

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

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P R O C E E D I N G S

1
2 AUGUST 10, 2009

9:06 a.m.

3 MS. KOROSSEC: We will go ahead and get started
4 here. Good morning, everyone. I am Suzanne Korosec. I
5 lead the Unit that produces the Energy Commission's
6 Integrated Energy Policy Report Unit, or IEPR. Welcome to
7 today's Staff Workshop on Advanced Generation Technologies.
8 The purpose of today's workshop is to present a preliminary
9 staff assessment on the current status of Advanced
10 Generation Technologies, to get public comment, and also to
11 discuss research and development opportunities that will
12 help the state achieve its goals to reduce statewide
13 greenhouse gas emissions, increase the amount of combined
14 heat and power capacity in the state by as much as 4,000 MW
15 by 2020, moving to net zero energy commercial buildings by
16 2030, and repowering or replacing aging power plants with
17 cleaner technologies.

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

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

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

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

18 For presenters and commenters, we ask you to
19 please speak very closely into the microphone; although it
20 sounds very loud here in the room, it is not very loud out
21 on the WebEx, so for the parties who are listening in, it
22 would be very helpful if you could remember to do that.
23 During the public comment period today, we will hear first
24 from folks in the room, and then we will open the lines to
25 hear from the WebEx participants. And for parties in the

1 room who make comments, you will need to come up to the
2 center podium and use the microphone there, and it is also
3 very helpful if you can remember to give the Court Reporter
4 your business card, so we can make sure that your name and
5 your affiliation are spelled correctly in the transcript.
6 We are also asking for written comments, and those are due
7 by 5:00 p.m. on August 17th, a week from today. So with
8 that, I will turn it over to Commissioner Byron, if you
9 would like to make some opening remarks.

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

19 Besides chairing these various committees and
20 being a Commissioner, I am a closet engineer. I have a
21 generation and technology background and a great deal of
22 interest in seeing development of these new technologies.
23 The purpose of this workshop is to discuss and receive your
24 input on the status of advanced generation technologies, and
25 also on our research, development, and demonstration needs

1 going forward, which is part of developing a roadmap, if you
2 will, for the Advanced Generation Program within our public
3 interest energy research division.

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

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

1 Commission staff, Avtar?

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

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

20 A little bit of background about the Advanced
21 Generation Program. Formerly, it used to be called
22 Environmentally Preferred Advance Generation, in short,
23 EPAG, and we tried to make it short as Advanced Generation
24 Program, and it is one of the eight research focus areas of
25 the Public Interest Energy Research Program. As you will

1 see through these presentations, that Advanced Generation
2 Program is very interlinked with all these other research
3 programs of the Public Interest Energy Research, and over
4 about 10 years, since 1998, when PIER was established, in
5 Advanced Generation Program, we have invested about \$102
6 million, which is roughly about 20 percent of the total PIER
7 investment. Advanced Generation Technology we see as an
8 opportunity for developing clean, reliable, affordable,
9 secure and sustainable power in California. All these
10 years, the focus of Advanced Generation Program has been
11 distributed generation and combined heat and power systems,
12 and in the beginning, the focus was how to reduce criteria
13 pollutants for prime movers like endurance turbines and fuel
14 cells. Then, around 2005, that focus shifted more towards
15 packaged systems for combined heat and power, and combined
16 cooling and heating power systems. And also, we developed
17 some analysis tools for assessing, designing, testing and
18 monitoring of these systems.

19 This small table is a very kind of qualitative
20 assessment of some attributes of different distributed
21 generation and combined heat and power technologies in terms
22 of fuel cells, hybrid fuel cell gas turbine cycles,
23 reciprocating engines, steam engines, micro turbines, gas
24 turbines, and also combined heat and power, and combined
25 cooling heating and power packaged systems. The attributes

