Nuts and Bolts of Technology: Closer Look at Utility-Scale Solar Power

Editors' Summary

Utility-scale solar power is coming into its own as various technologies compete for market share. On January 26, 2011, the Environmental Law Institute brought together a panel of experts to consider thermal and photovoltaic technologies. Among the issues discussed were permitting and siting on federal versus private lands, transmission, environmental impact considerations, and the potential for future growth in relation to other renewable energy sources.

Panelists:
Sara Kamins, Senior Policy Analyst, Renewables Procurement, Policy and Resource Planning, California Public Utilities Commission (moderator)

Lisa Belenky, Senior Attorney, Center for Biological Diversity
Alice L. Harron, Vice President, Project Development, Solar Millennium LLC
Arthur Haubenstock, Chief Counsel and Director, Regulatory Affairs, BrightSource Energy, Inc.
Tom Starrs, Managing Director, Utilities and Power Plants, SunPower Corporation

David Lazerwitz: Welcome. I'm David Lazerwitz. I'm a partner in the Environmental Law Department here at Farella [Braun + Martel LLP] and also co-chair of our clean-tech and renewable energy practice. I wanted to welcome you all here on behalf of Farella, the Environmental Law Institute, and Berkeley's Center for Law, Energy & the Environment. We appreciate all of you coming this evening for what should be a very interesting panel discussion on utility-scale solar.

This is, as you know, part of the series that we've been doing to drill deeper into the issues surrounding renewable energy. In the fall, we kicked off the series with a session regarding policy drivers as an overarching theme, and discussed how we got to where we are today, including renewable portfolio standards, stimulus funding, and technology improvements. As part of this continuing discussion, tonight we wanted to get into the nuts and bolts of utility-scale solar development, more from the technology perspective to get people to understand the different technologies. So, we've invited two solar thermal developers and a PV [photovoltaic] developer to come today. Lisa Belenky is here as well from the Center for Biological Diversity.

Just as a heads up for future events, we're going to be doing a session on the integration of renewable energy into the CAISO [California Independent System Operator] grid, addressing some of the hidden issues that are lurking with a great deal of renewable energy coming online, including issues of intermittency. Norma Formanek, the general counsel of EPRI, will be here and we'll have a CAISO representative and wind and solar developers on that panel as well. In May, we're going to take a closer look at distributed generation (DG), and specifically at DG in terms of issues from the converse of utility-scale development.

Let me introduce our moderator this evening, Sara Kamins. Sara is a senior policy analyst for the Renewables Portfolio Standard (RPS) Program in the energy division of the California Public Utilities Commission. Sara is the staff lead on designing and implementing RPS policy, which includes developing the renewable energy credit program, reviewing and approving utility renewable power and PPAs [power purchase agreements] and working with stakeholders on RPS-related legislation. Please join me in welcoming Sara and the panel this evening.

I. Introductions

Sara Kamins: Hi, everybody. Thank you for coming. I'm going to start off this evening by introducing the panelists. Then, each panelist is going to give a brief presentation, and afterwards, I'm going to ask the panelists questions focusing on various permitting issues, differences between the solar technologies, the benefits and obstacles these technologies are facing, and then price and markets trends. After that, we'll have some time at the end for audience questions.

First, we have Alice Harron. Ms. Harron is vice president for project development for Solar Millennium. She has led Solar Millennium's California solar thermal development efforts, including obtaining the License and Record of Decision from BLM [Bureau of Land Management] for the Blythe Solar Power Project, as well as the CEC [California Energy Commission] decision for the Palen Solar Power Project. Ms. Harron has also worked

Editors' Note: PowerPoint presentations referenced in this seminar, as well as an audio recording of the event, are available at http://www.eli.org/Seminars/past_event.cfm?eventid=582.

at PG&E, where she led negotiations for the acquisition of power plants, negotiated power purchase agreements for renewable energy, worked on the development of utility wind and solar thermal generation projects, and led a cross-functional team investigating commercial and political liability of obtaining renewable generation resources in British Columbia. She also worked at Calpine in the finance department and at PG&E's corporate nonregulated company, National Energy Group, in both its market assessment and finance department.

Next, we have Arthur Haubenstock. Arthur is chief counsel and director of regulatory affairs for BrightSource Energy. He's responsible for a wide variety of federal and state legislative, regulatory, and policy issues regarding renewable energy and climate change. Mr. Haubenstock also assists BrightSource on transactional matters and negotiated the power purchase agreement with Southern California Edison. He also serves as president of the Large-Scale Solar Association on the advisory board with the solar initiative and the Clean Power Campaign and on the stakeholder committee for the California Desert Renewable Energy Conservation Plan, DRECP.

Next, we have Lisa Belenky. Ms. Belenky is a senior attorney at the Center for Biological Diversity. Her work focuses on the protection of rare and endangered species and their habitat under state and federal law. In the last two years, Ms. Belenky has been heavily engaged on the siting and approval processes for large-scale solar development throughout California and Nevada, with the goal of ensuring conservation of our fragile desert ecosystems through a science-based landscape level approach to renewable energy siting.

We also have Tom Starrs. Mr. Starrs is the managing director of the Utility and Power Plants Americas' business unit at SunPower Corporation. Mr. Starrs manages market assessment and strategic planning, as well as early-stage business development and portfolio acquisitions. Before joining SunPower, he served as managing director of Solar Power for Iberdrola Renewables, and he's also held senior executive positions for PPM Energy, Schott Solar, and Bonneville Environmental Foundation. In addition, Tom has served on the boards of Solar Energy Industries Association, Solar Alliance, Large-Scale Solar Association, and the Center for Energy Efficiency and Renewable Technology.

So, thank you all for being here. We're going to start off with very short PowerPoint presentations from the panelists. I have asked the developers to specifically discuss the highlights of their company's technologies and the specific projects that they're working on in California and the surrounding area.

II. Concentrated Solar Power

Tom Starrs: I actually thought it would be easier since we're talking about technology to see how many people in the room understand—raise your hand if you feel comfortable explaining the distinction between solar thermal power generation and solar photovoltaic power generation.

I'll give you the 20-second synopsis of solar thermal: concentrating solar thermal power basically is a way for using solar to boil water to generate steam to run through a more or less conventional steam turbine generator to produce power. In some respects, it's not much different from the way we produce probably 60 or 70% of our electricity, except for the very important distinction that we're using solar energy to boil the water, rather than burning fossil fuels or using nuclear power to boil the water.

Solar photovoltaic technology is fundamentally different. It uses not the sun's heat but sunlight—photons—to directly generate electricity by having instead these semiconducting materials really not very different from a computer chip. And, as Becquerel discovered in 1839 and Einstein later on won a Nobel Prize for explaining, the semiconducting materials have this unique impact that when sunlight hits a photovoltaic cell, it generates a little bit of electricity. You do it over a large enough area, it produces a lot of electricity.

