2001 dollars. Converting to 2011 dollars, the figure becomes $180 billion. (http://www.dollartimes.com/calculators/inflation.htm)

[38] http://www.solardecathlon.gov

[39] Forgey, B. The Los Angeles Times: Los Angeles, CA. *Village sheds light on solar power.* 06 Oct 2002.

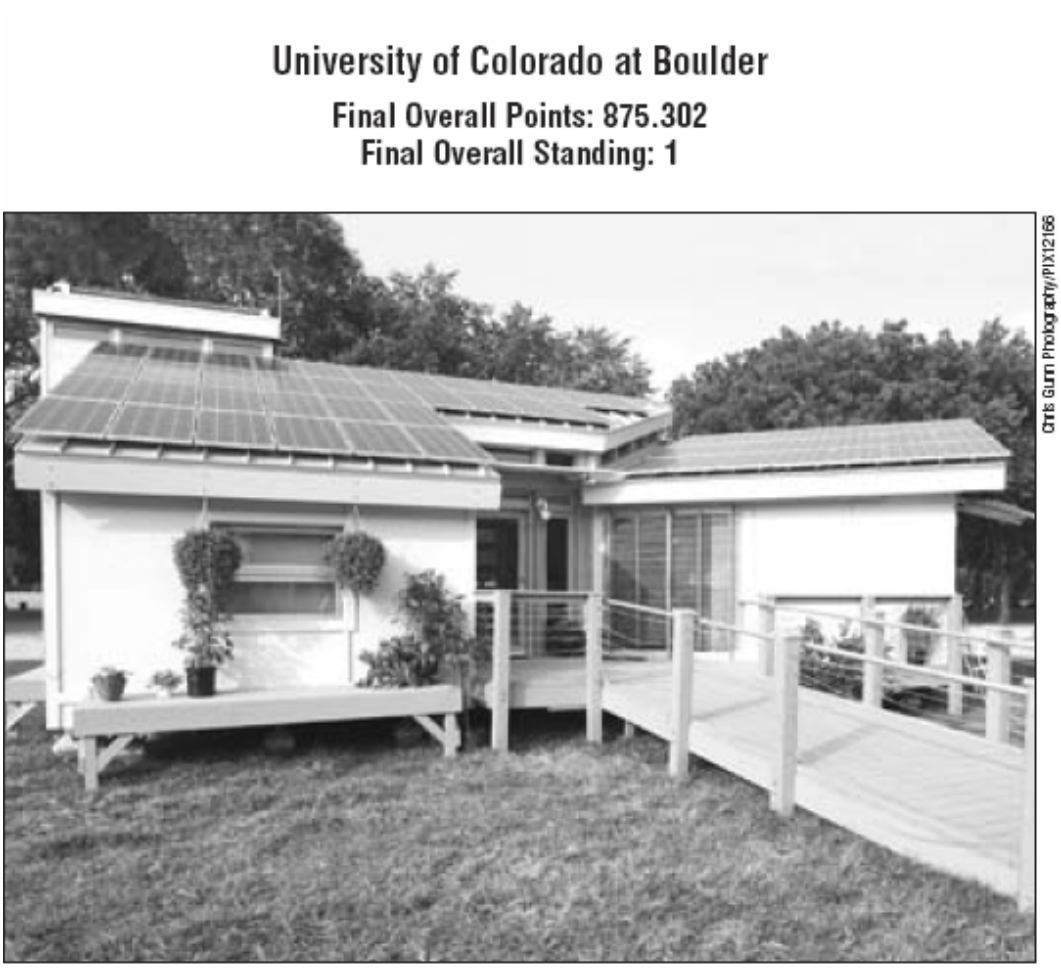

Figure 2. The University of Colorado's 2002 Solar Decathlon entry.

what experts consider the optimum slope.[40]

In 2002, Greenpeace was still trying to promote PV, only now using it as a tool to draw attention to the Kyoto Protocol. Greenpeace activists set up solar panels on the home of then Premier of Alberta Ralph Klein to protest his stance against the 1997 Kyoto climate change treaty.[41] A similar Greenpeace "solar install" was carried out in 2005 on the home of John Prescott, then Deputy Prime Minister of Britain.[42] While it is unclear if this led to more home solar PV installs among the general public, both high-profile men complained that their wives were home at the time and got scared when the Greenpeace activists started putting up the panels.

In 2005, the California Public Utilities Commission (CPUC) began developing the California Solar Initiative (CSI) program under Executive Order, and later in 2006

[40] Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy. *Solar Decathlon 2002: The Event in Review.* (http://www.nrel.gov/docs/fy04osti/33151.pdf)

[41] Harrington, C. The Toronto Star: Toronto, Ontario, Canada. *Alberta's Klein hits the roof over Greenpeace solar panels ; Activists install 'gift' at premier's Calgary home*. 12 Apr 2002.

[42] Beattie, J. The Evening Standard: London, England. *Greenpeace raiders try to put solar panels in Prescott roof*. 26 Apr 2005.

under State Law.[43] The program was given a budget of just over two billion dollars, ten percent of which was allocated for installing solar PV on affordable housing units (poor peoples' homes). In 2006, the California legislature passed Senate Bill 1,[44] establishing official goals for the California Solar Initiative. The three main goals of the CSI are: 1) to install 3,000 MW of solar by 2016, 2) to establish a self-sufficient solar industry within 10 years, and 3) to place solar energy systems on 50 percent of new homes, or building-integrated photovoltaics (BiPV), within 13 years. At the local level, Sonoma County and the city of Sebastopol are also flirting with mandatory BiPV requirements on all new construction.[45;46]

The city of Perris, California made some overtures in an attempt to curb their CO_2 emissions and produce green energy with PV. In April 2006, Perris contracted with New Jersey-based Honeywell to upgrade building systems and facilities to cut their energy use. Under the agreement, the company began retrofitting lights and installing high-efficiency heating and cooling units with programmable thermostats. The energy savings the upgrades produced, estimated at $1.8 million, will pay for the work over the course of the 20-year agreement. In addition, the company led a solar panel installation project to generate clean electricity for city facilities. Novato, California-based SPG Solar[47] designed and installed solar installations on carport roofs at the Perris library, firehouse, senior center and city hall, among others. The installations were completed in January 2008 and, in addition to the benefits provided by shaded parking spaces in sunny California, they can produce 370 kilowatts of electricity annually, or enough energy to power about 100 homes per year.[48]

[43] California Public Utilities Commission. *About the California Solar Initiative.* (http://www.cpuc.ca.gov/PUC/energy/Solar/aboutsolar.htm)

[44] http://www.leginfo.ca.gov/pub/05-06/bill/sen/sb_0001-0050/sb_1_bill_20041206_introduced.pdf

[45] Feinstein, M. Green Pages: Washington, DC. *Major California election successes in 2006*. 01 Jan 2007.

[46] Solar Sonoma County. *Sonoma County Solar Implementation Plan: Solar Sonoma County.* March 2010. (http://www.solarsonomacounty.org) (http://www.sonomacity.org/uploads/Reports%20&%20Other%20Docs/Solar%20Implementation%20Plan_FINAL.pdf)

[47] SPG Solar website. (http://www.spgsolar.com/index.php/markets-served/government-and-education/government/city-of-perris/)

[48] Anonymous. *Putting sunlight to work.* The American City & County: Nov. 2008. (http://americancityandcounty.com/pubwks/facilities/harnessing_solar_energy_1108/index.html)

The private sector makes a few tentative steps towards meeting California's new BiPV-related goals. On March 15th, 2008, two LEED-Certified[49] neighborhoods in San Jose, Orchard Heights and Falcon Place, were open to the public. The home manufacturing firm Pinn Bros. partnered with OCR Solar & Roofing for the project, using BP Solar's roof-integrated EnergyTile solar modules.[50] The homes will produce a total of 231,000 kWh per year and reduce greenhouse gases by 6.6 million pounds. Using other energy-saving features in the homes' construction, the homes are up to 35 percent above California's strong Title 24 Energy Efficiency Standards.[51] The CSI program has a two-tier system, requiring a 15% reduction (minimum) or a 30% reduction (recommended) in a building's heating and energy footprint.[52]

Even utilities, once long opposed to PV, are starting to get on board. Renewable energy sources have "a place going forward," said Jeff Brining, a Norwich Public Utilities engineer and energy efficiency program director. "We recognize that the problem is the economics aren't there yet, but we want the community to be ready to go when there is a breakthrough in technology. There really is no better way to learn than by doing."[53] The number of utility-scale PV arrays was certainly on the rise. A list of arrays of 100 kW and greater was compiled by Sandia National Laboratories in 2004. The list adds up to just over 492 MW installed around the world, 428 MW of which is in the United States, and 409 MW of which is in California alone.[54]

Students

During the 2006-2007 academic year, a group of Stanford graduate students

[49] Leadership in Energy and Environmental Design. See the U.S. Green Building Council website at http://www.usgbc.org/.

[50] Anonymous. U.S. Newswire: Washington, DC. *Pinn Bros. Fine Homes build's San Jose's first solar & LEED Certified neighborhoods*. 11 Mar 2008.

[51] For more on Title 24 standards, go to http://www.energy.ca.gov/title24/.

[52] For information on Title 24 standards in relation to the California Solar Initiative, go to http://www.gosolarcalifornia.org/documents/CSI_HANDBOOK.PDF.

[53] Daddona, P. McClatchy - Tribune Business News: Washington, DC. *Alternative energy products find a foothold at regional utilities*. 13 July 2009.

[54] Sandia National Laboratories. *Solar Power Plants, Worldwide: 100kW+ (as of 3/15/2004).* 15 Mar 2004. (http://photovoltaics.sandia.gov/docs/PDF/Solar%20Power%20Plants%20Worldwide.pdf)

started the Stanford Solar & Wind Energy Project (SWEP).[55] The branch dedicated to solar photovoltaics is called the Stanford University Solar Initiative (SUSI).[56] They are still in the process of determining Stanford's solar potential, taking such factors into account as the visual impact that a PV installation would have on each campus building.[57] Located in the sunlight-rich Southwest, they have so far determined that Stanford has a great solar resource, with about a 10 MW potential for the whole campus.

Abbotsford Middle School in Canada now utilizes wind, solar and a bicycle-powered generator to power their computer lab.[58] When government funding for the project was abruptly canceled, the school used their savings to pay for it.

In the 2009 Solar Decathlon, the trend was towards solar PV systems that produce more power than the homes needed. As a motivating incentive, teams get bonus points for excess power they feed back into the grid. Among the entries were homes built by the University of Illinois (9 kW), the University of Louisiana at Lafayette (7.8 kW), Cornell (8 kW), and the winners of the 2007 Solar Decathlon, the Technical University of Darmstadt in Germany (11.1 kW), whose two-story entry features solar panels on the roof and on all four sides of the house.[59]

2010s

There are two signs that solar PV has surely come of age in American capitalism. One is that solar panel theft is on the rise.[60] The other is that it is now a product worthy of the attention of aggressive salesmen, and a few California solar installers have received complaints for their aggressive sales tactics and shoddy installation work.

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[55] http://inversion.stanford.edu/swep/drupal

[56] http://inversion.stanford.edu/swep/drupal/?q=node/17

[57] SUSI's Google Group: http://groups.google.com/group/swep-pvproject.

[58] Ryan, D. The Vancouver Sun: Vancouver, B.C. *Abbotsford Middle School runs computer lab on green energy; Project uses wind turbine, solar panels and bike-powered generator.* 20 Oct 2009.

[59] Razzi, E. The Washington Post: Washington, DC. *All's Possible Under the Sun; Twenty student teams take over the Mall to show that solar-powered living is more than just a bright idea.* 10 Oct 2009.

[60] Simon, S. The Wall Street Journal: New York, NY. *Consumers --- Stop That (Solar) Thief! As more solar panels are stolen, companies find new ways to protect them*. 19 Oct 2009.

(Specifically, Pacific Home Remodeling and Sungate Energy Solutions, formerly known as American Home Craft) The companies send salesmen who are instructed not to leave the customers' home until a deal gets signed. Afterwards, the installers are slow in getting the job done, if at all, and the customer ends up with a smaller-than-average solar PV system (< 2kW). "Customers will hardly notice the difference on their electric bill," said Ben Airth, residential program manager for the San Diego-based nonprofit California Center for Sustainable Energy.[61] After months of waiting, one customer ended up complaining to the Better Business Bureau and the California Contractors State Licensing Board. In an effort to control prices, the CSI created a rule in 2010 that companies looking to offer customers state rebates couldn't charge more than two standard deviations above the mean price per watt. ($14.34 per watt in January 2011) [62]

In the wake of the 2008 housing bubble, not all solar ventures were smoothly going forward. One such victim was Oshara Village,[63] a planned eco-friendly housing development in Santa Fe, New Mexico. Only 128 of its 735 lots have been sold, and only 55 homes have been built. Century Bank filed for foreclosure against Oshara. The "village" was to feature PV for electricity, solar-oriented buildings for heat, and a water recycling program.[64]

Google currently leads the corporate world in investing in green energy technology, and is trying to get others to follow. They have invested in Nanosolar, [65] a solar PV manufacturer that promises to dominate the market with CIGS-based technology that boasts an impressive energy pay-back period of weeks instead of years.[66] They have also invested in several wind farms, and have provided $168 million to support construction of BrightSource Energy's 392 MW Ivanpah project in California's Mojave Desert, one of the first utility-scale solar thermal plants to enter construction in the U.S.

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[61] Wolff, E. McClatchy - Tribune Business News: Washington, DC. *Some solar prices sky high*. 06 Feb 2011.

[62] Ibid.

[63] http://osharavillage.com

[64] Sharpe, T. McClatchy - Tribune Business News: Washington, DC. *Bank moves to foreclose on Oshara Village development*. 04 May 2011.

[65] http://www.nanosolar.com

[66] LaPedus, M. Electronic Engineering Times. *Thin-film cells fatten solar market*. 19 Feb 2007.

in three decades. But even Google isn't above relying on help from the government. In June 2011, Google created a $280 million tax-equity fund to help SolarCity Corp. pay for rooftop solar systems. SolarCity finances the installation of photovoltaic panels on houses, and homeowners pay a monthly fee to lease the equipment. The investment was the first time a major corporation, rather than a finance company or utility, provided this type of financing for a solar installer. "It's part of our culture to try and find ways that we can make things better," said Rick Needham, Google's director of green business operations. Each deal, he said, is an opportunity "to support something that we think is important, which is deployment of more clean energy and doing it at a scale and in places where it can eventually lead to a lower cost of clean energy."[67]

The concept of energy payback is now being applied to houses, and not just to solar PV technology. In Århus, Denmark, the Simonsen family got to live in an "Active House" for a year and two months.[68] Over a time frame of forty years, the house will eventually produce more energy than was used to build it, and this takes into account the carbon footprint of every type of building material used in the home's construction. The house is a project of VKR Holding,[69] a group of companies dedicated to the craft of green building.[70] Another of their projects is already finished and impressing spectators: the Green Lighthouse on the University of Copenhagen campus.[71]

California continues to set the bar high on green building standards. On January 1st, 2011, CALGreen,[72] the nation's first mandatory Green Building Standards Code, officially took effect. Said Governor Schwarzenegger, "The code will help us meet our goals of curbing global warming and achieving 33 percent renewable energy by 2020 and

[67] Herndon, A. Bloomberg News. *Google Profits From Tax Credit to Boost Its $750 Million Clean Energy Plan*. 08 Jul 2011. (http://www.bloomberg.com/news/2011-07-08/google-profits-from-tax-credit-to-boost-750-million-energy-plan.html)

[68] Strongman, C. The Guardian: London. *Weekend: SPACE: A little power house: This hi-tech home creates more energy than it uses. But what's it like to live in - and how does that touchscreen work?* 06 Mar 2010.

[69] http://www.vkr-holding.com

[70] Hansen, E.K. IEEE Spectrum. *Denmark's Net-Zero Energy Home: With Home for Life, VKR Holding aims to bring carbon-neutral houses to the masses.* August 2010. (http://spectrum.ieee.org/green-tech/buildings/denmarks-netzeroenergy-home/0)

[71] http://greenlighthouse.ku.dk/english

[72] http://www.bsc.ca.gov/CALGreen/default.htm

promotes the development of more sustainable communities by reducing greenhouse gas emissions and improving energy efficiency in every new home, office building or public structure."[73]

At the local level in California, cities and towns are clamoring to get "green" bragging rights. Mayor R. Rex Parris of Lancaster, California has officially declared that Lancaster will become the greenest city in the state. "The goal is to produce more energy ... than we consume," Parris said. "I want to be the first city that does that, for a lot of reasons. One is bragging rights. But two, the cost of energy is going to be so astronomical in the future that the cities that are able to do that will have a competitive advantage…"[74]

At the federal level, there was a slight setback for PV-minded homeowners. The federal Energy Star program, a joint effort between the Environmental Protection Agency and the Department of Energy, no longer offers a 30 percent tax credit for solar panels installed by 2016.[75] The Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010, signed into law by President Obama on December 17, 2010, rolls the tax credits back to 2006 and 2007 levels, which were either 10% of the cost of improvement, or up to $500. This is now a lifetime limit, so if a homeowner has already received $500 between 2006 and 2010, they won't get any more.[76]

Advances are slowly being made in the effort to replace the United States' old energy infrastructure with a new upgraded "smart grid." Congress has directed $4.6 billion from the American Recovery and Reinvestment Act of 2009 ("stimulus money") towards its development. Southern California Edison, which covers parts of Los Angeles and the surrounding area, began distributing new electric meters to its customers in 2008. The "smart meters" can give the homeowner an instant report on the cost of electricity at any given moment, allowing them to adjust their power usage accordingly. For utilities,

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[73] Pruitt, A. Energy Boom. *California adopts nation's first mandatory green building standard.* 01 Feb 2010. (http://www.energyboom.com/policy/california-adopts-nations-first-mandatory-green-building-standard)

[74] Modesti, K. Daily News: Los Angeles, CA. *Lancaster pushes ahead with solar energy.* 12 Jul 2010. (http://www.dailynews.com/news/ci_15500800)

[75] Aubin, T. The Boston Globe: Boston, MA. *Changes That Pay: Your Home / Green Real Estate; Take advantage of rebates and free audits to make your home eco-friendly (and cut utility bills).* 06 Dec 2009.