1 that we normally look at are efficiency, emissions, cost,
2 and reliability and durability. On this chart, I am using a
3 couple of notations; one is cross mark, the other is a tech
4 mark kind of sign, and then there is a color scheme of
5 green, orange, and red. If it is like a cross mark, that
6 means it is not very good, pink, and if it is a tech mark,
7 it is more like it is good, green means it is acceptable,
8 orange means it is good, and red means that it is not
9 acceptable. So, as you can see here, fuel cells, they are
10 efficiency-wise pretty good, acceptable, emissions are good
11 and acceptable, cost is not, and reliability and durability
12 is still uncertain. Same thing goes pretty much with the
13 hybrid fuel cell and gas turbine cycles. In the case of
14 reciprocating engines, efficiency is reasonable, it is
15 acceptable, but emissions are not. Cost is pretty good,
16 reliability durability is pretty good. Steam engines
17 efficiencies are low, emissions are acceptable, cost is not,
18 durability reliability is not. Micro turbines, there again,
19 efficiency is low, but still it is acceptable in the sense
20 that, when you combine it with combined heat and power
21 packaged systems, you can still recover heat. Emissions are
22 acceptable, reasonably good, cost is okay, but, again,
23 reliability, durability, though it looks good, but it is yet
24 to be proven. Gas turbines that are slightly larger size,
25 their action is good, acceptable, emissions are good,

1 acceptable, cost is pretty good and acceptable, and
2 reliability durability is also acceptable and good, but
3 still there is room if we can move those towards green
4 signs. Then comes combined heat and combined cooling and
5 heating and power packaged systems, they efficiency is very
6 very good, emissions can be acceptable depending upon what
7 prime mover we are using, cost is reasonable, and the
8 overall attributes are reasonable. But, as you can see,
9 still there is room for improvement, and that is our hope
10 that with the future R&D, we can improve on these kinds of
11 typical attributes of these systems.

12 Then, moving forward, as I mentioned before, up to
13 2005, we focused on prime movers, after 2005 until 2008, we
14 focused on packaged systems. And moving forward from 2009
15 onward, we are considering including a full range of
16 advanced generation technologies which can help and show
17 progress in meeting California's energy policy goals. But
18 as we all know, resources are limited and always are
19 limited, so we will need some prioritizing of those
20 different technologies. I probably divided these advanced
21 generation technologies into three groups, small, medium
22 industrial scale, and larger scale, and they are just
23 general examples. On the small scale, we have distributed
24 generation combined heat and power, combined cooling heating
25 and power systems, but our focus could be on packaging and

1 integration of those. And typically they range from a few
2 hundred Kilowatts to up to about 20 Megawatts. Then, we get
3 into medium and industrial scale; again, similar systems for
4 the first one, but then we also get into co-generation
5 systems and the focus is more on the industrial
6 applications, and usually they are ranging about 20
7 Megawatts to less than 50 Megawatts. Then, we get into the
8 larger scale where these are 50 and up kind of systems, and
9 then we want to consider some of the advanced gas turbine
10 and integrated hybrid cycles.

11 And with that in the background, we started or,
12 rather, embarked on a roadmap exercise for the Advanced
13 Generation Program, and today's workshop is part of getting
14 the input from stakeholders because it is critical for our
15 roadmap process, and also we want to take this opportunity
16 of integrating our 2009 IEPR proceedings so that we can take
17 full benefit of the hearings, and also the policy and some
18 of the other activities that have been going on. And today
19 we are asking -- seeking your suggestions and ideas on
20 advanced generation research and development, as well as
21 input, feedback on the PIER Advanced Generation Vision, the
22 preliminary research opportunities, and target issues. And
23 this is kind of our preliminary list of some of the
24 questions that we have been pondering about this workshop
25 and this workshop's goal, and stakeholders' input, but this

1 is not the exhaustive list, this is just a partial list,
2 and we want -- we seek your full participation, your
3 comments, your ideas, to be presented not only in this
4 workshop today, but we will have other opportunities. And
5 before going into the detail about each of these questions,
6 we will present these questions again after the afternoon
7 presentation from Navigant, and we will have full discussion
8 based on that information, as well as the information which
9 will be presented during morning sessions.