I have like 25 slides and 35 seconds to cover them all, so I'm actually going to do a few, two or three, and then skip a bunch, and then do a few more of just pretty pictures. This is my one slide on SunPower. For those who have an interest, the company is a California-based company. I'll let you read the stats for yourself. We're one of the bigger companies in the solar PV arena. We're also one of the most vertically integrated. We do everything from manufacturing PV panels all the way down to designing and building solar power systems at every level, from residential through commercial and utility-scale power plants. So, we're very active in all three of those markets. We're a market leader in the United States in all three of those sectors.

PV technology is generally a commodity. Most of you have seen a power panel that looked something like this. Everyone wants to say theirs is different, so, I'll do the same. Ours is significantly different in that it's a higher efficiency technology. It was developed by a genius electrical engineering professor at Stanford University in the 1980s, and he innovated it in a couple ways that fundamentally means that for any given area of panel, we produce about 30 to 40%, up to 50% more electricity than most of our competitors, and about 100% more electricity than some of our competitors.

So, to bracket this, the measure of efficiency is how much of the sunlight that hits the module gets converted into electricity. And so, for a bunch of what I call thin-film technology, that figure is between 6 and 11%, for conventional, what I call polycrystalline or multicrystalline technology, that number is about 14 to 16%, and for ours it's about 19 or 20%. What that means is that we can produce more electricity in any given area, and therefore, we need less land area to produce a given amount of power, or less roof area for our residential or commercial rooftop applications.

In addition, another distinction for SunPower is that we are a market leader in using trackers that instead of just fixing the PV array towards the south, which is optimal for a fixed system, we actually have tracking arrays that tilts to the east in the morning, and then track the sun during the course of the day and tilt less in the afternoon. By doing that, we get about 25 to 30% more electricity per watt of generated capacity than a conventional fixed-tilt configuration. That also allows us to get more electricity from any given amount of solar panel area, basically.

Now, this is my one possibly intentionally provocative slide for my colleagues on the panel to comment on, and maybe we can use this as a frame for discussion later on. I've basically compared the PV or photovoltaic and CSP or concentrated solar power technologies by a handful of criteria. This is a slide I did over a year ago and just updated this afternoon. So, we can use this as a talking point later on. I'll let you guys glance at it briefly. I won't go through the details.

I will say this issue is a very important one that I want to address momentarily. The one fundamental advantage that the thermal technologies have is because they're thermal technologies, you can store heat much more easily and less expensively, at least at this point, than you can store electricity. My colleagues here on the panel have technologies that have better what we call ride-through characteristics. They are able to provide more continuity in that the power production will dip, but it won't dip as much. With PV technology, the response is instant. When the sun goes by any cloud, output will drop; it depends on how dark the cloud is, but let's say somewhere between 20 and 90%, and so you get a lot more variability or volatility in the output.

The other big advantage to CSP is the potential to provide long-term storage. That means that you could actually overbuild your solar field; you can use a bunch of the solar collectors to boil water, and you can use a bunch of the solar collectors to basically heat up a bunch of molten salt that goes into what essentially amounts to a giant thermos bottle and you store it. As the sun is going down in the late afternoon or in the evening, with PV technology, your output is going to go down. With the concentrating solar thermal technologies, you have at least the potential—at additional cost—to use that stored heat to maintain your output through the late afternoon or evening hours, and in theory actually even 24 hours a day, although the cost of that one would be pretty dramatic. That, to me, is the fundamental advantage of CSP. There are advantages that go the other way for PV. In the interest of fairness, I will reserve those for later.

This is our one of our tracking arrays. This is in Germany. This is a visual simulation, not a real photo, a visual simulation of the proposal, California Valley Solar Ranch Project. So, that's the array, a distance from the highway, another visual simulation of that project. This is an actual photo of some early-stage construction with the driving of our piers. After this, we're going to run a beam through these and then that beam holds the module and that sort of tilts. And that shows likely later stage with the tracker supports installed, and there's another view of the completed system. This one also is, I think, in Germany. These are the folks seeding between the rows after construction to restore some grassy areas.

In some areas in Germany and in the United States, we are using sheep to manage vegetation. It's actually better environmentally and cheaper to graze than to run lawnmowers, especially designed lawnmowers, underneath these arrays over 150 acres—

Audience Member: That's a separate profit center.

Sara Kamins: Thank you. I think Tom made a very good point that we have two different types of technology on the panel state, so we're going to move from PV now to solar thermal. We have two types of solar thermal represented on the panel. Let's have Arthur start off with the solar thermal power tower technology.

III. Solar Thermal Power Tower Technology

Arthur Haubenstock: John White, who many of you probably know, and certainly Tom and I know very well, is the executive director of CEERT. As John was saying, the grid is like a symphony, and you need a whole variety of different instruments, because storage is right now pretty much limited to pumped storage. [The grid] must be playing the right notes at the right time all together.

There are a lot of wonderful attributes of PV and a lot of wonderful attributes of different solar thermal technologies, and it becomes sort of popular to think about it as a dichotomy. I think it's a false dichotomy. I think that each different technology brings different things to the grid. It is way too early for any of us to be thinking this is the right solution or even this is the most inexpensive solution, because there are lots of different elements, different power characteristics, different things that the grid needs to provide at the least cost, at least emissions and most reliable power, which is what we're all looking for to achieve our renewables goals and our climate goals.

So, with that, I'll show a couple slides. I'm Arthur Haubenstock with BrightSource Energy. We're a privately held company. We've raised well over $300 million from a whole range of investors from Google to lots of other folks. We're very excited about what a great team we have. Our engineering team is the team that was behind the Luz projects, the 350 megawatts of solar troughs, which is the technology that Alice Harron will be talking about in a minute. Tom stole some thunder from me. I'll try to avoid stealing Alice's. That technology still provides the largest solar plant in the world, and these projects are still operating strong 30 years later.

In fact, they invested about a million dollars in R&D at the time that the policy support for renewables stumbled in the early 1990s. They went bankrupt, and that million dollars was recently put to good use in the last year or

two to vastly increase the efficiency of those plants. Those plants are going strong, providing lots of power in southern California. Those plants operate as QFs [Qualifying Facilities] and the economic signals that they operate on create problems for grid reliability that aren't necessarily part of the technology.

Part of what we do as developers depends on what the economic signal is that the regulators tell us to respond to, and that the public utilities therefore buy. We're told by the public utilities to produce as much renewable power as possible. That's not always a good thing when it comes to providing least cost, least emissions, most reliable power. That, ultimately, is what we have to focus on.

We have 2.6 gigawatts worth of contracts with Pacific Gas and Electric and Southern California Edison. We have some other projects that are pretty exciting. We just announced a project in Crete that's a 37-megawatt hybrid project, and that's going to be providing power on that island. There's a nice article on Grist by Todd Woody about that project that you might want to take a look at.[1]

We also are just about to put into operation a project with Chevron. Most folks don't realize that a lot of California's natural gas is actually used to make steam and inject it underground to loosen up the crude. The crude in California is pretty thick, and you have to inject various different things in it to pull it up. I first became interested in this because one of the oil companies was injecting a light fraction of petroleum that it didn't have any use for into the ground, which ultimately cropped up ruining a small beach town in southern California.