[76] http://energystar.supportportal.com/ics/support/kbAnswer.asp?deptID=23018&task=knowledge&questionID=32129.

new tools will enable them to quickly divert electricity around highly congested power lines, reducing the risk of power outages.[77]

While the new smarter grid gets developed and deployed, California's capital, Sacramento, continues its energy groundbreaking ways by looking into the similar yet different "microgrid." In energy engineering terms, the fundamental concept of a microgrid is defined as an integrated energy system consisting of distributed energy resources and multiple loads (i.e., buildings and appliances) operating as a single, autonomous grid either in parallel with or "islanded" from the main utility power grid. Utility engineers have historically opposed the concept of "islanding" on the basis of safety and lack of control of their own grids. Today, however, a host of new power conversion technologies has convinced the Institute of Electrical and Electronics Engineers[78] that islands of self-sufficient microgrids are no longer a threat to either workers or to the utility grid in general.

In the case of Sacramento, the Sacramento Municipal Utility District (SMUD) is planning a microgrid powered by solar photovoltaic panels, small combined heat and power units which use natural gas to generate both heat and electricity, and zinc flow batteries. Other utilities currently investigating microgrids include San Diego Gas & Electric, American Electric Power and Canada's B.C. Hydro.[79] Microgrids are also ideal for college campuses. The University of California San Diego already has a fully functioning microgrid that uses a diverse set of power sources, including 1.2 MW of PV panels.[80]

Students

Bill A1084 is currently working its way through the New Jersey State legislature. The bill would require solar panels on all new public school facilities.[81] As of October 1,

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[77] Vock, D. McClatchy - Tribune Business News: Washington, D.C. *Smart grid's growth now depends on states.* 18 Mar 2009

[78] http://www.ieee.org

[79] Asmus, P. Pike Research: Boulder, CO. *Will Utilities Such as SMUD Develop Microgrid Models for the Developing World?* 6 June 2011. (http://www.pikeresearch.com/blog/articles/will-utilities-such-as-smud-develop-microgrid-models-for-the-developing-world)

[80] Reitenbach, G. Sustainability Solutions Institute: UC San Diego. *Smart Power Generation at UCSD - November 1, 2010.* (http://ssi.ucsd.edu/index.php?option=com_content&view=article&id=416:smart-power-generation-at-ucsd-november-1-2010&catid=8:newsflash&Itemid=20)

[81] http://solar.calfinder.com/blog/news/mandatory-solar-jersey-schools

2010, New Jersey had over 200 MW of PV installed statewide,[82] but New Jersey's largest utility company, Public Service Electric & Gas Company (PSE&G), has plans to significantly increase that number. Through their "Solar 4 All" program approved by the New Jersey Board of Public Utilities,[83] PSE&G plans on installing 40 MW of panels on utility poles throughout its service district, which includes over 300 towns and cities. This has raised concerns among some New Jersey residents over cost and aesthetics, while others see the long-term benefits and even like how the panels look.[84]

Since piloting the Solar Affordable Housing Program in 2004, the Oakland, California-based non-profit GRID Alternatives[85] has solarized more than 1,300 homes of low-income families throughout Northern and Southern California, translating to more than $21 million in energy generated over the projected life spans of the systems. GRID is also mentoring local students and showing them the career possibilities of solar PV. Recently, the group worked with students and staff from the Alternative Energy Resources Occupations (AERO) Pathway program at Porterville Unified School District[86] to install two PV systems on local affordable-housing projects. One of the homeowners receiving the panels said, "I'm very happy and grateful for the work that they have been doing. I'm not sure how much this will save us. They said it saves quite a bit."[87]

Beverly High School in Beverly, Massachusetts, recently got a "green" makeover. The whole school was redesigned from a one-story building stretched out over the campus grounds to a more space-efficient four-story building. Their green energy output was nearly doubled from the original 100 kW Carter-era solar field, with a new 83 kW rooftop PV installation and a 10 kW wind turbine.[88] They are now tied with

[82] http://solarpanelspower.net/solar-power/solar-power-mandatory-in-all-future-new-jersey-schools

[83] http://www.pseg.com/family/pseandg/solar4all/attachments/July2909Solar4allrelease.pdf
[84] Various. The Record: Bergen County, New Jersey. *Your views*. 2 Apr 2011.

[85] http://www.gridalternatives.org

[86] http://phs-aero.portervilleschools.org

[87] Avila, E. McClatchy - Tribune Business News: Washington, DC. *PHS students help install solar panels*. 05 May 2011.

[88] Lillelund, L. Wicked Local Beverly with news from the Beverly Citizen: Beverly, Mass. *Beverly High ranks high among green buildings.* 2 Jun 2011. (http://www.wickedlocal.com/beverly/news/education/x724668053/Beverly-High-ranks-high-among-green-buildings#axzz1TT6DZnbn)

local green energy challenger Hopkinton High School which also boasts 193 kW of green energy.[89]

2011 and beyond

SEIA and GTM Research are predicting that the United States will become the world's leading PV market after 2010. Because of a slowdown in major European markets, particularly Germany and Italy, most PV manufacturers and developers are turning to the U.S. for the bulk of their sales. Cumulative grid-connected PV in the U.S. has now reached over 2.3 GW. Another 9 GW of concentrating solar projects have been approved and are waiting in the "pipeline" to be constructed.[90]

With the various national "green" goals to be met, whether it's 50% renewable power by 2030, an 80% reduction of GHG emissions by 2050, or parity with fossil fuel-based electricity, each solar project brings us that much closer. Combined with savings from energy efficiency, perhaps the goals will be met that much sooner.

[89] Solar Power Engineering. *Solar panels on a high school in Hopkinton.* 29 Oct 2010. (http://www.solarpowerengineering.com/2010/10/solar-panels-on-a-high-school-in-hopkinton/)

[90] Solar Energy Industries Association (SEIA) and GTM Research. *U.S. Solar Market Insight™: 1st Quarter 2011 - Executive Summary.* (http://www.seia.org/galleries/pdf/SMI-Q1-2011-ES.pdf)

CHAPTER TWO

A BRIEF PRIMER ON ECONOMICS

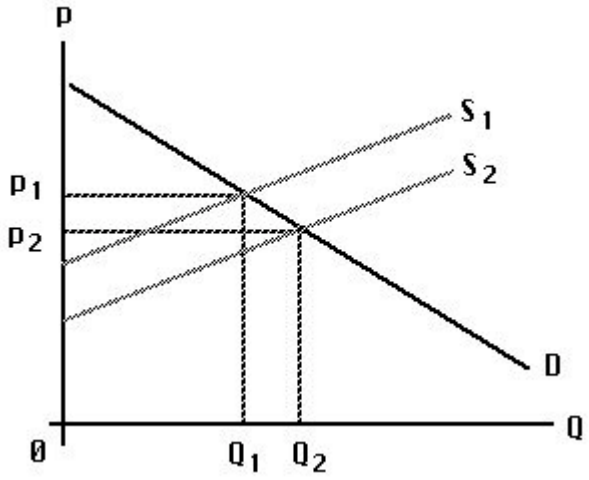

Figure 3. The effect of a subsidy on price and quantity.

Elementary economic theory gives us the downward-sloping demand curve and the upward-sloping supply curve that form a letter 'X'. Where the two lines cross represents the price at which supply and demand balance. Figure 3 illustrates the change that takes place with the addition of a subsidy to the equation. In the graph, P stands for the price of a given good or service, and Q represents the quantity of the good. The demand curve is the negatively-sloped line labeled D. The positively-sloped line labeled S_1 represents our initial supply of the good we wish to buy. When the government provides a subsidy for our good, it brings the price of the good down and shifts our supply curve down to S_2. The price drops from P_1 to P_2, thereby increasing the quantity demanded of the good from Q_1 to Q_2. In the context of this study, as the price of solar PV falls (either in real terms, or through tax incentives or breaks), demand for it will rise.

Recent technological advances and falling production costs have boosted the power production of, and interest in, solar PV. The state of California remains in the throes of an exponential growth in PV installations, with an expectation of growth from around 500 per year in 2000 to 50,000 by the end of the decade.[91] This growth arguably

[91] Roosevelt, Margot. *CALIFORNIA; Rays of progress on Solar Power; Study finds sharp increase in rooftop installations, with San Diego leading L.A. and San Francisco.* Los Angeles Times, 16 July 2009.

has led to continued PV cost reductions. A study done by the Lawrence Berkeley National Laboratory found that the average installed cost of PV systems, before incentives or tax credits, fell from $10.5/W in 1998 to $7.6/W in 2007.[92] These findings are similar to those of Maycock, who found that prices globally declined from $11/W in 1995 to less than $7/W in 2001.[93]

However, Wiser et al.[94] also have found that pre-rebate installed costs have tracked the level of their respective rebates to some degree, and that system purchasers have therefore not benefited from the full amount of the rebate, since system installers or retailers have captured some of it through higher prices. Percentage "caps" on rebate programs have also contributed to impeded cost reductions at best, and artificial cost inflation at worst. The California Energy Commission (CEC) and the California Public Utilities Commission (CPUC) originally had a 50% incentive cap on pre-rebate installation costs, but have since abandoned it. Wiser et al. recommend regular, structured reductions in rebate incentive levels as the best way of developing a sustainable PV market. This is the course that the CSI is currently on, with rebates automatically declining in "steps" based on the volume of solar megawatts within each utility service territory.[95]

Germany and Japan

The Renewable Energy Policy Network for the 21st Century (Ren21), in their online publication "Renewables 2011: Global Status Report," report that Germany is currently first (44% of global PV capacity) and Japan third (9%) in terms of worldwide solar PV capacity.[96] How this came to pass serves as a rich test case for others to follow

[92] Wiser, R., Barbose, G., and Peterman, C. *Tracking the Sun: The Installed Cost of Photovoltaics in the U.S. from 1998-2007.* Feb. 2009. Lawrence Berkeley National Laboratory. (http://eetd.lbl.gov/ea/ems/reports/lbnl-1516e.pdf)

[93] Maycock, P. 2002. "The World PV Market: Production Increases 36%." *Renewable Energy*

[94] Wiser, R., Bolinger, M., Cappers, P., and Margolis, R. *Analyzing historical cost trends in California's market for customer-sited photovoltaics.* Progress in Photovoltaics: Research and Applications. 2007. 15:69-85. (http://onlinelibrary.wiley.com/doi/10.1002/pip.726/pdf)

[95] Go Solar California website. (http://www.gosolarcalifornia.ca.gov/csi/rebates.php)

[96] Renewable Energy Policy Network for the 21st Century (Ren21). *Renewables 2011: Global Status Report.* (http://www.ren21.net/Portals/97/documents/GSR/GSR2011_Master18.pdf, page 23)

Fiscal Year	Number of Approvals	Installed Capacity	Max Subsidy/ System (%)	Max Subsidy/ System (¥/kW)	Max System Size (kW)	Budget (Billion ¥)
1994	539	1.9	50%	900,000	5	2.0
1995	1,065	3.9	50%	850,000	5	3.27
1996	1,986	7.5	50%	500,000	4	4.06
1997	5,654	19.5	33%	340,000	4	11.11
1998	6,352	24.1	33%	329,000	10	14.7
1999	15,879	57.7	33%	329,000	10	16.07
2000	20,877	74.4	33%	270,000	10	14.5
2001	29,389	114.7	33%	120,000	10	23.5

Source: Haas 2002

Figure 4. PV installations in Japan 1994-2001. (Source: Bolinger and Wiser)

on the subject of growing sustainable PV markets.

Japan

Japan had over 300 MW of solar PV in place at the end of 2000, most of which was installed through a residential capital cost buy-down program that began in 1994 and ended in 2001. When the program started, the maximum subsidy per system was 900,000 yen per kilowatt (up to 50% of installed costs). Over time, it declined to 120,000 ¥/kW in 2001 (up to 33% of installed costs).[97] As shown in Figure 4, despite the decline in incentive levels, there was an increase in PV installations over time. By the end of 2004, Japan became the first country in the world to have 1 GW of PV installed. When PV in Japan became cost competitive with fossil fuel-based electricity by 2005, then Prime Minister Junichiro Koizumi ended the subsidy program following pressure from the fossil fuel lobby and free-market advocates. Japan switched their funding focus from rooftop systems to utility-scale systems instead.[98] Japan subsequently fell to third place worldwide, behind Germany and Spain, in terms of total grid-connected solar PV capacity.[99]

After the economic meltdown of 2008, Japan's Ministry of Economic Trade and Industry announced the return of incentives for the residential PV market.[100] The incentives included a Japanese version of a feed-in tariff launched in November 2009,

[97] Bolinger, M., and Wiser, R. *Case Studies of State support for renewable energy: Support for PV in Japan and Germany*. Berkeley Lab and the Clean Energy Group, September 2002. (http://eetd.lbl.gov/ea/emp/cases/PV_in_Japan_Germany.pdf)

[98] Jenkins, J., The Breakthrough Institute. *Soaking up the sun: Solar power in Germany and Japan.* 7 Apr 2009. (http://thebreakthrough.org/blog/2009/04/soaking_up_the_sun_solar_power.shtml)

[99] Johnston, E. The Japan Times: Tokyo, Japan. *POWERING THE FUTURE: Despite headwinds, solar energy making progress, advocates say*. 24 Sep 2011. (http://search.japantimes.co.jp/cgi-bin/nn20110924f1.html)

[100] Burger, M. GLG Research. *Japan PV market turnaround?* 7 Jan 2009. (http://www.glgroup.com/News/Japan-PV-Market-Turnaround--30939.html)

and regional governments offered various local residential PV support such as subsidies, loans, and utility buy-back schemes and assistance through special utility funds specifically for green power. Japan's domestic market more than doubled in 2009 to 477 MW because of these incentives.[101]

Germany

Support for PV in Germany began in earnest in 1989, and went through three major phases: 1) the 1,000 Solar Roofs Program (1990-1995), 2) the 100,000 Solar Roofs Program (started in 1999) and 3) the Renewable Energy Sources Act (2000).

The 1,000 Solar Roofs Program provided rebates of up to 60% of installed costs for PV systems. By the time the program ended in 1995, roughly 2,250 systems totaling 5.25 MW had been installed.[102]

The 100,000 Solar Roofs Program was started in January 1999, with an initial goal of 300 MW to be installed by 2004. The program provided 10-year low interest loans (1.91% in 2001) with no money down and no interest payments for 2 years, working out to about a 20% subsidy. This, combined with an updated Renewable Energy Sources Act, prompted the government to roll back the 300 MW target date from 2004 to 2003.

The Renewable Energy Sources Act of 2000 (RESA) was a new and improved version of Germany's original feed-in law which had been enacted in January 1991. Under the old feed-in law, wind and solar shared the same tariff, around eight cents per kWh. This was sufficient to stimulate massive wind development throughout Germany, but left solar lagging far behind. To remedy this, the PV tariff was increased nearly 6-fold to about 50 cents per kWh under RESA, with a 5% decline each year to encourage cost reductions.[103]

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[101] Solarbuzz: San Francisco, CA. *Major Asia Pacific Photovoltaic markets expected to Grow 85% in 2010.* 7 Jul 2010. (http://www.solarbuzz.com/our-research/recent-findings/major-asia-pacific-photovoltaic-markets-expected-grow-85-2010)

[102] Bolinger, M., and Wiser, R. *Case Studies of State support for renewable energy: Support for PV in Japan and Germany*. Berkeley Lab and the Clean Energy Group, September 2002. (http://eetd.lbl.gov/ea/emp/cases/PV_in_Japan_Germany.pdf)

[103] Ibid.

Even though Japan may, for some, epitomize the ideal solar industry free of government subsidy, in terms of total PV capacity they now lag far behind Germany, a market that is still heavily subsidized. Germany is the largest solar market in the world with 44% of global PV capacity, compared to Japan's 9%. Germany installed around 6 GW of solar in 2010, for a grand total of almost 16 GW for the whole country.[104] Japan won the solar sprint in the 1990s, but Germany's winning the solar marathon in the 2010s.