10 Other opportunities that we have been considering,
11 one opportunity was on July 23rd, there was a committee
12 workshop on Combined Heat and Power, then today's August
13 10th, this is our staff workshop on Advanced Generation
14 Technologies, and we are also planning to have a WebEx
15 meeting with stakeholders on September 3rd, from 9:00 a.m. to
16 12 noon so that we can get additional comments. And then
17 all of that information, we will provide in the IEPR
18 proceedings, also. Our roadmap process will continue after
19 today and we hope that we will be able to finish our roadmap
20 document by the end of September, and then, from there on,
21 we will go for the implementation plan of that roadmap. And
22 hopefully in the future, we will update that roadmap and we
23 will seek your input and your feedback in future years,
24 also. My contact information is here, I can be called at
25 (916) 657-2002, and my e-mail address is there. And with

1 that, I finish my presentation and we can move to the next
2 one. Thank you.

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

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

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

1 of Mojave, which is a large coal plant in Nevada that was
2 shut down.

3 There are a few specific drivers that we think are
4 important in the future, these have been mentioned already,
5 the renewable portfolio standard, AB 32 greenhouse gases and
6 its implementation, including SB 1368 and the emission
7 performance standard, increased use of combined heat and
8 power, and the retirement of aging power plants and once-
9 through cooling. The renewables standard calls for 33
10 percent -- by 2020 to be renewables, by energy. AB 32 calls
11 for a 20 percent decrease from the 1990 levels by 2020 and
12 an 80 percent decrease by 2050. SB 1368, the Emissions
13 Performance Standard, essentially prevents long-term
14 contracts for coal, and we expect this to result in little
15 financing being available for coal plants, and essentially
16 no new coal, at least for California's consumption. The
17 increase in use of CHP, we have goals -- the AB 32 Scoping
18 Plan calls for 4,000 Megawatts of coal by 2020, along with
19 82,000 Gigawatt hours of generation.

20 This is a pie chart that relates to those goals.
21 The other category here indicates essentially natural gas
22 that is not once-through cooling, not aging, not any of
23 these specified areas. It includes hydro and renewables.
24 These other large sectors, nuclear, other aging gas-fired,
25 new OTC, these total to about 38 percent of the total

1 portfolio by capacity. Each of these -- the nuclear
2 plants, there are two nuclear plants in California, and they
3 are up for repowering. Other aging -- all these other
4 groups potentially will be changed in one way or another
5 with the current targets, so a large percentage of the
6 portfolio by capacity is going to change. This shows the
7 same break-out, but here it is by generation, Gigawatt
8 hours. We can see immediately that it is a small share.
9 Again, the nuclear power is 11 percent, is approximately the
10 same, but overall, the total of these areas of -- targeted
11 areas, I guess we could call them, is 19 percent. And the
12 smaller share by energy compared with the larger share by
13 capacity really points to the fact that what is being
14 targeted will need to be replaced as capacity, the larger
15 share of capacity relative to energy.

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

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

25 California's electric portfolio has -- we control

1 these coal plants that are listed on the side, they are all
2 out of state, they are either controlled through long-term
3 contracts or through direct ownership. But the contracts
4 are phasing out. They have a term and they are not likely
5 to be renewed. And this shows that these contracts are
6 phasing out over the next almost 20 years, and that this
7 energy and base load capacity will need to be replaced.

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

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

20 The renewable targets, we have targets of 33
21 percent renewables by 2020. Part of reaching the target
22 will force us to integrate -- a large share of these
23 renewables are like, currently, wind and solar, and if that
24 continues, we will face an issue about integrating a large
25 share of wind and solar into the system. Wind and solar are

1 intermittent resources, they have a daily and a seasonal
2 pattern of generation, but even around that daily and
3 seasonal pattern, they are extremely variable.

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

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

1 intermittent renewables.

2 The greenhouse gas policies, AB 32 has a target of
3 20 percent below 1990 levels by 2020 and 80 percent by 2050.
4 Advanced generation can have two roles in supporting these
5 policies, one, directly through higher efficiency of burning
6 the fossil fuels or other commodities, and indirectly,
7 again, with the role of the development of an integrated
8 system with increased shares from renewable intermittents.

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

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

23 MS. KOROSK: Alright, now we will be moving into
24 the section where we have the cutting environmental aspects
25 of advanced generation in California. And we will begin

1 with an introduction by Marla Mueller.