But, anyway, we are now producing steam with the sun and injecting that into the crude, allowing the crude to come up without the use of natural gas. We're very excited about that application, so it's not just in electricity; there are lots of great things that solar technology can do.

This is our basic technology. Those folks who are Boy Scouts or Girl Scouts have probably done some variation on it. Mirrors are used to collect solar energy, solar thermal energy, and direct it to a single point where it's concentrated. And for us, for our Ivanpah project, which has commenced construction, there are three units, two for Pacific Gas and Electric, and one for Southern California systems, a total of about 390 megawatts. Sixty thousand mirrors are on poles inserted right into the desert floor; no grading for these poles is necessary, and no concrete pads. It's a very low-impact design that allows for stormwater to flow naturally to the site.

Those 60,000 mirrors are focused from the top of a tower, where there's a conventional boiler. That creates some of the hottest and highest temperature, highest pressure steam in the industry. In fact, it's the highest solar temperature and pressure that has been created to date. We have a demonstration project in Israel that has reached about 110% of its expected performance, and we're very excited about that.

Back in the days of those Luz projects, when those trough projects were being built, our engineers were really excited about the tower power technology. DOE [U.S. Department of Energy] was very excited about the tower technology as well, and had a demonstration plant in Barstow. Honestly, the software wasn't there. It took lots of things like the Star Wars program—for those folks who remember, there was a controversy about the Star Wars program, because it turned out that the antimissiles were able to hit the missiles only because the missiles were signaling here I am, come hit me. Well, it turns out that that kind of closed loop software was what was really needed to make the tower technology to work. Each of the 60,000 heliostat mirrors has a very precise location, determined with a very detailed algorithm, because we're not flattening the earth but placing the heliostat in the desert floor as it is. Each mirror focuses at that tower to provide the right amount of heat at the right time to meet the economic signal.

Heliostats collect the sun and concentrate it on the boiler sitting on top of the tower to create steam. That steam goes to a very conventional power block, where we have a turbine. That's one of the basic advantages of solar thermal, again, as part of this mélange of different technologies that we need, which include wind and geothermal and distributed, to provide as much renewable energy as we can with the least amount of conventional power.

One of the great things about solar thermal is that, particularly with tower technology, we can shape the fuel collection, which is how we place the solar field to adapt to what time of year, what times of day, how much power we want to actually get. We can collect that and turn that into steam, and we can augment that, either through storage—and again, as Tom was talking about, solar thermal storage is a lot less expensive than electrical storage or even potentially pumped water storage, and that's something we're very excited about—or oil, natural gas, and, in the right location, such as Crete, other fossil fuel to reduce your overall carbon emissions and create a very reliable stream of steam that is going to go to a turbine.

And over the decades, whether it's been nuclear power or coal or natural gas, electricity has been coming from turbines, and the turbines had been becoming more and more sophisticated to provide the grid exactly what it needs, whether it's frequency response or voltage support or automatic generation control. The grid operators will know what that is capable of doing, what that signal is like coming from the turbine, and are able to control that to get the power flow exactly to what the grid actually needs. And that allows you to have a great deal of support, and that becomes important not just because of ride-through. That is an important thing when you have clouds come over solar fields. But as you start to see more renewables come online, the aggregate shape of load—load is the electrical demand—and the power supply start changing.

1. Todd Woody, *California Solar Startup in Greek Power Plant Deal*, Grist.com (Jan. 20, 2011), http://www.grist.org/article/2011-01-20-california-solar-startup-in-greek-power-plant-deal (last visited Apr. 6, 2011).

So, right now, in California, the peak tends to be a little bit after sunrise. It's mostly air-conditioning in the summer. But with a lot of distributed generation, we expect the peak is actually going to move out further at night, there are also some complications, because when you have wind, especially in California, you tend to have a lot of power come onto the grid at dawn and at dusk, and the grid has to constantly manage those because just like too little power is a problem, too much power is a problem too. It can burn down electrical equipment and cause it to fail much more frequently. It'll cause fires, and so on. You have to be able to manage that flow properly. With thermal storage and augmentation, you can actually match the output to what the need is.

Sara Kamins: Thank you very much. Okay, let's go to Alice, who will talk about our second solar thermal technology, parabolic trough.

IV. Parabolic Trough Technology

Alice Harron: Solar Millennium LLC is a subsidiary of Solar Trust of America, which is a joint venture of Solar Millennium AG, and we'll talk a little bit about some of their projects in Europe in MAN Ferrostaal. That's the best German I can do. We have extensive EPC [engineering, procurement, and construction] and solar thermal market strengths, a lot of it in Europe. Through our parent, we already have Andasol 1, 2, and 3 is in construction. Those are three 50-megawatt solar thermal plants with thermal storage, located in Spain. We've also been shortlisted for about 500 megawatts in Morocco. And we'll talk about the megawatts currently in development in the Southwest.

I was going to talk about three projects, Ridgecrest, Palen, and Blythe. We recently withdrew our Ridgecrest project. But Blythe is 1,000 megawatts of solar thermal, and recently received the CEC license. Palen is 500 megawatts, and it recently received its CEC license. Both are dry cooling; we are minimizing the use of water. That's the current visual simulation of Blythe. It's near Blythe Airport. That's basically four 250-megawatt units, the solar field, and the power block consisting of the generator turbine.

So basically, just what Tom had said, this is the schematic, and everything in red and to your left, all this is making heat. And just as he said, we used to make steam with coal, used to make steam with gas. Anybody here for making steam with nuclear? I thought so. There you go. So, [solar] is just another way of making steam. We put the steam through the turbine in front of the generator, and again, as I said, we do dry cooling because when steam comes out, water comes out, and you want to cool it. What we basically do with the air-cooled condenser is just flow, so it's a hit on efficiency but, again, it's like a 90% drop in use of water.

So, this is the permitting process visual. We go through the CEC and we're on BLM land, so we also go through the federal permitting process. But when I say we go through the CEC, that's really a one-stop shop, but I think you all know that it's multiple agencies that are involved: California Department of Fish and Game, U.S. Fish and Wildlife Service, a couple of water departments thrown in there. So, it's quite a bit. Just to try to give you a feeling of how long it takes, we basically, for Blythe, started the application in 2006, and we got the license for Blythe in 2010.

I also want to emphasize that I kind of like what you said, Arthur: it's a symphony. I wasn't really thinking about it, but you really need all sorts of instruments, and it's really the catalyst that's the conductor pulling it together. I really never thought that they were that artful.

And when I thought too, I'm not an engineer, I'm not a lawyer, I come more from a finance background, but when I talked to the engineers, they always remind me that I've got to stop thinking of just an electronic kilowatt hour just going through the system. You have to think, just what Arthur said, about ability, you have to think about support, and balancing the system. I remember a long time ago, right after the oil crisis, everybody said go coal, everybody go coal, we all went coal. And then we said, no, no, no, that's a bad idea; let's all go nuclear, we're all going to go nuclear. No, no, it's a bad idea. And the same thing happened with gas.

