BEFORE THE

CALIFORNIA ENERGY COMMISSION

In the Matter of:) Docket No. 09-IEP-1M

Preparation of the 2009 Integrated Energy Policy Report (2009 IEPR)

STAFF WORKSHOP ON RD&D OF ADVANCED GENERATION TECHNOLOGIES

CALIFORNIA ENERGY COMMISSION
HEARING ROOM A
1516 NINTH STREET
SACRAMENTO, CALIFORNIA

MONDAY, AUGUST 10, 2009

9:00 A.M.

Reported by:
Peter Petty CER**D-493

COMMISSIONERS PRESENT

Jeffrey D. Byron, Presiding Member, IEPR Committee

STAFF PRESENT

Suzanne Korosec, IEPR Lead
Avtar Bining
Daryl Metz
Marla Mueller
Joe O'Hagan
Guido Franco

ALSO PRESENT

Presenters

Jack Brouwer, UC Irvine
Elizabeth Burton, Lawrence Livermore National Laboratory
David Walls, Navigant Consulting
Jose Luis Contreras, Navigant Consulting

Public

Robert F. Williams, PE, Retired
Edwin Sayre, BS, MS, Met. Eng., Engineering Consultant, ACRE
Michael Theroux, Theroux Environmental
Carl Walter, PE, ACRE
Bryce Johnson, ACRE
Bob Burt, Insulation Contractors Association

I N D E X

P R O C E E D I N G S

AUGUST 10, 2009 9:06 a.m.

MS. KOROSEC: We will go ahead and get started here. Good morning, everyone. I am Suzanne Korosec. I lead the Unit that produces the Energy Commission's Integrated Energy Policy Report Unit, or IEPR. Welcome to today's Staff Workshop on Advanced Generation Technologies. The purpose of today's workshop is to present a preliminary staff assessment on the current status of Advanced Generation Technologies, to get public comment, and also to discuss research and development opportunities that will help the state achieve its goals to reduce statewide greenhouse gas emissions, increase the amount of combined heat and power capacity in the state by as much as 4,000 MW by 2020, moving to net zero energy commercial buildings by 2030, and repowering or replacing aging power plants with cleaner technologies.

Our agenda will begin with a presentation by Energy Commission staff on the goals for today's workshop, followed by an overview of California's Generation Portfolio. We will then hear about air quality, water, climate change, and carbon sequestration as it relates to advanced generation technologies. We will break for lunch around noon, and resume with a discussion of efforts underway here at the Commission to develop a roadmap for the

Advanced Generation Program Area of the Energy Commission's Public Interest Energy Research Program. After that, we will have public comments for all the day's discussions.

Just a few housekeeping items before we get started. The restrooms are out the double doors and to your left. There is a snack room on the second floor at the top of the stairs, under the white awning. And if there is an emergency and we need to evaluate the building for any reason, please follow the staff out the doors to the park that is diagonal to the building, Roosevelt Park, and we will wait there for the all clear signal.

Today's workshop is being broadcast through our WebEx conferencing system and parties need to be aware we are recording the workshop. The recording will be available shortly after the workshop is over and placed on our website, and we will also have a transcript when that becomes available, which is usually a couple of weeks.

For presenters and commenters, we ask you to please speak very closely into the microphone; although it sounds very loud here in the room, it is not very loud out on the WebEx, so for the parties who are listening in, it would be very helpful if you could remember to do that. During the public comment period today, we will hear first from folks in the room, and then we will open the lines to hear from the WebEx participants. And for parties in the room who make comments, you will need to come up to the center podium and use the microphone there, and it is also very helpful if you can remember to give the Court Reporter your business card, so we can make sure that your name and your affiliation are spelled correctly in the transcript. We are also asking for written comments, and those are due by 5:00 p.m. on August 17th, a week from today. So with that, I will turn it over to Commissioner Byron, if you would like to make some opening remarks.

COMMISSIONER BYRON: Thank you, Ms. Korosec. Good morning, everyone. I am Jeff Byron. I chair the Integrated Energy Policy Report Committee, the Electricity and Natural Gas, and also our Siting Committees, as well. And my Associate Member on the IEPR Committee is Commissioner Boyd, who could not be here this morning. I hope to be here for at least the first couple of hours; Monday mornings are challenging, there is always a lot of other things pulling at our time.

Besides chairing these various committees and being a Commissioner, I am a closet engineer. I have a generation and technology background and a great deal of interest in seeing development of these new technologies. The purpose of this workshop is to discuss and receive your input on the status of advanced generation technologies, and also on our research, development, and demonstration needs going forward, which is part of developing a roadmap, if you will, for the Advanced Generation Program within our public interest energy research division.

Now, as you know, the focus -- as you may know -- the focus of the IEPR Committee has primarily been energy policy, and we spent a great deal of time on that, and we have had a number of workshops over the last couple of months. But besides setting all of those ambitious policy goals, renewables, and replacing less efficient power plants, addressing the repowering needs of the once-through cooling, or coastal power plants, they all depend heavily on developing new generation technology or advancing those existing technologies. So I am reminded we are not always dependent upon, or looking for those disruptive technologies, we are looking for incremental advancements, and I am proud to be a part of this Commission, where we continue to invest in the research that is necessary to make those advancements. And I am talking about both renewables and conventional generation technology. So I am looking forward to receiving your input today and the public comment, and I would like to thank everyone for being here. I think our workshop goes until about 3:00, I hope to make it back later this afternoon to hear the close and the public comments. Ms. Korosec?

MS. KOROSEC: All right, we will start with Energy

Commission staff, Avtar?

MR. BINING: Thank you, Suzanne. Good morning. My name is Avtar Bining and I am in the Advanced Generation Program of the Public Interest Energy Research, a program of the California Energy Commission. Before I start my formal presentation, I would like to introduce a couple of people who are from our Advanced Generation Program, and Energy Generation Research Office of Energy Research and Development Region. First, there is Mr. Ken Koyama, he is Office Manager of the Energy Generation Research Office; next is Mr. Fernando Pina, he is Supervisor of the Advanced Generation Program Group; I see Mike Langley sitting in the back, he is in the Advanced Generation Program; and I see Diana Mircheva, also from Advanced Generation Program. And we have one more person in our group, I do not see him here, his name is Rizaldo Aldas.

So with that, I will start with my presentation, as the title slide shows, the workshop goals, but I will be quite brief about my slides.

A little bit of background about the Advanced Generation Program. Formerly, it used to be called Environmentally Preferred Advance Generation, in short, EPAG, and we tried to make it short as Advanced Generation Program, and it is one of the eight research focus areas of the Public Interest Energy Research Program. As you will see through these presentations, that Advanced Generation Program is very interlinked with all these other research programs of the Public Interest Energy Research, and over about 10 years, since 1998, when PIER was established, in Advanced Generation Program, we have invested about $102 million, which is roughly about 20 percent of the total PIER investment. Advanced Generation Technology we see as an opportunity for developing clean, reliable, affordable, secure and sustainable power in California. All these years, the focus of Advanced Generation Program has been distributed generation and combined heat and power systems, and in the beginning, the focus was how to reduce criteria pollutants for prime movers like endurance turbines and fuel cells. Then, around 2005, that focus shifted more towards packaged systems for combined heat and power, and combined cooling and heating power systems. And also, we developed some analysis tools for assessing, designing, testing and monitoring of these systems.

This small table is a very kind of qualitative assessment of some attributes of different distributed generation and combined heat and power technologies in terms of fuel cells, hybrid fuel cell gas turbine cycles, reciprocating engines, steam engines, micro turbines, gas turbines, and also combined heat and power, and combined cooling heating and power packaged systems. The attributes that we normally look at are efficiency, emissions, cost, and reliability and durability. On this chart, I am using a couple of notations; one is cross mark, the other is a tech mark kind of sign, and then there is a color scheme of green, orange, and red. If it is like a cross mark, that means it is not very good, pink, and if it is a tech mark, it is more like it is good, green means it is acceptable, orange means it is good, and red means that it is not acceptable. So, as you can see here, fuel cells, they are efficiency-wise pretty good, acceptable, emissions are good and acceptable, cost is not, and reliability and durability is still uncertain. Same thing goes pretty much with the hybrid fuel cell and gas turbine cycles. In the case of reciprocating engines, efficiency is reasonable, it is acceptable, but emissions are not. Cost is pretty good, reliability durability is pretty good. Steam engines efficiencies are low, emissions are acceptable, cost is not, durability reliability is not. Micro turbines, there again, efficiency is low, but still it is acceptable in the sense that, when you combine it with combined heat and power packaged systems, you can still recover heat. Emissions are acceptable, reasonably good, cost is okay, but, again, reliability, durability, though it looks good, but it is yet to be proven. Gas turbines that are slightly larger size, their action is good, acceptable, emissions are good, acceptable, cost is pretty good and acceptable, and reliability durability is also acceptable and good, but still there is room if we can move those towards green signs. Then comes combined heat and combined cooling and heating and power packaged systems, they efficiency is very very good, emissions can be acceptable depending upon what prime mover we are using, cost is reasonable, and the overall attributes are reasonable. But, as you can see, still there is room for improvement, and that is our hope that with the future R&D, we can improve on these kinds of typical attributes of these systems.

Then, moving forward, as I mentioned before, up to 2005, we focused on prime movers, after 2005 until 2008, we focused on packaged systems. And moving forward from 2009 onward, we are considering including a full range of advanced generation technologies which can help and show progress in meeting California's energy policy goals. But as we all know, resources are limited and always are limited, so we will need some prioritizing of those different technologies. I probably divided these advanced generation technologies into three groups, small, medium industrial scale, and larger scale, and they are just general examples. On the small scale, we have distributed generation combined heat and power, combined cooling heating and power systems, but our focus could be on packaging and integration of those. And typically they range from a few hundred Kilowatts to up to about 20 Megawatts. Then, we get into medium and industrial scale; again, similar systems for the first one, but then we also get into co-generation systems and the focus is more on the industrial applications, and usually they are ranging about 20 Megawatts to less than 50 Megawatts. Then, we get into the larger scale where these are 50 and up kind of systems, and then we want to consider some of the advanced gas turbine and integrated hybrid cycles.

And with that in the background, we started or, rather, embarked on a roadmap exercise for the Advanced Generation Program, and today's workshop is part of getting the input from stakeholders because it is critical for our roadmap process, and also we want to take this opportunity of integrating our 2009 IEPR proceedings so that we can take full benefit of the hearings, and also the policy and some of the other activities that have been going on. And today we are asking -- seeking your suggestions and ideas on advanced generation research and development, as well as input, feedback on the PIER Advanced Generation Vision, the preliminary research opportunities, and target issues. And this is kind of our preliminary list of some of the questions that we have been pondering about this workshop and this workshop's goal, and stakeholders' input, but this is not the exhaustive list, this is just a partial list, and we want -- we seek your full participation, your comments, your ideas, to be presented not only in this workshop today, but we will have other opportunities. And before going into the detail about each of these questions, we will present these questions again after the afternoon presentation from Navigant, and we will have full discussion based on that information, as well as the information which will be presented during morning sessions.

Other opportunities that we have been considering, one opportunity was on July 23rd, there was a committee workshop on Combined Heat and Power, then today's August 10th, this is our staff workshop on Advanced Generation Technologies, and we are also planning to have a WebEx meeting with stakeholders on September 3rd, from 9:00 a.m. to 12 noon so that we can get additional comments. And then all of that information, we will provide in the IEPR proceedings, also. Our roadmap process will continue after today and we hope that we will be able to finish our roadmap document by the end of September, and then, from there on, we will go for the implementation plan of that roadmap. And hopefully in the future, we will update that roadmap and we will seek your input and your feedback in future years, also. My contact information is here, I can be called at (916) 657-2002, and my e-mail address is there. And with that, I finish my presentation and we can move to the next one. Thank you.

MS. KOROSEC: Next, we will hear from Mr. Metz of the Energy Commission staff.

MR. METZ: I am Daryl Metz, I am with the Electricity Analysis Office. I am going to speak a little bit about the existing California Generation Portfolio, some of the policies that result from that, the existing policies, and how that might change the portfolio, and what kind of resulting portfolio there might be. And, again, some roles that advanced generation technology may play in the future.

I am going to start with the current mix and I am going to slice that a couple different ways to try to be able to explain how we look at the portfolio. This is a break-out of California's portfolio by sources of energy. There are three points I would like to make about this comparison between 2002 and 2008, the first one is we see some growth from 273,000, from 274,000 to 307,000 and change. That growth has been approximately equal to the amount of gas growth from 92,000 plus to 122,000 plus. And the third thing that I would like to point out is that specified imports of coal have decreased. I will talk a little bit more about how specified imports of coal have decreased in the future. Most of that has been the result of Mojave, which is a large coal plant in Nevada that was shut down.

There are a few specific drivers that we think are important in the future, these have been mentioned already, the renewable portfolio standard, AB 32 greenhouse gases and its implementation, including SB 1368 and the emission performance standard, increased use of combined heat and power, and the retirement of aging power plants and once-through cooling. The renewables standard calls for 33 percent -- by 2020 to be renewables, by energy. AB 32 calls for a 20 percent decrease from the 1990 levels by 2020 and an 80 percent decrease by 2050. SB 1368, the Emissions Performance Standard, essentially prevents long-term contracts for coal, and we expect this to result in little financing being available for coal plants, and essentially no new coal, at least for California's consumption. The increase in use of CHP, we have goals -- the AB 32 Scoping Plan calls for 4,000 Megawatts of coal by 2020, along with 82,000 Gigawatt hours of generation.

This is a pie chart that relates to those goals. The other category here indicates essentially natural gas that is not once-through cooling, not aging, not any of these specified areas. It includes hydro and renewables. These other large sectors, nuclear, other aging gas-fired, new OTC, these total to about 38 percent of the total portfolio by capacity. Each of these -- the nuclear plants, there are two nuclear plants in California, and they are up for repowering. Other aging -- all these other groups potentially will be changed in one way or another with the current targets, so a large percentage of the portfolio by capacity is going to change. This shows the same break-out, but here it is by generation, Gigawatt hours. We can see immediately that it is a small share. Again, the nuclear power is 11 percent, is approximately the same, but overall, the total of these areas of -- targeted areas, I guess we could call them, is 19 percent. And the smaller share by energy compared with the larger share by capacity really points to the fact that what is being targeted will need to be replaced as capacity, the larger share of capacity relative to energy.

This is a slide that just shows the fuel inputs. I will just mention at this point that the existing portfolio of these OTCs and aging power plants have fairly high heat rates, they are fairly inefficient, they have heat rates of around 11,000.

This is existing coal-fired generation contracts. Let me back up here for a second. There was one thing that I left out of these charts here. This other category did not include out-of-state coal.

California's electric portfolio has -- we control these coal plants that are listed on the side, they are all out of state, they are either controlled through long-term contracts or through direct ownership. But the contracts are phasing out. They have a term and they are not likely to be renewed. And this shows that these contracts are phasing out over the next almost 20 years, and that this energy and base load capacity will need to be replaced.

Again, another slice of slicing out California's thermal electric plants, this shows the vintage of the plants. What I would like to show you here is that there is quite a bit of new generation, 33 percent since 2000, but almost 42 percent before 1980, so this is a substantial amount of old plants in our system.

Again, the once-through power plants and the aging power plants specifically provide capacity, they have a relatively low utilization rate, they have high costs of operation, and they function to support reliability in a specific area, so that function will need to be replaced, how it will be replaced has not really been determined.

The renewable targets, we have targets of 33 percent renewables by 2020. Part of reaching the target will force us to integrate -- a large share of these renewables are like, currently, wind and solar, and if that continues, we will face an issue about integrating a large share of wind and solar into the system. Wind and solar are intermittent resources, they have a daily and a seasonal pattern of generation, but even around that daily and seasonal pattern, they are extremely variable.

The changing pattern of the wind and solar are going to need to be firmed up, something is going to have to fill in when the wind does not blow, or the sun is not shining. So there is going to be a changing need for ramping up and ramping down, turn-down capability. And there is going to be a need for a large amount of capacity that is able to operate efficiently over 40 to 100 percent capacity range. Wind can be thought of as a base load intermittent resource, and in this sense, the base load of California will change. The wind blows at night and there will be -- it will provide base load capacity at night; but at the same time, there are times when the wind does not blow and you are going to need to have some way to firm that up, so you are going to need another type of base load generator that will be able to be ramped up and provide firming capability. Advanced generation can -- or at least can potentially meet these goals.

Other renewable issues include that other forms of renewables like biomass, geothermal, and possibly storage -- I do not know if storage actually falls under the renewable category -- can provide dispatchable capacity to firm up and aid in the integration of the other renewables, the intermittent renewables.

The greenhouse gas policies, AB 32 has a target of 20 percent below 1990 levels by 2020 and 80 percent by 2050. Advanced generation can have two roles in supporting these policies, one, directly through higher efficiency of burning the fossil fuels or other commodities, and indirectly, again, with the role of the development of an integrated system with increased shares from renewable intermittents.

There is a need for advanced combined heat power technologies. Currently, combined heat and power is a relatively small percent of the portfolio. We have a target of 4,000 Megawatts and 32,000 Gigawatt hours by 2020. Again, advanced generation can provide to directly reduce the amount of fuel used. Combined heat and power does that directly by using the waste heat or it has a lower rate of waste heat, and providing dispatchable forms of combined heat and power.