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

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

15 DR. BROUWER: Thank you very much, Marla. I am
16 pleased to have received the support of Marla, in
17 particular, but also of the California Energy Commission
18 over several years to enable us to do this research. I also
19 want to thank my collaborators, Professor Scott Samuelson in
20 our group, but also Professor Donald Dabdub of the
21 Computational Environmental Sciences Laboratory at UCI. I
22 am going to give an overview of the methodology and tools
23 that we have developed, and then talk about the regional air
24 quality impacts of advanced generation technologies, and
25 provide a brief summary. The methodology that we have been

1 able to develop is one that can look at various future
2 technologies. Examples of that include electric vehicles,
3 they include plug-in hybrid electric vehicles, or fuel cell
4 vehicles, or other infrastructure, like energy
5 infrastructure, new types of electric grids, or hydrogen
6 infrastructure, but in particular the focus of our efforts
7 to date has been on distributed generation and this is an
8 example of a fuel cell installation, one of the distributed
9 generation technologies we have considered, but there are a
10 whole host of distributed generation technologies that we
11 include in our analyses, including gas turbines,
12 microturbines, internal combustion engines, and the idea
13 here is to look into the future and then to develop as a
14 result of a significant and robust methodology new spatially
15 and temporally resolved emissions that we can introduce into
16 a 3-D air quality model, so that we not only assess the
17 emissions, but also the resulting air quality impacts by
18 considering the atmospheric chemistry and transport. From
19 that, we can get air quality impacts and provide feedback to
20 the scientific community to regulatory bodies and the
21 general public.

22 So how do we spatially allocate these emissions?
23 We use a strategy whereby geographic information systems
24 data is used to allocate various distributed generation
25 technologies according to the local land use. So, for

1 example, if there is an industrial site, or industrial land
2 use, you could expect there to be a higher likelihood that
3 they would adopt a gas turbine combined heat and power
4 system, for example. Whereas, in a residential area, you
5 might only have consideration of quiet fuel cell technology
6 or photovoltaic technologies.

7 This is an example of the GIS data that we use in
8 the Long Beach area, but we also have data throughout the
9 San Joaquin Valley, another area that I will show you. And
10 you can see here that the Geographic Information Systems
11 data can allocate our emissions spatially in various areas
12 throughout the state. We also have to allocate these
13 emissions temporally because the time at which the emissions
14 are released into various air basins has an impact on the
15 resulting air quality. So, for example, if we are looking
16 at the air quality associated -- or the emissions associated
17 with the residential sector, you can see them in this upper
18 chart here, the typical operating end-use electricity
19 profile has a peak that occurs in the evening, whereas, in
20 the commercial sector, you may have peaks that occur during
21 the day, or in the evening, depending on the type of
22 commercial application one is considering. So we spatially
23 and temporally allocate these future emissions, and then add
24 them to the overall emissions that we expect in the future,
25 and then we solve this governing dynamic equation, which

1 takes into account the convection and the advection, as
2 well as all the sources and sinks, the aerosol atmospheric
3 chemistry, and the gas phase atmospheric chemistry. And to
4 do this in the South Coast Air Basin, we use the SCAQS
5 study, the Southern California Air Quality Study of 1987, as
6 the meteorological input. In the Central Valley, we use the
7 CCOS Study which measured the meteorology in the summer of
8 2000, and the CRPAQ Study which measured in over two years,
9 in December of 1999 through February of 2001, the
10 meteorology associated with particulate matter episodes. So
11 what we are considering is meteorology associated with high
12 PM and/or high ozone concentrations in these basins. And we
13 do this both in the Central Valley, as well as the South
14 Coast Air Basin.

15 So this is what kind of results. If you look at
16 the air quality, this is ground level ozone plotted on an
17 hourly basis, for a future scenario occurring in this year,
18 2023, the year that we need to have compliance with federal
19 standards in the South Coast Air Basin. And what you see is
20 that, typically, ozone will build up in the eastern portions
21 of the basin, and also exceed federal standards for a
22 certain period of the day in the late afternoon. We can
23 also predict 24-hour particulate matter. In this particular
24 case, this is PM 2.5. Since the standard is based on a 24-
25 hour average, that is what I am showing here, and what you

1 can see is that there are relative peaks in the Long Beach
2 area and in the Riverside area, Long Beach due primarily to
3 direct emissions of PM, and in Riverside due to direct
4 emissions plus secondary organic air cell formation.