All I'm saying is that sometimes things look like a panacea, but you've got to realize that it's not just one technology that's a solution. PV had some great attributes. I'm still learning about your solar tower. It has some great attributes. And I also agree with what Arthur said, that you also have to have the pricing mechanism involved. California has a pricing mechanism in this contract for kilowatt hour. The kilowatt hour is not a kilowatt hour is not a kilowatt hour. Just what some of the things that Arthur was saying, the stability, etc., we can't keep just socializing the cost and saying, okay, well, I got to do all this because all I'm getting is kilowatt hours.

Sara Kamins: Lisa, you are up next to discuss CBD's role in the permitting process for solar projects.

V. Permitting Solar Projects

Lisa Belenky: I'm Lisa Belenky, I'm with the Center for Biological Diversity, and I'm an attorney, and I've been working for almost two years now on a lot of the renewable energy projects. We've been looking at the siting. Obviously, the Center has been very active in looking at global warming issues, and we really need to reduce greenhouse gas emissions, and now we have the projects trying to get sited, primarily, a large part of them on public land. I've been working on the projects in California and Nevada quite extensively, so then we get to the place, well, how do we actually get this sited in a way that is not going to destroy other values that we have, other habitat and endangered species, and overuse water, etc.?

Water use is obviously a big issue. All of these three [presenters before me] have discussed that question. Also, one

of the issues between the different technologies is whether they need very flat land, and some of the technologies can do better with some slope or unevenness; whereas, the solar trough, in particular, needs it to be very flat, and they do grade because of the tolerance for the fluid that runs down the end of the trough and around the field.

Some of them have more or less flexible designs. Alice showed you a photo of the designs for the Blythe project, it's kind of square and boxy, but the world isn't flat, so, trying to get very large pieces sited on lands that are, you know, have washes and they have very sensitive species that are following the loss of for example, lot of riparian even in the deserts, we have dry wash woodlands, etc.

If we have multiple small units that may help—the PV is looking at putting together smaller pieces on a bigger piece of land, etc., but that may also have other problems—and some of you who are scientists perhaps or you've dealt with these issues before have a lot of small patches fragment remaining habitat. Smaller units could avoid some of the resources directly, but then you may be actually increasing in some ways your edge effects footprint. So, it's a non-simple project and process, and so it's been really challenging, I have to say, and I've worked with all of these folks on projects. So, I just wanted to put up a little bit of a slide.

The first two figures are actually a little bit old now, but still valid. The first shows potential for concentrating solar power in California. You can see the highest potential in certain parts of the California desert and then in the Central Valley. The second figure is the technical PV potential, which has a greater area, that you can put it all the way up into northern California, but it also tends to follow the shape of the desert.

I put in this very good slide that shows the habitat for the desert tortoise, the threatened desert tortoise population. You can see very much it's this rain shadow formation in southern California that creates the desert; it also creates this habitat. So, the two things are just really overlaid. This is the best desert tortoise habitat and the highest solar potential. So, that created some of the issues and, again, depending on the size or the particular technology, whether you can avoid the most sensitive areas.

This is just a slide with a lot of our favorite critters out there, some of the plants; there's a kangaroo rat. Now, people don't like the word rat but kangaroo rats are actually very important. They dig into the soil, they keep the soil aerated, they move seeds throughout the desert. Some people call them the engineers of the desert, and we have several listed species both in the desert and up in the Central Valley, the Carrizo Plain area. There are some lizards there, and we've got some birds and also some rare plants. So, it's really a very rich area. I know people say, oh, just put it in the desert, there's nothing there, but most of you wouldn't say that because if you've been out there, especially in the spring, you can really see the diversity and the incredible living world really, and we're just so lucky to have it.

Then, I just wanted to talk a little bit about scale. This is a map of San Francisco; most of you know how big San Francisco is or you know how big it feels. And we added the outlines of the Blythe project. The Blythe project here covered several neighborhoods. Golden Gate Park, for example, is about 1,100 acres. Some of these projects are 6,000 acres, 10,000 acres. So, it is really a question, how do you site such a big project out there, and what are the kinds of issues we need to deal with as far as both destroying the habitat under the footprint and the edge effects and connectivity throughout a larger area of habitat?

Some of these issues may go both ways. BLM right now is looking at putting together some zones on public lands, where we could cluster some of the big projects. Is that a really great idea because of minimized edge effects, or is it really a bad idea because you'd have just one giant area that was completely devoid of habitat? People have argued it both ways, and I guess I'm just here to say it's non-simple and we're working really hard to preserve the most important areas and also to get some solar power out there on the ground and built in California.

VI. Discussion

Sara Kamins: I want to put one slide up just to show you from a regulatory point of view what we're thinking about here, because we have three great technologies, and there's a question about how they're going to fit within the portfolio to meet California's RPS going forward. They're all building projects in California, and because we are here today comparing the technologies and talking about market trends, I assume that they are planning for more projects. This is a chart that we recently released in our quarterly report to the legislature that shows our progress toward meeting our 20% RPS mandate, as well as the 33% state goal.

The blue line is the 20% target, and the orange line is the 33% goal. We've actually done a lot of contracting in California, so we're pretty close to meeting these targets on a contract basis. This chart also does not include existing QF projects whose contracts are going to run out in the next couple of years, and utilities will most likely re-contract with them. Of course, we aren't all the way there yet because some of these projects that are shown in the chart as under contract just aren't going to come to fruition.

So, as I'm thinking about this, while we compare the technologies represented on the panel today, we have to think about how many more projects we're going to do in California. I don't know. One of the things that we want to talk about here is the value of the different projects to fill the net short that we have going forward.

Okay, so on permitting, I want to direct this first question to one person who works for a solar thermal company and one person who works for a PV company and discuss their experiences and the challenge they face. There are different levels of permitting: local, state, and federal. So, Alice, I know you worked a lot on this, could you discuss what the lessons learned have been and what

the challenges have been so far for getting through the permitting processes?

Alice Harron: Basically, our projects started off in what is politically called the back-track projects. We're solar thermal, so when we go through permitting, we go through the CEC, and we're on federal land, so we also go through the federal permitting process. At first, it was a joint process all the way through the staff assessment and the draft EIS [environmental impact statement], and I think that was brought sometime in March. And then BLM and then CEC split their ways, and we had a separate CEC decision and a BLM [decision].

I'm not sure about the lessons learned; it was quite a bit of work. When you do development, I mean, we're focusing on permitting, but you have to do a lot of outreach. You have to go to the local. You have to think, "we're going to be their neighbor for the next 30 years." I actually like that part of the job. We did a lot of outreach to Native American groups, and I want to be clear, it's BLM who does the §106 government-to-government consultation, but I really wanted to go out there and explain our project.