The conclusions are advanced generation technologies are needed to incorporate these intermittent renewables and replace coal, aging power plants, once-through cooling, steam turbines, with efficient, flexible, clean, affordable, and provide system reliability.

MS. KOROSEC: Alright, now we will be moving into the section where we have the cutting environmental aspects of advanced generation in California. And we will begin with an introduction by Marla Mueller.

MS. MUELLER: Good morning. I am Marla Mueller. I am with the PIER Program in the environmental area, and the area I work in is Air Quality. And over the years, we have been looking at the air quality implications of distributed generation. We want to be sure, we know that we need DG and we want to be sure that it is done so that it improves and does not hurt the environment.

A lot of this research has been done by U.C. Irvine and this morning you are going to hear from Dr. Jack Brouwer, the Associate Director of National Fuel Cell Research Center, about some of the findings that they have come up with, looking at regional air quality impacts of DG and CHP.

DR. BROUWER: Thank you very much, Marla. I am pleased to have received the support of Marla, in particular, but also of the California Energy Commission over several years to enable us to do this research. I also want to thank my collaborators, Professor Scott Samuelsen in our group, but also Professor Donald Dabdub of the Computational Environmental Sciences Laboratory at UCI. I am going to give an overview of the methodology and tools that we have developed, and then talk about the regional air quality impacts of advanced generation technologies, and provide a brief summary. The methodology that we have been able to develop is one that can look at various future technologies. Examples of that include electric vehicles, they include plug-in hybrid electric vehicles, or fuel cell vehicles, or other infrastructure, like energy infrastructure, new types of electric grids, or hydrogen infrastructure, but in particular the focus of our efforts to date has been on distributed generation and this is an example of a fuel cell installation, one of the distributed generation technologies we have considered, but there are a whole host of distributed generation technologies that we include in our analyses, including gas turbines, microturbines, internal combustion engines, and the idea here is to look into the future and then to develop as a result of a significant and robust methodology new spatially and temporally resolved emissions that we can introduce into a 3-D air quality model, so that we not only assess the emissions, but also the resulting air quality impacts by considering the atmospheric chemistry and transport. From that, we can get air quality impacts and provide feedback to the scientific community to regulatory bodies and the general public.

So how do we spatially allocate these emissions? We use a strategy whereby geographic information systems data is used to allocate various distributed generation technologies according to the local land use. So, for example, if there is an industrial site, or industrial land use, you could expect there to be a higher likelihood that they would adopt a gas turbine combined heat and power system, for example. Whereas, in a residential area, you might only have consideration of quiet fuel cell technology or photovoltaic technologies.

This is an example of the GIS data that we use in the Long Beach area, but we also have data throughout the San Joaquin Valley, another area that I will show you. And you can see here that the Geographic Information Systems data can allocate our emissions spatially in various areas throughout the state. We also have to allocate these emissions temporally because the time at which the emissions are released into various air basins has an impact on the resulting air quality. So, for example, if we are looking at the air quality associated -- or the emissions associated with the residential sector, you can see them in this upper chart here, the typical operating end-use electricity profile has a peak that occurs in the evening, whereas, in the commercial sector, you may have peaks that occur during the day, or in the evening, depending on the type of commercial application one is considering. So we spatially and temporally allocate these future emissions, and then add them to the overall emissions that we expect in the future, and then we solve this governing dynamic equation, which takes into account the convection and the advection, as well as all the sources and syncs, the aerosol atmospheric chemistry, and the gas phase atmospheric chemistry. And to do this in the South Coast Air Basin, we use the SCAQs study, the Southern California Air Quality Study of 1987, as the meteorological input. In the Central Valley, we use the CCOS Study which measured the meteorology in the summer of 2000, and the CRPAQ Study which measured in over two years, in December of 1999 through February of 2001, the meteorology associated with particulate matter episodes. So what we are considering is meteorology associated with high PM and/or high ozone concentrations in these basins. And we do this both in the Central Valley, as well as the South Coast Air Basin.

So this is what kind of results. If you look at the air quality, this is ground level ozone plotted on an hourly basis, for a future scenario occurring in this year, 2023, the year that we need to have compliance with federal standards in the South Coast Air Basin. And what you see is that, typically, ozone will build up in the eastern portions of the basin, and also exceed federal standards for a certain period of the day in the late afternoon. We can also predict 24-hour particulate matter. In this particular case, this is PM 2.5. Since the standard is based on a 24-hour average, that is what I am showing here, and what you can see is that there are relative peaks in the Long Beach area and in the Riverside area, Long Beach due primarily to direct emissions of PM, and in Riverside due to direct emissions plus secondary organic air cell formation.

We have done this also in the San Joaquin Valley. I am showing on the left-hand side the one-hour average ozone concentrations as they vary throughout the day, and on the right-hand side, the one-hour average PM 2.5 for the year 2023. And what you can see is that ozone concentrations at the ground level end up peaking in the Bakersfield area, which is consistent with observations, but also have relative peaks in the Fresno, Stockton, and Sacramento areas, as well. Similarly, particulate matter tends to peak near Stockton and some of the major Metropolitan areas in the San Joaquin Valley.

Now, if we were to add DG emissions to these cases and show you these plots, they would look relatively similar because the introduction of DG introduces a very small amount of emissions. As a result, most of my plots that I will show you today will be difference plots, and that is what I am showing here for the case of one hour ground level ozone, for a generic case. So what you see in the middle of this, the green represents no change for the added emissions of DG. But if you have a reduction due to the introduction of this new technology, then it will appear to tend towards blue. If you have an increase in resulting atmospheric concentrations, it will tend towards the yellow or red. Okay, so you can see in some times of the day, because of the introduction of distributed generation, you have reductions in ozone; other times, in other locations, you have increases due to the same introduction of new technology.

So let me get to, then, some of the regional air quality impacts that we studied. In the first plot, I am talking about the effects of various distributed generation technologies, and what you can see are four different cases of introducing different types of distributed generation technologies into the South Coast Air Basin. In the upper left-hand side, you can see an all fuel cell case, in which you can see the difference between the baseline case and adding all this additional generation into the basin is very small, most of it appears to be green, with slight increases that you can see in these regions in the eastern portion of the basin, which are about a half a ppB of increased ozone concentration. On the other hand, if we introduce all the DG, according to the CARB standard, we see also most of it tends to be green, indicating no impact of introducing the DG into the basin, but maybe a slightly higher tendency towards yellow. If we, however, introduce a larger market share, you can see that the increases grow, and in this particular case, the peak difference in ozone concentration is about 1 ppB for a 45 percent market penetration.

Finally, in the bottom right-hand side, I am showing a case where we are using all internal combustion engines, these are reciprocating engines, that in this particular case were installed at the current backed level in the South Coast Air Basin. And then you can see, of course, that the impacts become quite a bit more substantial with 3 ppB increases in the eastern part of the basin for this particular case.

We have also studied the impact of distributed generation versus introducing central power into similar air basins. In this particular case, I am showing the difference between central generation as installed at Huntington Beach versus distributed generation in the same generation amount, okay, the same generation amount. Both cases introduced 1,200 Megawatts of new generation. So on the left-hand side, you see the peak ozone difference and peak PM 2.5 difference associated with the central generation at Huntington Beach. And what you can see is that there is a region downstream of the power plant that actually experiences lower ground-level ozone concentrations, but other areas that show about a 2 ppB increase associated with a central power plant. Whereas, in the DG case, for the same amount of power introduced, all of the region shows a slight reduction in ground level ozone concentrations. Similarly, for the particulate matter case, you see the downstream of the central power plant you have about a 2 microgram per meter cube increase in particulate matter, whereas, in the case of the DG, it is relatively no impact.

Now, one of the things I was asked to focus upon was CHP. And we found in our study that CHP is very important to air quality. And in most of the subsequent plots, I am going to be plotting the difference plot of the more CHP case on the left-hand side, and the less CHP case, or even zero CHP, on the right-hand side. And what you can see here, this is one of the realistic scenarios that we investigated where 18 percent of the increased power demand between 2007 and 2023 was met by a DG mix, and this DG mix was mostly gas turbines, but also had a substantial amount of internal combustion engines, and 4 percent fuel cells, 10 percent PV. In the case where we had more CHP, shown on the left-hand side, 60 percent of units included combined heat and power, displacing boiler emissions; in the case with less CHP, only 10 percent of the units had CHP, and in both of those cases, only 50 percent of the total waste heat was actually recovered. Okay? Well, what you can see is that, when we have more CHP, the ground level ozone concentrations tend to actually have a reduction in ozone, whereas, it is a relatively flat, or slight increase, in ground level ozone associated with the less CHP case. If we try to bound this problem by introducing all the DG with CHP on the left-hand side, versus a case that has no CHP whatsoever, you can see that there is a substantial basin-wide reduction in ground-level ozone concentrations caused by using all CHP units, whereas there is about a .5-1.0 ppB increase for introducing DG with no CHP whatsoever. Now, these are not realistic cases, but they are trying to bound the problem.

We looked at this problem also in the San Joaquin Valley, and what you can see on the left-hand side, again, is a case in which we introduced DG with CHP, and there is virtually no impact on ground-level ozone concentrations, even though we are introducing a pretty substantial amount of DG in this case. However, the same amount of distributed generation installed with no CHP whatsoever leads to a .2 ppB increase, spread kind of throughout the San Joaquin Valley. Similarly, PM 2.5 depends upon CHP. And you can see here a case with CHP leads to substantially less PM 2.5 impacts, especially if you look around the Bakersfield, Visalia, and Fresno areas, you can see that the case with CHP has a substantially less PM 2.5 resulting concentrations.

And finally, again, to bound the problem, what we did was we did a case that had all CHP, with one set of DG that was installed, and no CHP with another equivalent, otherwise, set of distributed generation. And what you can see is that there is actually substantial decreases in ground-level ozone concentration when we introduce CHP into all of the DG, and that is on the order of .5 to 1.0 ppB, whereas, in a case where we have no CHP, we have about a .2 ppB increase in ground-level ozone concentrations, kind of spread, again, throughout the basin. That case is a little more complex with PM 2.5, PM 2.5 peaks in the winter in the San Joaquin Valley, but what you can essentially see is that, when you do introduce CHP cases, there is some direct emissions of particulate matter that somewhat increase the concentrations locally, but downstream from that, because of reduced nitrogen oxide emissions, the secondary organic aerosols end up being lower, so you see kind of blue areas that kind of surround the major areas where we have distributed generation installed with CHP. In the case without CHP, you can see that the increase is kind of spread throughout the basin on the order of .5 micrograms per meter cubed increase.

So in summary, we are grateful for Energy Commission support that has allowed us to develop these tools and, in particular, enabled us to rigorously analyze the temporal and spatial impacts of various future energy technologies. We have applied these tools to understand the air quality impacts of many different future technologies that focused on DG today. Low criteria pollutant emissions, especially those associated with, for example, the CARB 2007 standards, I showed you one case there, or associated with clean DG, like fuel cells, do result in cases where our air quality goals are met. Combined cooling, heating and power and combined heat and power are important technologies, as we have heard already, with regard to reducing greenhouse gases, but we have also found that they are really important for improving air quality, as well. And we studied that both in the South Coast Air Basin, as well as the San Joaquin Valley. So I thank you for your attention.

COMMISSIONER BYRON: Mr. Brouwer, a quick question. I am not an air quality expert. You have got some interesting conclusions on a relative basis of the benefits of CHP, but can you give me a sense where these fractional parts per billion and micrograms per cubic meter, where those are on the scale of health effects? In other words, where are the limits, or CARB limits, for these various criteria pollutants?

DR. BROUWER: Yeah, with regard to health effects, typically one would refer back to the federal standards or the state standards for those quantities, and the federal standards now for ozone are on an eight-hour basis, and it is 88 ppB, I believe, for ozone. And any excedence above the 88 ppB, okay, is considered a violation just once during a three-year period. So it is important, even one ppB differences may result in excedance whereas, otherwise, you would not if you are concerned about that. On PM 2.5 -- oh, and at the state level, there is a one-hour standard that I believe is 80 ppB. For PM 2.5, it is 65 micrograms per meter cubed at the state level, and the federal, I believe, is 100 micrograms per meter cubed. So these are an order of one percent to two percent differences that I am talking about.

COMMISSIONER BYRON: Right.

DR. BROUWER: But if you are right on the edge there, it makes a big difference.

COMMISSIONER BYRON: Alright, thank you.

DR. BROUWER: Any other questions? Well, thank you very much.

MS. KOROSEC: Thanks, Jack. Next we will hear about water issues from Joe O'Hagan.

MR. O'HAGAN: Good morning, Commissioner Byron, good morning. My name is Joe O'Hagan. I am in the PIER Environmental Research area dealing with Aquatic Resources. My co-author for this morning's presentation is John Maulbetsch, a consultant who did a lot of the power plant cooling research that PIER has funded. Avtar asked me to talk today about water issues for advanced generation and, in one sense, it is the -- the water issues are actually old, these are issues that are going way back since the Germans started using dry cooling in World War II, and, certainly, cooling tower issues have been with us for a lot longer. So the question becomes why is water important. Other issues I would like to address would be how do power plants use water, sort of a brief review of cooling technologies and their associated trade-offs, research, and some of my thoughts on what we will be seeing in the coming future in terms of power plant cooling. Now, I am focusing on combustion, thermal technology, gas-fired for the most part in California, but a lot of these issues apply equally to geothermal concentrating solar power such as parabolic troughs, certainly biomass plants, as well.

So why is power plant water use important? In this somewhat cryptic figure up here on the right-hand side of the screen is estimated water -- freshwater withdrawals in California from the year 2000. This is U.S. Geologic Survey data that was collected. And you can see that, in the middle, on the right-hand side, is the thermal electric power, it is these two narrow lines running from the saline source -- surface water, rather -- and the groundwater coming in the middle, and you can see, then, the relative comparison on a statewide basis that power plant water use is quite minor. You can see that the use of thermal electric water on a statewide basis is quite minor, however, on a local or regional basis, power plant water use can be significant. We use the comparison that a modern gas-fired combined cycle power plant can use about 3 million gallons of fresh water a day, which is as much water as the residence of a community of 12,000 people would use in that same day. So there are real trade-offs in terms of water use and what is the appropriate cooling technology, and it is has been a major issue from my experience in the last 20 years on power plant siting, and I know it continues to today.

One of the focuses of the PIER Program has been reducing power generation's effects on fresh water supplies within the state. How does a power plant use water? This bar chart compares different technologies all the way from a hypothetical nuclear and coal through oil, which you do not see much anymore, gas, simple combustion turbines, combined cycle, IGCC which, you know, we really have not seen yet, solar thermal, which I believe, in that case, the parabolic trough, solar PV, which uses no water to speak of, as does wind, it uses none, and then bio-fuel. And you can see that the major -- that blue color in the bars -- is for cooling, that is, this is steam condensation, all of these technologies use a steam turbine to generate electricity. The one exception would be to use the simple combustion turbine there, and the water use there is that darker color is the water injection to improve the efficiency of the turbine and things. So you can see that, based on technology, based on cooling technology, water use can vary quite a bit. This graph was based on re-circulating cooling towers being used.

So the question is, is how can we use less water without cost in energy efficiency penalties. And there are two basic approaches, what we call degraded water sources, which is using wastewater treatment effluent, contaminated groundwater, contaminated surface water, brackish surface water, or water conserving cooling technologies, primarily dry cooling, though hybrid is also an option, which is basically a hybrid between wet and dry cooling. Now, degraded water sources, as I mentioned, there are different possible sources, produced water which comes up with oil and gas production, irrigation return flows, or contaminated groundwater. The big problem with these different sources is the consistent supply with consistent quality. Certainly, there are real issues when you use poor quality waters, the bio fouling corrosion, scaling of your heat transfer surfaces will degrade the performance of the power plant, there are disposal issues, basically there are concentration as you run it through the cooling towers, so you are going to have a pretty heavy brew that you are going to have to dispose of, of the blow down. And then there is also drift and health issues like Legionella. The big issue, I think, the one thing I would mention is that sea water can be used in cooling towers, there are about 50 applications in the United States that use it, there are some penalties associated with it, it costs about 30 percent more. There is a slight efficiency hit from using salt water. I think, in California, the biggest issue is going to be the drift because, for those air districts that require offsets for PM10 emissions that include those from the cooling towers using saltwater is going to be very expensive, if you can find the offsets, much less afford them. So that is a concern, but you can, in light of what the State Board is proposing, technically, using saltwater in cooling towers is feasible and has been demonstrated over and over.

This is a schematic from the National Energy Technology Lab showing sort of the lay-out of the different cooling technologies available. As you will appreciate, there are efforts to phase out once-through cooling in California. The major cooling types we see are the re-circulating where the water is wet and you are using water over and over again. Cooling towers there in the center is the primary technology. Cooling ponds is pretty much an old technology, it is phased out. I am not aware of any

California applications maybe in the last 20 years. On the right there, dry cooling, there are two types -- indirect and direct; generally, when we talk about dry cooling, we are talking about air cooled condensers, and that is your direct cooling, indirect is not used very much, worldwide, actually, it does have some added advantages, but it has a lot of disadvantages. First of all, you would have to have a surface condenser, as you would with wet cooling, and then you would also have to have your air cooled condenser. So it duplicates the equipment and it can be quite expensive and it is less efficient. So basically where we are talking about dry cooling, it is through direct air cooled condenser.