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

16 Now, if we were to add DG emissions to these cases
17 and show you these plots, they would look relatively similar
18 because the introduction of DG introduces a very small
19 amount of emissions. As a result, most of my plots that I
20 will show you today will be difference plots, and that is
21 what I am showing here for the case of one hour ground level
22 ozone, for a generic case. So what you see in the middle of
23 this, the green represents no change for the added emissions
24 of DG. But if you have a reduction due to the introduction
25 of this new technology, then it will appear to tend towards

1 blue. If you have an increase in resulting atmospheric
2 concentrations, it will tend towards the yellow or red.
3 Okay, so you can see in some times of the day, because of
4 the introduction of distributed generation, you have
5 reductions in ozone; other times, in other locations, you
6 have increases due to the same introduction of new
7 technology.

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

1 particular case, the peak difference in ozone concentration
2 is about 1 ppB for a 45 percent market penetration.

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

11 We have also studied the impact of distributed
12 generation versus introducing central power into similar air
13 basins. In this particular case, I am showing the
14 difference between central generation as installed at
15 Huntington Beach versus distributed generation in the same
16 generation amount, okay, the same generation amount. Both
17 cases introduced 1,200 Megawatts of new generation. So on
18 the left-hand side, you see the peak ozone difference and
19 peak PM 2.5 difference associated with the central
20 generation at Huntington Beach. And what you can see is
21 that there is a region downstream of the power plant that
22 actually experiences lower ground-level ozone
23 concentrations, but other areas that show about a 2 ppB
24 increase associated with a central power plant. Whereas, in
25 the DG case, for the same amount of power introduced, all of

1 the region shows a slight reduction in ground level ozone
2 concentrations. Similarly, for the particulate matter case,
3 you see the downstream of the central power plant you have
4 about a 2 microgram per meter cube increase in particulate
5 matter, whereas, in the case of the DG, it is relatively no
6 impact.

7 Now, one of the things I was asked to focus upon
8 was CHP. And we found in our study that CHP is very
9 important to air quality. And in most of the subsequent
10 plots, I am going to be plotting the difference plot of the
11 more CHP case on the left-hand side, and the less CHP case,
12 or even zero CHP, on the right-hand side. And what you can
13 see here, this is one of the realistic scenarios that we
14 investigated where 18 percent of the increased power demand
15 between 2007 and 2023 was met by a DG mix, and this DG mix
16 was mostly gas turbines, but also had a substantial amount
17 of internal combustion engines, and 4 percent fuel cells, 10
18 percent PV. In the case where we had more CHP, shown on the
19 left-hand side, 60 percent of units included combined heat
20 and power, displacing boiler emissions; in the case with
21 less CHP, only 10 percent of the units had CHP, and in both
22 of those cases, only 50 percent of the total waste heat was
23 actually recovered. Okay? Well, what you can see is that,
24 when we have more CHP, the ground level ozone concentrations
25 tend to actually have a reduction in ozone, whereas, it is a

1 relatively flat, or slight increase, in ground level ozone
2 associated with the less CHP case. If we try to bound this
3 problem by introducing all the DG with CHP on the left-hand
4 side, versus a case that has no CHP whatsoever, you can see
5 that there is a substantial basin-wide reduction in ground-
6 level ozone concentrations caused by using all CHP units,
7 whereas there is about a .5-1.0 ppB increase for introducing
8 DG with no CHP whatsoever. Now, these are not realistic
9 cases, but they are trying to bound the problem.

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

24 And finally, again, to bound the problem, what we
25 did was we did a case that had all CHP, with one set of DG

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

21 So in summary, we are grateful for Energy
22 Commission support that has allowed us to develop these
23 tools and, in particular, enabled us to rigorously analyze
24 the temporal and spatial impacts of various future energy
25 technologies. We have applied these tools to understand the

1 air quality impacts of many different future technologies
2 that focused on DG today. Low criteria pollutant emissions,
3 especially those associated with, for example, the CARB 2007
4 standards, I showed you one case there, or associated with
5 clean DG, like fuel cells, do result in cases where our air
6 quality goals are met. Combined cooling, heating and power
7 and combined heat and power are important technologies, as
8 we have heard already, with regard to reducing greenhouse
9 gases, but we have also found that they are really important
10 for improving air quality, as well. And we studied that
11 both in the South Coast Air Basin, as well as the San
12 Joaquin Valley. So I thank you for your attention.