In the permitting process, I think there are some lessons learned about working through issues in a timely manner, understanding various stakeholders, including environmental organizations. I think you just have to keep driving towards a solution. You can delve into data and just keep digging and digging, but it's really what you resolve. How do you make sure that you're mitigating or you're protecting as much habitat as possible? How do you make sure that you understand what the regulators and all the other stakeholders really, really need?

Arthur Haubenstock: The big difference between the solar thermal and PV, at least in California, is that the California Energy Commission has exclusive jurisdiction over permitting for solar thermal for 50 megawatts or larger. PV is permitted by the county and through the various different agencies. The CEC is essentially a one-stop shop for permitting, which is theoretically faster and theoretically, under statute, a one-year process. For us, it was about three-and-a-half years.

One of the things that I think everybody learned is that it is critical to do some of that outreach early on, especially when you start investing large amounts of money into research and design, and for our technology in particular, because each one of those heliostats is very carefully put in a particular place and the facility is designed around that. Understanding what the stakeholder concerns are early on and being able to adapt to that early on would make for a much better, less controversial process. I think that's one of the most important lessons.

I think ultimately the agencies have learned a great deal about how to work together and how their processes are similar and how they're not, and so we've seen tremendous progress in how quickly the agencies can move together. I think we also need to make sure that they're not just working together quickly but they're also working together in a more deeply and more responsive fashion, and that will make the whole process less controversial and allow a lot of the environmental organizations that want to support renewable energy feel better about supporting renewable energy because their concerns have been incorporated into the process overall.

Tom Starrs: Our experience at SunPower with the PV technology is very different in a number of respects, and I'll elaborate a little bit on what's already been covered. Virtually, none of the projects that we are actively developing are on public land.

We stayed off of the public land for a variety of reasons. As Arthur noted, solar thermal technology is not subject to the CEC's licensing authority, so for both those reasons we are subject primarily to, for our California projects, CEQA [California Environmental Quality Act] jurisdiction at the county level. Our permitting is handled essentially at the county level. That doesn't mean we don't have federal engagement; we do, because at least where there are endangered species issues, U.S. Fish and Wildlife Service gets involved as with the California Department of Fish and Game. But essentially it's a fundamentally different kind of process.

Another thing, our company has made the decision to stay off of the pristine desert lands. That was a very deliberate and conscious decision. I'll tell a quick anecdote. About a year-and-a-half ago, a team from SunPower went down and met with David Myers from the Wildlands Conservancy. David is, I think we would all agree, one of the most fervent and eloquent advocates for the protection of the pristine desert landscape. He's worked very closely with Sen. [Diane] Feinstein (D-Cal.) on federal legislation to protect big swaths of the Mojave Desert. And David gave us some guidance essentially on what to do and what not to do, and one of the things that he encouraged us to do is to focus on our solar project development efforts on disturbed lands, either agricultural or grazing land that had less environmental value.

I will say, before Lisa does, that the California Valley Solar Ranch project in the Carrizo was the site that we selected years ago. We do have significant endangered species issues there, but our other large projects, including projects we've just announced in the last few weeks, are in the Antelope Valley area of California and in the Central Valley. All are on previously disturbed lands, mostly fallow or dewatered agricultural lands. I think that's going to be an advantage for us over time, but, frankly, it's not entirely clear that that's going to be an advantage for us at this point.

Lisa Belenky: Actually, the California Energy Commission is doing a whole process on the lessons learned on permitting. I guess there's a couple of things I just want to echo.

One of the things that Arthur pointed to is that by the time any of these permitting processes come to a point where there is a public document, like what they call the

Energy Commission Staff Assessment or the EIS, often, the developer is extremely wedded to their design and their site way before the public ever really has any idea of what's going on, even sometimes way before a scoping notice. So, it just creates this very early conflict that even though of course our federal and state permitting laws require alternatives and require looking at ways to change the project to make them less, it's really been very hard for the public and for the activists and people in the environmental community to really engage with these projects in a positive way when the first thing we see is a project that the developers are so incredibly wedded to. They have millions of dollars sometimes already in development, and it makes it very hard for them to see the advantages of change.

Now that said, some of them have gone a long way to try and make changes within that, within a narrow scope, but I think especially for members of the public, the members of the Center, and other activists I work with, this is probably one of the hardest pieces of this. We're dealing with very, very large industrial projects that have not only huge footprints but a lot of the technology behind them, and so it's a very hard fit I think for the way we use our environmental review process. I think that is one of the lessons learned.

I think for the industry, we're hoping the lesson they learned is that, as Arthur said and some other people have mentioned, really go to the public early and find out what you can about the site. Often, the people who know the most about the site and the problems with it are going to be people who have been working in that landscape for a long time. They may not be the people at the agencies, and so it can be a little tricky to find out that information.

Those are some of the lessons we've learned and learned the hard way, and I do think that a lot of the developers have also learned that lesson and are coming to us very, very early now with some of their suggestions of places that they're thinking of developing.

Sara Kamins: As you all may know, the federal government provided certain funding for new solar thermal projects through the American Recovery and Reinvestment Act (ARRA), and there are deadlines that developers have to meet in order to get this federal funding. And Gov. [Arnold] Schwarzenegger last year made it a really big priority for the state to permit projects in time for California projects to get this federal funding, and the CEC as a result expedited a lot of permitting and got a lot done last year, and the governor said it was a really big success. But other people have somewhat criticized the fact that the state expedited permitting.

Could a couple of the panelists respond to whether you think the expedited permitting increased the potential for litigation risk for the state and for other agencies, or whether you think it was a good thing?

Lisa Belenky: Well, I think it certainly increased the litigation risk and it increased, I think, to a large extent the vulnerability of the agencies in that litigation. And I'd say that we have done—we don't have any pending litigation on solar projects, but having read all of the complaints that have been filed, a lot of these things are things that we were telling the agency quite early on, and so it's hard. I do think the rushing was part of that, but I don't think that's the only thing.

The rushing made it a little bit more likely that some of those problems would happen, but I have to say I think there's a culture in some of the agencies, particularly, for example, BLM and, again, they're changing as well, I think, in response to all of this, but to really not listen to certain things. I think that said, it may in fact change some of these agency cultures that have been pretty ingrained.

Arthur Haubenstock: You know, echoing what Lisa just said, I don't know that the problems that have been alleged really have anything to do with how quickly the projects progressed in this last year, for the most part. I mentioned earlier that our project was a three-and-a-half-year project, and so, when in the press you talk about fast-tracking it, and I guess given that the statutory mandate is for a one-year permitting process, we're somewhat at a loss other than the label that was applied to it, and I think the label itself was unfortunate. I do think that the cultures are changing.

I think it's very difficult for any large entity and particularly government entities to do anything new, and for government entities that aren't used to working together to have to work together and to try to do it quickly is difficult. If nothing else, the ARRA deadlines helped create a process in which the agencies were brought to work together. One of the great lessons learned was the creation of the Renewable Energy Action Team and the Renewable Energy Policy Group, the working level and policy level consortiums of federal and state agencies that are looking at these renewable energy projects and trying to figure out how to address them in the most efficient, most responsible way.