Just to sort of review the different cooling technologies, this is once-through cooling, that is a picture of Diablo Canyon there, I think we are all familiar with this approach where you just take in large quantities of water, maybe 20-50,000 gallons per Megawatt per hour, run it by your condenser where it picks up the heat, and then you discharge it usually back to the same body of water. You do not consume the water; there is very little relative evaporation. This has been used in California since at least 1950, probably earlier. And it is very efficient. You have very cold water to condense your steam, and it is fairly consistent temperature throughout the year. In

August, the big concern has been the biological impacts from once-through cooling, the entrainment and impingement of aquatic organisms, so not only is the State Board coming up with a proposed policy to phase out this cooling technology, but the U.S. Clean Water Act 316B rules certainly pretty much eliminates any new power plants, green field sites, using this technology. And the other concern is, then, the discharge of that heated water, which often can be 30 degrees above the ambient water temperature, and there is associated biological effects with that and that is turning out to be a constraint for some power plants, as well.

Now, wet cooling, which we are all pretty much familiar with, uses significantly less water, but it does consume more water. There is less water withdrawal, but much of the water, as you can see in the picture there, is evaporated away. This is a mature technology, it has been around for quite a while. Most power plants use this cooling technology, except for the older coastal plants and on our Bays and Estuaries, that is the subject of the State Board's policy. But if you are going to have a steam turbine, generally using cooling towers, you do consume water, what water is not evaporated becomes -- builds up in salts in concentrations, and then you have to do what they call "blow down," and then that raises disposal issues and water quality concerns, it has a higher parasitic load because, as you can see in this schematic, there are fans that you need to keep the air moving, and since you are dealing with warmer water, there is less plant efficiency, and then there are also concerns over the visible plume, as well as drift concerns.

Dry cooling -- this is air cooled condenser, this is where you directly route the steam from the steam turbine to a condenser, which is basically shaped as an A-frame, and you run it through these different stoops which are fanned to enhance heat transfer, you use no water at all for cooling, so, for many power plants, we are talking about a reduction of up to 95 percent of their water consumption. You do not have a plume or drift issues, either. The picture below, which is a power plant near Las Vegas is -- you cannot get the full feeling of it because of the wind walls, but basically within that structure in the front is an A-frame, these headers on top are what route the steam there, and then they flow down the sides of the condenser and then the heat is dissipated to the atmosphere. Obviously, when there is warmer temperatures out, the efficiency of dissipating that heat and condensating the steam is lower, and that creates back pressure on your steam turbine, and that will reduce generation. There is overall lower plant efficiency because of that issue, there is also a higher parasitic load because you really need a lot of fan power to move that air through the condenser, then, as I mentioned, once the ambient temperature rises above design levels, you see a drop-off in plant efficiency, it takes a lot of space, and it is subject more so than wet cooling to wind effects, and I will talk more about that later.

So the big concern is that, what is the comparison of dry cooling and wet cooling. And this is a schematic that was done by John Maulbetsch, this is from 2002, so I would say that the numbers, absolute numbers, may be off now, but I think the relative values are still appropriate, and even he has optimized the low first cost, and that was just a difference in designing your plant for long-term efficiency, or designing your plant to minimize capital costs and suffer operating efficiency penalties such as not sufficient fan power in either your wet or dry cooling, but you can see that dry cooling is significantly more expensive and that your operating and maintenance on an annual basis which you can assume is about one percent of your capital costs, will also be a lot higher for dry cooling, but then again, you do eliminate 95 percent of your water use.

Now, hybrid cooling, which is very appealing, I would say, because it addresses some of the issues associated with both dry and wet cooling, is a system where basically you would have wet cooling towers and air cooled condensers. Now, these may be configured in different ways and you may design it from anywhere from where you are using 80 percent wet to 20 percent wet, with a remainder captured by the dry cooling. Now, it is cheaper than using an air-cooled condenser, depending on the size of the ACC in the wet cooling towers because you are having two different condenser systems, but you do eliminate the hot day penalties. Dry cooling, you may get up to a 10 percent penalty loss on a very hot day for a gas-fired combined cycle. If you are using a hybrid system, you can switch the wet cooling and that is eliminated. You can trade off energy conservation versus water conservation. You are still using water, the capital costs are greater than wet -- a lot greater, because you are putting on an air cooled condenser, in addition, we have very limited experience. The plant that is depicted there is in Argentina. There is a new plant, it has just been built in Colorado, and the truth of the matter is, the energy industry is very very risk adverse, and there is very very limited operating experience with these hybrid systems. There have been hybrid cooling systems by the major vendors available for years and years, but in terms of utilities, scale, applications, in the United States there is almost nil experience. And so I do not think this technology will be adopted until there is some track record with a few of these initial facilities in adopting them.

The research program here at PIER, we tried to look at some of these hot day penalty issues associated with dry cooling and one of them was what we call the spray enhancement, and the picture on your upper right there shows a spray system where we were spraying air to be entrained by the fans, which were right above it, and then to cool the temperature of the air passing through the air cooled condenser. The attempt there is you lower the temperature of that air and that increases your efficiency of the condenser performance and several studies have been done by PIER that have showed that you can recapture about 80 percent of the loss efficiency from the heat penalty if you use spray enhancement, but it does raise issues and there is concern about water condensing on your heat transfer surfaces, which would lower their efficiency, there are the rain back issues. So it does raise some concerns, but for short term resolution to your heat penalty problems, it works, and there are a number of power plants that use this on an ad hoc basis during the summer to reduce those effects. And then the other issue is the wind effects on air cooled condensers and, once again, that lower picture is the wall, the gray walls you are seeing there are wind walls to avoid wind effects on the condensers. What you find is that there are two phenomena that effect air cooled condenser performance relating to wind, one is that the hot air exiting the top of the condenser is captured by a cross wind, which knocks it back down and it is entrained back into the condenser, so your ambient air temperatures passing through the condenser are higher and, of course, that lowers efficiency. The other one is that we found that a cross wind effect actually starves the fans on -- usually these are the ones on the periphery of the ACC, and that lowers the efficiency quite a bit. In this graph on the lower-hand side shows a combination of both wind and temperature effects, and as the wind and temperature picks up, the back pressure starts to increase for the turbines and there is -- a lot of turbines cannot handle that high a temperature. For some of the dry cooling power plants, they do have higher back pressure turbines, but nonetheless, when you start to get up to six, seven bars of mercury, I think, you know, you are going to have problems and you are going to have to start ramping it back, and even there has been outages where sudden back pressure increases due to wind make the turbines automatically go offline and shut down the whole plant. So PIER has been doing research on that. We showed that that overall re-circulation of hot air from turbine exhaust is causing a minor effect and this wind effect on fan performance, it is a major impact on ACC performance, and we are having some continuing research to look at ways to mitigate that effect.

Well, one thing I would like to say before I head over to questions is, I think what we are going to see in the future is greater adoption of hybrid cooling technology. I think people are concerned about water conservation, but also the energy losses associated with an all dry system. I think where it is really necessary, you can have a hybrid system where you can reduce water demand, but still avoid that energy penalty. And this is a picture of a hybrid system in Goldendale, Colorado, I think it is about a 235 Megawatt plant, and you can see in the lower right-hand corner, there is a two cell cooling tower, and then there is about a 10 cell ACC, so I am not exactly sure of the ratio of dry to wet, but I would say it is probably about 50 percent, so you can -- you will see, I think, with more years of experience with this technology, and at this facility and others, that you will start to see people adopting this a lot more. Another issue facing us in the future is carbon dioxide reduction. You know, if we go and we retrofit existing gas-fired power plants here in California, there is an energy fitness penalty associated with the technologies to capture that. They also require water for the steam processes to cool the compressors and that sort of thing, so you will see that actually the power plants' water demands will go up with that technology. For coal, the integrated gas combined cycle facilities would use more water than a straightforward pulverized coal power plant, that is not counting slurry delivery of the coal, or water use associated with the mining, but just the power plant itself. So, to deal with our CO_2 sequestration issues, there may be additional pressure on water use within the state, as well as for the energy that we import from out of state. So, thank you, and if there are any questions?

COMMISSIONER BYRON: Mr. O'Hagan, maybe a couple of questions. I am not really familiar with the hybrid cooling technology, and I think you have answered why, we really have not seen very many applications of that, if any, in the United States. But two questions, one is, is one of the reasons we are not seeing that because it looks as though you have got significant higher capital costs associated with both dry and wet cooling systems in the same power plant?

MR. O'HAGAN: Well, ideally a hybrid system, as long as you are not more than 80 percent dry, a rule of thumb is it is probably still going to cost less than 100 percent dry system. I think we are seeing a lot more dries because people have more experience with it, it does resolve the water use issue. I mean, that 500 Megawatt power plant that is going to use, you know 3 million gallons of water per day is going to use only a few hundred gallons of water for hotel load, for steam make-up, so it really resolves a lot of issues. I would say that graph that showed the comparisons of cost did not factor in the costs of water, or the costs of transporting the water to the power plant, treating the water, nor disposal, so in some cases the water is just not available, some cases, you know, it is not reliable, so a number of power plant operators have opted for dry cooling just to avoid these issues, and I think we will see more and more of that. I think the hybrid, though, in certain situations, it will be adopted and embraced, and that we will see a lot more of that.

COMMISSIONER BYRON: However, will the hybrid cooling plant meet this Commission's siting criteria on the use of water?

MR. O'HAGAN: Well, my reading of the policy is that it is water conserving cooling technology, so I would think that a hybrid system that conserved certainly water compared to 100 percent wet would meet that criteria; certainly, in terms of the impacts on the water supply, that would have to be addressed on a case by case basis.

COMMISSIONER BYRON: Okay, one other clarification going way back to your earlier slide that showed the water use per gallons per Megawatt hour. And, of course, you indicated that, on nuclear, it was about 800 gallons per Megawatt hour, but that is really not applicable to

California --

MR. O'HAGAN: That is correct. These are power plants using cooling towers.

COMMISSIONER BYRON: Okay, I also note solar is very high and I think you will find this Commission is not going to accept that kind of water usage for renewable technology. All right, thank you, Mr. O'Hagan.

MR. O'HAGAN: Thank you.

MS. KOROSEC: Alright, thanks, Joe. Next, we will hear from Guido Franco, who will be talking to us about climate change issues.

MR. FRANCO: Good morning, Commissioner Byron. Good morning, ladies and gentleman. I am going to be talking about the implications of climate change concerns and the balance of energy generation. And I am going to be using the following outline. First, I am going to give you some background information that I think is going to be useful for the rest of my presentation. And then I would like to talk about the implications of climate change to balanced electricity generation systems. That will be followed by a brief discussion about PIER climate change projects that I think will be useful in the long-term. And then I will end with some final remarks.

So let's start with background information. So let's look at historical generation and CO_2 emissions from the combustion of fossil fuels in California. The graph on the upper right left shows that total energy from the combustion of fossil fuel has more or less doubled in the last 60 years. This is a graph that goes from 1960 to 2005. And the same is true for the amount of energy that has been combusting in power plants in California that has been going for about 1,000 Btu to about 2,000 Btu. Now, let's look at carbon dioxide emissions from the combustion of fossil fuels. The emissions for the combustion of all the fossil fuels in California to generate energy, not only electricity, is also going up significantly. However, CO_2 emissions from the combustion of fossil fuels in the state power plants, only power plants located in California, has actually more or less remained the same. There was a big -- in the late 1990s, it was mostly because during that time we were burning a lot of our residual fuel oil, if you can believe it, and we also -- I mean, for example, for enhanced [inaudible], we were burning actually crude oil. So at that time, natural gas became less expensive than residual fuel oils, and there was a big switch from residual fuel oil in power plants in California to natural gas, and later the natural gas became more expensive in terms of the oil, but, of course, the air quality regulators decided to impose restrictions with respect to the amount of NO_x emissions, and natural oxides of nitrogens that could be a medium for power plants, and that impeded the return of the burning of residual fuel oil. Now, with respect to CO_2 emissions associated with electricity imports, this is a very controversial issue, I think a prior speaker talked about this. The only thing that I would like to say is that, in AB 32, it is required to take into account the CO_2 emissions associated with our state power plants in California.

Now a little more information about climate projections for California. As you may know, the public interest in the Air Resource Program has a relatively robust regional climate change program in California. It created what we call the California Climate Zone Center. That was the first state sponsored research initiative in the United States, now there are two more that I know, and more are being created. The Climate Zone Center went into business in 2003. And one of the things that we have been doing is to develop regional climate projections for California, not only for research, but also for long-term planning. Some of these regional climate projections are being used, for example, for the State Water Plan and for the State Forestry Plan. So what the global climate modelers -- there used to be about 16 climate modelers around the world, and now there are about 20 -- they used the estimated, well, the different scenarios, global emissions scenarios, used in cash and import to the global climate models, and this is a real example of an output, generate projections of how climate will change around the world. Of course, the grid sizes that are used are too coarse for California, I mean, here you have, assuming the outputs of the region that we consider California, the grid sizes for the global climate models is on the order of 150 to 300 Kilometers, that is too coarse for California. For example, the San Francisco Bay Area and, more or less, Sacramento will be considered to be one big region having the same temperature, and we know that is not the case. So what we have done in the last few years is to develop actually different groups in California, research groups in California have developed what we call statistical down-screen techniques. What you do is to use the outputs from the global climate models that are more believable, for example, high level pressures, atmospheric pressures, to develop a statistical relationship between those features of the global climate models that are credible with local conditions. And doing that, they are able to develop projections for California when grid size is on the order of 7 X 7 miles. The role of this is that this is a statistical down-screen technique that only -- that can only be used for certain parameters, for example, temperature and precipitation, but we do not have information about how, for example, solar radiation reaching the ground level would change, or how wind patterns could change under climate change.

So what are the models telling us? The models are telling us that global emissions -- and, here, we have two scenarios that we have been using, the A-2 scenario is a scenario where there are more or less rapid increases in emissions in the rest of the century, and the big one scenario is a relatively mild scenario, we called the green scenario, but actually it is not very green. So the graph on the lower left shows historical, already observed increases in temperature in California and what is projected under the A-2 scenario. So they are different realizations about, you know, how temperatures may go up in California. In this case, I am showing only three of the estimated increases in temperature. I mean, the graph here shows that you can go up by 80 degrees Fahrenheit; that is average temperature and that is a lot. Under the big wide scenarios, temperatures still go up, but they are more or less half of what happened under the A-2 scenario. But the warming will not be uniform in California, so statewide research is one thing, but actually what we need for planning and for research is these types of graphs, you know, showing how different regions in California will experience warming. And this is just one example, and we have multiple examples like this.

Now, with respect to precipitation, most of the new global climate models that were run for the Fourth Assessment Report, the Integrated Panel on Climate Change Report, now suggests that there is going to be a drying trend in the U.S., Southwest and in California, in particular, so this is a very worrisome new finding, hopefully the models are wrong, but that is what the models are telling us. So according to the climate scientists, the drying trend that we are already seeing in the Southwest and in California is just the beginning of a long-term trend. So here is a graph from Danielle Cayan, all from Scripps Institute of Oceanography. I think what is important to show is that we used six global climate models to study what may happen in California, and the vast majority of the models suggest, again, a drying trend in California for different periods, from the next, you know, 20-30 years, in the middle of the century, end of the century, the same drying trend.

With respect to sea level projections, the last Integrated Panel on Climate Change Report suggested that sea levels would go up by about -- I think it is about 30 inches. But that finding has been very controversial, in part because they rely on old information. There have been new papers that have been released in the last two years suggesting that sea level rise could be much higher. For the work that we are doing here in the Energy Commission and it is being now used by other agencies, we estimate that sea level rise in California could go up to 1.4 meters, about 55 inches, by the end of the century, with very steep trajectories that, again, depend -- the actual estimated rise depends on the global emissions. But one thing that is important to understand is that, even if we reduce global emissions right now, and very dramatic reductions, sea levels will continue to go up. I did put a graphic here showing the big one is an area where [inaudible] and we will have scenes that will be almost undistinguishable sea level rise for both scenarios. So the sea level rise will continue for the next 90 years and continue in the following centuries because of the thermal condition of the ocean and the fact that the greenhouse gasses stay in the atmosphere for long periods of time.

So what are the implications of climate change to advanced energy -- I put here electricity technologies -- actually, I do not have too much to say. But I just want to tell you that there are groups that have been funded by the U.S. Global Climate Change Program, and what they have been doing is to look at how technologies would have to change in the future under policies restricting the emissions of greenhouse gas in California. So this is the result for one of those models, the MiniCAM model, that is supported by the Pacific Northwest National Laboratory. So this is just for the electricity sector at the U.S. level. So this is the reference scenario, we see, you know, there is a lot of natural gas, the blue bars, we have a significant amount of renewables, some nuclear, even some commercial biomass. But this is the reference scenario. And under the more restrictive scenario, we have, you know, a huge increase in nuclear. According to this model, they are all scenarios without nuclear, or with restricted use of nuclear, you know, we have lot of renewables, and the rest is carbon capture and sequestration. So even, you know, coal, natural gas, everything is captured and sequestered, and it starts by the middle of the century. So the other thing this graph does not show is that these assimilations would suggest that there would be a rapid electrification of the energy system. And here I am not talking about just the electricity, of course, but I am talking about transportation, whatever uses energy. So there will be a rapid electrification of the energy system and an 80 percent reduction from developed countries, and that has been -- I think the scientists would suggest that is the level that we should aim for, means that the deployment of zero or close to zero greenhouse gas emitting technologies actually seems to be far away, but actually it is around the corner, you know, in 20 to 30 years from now.