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

21 DR. BROUWER: Yeah, with regard to health effects,
22 typically one would refer back to the federal standards or
23 the state standards for those quantities, and the federal
24 standards now for ozone are on an eight-hour basis, and it
25 is 88 ppB, I believe, for ozone. And any exceedence above

1 the 88 ppB, okay, is considered a violation just once
2 during a three-year period. So it is important, even one
3 ppB differences may result in exceedance whereas, otherwise,
4 you would not if you are concerned about that. On PM 2.5 --
5 oh, and at the state level, there is a one-hour standard
6 that I believe is 80 ppB. For PM 2.5, it is 65 micrograms
7 per meter cubed at the state level, and the federal, I
8 believe, is 100 micrograms per meter cubed. So these are an
9 order of one percent to two percent differences that I am
10 talking about.

11 COMMISSIONER BYRON: Right.

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

14 COMMISSIONER BYRON: Alright, thank you.

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

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

19 MR. O'HAGAN: Good morning, Commissioner Byron,
20 good morning. My name is Joe O'Hagan. I am in the PIER
21 Environmental Research area dealing with Aquatic Resources.
22 My co-author for this morning's presentation is John
23 Maulbetsch, a consultant who did a lot of the power plant
24 cooling research that PIER has funded. Avtar asked me to
25 talk today about water issues for advanced generation and,

1 in one sense, it is the -- the water issues are actually
2 old, these are issues that are going way back since the
3 Germans started using dry cooling in World War II, and,
4 certainly, cooling tower issues have been with us for a lot
5 longer. So the question becomes why is water important.
6 Other issues I would like to address would be how do power
7 plants use water, sort of a brief review of cooling
8 technologies and their associated trade-offs, research, and
9 some of my thoughts on what we will be seeing in the coming
10 future in terms of power plant cooling. Now, I am focusing
11 on combustion, thermal technology, gas-fired for the most
12 part in California, but a lot of these issues apply equally
13 to geothermal concentrating solar power such as parabolic
14 troughs, certainly biomass plants, as well.

15 So why is power plant water use important? In
16 this somewhat cryptic figure up here on the right-hand side
17 of the screen is estimated water -- freshwater withdrawals
18 in California from the year 2000. This is U.S. Geologic
19 Survey data that was collected. And you can see that, in
20 the middle, on the right-hand side, is the thermal electric
21 power, it is these two narrow lines running from the saline
22 source -- surface water, rather -- and the groundwater
23 coming in the middle, and you can see, then, the relative
24 comparison on a statewide basis that power plant water use
25 is quite minor. You can see that the use of thermal

1 electric water on a statewide basis is quite minor,
2 however, on a local or regional basis, power plant water use
3 can be significant. We use the comparison that a modern
4 gas-fired combined cycle power plant can use about 3 million
5 gallons of fresh water a day, which is as much water as the
6 residence of a community of 12,000 people would use in that
7 same day. So there are real trade-offs in terms of water
8 use and what is the appropriate cooling technology, and it
9 is has been a major issue from my experience in the last 20
10 years on power plant siting, and I know it continues to
11 today.

12 One of the focuses of the PIER Program has been
13 reducing power generation's effects on fresh water supplies
14 within the state. How does a power plant use water? This
15 bar chart compares different technologies all the way from a
16 hypothetical nuclear and coal through oil, which you do not
17 see much anymore, gas, simple combustion turbines, combined
18 cycle, IGCC which, you know, we really have not seen yet,
19 solar thermal, which I believe, in that case, the parabolic
20 trough, solar PV, which uses no water to speak of, as does
21 wind, it uses none, and then bio-fuel. And you can see that
22 the major -- that blue color in the bars -- is for cooling,
23 that is, this is steam condensation, all of these
24 technologies use a steam turbine to generate electricity.
25 The one exception would be to use the simple combustion

1 turbine there, and the water use there is that darker color
2 is the water injection to improve the efficiency of the
3 turbine and things. So you can see that, based on
4 technology, based on cooling technology, water use can vary
5 quite a bit. This graph was based on re-circulating cooling
6 towers being used.