Perhaps because of this, some Conservative German lawmakers would like to relax government incentives for PV, saying that solar threatens to overburden consumers with high electricity bills. Reducing incentives for solar would favor wind, a more natural fit for utilities, as the size and cost of a wind farm is too high for the average individual homeowner.[105] On the other hand, there are dangers involved if the solar market grows too fast, and Germany has recently implemented new reductions of solar feed-in tariff (FiT) rates.[106] German FiT rates are now to be changed based on cumulative PV installed between March and May 2011. If the total is greater than 6.5 GWp, the FiT will be cut by 12%. If the total is less than 2.5 GWp, the FiT will be increased by 2.5%. These represent the maximum reduction and maximum increase (or minimum reduction), respectively, with other steps in between.[107]

California - The Berkeley FIRST program

In 2008, the city of Berkeley launched a pilot program called the Berkeley Financing Initiative for Renewable and Solar Technology (FIRST) to install solar PV

[104] Green World Investor. *Germany solar energy market world's biggest - Green subsidies fuel growth German Photovoltaic Panel, Cell, Inverter Manufacturers.* 19 Mar 2011. (http://www.greenworldinvestor.com/2011/03/19/germany-solar-energy-market-worlds-biggest-green-subsidies-fuel-growth-german-photovoltaic-panelcellinverter-manufacturers/)

[105] Landler, M. The New York Times: New York, NY. *Germany debates subsidies for Solar industry.* 16 May 2008. (http://www.nytimes.com/2008/05/16/business/worldbusiness/16solar.html?_r=2&scp=1&sq=Solar+Valley+Overcast)

[106] Renewable Energy World.com. *German FIT Reduction Deal Reached.* 07 July 2010. (http://www.renewableenergyworld.com/rea/news/article/2010/07/german-fit-reductions-set)

[107] Osborne, M. PV Tech. *Agreement reached on new German feed-in tariff, maximum 12% regression.* 14 Jan 2011. (http://www.pv-tech.org/news/agreement_reached_on_new_german_feed_in_tariff)

systems using a unique financing mechanism they developed. The high up-front cost of these systems would be lumped in with the property tax payments, and paid off over a period of twenty years. The program was a small one: the total budget was $1 million, and a maximum of 40 projects were to be approved. By the end of the program, however, only 13 projects were completed at a total cost of $336,550. Due to time constraints, the pilot was unable to replace applicants who withdrew.

The authors of the Berkeley FIRST Final Evaluation[108] observed that interest in the program was high: the 40 reservation slots were filled within the first 15 minutes of the opening of the online application. Furthermore, some of the applicants, who either dropped out of the program or never made it into the program in the first place, still wanted to invest in a solar PV project and sought out alternative funding sources to do so. A home equity loan was a popular alternative, and was actually less costly than the Berkeley FIRST program. The majority of people who withdrew from Berkeley FIRST said that the program's interest rate was too high.[109]

The idea behind Berkeley FIRST has since evolved into a wider movement called PACE, an acronym for "Property-Assessed Clean Energy." Since the completion of the Berkeley pilot, the Federal Housing Finance Authority, Freddie Mac and Fannie Mae have all issued strict rulings against any PACE programs that give a PACE loan either equal status to, or precedence over, a mortgage in the event of foreclosure (AKA a "superior lien"). These rulings have effectively halted PACE programs. The agencies argue that PACE loans could increase foreclosures, increase debt loads and place mortgage loans at risk. Proponents of PACE argue that the program can reduce the cost of home ownership, providing stability in the housing market.[110] The group PaceNOW[111] is lobbying Congress to approve H.R. 2599, the PACE Assessment and Protection Act of 2011. The bill currently has bipartisan support in the House of Representatives.[112] H.R.

[108] Planning and Development Dept., Office of Energy and Sustainable Development, City of Berkeley, California. *Berkeley FIRST Final Evaluation.* November 2010. (http://www.ci.berkeley.ca.us/uploadedFiles/Planning_and_Development/Level_3_-_Energy_and_Sustainable_Development/Berkeley%20FIRST%20Final%20Evaluation%20current.pdf)

[109] Ibid.

[110] Ibid.

[111] http://pacenow.org/blog

[112] http://www.govtrack.us/congress/bill.xpd?bill=h112-2599. The full text of the bill is available

2599, sponsored by Reps. Nan Hayworth (R-N.Y.), Dan Lungren (R-Calif.) and Mike Thompson (D-Calif.), will prevent federal housing regulators from adopting policies that contravene established state and local property assessed clean energy laws.[113]

MASH & SASH

Ten percent of CSI funds, or just over $200 million, have been legislated to provide solar PV for affordable housing units. These have been split into two programs: MASH (Multifamily Affordable Solar Housing)[114] and SASH (Single-family Affordable Solar Housing).[115] The overall goals of the MASH program are to: 1) stimulate adoption of solar power in the affordable housing sector, 2) improve energy utilization and overall quality of affordable housing through the application of energy efficiency and solar technologies, 3) decrease electricity cost and usage without increasing monthly household expenses for affordable housing occupants, and 4) increase awareness and appreciation of the benefits of solar among affordable housing occupants and developers.

The MASH program is designed so that the benefits of the installed solar systems would go to both landlords and tenants. To do so, it uses a Virtual Net Metering (VNM) tariff program, a tariff that allows MASH participants to install a single solar PV system per service delivery point that covers the electricity load of a multi-unit building's common areas (laundry room, parking lot lighting) and the tenants' individual meters in a building.[116] In addition, the MASH program is divided into two "tracks." Track 1 incentives provide fixed, upfront capacity-based incentives for solar PV systems that offset common area and tenant loads. Track 2 offers higher incentives to applicants who provide quantifiable "direct tenant benefits" (i.e. any operating cost savings from solar that are shared with their tenants).[117]

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at http://pacenow.org/blog/wp-content/uploads/HR-2599-PACE-Protection-Act-of-2011.pdf.

[113] New Jersey State League of Municipalities website. (http://www.njslom.org/letters/2011-0726-PACE.html)

[114] http://www.gosolarcalifornia.org/affordable/mash.php

[115] http://www.gosolarcalifornia.org/affordable/sash.php

[116] Multifamily Affordable Solar Housing Semi-Annual Progress Report: July 26, 2010. (http://www.cpuc.ca.gov/NR/rdonlyres/C0EEF9DF-1EF4-4C9A-965D-683205D59293/0/MASHSemiAnnualProgressReport_July2010.pdf)

[117] http://www.cpuc.ca.gov/PUC/energy/Solar/mash.htm

The SASH program only offers the Expected Performance-Based Buydown (EPBB) incentive, an upfront lump sum payment based on how much power the PV system is expected to produce, and restricts this to customers serviced by one of the three main investor-owned utilities: Pacific Gas and Electric (PG&E), Southern California Edison (SCE), or San Diego Gas & Electric Company (SDG&E).[118]

Since both MASH and SASH are new programs, they have provided learning opportunities for their administrators. The CPUC noted that "[s]ince its creation in October 2008, the Multi-family Affordable Solar Housing program has been such a hit with contractors and low-income housing agencies that many of the incentives have been fully allocated, and there is a waiting list to participate in the program."[119] The CPUC found it unnecessary to spend their entire marketing budget, since MASH Track 1 was oversubscribed early. However, they did have to do extra marketing to remind people about the Track 2 program, and ultimately requested that excess Track 2 funds be reallocated to Track 1. The authors of the MASH Semi-Annual Progress Report, the California Center for Sustainable Energy[120] (on behalf of the CSI program administrators), also recommended reducing the Track 1 incentive rates in order to fund more PV projects, a strategy also recommended by Navigant Consulting.[121]

Regarding SASH, Navigant observed: "The original SASH design envisioned the use of community financing to cover the gap between the full solar system cost and the SASH incentive, this model did not prove feasible. Given the recession and the tight credit market, loans were less readily available than they were at the time the program was designed. Clients may have also been less willing to take on debt to participate in SASH given the downturn in the housing market."[122]

[118] Single-family Affordable Solar Homes (SASH) Program, Q1 2011 Program Status Report. April 2011. GRID Alternatives, California Public Utilities Commission, and Go Solar California. (http://www.cpuc.ca.gov/NR/rdonlyres/BE2A2B11-A16A-4687-A556-39E337E9F1E4/0/2011Q1SASHREPORT.pdf)

[119] California Public Utilities Commission. *California Solar Initiative 2011 Annual Program Assessment (Legislative Report)*. (http://www.cpuc.ca.gov/PUC/energy/Solar/apa2011.htm)

[120] http://www.energycenter.org

[121] Navigant Consulting. *California Solar Initiative SASH and MASH Program Administrator Performance Assessment Report.* Presented to: The California Public Utilities Commission. April 5, 2011. (http://www.cpuc.ca.gov/NR/rdonlyres/3A60572D-725B-434E-A525-077428DE4E5D/0/CSIMASHandSASHPAAssessmentReport_2011.pdf)

[122] Ibid.

Power Purchase Agreements

A power purchase agreement (PPA) allows the customer to avoid the high up-front cost of solar equipment by leasing it from a third party. The host customer agrees to have solar panels installed on the property, typically on the roof, and signs a long-term contract with the solar services provider to pay them for the power generated by the PV system. The PPA purchase price of the generated electricity is typically at or slightly below the rate the customer would normally pay, and the PPA rates are typically flexible to account for decreases in system efficiency as the system ages. The duration of most solar PPAs can range from six to 25 years.[123] Host customers can either be individual homeowners or corporate clients. SolarCity[124] of Foster City, California caters to both residential and corporate clients, while SunEdison[125] of Beltsville, Maryland and MMA Renewable Ventures (MMA)[126] of San Jose, California handle mostly large corporate PPAs for companies like Wal-Mart and Whole Foods.[127] MMA also handled the financing of the 15 MW PV plant at Nellis Air Force Base in 2007.[128]

Interest in solar PPAs is starting to accelerate in the 2010s. The Arizona Public Service Company has signed a PPA with Starwood Solar for a 290 MW concentrating solar trough plant to be built by Lockheed Martin. It will be completed in 2013, and will provide power to 73,000 APS electricity customers.[129] Abengoa Solar also signed a PPA with APS to purchase power from Solana, the name for what will be the world's largest parabolic trough concentrating solar power (CSP) plant.[130] Located southwest of Phoenix, it will produce enough electricity to serve 70,000 customers, and will include

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[123] U.S. Environmental Protection Agency: Green Power Partnership. *Solar Power Purchase Agreements.* (http://www.epa.gov/greenpower/buygp/solarpower.htm)

[124] http://solarcity.com

[125] http://www.sunedison.com

[126] http://www.mmarenewableventures.com

[127] Peters, L. Semiconductor International. *Solar rebates target corporations.* Jul 2008.

[128] FinancialWire: Forest Hills, NY. *Nellis Air Force Base, MMA Renewable Ventures Close Financing*. 10 Oct 2007.

[129] Anonymous. *Starwood Energy Group Global, Llc; Starwood Energy Signs Power Purchase Agreement with Arizona Public Service Co.; To Build the World's Largest Dispatchable Solar Plant with Lockheed Martin*. Biotech Business Week: 08 Jun 2009.

[130] http://www.solanasolar.com; http://www.aps.com/main/green/Solana/default.html

six hours of molten salt thermal energy storage capacity.[131] It is expected to be operational by 2013.

Staples, the business supply company, with 95% of its buildings leased, has seen great success with PPAs. As of 2009, they have over 25 active solar rooftops, each one producing 5-30% of the facility's annual energy needs. "The long-term price certainty is important," says Jake Swenson, sustainability manager for Staples. "We're seeing savings increase over time as the utility rates increase more than our escalation rates in the PPA."[132]

PPAs also work for slightly smaller installations. Constellation Energy Group of Baltimore built a 525 kW PV system to generate power for Patriot Place, the 1.3-million-square-foot entertainment, retail and dining complex next to the New England Patriots' Gillette Stadium in Foxborough, Mass. Under a 20-year PPA, Constellation will own the PV equipment and sell power to Patriot Place.[133] Real Goods Solar installed 790 kW of solar on four affordable housing communities in California: three in San Francisco and one in Richmond. The upfront costs have been significantly reduced by the MASH program and by San Francisco Mayor Gavin Newsom's GoSolarSF program.[134] Siemens Industry has recently announced its own PPA program. "…[b]oth the financial and technical barriers associated with implementing solar energy are mitigated-we take on the risk-while our customers reap the rewards of clean energy and lower utility bills," said Andreas Schierenbeck, president of the Building Technologies division of Siemens.[135]

Of all the programs mentioned above, the Go Solar California program provides the most comprehensive data available to the public about the PV installations in their program. It therefore represents the basis for the data analysis of this thesis, and the next chapter will provide the details on how it was used in conjunction with Census data.

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[131] Anonymous. "Abengoa Solar Closes Financing for the World's Largest Solar Generation Plant." *Transmission & Distribution World*: Jan. 2011.
[132] Morton, J. "Maximize your Power Purchase Agreement." *Buildings*: September 2010.
[133] Anonymous. The Washington Post: Washington, DC. *Local business.* 08 Oct 2009.
[134] Anonymous. Economics Week. *Real Goods Solar; Real Goods Solar to Install Low Cost Solar Energy at Bay Area Affordable Housing Communities*. 18 Dec 2009.
[135] The Pak Banker: Lahore, Pakistan. *Siemens Introduces Solar Power Purchase Program*. 27 Mar 2011.

CHAPTER THREE

METHODOLOGY

The California Energy Commission (CEC) and the California Public Utilities Commission (CPUC) provide data on California solar photovoltaic (PV) installations to the general public through the California Solar Statistics web site.[136] For this thesis, the Working Data Set for February 2nd, 2011 is used as the reference data set. Raw Data Sets are archived on a weekly basis online[137], but not the Working Data Sets. According to their FAQ page,[138] a Raw Data Set becomes a Working Data Set once the program administrators check it for errors. For this reason, a Working Data Set was chosen.

After sorting the Working Data Set, the number of PV installations were counted by county, then by city. Cities were cross-checked against the 2000 Profiles of General Demographics Characteristics (for California),[139] and those not appearing in the census data were eliminated from the list. PV installations were also counted separately in residential and non-profit categories. Four different regressions were performed with Census 2000 data: County/Residential, City/Residential, County/Non-Profit and City/Non-Profit. These same four were done later with ACS 2005-2009 data.

Data Set 1: California Census Data, Year 2000 – Summary File 3 Files

Rather than extracting and rearranging census data from the 2000 Profiles of General Demographics Characteristics PDF file, the California Summary File 3 (SF3) files were utilized for the statistical tests.[140] There are four types of Summary Files.[141]

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[136] http://www.californiasolarstatistics.ca.gov/current_data_files/
[137] http://www.californiasolarstatistics.ca.gov/archived_data_files/
[138] http://www.californiasolarstatistics.ca.gov/faq/
[139] http://www2.census.gov/census_2000/datasets/demographic_profile/California/2kh06.pdf
[140] http://www2.census.gov/census_2000/datasets/Summary_File_3/California/
[141] For Census 2000: Summary File 1 presents counts and information (age, sex, race, Hispanic/Latino origin, household relationship, whether residence is owned or rented) collected from all people and housing units. Summary File 2 contains population and housing characteristics iterated for many detailed race and Hispanic or Latino categories, and American Indian and Alaska Native tribes. Summary File 3 presents detailed population and housing data (such as place of birth, education, employment status, income, value of housing unit, year structure built) collected from a 1-in-6 sample and weighted to represent the total population. Summary File 4 contains tabulations of population and housing data collected from a sample of the population. The data are shown down to the census tract level for 336 race, Hispanic or Latino, American Indian and Alaska Native, and ancestry categories. (http://factfinder.census.gov/servlet/DatasetMainPageServlet)

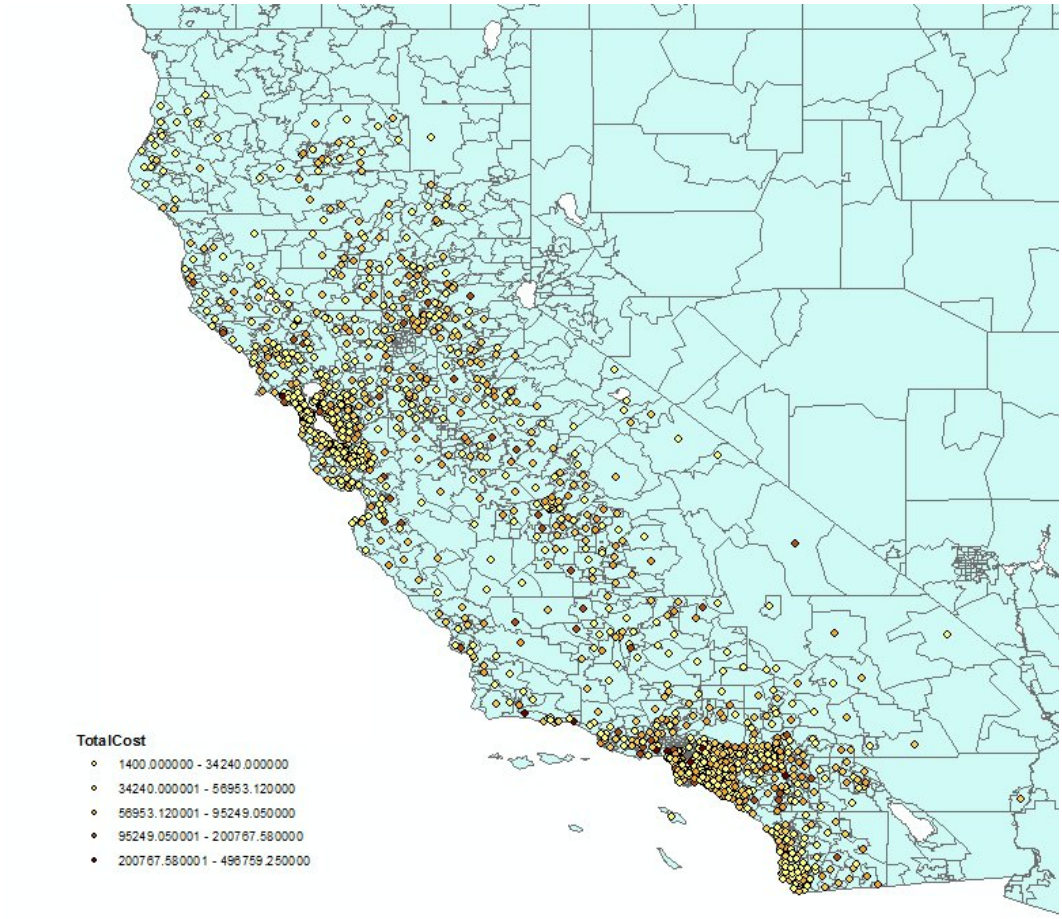

Figure 5. Map of PV installations in California.