The only thing with these things is that we have to be cautious with [inaudible]. In this case, it seems that the carbon capture and sequestration is the silver bullet that would allow us to continue burning, however, there are older assessments that they are more realistic with respect to renewable technologies that assumed that it would be more renewables and also carbon capture and sequestration still remains an improved technology. So that was the good news. So now let's go to -- no, no, I am sorry, now let's go to the good news. So the good news is that we are working already on this issue, for example, we have a project with LBNL and UC Berkeley and UC Davis to study potential energy pathways for California by 2050, integrating the knowledge that we already have about energy efficiency, renewables, etc. etc., including advanced energy technologies. This is a bottom up type of exercise that will improve from the Pacala-Socolow Study that was published in 2005 in *Science* magazine. We will do a much better job, of course. So that is a bottom up type of a study. But we also are funding the developing of a new version of the MiniCAM model for California that will be embedded into the U.S. and global model to train, to account, interactions between what California may do and what may happen in the U.S. as a whole, and in the rest of the world. We also -- I mean, one thing is that we always talk about how restrictions in the amount of greenhouse gas emissions, that that can be [inaudible] will affect the energy system, but also we do not think about the fact that climate change, itself, will affect the energy system. And here just, again, two examples, I mean, of course, higher temperatures will change the amount for energy, especially for air-conditioning, but also the energy infrastructure in California will be affected, so we just studied a new project with LBNL on this topic, you know, looking for example of how coastal power plants could be affected. This is a map showing about -- I think it is about 30 power plants in California that are having initial assessments that are a risk, or something has to be done to study the potential impacts of civil rights in this case, to these coastal power plants. We are working very closely with the utilities on this and we welcome the participation, all that would like to join us, on this study. As always, the science will be evolving with time, so this type of study will have to be updated periodically. The other issue has to do with the potential impact of climate change on renewable sources of energy. As I said before, the studies that we have already on the considered temperatures and precipitation, but the wind patterns could also change, the amount of clouds that we will have, I am told, our atmosphere could change, and that would impact the photovoltaic solar technologies, for example. So we have with Scripps some funding from the RD&D Committee here at the Commission to do a study about the potential impacts of climate change on renewable sources of energy. In part, we have already started the project. There is a group of researchers at Scripps, LLNL, that is Lawrence Livermore National Lab, U.C. Santa Cruz, and Santa Clara University, they are developing new probabilistic climate studies for California. And for the first time, we are using dynamic models, these are the same type of models that you use to forecast how weather conditions will change, they assume the Physics involved, so those models are highly -- I mean, we need huge computation resources, so they are being drawn using super computers, so this is the model domain that we are using, model Domain A is we are using a resolution of 30 X 30 Kilometers, and the model in Domain B, that is California, we will be using a resolution of 10 X 10 Kilometers. This model will provide information to us about how wind patterns make change, how solar radiation reaching the ground would change, and that information will be used to estimate how climate change itself will affect renewables energy resources in California.

So, final remarks. So I only have actually one final remark, and for my climate change perspective, advanced energy generation technologies are technologies with zero or near zero net greenhouse gas emission profiles.

So I think it is a very simple conclusion, at least that has, I believe, huge implications for future advance in the technologies in California and around the world. Thank you very much.

COMMISSIONER BYRON: Ms. Korosec, should we take a break?

MS. KOROSEC: That would be appropriate if you feel the need for that. We could certainly take a 10-minute break right now.

COMMISSIONER BYRON: I think we are well ahead of schedule. I think a 10 or 15-minute break would be a good idea.

MS. KOROSEC: Okay, let's do a 15-minute break and come back at five minutes to 11.

COMMISSIONER BYRON: Thank you.

MS. KOROSEC: Thank you.

[Off the record at 10:39 a.m.]

[Back on the record at 10:57 a.m.]

MS. KOROSEC: We are going to go ahead and resume. Commissioner Byron apologized, but he had to leave for another meeting, but we are going to go ahead and hear from our last speaker on this morning's session; however, just a little bit of a change in the agenda. We will be starting our afternoon presentation a little bit earlier, since we are so far ahead of schedule, have some introductory remarks, and then break for lunch and continue with the presentation after lunch. Alright, with that, I will turn it over to Elizabeth Burton.

MS. BURTON: Thank you, Suzanne. Good morning. I have been working here at the Energy Commission as a consultant for a couple of years on carbon capture and sequestration, and how that technology will be relevant to California in its attempts to meet its particularly 2050 climate change goals. So I want to give you basically a brief introduction to what CCS is, for those of you that are not familiar with it, and then discuss how it is relevant to California and how we can move forward with this technology.

I do want to clarify one thing. Guido made the point that, in some circles, CCS is often looked upon as a silver bullet type of technology, and I do not think that we ever really view it that way, it is not a silver bullet, but it certainly is a technology that can increase the likelihood substantially that we will meet our 2050 goals that climate change scientists say are absolutely necessary for us to meet in order to avoid particularly severe consequences of continuing to emit large amounts of carbon into the atmosphere. So the premise that we are moving ahead on is that this is an enabling technology to move us through a short to medium transition period, to get our heavily dependent economy off the fossil fuels, but is not a silver bullet technology that will just allow us to continue to burn fossil fuel and do business as usual, and just assume we can stick it in the ground and sequester it.

Carbon Capture and Sequestration technology basically means that we take large industrial point sources of CO_2, we capture the CO_2 emissions from the stacks, and then we sequester it underground in a geologic formation that is highly likely to retain it at 99 plus percent over hundreds of years, to get us out of this sort of short to medium-term difficulty we have, being a fossil fuel economy.

The main points that I want to make today are really three-fold. The enabling, or key piece of legislation related to CCS in California is Assembly Bill 1925, to date. And this required simply a report by the Energy Commission and the Department of Conservation, making recommendations to policy makers on how to accelerate CCS adoption. So there is definitely a legislative mandate here to include this technology in future considerations of how we meet our climate change goals. Now, for California, the whole CCS debate is, in fact, somewhat different because we do not have a lot of in-state coal use, and CCS has traditionally been viewed as sort of a coal associated technology, not something you would slap on a natural gas plant, or something else. The process to develop the policies and regulations and statutes has to rely on early demonstration projects that involve multiple agencies and will need to be regional, these are the basic conclusions out of the first Assembly Bill 1925 Report that was completed in 2007 as part of the IEPR. We are going to deliver another report in the time frame of about the end of 2010 because the technology right now is just taking off for a number of reasons. There are a few early projects going forward in California and there is quite a bit of stuff going on at the International and at the National level in CCS that we wanted to take advantage of before we made the final recommendations to the Legislature, so there will be a second follow-on report after the 2007 report that was completed.

Just a review. I think you have heard a lot about this already this morning, but very quickly, the Executive Order S305, established three target reduction levels for greenhouse gas emissions in California, to 2000 levels by 2010, 1990 levels by 2020, and then 80 percent below 1990 levels by 2050. And AB 32 codified the second bullet into law, so the 1990 levels are supposed to be achieved by 2020. The Air Board, as you know, is in charge of that. AB 1368 is another relevant piece of legislation that is related to the whole concept of putting CCS on line in the state; this is the emissions standards to prohibit long-term power purchase agreements for base load power, with emissions greater than that standard. And CCS is one way that some facilities may, in fact, be able to meet the standard.

Just to kind of put these climate change goals in a context, we are sort of a pinnacle progression here, if you want, with some numbers on the left side. Right now, 2000 levels would be 484 million metric tons in 2004 down to 457 million metric tons. By AB 32, that has to be reduced somewhat, it is not a huge difference, and it is something that the Air Board believes that we can actually achieve without a great deal of pain and change. But when we start looking at 2050, we see a huge reduction in the amount of carbon and, based on projections of population and fuel use, we are looking at about 800 million metric tons if we did business at normal, and that has to be reduced by nearly ten-fold to get us where we need to be, to meet our climate change goals. And it is very difficult to see how we can get there without some kind of stopgap technology like CCS to allow us to continue to not freeze in the dark, so to speak, and tank the economy that depends so much on fossil fuel right now.

Just to kind of review again, these are out of the '07 IEPR. CCS is a potential application for up to about 45 percent of California's emissions. These are just some simple pie charts that show what California's break-out of energy sources is. On the left, again, it is mostly natural gas for power, but also the large transportation sector gives us a lot of petroleum use and, again, through refineries or switchovers to electric fuel cars, we can think about CCS even for some of those other sectors. By sector, again, you have probably all seen these before, transportation is the largest thing, and then the graph to the far right, greenhouse gas emissions by sector, the three sectors where CCS has potential application, the industrial sector, in-state electricity and, of course, electricity imports, which we get, still, a lot of our electricity from coal-fired plants out of state. So overall, about half the pie could really benefit from CCS technology.

Again, from the 2007 IEPR, the way that California has thought to get to the 2020 goal breaks out something like this. This is a wedge diagram specific for California, along the idea of the things that Socolow first spun out a few years ago in his *Science* article of using wedges to meet emission level targets, and here we see the pink wedge would be transportation reductions, electricity and natural gas reductions in the yellow, through efficiency standards, without CCS included, other known reductions like forest conservation, land use change shown in the blue, and then this big white wedge as of 2007. My understanding is that people are feeling better about how to remove this white unknown wedge, which is the needed additional reductions just to meet 2020 goals, and there is some confidence that we can get there without a huge deployment of CCS, which is good, however, when you start extrapolating this again to getting down to 85.5 million metric tons of that huge -- that white space gets to be quite huge, and it is hard to understand how we can get to 2050 goals without CCS. And, in fact, there are a few early projects that are ramping up right now in California that can even help us get to the 2020 goals, and should be studied heavily right now, just because this is a technology with a fairly long term because of infrastructure issues to get off the ground, so we need to start now to be ready for 2050.

The first report, in fact, basically went over kind of what we would have to do technically and economically to make CCS feasible in California, and I just want to very quickly review what was in that report and the conclusions and recommendations that were made in that. First, the role of CCS in California, this is basically a list of the chapter titles, was a review of how CCS might fit into California's policy legislation and its climate change emissions reduction goals, a review of the key implementation issues and, again, it was found that these were not by and large technical issues, but regulatory and statutory issues. And this actually echoes what a lot of other states are finding and, in fact, at this point in time, 32 other states have taken legislative action of some kind to try to promote CCS adoption in their states. Chapter 3 was a review done by the Department of Conservation, the Geological Survey looked at basins throughout California and where sources were located, and the geology of California actually lends itself quite well to carbon sequestration, there are lots of places in the subsurface that make secure traps, and the capacity is more than sufficient to put California's CO_2 emissions away for hundreds of years. Chapters 4 through 9 basically looked at -- well, actually 4 through 8 -- looked at the different aspects of the technology for CCS and basically we can borrow a lot of existing technologies, we do not have to invent anything new to make CCS happen. Capture technologies are certainly expensive, but they do exist, and they do work quite well. Site characterization and certification, while we need protocols to be in place, so there is some rational framework across agencies to certify sites, we know how to do that and a lot of the technology to do this sort of geologic site characterization comes out of the oil industry and is quite well adaptable to CCS issues. Likewise, monitoring and verification and risks, and risk management, the technologies that are necessary are existing and are in place, and need maybe some adaption to work for CCS. And likewise, remediation and mitigation, if one of these sites should leak, we do know how to do that. So the bottom line here is that, really, the barriers are not technological here, but they are more statutory and regulatory, and right now economic. It is not cheap to start thinking about capturing the CO_2. The capture costs are high. It does not cost that much to actually sequester it, but we have to think about the cost of doing this as we move forward. Statutory and regulatory frameworks are ambiguous and messy and could actually end up increasing the costs, as well, if we do not move forward in a rational way.

And then, finally, recommendations. And these were adopted both by the Commission and the Department of Conservation. Basically there is a lot going on right now, worldwide, and the Department of Energy has seven partnerships going on across the country. WESTCARB is the partnership to which California belongs and that partnership is directed by the Energy Commission. These are the regional carbon sequestration partnership programs and DOE is putting a significant amount of energy and money into these to try and make carbon sequestration happen at a large scale. The goal for the Phase 3 program of the DOE partnerships is to put a million metric tons of CO_2 in the ground over five years, for each partnership to have a project like that.

A second recommendation is to consider geologic sequestration within any of the energy carbon framework of the western region. Again, because we import a lot of electricity, it does not really make that much sense for California to think of CCS in isolation of the whole energy picture. Does carbon flow with the energy is the question, and how does that work with respect to carbon credits and the whole carbon market system?

Further examination of early opportunities within the state, we are already starting this. One big opportunity is going to be looking at EOR, which is enhanced oil recovery with CO_2, which actually gives us a value for the carbon and is a big component in some of the early projects that are just now starting up and are in the permitting phase within the state. There is a very great need to develop and improve cost estimates and to include CCS as a greenhouse gas reduction strategy in state planning; I am happy to say that that is actually happening since the 2007 report. And then, again, we have to get together with the other agencies and start looking at existing statutes and the ambiguities that exist, and then figuring out how to either advocate for legislation, or develop some kind of a framework that has continuity of protocols in order that industry can move forward with projects as they become viable.

Recommendation 1, learning from pilot projects is absolutely critical, there is really no substitute. As I am sure many of you know for learning by doing, and the DOE partnerships really focused on this idea. They wanted in a Phase 2 to look at small pilots, to figure out how this could be done, and then in Phase 3 to really go move on to something at an industrial scale to provide this kind of learning by doing experience. WESTCARB Phase 2 and Phase 3 pilots, in particular, provide the lessons learned that are specific to California, and right now we also have some early industry experience that we can draw on, particularly the Hydrogen Energy Project that is right now in its permitting phase here at the Energy Commission.

Recommendation 2, again, this is this concept that we have to look at not just the carbon flow regionally in thinking about whether it goes into the inventory or not, and the energy flow, but how CCS might best impact this in a regional context. So electricity flows into California, 20 to 30 percent of our electricity comes from out of state, but because it is coal rather than natural gas that is a fuel source, this actually accounts for a great deal more of our emissions of greenhouse gasses -- 40 to almost 60 percent.

Another thing that I think that has to be into the mix, transportation fuels are exported, so we have a lot of refinery emissions that are actually, if you want, belong to fuels that get used out of state, so how does that go into the mix? So does carbon actually flow with the energy? And I think having some kind of regional policy agreement, understanding, with our neighboring states is going to be key to properly deploying CCS in the future, for optimally deploying it, anyway.

Recommendation 3, again, this is looking at these early in-state opportunities. There is a big opportunity to offset this huge cost of CCS through advancing EOR opportunities; this is not a trivial thing to do, however, because you have got to have a pipeline infrastructure to get the CO_2 from the sources to the EOR sites. There are lots of oil fields, certainly, in California which are just chomping at the bit to use the CO_2 should it become available at a reasonable price. And 80 percent of the emission sources, in fact, are within 50 Kilometers, so we are not talking about hugely long pipelines, but we still need to have that infrastructure in place for this to become a viable way to enable CCS. There are some regulatory challenges and, certainly, in terms of carbon credits for a source that feeds its CO_2 into a pipeline that may feed a number of different EOR operators, it is not at all clear how we are going to give them credit for meeting some kind of a cap limit like SB 1368, or even a more stringent requirement that may come up in the future.

Recommendation 4, again, this in some ways relates to number 3. CCS costs are high and they are problematic unless we have a value set for carbon. It is likely, in fact, that carbon will have a value in the U.S. fairly soon, whether that comes through a tax, or some sort of a nominal value through a cap and trade system is still perhaps up in the air. In California, it looks like we are moving definitely toward a cap and trade system, and the other way of kind of getting more at the cost is with work beginning here at the Energy Commission to look at CCS when the cost of electricity generation models and scenario planning is done.

And then, finally, Recommendation 5. There are various agencies that are going to have jurisdiction because, now, all of a sudden, when we think about doing a power plant siting, it is not just the surface site, but it is also the subsurface site that may have to be considered. The California Department of Conservation, Division of Oil and Gas right now permit underground injection for EOR. The EPA Region IX permits underground injection if we are looking at a saline formation, so we have a split authority for the subsurface right now. California Air Resources Board may have a role to play in terms of certifying that these sites meet their climate change mitigation goals, and in giving sources of CO_2 that sequester credit for meeting their mitigation requirements. The Office of the State Fire Marshall right now would permit and regulate CO_2 pipelines, and then the Energy Commission itself does the power plant siting and the CEQA permitting. And then, of course, there is a host of local agencies that would also be involved. And, again, a lot of other states have already started tackling these issues and some have even introduced legislation to streamline this process.