7 So the question is, is how can we use less water
8 without cost in energy efficiency penalties. And there are
9 two basic approaches, what we call degraded water sources,
10 which is using wastewater treatment effluent, contaminated
11 groundwater, contaminated surface water, brackish surface
12 water, or water conserving cooling technologies, primarily
13 dry cooling, though hybrid is also an option, which is
14 basically a hybrid between wet and dry cooling. Now,
15 degraded water sources, as I mentioned, there are different
16 possible sources, produced water which comes up with oil and
17 gas production, irrigation return flows, or contaminated
18 groundwater. The big problem with these different sources
19 is the consistent supply with consistent quality.
20 Certainly, there are real issues when you use poor quality
21 waters, the bio fouling corrosion, scaling of your heat
22 transfer surfaces will degrade the performance of the power
23 plant, there are disposal issues, basically there are
24 concentration as you run it through the cooling towers, so
25 you are going to have a pretty heavy brew that you are going

1 to have to dispose of, of the blow down. And then there is
2 also drift and health issues like Legionella. The big
3 issue, I think, the one thing I would mention is that sea
4 water can be used in cooling towers, there are about 50
5 applications in the United States that use it, there are
6 some penalties associated with it, it costs about 30 percent
7 more. There is a slight efficiency hit from using salt
8 water. I think, in California, the biggest issue is going
9 to be the drift because, for those air districts that
10 require offsets for PM10 emissions that include those from
11 the cooling towers using saltwater is going to be very
12 expensive, if you can find the offsets, much less afford
13 them. So that is a concern, but you can, in light of what
14 the State Board is proposing, technically, using saltwater
15 in cooling towers is feasible and has been demonstrated over
16 and over.

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

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

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

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

13 Now, wet cooling, which we are all pretty much
14 familiar with, uses significantly less water, but it does
15 consume more water. There is less water withdrawal, but
16 much of the water, as you can see in the picture there, is
17 evaporated away. This is a mature technology, it has been
18 around for quite a while. Most power plants use this
19 cooling technology, except for the older coastal plants and
20 on our Bays and Estuaries, that is the subject of the State
21 Board's policy. But if you are going to have a steam
22 turbine, generally using cooling towers, you do consume
23 water, what water is not evaporated becomes -- builds up in
24 salts in concentrations, and then you have to do what they
25 call "blow down," and then that raises disposal issues and

1 water quality concerns, it has a higher parasitic load
2 because, as you can see in this schematic, there are fans
3 that you need to keep the air moving, and since you are
4 dealing with warmer water, there is less plant efficiency,
5 and then there are also concerns over the visible plume, as
6 well as drift concerns.

7 Dry cooling -- this is air cooled condenser, this
8 is where you directly route the steam from the steam turbine
9 to a condenser, which is basically shaped as an A-frame, and
10 you run it through these different stoops which are fanned
11 to enhance heat transfer, you use no water at all for
12 cooling, so, for many power plants, we are talking about a
13 reduction of up to 95 percent of their water consumption.
14 You do not have a plume or drift issues, either. The
15 picture below, which is a power plant near Las Vegas is --
16 you cannot get the full feeling of it because of the wind
17 walls, but basically within that structure in the front is
18 an A-frame, these headers on top are what route the steam
19 there, and then they flow down the sides of the condenser
20 and then the heat is dissipated to the atmosphere.
21 Obviously, when there is warmer temperatures out, the
22 efficiency of dissipating that heat and condensating the
23 steam is lower, and that creates back pressure on your steam
24 turbine, and that will reduce generation. There is overall
25 lower plant efficiency because of that issue, there is also

1 a higher parasitic load because you really need a lot of
2 fan power to move that air through the condenser, then, as I
3 mentioned, once the ambient temperature rises above design
4 levels, you see a drop-off in plant efficiency, it takes a
5 lot of space, and it is subject more so than wet cooling to
6 wind effects, and I will talk more about that later.