I think we've seen a sea change in that the government agencies are working together better and are feeling better about the processes, and we're feeling better about the processes. I think, from what I'm hearing, the environmental groups are thinking in general this is a good progression, even if it hasn't quite gotten where it needs to go yet. So, it did help focus the mind. I think that was great. But I think that obviously we have a lot to go. And we need to look back at this last year, figure out how to do it better than we did.

Sara Kamins: Thanks. The next question is for Tom about solar PV technology price trends. When I started working on renewable energy programs several years ago, everyone was talking about how renewable energy technology was a little expensive right now, but over time, the prices were going to decline. We haven't seen renewable technology prices decline much, except for solar PV, and we've seen a lot of decline in the last couple of years. So, Tom, could you

discuss the major cost drivers for solar PV technology? Is it just that module prices that are going down, or are there other factors?

Tom Starrs: It's both the cost of the PV modules, which have declined substantially—I'll come back to that in a minute because that's probably the single most important driver—but also, declining cost in what we call the balance of plan or balance of systems, so that's everything else basically besides the modules.

My company has announced a cost roadmap that for a public company reduces the cost of our modules to about a dollar per watt in 2014, so it's a substantial reduction even from today. But that's looking forward, that's forecasting. I mean, the simple fact is that—this is again publicly available data—the price of PV technology around the world, because it's essentially a global commodity market, declined about 50% over less than 18 months in 2008 to 2009.

And for those of you who are businesspeople as well as lawyers, to me, the fascinating thing about that is if the price declines that much, most of the companies in the industry are still profitable after a 50% price cut. Now, so the sort of good and bad news is embedded in that. The bad news is they're a lot less profitable than they were before, but the good news is they are still profitable. And there is a history behind that that has to do with a different kind of lessons learned than this audience might be interested in, but fundamentally the story behind that is that you had a period during which really massive government support, primarily in Europe, in Germany in particular, officially sustained the market on the demand side for PV technology.

Cost is not the same as price. So, the costs were going down as they historically have gone down at a rate of about 8% per year. That's not five years of data; that's about 40 years of data. Okay, 8% price hike per year of long-term average—I'm sorry, cost-decline path. There was a period for about five, six, almost seven years when the cost continued to go down but the prices were level or even climbing. Again, that was sort of an artificial period driven primarily by the German market.

So, what we saw in 2008-2009 was essentially a price collapse down to the historical cost path. Going forward, we're expecting that's not the end of the cost reductions. I'm mean, our company and the industry generally is anticipating cost reductions in accordance with that multi-decade path going forward. And I think it's very interesting, it's very challenging.

But a lot of it, by the way, has been driven by scale economies. I've been doing solar work from long before there was a market, but I was running the U.S. business for a company called Schott Solar in the early 2000s. And I remember in 2001-2002, it was big global news when companies started building a manufacturing plant that produced 20 megawatts per year with their modules. And now, my company is building a plant that makes 1,000 megawatts per year worth of modules, and there are others who have financed even bigger plants.

So, a big part of the cost decline is associated with the scale of economies in the industry overall. As the industry continues to grow, we will continue to see cost reduction from scale of economies. The rest of the cost reductions are basically geeky technical stuff associated with just incremental improvements in the technology, conversion efficiency, thinner cells, wafers, and cells with lots of other little things.

Arthur Haubenstock: I was at an ACORE conference in Washington about a month ago. Hudson Clean Energy had a fascinating slide that showed the price decline of coal when it was introduced, and the price decline of other fossil fuels when they were introduced. Every single major energy technology had pretty much the same curve, and you really see it in wind from the last 10 years, 20 years. The one technology that did not follow the same basic price-curve reduction was nuclear, and you can draw your own conclusions about that.

If you look at all these different technologies, when you make that kind of an investment—and there has been a lot of arguments about this in *Wall Street Journal* op-eds recently, which has been a little disturbing—at the top end of the curve, you see a tremendous benefit—but you have to hang in there. You have to have a very solid steady economic and regulatory signal, because when you have a sporadic signal like you do with the ITC grant, which was renewed for one year, which doesn't create the kind of investment that you need to get that kind of decline, you don't see the benefit.

Sara Kamins: Tom mentioned European subsidies had an effect on prices. I've also been hearing a lot about the massive Chinese subsidies on solar PVs. He mentioned how the Chinese subsidies are going to affect business here in California, so, I'd like to hear from the solar thermal folks about the how price declines in solar PV and the Chinese subsidies might affect their market outlook on the solar thermal market.

Tom Starrs: The Chinese subsidies have been focused less on deployment, so they affect less the cost of energy. They've been more subsidies to support domestic manufacturing. It's actually an incredible story. There essentially were zero in PV modules manufactured in China in probably 2001-2002 and, now, the Chinese produce a majority of the world's PV modules, all at a time when the market has been growing explosively. I mean in the order of about 60% growth per year. So, the Chinese went from producing nothing to producing about 55% of the PV modules globally at a time when the market was expanding. It's just an incredible story.

I can tell you a personal story about being in China seeing one of these companies, and, by the way, I have very mixed feelings about this. I was at the headquarters of this

company and almost literally as far as you could see was one fab, as you call them, fabrication plant after another. I've never been to Dearborn, I've never been to Ford, I'm just picking on them. But it made me think like maybe this is what it's like in Dearborn, where Ford has its headquarters, and then the first plant is the one where they built the Model Ts, and the next one is where they built the Model As, and the first one of course is a museum or something. And then, in a far distance as far the eye can see, is the plant where they make, for example, the Ford Focus today. But that history for Ford is almost a 100-year history, and for this Chinese company in these offices I was sitting in, the oldest plant was seven years old.

I mean you couldn't permit one of those facilities in the United States. You couldn't permit and finance and build probably a single one of those plants in the United States in that time frame. And they were doing one every six months basically. It was an astonishing story.

Now, the mixed feeling is, frankly, I don't think they're doing that with the same kind of attention to environmental laws or labor laws or lots of other considerations that are near and dear to our hearts, so I'm not—this is not a matter of envy, it's just a matter of fact that it's just a very, very different cultural environment for promoting the growth of the business. I'm very happy to be working for a U.S.-based company that's doing things differently, but it does create pretty significant challenges. Among the many things that the Chinese are bringing to bear is essentially zero cost money for the startup and ramping of these companies, Chinese manufacturers.

Arthur Haubenstock: A couple of things. On the Chinese part of things, from a climate change perspective, if we don't do something about the quantity of coal that China is burning, then it doesn't matter what we do in the United States. And so, it's a very positive thing that they are investing seriously in renewable energy, and I hope they continue to. I don't know that that is a problem for us.

PV will continue to reduce in price. There are lots of questions about materials and so on, and where the endpoint is going to be, but there's no question that PV has a great deal to go before we've run out of PV applications. There are a lot of wonderful things that PV is going to do in this country, and a lot of the technology and ingenuity is happening here in the United States, just as it did with software. There are a lot of jobs that are going to come to the United States. It does rub me a little bit in the wrong way to worry too much about which country is doing what, but it is important to try to source things here; it is important to try to get jobs and economic stimulus here.