And I think I will stop there. This is just a map to show what the potential is, as I mentioned before, the whole Central Valley and a lot of these large basins in California are the prime sequestration sites, and again, you can see, I hope, and the purple there, too. The yellow is the saline formations and the purple there is the oil and gas reservoirs which would all be good sequestration sites. And the sources are shown here on the left, the refineries, the power plants, and the large cement and lime plants in the state. So those would be the targets that would match up again pretty well with the subsurface formations. So thank you very much for your time and attention.

MS. KOROSEC: Do we have any questions for Elizabeth? Alright, in that case, we will move on.

MR. BINING: There is a little change in plan because we are ahead of schedule, so we thought that we can start with our afternoon presentation now, so that we can cover as much of a portion of that presentation as we can before we break for lunch. And before we do that, I would like to introduce a team of Navigant Consulting, Inc., who has been helping us in putting together this roadmap. We started on this roadmap project in around May, and then continued with a few of the tasks in that project, and today we have completed two major tasks of that project. The first one was to put together a background paper which will give us the current status of the technologies for advanced generation, so that we can fully understand where do we stand now on advanced generation technologies. And the second part is to set a roadmap framework. So the information that Navigant will be presenting will be mostly on two aspects, a background paper of the current status of advanced generation technologies, and the roadmap framework. The presentation will be made by David Walls, and he is pretty knowledgeable about advanced generation technologies and has worked on a number of projects with the National Energy Technology Lab from the Department of Energy, and has been focusing on advanced generation technologies. His colleague is Jose Luis Contreras. He is the Project Manager on this project. And then we have Erin Palermo, and I do not have the full name for Hiro, but we will get that name. So it is a four-person team that has been helping us to put together this background paper, roadmap framework, and we will continue with that over the next couple of months to finish the roadmap and the implementation plan. So with that, I request David to start his presentation.

MR. WALLS: Thank you, Avtar. My name is David Walls, as Avtar introduced, and I would like to thank the California Energy Commission for supporting us with this work. And what I am going to do this morning is start the presentation with a bit of the overview and background, and then we will break for lunch and come back in the afternoon, and we will go into a discussion of the individual technology areas.

As Avtar explained, the focus of our work has been to develop a background paper for the development of the advanced generation roadmap. The background paper includes a review of policies and issues impacting California and the advanced generation market, and also extensive work went into investigating the status of a broad range of advanced generation technologies. The current status, current research going on of the parts of the industry, universities, Department of Energy, international, as well, to get a good perspective of other activities going on. And then we have developed from that preliminary issues and a preliminary framework for the roadmap that we will review with you this afternoon.

So I am going to start with just an overview of the guiding policy framework, and discuss an overview of that. Much of the policy framework has been reviewed by other presenters this morning, so much of the issues that I will be mentioning are issues others have been discussing in more detail, and then we will continue, as I said, later with discussion of the technologies and key issues, and conclude with development of the roadmap framework that we will then get your comments on.

The energy policy goals that impact advanced generation in California, there are many of them. Some of the more important ones are AB 32, limiting greenhouse gas emissions to 1990 equivalent levels by 2020. The Governor's Executive Order S305, to reduce greenhouse gas emissions to 2000 by 2010, to 1990 levels by 2020, and 80 percent below the 1990 levels by 2050, the AB 32 Scoping Plan, with the objective of developing 4,000 Megawatts of additional CHP capacity in the state by 2020, then we have some of the past IEPR studies that were done with specific goals outlined. Some of the more important ones are the IEPR 2007 net zero energy for new construction through the use of CHP, which is 2020 for residential applications of CHP, and 2030 for commercial applications of CHP. So zero net energy through the use of CHP.

The IEPR 2008 update discussed the elimination of once-through cooling between 2015 and 2021. That has an impact, of course, on cooling technologies and the choice of power generation technologies. And the additional objective of repowering and retiring, replacing aging power plants by 2012. Additional policy that should be mentioned is SB 1368, which is the emissions standard that impacts imported electricity from out of state.

MR. WILLIAMS: Just a brief clarification. Is the 2010 standard four months from now? Or --

MS. KOROSEC: Excuse me; could you come up to the microphone, otherwise the people on the line cannot hear you.

MR. WILLIAMS: Sorry. I just wanted to clarify, is the 2010 goal four months from now, or 16 months from now? Is the 2010 goal four months from now, or 16 months from now?

MR. WALLS: I will leave that question to someone from the California Energy Commission to address. Any comments? In terms of the policy framework issues, largely focus on emissions reduction and environmental impacts. In general, our review focused on policy related to the non-renewable generation for large and distributed generation technologies because that is really the focus of this program. Also of note, natural gas is the state's primary source of generation fuel for non-renewable generation technologies, so natural gas will play an important role in considering technology options for R&D.

In terms of California specific policy issues, some things that were noted in our review that are issues for consideration, there are no specific goals for natural gas power plant efficiency. The goals are implied through emission standards. So while there are no specific objectives of certain heat rate or efficiency goals, emissions is a primary overlying objective in most of the policy impacting natural gas. Now, while there is interest in carbon capture and sequestration research, there are also no specific targets or goals, currently. As the previous speaker discussed, there is significant opportunity, however, in the state for carbon capture and sequestration as it might apply to natural gas within the state, and of course to coal power plants out of state that California imports power from. The policy addresses the importance of CHP, but little of the policy specifically addresses specific types of DG technologies. CHP is referred to generally in most of the policy as an over-arching technology and packaging, although, as we get into our discussion, CHP has to be looked at in specific context of its application to individual technologies, whether it be gas turbines, reciprocating engines, micro turbines, fuel cells, etc. Each technology used for distributed generation has application, can be packaged for CHP, but the issues impacting each of those technologies are different.

California has the goal to retire or repower aging power plants by 2012. That time frame and scope is currently being reviewed. The policy to eliminate once-through cooling from 2015 to 2021 was discussed earlier. The State Water Resources Control Board is working on the details of how this could be achieved, but there are, of course, some significant technology development and application issues associated with the choice of technologies, whether it be dry technologies, hybrid, or other alternative techniques.

Advanced generation can contribute to higher market penetration of renewable energy through both the fuel flexibility of the technologies. I would like to identify, or point out, I guess, the importance of fuel flexibility in looking at advanced generation, and specifically some of the distributed generation technologies. The ability to use alternative fuels, many of those fuels could be developed from renewable resources, or waste fuels. And that is an important research opportunity. But also there is an opportunity for the advanced generation technologies to work together with renewables to address some of the intermittency issues, issues associated with ramping, wind cut-out issues, for example, time of day issues, all of those have to be addressed through either combinations of energy efficiency, storage, or integration with fossil and conventional technologies.

In terms of other policy framework issues for consideration, significant investment and activity at the federal level right now is focused on coal, primarily the role of the federal government to address coal research and development issues. A significant investment is being made right now through the Recovery Act; the Department of Energy is investing on the order of $3.4 billion related to advanced coal generation technology for basic research and development, and also for deploying carbon capture and sequestration through several demonstration projects throughout the country. So one of the opportunities will be to monitor some of these activities, potentially to learn from them, to work together with the Department of Energy where these programs are much more expensive and have broader application across the country.

This next page is a description, or a list of the technologies that we have reviewed in the development of the background paper. We looked at a total of 26 technologies and we divided them into two groups, one being the primary focus technologies, those are the technologies that we investigated in more detail, that have much broader application to California, much more higher level of importance, and the secondary focused technologies,

technologies we also investigated, have importance to the State of California, as well, but for various reasons might be better addressed through monitoring activities or collaboration with other types of organizations like the U.S. Department of Energy.

Just going through these quickly and, then, as I said earlier, what we will do is we will break for lunch and then come back and discuss each of these categories individually. The primary focused technologies include distributed generation and combined heat and power, as I mentioned earlier. The prime movers that we looked at were fuel cells, the four primary fuel cell technologies of molten carbonate, solid oxide, protonic exchange membrane, and foss acid, and the activities going on to further develop those fuel cell technologies for distributed generation, stationary power. Hybrid fuel cell gas turbine cycles, the integration using various approaches to integrate fuel cells in gas turbine, taking advantage of the waste heat recovery either for fuel reforming or for additional integration efficiency improvement opportunities. There are a few companies and research initiatives going on in that area. Some of the highest efficiencies are potentially obtained through these types of cycle options. Reciprocating engines, kind of the work horse of the distributed generation field, which is most of the market today; there are significant opportunities there for efficiency improvement, emissions reductions, and packaging for CHP applications. Stirling engines, indirect heat engines that have a wide application in both the renewables area through direct use with solar energy, but can be used with many different alternative and low value fuels in heat engine type applications, there are several research initiatives going on in that area. Micro turbines, the primary focus of micro turbines or primary interest is for combined heat and power applications. There are a few companies developing those technologies, a couple here in California. Gas turbines, primarily here. We are talking about small gas turbines for distributed generation, but for advanced co-generation or CHP applications.

The next category is cooling, combined cooling, heating and power, which the technology of interest here is absorption chillers, which is the primary area for technology research. Right now, the cost of combined cooling, heating and power is high and there is an opportunity for more work in packaging systems and looking at applications, so we have investigated some of the technology opportunities there.

The next category is advanced gas turbine cycles. Again, because of the importance of natural gas to the California advanced generation portfolio, there are a number of opportunities here to improve efficiency, and improving efficiency has the benefit of, of course, reducing emissions and reducing carbon emissions. Advanced generations in the application for industrial co-generation is a fairly basic application. Inlet cooling to reduce the inlet temperatures, especially in areas with warmer climate, it is done a number of ways. Many of these technologies here are what we might call incremental improvements in efficiency and emissions, but nevertheless can be important in terms of looking at the total portfolio. Recuperation is the capturing of waste heat for heating inlet air temperature before it goes into a combustor for net efficiency improvements in gas turbine cycles. Inter-cooling and recuperating is the combination of a couple of different steps here, which can have benefits for flexible turbines that could be used for renewable integration, potentially used in more peaking and cycling application. Heat recovery, one of the basic technologies used for combined cycle applications. Advanced simple cycle for peaking is the development of advanced gas turbines that are more flexible, start up more quickly, require less maintenance for use to firm -- potentially firm renewable capacity. Hybrid renewable cycles, hybrid renewable cycles really first to a number of different combinations of gas turbine cycles with renewables, such as solar thermal for either some type of inlet cooling, potentially, or recuperation type application to improve the overall heat rate of the gas turbine cycle; again, a way to incorporate renewables together with advanced gas technologies. Integrated gasification simple cycle, the California Energy Commission has done work in this area in the past, potentially important technology for basically recovering energy and reforming natural gas to make hydrogen to improve the overall efficiency of a simple cycle gas turbine could be applied to biomass, for example, alternative fuels, as well, but a potentially interesting technology for further development.

Then we have some of the replacement for once-through cooling. Technologies were discussed earlier this morning -- dry cooling, wet cooling, alternative cooling, water options and hybrid cooling towers, or hybrid cooling systems that were discussed in more detail this morning.

And then carbon reduction, we have specifically here broken up pre-combustion capture of carbon, and the application of this technology to natural gas would be an opportunity to remove carbon for application and combined cycle, or simple cycle gas turbine running the turbine on hydrogen rich stream and then sequestering the carbon in some type of a potentially enhanced soil recovery or something, some application like that. So those are some of the technologies that we focused on in more detail. Various opportunities exist there for R&D to become part of the future roadmap for the advanced generation portfolio.

The secondary focused technologies that we looked at, we looked at the advanced coal and biomass combustion area, looking at primarily three types of advanced combustion, integrated gasification combined cycle, which many people feel has the most potential for an option for carbon capture and sequestration of coal, or biomass. Ultra super critical pulverized coal is the higher pressure, higher temperature steam cycle has the benefit of higher efficiency, would require post-combustion carbon capture and removal, but has a higher net efficiency, and then super critical circulating fluidized bed combustion. Circulating fluidized bed combustions is a pretty widely used technology applied to super critical steam conditions, is more advanced, and an opportunity for use with biomass or other low grade fuels. Most of these technologies are of interest in other parts of the country. They probably will not have direct application here in California, but could be part of future imported electricity if used with carbon capture and sequestration. Then we have the carbon capture and sequestration category of post-combustion capture, and geological sequestration, just breaking down the two components of carbon capture and sequestration, and looking at some of the technology developments there.

And then, in the advanced nuclear power area, we focused primarily on looking at some of the advanced nuclear technologies that are being proposed for future plants in the U.S., that are still in the early commercial development stages. Again, because of the moratorium that we have in California for nuclear, we felt it appropriate for this to be a secondary focused technology because it is not likely a new nuclear power plant will be built in California for some time.

So what I would like to do is let everyone break for lunch and we will regroup at 1:00, and then continue through more detailed review of some of the background paper material and the technologies, and then discuss the framework for the roadmap and then look for your comments. Thank you.

MS. KOROSEC: Yes, we will return at 1:00. Thank you.

[Off the record at 11:50 a.m.]

[Back on the record at 1:00 p.m.]

MS. KOROSEC: We left off before lunch with the presentation from Navigant.

MR. WALLS: Good afternoon, David Walls again. I am going to continue where we left off before lunch. We were going through the primary and secondary technologies that were profiled in the background paper, and we will start with distributed generation and combined heat and power takeaways. In each area, we look at some of the take-aways and some of the research issues.

Cost is still the limiting factor with many of the distributed generation technologies. Most are focused on techniques for either fundamental cost reduction, or systems work associated with cost reduction. As mentioned earlier, CHP is typically the most cost-effective application due to higher operating efficiency associated with the heat recovery. There is a recent trend and interest in developing more fuel flexible distributed generation and CHP systems, so a number of the technologies, whether it be fuel cells, micro turbines, Stirling engines, or whatever, the research is focused on applying those technologies using different types of fuels. There has been limited investment in communication control technologies for DG. There has been -- I will not say there has not been investment, there has been -- but there is an opportunity for more investment in this area, specifically linking some of the technologies to the Smart Grid, and over the next few years we expect to see more of a focus on that.

Rule 21 has been successful in removing some of the fundamental barriers to interconnection. Now, we can focus on more of the technical issues associated with communication and control. The highest efficiencies are achieved with hybrid cycles, using typically fuel cells and gas turbines, efficiencies of 60-70 percent are achievable, and have been demonstrated, some of the technologies under development. Now, there is considerable funding that has been applied to transportation applications in technology development for fuel cells. There has been more limited funding for stationary power applications. This has been a general trend over the past few years, specifically driven by some of the DOE initiatives to invest more in transportation applications and the hydrogen economy. And the stationary applications and benefits have been achieved through that, or benefits in terms of the research in transportation fuel cells, but the target in many cases has been the transportation application, first.

PIER and the Electricity Analysis Office have done several things recently related to CHP. They have done an industrial CHP market potential study and updated the 2005 CHP market study to more specifically identify what the market opportunity for CHP is in California, and that is a significant opportunity.

Avtar presented this slide earlier, he had a little more detail in terms of some specific thinking about the stage of development of some of these technologies, but this is a snapshot that shows what some of the various distributed generation technologies and applications and the relative strengths and weaknesses of some of the technologies, a check meaning it is a good application, and "x" meaning it is a less favorable application of the technology. Fuel cells, for example, are applicable; depending on the specific technology, some have higher temperature and are actually better for CHP like the higher temperature solid oxide and molten carbonate. They are better for base load applications. They can be used for a back-up in peak shaving, and specifically some of the PEM technologies, they are less attractive for strictly cycling applications. Hybrid fuel cell gas turbine cycles, similar applications, similar in terms of their strengths and weaknesses. They are less attractive for cycling, but more attractive for the CHP or base load, probably base load being one of the stronger applications for hybrid fuel cell gas turbine cycles. Reciprocating engines are applied across the board. The specific technology is slightly different in terms of the details in how they are applied; the higher speed engines used for cycling, lower cost, some of the medium speed engines are used more for base load or CHP. But there are applications across the board. Stirling engines are most attractive for CHP and base load. Micro turbines most attractive for CHP and for cycling. They are more flexible in terms of the ability to start and stop many of the smaller micro turbines being developed from the turbo charger family of technologies. Gas turbines, really here focusing on what we would call small gas turbines up to 5 or 10 Megawatts, are applied across the board in terms of CHP, or base load, or for cycling.

Fuel cells, in general, the current status, as I mentioned, this considerable funding that has been applied for technology development for transportation, there has been less available for stationary power. Some of the funding has gone towards deployments and demonstration. Companies like Fuel Cell Energy, Plug Power, Ballard, various other companies have participated in those demonstrations and have stationary power units that have been demonstrated. With the current focus on plug-in hybrids in the transportation sector, it is our expectation that this is probably going to be a trend away from funding going towards fuel cells, and towards plug-in hybrids and transportation. This will result in less funding spillover for stationary fuel cell research.

Some of the non-technical barriers that are facing fuel cells are the high capital cost, fuel cells have always faced a low production, high cost issue in terms of, in order to achieve low cost, they need to be manufactured in higher volumes, and the market has not developed, or there has not been significant enough incentive applied to help develop the market, to help fuel cell companies lower cost.