The SF3 files contain detailed population and housing data, and generally seemed to be the best fit of the four Summary File types for purposes of this study. There are 76 SF3 files of California Census data, and there are 16,520 columns of numbers distributed unevenly among the 76 files. (For use in statistical programs, there are less than 256 columns per file.) Each column of data represents a specific variable. Variables are further organized into subgroups based on the Census subject matter they represent (people or housing, different ethnic groups, etc.). The preparers of the SF3 files went to great pains to make sure that subgroups of variables aren't split between two files. For the column headers (the variable names), the Microsoft Access Summary File 3 template file was used.[142] See Appendix A for more detailed information about how this was done.

The 2000 Profiles of General Demographics Characteristics PDF file was used to match city and county population data in the first SF3 file to make sure the correct rows for cities and counties in the SF3 files were being used. (For example, data for the town of Garberville is in row number 102812, and data for Yuba County is in row number

[142] http://www.census.gov/support/2000/SF3/Acc2000.zip

87537 in the SF3 files) The next step was to convert the SF3 files into files that could be used in the statistical program R.[143]

Java to the Rescue

Java™ is a computer language available for free on the web at http://www.java.com and at the Oracle Corporation's website. (http://www.oracle.com) Java programs were written and used to perform data-handling tasks which, if done manually, would simply have taken too long. The SF3 files aren't encrypted, and are set up in a Comma-Separated Values (.csv) format. The SF3 files as they are, however, easily exceed the row limits of the statistical tool, R. Using lists of row numbers for 58 counties and 1,040 cities, Java programs were then used to make shortened versions of the SF3 files containing only the necessary rows. Other Java programs were used to automatically add PV installation data and column headers to the new files, and to automatically calculate r^2 values for all variables, among other tasks. The r^2 values were double-checked in R to make sure the Java programs worked correctly.

Census Variables

Each of the 16,520 columns of Census data has a unique alphanumeric code which will be referred to in this thesis as a "variable." Each variable begins with one of four prefixes: P, PCT, H or HCT. (P for people, H for housing) This prefix is followed by three numeric digits. Next, some variables involve data for specific ethnicities. The Census data uses nine different categories for race, and these are labeled with one letter from A to I.[144] Finally, the variable name is ended with its own unique, identifying suffix of three numeric digits.

Consider, for example, the variable PCT066A009. The PCT066 group stands for "Sex by Age by Armed Forces Status by Veteran Status for the Population 18 years and over." The A is for the "White alone" ethnic group, and the "009" describes men over 65 years old currently serving in the Armed Forces, of which there are none (Californians). Similarly, the variable PCT066A020 describes white women over 65 years old currently

[143] Available at http://www.r-project.org/.

[144] The nine Census categories for race are: A) White alone, B) Black or African American alone, C) American Indian and Alaska Native alone, D) Asian alone, E) Native Hawaiian and Other Pacific Islander alone, F) Some other race alone, G) Two or more races, H) Hispanic or Latino, and I) White alone, not Hispanic or Latino. For the ACS data, the categories are the same, but H and I have traded places.

serving in the Armed Forces, of which there are none (Californians). This is the same for the other eight Census ethnic groups. Another variable that is all zeroes is PCT064A014, or "Residence in 1995 for the Population 5 years and Over—State and County Level (White alone)." The "014" stands for "In Puerto Rico in 1995: Same municipio." Similarly, if it were "015" it would mean "In Puerto Rico in 1995: Different municipio." *Municipio* means municipality, or country subdivisions, of which Puerto Rico has 78. Coincidentally, of the nine Census ethnic groups, none were in Puerto Rico in 1995 (Californians).

Columns of Census data will be referred to here as variables.

Data Set 2: The American Community Survey, 2005-2009: 5 Year Summary Files

For comparison to the results of the 2000 Census, a second data set was used: the American Community Survey Estimate for 2005-2009. The files used are available online.[145] Compared to the Census 2000 SF3 files, the ACS files are much less orderly. The .zip file contains 235 files: 117 estimate files, 117 margin of error files, and one geography file explaining what each row in the data refers to. The files vary widely in size, and 56 of them are completely empty! An Excel spreadsheet contains the variable names and is available online.[146] The ACS has a different but similar system as the Census for naming variables, and has a total of 21,207 columns of data (referred to here as "variables").

The ACS files were processed in a similar manner using Java programs, with variable names and PV installation data added to shortened custom spreadsheets. Again, the same four categories were considered: County/Residential, City/Residential, County/Non-Profit and City/Non-Profit. Regression values were computed with Java and double-checked in R.

[145] http://www2.census.gov/acs2009_5yr/summaryfile/2005-2009_ACSSF_By_State_All_Tables/California_All_Geographies_Not_Tracts_Block_Groups.zip

[146] http://www2.census.gov/acs2009_5yr/summaryfile/Sequence_Number_and_Table_Number_Lookup.xls

CHAPTER FOUR

RESULTS OF STATISTICAL ANALYSIS

Regression tests were performed with California solar PV data as the response variable. Four categories of California Census 2000 data and four categories of American Community Survey data for the period 2005-2009 were used separately as the explanatory variable in eight separate tests. The eight categories used were Census 2000/County/Residential, Census 2000/City/Residential, Census 2000/County/Non-Profit, Census 2000/City/Non-Profit, ACS/County/Residential, ACS/City/Residential, ACS/County/Non-Profit and ACS/City/Non-Profit. The r^2 values of the county categories (~0.80) were higher than the city categories (~0.50), and this was consistent between the 2000 Census and the ACS 2005-2009 data.

There are 16,520 different variables in the 2000 Census, and 21,207 in the ACS 2005-2009 data. For practical reasons, analysis was restricted to the top 20 "variables" with the highest r^2 values for each of the eight categories. In general, a portrait is painted of a middle-class, mostly white California resident who has adapted his or her lifestyle to avoid the harsh California metropolitan commutes.

Geographic Mobility

There are five variables within the top 10 of the Census 2000/County/Residential category that deal with "Residency in 1995." These five variables are all in the same subgroup: PCT064I, or "Residency in 1995 for the Population 5 years and over - State and County Level (White Alone, not Hispanic or Latino)." Taken together, given that their r^2 values are so close together, these five variables suggest that 1) the more recently a white California resident has moved, the more likely they are to use solar PV, and 2) if they're coming from out of state, they're slightly less likely to use PV than someone who's moving to a different California county. Of the PCT064I group, the three variables with the smallest r^2 values in this group are PCT064I016 ("Elsewhere in 1995", $r^2 = 0.59$), PCT064I017 ("U.S. Island areas", $r^2 = 0.60$) and PCT064I018 ("Foreign country or at sea", $r^2 = 0.58$).

In the ACS 2005-2009/County/Residential category, the variable with the highest r^2 value is for people who have moved from a different state, and who are married but

Table 1. Census 2000/County/Residential category - highest r^2 values.

Variable	Description	r^2 value
PCT017019	Ancestry (2nd Ancestry Reported): Australian	0.80
PCT064I006	Residence in 1995 for the Population 5 years and over - State and County Level (White alone, not Hispanic or Latino): In United States in 1995, Different County	0.80
HCT015014	Aggregate Household Income in 1999 (Dollars) by Tenure by Age of Householder by Year Structure Built: Owner Occupied: Householder 35 to 64 years: Built 1999 to March 2000	0.80
PCT064I008	Residence in 1995 for the Population 5 years and over - State and County Level (White alone, not Hispanic or Latino): In United States in 1995, Different State	0.80
PCT064I012	Residence in 1995 for the Population 5 years and over - State and County Level (White alone, not Hispanic or Latino): In United States in 1995, Different State: West	0.79
PCT064I011	Residence in 1995 for the Population 5 years and over - State and County Level (White alone, not Hispanic or Latino): In United States in 1995, Different State: South	0.79
PCT064I010	Residence in 1995 for the Population 5 years and over - State and County Level (White alone, not Hispanic or Latino): In United States in 1995, Different State: Midwest	0.79
PCT016054	Ancestry (1st Ancestry Reported): Luxemburger	0.78
PCT072I013	Age of Householder by Household Income in 1999 (White alone, not Hispanic or Latino): Householder under 25 years, $60,000 to $74,999	0.78
PCT016071	Ancestry (1st Ancestry Reported): Slovene	0.78
PCT063I008	Place of birth by Citizenship Status (White alone, not Hispanic or Latino): Born in Other State in the United States: West	0.78
PCT065I015	Means of Transportation to Work for Workers 16 Years and Over (White alone, not Hispanic or Latino): Other means	0.78
PCT019070	Place of Birth for the Foreign-Born Population: Africa: Other Eastern Africa	0.77
PCT016039	Ancestry (1st Ancestry Reported): Finnish	0.77
PCT016058	Ancestry (1st Ancestry Reported): Northern European	0.77
PCT017070	Ancestry (2nd Ancestry Reported): Slovak	0.77
PCT073E025	Sex by Work Experience in 1999 by earnings in 1999 for the Population 16 years and over (Native Hawaiian and Other Pacific Islander alone): Male, Worked full-time, year round in 1999: With earnings: $100,000 or more	0.77
HCT015035	Aggregate Household Income in 1999 (Dollars) by Tenure by Age of Householder by Year Structure Built: Renter Occupied: Householder 15 to 34 years: Built 1999 to March 2000	0.76
HCT015015	Aggregate Household Income in 1999 (Dollars) by Tenure by Age of Householder by Year Structure Built: Owner Occupied: Householder 35 to 64 years: Built 1995 to 1998	0.76
PCT010041	Age by Language Spoken at Home for the Population 5 Years and Over: 5 to 17 years: African Languages	0.76

separated. (Variable #B07008.22.27, $r^2 = 0.80$) Also in the same category are native Californians who moved away but have now returned to the state (Variable #B07007.22.27, $r^2 = 0.78$). In the ACS 2005-2009/City/Residential category, there are four mobility variables in the highest r^2 values, all for people who have moved to California from a different county. Compared to the Census 2000 variables, the influence of solar on new residents coming from another state has decreased. Geographical mobility is not strongly correlated in the ACS/Non-Profit categories.

In sum, it appears that people coming to California from outside its borders are more likely to install solar PV than those who have resided in the state permanently.

Ethnicity categories

Although a number of ethnicity-related variables were among the top variables in all eight categories in terms of r^2 values, it should be noted that the findings of this study have a certain shelf life. According to a report from the U.S. Department of Commerce,

Table 2. Census 2000/City/Residential category - highest r^2 values.

Variable	Description	r^2 value
PCT064I007	Residence in 1995 for the Population 5 years and over - State and County Level (White alone, not Hispanic or Latino): In United States in 1995, Different County, Same State	0.49
PCT018057	Ancestry (Total Categories Tallied) for people with one or more ancestry categories reported: Northern European	0.49
HCT006013	Tenure by Year Structure Built by Units in Structure: Owner occupied: Built 1995 to 1998: 2 to 4 units	0.49
HCT015035	Aggregate Household Income in 1999 (Dollars) by Tenure by Age of Householder by Year Structure Built: Renter Occupied, Householder 15 to 34 years, Built 1999 to March 2000	0.47
PCT064I006	Residence in 1995 for the Population 5 years and over - State and County Level (White alone, Not Hispanic or Latino): In United States in 1995, Different County	0.47
HCT006029	Tenure by Year Structure Built by Units in Structure: Owner occupied, Built 1980 to 1989, 2 to 4 units	0.46
PCT065I012	Means of Transportation to Work for Workers 16 Years and Over (White alone, not Hispanic or Latino): Motorcycle	0.46
PCT063I008	Place of birth by Citizenship Status (White alone, not Hispanic or Latino): Born in Other State in the United States: West	0.46
HCT030I003	Units in Structure (White alone, not Hispanic or Latino householder): 1, attached	0.45
PCT064I012	Residence in 1995 for the Population 5 years and over - State and County Level (White alone, Not Hispanic or Latino): In United States in 1995, Different State, West	0.44
P025012	Residence in 1995 for the Population 5 years and over - MSA/PMSA Level: Not in an MSA/PMSA in 1995	0.44
PCT017059	Ancestry (2nd Ancestry Reported): Norwegian	0.44
P050015	Sex by Occupation for the Employed Civilian Population 16 years and over: Male; Life, physical, and social science occupations	0.43
PCT017070	Ancestry (2nd Ancestry Reported): Slovak	0.43
HCT030I005	Units in Structure (White alone, not Hispanic or Latino Householder): 3 or 4	0.43
HCT006037	Tenure by Year Structure Built by Units in Structure: Owner Occupied: Built 1970 to 1979: 2 to 4 units	0.43
HCT005035	Tenure by Age of Householder by Year Structure Built: Owner Occupied: Householder 45 to 54 years: Built 1995 to 1998	0.43
PCT066I017	Sex by Age by Armed Forces Status by Veteran Status for the Population 18 years and over (White alone, not Hispanic or Latino): Female: 18-64 years old: Civilian: Veteran	0.42
H049004	Plumbing Facilities by Occupants per Room by Year Structure Built: Complete Plumbing facilities: 1.00 or less occupants per room: Built 1999 to March 2000	0.42
HCT015015	Aggregate Household Income in 1999 (Dollars) by Tenure by Age of Householder by Year Structure Built: Renter Occupied: Householder 35 to 64 years: Built 1995 to 1998	0.42

America is becoming more diverse, and the racial profile of America will look remarkably different in 2050 than it does now. Among its predictions, the report projects that "[t]he faster growth of minority groups will lead to a substantial decrease of the proportion of the non-Hispanic White (i.e., non-Minority) population, a 21-point drop from 74 percent to 53 percent."[147] Therefore, the results of a study similar to this one done ten or twenty years from now could look quite different compared to the present study.

That being said, the ancestry category with the highest r^2 values and strongest general presence among the top variables is Northern European. The Census Bureau defines 'Northern European' as including the UK (England, Scotland, Wales, Northern Ireland, Guernsey, Jersey and Isle of Man), Denmark, the Faroe Islands, Iceland, Ireland,

[147] He, W. and Hobbs, F. *Minority Population Growth: 1995 to 2050, The Emerging Minority Marketplace.* Washington: U.S. Department of Commerce, Minority Business Development Agency, 1999. (http://faculty.washington.edu/mbarreto/courses/minoritypopulation2050.pdf)

Table 3. Census 2000/County/Non-Profit category - highest r^2 values.

Variable	Description	r^2 value
PCT065I014	Means of Transportation to Work for Workers 16 Years and Over (White alone, not Hispanic or Latino): Walked	0.76
PCT016054	Ancestry (1st Ancestry Reported): Luxemburger	0.75
PCT064I009	Residence in 1995 for the Population 5 years and over - State and County Level (White alone, Not Hispanic or Latino): In United States in 1995, Different State: Northeast	0.73
PCT065A012	Means of Transportation to Work for Workers 16 Years and Over (White alone, not Hispanic or Latino): Motorcycle	0.72
PCT018002	Ancestry (Total Categories Tallied) for people with one or more ancestry categories reported: Acadian/Cajun	0.71
PCT065G012	Means of Transportation to Work for Workers 16 Years and Over (Two or More Races): Motorcycle	0.71
PCT019007	Place of Birth for the Foreign-Born Population: Other Northern Europe	0.71
HCT018073	Household Income in 1999 by Gross Rent: $50,000 to $74,999: With cash rent: $100 to $199	0.70
PCT010041	Age by Language Spoken at Home for the Population 5 Years and Over: 5 to 17 years: African Languages	0.70
P050062	Sex by Occupation for the Employed Civilian Population 16 Years and Over: Female: Life, Physical and Social Science Occupations	0.69
PCT065C014	Means of Transportation to Work for Workers 16 Years and Over (American Indian and Alaska Native alone, not Hispanic or Latino): Walked	0.69
P146I016	Households by Age of Householder by Household Type (Including Living Alone) by Presence of Own Children Under 18 Years (White alone, not Hispanic or Latino): Householder 15-64 Years: Nonfamily households: Householder not living alone	0.69
P050015	Sex by Occupation for the Employed Civilian Population 16 Years and Over: Male: Life, Physical and Social Science Occupations	0.69
PCT017035	Ancestry (2nd Ancestry Reported): Eastern European	0.69
PCT018027	Ancestry (Total Categories Tallied) for people with one or more ancestry categories reported: Celtic	0.68
PCT055086	Poverty Status in 1999 of Unrelated Individuals by Sex by Age by Householder Status (Including Living Alone): Income in 1999 at or above poverty level: Female: Under 25 years: Nonfamily householder: Not living alone	0.68
PCT016058	Ancestry (1st Ancestry Reported): Northern European	0.68
HCT034I003	Plumbing Facilities (White alone, not Hispanic or Latino Householder): Lacking complete plumbing facilities	0.68
P014012	Household Type by Household Size: Nonfamily households: 3-person household	0.68
PCT064I013	Residence in 1995 for the Population 5 years and over - State and County Level (White alone, Not Hispanic or Latino): In Puerto Rico in 1995	0.68

Norway (including Jan Meyen and Svalbard) and Sweden.[148] It is the second highest variable in the Census 2000/City/Residential category ($r^2 = 0.49$) and the top four variables of the ACS 2005-2009/City/Residential category (r^2 values: 0.52, 0.52, 0.51 and 0.51). "Place of birth for the foreign-born population: other Northern Europe" is the seventh highest variable in the Census 2000/County/Non-Profit categories ($r^2 = 0.71$).