I think we have to see what's happening in Washington just over the last couple of days to look at which way the policies are going and what is going to get support. And we have to understand, those of us interested in renewable energy and climate, that jobs are where it's at; the economy is where it's at, and we must try and source things in the United States and recognize that bringing jobs here is important. San Bernardino has one of the highest unemployment rates in the country, and it's far worse for construction workers. So, we're really happy about bringing jobs to that county. Providing work will ultimately create a cadre of very experienced people who could go from project to project and be able to bring those skills and that money back to the counties.

It's not really a direct problem for solar thermal in the same sense as it is for PV. Again, we see that the market is segmented differently. We don't see that solar thermal and PV are really entirely in the same market segment.

Our same engineering team was able to bring the prices for solar trough down by over 66% in a small number of years. Now, let me give you one example of what's happening with our technology. When we first built our heliostats for our solar project in Israel, the heliostats were put together largely by hand. We built the facility to create the heliostats for the Chevron project. We were building heliostats one in about every five minutes. We've now got that down to 90 seconds. Our engineers plan to reduce it further still.

Turbines are what they are. Turbine prices aren't going to change very much. That's going to be across the whole energy industry. But in terms of the solar field, we're confident that we're going to get that down tremendously and that we'll be increasingly cost-competitive to a point where a lot of the tax subsidies and so on really won't matter quite so much. Because a lot of that technology is actually sourced here in the United States—and I could bring up a slide if you want it, showing where a lot of materials are coming from, where the glass is coming from. We're producing the heliostats actually onsite, because it doesn't make sense to transport them.

Solar thermal really has a local aspect to it that is not going to be troubled quite so much by the China equation. And again, because if you want to displace conventionals [and have a reliable grid], then you're going to need not just PV; you're going to need solar thermal, you're going to need wind, you're going to need geothermal, you're going to need that mix that collectively provides what the grid needs.

Audience Member: Hello. I'm with the California Energy Commission. Thanks for not bashing us too much. I did work with Alice on a project and Lisa—so, if anyone wants to ask a question on siting stuff, feel free to see me afterwards.

My question to the panel is, it doesn't appear that maybe there's going to be any cap-and-trade program on a federal level. But with RPS and the price coming down, in your view, how important is it for price on carbon or some federal cap-and-trade program to your industries? Are we getting to a point where we can actually push through this and companies can move forward and start to have plants for deployment without federal cap and trade or some form of carbon tax?

Tom Starrs: I think that the technologies represented at this table, the companies represented here, all will be able to produce power at a price that's competitive, not necessarily at the lowest price, but when you account for a variety of different factors and other considerations, not necessarily or exclusively a carbon tax or other carbon pricing schemes. I'm very confident we'll all be doing that; I would say within a decade. That's being conservative.

I think the challenge is getting from here to there, so let me give you two answers. The first is that we really are dependent on the financial and other sort of incentive structures that are in place today to drive the growth of our company. These are not mature industries or mature technologies, and so we are still dependent on that, but we won't be for very long. And I think that the challenge for policymakers and for the industry is to find that right balance.

I really want to reinforce what Arthur said, which is the worst industrial policy is the industrial policy we've had for a long time in renewables until recently, which was year-to-year policy support. In all that, it would create sort of a land-rush kind of mentality to get projects done on a year-to-year basis, because you have to have your projects operating by the end of the year. What it actually did not do was encourage manufacturers in particular and other sectors, you can think of sort of ancillary sectors in the economy like financiers and investors. They really didn't pay any attention to the industry because it was way too ad hoc.

There was a huge impetus and a huge step forward for our industries when Congress renewed the federal investment tax credit for solar for essentially a 10-year period through 2016. To me, it would be interesting to hear others reinforce me or not, but to me, that was a huge signal that had overnight transformed the U.S. market and drove a huge amount of international interest in the U.S. market and has contributed substantially to get us to where we are today. I think we do need continuous support. I think it's measured in years, and not that many years. And I think that at the end of that period, we'll have technologies and companies that are able to stand alone without the kind of financial support that they're requiring now.

Before I go on, a point that actually President Barack Obama made in his speech the other night, it's always worth noting that there is no such thing as free market energy. There never has been. We have massive subsidies associated with basically every energy technology, including coal, oil, gas, and probably especially nuclear. The idea that's gotten traction in the last couple of decades of eliminating the subsidies and financial support for renewables as far as sustaining the deeply embedded (in the tax credit) incentives and subsidies for other technologies, other energy technologies, including carbon-based, hydrocarbon technology. It doesn't make a lot of sense to me, and I hope that we can do something about that as well.

Lisa Belenky: I think that the carbon tax and/or cap-and-trade system is extremely important for the other side of this, which is reducing the greenhouse gases, because until we can do something that's really going to incentivize taking offline the existing coal-fired plants and the gas-fired plants, at least reducing them or putting them in the proper place that they should have, we're not going to really get where we need to go as far as reducing greenhouse gas overall emissions and hopefully bring our load in the atmosphere down. And so, I think that's still a critically important program, whether or not it's necessary for these particular solar technologies.

Arthur Haubenstock: Let me echo what Lisa just said and take the opportunity to thank Mike Rafferty for one of my favorite stories. Mike is here in the audience. Many years ago, I was working on a Superfund site and he was a consultant on that site, and he was telling me a story about going down to South America and being asked by the local government how they could clean up a river by stopping the pollution that was going into the river. He asked what laws and regulations and penalties were in place to keep them from going to the river. And they said, well, there really aren't any; we want to show that it's more cost effective to stop polluting the river than it would be to continue polluting the river. And he explained that unless there are some costs associated with polluting the river, it's always going to be cheaper to keep polluting the river. You need to have some sort of a feedback mechanism.

Unless there is a cost associated with putting carbon in the atmosphere, we're going to continue to put carbon in the atmosphere. That's just the way our economy works. There have been lots of interesting questions about changing the way our economy works, but I think it's going to be hard to put a carbon tax on.

That said, I agree with everything that Tom said. I do think the investment tax credit is very valuable. Unfortunately, it's not all that valuable right now. When you think about an investment tax credit, it's only good if you have a tax liability. And tax liabilities tend to lag behind the economy because you have to be making a profit in order to have a tax liability. That's why the investment tax grant is so important—it's revenue-neutral. It really doesn't matter whether you're issuing it as a grant or as a credit, but it makes a big difference when there are not a lot of people out there with a tax appetite. So, there is that piece of it.

As far as the climate, as far as a carbon tax goes, honestly, I don't think it drives renewable energy that much; RPS is a much bigger driver. All the studies that I've seen have suggested that a carbon tax would have to be so high in order to really make renewable energy happen to a greater extent, that it realistically wouldn't be a direct driver. But I think Lisa is exactly right; it's important in order to make sure that the alternatives for renewable energy show their true cost.