High temperature fuel cells offer advantages in terms of efficiencies, efficiencies of greater than 40 percent and higher are achievable with some of the solid oxide and molten carbonate fuel cells. But that technology is generally considered to be receiving less funding. Research opportunities that we identified would be increasing fuel flexibility and increasing stack life. One of the issues facing fuel cells is the stack life is typically limited to about five years or less, and that is significantly limiting application. Until stack life can be more consistent with other distributed generation technologies, they probably will be less accepted and the life cycle cost will continue to be high because of that maintenance requirement. Improving the reliability, fuel reformer design, the fuel reformer being what is used to convert the fuel to hydrogen, whether it be a natural gas, or some type of a liquid fuel, renewable fuel, reducing the size and system complexity to lower cost is an opportunity. Again, standardization is a key need for reducing fuel cell cost and efforts could be applied there. Then, longer term research issues do focus on lower cost materials, membrane technologies, and those types of opportunities. Many of those issues are probably more expensive research initiatives.

Related to the fuel cell technology is the hybrid fuel cell gas turbine cycle. There are several systems in the stage of what I would call the early commercial development. There are two, at least two, successful demonstrations of this technology that have been made. They are generally smaller systems, 1 to 5 Megawatts, and they are targeting efficiencies of greater than 60 percent. Systems are fairly complex because of the extensive integration of the two technologies, leading to fairly high cost, greater than $5,000 a Kilowatt, or so. The development cost for companies developing this technology is significant, so it is a significant development risk for companies in this business. You know, investments of on the order of hundreds of millions of dollars is required to develop these systems. So it is a broad group of stakeholders involved in technology development from industry, to national labs, to universities.

Some of the research opportunities are general advancement of the solid oxide and molten carbonate fuel cell technologies required to meet the demands of a hybrid cycle, and development of specialized turbine components and turbine designs that integrate the flow and thermal input parameters from fuel cells. So it is more of a packaging and systems development requirement than some of the fundamental turbine technology, but just the same, it does require new designs and new development.

Reciprocating engines are -- one of the significant advantages they have is low first cost, proven reliability, significant potential for heat recovery, although it is a lower quality heat, meaning lower temperature, less potential to produce steam, more potential for hot water in co-generation using reciprocated engines. Emissions on a relative basis to the other distributed generation technology are higher, and so that leads to some of the opportunities. Some of the major barriers to broader application have been higher maintenance costs, and the frequency of maintenance intervals, oil changes, overhaul requirements due to wear, mechanical parts, vibration, those types of problems. Current research is exploring the operating and maintenance cost reductions and focused on reducing emissions. In terms of research opportunities, there is more opportunity to look at full waste heat recovery and taking advantage of more of the low temperature waste heat from reciprocating engines. Also, increase in the application of use of alternatives fuels, such as landfill gas or digester biogas and other fuels, reciprocating engines have been applied in many of those cases, but there is further opportunity for development there. And achievement of U.S. DOE's fuel to electricity efficiency target of 50 percent on a lower heating value basis by 2010, that would be a 30 percent increase over today's average, and so that is just around the corner; I would say there is maybe opportunity for improving efficiency overall, though, is an opportunity.

Stirling engines currently have a relatively high cost, mostly due to the fact that they are produced in low volume, but they can achieve low emissions compared to IC Engines, they are an external heat engine, so part of that class of technologies. They have undergone some significant R&D development over the past few years, but efficiencies have been generally low, on the order of 20 percent or less, so there is an opportunity to develop and work on efficiency improvements. There is opportunity for research on landfill gas as a fuel. Stirling engines, as I mentioned as well, have been applied to concentrate in solar, those are in early commercial application, although some of the companies developing that technology are struggling. Creation of package systems for residential and small commercial CHP is a research opportunity. There are other initiatives working on these systems that would be combined heat and power with the systems being in some cases heat following, instead of electricity following, potentially. As an application, we are looking at basic -- or different types of packaging configurations.

Microturbine research and development is fairly mature at this point. A number of companies have launched this technology over the past several years and are in various stages of commercial manufacturing. There is research needed to improve efficiency, however. Most of the microturbine technology available is still relatively low in efficiency, in the range of 20 to 30 percent. But they are attractive in applying the technology to various alternatives fuels. The real opportunities for cost reduction have not materialized, that is an issue. The early projections where that cost would come down much more significantly, to the order of $300-$400 a Kilowatt, most microturbines are still up closer to $1,000 a Kilowatt, or more.

Cycle enhancements are a research opportunity to address some of the power losses and improve efficiency and improve operation in areas of high temperature, being an air-breathing engine, like a gas turbine, microturbines suffer from efficiency and output loss at high temperatures and at elevation. So opportunities to integrate microturbines with inlet cooling or other improvements, to capture some of that efficiency improvement, would be an opportunity. Pairing microturbines with fuel cells, again, this is more of our hybrid development focused on maybe smaller sized applications in the hundreds of Kilowatts ranges, as opposed to Megawatt range.

Small gas turbines, again, a fairly proven accepted technology. They are proven to be reliable. They, however, in the sizes greater than 3 Megawatts, tend to be less cost competitive with reciprocating engines. The production volumes for gas turbines in this size range are lower than reciprocating engines, so the costs are generally higher. They have -- PIER has funded several demonstration projects to address catalytic combustion, reducing NO_x emission; that has been successful. There are opportunities to apply more of the small gas turbines to CHP applications in a number of different industries. Oil recovery, chemicals, paper production, food processing, universities, so small commercial -- or not small commercial, probably larger commercial -- universities, institutions, penal institutions, places like that where they have significant heat loads, hospitals would be an example, would be good applications, again, focused on standardization of packaging and lowering of cost. So the research opportunities are improving the energy and environmental performance, lowering capital cost. Other opportunities would be technology demonstrations and providing technical assistance in the implementation and basically reporting lessons learned, getting information out, assisting with additional associated studies, associated with the application of small gas turbines, especially as could be applied to combined heat and power, or co-generation.

The next category is cooling combined heating and power. Generally, we are talking about applications that incorporate absorption chillers into the cycle as a way to make higher utilization of waste heat. In California, there is less opportunity to use waste heat in all co-generation applications, so broader development of the combined heat and power and cooling market will require emphasis on absorption chillers. Electric chillers are another opportunity, however, more difficult to take advantage of the waste heat in some of the technologies that we talked about, such as the gas turbine technologies, or reciprocating engines. The issues are relatively high cost, relative to the efficiency benefits, so while the efficiency can be high, from a financial standpoint, the pay-back in many cases is not as attractive as it needs to be. The overall efficiency is lower for systems that are paired with absorption chillers, compared to other straight CHP systems that can take more advantage of all the waste heat, the issue being generally that absorption chilling has an additional efficiency loss associated with it, hence the net cycle efficiency is slightly lower. As I said, the primary benefits of the technology are broader application of CHP in areas of warmer climate. Currently, an issue is cost. We are talking about greater than $600 per ton for a double-effect absorption chiller; that cost needs to be reduced for broader application. Current research focuses on pairing absorption chillers with reciprocating engines and microturbines to capture some of the smaller packaged applications. So some of the research opportunities would be further reducing cost and improving efficiencies with CHP and absorption chillers, also associated with pre-packaging systems to reduce cost.

In the next category, we have quite a few different technologies to cover because of the high interest in these technologies in the market here in California. This is the advanced gas turbine technologies and associated system and cycle technologies. Most of these technologies are fairly mature and are incorporated into new plants. There are opportunities to improve the efficiency of existing plants by doing retrofitting. However, cost is an issue. Limited research has been done in this area in recent years, most of the research in advanced gas turbine technology was focused on 10 years or more ago. And there has also been limited research on, and demonstration of retrofit applications, generally, the issue being there is always a trade-off between a retrofit versus a complete replacement or re-build of the system.

Recent emphasis of the Original Equipment Manufacturers, the OEMs, has focused on materials, higher temperature combustion, higher pressure cycle development associated with some of the aero derivative engines, companies like GE, Pratt & Whitney, Rolls Royce, working more on applying technology developed in the aerospace industry to power generation.

There has been more research done outside the U.S. on incorporating gas turbines into renewable hybrid cycles, to address issues of intermittency. We think that might be an opportunity for additional research here that would be applicable in California. While there are significant incentives for renewables, generally hybrid renewable gas turbine systems would not qualify, so that is a bit of a barrier to broader marketed adoption and interest in this technology.

And lastly, there is a large technical market potential, as studies have demonstrated, supported by CEC, the California Energy Commission here, in industrial co-gen and heat recovery, and so there is significant opportunity to increase the market penetration of co-gen systems.

So we will discuss each of these several categories here in a bit more detail. Industrial co-generation, while it is generally accepted as a mature technology, it has been used for many years at industrial, large commercial institutional applications, there is still a lot of unrealized market potential. The California Rule

21 that helped to facilitate interconnection issues helped DG applications up to 10 Megawatts, but for applications greater than 10 Megawatts, has not been as helpful. An additional issue or barrier for industrial co-generation has been tax depreciation policies which generally have not, I would say, encouraged, they somewhat discouraged, industrial co-gen more broadly, and impact the financing. Financing for these types of applications is a significant issue and one of the areas currently being addressed by the U.S. Department of Energy Loan Guarantees, which may help to some degree.

So research opportunities, again, improvement in fuel flexibility and efficiency, to improve the life cycle cost benefit ratio, and other near-term R&D opportunities, again, are lowering emissions from gas turbines and NO_x emission controls.

Inlet cooling. Inlet cooling generally is a technology applied to gas turbines in hot climates to increase the power output, it does have a benefit for efficiency, as well, and generally required in order to get full capacity from a gas turbine. Typically, gas turbines are used for peaking during hot days and during hot days they are impacted more by inlet temperatures in terms of losing output. So this has a benefit in terms of increasing the available capacity, as well as improving efficiency.

There are a number of different approaches being used for inlet cooling, such as foggers, water spray, inlet cooling systems. Many of these, as I discussed, are considered proven and mature, but there are opportunities for broader application of this technology and can be a way to improve efficiency, overall. In some cases, there is a lack of awareness and negative perceptions of the barriers, such as impact on maintenance, impact on cost, impact on complexity, impact on reliability, those are some of the issues that are a barrier to broader inlet cooling applications. So some of the research opportunities associated with more understanding the reliability impact, the corrosiveness of some of the inlet cooling techniques, pitting associated with inlet foggers, and understanding more specifically what some of the performance improvements are. There is additional opportunities associated with understanding the limits of using inlet fogging for inter-cooling, as well. So there are a number of research opportunities associated with different types of cycles, different types of applications of inlet cooling that could be researched further.

Recuperated gas turbine cycles is the recovery of waste heat for improving the overall efficiency by boosting the inlet temperature to combustor. This has been applied to smaller gas turbines, it has not been applied more broadly, generally because of retrofit issues, changes in -- it does have an impact on pressure ratio and other technical issues associated with the turbine. Larger gas turbines are less well-suited to recuperation due to higher pressure ratios, so there tends to be less of an opportunity for larger gas turbines, say, greater than 20 Megawatts, or so. Cycle produces less power, generally when it is recuperated, and results in less waste heat available for combined heat and power. So you have to look at the overall application to decide if this is the right technology for a particular application. In general, the research opportunities, this is an area that has not had as much research associated with understanding the complexities of the cycles and the overall impacts; there is an opportunity for more cycle research. There is the success of the cycle also will depend on the cost and the durability and reliability of the recuperator section, and so there is an opportunity there for a better understanding of some of those issues.

Related technology is the Inter-Cooled Recuperated gas turbine cycle, the ICR cycle. There was quite a bit of work done on this technology during the '90s. A couple of companies were working on this technology, Westinghouse, Rolls Royce, and others, and had developed prototypes for designs in marine propulsion, initially, not for stationary power. Again, this is an overall cycle improvement. It would have an impact and make the technology less attractive for co-generation, but it could be an attractive way to improve gas turbine efficiency. It is most applicable to small to medium size gas turbines in the 5-25 Megawatt size range. A cycle life, this is being developed for microturbines for vehicular applications that could be applied to stationary power, the Recuperator and the Inter-Cooler add significant cost and complexity, that is an area where there is additional research opportunity, both in terms of the life of the parts, and the cost, again, the recuperator being a heat-exchanger that needs to have significant durability and be able to run through cycles, long lifetime cycles without cracking or deteriorating. So reliability is an issue.

General category of heat recovery, this is a broad category here, we have not really attempted to break it down into a lot of different sub-technologies, but heat recovery, in general, is a broad opportunity for power generation improvement, you know, applied. It can be applied to many cycles where there is waste heat available, fundamentally from an industrial process. One of the sub-technologies are organic ranking cycles and other types of cycles that are really focused on recovering lower temperature waste heat. The economics and operation somewhat are similar to renewables in the fact that there is no fuel cost associated with the heat recovery project, but there is a significant upfront capital cost. Some have tried to put heat recovery in the category of renewables for this reason. There is, you know, based again on the analysis that has been done in the CHP market, a significant unrealized market potential for heat recovery in industrial and commercial applications in California.

The implementation of this technology in terms of research opportunities is highly site-specific, which is one of the barriers to the application. It requires a significant amount of site engineering to incorporate systems into industrial designs, and initially -- well, so far there has been limited detailed market characterization, so we think there is more opportunity there to do more market characterization and help develop, or help identify some of the more specific early market opportunities. The uncertainty of waste heat temperature and through put have also slowed development; again, many of the processes might have variable heat generation, and so that uncertainty may impact the financial attractiveness of some of the heat recovery opportunities.

The next technology we looked at was advanced simple cycle technology applied to peaking, or cycling application. The advantage of the technology is high efficiency, high reliability, a fast start-up, and low emissions. There is an opportunity to combine advanced simple cycle turbine technology with many of the sub-technologies we have just been through, like Inter-Cooling Recuperation, reheat steam injection for overall efficiency improvement. The focus here, and in terms of advanced simple cycle turbine, is operating flexibility and reliability so that more life can be achieved with these turbines. Generally, these turbines might have higher costs compared to base load technology if you look at them on an application basis because they generally are operated a limited number of hours. So that is always difficult to make them look financially attractive. As we incorporate more renewable energy into the grid, though, the flexibility of advanced gas turbines for simple cycling applications would become more attractive. Some of the research opportunities here would be work on fuel flexibility, which is a barrier in some cases to broader application, and because natural gas may be perceived as being more volatile in pricing and can limit the market application for simple cycle gas turbines like this.

Hybrid renewable cycles, again, that is a broad category of different types of technologies focused on helping renewables overcome some of the intermittency issues. We categorize it as an emerging technology, just entering commercial development in some areas. Focus has been on small scale demonstrations; large scale demonstrations are still in planning. But more of the investment and demonstration of these technologies has been done internationally because there is less funding and less incentives available for the technology in the U.S. So there is research opportunities here associated with looking at ways to incorporate turbines with concentrating solar, to facilitate the development of some of those projects, or research on small scale demonstrations to fully understand the optimization integration issues. There are a number of different ways that solar, for example, solar heat could be used to integrate with the gas turbine cycle to improve efficiency. So there are opportunities for further analysis of some of those cycles, and opportunities to look at how solar, for example, could be integrated with combined cycle plants that might require scales of 50 Megawatts or larger. So there are a number of different demonstration opportunities that might be available, as well as studies associated with cycles to understand some of the optimization and integration issues.

Integrated Gasification Simple Cycle is a technology that has been investigated in the past by the California Energy Commission, it could be a way to reduce emissions and improve efficiency of either internal combustion engines or gas turbines for DG applications. So it has been applied. This says "Integrated Gasification Simple Cycle," but it could be applied to both gas turbines or internal combustion engine cycles. It does require extra components and complexity. Basically you are doing fuel reforming of the natural gas and using the hydrogen as the primary fuel for the turbine. It has benefit of potentially improving the cycle efficiency, however, it does require significant modification to the turbine design to incorporate the technology. This is one of the barriers for development of this, is the cost associated with the technology development, and the turbine equipment manufacturers would need to be involved in this type of development. So it requires significant demonstrations and verification of the components, both for internal combustion engines and gas turbines. Research on the combustion of hydrogen rich fuels needs to be done for both gas turbine and IC engines, to the extent they would be applied to the cycle. So there is some initial component testing and analysis that would need to be done before full cycle demonstrations really would be a potential.

The next category is the replacement for once-through cooling technologies. As we discussed this morning, there are a number of opportunities there, but some of the issues are incorporating the plants with any alternative technologies is expensive and will impact efficiency. So that is always going to be a barrier. Some of the older plants, the older ranking cycle thermal plants, are more likely to shut down due to this policy than to eliminate the once-through cooling, so that is a barrier again to some of the retrofit. And the costs are highly dependent on the site and what is available in terms of space and alternative water. Typically, dry cooling is most expensive, followed by hybrid cooling, then closed wet cooling towers. Wet cooling towers utilized in sea water still represent a significant improvement, however, over once-through cooling. It could be a retrofit opportunity in some cases. Space is an issue, as I said, due to the space required for cooling towers, so many of these coastal applications, that is a limiting issue for retrofitting.

The next category we touched on, and I think I have mentioned this, but if you go to our report, there is a significant detail on each of these technologies and a summary of the research going on in other areas in the world, including the U.S., but other areas, as well, that we have summarized, if you want to refer to that. Pre-combustion carbon capture is an area that has not had as much attention as one of the ways for carbon capture and sequestration. Typically, the costs are going to vary widely and the cost of retrofitting plants is prohibitive, however, it could be an attractive option and applicable here in California. There has been a lack of utility scale demonstrations, and that is limiting development adoption. The Recovery Act funding could assist this, but I do not believe there will be many of the demonstrations focused on pre-combustion capture. The most likely demonstration that would fall into that category would be integrated gasification combined cycle. I do not believe there is any proposed pre-combustion capture of natural gas that is being proposed. The IGCC plants generally, with pre-combustion capture, have the lowest energy requirements, if you look at carbon capture. And, as I said, there has been little research on pre-combustion capture for natural gas plants, and that would be an opportunity.