Finnish as First Reported Ancestry is the 14th highest variable in r^2 value in the Census 2000/County/Residential category ($r^2 = 0.77$). Interestingly, people of Finnish ancestry are more correlated with solar in the ACS 2005-2009 survey than in the Census 2000 data. In the ACS 2005-2009/County/Residential category alone, there are five Finnish ancestry variables ranging from fifth to eleventh place (r^2 values: 0.78, 0.78, 0.78, 0.77 and 0.77). People who speak Scandinavian languages at home and English "less than 'very well'"[149] place 13th and 14th in the ACS 2005-2009/County/Non-Profit

[148] http://www.census.gov/acs/www/Downloads/data_documentation/CodeLists/Foreign_Country_Code_List_062310.pdf

[149] ACS Category B16001: Language spoken at home by Ability to speak English for the population 5 years and over. Ability to speak English is broken up into a binary classification: those who 1) speak English "very well" and 2) less than "very well."

Table 4. Census 2000/City/Non-Profit category - highest r^2 values.

Variable	Description	r^2 value
PCT065I012	Means of Transportation to Work for Workers 16 Years and Over (White alone, not Hispanic or Latino): Motorcycle	0.48
PCT065I005	Means of Transportation to Work for Workers 16 Years and Over (White alone, not Hispanic or Latino): Public transportation	0.47
PCT065B007	Means of Transportation to Work for Workers 16 Years and Over (Black or African-American alone): Streetcar or trolley car	0.47
HCT030I004	Units in Structure (White alone, not Hispanic or Latino householder): 2	0.46
PCT065I013	Means of Transportation to Work for Workers 16 Years and Over (White alone, not Hispanic or Latino): Bicycle	0.46
PCT065I014	Means of Transportation to Work for Workers 16 Years and Over (White alone, not Hispanic or Latino): Walked	0.46
PCT065I006	Means of Transportation to Work for Workers 16 Years and Over (White alone, not Hispanic or Latino): Bus or trolley bus	0.45
HCT014005	Aggregate Household Income in 1999 (Dollars) by Tenure by Age of Householder by Units in Structure: Owner Occupied, Householder 15-34 years, 2 to 4	0.45
HCT014013	Aggregate Household Income in 1999 (Dollars) by Tenure by Age of Householder by Units in Structure: Owner Occupied, Householder 35-64 years, 2 to 4	0.44
H079005	Aggregate value (Dollars) for all owner-occupied housing units by Units in structure: 3 or 4	0.43
P146D024	Households by Age of Householder by Household type (including Living Alone) by Presence of Own Children under 18 Years (Asian alone householder): Other family: Male householder, no wife present: With own children under 18 years	0.43
PCT065E007	Means of Transportation to Work for Workers 16 Years and Over (Native Hawaiian and other Pacific Islander alone): Streetcar or trolley car	0.43
HCT003013	Tenure by Household Size by Units in Structure: Owner occupied, 2-person household, 2 to 4 units	0.43
HCT030D004	Units in Structure (Asian alone householder): 2	0.43
PCT065A008	Means of Transportation to Work for Workers 16 Years and Over (White alone): Subway or elevated	0.43
PCT019005	Place of birth for the Foreign-Born Population: Ireland	0.42
PCT019035	Place of birth for the Foreign-Born Population: China, excluding Hong Kong and Taiwan	0.42
PCT065A007	Means of Transportation to Work for Workers 16 Years and Over (White alone): Streetcar or trolley car	0.42
PCT065D005	Means of Transportation to Work for Workers 16 Years and Over (Asian alone): Public transportation	0.42
HCT008021	Tenure by Year Householder moved into unit by Units in structure: Owner occupied: Moved in 1990 to 1994: 2 to 4	0.42

category. Danish (r^2= 0.78), Norwegian (r^2 = 0.77) and Welsh (r^2 = 0.77) also show up in the highest 20 r^2 values of the ACS 2005-2009/County/Residential category.

There are other non-Northern European ancestry categories among the highest r^2 values. Acadian/Cajun shows up in both Census 2000 and the ACS. Appearing in the Census 2000 categories are Celtic, Luxemburger, Slovene and Slovak. Appearing in the ACS 2005-2009 categories are Swiss, Belgian and Cypriot. In the Census 2000 County categories, "Other Eastern Africa" shows up thirteenth in the County/Residential variables, and African languages spoken at home in the County/Residential and County/Non-Profit categories.

Household Income

In the Census 2000/County/Residential category, a variable related to income, PCT072I013, is in the highest r^2 values. PCT072I refers to "Age of householder by Household Income in 1999", the I is for the "White alone (not Hispanic or Latino)" ethnic group, and the "013" refers to a householder under 25 years old who made

Table 5. ACS 2005-2009/County/Residential category - highest r^2 values.

Variable	Description	r^2 value
B07008.22.27	Geographic Mobility in the past year by Marital Status for current residence in the United States: Moved from different state: now married, except separated	0.80
B10937H.56.14	Age of Householder by Household Income in the past 12 months (in 2009 inflation-adjusted dollars) (White alone, not Hispanic or Latino householder): Householder under 25 years: $75,000 to $99,999	0.79
B04001.14.21	First ancestry reported: Belgian	0.79
B04001.14.33	First ancestry reported: Danish	0.78
B04005.16.39	People reporting multiple ancestry: Finnish	0.78
B07007.22.27	Geographical Mobility in the past year by Citizenship Status for Current Residence in the United States: Moved from abroad: Native	0.78
B04003.15.39	Total ancestry reported: Finnish	0.78
B04006.16.39	People reporting ancestry: Finnish	0.78
C24020.73.10	Sex by Occupation for the Full-Time, Year-Round Civilian Employed Population 16 Years and over: Male: Life, physical, and social science occupations	0.78
B04001.14.39	First ancestry reported: Finnish	0.77
B04002.14.39	Second ancestry reported: Finnish	0.77
B25055.98.12	Age of Householder by Meals included in rent: Householder 75 years and over: Meals included in rent	0.77
B25112.101.3	Aggregate Gross Rent (Dollars) by Year Structure Built: Aggregate gross rent (dollars): Built 2000 to 2004	0.77
C24010.72.10	Sex by Occupation for the Civilian Employed Population 16 Years and over: Male: Life, physical, and social science occupations	0.77
B04003.15.21	Total ancestry reported: Belgian	0.77
B04004.15.93	People reporting single ancestry: Welsh	0.77
B04002.14.59	Second ancestry reported: Norwegian	0.77
B04006.16.21	People reporting ancestry: Belgian	0.77
B04002.14.90	Second ancestry reported: Swiss	0.76
B04005.16.21	People reporting multiple ancestry: Belgian	0.76

$60,000 to $74,999 in income in 1999. The PCT072I group of variables consists of 120 variables: 17 income groups, 7 age groups, plus an extra variable for "total." As expected, the lowest income brackets have the lowest r^2 values. For example, PCT072I020, or a householder 25 to 34 years old with an income in 1999 less than $10,000, has an r^2 value of 0.45. However, two high-income groups also have low r^2 values: householders under 25 with income between $125,000 and $149,999 have an r^2 value of 0.46, and householders 25 to 34 years old with income of $200,000 or more have an r^2 value of 0.48. The high-income age bracket with the highest r^2 value is for householders 45 to 54 years old, with an r^2 value of 0.60. Among the top 10 r^2 values of the entire PCT072I group in the Census 2000/County/Residential category, the lowest income bracket is "$30,000 to $34,999" (age: under 25, $r^2 = 0.70$) and the highest income bracket is "$125,000 to $149,999" (age: 45 to 54, $r^2 = 0.70$).

Among "Black or African American Householders" (the PCT072B variables group), the high-income ($200,000 or more in 1999) age bracket with the highest r^2 value is for homeowners 35 to 44 years old. ($r^2 = 0.37$) Among "American Indians and Alaska native Householders" (the PCT072C group), the high-income age bracket with the highest r^2 value is for homeowners 45 to 54 years old. ($r^2 = 0.64$) Among "Asian Householders" (the PCT072D group), the high-income age bracket with the highest r^2

Table 6. ACS 2005-2009/City/Residential category - highest r^2 values.

Variable	Description	r^2 value
B04003.15.58	Total ancestry reported: Northern European	0.52
B04006.16.58	People reporting ancestry: Northern European	0.52
B04001.14.58	First ancestry reported: Northern European	0.51
B04004.15.58	People reporting single ancestry: Northern European	0.51
B07004H.22.4	Geographical Mobility in the past year by Race (White alone, not Hispanic or Latino) for current residence in the United States: Moved from different county within same state	0.49
C24020.73.10	Sex by Occupation for the Full-Time, Year-Round Civilian Employed Population 16 years and over: Male: Life, physical, and social science occupations	0.48
B04005.16.90	People reporting multiple ancestry: Swiss	0.48
B04002.14.90	Second ancestry reported: Swiss	0.47
B25032H.97.3	Units in Structure (White alone, not Hispanic or Latino householder): 1, attached	0.47
B07010.23.44	Geographical Mobility in the past year by Individual Income in the past 12 months (in 2009 inflation-adjusted dollars) for current residence in the United States: Moved from different county within same state: With income: $75,000 or more	0.47
C24010.72.10	Sex by Occupation for the Civilian Employed Population 16 years and over: Male: Life, physical, and social science occupations	0.47
B07004A.22.4	Geographical Mobility in the past year by Race (White alone) for current residence in the United States: Moved from different county within same state	0.46
B04003.15.90	Total ancestry reported: Swiss	0.45
B04006.16.90	People reporting ancestry: Swiss	0.45
B04003.15.25	Total ancestry reported: Cajun	0.45
B04006.16.25	People reporting ancestry: Cajun	0.45
C24060.76.39	Occupation by Class of worker for the Civilian Employed Population 16 years and over: Life, physical, and social science occupations	0.45
B04001.14.33	First ancestry reported: Danish	0.45
B07010.23.36	Geographical Mobility in the past year by Individual Income in the past 12 months (in 2009 inflation-adjusted dollars) for Current Residence in the United States: Moved from different county within same state: with income	0.44
B25055.98.12	Age of householder by Meals included in rent: householder 75 years and over: meals included in rent	0.44

value is for homeowners 55 to 64 years old. ($r^2 = 0.47$) Among "Hispanic or Latino Householders" (PCT072H), the high-income age bracket with the highest r^2 value is for homeowners 35 to 44 years old. ($r^2 = 0.45$) Among "Native Hawaiian and other Pacific Islander alone Householders" (PCT072E), the high-income age bracket with the highest r^2 value is for homeowners 35 to 44 years old. ($r^2 = 0.66$) This is the highest r^2 value for any group in the high-income bracket.

Looking at the nine ethnicity categories in the PCT072 variable group for the top 100 r^2 values (out of 1080), the income group with the most high r^2 values is the $75,000 to $99,999 group. The age groups with the highest r^2 values in the top 100 are the "75 and older" groups (20), "Under 25" (19), and "35 to 44 years old" (16).

In the Census 2000/City/Residential category, the "White" (A) and "White, not Hispanic or Latino" (I) variables have high r^2 values, and the most represented age groups are "Under 25", "25 to 34" and "35 to 44". The highest r^2 value, however, was for PCT072D014, or Asians under 25 who make $75,000 to $99,999 a year ($r^2 = 0.42$).

In sum, it appears that those in the middle class are more likely to install solar PV

Table 7. ACS 2005-2009/County/Non-Profit category - highest r^2 values.

Variable	Description	r^2 value
B08105E.26.5	Means of Transportation to Work (Native Hawaiian and other Pacific Islander alone): Walked	0.78
B08105H.26.5	Means of Transportation to Work (White alone, not Hispanic or Latino): Walked	0.75
B08505H.4.5	Means of Transportation to Work for Workplace Geography (White alone, not Hispanic or Latino): Walked	0.75
B08113.27.34	Means of Transportation to Work by Language spoken at home and Ability to speak English: Walked: Speak only English	0.74
B08513.4.34	Means of Transportation to Work by Language spoken at home and Ability to speak English for Workplace Geography: Walked: Speak only English	0.74
B04003.15.25	Total Ancestry reported: Cajun	0.73
B04006.16.25	People reporting Ancestry: Cajun	0.73
C24060.76.99	Occupation by Class of Worker for the Civilian Employed Population 16 years and over: Professional and Related Occupations: Life, physical, and social science occupations	0.72
B08511.4.22	Means of Transportation to Work by Citizenship Status for Workplace Geography: Walked: Native	0.72
B08111.26.22	Means of Transportation to Work by citizenship status: Walked: Native	0.72
B08105H.26.6	Means of Transportation to Work (White alone, not Hispanic or Latino): Taxicab, motorcycle, bicycle, or other means	0.71
B08132.29.66	Means of Transportation to Work by Time leaving home to go to work: Walked: 6:30 a.m. to 6:59 a.m.	0.71
B16001.41.27	Language spoken at home by Ability to speak English for the population 5 years and over: Scandinavian languages	0.70
B16001.41.29	Language spoken at home by Ability to speak English for the population 5 years and over: Scandinavian languages: Speak English less than "very well"	0.70
B08505H.4.6	Means of Transportation to Work for Workplace Geography (White alone, not Hispanic or Latino): Taxicab, motorcycle, bicycle, or other means	0.70
B08505A.4.5	Means of Transportation to Work for Workplace Geography (White alone): Walked	0.70
B08105A.26.5	Means of Transportation to Work (White alone): Walked	0.70
B08532.6.66	Means of Transportation to Work by Time arriving at work from home for Workplace Geography: Walked: 6:30 a.m. to 6:59 a.m.	0.69
B04003.15.30	Total Ancestry reported: Cypriot	0.69
B04006.16.30	People reporting Ancestry: Cypriot	0.69

than those in the upper and lower classes.

Modes of Transportation to Work

Variables representing modes of transportation dominate the highest r^2 values of the ACS Non-Profit categories and, not surprisingly, none of them reflect people driving to work alone. On the other hand, carpooling is also not among the highest r^2 values of any category. Transportation variables within the highest r^2 values are generally more numerous in the city categories than the county categories, and more numerous in the ACS categories than the Census 2000 categories.

Transportation trends have shifted from more motorcycles in 2000 to less in 2005-2009. In 2005-2009, walking to work categories have high r^2 values, especially among workers leaving home between 6:30am and 6:59am. By comparison, in the Census 2000/County/Non-Profit results, variable #P034007 (Time Leaving Home To Go To Work For Workers 16 Years And Over: 6:30am to 6:59am) has an r^2 value of 0.55, ranking 2,654th out of 16,520.

Table 8. ACS 2005-2009/City/Non-Profit category - highest r^2 values.

Variable	Description	r^2 value
B25032H.97.4	Units in Structure (White alone, not Hispanic or Latino householder): 2	0.48
B08105H.26.4	Means of Transportation to Work (White alone, not Hispanic or Latino): Public transportation (excluding taxicab)	0.47
B01001E.11.16	Sex by Age (Native Hawaiian and Other Pacific Islander alone): Male: 85 years and over	0.46
B08528.5.38	Means of Transportation to Work by Class of Worker for Workplace Geography: Public transportation (excluding taxicab): Private for-profit wage and salary workers: Federal government workers	0.46
B08519.3.44	Means of Transportation to Work by Workers' Earnings in the past 12 months (in 2009 inflation-adjusted dollars) for Workplace Geography: Walked: $65,000 to $74,999	0.45
B04004.15.58	People reporting single ancestry: Northern European	0.45
B08113.27.26	Means of Transportation to Work by Language spoken at home and ability to speak English: Public transportation (excluding taxicab): Speak only English	0.45
B08119.27.35	Means of Transportation to Work by Workers' Earnings in the past 12 months (in 2009 inflation-adjusted dollars): Public transportation (excluding taxicab): $65,000 to $74,999	0.45
B25117.102.20	Tenure by House Heating Fuel: Renter occupied: other fuel	0.45
B08006.25.27	Sex of Workers by Means of Transportation to Work: Male: Public transportation (excluding taxicab): Streetcar or trolley car (carro publico in Puerto Rico)	0.45
B08119.27.36	Means of Transportation to Work by Workers' earnings in the past 12 months (in 2009 inflation-adjusted dollars): Public transportation (excluding taxicab): $75,000 or more	0.45
B08124.27.26	Means of Transportation to Work by Occupation: Public transportation (excluding taxicab): Management, professional, and related occupations	0.45
B04001.14.58	First Ancestry reported: Northern European	0.45
B04003.15.58	Total Ancestry reported: Northern European	0.45
B04006.16.58	People reporting Ancestry: Northern European	0.45
B08128.28.38	Means of Transportation to Work by Class of worker: Public transportation (excluding taxicab): Private for-profit wage and salary workers: Federal government workers	0.45
B08519.3.45	Means of Transportation to Work by Workers' earnings in the past 12 months (in 2009 inflation-adjusted dollars) for Workplace Geography: Walked: $75,000 or more	0.45
B08534.6.109	Means of Transportation to Work by Travel time to work for Workplace Geography: Walked: 45-59 minutes	0.45
B08534.6.84	Means of Transportation to Work by Travel time to work for Workplace Geography: Streetcar or trolley car (carro publico in Puerto Rico), subway or elevated: 15-19 minutes	0.45
B08006.25.10	Sex of Workers by Means of Transportation to Work: Streetcar or trolley car (carro publico in Puerto Rico) (both sexes)	0.44

Occupations

The group of occupations in the census data that is most closely related to solar PV usage is "Life, physical, and social science occupations." The Bureau of Labor Statistics definition covers a large and diverse set of occupations from historians to economists, physicists, astronomers, animal scientists, food scientists and technicians, and forest and conservation technicians, to name just a few. The suggestion should be obvious, but the more likely one is to work with solar PV in the workplace and have knowledge of its associated benefits, the more likely one is to use solar PV to generate power at home.