Alice Harron: But I want to go back to the ARRA or the fast-track permitting. When we had the fast-track permitting—Lisa brought up we maybe have more litigation, and Arthur brought up that it was good that the agencies worked together. You also have to understand the developer's point of view. We got started after BrightSource, and so, to me, what happened was the regulators became very, very conservative in order to make sure that they were covered, and that items that might have been contentious where I wanted drive for resolution, I basically had to give up in order to meet that deadline. But there is the other side of it, because I do think fast-track is a misnomer. I think it's really the developer who may have with more time been able to argue for more reasonable conditions that really had to give up and move on. And so, I do think that there are a lot of very, very conservative conditions for our project.

Sara Kamins: Do you think it was the ARRA funding deadlines or more of the CEC process that led to this situation?

Alice Harron: I think it was that we had a deadline, and we had to meet that deadline, and I could have my attorney argue much harder and try to get those conditions down. We did drive for resolution. I don't want to put anything down on the people who we negotiated with because they were doing their jobs. It's just that the pressure on us to get a permitted project was so great, where by the end of the year, there were things that I would have argued more strenuously.

So, I think that when people want to say, you know, well, CEC actually didn't do this, or even BLM, I think in my discussions with them, I felt that they really wanted to be extra careful to make sure that because we were going quickly—or supposedly quickly because you're right, it's only a year process—that we didn't miss anything.

Audience Member: Could you describe how the revenue side of the global market works?

Tom Starrs: I'll give you the quick and dirty and then let others elaborate. Basically, there are two possibilities for us. We can build and sell power plants to utilities, then they own and operate it, and they produce the power basically on their own account and distribute it to their customers. Or we can design and build power plants and sell them to a nonutility, independent power producer that sells the energy to a utility under a long-term power purchase agreement or PPA. Those are basically the two structures.

Audience Member: Is there a special pricing that the developer would get independent of the power producer?

Tom Starrs: No. It's a competitive wholesale market. The only thing that substantially drives the market price signal is the renewable or state tax renewable portfolio standards. Then, that creates essentially a differentiated market for renewable energy, right? So, the utility has to buy or produce 20% of its electricity from renewables, and that creates a different market for renewables. And as a practical matter, that means they have to be willing to pay more, so, it does create different pricing. The utilities generally, when they're subject to an RPS, will end up paying more for electricity from a renewable facility than from a natural gas-fired or coal-fired facility.

I can't talk about specific pricing terms. Of course, the price of gas is very volatile, so, I'm going to give a very rough number from the cost of delivered energy or the cost of energy from a natural gas-fired power plant. There's probably a bunch of experts in the room, but I'm going to say today with gas in the $4.00 dollar range—what do you think—6 cents? Six cents give or take a penny, 6 cents per kilowatt hour. And the long-term power purchase agreements that the California utilities are signing for renewables are very roughly speaking and in terms of a range twice that, about 12 cents, okay?

Sara Kamins: I'll just add from the PUC's perspective. We have RPS as the main program in California to incentivize utility-scale renewables. In each year, each of the regulated utilities holds an auction or solicitation where the independent power producers can bid into the solicitation. So, California is very focused on the competitive market, and so, we encourage everybody to participate in those annual competitive solicitations to reduce the prices that the utilities can get. Then, the utilities choose the projects based on least-cost, best-fit evaluation criteria to get the highest value for their customers. You can also negotiate outside of the competitive solicitation process. It's not always encouraged, but in some cases it's necessary.

Tom Starrs: One other quick note, which is a plug for all of our technologies, is that it's very hard, I think almost impossible, to get a producer of a natural gas-fired power plant to give a utility a 25-year contract for power because, again, the price of natural gas is so volatile, and you can hedge against some of that volatility but only for typically a five- or maybe 10-year period.

So, one huge advantage for us in power technologies is that because all the costs are upfront, we know essentially what our cost of energy is going to be for 25 or 30 years. And so, we can sign power purchase agreements for 25 or 30 years, and that's a big advantage for us and it's also a big advantage for the public. But I don't think anybody really expects the cost of electricity to come down substantially over time. Also, people don't like volatility, people don't like the uncertainty associated with prices, whether they go up or down. I mean it sounds silly in a way, but that volatility itself causes one of the problems. Even when the price of energy goes up and then plummets down again, that actually causes its own problem from an economic perspective.

So to me, one of the huge values that we don't talk about much—we talk about the environmental benefits of renewables—one of the other major benefits is that it's basically

a fixed-price resource, and we can provide electricity at a price that's known and knowable for decades to come.

Arthur Haubenstock: I think that's exactly right, a very good way to think about it. One other way that you might start to think about it is you look at the very high capital cost of a lot of these projects. You're buying all of your fuel for 30 years or more upfront. So, with a natural gas plant, what you'll often do is you'll put in the capital cost, and then you'll have a tolling contract with the power utility who will buy the gas separately and toll it through a power plant. Here, you're buying all that fuel, and these plants last. The Luz plants are now 30 years old, and they're producing 10 to 20% more efficiently than they had been when they were first built, and there's no end in sight. So, these are incredible investments and essentially hedging projects or products for the energy market for a very long time for California.

Sara Kamins: The hedging value of renewable energy projects was essentially a primary reason why the RPS was passed in California. It was right after the energy crisis. The California legislators wanted that long-term hedge that fixed-price RPS contracts can provide. Surprisingly, it wasn't the global warming benefit that a lot of people talk about as the primary benefit of a renewable program that was the reason that the legislators passed the program 10 years ago.

Audience Member: How do the counties view the solar projects?

Sara Kamins: Talking about jobs and economics?

Alice Harron: In terms of jobs and economics, one of our projects is in Riverside County. It had about a 16% unemployment rate. What was really interesting was when we went down to meet with some county officials from the city, we also met with the community college people. The benefits were not just the jobs, we're just starting construction, but their real interest was in all the other economic benefits. Our EPC contractor is going to need a lot of local supply. They'll want to import—for lack of a better word—a lot of supplies. EP, engineering and procurement contractor, they're the ones who actually build. He had a meeting with the Ace Hardware guy. All sorts of infrastructure, hotels, etc., people are very excited about that.

The other thing that I thought was really interesting was not just the immediate jobs but also the education for green jobs, because our operations guy met with the community college, and they just sat there and talked about a curriculum to educate people in the area, so that when our project comes online, these people have well-paying jobs. It's an incentive for us because we don't want to have to relocate people to Blythe. And this is nothing against Blythe, but that's a lot of relocation. We don't want to do that, and the locals want the jobs, and so that's the part I get really excited about, because you hear in all these policy forums about, oh, yeah, we want green jobs, we want green jobs. But when you actually start the project and meet with the locals, you really see the impact on these people, and you really see this actually being implemented.

David Lazerwitz: Well, I wanted to thank everybody. I think to draw on Tom's analogy, you were a great symphony coming together. We really appreciate it. Please stick around, we're going to have a reception afterwards, but join me in thanking the panel and Sara Kamins.