Research Report
The Preconditions for Expanded Solar Power in California

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During the summer of 2009, I worked with Professor Gary Evans on assessing the cost feasibility of large-scale solar electricity generation in California. Initially, our goal was "to use sensitivity analysis to evaluate the cost-effectiveness of off-site (remote-installation) solar electricity generation, considering different technologies and grid structures for the power market in the state of California." We wanted to determine which variables would most affect the cost effectiveness of solar power projects, and how that might impact the pace of implementation and the likelihood of realizing California program goals.

We worked on this project from the end of May to the end of July, and at the end of July, revaluated the focus of the research. Although the evaluation of cost-effectiveness remains the goal of the project, political and economic developments through 2009 are stagnating the expansion of solar energy. The central problems are the slow pace and complexity of the surveys undertaken by the *Renewable Energy Transmission Coordinating Committee*, which define the specifics of the roll-out for renewable power in California, and the unusually low cost of natural gas in 2009, which is inhibiting the ability and willingness of power purchasers to agree to the long-term power purchase agreements that are required for the financing of new renewable power generating facilities.

Professor Evans concluded that the current deadlines (2012 and 2020) for renewable energy adoption in California will not be met. For the last two weeks of the project, we explored some of the roadblocks to solar power adoption in California. Professor Evans is continuing research on this subject during his year on sabbatical. In this report, I aim to summarize the proceedings of the research and on the knowledge I gained from the project.

We initially focused our efforts on researching the cost-effectiveness of solar electricity generation. We quickly decided to limit our scope of "solar electricity generation" to photovoltaics (PV), solar thermal power plants, and Stirling Dishes. After making this decision, I began to familiarize myself with these forms of energy generation; I studied the underlying concepts behind these means of energy generation, various cutting-edge technologies, and predictions for future price trends. Upon completing this portion of the research, I wrote up a section for the final report outlining the technologies that were relevant to our research. Following this, I researched and wrote another section on California's Renewable Power Mandates (which require that, by 2013 (initially 2010) and 2020, 20% and 33% (respectively) of California's energy come from renewable resources), and other government legislation that either encourages or discourages renewable energy generation. These sections served as an explanation of the conditions motivating our research.

Upon completing these sections, I changed focus to familiarize myself with the Matlab programming language. Professor Evans required that I focus on learning the GUI editor in Matlab, so that I could create an easy-to-use interface for performing sensitivity analysis. We never did perform sensitivity analysis over the summer, although sensitivity analysis will play a role in the final version of the report. Regardless, learning the basics of Matlab has prepared me for Engineering 59, which closely integrates Matlab into the coursework.

As part of the effort to build a foundation for cost analysis, Professor Evans required me to research—in addition to the various forms of technology germane to our research—the driving forces behind the pricing of these technologies, the state of the renewable energy regulatory environment in California, Matlab coding basics, Power Purchase Agreements (PPAs), Competitive Renewable Energy Zones (CREZs), and solar energy cost estimates.

PPAs are legal contracts signed by energy generators and energy purchasers (for the purposes of our research, utilities), where the purchasers agree to buy energy from the generators at a specified rate for a certain amount of time (frequently, these agreements are binding for a number of years). Generally, PPAs encourage the development of independently owned energy generation, and as a result of the massive investment required to develop a solar power plant, PPAs are essentially unavoidable in this arena. My work on this subject entailed writing a section explaining how PPAs apply to solar electricity generation, which would fit into the final report.

Describing CREZs proved to be much more involved. For this section of the report, I read a report by the Renewable Energy Transmission Initiative (RETI) describing what CREZs are and how they allow California to best take advantage of their natural renewable resources. CREZs are areas of land (confined to California, some parts of Nevada, Arizona, Baja California, and the Pacific Northwest) that have a combination of high renewable energy potential, proximity to existing transmission lines/substations, and minimal potential environmental impact. After reading the lengthy report, I wrote a large section for the final report describing RETI, the concept of CREZs, and why CREZs are such crucial tools for evaluating the cost of adopting California's RPSs.

Since CREZs are such an integral part of explaining the difficulties California faces in adopting renewable energy, I will briefly explain the concept so that the reader can understand why we placed such an emphasis on them. RETI identified these CREZs with the intention to "inform RETI decisions regarding major electric transmission projects needed to access [available renewable energy]" (RETI, "Phase 1B: Final Report"). Extra transmission lines and substations would extensively inflate the already-substantial investment required to integrate renewable energy into California's power grid. So, RETI ranks these CREZs according to (primarily, but not solely) the transmission costs needed to develop renewable energy in each zone. Other factors that contribute to the rank of each CREZ are the cost of generating the energy at each site (different forms of energy generation are more suited to different CREZs, and each have different costs associated with them), the value of the energy at each site, and the ability of each site to reliably provide energy. So, judging by the comprehensive approach that RETI took in identifying and ranking these zones, we devoted much time to explaining exactly

what they are so that readers of the report can recognize that these zones will be integral in planning California's renewable energy future.

Finally, I wrote a smaller section summarizing a cost study on solar panels; the study incorporated factors such as power line loss into the "real" value of solar panels, a subject which Professor Evans and I saw relevant to large-scale solar power generation and transmission. However, the study concluded that line losses were quite minimal, so we will most likely not have to consider that aspect of the solar energy's value in the final report.

Reflecting on this project, I was slightly put off by the change of focus in the project, although I certainly feel that the shift was necessary to maintain our original goal with this project, which was to educate people on the state of solar energy in California. Additionally, such events were quite foreseeable when we decided to perform research in this area, as the systems governing energy development and transmission are quite complex and arcane. Furthermore, such an experience has probably exposed me to some of the realities of research, such as sudden changes of focus. In the end, I am quite pleased with the direction that this research is taking, and I undeniably learned a considerable amount on the mechanisms behind solar power plant development. I hope that this research has a fulfilling conclusion, and serves to educate others on the subject of solar power plant development in California.

Works Cited

Following is a list of the various articles and web pages that I used to write my contribution to the report this summer.

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