Among the highest r^2 values in the eight categories, the variable is in Census 2000/City/Residential (male), Census 2000/County/Non-Profit (male and female),

ACS/County/Residential (male), ACS/City/Residential (male, male, unisex), and ACS/County/Non-Profit (unisex).

However, for the ACS/City/Non-Profit category, "Management, professional, and related occupations" have higher r^2 values than the "Life, physical, and social science occupations." The top three highest contenders among variables in this category related to "Life, physical, and social science occupations" are: #C24060.76.129 ("Occupation By Class Of Worker For The Civilian Employed Population 16 Years And Over: Local, state, and federal government workers: Life, physical, and social science occupations", $r^2 = 0.35$), #C24020.73.10 ("Sex By Occupation For The Full-Time, Year-Round Civilian Employed Population 16 Years And Over: Male: Life, physical, and social science occupations", $r^2 = 0.32$) and #C24010.72.10 ("Sex By Occupation For The Civilian Employed Population 16 Years And Over: Male: Life, physical, and social science occupations", $r^2 = 0.32$).

To reiterate, among all occupations, the data suggest that people employed in the "Life, physical, and social science occupations" seem most likely to install solar PV.

Year Structure Built

Census 2000

The data suggest that solar PV is associated with newer construction - dwellings built within the last ten to thirty years. In the ACS/County/Residential category, the variable for aggregate gross rent for structures built between 2000 and 2004 has an r^2 value of 0.77. In general, among the highest r^2 values, the newer the structure is, the higher the r^2 value. For slightly older structures, in the Census 2000/City/Residential category, HCT006029 (Tenure by Year Structure Built by Units In Structure: Owner-occupied: Built 1980 to 1989: 2 to 4 units) has a higher r^2 value than HCT006037 (Tenure by Year Structure Built by Units In Structure: Owner-occupied: Built 1970 to 1979: 2 to 4 units), but both are in the highest r^2 values.

Of variables dealing with tenure (owner-occupied vs. renter-occupied), there are six owner-occupied variables and only three renter-occupied variables related to solar usage. This supports the perception that renters are less likely to be in a position to install PV than the owners of the buildings.

ACS 2005-2009

In the ACS, the variable group B25034 deals only with "Year Structure Built."[150] In the ACS/County/Residential category, the three B25034 variables with the highest r^2 values are: structures built 1990-1999 ($r^2 = 0.68$), structures built 1970-1979 ($r^2 = 0.68$), and structures built 1980-1989 ($r^2 = 0.64$). The lowest r^2 value is for structures built 1939 and earlier ($r^2 = 0.28$). In the ACS/County/Non-Profit category, the three B25034 variables with the highest r^2 values are: structures built 1939 and earlier ($r^2 = 0.53$), structures built 1970-1979 ($r^2 = 0.52$), and structures built 1960-1969 ($r^2 = 0.49$). The lowest r^2 value is for structures built 2005 and later ($r^2 = 0.25$).

In the ACS/City/Residential category, the three B25034 variables with the highest r^2 values are: structures built 2000-2004 ($r^2 = 0.33$), structures built 1990-1999 ($r^2 = 0.33$), and structures built 2005 or later ($r^2 = 0.28$). The lowest r^2 value is for structures built 1940 to 1949 ($r^2 = 0.06$). In the ACS/City/Non-Profit category, the three B25034 variables with the highest r^2 values are: structures built 1939 and earlier ($r^2 = 0.21$), structures built 2000-2004 ($r^2 = 0.14$), and structures built 1990-1999 ($r^2 = 0.13$). The lowest r^2 value is for structures built 1950-1959 ($r^2 = 0.06$).

These r^2 values suggest opposite agendas between the residential sector, where the tendency is to upgrade newer buildings first, and the non-profit sector, where businesses tend to upgrade older buildings first.

Units in Structure

For the Census 2000 categories, there are seven variables dealing with two to four units in a structure. Four is the highest amount of units among the highest r^2 values, which suggests that a major trend in solar PV at the time was installations for small complexes of apartments or condos. In progressing to the ACS categories, units-in-structure variables only appear twice. This suggests that, in moving from the Census 2000 data to the ACS 2005-2009 data, the number of units in a structure is becoming a less significant factor, perhaps due to the sharp increase in residential PV installations.

[150] Other variable groups in the ACS combine it with another factor, such as B25108, or "Aggregate Value (Dollars) by Year Structure Built," or B25107, or "Median Year by Year Structure Built."

Table 9. German- and Japanese-related r^2 values.

Census 2000	ACS 2005-2009	Description	Census County/Res		ACS County/Res	Census City/Res		ACS City/Res	Census County/NP		ACS County/NP	Census City/NP		ACS City/NP
German			**r^2 value**		**r^2 value**	**r^2 value**		**r^2 value**	**r^2 value**		**r^2 value**	**r^2 value**		**r^2 value**
PCT016	B04001	ANCESTRY (FIRST ANCESTRY REPORTED)												
PCT016042	B04001.14.42	German	0.72	<	0.73	0.40	<	0.41	0.52	>	0.50	0.19	<	0.20
PCT016043	B04001.14.43	German Russian	0.50	>	0.34	0.15	>	0.03	0.42	>	0.41	0.07	>	0.02
PCT016060	B04001.14.60	Pennsylvania German	0.67	>	0.65	0.27	>	0.22	0.51	>	0.47	0.14	>	0.09
PCT017	B04002	ANCESTRY (SECOND ANCESTRY REPORTED)												
PCT017042	B04002.14.42	German	0.72	<	0.72	0.39	>	0.39	0.56	>	0.53	0.21	>	0.20
PCT017043	B04002.14.43	German Russian	0.41	>	0.06	0.03	>	0.00	0.53	>	0.04	0.04	>	0.00
PCT017060	B04002.14.60	Pennsylvania German	0.61	>	0.58	0.18	<	0.20	0.57	>	0.51	0.12	>	0.12
PCT018	B04003	ANCESTRY (TOTAL CATEGORIES TALLIED)FOR PEOPLE WITH ONE OR MORE ANCESTRY CATE-GORIES REPORTED												
PCT018041	B04003.15.42	German	0.72	<	0.73	0.40	<	0.40	0.53	>	0.52	0.20	<	0.20
PCT018042	B04003.15.43	German Russian	0.51	>	0.33	0.13	>	0.04	0.48	>	0.39	0.08	>	0.02
PCT018059	B04003.15.60	Pennsylvania German	0.66	>	0.65	0.27	>	0.24	0.54	>	0.50	0.15	>	0.12
PCT019	B05006	PLACE OF BIRTH FOR THE FOREIGN-BORN POPULATION												
PCT019011	B05006.18.17	Germany	0.64	<	0.67	0.20	<	0.26	0.60	<	0.61	0.14	<	0.18
Japanese														
PCT019	B05006	PLACE OF BIRTH FOR THE FOREIGN-BORN POPULATION												
PCT019038	B05006.18.53	Japan	0.48	>	0.47	0.17	>	0.16	0.52	>	0.51	0.13	>	0.11

German and Japanese

Since Germany and Japan represent significant PV markets in and of themselves, it would probably be worth noting how their Census counterparts fared in the various regression tests. The variable with the highest r^2 value is German as First Reported Ancestry for the County/Residential category. The r^2 value for this variable in the Census 2000/County/Residential category is 0.72, and it increases to 0.73 in the ACS 2005-2009/County/Residential category.

The second highest variable is for Pennsylvania German as First Reported Ancestry. The r^2 value for this variable in the Census 2000/County/Residential category is 0.67, and it decreases to 0.65 in the ACS 2005-2009/County/Residential category. According to 2000 Census data, there is a small Pennsylvania German population living in Southern California in the following counties: San Bernardino, Orange, Riverside and San Diego.[151]

Both sets of Census data only have one category for Japanese in common: Place of Birth for the Foreign-Born Population. All r^2 values decrease when moving from Census 2000 to ACS 2005-2009, and the highest r^2 pair is in the County/Non-Profit

[151] Map of Pennsylvania Dutch in the United States, Census Bureau 2000. Valparaiso University Online. (http://www.valpo.edu/geomet/pics/geo200/pct_pa_german.pdf)

categories. If nothing else, this seems to be consistent with the fact that the German PV market has overtaken the Japanese PV market in terms of total installed capacity since the 1990s. The r^2 values for the German foreign-born population also reflect this, showing the biggest increases in r^2 value from Census 2000 to ACS 2005-2009, and this is consistent for all categories. Except for County/Non-Profit, all categories have an increase of r^2 greater than 0.01.

Summary

Given the wealth of information contained in the Census data, a detailed picture of who is using solar PV is beginning to emerge. The highest r^2 values of the eight categories have certain factors in common. People who have recently moved, people who are mostly of Northern European descent, mostly middle income, mostly with science-related jobs, and who live in relatively new buildings, are all factors with the highest r^2 values. In the next section, some of these factors will be examined more closely to see how they're related to PV in the current literature.

CHAPTER FIVE

A POST-RESULTS LITERATURE REVIEW

Given the high number of highly significant factors in this study, attention will be paid to a small number of them. The analysis will focus on the roles that Australia, Northern Ireland, Finland and motorcycles have played in this study, with additional sections about Germany and Japan.

Australia

For the Census 2000/County/Residential category, respondents reporting Australian as their second ancestry was the census variable most related to solar PV usage. ($r^2 = 0.80$) One major contributing factor to this could be the airline industry, since Los Angeles International Airport (LAX) is a main hub of Australian airline Qantas. According to LA Inc., the Los Angeles Convention and Visitors Bureau, Australia emerged as the top "feeder market" for overseas tourists to Los Angeles in 2010.[152] Australia and California also share the international presence of several solar PV companies like Kyocera,[153] BP Solar,[154] Solar Power Inc.,[155] SunPower,[156] SolFocus,[157] and partnerships between California-based companies like Solar EnerTech and Australia-based companies like Aussie Solar Installations.[158]

[152] Sewell, A. Los Angeles Times: Los Angeles, CA. *TOURISM; G'day L.A.: Aussies top list of city's overseas visitors in 2010*. 05 Jan 2011.

[153] Business Editors/Environment Writers. Business Wire: New York, NY. *Kyocera names new President for U.S.-based solar energy unit; company veteran Steven C. Hill to lead Kyocera's solar business in the Americas and Australia.* 16 Jan 2004.

[154] Anonymous. U.S. Newswire: Washington, DC. *Pinn Bros. Fine Homes builds San Jose's first solar & LEED-Certified neighborhoods.* 11 Mar 2008. BP Solar has solar cell plants in Sydney, Australia; Frederick, MD; and many others.

[155] Anonymous. Business Wire: New York, NY. *Solar Power, Inc., announces Second Quarter 2009 financial results.* 13 Aug 2009. Solar Power Inc. extended sales to Europe and Australia.

[156] Anonymous. PR Newswire: New York, NY. *SunPower and Southern California Edison sign contracts for 711 megawatts of solar power.* 10 Jan 2011.

[157] Anonymous. Business Wire: New York, NY. *SolFocus partners with Bechtel to deliver renewable power for California agribusiness*. 1 Apr 2011.

[158] Anonymous. Business Wire: New York, NY. *Solar EnerTech enters into sales contract with Australian solar company.* 03 Feb 2010. Solar EnerTech of Mountain View, CA, is partnering with Aussie Solar Installations to distribute their solar panels in Australia.

Australia has jumped headlong into the solar race, finally using to their advantage the fact that they have the highest average solar radiation per square meter of any continent in the world.[159] According to the Australian Clean Energy Council, there was over 300 MW of solar PV capacity for all of Australia at the end of September 2010.[160] However, they do plan on increasing that figure severalfold in the coming decades. The Australian Government has set an official Renewable Energy Target (RET) of 20% by the year 2020, which encompasses all forms of renewables. The goal will be reached with the help of funds generated from a carbon tax.[161] While they set no specific goals for PV, they do claim that the RET has already "encouraged significant deployment of small systems, with around 300,000 solar panel systems supported under the RET since 2001," and that "around 600,000 domestic and commercial solar water heaters and heat pumps have been supported under the RET."[162] The Australian Government has also allocated $5.1 billion to its Clean Energy Initiative.[163]

Australia is partnering with the United States through the US-Australia Solar Energy Collaboration (USASEC). Announced on November 7, 2010, the long-term goal of USASEC is to develop technologies that will bring the cost of PV-generated electricity down to "prices compatible with electricity from conventional sources," and to generally increase the speed of solar energy technology development.[164] The Australian Government also committed funding of up to $50 million from the Renewable Energy

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[159] *Australian Energy Resource Assessment. Chapter 10: Solar Energy.* (https://www.ga.gov.au/image_cache/GA16862.pdf)

[160] Australian Clean Energy Council website. *Technologies: Solar PV.* (http://www.cleanenergycouncil.org.au/cec/technologies/solarpv.html)

[161] Australian Government: Department of Resources, Energy and Tourism. *Energy: Enhancing Australia's Economic Prosperity*. (http://www.ret.gov.au/energy/clean/Pages/CleanEnergy.aspx); Australian Government: Department of Climate Change and Energy Efficiency. *Renewable Energy Target.* (http://www.climatechange.gov.au/en/government/initiatives/renewable-target.aspx)

[162] The Department of Climate Change and Energy Security: Government of Australia. *Securing a clean energy future: The Australian Government's Climate Change Plan.* 2011. ISBN 978-0-642-74723-5. (http://www.cleanenergyfuture.gov.au/wp-content/uploads/2011/07/Consolidated-Final.pdf)

[163] Media press release: Australian Government. *US and Australia join forces on solar power.* 7 Nov 2010. (http://www.pm.gov.au/press-office/us-and-australia-join-forces-solar-power.)

[164] Australian Government, Dept. of Resources, Energy and Tourism. (http://www.ret.gov.au/energy/clean/cei/asi/Pages/default.aspx)

Future Fund, which will be managed through the new Australian Solar Institute.[165] The goal is to make Australia a key player in the development of solar energy technologies in the Asia-Pacific region. One way this is being done is through the establishment of the Australian Renewable Energy Agency (ARENA), a new independent agency whose mission is to fund development of a range of renewable energy sources, including solar, geothermal and biofuels.[166] The government has also committed $1.5 billion to the Solar Flagships program to support the construction of four large solar PV power plants totaling 760 MW, and three solar thermal plants totaling 555 MW.[167] Solar energy use in Australia has been projected to increase 5.9 per cent per year to 24 petajoules by 2030.[168]

Local governments have set their own targets as well. In particular, Sydney has established an ambitious, holistic five-point plan called Sustainable Sydney 2030. The plan involves: 1) making the city center friendly for people and global business, 2) building an improved "sustainable" public transport system that reduces congestion, 3) making the city friendlier for pedestrians and cyclists with a plan that includes planting more trees, 4) community hubs where more businesses and government services are within walking distance, and 5) initiatives to make the city more energy and water efficient.[169] For starters, the Sydney town hall has gone solar courtesy of Suntech Power, a company that has installed 240 solar panels for a 48kW rooftop installation.[170] Sydney plans on eventually installing PV on 24 city buildings.[171]

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[165] http://www.australiansolarinstitute.com.au/

[166] Thompson, J. Australia: ABC News. *Greens hail win on renewables agency.* 8 Jul 2011. (http://www.abc.net.au/news/2011-07-08/greens-hail-win-on-renewables-agency/2787118)

[167] Australian Government: Department of Resources, Energy and Tourism. *Solar Flagships Project Descriptions - Round 1.* (http://www.ret.gov.au/resources/Documents/solar_flagship/SF_Round_1_Project_Descriptions.pdf)

[168] *Australian Energy Resource Assessment. Chapter 10: Solar Energy.* (https://www.ga.gov.au/image_cache/GA16862.pdf)

[169] http://www.cityofsydney.nsw.gov.au/2030/theplan/

[170] Hughes, E. PV-Tech: Solar Media Limited. *Project Focus: Suntech installs first Pluto cells in Australia on Sydney Town Hall.* 19 Apr 2010. (http://www.pv-tech.org/news/project_focus_suntech_installs_first_pluto_cells_in_australia_on_sydney_tow)

[171] City of Sydney. *State of the City 2011: Sustainable Sydney 2030*. (https://s3.amazonaws.com/media.cityofsydney/2030/documents/State-of-the-City-report-2011.pdf)

Individual homeowners also are taking solar matters into their own hands. In Gold Coast in Southeast Queensland, for example, homeowners there are springing for PV installations with over 100 panels. Siggi Schnitzler installed 138 panels on his house. After doing the math, he calculated it would take five years to pay for the initial investment of $100,000, after which he will make $22,000 a year in profit for extra power sold back to the grid.[172] The Gold Coast and Hinterland Environment Council (Gecko) is encouraging residents to embrace solar for their homes. Gecko's Solar Savers Challenge wanted to get 1000 Gold Coast and Tweed residents to install solar panels or solar hot water by the end of 2010.[173] To publicize the contest, Gecko produced and aired a number of TV advertisements, and created a "Guide to Going Solar" which is described on their website as "a community service initiative designed to help you make an informed and confident decision about going solar." Their website does not say how the Challenge ultimately turned out, but they still offer a lot of information about the benefits of solar PV and solar hot water heating, and conclude by saying "Although the Solar Savers program has ended, you can still join the Challenge…"[174]

Ireland

The ancestry variable "Ireland as Place of Birth for the Foreign-Born Population" had a high r^2 value in the Census 2000/City/Non-Profit category, and those results merit further attention. In 2006, the government of Northern Ireland mandated that, starting in 2008, all new homes were to have solar panels. This plan was announced by then Secretary of State Peter Hain, who had cut his own energy bills in half with solar.[175] Northern Ireland Electricity (now Power NI)[176] offered to subsidize home PV installations through a program called Plug in The Sun, which gave homeowners up to 65% funding to install either 1.5 kW or 3 kW PV systems on their homes. The program was done in

[172] Elder, J. The Gold Coast Bulletin: Southport, Queensland, Australia. *How to have funds in the sun: install 138 solar units.* 24 Mar 2011.