The next category, advanced coal and biomass combustion, again, now we are into our secondary technologies here, secondary focused technologies. There is limited generation from coal in the state, however, 17 percent of the power consumed is from coal plants, so there is certainly some interest in this, and following developments and opportunities. DOE has extensive efforts underway for the development demonstration of advanced coal and biomass combustion technologies. Repowering old coal plants could be an opportunity to the extent there was carbon capture and sequestration linked to them, however, it maybe less likely.

Post combustion carbon capture and sequestration is a more likely approach being investigated for carbon capture. Again, in California, most of the opportunities here would be mostly linked to natural gas plants and would require probably linking the captured carbon for sequestration with enhanced oil recovery. This is a better technology approach for retrofitting because you are capturing the carbon after combustion. When we discuss the pre-combustion capture, that would require changes to the turbine cycle due to the fact that you are using hydrogen as a fuel. And post-combustion capture, you are not impacting the turbine. Post-combustion capture is more energy intensive than pre-combustion capture, generally. But the overall efficiency penalty is probably similar. It does require additional development cost improvement. Compared to other carbon reduction approaches, it is generally going to be more expensive.

The success of enhanced oil recovery sequestration depends on alignment, really, of interests between the oil producer and the society's need to reduce carbon, so there is an opportunity here to align those needs and really take advantage of the need for carbon for CO_2 to be used for enhanced oil recovery. That could create an opportunity here.

Advanced nuclear power, just a few bullets here on the various nuclear technologies. There are various technologies currently competing for combined construction and operating licenses so that they can be the first new nuclear reactor to be built in the United States in many years. However, the earliest new nuclear reactor likely to be operational in the U.S. is in about 2016, and that may be optimistic. Cost is highly uncertain in any of these technologies because there is no experience in building new plants in the United States, and not significant experience internationally. A significant issue is that there is still no facility for nuclear waste disposal in the U.S., which is going to continue to impede the market development, and there are some other research initiatives going on in more advanced technologies abroad, such as modular technologies, pebble bed reactors, and technologies in those types of things. Most of that research and development is going on internationally in places like China and South Africa. And California's moratorium on new nuclear is still in place.

So now we have covered a lot of the technologies that we have looked at. There are a series of trends and issues that we have identified, that could have a significant impact on advanced generation technologies in California. Recent studies have found that generation from natural gas could be reduced by 15 percent by 2020. Under current policy, the state will need to replace or repower 66 aging natural gas plants by 2010. That would be a combined capacity of about 17,000 Megawatts, 40 percent of the gas-fired plants, and it represents about 40 percent of the natural gas-fired plants, and 25 percent of all power generation capacity. However, the scope and time frame of this goal is still under review. Another issue is, despite improvements, energy intensity from desalination remains high. Energy and greenhouse gas impacts will need to be considered when assessing desalination projects. We bring this up because there are a number of desalination projects being proposed that could be a significant demand for power generation capacity, and also represent opportunity for research and development.

California's current electric generation portfolio is generally cleaner than most of the portfolio in the U.S., but is more expensive than the United States average. The Smart Grid is expected to increase the value of photovoltaic's and other distributed generation, however, it is going to require more coordinated involvement of various stakeholders. That means more integration with other conventional fossil generation plants for operation. So there is a need to overcome the technical and the non-technical challenges associated with the renewable energy intermittency.

The net zero energy new construction for commercial buildings is going to have an impact on the efficiency of and opportunities associated with distributed generation. As we mentioned earlier, the goals there, again, are net zero energy use in new construction in the commercial sector by 2030, and net zero in the residential sector by 2020.

Another significant issue that adds to uncertainty in a lot of this forecasting is that natural gas deliverability and supply scarcity projections vary. Some recent projections have indicated that more natural gas is available probably at a lower price for a longer period, but we know the issues have been raised in the past about natural gas price and availability uncertainties. So these are a number of issues and trends that we need to think about as we think about research opportunities that will impact the advanced generation research portfolio in various ways.

We have worked together with the California Energy Commission, with Avtar, to develop a preliminary vision for the 2020 PIER Advanced Generation Vision. I will just read it to you. "The PIER Advanced Generation Program provides key RD&D that enables California to generate energy efficient, abundant, affordable, reliable, and environmentally friendly electricity, and other forms of power from small to large power plants, including distributed generation and combined heat and power, using clean, non-renewable fuels and fuel flexibility capability in order to help reach the greenhouse gas emission reduction targets." Kind of a long paragraph, but represents a lot of things that we are trying to incorporate into the vision for the Advanced Generation Program. I will just leave that for a second for you to take a look at.

MR. WILLIAMS: May I ask a question while we are --

MR. WALLS: Can you come up to the microphone, please?

MR. WILLIAMS: I am Bob Williams. I am a retiree, so I do not spend as much time as I might on this. I have been sitting here curiously listening how you address air-conditioning needs in the CHP technologies. Is there a simple way to state your assumption there?

MR. WALLS: Well, one of the approaches would be to use some type of absorption chilling, absorption cooling, either through heat recovery or electric absorption chilling.

MR. WILLIAMS: Well, I think your report would benefit by doing a comparison to a heat pump because, as the temperature heats up, it strikes me that more and more of the load is going to shift to a need for air-conditioning, rather than a need for district heating.

MR. WALLS: Thank you. Next, I would like to review a summary of our preliminary ideas regarding research opportunities. We have developed three primary platforms for proposed program areas for PIER Advanced Generation. The first would be commercial CHP and combined cooling, heat and power, and that area would support the development of cost-effective CHP, and CCHP systems for commercial buildings and their wide-scale deployment. The second research platform would be focused on industrial co-generation systems to support the development of cost-effective industrial co-generation systems and their wide-scale deployment, and the third platform area would focus on advanced gas turbine cycles to support the development and wide-scale adoption of cost-effective advanced gas turbine cycles, including integrated hybrid renewable cycle systems, which could significantly improve the efficiency and fuel flexibility of natural gas power plants. So these areas would focus on primarily improving efficiency and reducing emissions of greenhouse gases for large scale and distributed CHP, fueled with clean fuels and fuel flexible systems.

The PIER Program has limited resources, PIER advanced generation has limited resources, and so it needs to focus those resources in a few key areas, and it needs to avoid duplicating efforts with funding and other research going on in other program areas. As such, it needs to work closely with those areas to leverage investment and activity across the PIER organization. Some of those areas are the residential single family CHP, as discussed. The technologies there are currently not cost-effective, as the thermal load is too small relative to the electricity load. So we recommend continuing to monitor technology progress in this area due to the high technical potential for residential CHP and CCHP.

In terms of distributed generation systems primarily used for base load, peaking, or back-up power in cycling, we would recommend the focus be on more efficient cost-effective environmentally friendly CHP systems. So, again, less focus on distributed generation that does not involve CHP. And then, in terms of DG and CHP interconnection rules and standards, this area would be primarily addressed by the Smart Grid Research of the PIER Energy Systems Integration Program.

In terms of some of the other areas, renewables, including the management of intermittency issues, through the co-location of renewables and traditional gas-fueled systems, would be primarily addressed by the PIER Renewable Energy Technologies Program; the Advanced Generation Program would provide support to that.

In terms of water use in power plants, including replacement technologies for once-through cooling, this is primarily addressed by the PIER Energy-Related, Environmental, Research, Industrial, Agriculture and Water and End-Use Efficiency Programs. Again, the Advanced Generation Program would provide support to this and let the other PIER area take the lead.

Carbon capture and sequestration, work in this area is primarily focused on coal fueled power generation being addressed by DOE. We would recommend that the program continue to monitor cost-effective application to our carbon capture and sequestration to natural gas fuel powered generation.

And in terms of nuclear, with the moratorium still in place, we would recommend that this area just be monitored at the current time.

So in each of the target research areas, the PIER Advanced Generation Program would need to focus on a few key research issues for development. We have a preliminary list of potential research issues for the program to focus on here. In the first category, in commercial CHP and combined heat and power, a focus would be on systems packaging and integration as the primary focus area, and then market regulatory mechanisms for the incorporation of commercial CHP as a secondary area, to complement the CHP program.

In the Industrial Co-Generation Systems area, the focus would we on systems packaging and integration, again, as the primary focus, with the emphasis on cost reduction and improving market adoption. So the identification of cost-effective sites would be a secondary focus, and focus on market and regulatory mechanisms would also be a secondary focus in this area to support this.

In the area of Advanced Gas Turbine Cycles, new technology development of integrated hybrid renewable cycles would be a primary area of focus, again supporting the PIER Renewables Program, and new technology demonstration of advanced generation technologies as they might be applied, trying to leverage DOE resources as it might be applied to California specific issues. And, again, market and regulatory mechanisms associated with broader adoption that would advance gas turbine cycles would be a secondary focus area.

So we have covered a lot of material here. The real objective of today's session here, the workshop, is to obtain input and feedback associated with the proposed vision, and the preliminary research opportunities and target issues that have been presented. So what we would like to do is raise some questions here and then we will open it up to the audience for public comments. Some of the questions you might consider in formulating comments are:

What are the additional research opportunities which should be considered as part of the PIER Advanced Generation Program? Does the PIER Advanced Generation Preliminary Vision capture the right objectives for the program's future? Do the preliminary research areas that were presented on the previous slide, do they capture the appropriate target use of PIER's Advanced Generation Future Program? And are the secondary focus areas appropriate? Are there other focus areas that you think should be considered? And do the preliminary research issues capture appropriate research needs for the program to focus on? And finally, what areas can the Energy Commission most effectively devote resources which will show progress in meeting California's energy goals as part of the 2009 IEPR Proceedings?

So consider some of those questions and I guess I would like to open it up to -- maybe you have questions first, and then comments? Maybe questions and then we will open it up to comments. Yes, question or comment?

MS. KOROSEC: Come up to the microphone, please.

MR. SAYRE: I realize you are right to do your study based on what our Legislature has been providing for you, however, you talk about the moratorium for nuclear. What the tests of the population of California, 82 percent are in favor of California going ahead with nuclear power plants, yet the Legislature will not let that happen. Can you go on beyond what the legislation wants because of what the people in California want?

MR. WALLS: I think that is beyond the scope of what I can comment on.

MR. SAYRE: Higher than your pay grade.

MR. WILLIAMS: I have got a question for you. Bob Williams, again. I have heard a lot of talk about the significant cost penalties, economic penalties for carbon sequestration. I would appreciate it if you could express that either as a dollar per Kilowatt figure, or as a percentage increase in the capital costs and generating costs of the power plant.

MR. WALLS: Right. That is a good question. The actual cost varies significantly with the specific technology and choice, so it makes it a difficult question to answer with a definitive statement. The range is probably on the order of 20-40 percent, and it really depends on whether you are talking about pre-combustion capture as applied to integrated gasification combined cycle, or you are talking about post-combustion capture in a pulverized coal plant, or something like that. So the range does vary significantly. And so it is difficult to provide kind of a definitive answer to that question.

MR. WILLIAMS: It might be nice in the final report to add it to each category. Recognizing that the money always runs out before the end of the project, it still would be nice perhaps to include that factor as you discuss each one of the technologies. I realize that it is a technology dependent question, but the cost penalty, the capital costs, and the generation cost penalty for the carbon capture technologies would be an appropriate merit to put on each of your technologies, in my view.

MR. WALLS: Yeah, thank you.

MR. WILLIAMS: Thank you.

MR. WALLS: Some of those details are in the body of the report.

MR. THEROUX: Good afternoon, excellent report and coverage of the report, as well. Two pieces of the puzzle that I was listening for and did not find -- Michael Theroux, Theroux Environmental -- and I would not ask so much for a detailed response on this, but perhaps consideration as to where they would fit. First is the development, the parallel development, of use of algae as a mechanism for capturing CO_2 and how that fits into this whole puzzle, CCS and Advanced Generation. The second, a development that I have been watching in solid oxide fuel cells, cylindrical framework solid oxide fuel cells, for both down hole redevelopment, and also to use those curious little cylinders for the 600 degrees C. heat that they generate to provide a thermal source inside of retorts for paralysis and gasification. Those two paths seem to be both showing some very nice progress recently in this arena of ancillary systems to advanced generation. The question that I actually have, though, has to do with integration. It appears that one of the steps that I am seeing in project development is not really addressed here, and that is, all right, we have got a lot of different systems, and we understand that integrated packages make the most sense, we are talking on one side of sustainable community development and we have the questions of Smart Grid and all its intricacies; it seems that our focus has almost leaped in front of what the agencies' attention is, in that we need to be concerning ourselves with community scale integration, not just power generation, but the fuels and the waste management and the air quality and the rest of it, once again, but how do these new tools and our ability to lace them together fit within our community specifically? So that would be the question that I would ask, as to what you might put your finger on. So, thank you.

MR. WALLS: Thanks. Well, I think what you are getting to is kind of a broader systems issue that goes beyond some of the specific technologies and looks at kind of broader applications, which could be a proposed research area, I suppose, something along those lines. Yes, Avtar, would you like to address it?

MR. BINING: Yeah, in our renewables program, we do have that System Communities Program and we did not want to overlap with them, but that is why we mentioned about integration with other systems, it could be renewables, and then how it gets integrated by application site. The Renewables Group is taking the lead on that.

MR. THEROUX: Okay, thank you.

MS. KOROSEC: Alright, if there are no other questions, let's go ahead and begin the public comment period. We do have several blue cards that people filled out, although that is not necessary if you want to comment, but we will start with those. Commissioner Byron, would you like to --

COMMISSIONER BYRON: Absolutely, Ms. Korosec, and my apologies for not being here to hear all of the presentations, but I did want to come back and make sure I heard public comment. I do have some blue cards and these are just a courtesy that we take them in the order received, but it does not prohibit anyone else from speaking that wishes to do so. However, if you indulge me, I will just call them in the order they were handed to me. The first public commenter requesting to speak is Carl Walter, ACRE, which I believe is -- well, you will have to describe the organization, Mr. Walter.

MR. WALTER: It is -- I am really speaking for myself. ACRE is the Advocates for Clean Responsible Energy, and it is an organization of engineers and metallurgists and people who have worked in the nuclear field for 20 years, and most of us are retired. I have prepared some comments, a very short list of comments for today's meeting. I have addressed the Commission previously on two occasions, and you can find more detailed information in those dockets and I will not bother reading those numbers to you now, but they are in the paper I turned in.

COMMISSIONER BYRON: I do have them in front of me.

MR. WALTER: Good. Both of these documents address the need for nuclear power in California. But apparently their valuable content has fallen on deaf ears because nothing has happened as a result of these documents. Basically, my position is that California needs to be putting in considerably more nuclear power plants if it is to meet its needs for electricity in the future that is safe, clean, reliable, and economical. Nuclear power can be sustainable for centuries by utilizing advanced design concepts. In order for California to be a leading proponent of this new technology, the Warren-Alquist Act of the 1970s must be repealed to allow the construction of new nuclear power plants within the state, and justify research in the area of advanced designs. This current workshop on advanced generation and public interest energy research must include three recommendations, 1) to repeal the Warren-Alquist Act, 2) to support deployment in our state of existing designed nuclear electric power plants, and 3) to support research of advanced multi-purpose nuclear power plants that can provide electricity, heat, hydrogen production, and sea water desalination. Thank you.

COMMISSIONER BYRON: Thank you, Mr. Walter. The next card I have is Mr. Edwin Sayre.

MR. SAYRE: Sayre.

COMMISSIONER BYRON: Sayre, forgive me.