[173] Bedo, S. The Gold Coast Bulletin: Southport, Queensland, Australia. *Sun is shining on our solar savers.* 11 Jun 2010.

[174] Gecko - Gold Coast and Hinterland Environment Council. (http://gecko.org.au/education/solar-information/)

[175] Morton, R. Belfast Telegraph: Belfast. *New homes must have solar panels.* 24 Jul 2006.

[176] Anonymous, Power NI. *Plug in The Sun for an Eco New Year!* 31 Dec 2007. (http://www.powerni.co.uk/index.php/2007/12/31/plug-in-the-sun-for-an-eco-new-year/)

conjunction with Northern Ireland's Department of Enterprise, Trade and Investment (DETI) Reconnect grant for solar PV.

To make Ireland a contender in the global green energy race, the Sustainable Energy Authority of Ireland (SEAI)[177] has developed a 5 year strategic plan (2010-2015) to make Ireland a "recognized global leader in sustainable energy."[178] The plan is mandated by Ireland's "Sustainable Energy Act 2002,"[179] and is broken down into three Key Strategic Objectives. The first objective is "Energy efficiency first," with plans to 1) make all new construction energy positive, and 2) implement an aggressive retrofit program for existing buildings.

The second Key Strategic Objective advocates the use of low-carbon energy sources, recognizing and acknowledging the threat of climate change. Brendan Halligan, Chairperson of SEAI, writes "The urgency and scientific certainty of the climate change crisis is growing, and there is widespread consensus on the imperative to make deep cuts in greenhouse gas emissions."[180] The development of solar in conjunction with microgeneration is a part of their renewable energy portfolio.

The third Key Strategic Objective involves "innovation and integration," and "innovation in technology and behaviours [sic]." SEAI's strategic plans for the "greening" of Ireland extend past 2015. Within 15 years (by 2025), renewable energy sources will represent over half of electricity supply, and renewable sources for heat will be "the norm." All new buildings will be energy self-sufficient, and most new car purchases will be electric vehicles. Within 25 years (by 2035), the goals reach a little further. Ireland will have an energy system rooted in local, green electricity. All buildings will be at least energy self-sufficient, and Ireland will be an exporter of energy, electricity, expertise, and sustainable technologies.

These are worthy plans for every country to establish, but Ireland has catching up

[177] http://www.seai.ie

[178] Sustainable Energy Authority of Ireland. *Strategic Plan 2010-2015*. (http://www.seai.ie/Publications/SEAI_Publications/SEAI_5yr_strategy.pdf)

[179] The full text of the "Sustainable Energy Act, 2002" is available online at http://www.irishstatutebook.ie/2002/en/act/pub/0002/index.html.

[180] Sustainable Energy Authority of Ireland. *Strategic Plan 2010-2015*. (http://www.seai.ie/Publications/SEAI_Publications/SEAI_5yr_strategy.pdf)

to do to become as great an exporter of solar expertise and products as Germany, Japan, or even Australia. Strides are beginning to be made, however. Ireland-based Surface Power, a manufacturer of solar thermal products, formed a strategic partnership in 2010 with Florida-based Solar Energy Initiatives,[181] a developer of solar PV installations. They plan on establishing a distribution hub in South Carolina.[182]

There's also movement on the imports front. In October 2010, Sovello AG, a PV manufacturer based in Thalheim, Germany, received the approval certificates to sell its modules to the UK, Australia, Ireland, Florida, and California. The approving agency in California was Go Solar California, and the SEAI in Ireland.[183]

The CEC recently approved seven solar power plant proposals, one of which was the 664 MW Calico Solar Project planned for San Bernardino County.[184] Calico Solar is a subsidiary of Houston, Texas-based Tessera Solar North America, itself a unit of renewable-energy company NTR of Dublin, Ireland. NTR, unfortunately, appears to have overextended itself financially, to say the least, as they've had to sell off their part of the Calico project and the Imperial project, another proposed California-based solar power plant.[185] Ireland's private sector alone is not sufficient yet to get SEAI's ambitious job done.

Finland

In the ACS/County/Residential category, five Finnish ancestry variables are

[181] http://www.solarenergyinitiatives.com

[182] Your Industry News. Aberdeen, UK: Red Mist Media Ltd. *Ireland's Surface Power Signs Major Strategic Partnership Agreement with Solar Energy Initiatives.* 18 Mar 2010. (http://www.yourindustrynews.com/ireland%27s+surface+power+signs+major+strategic+partnership+agreement+with+solar+energy+initiatives_46759.html)

[183] PV Magazine Online. *Sovello modules now certified in Australia, Ireland, UK, Florida and California.* 03 Jan 2011. (http://www.pv-magazine.com/services/press-releases/details/beitrag/sovello-modules-now-certified-in-australia--ireland--uk--florida--and-california_100001889/)

[184] Greenspace: Los Angeles Times Online. *San Bernardino solar installation approved.* 28 Oct 2010. (http://latimesblogs.latimes.com/greenspace/2010/10/calico-solar-installation-approved.html)

[185] Irish Independent News Online (Independent.ie). Independent News & Media PLC: Dublin, Ireland. *Sun sets on NTR plan.* 06 Mar 2011. (www.independent.ie/business/irish/sun-sets-on-ntr-plan-2567666.html)

among the highest r^2 values. The United States and Finland seem to have a common philosophy in regards to energy usage: according to Voutilainen, the energy use per capita of Finland and the United States is roughly the same, and Finland is increasing its nuclear capacity, even as other EU countries are decreasing theirs.[186] The forestry industry is one of Finland's largest, accounting for 30% of national electricity use.[187] Nevertheless, Finland is making advances towards more solar capacity, and is at least willing to play host to other countries' solar ambitions. In 2008, Israel-based Solel opened a plant in Finland to produce parabolic solar reflectors.[188] Solel developed the equipment design which was then built by Glaston,[189] an international glass technology company. Glaston itself moved its head office to Helsinki in 2011.[190]

Examples of green Finnish architecture provide an exemplary model for the rest of the world to follow. Eco-Viikki, for example, is called "the world's largest and most ambitious green housing development." It features a university campus (the University of Helsinki), marshland, livestock grazing areas, and 13,000 housing units, all designed to produce a self-sufficient environment with reduced emissions, renewable energy technology, gray-water systems to recycle sink and tub water, and land for residents to grow their own food.[191] It was the result of a long, collaborative and competitive process: the final design of Eco-Viikki was chosen from a total of 91 received proposals. In August 1994 the initial site was chosen from four candidates, construction began in autumn 1998, and the last low-rise block of flats was completed in early autumn 2004.[192]

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[186] Voutilainen, P. *Developing energy policy for Europe: A Finnish perspective on energy cooperation in the European Union.* Energy Law Journal: 2008. Vol. 29, No. 1., pg. 121.

[187] Statistics Finland. *Greenhouse Gas Emissions in Finland 1990-2005: National Inventory Report to the UNFCCC*. 15 Apr 2007. (http://www.stat.fi/tk/yr/fi_nir_150407.pdf)

[188] Anonymous. IceNews.com. *Commercial solar panel manufacturing plant opens in Finland.* 21 Sep 2008. (http://www.icenews.is/index.php/2008/09/21/commercial-solar-panel-manufacturing-plant-opens-in-finland/)

[189] http://www.glaston.net

[190] Glaston Oyj Abp Company Announcement. *Glaston Corporation's head office to Helsinki.* 31 May 2011. (https://newsclient.omxgroup.com/cdsPublic/viewDisclosure.action?disclosureId=456244&messageId=555294)

[191] Doherty, D. McClatchy-Tribune Business News: Washington, DC. *Green-house effect*. 30 Aug 2009.

[192] City of Helsinki, Ministry of the Environment. *Eco-Viikki: Aims, Implementation and Results*. 2005. ISBN 952-473-455-9. (http://www.hel.fi/static/ksv/julkaisut/eco-viikki_en.pdf)

Figure 6. Eco-Viikki. Photo courtesy of the Ministry of the Environment, City of Helsinki.

An integration of PV cells was tested on a multi-family building, where 200 m^2 of cells were incorporated into balcony railings, producing up to 20 percent of the property's needs.[193]

The Solar Decathlon spawned a European counterpart in 2010. The Finnish entry, "Luukku House," won first prize for architecture.[194] The home was made almost exclusively of wood, Finland's most abundant resource. The home's high-efficiency insulation was achieved using thick and tight insulation, and quadruple-glazed frameless units fixed directly to the frame for windows. Energy-efficient equipment, grey water recycling, and building materials with a low carbon footprint helped the home achieve a low overall environmental footprint.[195] The home featured 9.01 kW of PV panels on the

[193] Swedish Environmental Research Institute Ltd. European Sustainable Urban Development Projects. *Benchmark Study: Viikki.* (http://www.secureproject.org/download/18.360a0d56117c51a2d30800078421/Viikki_Finland.pdf)

[194] Alter, L. New York: Treehugger: a Discovery Company. *Gorgeous Woodsy Finnish Entry in Solar Decathlon Wins First Prize For Architecture*. 24 June 2010. (http://www.treehugger.com/files/2010/06/gorgeous-green-architecture-finnish-entry.php)

[195] Meinhold, B., Inhabitat LLC. *Finland unveils ultra-efficient energy positive Solar Decathlon house.* 10 June 2010. (http://inhabitat.com/finland-unveils-ultra-efficient-energy-positive-solar-decathlon-house/)

roof.[196] In the "Electrical Energy Balance" contest, Luukku finished ninth out of the 17 entrants in a close race.[197]

An earlier example of energy-efficient Finnish architecture is the IEA5 House in Jakobstad (Pietarsaari) in Northwest Finland, a demonstration project named after the agency that led to its creation, the International Energy Agency.[198] The house was built in 1993 with the goals of building a low energy house that used as little energy as possible, as part of IEA's Task 13 (advanced solar low-energy buildings).[199] The house did not achieve the desired energy goals at first, but with further tinkering and technical development it is now a nearly zero-energy building, with roof space sporting a solar PV and a solar heat system.[200]

The motorcycle

The motorcycle as means of transportation shows up frequently among the highest r^2 values of the Census 2000 variables. In the Census 2000/City/Non-Profit category, the motorcycle as means of transportation to work for white workers 16 years and older has the highest r^2 value. (PCT065I012, $r^2=0.48$) In the Census 2000/City/Residential category, PCT065I012 has the seventh highest r^2 value of all variables. In the Census 2000/County/Non-Profit category, PCT065A012 (White alone) and PCT065G012 (Two or more races) have the fourth and sixth highest r^2 values,

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[196] Project manual, Team Finland. (http://www.sdeurope.org/wp-content/uploads/downloads/2010/11/AAL_CDPM_2010-09-22.pdf)

[197] SD Europe official website. *Results 2010*. (http://www.sdeurope.org/?page_id=3141&lang=en#4); Luukku House's official website is still up at http://www.sdfinland.com.

[198] Nieminen, J. *Low-energy residential housing.* Energy and Buildings: Vol. 21, Issue 3, 1994, pp. 187-197.; Nieminen, J., VTT Technical Research Centre of Finland. *Improving energy efficiency is revolutionizing building in Finland*. 18 Mar 2011. (http://www.solarthermalmagazine.com/2011/03/18/improving-energy-efficiency-is-revolutionizing-building-in-finland/)

[199] International Energy Agency, Solar Heating & Cooling Programme. *Task 13: Advanced Solar Low-Energy Buildings; Final Task Management Report - October 1996*. Prepared by Anne Grete Hestnes, Operating Agent for The Royal Ministry of Industry and Energy. (http://www.iea-shc.org/outputs/task13/task13_advanced_solar_low_energy_buildings.pdf)

[200] Ab Alf Slussnäs Oy website about IEA5 House. They are a Finnish heating, ventilation and sanitation company. (http://www.alfslussnas.fi/en/lowenergy/IEA5); VTT website about IEA5 house. Jyri Nieminen, Customer Manager. (http://www.vtt.fi/service/con/energiatehokkaat_ratkaisut.jsp?lang=en)

respectively. Among the top variables in the ACS 2005-2009, the following motorcycle-related variable is 11th in the top r^2 values of the ACS/County/Non-Profit category: "Means of Transportation to Work for Workplace Geography (White alone, not Hispanic or Latino): Taxicab, motorcycle, bicycle, or other means" (B08505H.4.6). Therefore, riding a motorcycle to work rather than driving a car helps explain the installation of solar PV in California.

The motorcycle is also the vehicle of choice among many environmental activists. Jim Harvey from Chicago now lives in the Mojave Desert and works on behalf of both solar power and preserving the desert environment, two goals he has found to be mutually exclusive when it comes to siting industrial-scale solar power plants. In particular, he opposes BrightSource Energy's proposed $3 billion, 392 MW Ivanpah Solar Electric Generating Station. Harvey also has found himself at odds with some of the national environmental groups, whom he views as getting too cozy with the solar energy companies.[201] In his spare time he tinkers with a fleet of antique Harley-Davidson motorcycles, and at regular intervals heads out to tour the West's open roads on his bike, often accompanied by his wife Catherine.[202]

Solar power is making inroads into the motorcycle industry, or at least onto its buildings. A Harley-Davidson dealership in Santa Barbara now has a 36 kW solar installation on its roof. The system generates approximately 80% of the dealership's total electrical load, with potential for future expansion. The dealership took advantage of the City of Santa Barbara's fast-track permit program for solar PV systems, which resulted in the approval of the installation plan and the issuance of a permit in only one week. This was exciting news for Solar Electrical Systems, the installers of this PV system, which usually has to wait about 90 days to receive a permit.[203] Meanwhile, California-based

[201] The conflict over Ivanpah does have a happy ending, as the Center for Biological Diversity and BrightSource representatives agreed to set land aside for the sake of the endangered desert tortoise. Press release from the Center for Biological Diversity. *Center for Biological Diversity and BrightSource Commit to Desert Protections*. 22 Oct 2010. (http://www.biologicaldiversity.org/news/press_releases/2010/ivanpah-10-22-2010.html)

[202] Lewis, J. High Country News: Paonia, CO. *High noon.* 11 May 2009.

[203] Anonymous, renewableenergyworld.com. *Santa Barbara Harley-Davidson Powers Up With Kyocera Solar Modules.* 16 Aug 2004. (http://www.renewableenergyworld.com/rea/partner/kyocera-solar-inc-1786/news/article/2004/08/santa-barbara-harley-davidson-powers-up-with-kyocera-solar-modules-11747)

Solyndra provided a motorcycle parts warehouse in Germany with its unique brand of solar PV system. It is the largest Solyndra system in Germany to date, and the second largest Solyndra system worldwide. A local German company did the installation work for Solyndra.[204]

Converting a fossil fuel-based motorcycle to solar-generated electric seems to be relatively simple in engineering terms, and a rewarding hobby as well. Richard Gryzch converted his motorcycle to run on solar and electric, with solar panels attached to the cycle's frame. His motorcycle has a range of 50 miles and can reach speeds of 90 mph, both of which he plans on increasing in the near future.[205]

All-electric motorcycles have already made it into the marketplace. Zero Motorcycles of Scotts Valley, California boasts the cleanest recycling practices in the industry, and note that their motorcycle "will produce less than one-eighth of the CO_2 pollution per mile at the power plant than a gas powered motorcycle."[206] Portland, Oregon-based MotoCzysz is trying to beat speed records with their E1pc electric motorcycle.[207] Motorcycle racetracks themselves also have the chance to make amends for their carbon footprints. Infineon Raceway in Sonoma, California has installed 350 kW of solar power. A total of 1,652 panels were put in place around the track, and will produce approximately 41 percent of Infineon's power needs.[208]

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[204] Anonymous, Green Energy News. *Solyndra Cylindrical Photovoltaic (PV) System for Motorcycle Parts Warehouse in Germany.* 28 Oct 2010. (http://www.green-energy-news.com/nwslnks/clips1010/oct10028.html)

[205] June, L., engadget.com. *DIY Solar Flyer motorcycle tearing around Phoenix, Arizona.* 06 May 2009. (http://www.engadget.com/2009/05/06/diy-solar-flyer-motorcycle-tearing-around-phoenix-arizona/#continued)

[206] http://www.zeromotorcycles.com/cleanest.php

[207] Procter, G. Motorcyclenews.com. 04 Jun 2009. *Exclusive photo: finished MotoCzysz E1pc revealed, claiming V-MAX-beating acceleration*. (http://www.motorcyclenews.com/MCN/News/newsresults/New-bikes/2009/June/jun0409-E1pc-exclusive-picture/)

[208] GetSolar staff, getsolar.com. *California racetrack unveils solar plans.* 23 Nov 2010. (http://www.getsolar.com/News/California/Solar-Panels/California-Racetrack-Unveils-Solar-Plans-800252650)

Germany

Most of the specific ancestries with the highest r^2 values (e.g., not general like Northern European) generally didn't stay high when moving from the Census 2000 to the ACS 2005-2009. The variables for German ancestry, however, had r^2 values that were fairly high, and showed a slight increase in moving from the Census 2000 to the ACS 2005-2009. This is perhaps a testament to their continued push to promote PV as a domestic energy source; on the other hand, the r^2 values would likely look different had the Census 2000 data and the ACS 2005-2009 data been compared to different sets of PV data in the regression tests.

As with Australia's example, California and Germany have many solar PV business links in common. Several companies have regional offices in both California and Germany: Nanosolar,[209] Soltecture,[210] The Bosch Group,[211] Q-Cells,[212] SunPower,[213] Trina Solar,[214] Solar Frontier[215] and SonnenWerft GmbH (*Sundock* in English).[216] JA Solar,[217] one of the biggest producers of PV in 2010, is based in China but has offices in both Munich, Germany and Milpitas, California.

To help promote the strengthening of business ties between California and Germany, there is an annual conference created by the California branch of the German American Chamber of Commerce called Germany California Solar Day. The seventh Germany California Solar Day was held at UCLA's Institute of the Environment on September 27th, 2011.[218] Woodrow Clark II, co-recipient of the 2007 Nobel Peace Prize with Al Gore, gave the event's keynote address, saying "America needs to learn from Germany and other nations about the Green Industrial Revolution that has already started there and in parts of Asia."[219] Among the German delegate solar companies in attendance

[209] http://www.nanosolar.com
[210] http://www.soltecture.com
[211] http://www.bosch-solarenergy.com
[212] http://northamerica.q-cells.com/en
[213] http://us.sunpowercorp.com
[214] http://www.trinasolar.com/eu
[215] http://www.solar-frontier.com
[216] http://www.sundock.net
[217] http://www.jasolar.com
[218] CleanTechies. *7th Germany California Solar Day | Los Angeles, CA*. (http://events.cleantechies.com/7th-germany-california-solar-day-los-angeles-ca/4843/)

[219] German Chamber Network (AHK) press release. *7th Germany California Solar Day: Solar Companies Explore Business Opportunities in Southern California*. 27 Sep 2011. (http://www.ahk-usa.com/en/events/san-francisco/single-view/events/germany-california-solar-

were Adler Solar Services GmbH,[220] GP Joule GmbH,[221] hb Solar International GmbH,[222] Lahmeyer International GmbH,[223] LCS Solarstrom AG,[224] Loser Chemie GmbH,[225] and Orange Solar GmbH.[226]

Q-Cells, one German solar company that apparently didn't need to attend, has been selected by Pacific Gas and Electric (PG&E) as a "preferred partner" to help add solar capacity in California's Central Valley. Q-Cells and PG&E will collaborate on a program called the utility-owned generation (UOG) program, involving 250 MW of utility-owned solar to be developed over five years in 50 MW installments.[227] "Q-Cells' partnership with PG&E is another example of our highly competitive solar PV solutions for the North American market," said Marc van Gerven, managing director of Q-Cells in North America.[228]

Japan

There is only one variable in each census data set relating to Japan as the place of birth for the foreign-born population. As with Germany, there were relatively consistent r^2 values between the Census 2000 and the ACS 2005-2009, but the trend was opposite compared to Germany. The Japanese r^2 values went slightly down where the German r^2 values went slightly up. This could perhaps be interpreted as a testament to the slightly less dominant PV market of Japan.

As with Australia and Germany, California and Japan have several solar businesses in common. Even though Germany has installed more solar domestically, the Earth Policy Institute found that Japan produced over 100 MW more solar in 2010 (2,169

day/?cHash=42ba39c031d33fc74bf998c109b0c4f4)

[220] http://www.adlersolar.de
[221] http://www.gp-joule.com
[222] http://www.hbsolar.eu/en.html
[223] http://www.lahmeyer.de
[224] http://www.lcs-solar.com
[225] http://www.loserchemie.de
[226] http://www.orange-solar.de
[227] Q-Cells press release. San Francisco, CA. *Q-Cells Selected by PG&E as Preferred Partner for Utility-Owned Generation Program: Q-Cells to Build 10 MW and 20 MW Solar Power Plants for PG&E in California's Central Valley*. 17 Oct 2011. (http://northamerica.q-cells.com/en/pressrelease/qcell_selected_by_pge_as_preferred_partner.html)

[228] Osborne, M. PV Tech News. *SPI: 2011: PG&E teams with Q-Cells on two solar power plants in California*. 17 Oct 2011. (http://www.pv-tech.org/news/spi_2011_pge_teams_with_q_cells_on_two_solar_power_plants_in_california)

MW total) than did Germany (2,022 MW).[229] Japan is home to some of the largest, most globally recognized companies that now dabble in solar PV production: Sharp,[230] Sanyo-Panasonic,[231] Mitsubishi,[232] Toshiba[233] and Honda[234] all now produce solar panels. Kyocera is a Japanese company with offices in Scottsdale, Arizona, but they plan on opening a manufacturing plant in San Diego by 2013.[235]

Suntech Power[236] is currently the world's largest producer of solar panels. In 2010 they produced 5.8% of all new global solar PV for the year.[237] Their global headquarters is located in Wuxi, China, but they have regional offices in every major PV market, including Japan, Germany, and San Francisco.

Japan's Eurus Energy Holdings Co. and Sharp are teaming up with NRG Energy Inc. of the United States to build 45 MW solar farms in California. The power will be sold to Pacific Gas & Electric for 20 years. Tokyo Electric Power Co. Inc., Asia's biggest utility, owns 60 percent of Eurus Energy and trading firm Toyota Tsusho Corp. owns the remaining 40 percent.[238]

However, it's not strictly a one-way street with Japan always aiding California. In the wake of the devastating tsunami that struck Japan following a massive earthquake on March 11th, 2011, green energy entrepreneur Elon Musk is helping to rebuild a small part of Japan's energy infrastructure. Through his foundation, Musk has donated

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[229] An Excel spreadsheet of data is available at http://www.earth-policy.org/datacenter/xls/indicator12_2011_all.xls.

[230] http://www.sharpusa.com/SolarElectricity.aspx

[231] http://us.sanyo.com/Solar; http://www.panasonic.com/industrial/solutions/alternative-energy.aspx

[232] http://www.mitsubishielectricsolar.com/; http://www.mitsubishielectric.com/bu/solar/

[233] http://www.toshiba.co.jp/env/en/energy/solar.htm

[234] http://world.honda.com/SolarCell/

[235] Anonymous. The New Statesman: Blackfriars, UK. *Kyocera to develop solar modules for US market.* 05 Mar 2010. (http://www.newstatesman.com/energy-and-clean-tech/2010/03/kyocera-solar-jobs-california)

[236] http://www.suntech-power.com

[237] SolarServer.com, Heindl Server GmbH. *Top 10 PV producers (2010)*. (http://www.solarserver.com/service/statistics-and-market-research/pv-overview/pv-producers.html)

[238] Reuters. *Japan's Eurus Energy joins in California solar boom*. 27 Sep 2010. (http://af.reuters.com/article/energyOilNews/idAFTOE68Q05Q20100927)

$250,000 for a solar PV project to be built in Soma City in the Fukushima prefecture. The PV plant will be sited on reclaimed industrial land not suitable for agriculture, and the solar arrays will be made of panels manufactured in Japan.[239]

Summary

Future versions of this study could be expanded in scope with a questionnaire sent to a randomly selected sample of a given population as a strategy to confirm the results of statistical analysis. In terms of ancestry and the foreign-born population, we might expect to see high r^2 values from China as they currently dominate the PV export market, having produced over twice as much PV as Germany and Japan combined in 2010. More important, of course, is that solar PV be deployed to the fullest extent possible on the one hand, and on the other hand to collectively reduce our "footprints" as much as possible, be they electrical, carbon-based, or otherwise. In a more ideal world, the Solar Decathlon would be redundant, and a study like this one unnecessary.

[239] SolarServer.com, Heindl Server GmbH. *Elon Musk donates solar PV project to Soma City in Fukushima prefecture, Japan*. 03 Aug 2011. (http://www.solarserver.com/solar-magazine/solar-news/current/2011/kw31/elon-musk-donates-solar-pv-project-to-soma-city-in-fukushima-prefecture-japan.html)

CHAPTER SIX

CONCLUSIONS

While the large up-front cost of solar PV remains a barrier to its widespread use, there are still some facts in solar's favor. First, enough sunlight hits the earth every 40 minutes to equal every person's power usage for a year. Second, according to the American Solar Energy Society, fossil fuels such as coal, oil and natural gas are being depleted at a rate 100,000 times faster than they are being formed.[240] And while basic economic theory tells us that a resource that becomes scarce, like fossil fuels, increases in price and leads to the seeking out and use of alternatives, economists do not usually consider that 1) the environment in which the resource has been used becomes too toxic to live in, and 2) as the resource becomes more and more scarce, and the price of the resource approaches infinity in response, the marketplace and the rest of society might not react calmly in response, while scrambling to seek out and use alternatives. Embracing solar PV as a serious alternative for electrical generation may prevent either of those scenarios from becoming a reality.

The statistical analysis presented in this thesis found that mostly white, middle class individuals in California who have rejected its "commuter class" mentality have responded the most to the PV rebate program. As a potential marketing strategy for PV manufacturers, for example, should any single demographic therefore be exclusively catered to? The administrators of the California Solar Initiative don't think so. A portion of the CSI budget is set aside to put PV on the homes of poor people; on the other hand, only to the tune of 10% of the program budget, or $216 million. And perhaps attempting to address income equality through PV isn't necessarily a good idea just yet: the census data says that the fastest growing income groups in California from 2000 to (ACS) 2005-2009 are those making $75,000 or more a year. However, this may not take into account the global economic meltdown in the fall of 2008.

Of course it is now possible to bypass the whim of the potential PV consumer entirely through building-integrated PV and new industrial-scale PV plants on the horizon. Recently, the Department of Energy announced a $1.4 billion partial loan guarantee to support the launch of Project Amp, a rooftop solar program for warehouses

[240] Graves, S. The Press Democrat: Santa Rosa, CA. *Solar power alternative cuts bills; Even in Winter, photovoltaic systems can provide adequate energy for homes. [City edition]* 25 Jan 2003.

and distribution centers across the U.S. The money will allow Prologis,[241] a developer of industrial real estate, to install enough PV on some of its warehouses and distribution centers to generate 733 MW of power over four years. The buildings themselves don't use a lot of energy, and the excess energy will be fed back to the grid. U.S. Energy Secretary Steven Chu said, "...Project Amp will create at least a thousand jobs across the U.S. and increase our global competitiveness in the clean energy race."[242]

Solar photovoltaic technology has sufficiently matured to the point of costing the same or less than fossil fuel-based forms of electricity generation. Even so, there's still more room for improvements on the horizon. The average conversion efficiency of solar panels today is about 10-16%. The problem is that the majority of electrons hitting the panels "thermalize," making them unusable for converting to electricity. Hot carrier solar cell technology is attempting to change all that. By extracting electrons before thermalization, the photovoltage can be increased, reaching conversion efficiencies as high as 68%.[243]

The National Renewable Energy Lab has a large database online (the NCPV Hotline[244]) detailing solar PV projects that are getting approved all around the world. For nations, cities and municipalities, it has now become a race to become the eco-friendliest of all. Washington State can surely follow suit. As Olympia-based South Sound Solar notes on their website, "We have 70% of the sun that Germany, the leading user of solar does. We have some of the best incentives in the country, and solar panels are actually more efficient in cooler climates."[245] Eastern Washington, which is much sunnier than Western Washington, could surely host some SEGS-style power plants. Or perhaps the Arizona Public Service model for off-grid customers mentioned earlier could be

[241] http://www.prologis.com

[242] ENR Mountain States: Denver, CO. (a division of McGraw-Hill) *NREL Program turns warehouses into rooftop solar powerhouses.* 20 Jul 2011. (http://mountainstates.construction.com/mountainstates_construction_firms/2011/0720-NRELProgramTurnsWarehousesIntoRooftopSolarPowerhouses.asp?page=2)

[243] Stanford University Global Climate & Energy Project. Abstract: *Hot Carrier Solar Cell: Implementation of the Ultimate Photovoltaic Converter*. Issued September 2008. (http://gcep.stanford.edu/research/factsheets/hotcarriersolarcell.html)

[244] http://www.nrel.gov/pv/news_hotline.html

[245] http://southsoundsolar.com/products/faqs/

implemented in Eastern Washington, as the population density rapidly decreases away from a few crowded cities.[246]

In general, things are moving and changing so fast in the PV field right now, that deep analysis of long term trends is in short supply. As PaceNOW observed about Property-Assessed Clean Energy programs, "As more programs are launched and as existing programs mature, additional data will emerge to help further analyze the economic impact of PACE."[247] The same can currently be said of most American PV incentive programs and their respective impacts, economic, environmental or otherwise.

California's PV incentive program has clearly been successful at deploying PV onto residential rooftops. To reiterate from earlier, California remains in the throes of an exponential growth in PV installations, with an expectation of growth from around 500 per year in 2000 to 50,000 by the end of the decade. Obviously, exponential growth of most things cannot continue forever, but solar PV still has a large market to fill: in 2008, solar accounted for less than 1 percent of global electricity generation.[248] Given this small market share, PV's downstream benefits of job growth and a cleaner environment will probably also be hard to measure, or justify in the shadow of the larger, entrenched players like oil and nuclear. Further growth of solar PV will be dependent on government subsidy of one form or another far into the unforeseeable future, as the technology is still unable to produce vast enough amounts of energy to fuel its own self-sustaining growth.

But based on the experiences of Germany and Japan, one can say that if a government stays committed to funding the manufacture and domestic deployment of PV, the more PV they will end up having in the long run. Japan subsidized the deployment of PV from 1994 to 2004, and currently has only 9% of global solar PV capacity. Germany has continued to subsidize PV since 1989, and they now have 44% of

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[246] A low-detail population map of Washington State counties is available at http://www.ofm.wa.gov/pop/popden/histmaps.pdf. A set of much higher-detail maps of each county are available at http://www.ecy.wa.gov/services/gis/maps/county/popden/popden-co.htm.

[247] PaceNOW. *Property Assessed Clean Energy ("Pace") Programs White Paper: Helping achieve environmental sustainability and energy independence, improving homeowner cash flow and credit profile, protecting mortgage lenders, and creating jobs*. 22 Apr 2010. (http://votesolar.org/wp-content/uploads/2009/05/PACE-White-Paper.pdf)

[248] The Pew Center on Global Climate Change. *Solar Power (Quick Facts).* (http://www.pewclimate.org/technology/factsheet/solar#_ednref2)

global solar PV capacity, the most of any country in the world.[249] A similar study to the one presented in this thesis done with Germany instead of California might provide valuable insights on what California should do in the future, especially if there exists detailed data that chronicles Germany's many years of solar experience.

[249] Renewable Energy Policy Network for the 21st Century (Ren21). *Renewables 2011: Global Status Report.* (http://www.ren21.net/Portals/97/documents/GSR/GSR2011_Master18.pdf, page 23)

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APPENDIX A

Getting variable names for the California Census 2000 data, and for ACS 2005-2009 data

Census 2000

1) The California Census 2000 Summary File 3 files are available online at http://www2.census.gov/census_2000/datasets/Summary_File_3/California.

2) Download and unzip Acc2000.zip from http://www.census.gov/support/2000/SF3/Acc2000.zip.

3) Open the file SF3.mdb with Microsoft Access.

4) In the 'Tables' window on the left, scroll down to the "Tables" table at the bottom of the list.

5) Open the "Tables" table. You will see a list of alphanumeric codes under the 'FieldNum' column, with descriptions of their Census categories under the 'Text' column. Export the table as an Excel spreadsheet.

ACS 2005-2009

The alphanumeric codes for the ACS 2005-2009 files are in an Excel spreadsheet (Sequence_Number_and_Table_Number_Lookup.xls) which is available online at http://www2.census.gov/acs2009_5yr/summaryfile/.

APPENDIX B

ABBREVIATIONS / ACRONYMS

AC - alternating current

ACS - American Community Survey (http://www.census.gov/acs/www/)

ARENA - The Australian Renewable Energy Agency

Berkeley FIRST - Financing Initiative for Renewable and Solar Technology

BiPV - Building-integrated photovoltaics

CEC - California Energy Commission

CPUC - California Public Utilities Commission

CSI - California Solar Initiative (http://www.gosolarcalifornia.ca.gov/csi/index.php)

CSV - Comma-Separated Values

DC - direct current

DETI - Department of Enterprise, Trade and Investment (Northern Ireland)

EPBB - Expected Performance-Based Buydown

EU - European Union

EV - electric vehicle

FiT - Feed-in Tariff

GHG - greenhouse gases

GmbH - Gesellschaft mit beschränkter Haftung ("German company")

GW - gigawatt

kW - kilowatt

LEED - Leadership in Energy and Environmental Design

LIEE - Low Income Energy Efficiency program

MASH - Multifamily Affordable Solar Housing program

MW - megawatt

OPEC - Organization of Petroleum Exporting Countries (http://www.opec.org)

PACE - Property-Assessed Clean Energy

PG&E - Pacific Gas and Electric

PPA - power purchase agreement

PSE&G - Public Service Electric & Gas Company

PV - photovoltaic

RET - Renewable Energy Target (Australia)

SASH - Single-family Affordable Solar Housing program

SCE - Southern California Edison

SDG&E - San Diego Gas & Electric Company

SEGS - Solar Energy Generating Systems

SEAI - Sustainable Energy Authority of Ireland

SEIA - Solar Energy Industries Association (http://www.seia.org)

SF3 - Summary File 3 (Census)

SUSI - Stanford University Solar Initiative

SWEP - Stanford Solar & Wind Energy Project

UOG - Utility-Owned Generation

VNM - Virtual Net Metering