MR. SAYRE: I am also here representing ACRE, retired engineer who has built nuclear power plants and maintained them all around the world. What I want to talk about is smaller nuclear power plants, 10-200 Megawatts that are ideal for California's future. So nuclear power plants are under development that may have the potential for being throttleable and still maintain efficiency and be economical. The ideal design is from 30-100 Megawatts capacity and to be able to turn it on in minutes' time and pick up the load in the Grid and to be turned off when they are not needed, with solar and wind power prevailing. Some of the small nuclear power plant designs can be turned on in a few minutes, but they can be collected in groups and operated in varying percentages of outputs of the grid in order to keep the grid stabilized and to take care of the off and on problems with your renewables. One of those is a -- and this is kind of an old system, this is a small gas cooled, throttleable nuclear power plant that was developed back in the Aircraft Nuclear Plant Program during the 1950s, and these concepts can probably fulfill these needs with the improved performance gained in advanced technology over the past 50 years. I have figures in here that people can see, that have these. There is a sketch of a small fast nuclear reactor power plant with total cycle of noble gas going from the compressor through the electrical heater, fast reactor, and through the turbine, and it is used to start the power in just a few seconds, which can be used and destabilized when you are working with the wind and solar power. Another one that is being developed by a company now is the New Scale nuclear power plant, another possible small nuclear plant that can fulfill the variable needs in the power -- 40 Megawatt water cooled reactor. While it will not be efficient to turn on and off in a very few minutes, a group of them can be put to the grid and operated on a percentage basis to regulate the input variations on the renewables. Another one is the Hyperion nuclear power plant and it was actually developed at Los Alamos Nuclear Lab and it is being done now by a commercial group, and the Hyperion nuclear reactor is a new unique design with Uranium hydride fuel, with the hydride fuel and a hydrogen atmosphere inside a hot chamber, the reaction is automatically controlled and a very safe system. The heat is generated to an extent so a heat exchanger can provide steam for a steam turbo generator system. The fuel in this reactor is a performance of eight to 10 years, and it makes it possible for the reactor to be placed in a chamber, underground, for a very safe environment, and instead of refueling on-site like most nuclear reactors, this reactor is replaced after it runs low on energy and they take the reactor out, back into the factory, and re-do it to go into another new plant. The last one to talk about is one that is being developed at Lawrence Livermore Laboratory. You may have heard of that, it is called LIFE, it is a Labor Initiated Fusion Fission Energy nuclear power plant. This kind of power is under development there and the concept is fission and fusion combined. What you have is -- it will be a long time in development, but it will have many advantages in the future because it does have major safety situation, you never have complete fusion, it never has a possible meltdown of a fission plant, and it has a possibility of being throttleable and to be turned on and turned off. All of these types of plants, there are major sources of throttleable electric power to integrate with our renewables that we are pushing for California, and they are gas turbines and small hydro plants, and even some small coal power plants. But the thing about it is, with the nuclear, you can integrate these small nuclear plants with the renewables and have a good stable grid situation.

COMMISSIONER BYRON: Thank you, Mr. Sayre. Mr. Bryce Johnson.

MR. JOHNSON: Thank you. I will be speaking on behalf of myself, as well as ACRE. I am a retired nuclear engineer with 47 years experience in this field. That makes me prejudiced toward nuclear energy, but prejudiced does not equate to being wrong anymore than lack thereof equates to being right. When choosing energy sources, it is necessary to consider a few attributes such as longevity, which is the amount of the source, cost, energy efficiency, and safety are also paramount. It is difficult to determine the order of importance of these attributes because they are all interrelated. I will also discuss a subset of safety which is the lack of harmful emissions, since it is specifically treated because of the current national obsession with greenhouse gasses and global warming. Only solar and wind energy of the renewable sources will be discussed here because these are the cornerstone of the CEC Energy Policy, and because they have the greatest potential for expansion. In terms of longevity, wind and solar are forever, so they easily claim the prize in that attribute. U.S. Coal is estimated to last 250 years; oil is but a few decades away, at best, from becoming prohibitively expensive, even though not entirely extinct. Natural gas has been recently augmented by the development of horizontal drilling and fracturing its shell deposits to bring new source back from the brink of extinction. This is fortunate, in part, because natural gas can replace oil readily, as a fuel for internal combustion engines, which are essential for maintaining our current civilization. But this silver lining has a cloud. These wells have significantly less gas than the traditional gas well and they have greatly increased the number of wells required per unit of gas production. These facts do not bode well for sustained natural gas supplies, but they may still provide a bridge from the inevitable oil shortfall to a more sustainable means of maintaining our life preserving internal combustion engines. In contrast to oil and gas, nuclear energy sources are so huge that they can actually be treated as renewable. Both Thorium and Uranium, which are abundant elements in the earth's crust, can reproduce a staggering amount of energy per unit weight, typically 2 to 3 million times as much as that of fossil fuels. However, in the current power reactors, only five-tenths of one percent of the mined Uranium readily undergoes fusion. That still amounts to a

15,000:1 energy production advantage over fossil fuels. Advanced reactors have been developed primarily in the United States that convert the initially non-fissile portion of the Uranium, which is U238, to that which can fission and thereby increase energy production by one hundred fold. And the United States has sufficient U238 that is already mined and separated to supply its entire energy needs for over 700 years in these advanced reactors. Unfortunately, it is our Government's policy not to deploy these reactors. Well, France, Russia, and Japan utilized the technology developed in the United States to vastly multiply their energy resources. Energy efficiency is measured by the energy payback ratio, that is, the ratio of energy output to the energy input required to produce this output. Its common measure is called "energy payback ratio." EROEI, hard to get that straight, is another common term for it, and it can vary from nearly zero to very large numbers. It significantly impacts the cost and longevity of the source. While the EPR is simple in concept, it is determination is difficult because of the great many factors contributing to energy input and the difficulty in determining appropriate values for these. These problems create a wide range of individual EPR estimates and provide ample opportunity for biasing the results. Typical EPR values for our common energy sources are as follows: for the advanced nuclear fuel cycles, an energy production ratio of greater than 1,000 can be attained. Next comes hydroelectricity, which is generally in the range of the low 100s, current once-through nuclear cycles using centrifuge enrichment comes in at 51, coal is 19, current once-through nuclear fuel cycle with diffusion enrichment is 19. The reason for the difference between these two types of nuclear cycles is that the fusion and enrichment is an extremely energy intensive process. When --

COMMISSIONER BYRON: Mr. Johnson, forgive me for interrupting. I think, if I am following what you are doing, you are reading from your five pages and you have about three more pages to go --

MR. JOHNSON: No, I have only -- I only have one and a half pages to go. So if you would let me finish, I would appreciate it. I will try to speed up. I will hurry through these. When you count for intermittency, it is 18, natural gas is 12, oil from Saudi Arabia is 10, liquid natural gas is 6, solar thermal is 6, solar electric is 5, U.S. oil is 3, and Ethanol and biodiesel range from less than one to 2.5, and that depends on who is doing the analysis. The corn industry gets 2.5 and universities get less than one. Canadian tar sands, they get from less than one to 2.5, the same amount. So the people from the tar sands interest industry get 2.5, and people from Quebec

Hydro get less than one. Similarly, we have cost numbers. These numbers are from Europe. It seems that the United States energy organizations are determined not to commit to a side-by-side comparison. The numbers represent an average of between 2005 and projections to 2030. Gas is 4.325, which is in terms of hundredths of a Euro, which is about a penny, coal is 5.3, nuclear is 4.75, wind is 7.8. There is no reason to expect the United States or California to differ so significantly from these figures. Gas, coal and nuclear are all within a few percent of one another, but wind is almost double any of these, California's latest public show of electricity cost is with $.22 per Kilowatt hour. It is claimed, however, that it can be reduced to $.13. If we give it credit for reducing by at least half that amount, we find that wind is more than twice -- solar is more than twice the cost of wind, and more than three times the cost of nuclear or fossil fuel. California is basing its electric future on the world's two most costly sources, and the state is paying an exorbitant subsidy for these sources when it is already up to its eyeballs in debt. Below, as a means of addressing the emissions thing, we have the amount of carbon released per Kilowatt hour developed in Japan. Coal has 950 grams per Kilowatt hour, gas for thermal purposes has 882, gas for combined cycle electricity has 480, solar voltaic has 66, wind has 16.2, and nuclear has 15.3, and hydro has 7. Gas is not significantly different than coal in carbon emissions, and even by CEC's projection, we will be mostly using gas for decades to come. Nuclear matches exceed all other items in sustainability, efficiency, and cost, and hydro and nuclear are the best relative to carbon emission. But the state government maintains a law against nuclear power and hydro sites are all used up. So we are stuck with wind, solar and natural gas for the future. The only thing wrong with this limitation is that it is inadequate for our future energy needs. The sustainability of natural gas is by no means assured, and the conventional wisdom among energy experts, including the President of the American Wind Energy Association is that renewables of wind and solar can never exceed 20 percent of our energy needs. Beyond that level, the intermittency imposes impossible restrictions. The CEC calls for us to achieve 30 percent in 10 years, the same president of AWEA, the American Wind Energy Association, has said that it will require 30 years to achieve even 10 percent. The CEC plan is totally devoid of any realism. The state currently bans nuclear energy because a waste repository must be licensed and reprocessing of used nuclear fuel has to be achieved. Since the national government has cancelled both of these projects, permanence of this ban seems assured. But without reprocessing, we will never achieve the closing of the fuel cycle, and we will never expand our energy capacity by the factor of 100 that this enables. Further, the irrational fear of nuclear waste that has been allowed to invade the national psyche is probably the greatest hoax that has ever been perpetrated on a large group of people. Nuclear waste has never been and never will be an issue. Used nuclear fuel has been safely handled for over 50 years in this country with no incident and no one being harmed because of the effectiveness of those procedures that are in place. Due to its radioactive decay, the used fuel can be safely handled within 15 to 20 years of removal from the reactor. There is no necessity for millions, tens of thousands, or even many hundred years of storage, and it does not have to be stored underground. We routinely deal with hazards that are hundreds of times more likely to harm us than nuclear waste, and we completely ignore them. But I have digressed from the CEC Energy Plan. I did that because nuclear power is the only means of solving California's energy problem, and I wanted to explain the folly of holding it hostage to reprocessing and the nuclear waste issue. I would like to summarize our current CEC Energy Plan as a means to guarantee that California will be the first political entity to suffer the cataclysm of an energy shortfall and also to assure that we pay the world's highest price for energy that we could manage to produce on our way to this economic oblivion. Thank you.

COMMISSIONER BYRON: Thank you, Mr. Johnson. Mr. Robert Williams is next.

MR. WILLIAMS: Thank you, sir. I am going to -- I assume you have a copy of my prepared remarks --

COMMISSIONER BYRON: I do.

MR. WILLIAMS: And I am willing to try to depart from them in order to adhere to the time line. I, too, am a retiree first from the U.S. Navy, then from General Electric, where I designed water reactors, and then for Electric Power Research where I was a Program Manager in the Fuel Cycle area, specializing in high level waste disposal and spent fuel storage, and finally, a consultant to the DOE on a part-time basis after my retirement in 1994. I am trying to -- I have testified the last three years to the CEC about how the essence of the Warren-Alquist Act has been achieved, and my prepared remarks do address that. I am searching for a political compromise, some way that the CEC staff can start to include nuclear power in their studies, so that some of the advantages, the cost advantages, the siting disadvantages if there are any, can be addressed. It strikes me that somebody like yourself and like the manager of this program could propose to the Legislature that you begin some studies on the basis not that the Warren Alquist Act be repealed, but that a bypass, an exception for two plants to be a demonstration plant of some sort would be advanced and the loophole, then, would be to study the type of two plants. The two plants might lead to four plants, with one being -- or with two of them being desalinization demos and two of them being power demos, and you might even get it up to six plants if you said one of them, or two of them need to be high temperature reactors that produce hydrogen for this clean fuel economy. So my prepared remarks outline why I think the requirements for reprocessing and waste disposal have been adequately demonstrated, that they might justify this demonstration amendment to the Warren-Alquist Act. One of the main reasons for doing that is we are on the verge of conceding a trillion dollar industry. It would be like deciding that we are not going to make jet airplanes, even though we pioneered them and have the Boeing Company. We are conceding a trillion dollar industry, which is the nuclear power industry, to the French, and the Japanese, and pretty soon the Chinese, who are in the process of building 50 of them over the next 20 years. I hate to see our kids lose that job opportunity. I also believe that the United States requires some effort to reindustrialize. So that brings me to point 2. The solar energy and wind energy technologies are very modular and relatively small. My understanding, from talking to my stockbroker, is that the best solar energy company on the market today is a Chinese company that already has 50 percent of the market in a particular kind of solar panel. General Electric is doing worldwide sourcing of its wind turbines. So the bottom line is that we will have almost as big a balance of payment, deficit, buying these green energies, even though Nancy Pelosi says the main reason for wind and solar is jobs, jobs, and jobs. The thing that will really lead to jobs in the United States is big nuclear plants that have got a lot of concrete and Rebar and heavy section pressure vessels that are not as practical to build overseas as they are here. So these will lead to good manufacturing jobs, good construction jobs, and jobs in the United States. In my view, the United States desperately requires reindustrialization. The third point, very briefly, has to do with water. I think water will be as big a crisis as energy if there is global warming, and some of your remarks by the staff here, I think, bear that out. The point I would make is two-fold. I would have the staff study canals from British Columbia and Alberta, Lake Kootney is a long lake on the Canadian-U.S. border, and it is in a perfect elevation to have an inland canal from Canada down to Nevada and even approach in California. But the second thing we need to do is consider desalting plants that are powered by nuclear power, and the reason for doing that is that the thermal energy which is the cost driver for these things, is by far the least expensive of any of the energy options that we can consider that are not very intermittent. So as an expert on the fuel cycle, I can tell you that nuclear energy, even if we triple the price of Uranium, will still stay under a dollar per million Btu's and this will compare to natural gas, you know, in the last few years it is has been $4.00 per million Btu's, and oil is at $6.00 per million Btu's, headed higher. So I think a good case could be made for two, or four, or six demonstration nuclear plants, and that is not woven into my argument here in the written papers, but that might be the vehicle for the compromise that we need, first for the studies to start considering nuclear power, and then, second, for the state to really start to get on the bandwagon before the ship leaves the station. Thank you.

COMMISSIONER BYRON: Thank you, Mr. Williams. The next card I have is Mr. Bob Burt.

MR. BURT: I am Bob Burt, Insulation Contract Association, and you might gather from my association, my principal concern is the commercial side of energy efficiency. I would add that I have been greatly impressed by the comments I have already heard. I have two very brief comments, one, apparently the people who make decisions on money are under the impression that the much maligned deniers will turn out to be right because there seems to be very little action on this program when it comes to spending money. My second point is that, in view of the large numbers of dollars that people are talking about spending in this program, even though near term there may not be that much, since this is an IEPR meeting, let me suggest that the people -- some of the people -- tasked with this workshop be further tasked to try to make a guess as to the near term expenditures in this program, so that the avoided cost menus that we have could be updated. The reason for that is that there are a number of presently marginal energy efficiency measures which would suddenly become very effective, and the value, as the IEPR points out, of managed efficiency is that Kilowatt hour which is not doing it at all, does not send out any greenhouse emissions. That closes my comments. I welcome questions.

COMMISSIONER BYRON: Thank you, sir. That is all the blue cards I have. Is there anyone else that wishes to make public comment at this time? That being the case, we are at the end of the agenda. Let me just provide a few closing remarks.

Once again, I think this subject, the advanced generation technology, at least to me, indicates again how energy and environment issues always seem to intersect. California has set the highest environmental standards than the rest of the United States with regard to CO_2 air emissions, water use impact on marine biology, and of course we recognize that energy efficiency is the key -- the first key that we use prior to trying to generate additional electricity, and there is some recent studies that indicate from the Department of Energy that there is a great deal more energy efficiency to be had, and this Commission will pursue that, and is doing so with its goals. But we need and depend upon technology advancement and generation in order to pick up the shortfall, if you will, the necessary generation that we need to run our economy.

I think the input that we received today is extremely valuable. I particularly appreciate the comments of all of the folks that commented from ACRE and on behalf of themselves on behalf of nuclear. In my mind, it is clear that nuclear is going to continue to play a role in reducing CO_2 throughout the world. Gentlemen, I was at a meeting last week of the Electric Power Research Institute's Annual Summer Meeting and a number of utility executives from around the country, and they did some real time polling, and it is interesting, when asked the question, how will they -- in what way do they see reducing CO_2 to be most effective, it was not renewables, it was not energy efficiency, it was not carbon capture and sequestration, more than 80 percent of them said nuclear. So, in all likelihood, nuclear will continue in some way in this country, but as many of you indicated, we do have a limitation here in California, namely the laws as currently written. Oh, and I should add, there were some other really interesting examples. South Korea has an incredibly successful program in this regard, and they are headed down the nuclear path, and some of you mentioned obviously the French and the Chinese. But we have had this moratorium on nuclear in the State of California for over 30 years, primarily based upon the closing of the fuel cycle. We have had workshops in this Commission in attempts to try and make findings that we think would stand up in the Legislature and have not been able to do so. I would only offer -- and it is off topic, somewhat to what we are trying to do in today's workshop -- but I would only offer that any changes towards an attitude in nuclear in this Commission and in this Legislature would have to start in the Legislature. As you know, there are individuals that have attempted to put forth legislation, that have not been successful getting it out of committee, but that is really where that change will need to take place. I appreciate your being here and for your comments. I read them in entirety and will of course consider them, but I think you understand the limitations that we are facing under the law. If there is nothing else to add at this point --

MS. KOROSEC: I just wanted to remind people that written comments are due on August 17th and also for those on the WebEx who are callers and are not identified by name, if you do want to have any additional information, please contact Avtar Bining and his contact information is on his presentation that was given at the beginning of the day today.

COMMISSIONER BYRON: Thanks to all of you for being here and to the staff for the workshop. Well done. We will be adjourned.

(Whereupon, at 2:48 p.m., the workshop was adjourned.)

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REPORTER'S CERTIFICATE

I do hereby certify that the testimony in the foregoing hearing was taken at the time and place therein stated; that the testimony of said witnesses were reported by me, a certified electronic court reporter and a disinterested person, and was under my supervision thereafter transcribed into typewriting.

And I further certify that I am not of counsel or attorney for either or any of the parties to said hearing nor in any way interested in the outcome of the cause named in said caption.

IN WITNESS WHEREOF,

I have hereunto set my hand this 17th day of August, 2009.

Peter Petty CER**D-493