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

22 Now, hybrid cooling, which is very appealing, I
23 would say, because it addresses some of the issues
24 associated with both dry and wet cooling, is a system where
25 basically you would have wet cooling towers and air cooled

1 condensers. Now, these may be configured in different ways
2 and you may design it from anywhere from where you are using
3 80 percent wet to 20 percent wet, with a remainder captured
4 by the dry cooling. Now, it is cheaper than using an air-
5 cooled condenser, depending on the size of the ACC in the
6 wet cooling towers because you are having two different
7 condenser systems, but you do eliminate the hot day
8 penalties. Dry cooling, you may get up to a 10 percent
9 penalty loss on a very hot day for a gas-fired combined
10 cycle. If you are using a hybrid system, you can switch the
11 wet cooling and that is eliminated. You can trade off
12 energy conservation versus water conservation. You are
13 still using water, the capital costs are greater than wet --
14 a lot greater, because you are putting on an air cooled
15 condenser, in addition, we have very limited experience.
16 The plant that is depicted there is in Argentina. There is
17 a new plant, it has just been built in Colorado, and the
18 truth of the matter is, the energy industry is very very
19 risk adverse, and there is very very limited operating
20 experience with these hybrid systems. There have been
21 hybrid cooling systems by the major vendors available for
22 years and years, but in terms of utilities, scale,
23 applications, in the United States there is almost nil
24 experience. And so I do not think this technology will be
25 adopted until there is some track record with a few of these

1 initial facilities in adopting them.

2 The research program here at PIER, we tried to
3 look at some of these hot day penalty issues associated with
4 dry cooling and one of them was what we call the spray
5 enhancement, and the picture on your upper right there shows
6 a spray system where we were spraying air to be entrained by
7 the fans, which were right above it, and then to cool the
8 temperature of the air passing through the air cooled
9 condenser. The attempt there is you lower the temperature
10 of that air and that increases your efficiency of the
11 condenser performance and several studies have been done by
12 PIER that have showed that you can recapture about 80
13 percent of the loss efficiency from the heat penalty if you
14 use spray enhancement, but it does raise issues and there is
15 concern about water condensing on your heat transfer
16 surfaces, which would lower their efficiency, there are the
17 rain back issues. So it does raise some concerns, but for
18 short term resolution to your heat penalty problems, it
19 works, and there are a number of power plants that use this
20 on an ad hoc basis during the summer to reduce those
21 effects. And then the other issue is the wind effects on
22 air cooled condensers and, once again, that lower picture is
23 the wall, the gray walls you are seeing there are wind walls
24 to avoid wind effects on the condensers. What you find is
25 that there are two phenomena that effect air cooled

1 condenser performance relating to wind, one is that the hot
2 air exiting the top of the condenser is captured by a cross
3 wind, which knocks it back down and it is entrained back
4 into the condenser, so your ambient air temperatures passing
5 through the condenser are higher and, of course, that lowers
6 efficiency. The other one is that we found that a cross
7 wind effect actually starves the fans on -- usually these
8 are the ones on the periphery of the ACC, and that lowers
9 the efficiency quite a bit. In this graph on the lower-hand
10 side shows a combination of both wind and temperature
11 effects, and as the wind and temperature picks up, the back
12 pressure starts to increase for the turbines and there is --
13 a lot of turbines cannot handle that high a temperature.
14 For some of the dry cooling power plants, they do have
15 higher back pressure turbines, but nonetheless, when you
16 start to get up to six, seven bars of mercury, I think, you
17 know, you are going to have problems and you are going to
18 have to start ramping it back, and even there has been
19 outages where sudden back pressure increases due to wind
20 make the turbines automatically go offline and shut down the
21 whole plant. So PIER has been doing research on that. We
22 showed that that overall re-circulation of hot air from
23 turbine exhaust is causing a minor effect and this wind
24 effect on fan performance, it is a major impact on ACC
25 performance, and we are having some continuing research to

1 look at ways to mitigate that effect.

2 Well, one thing I would like to say before I head
3 over to questions is, I think what we are going to see in
4 the future is greater adoption of hybrid cooling technology.
5 I think people are concerned about water conservation, but
6 also the energy losses associated with an all dry system. I
7 think where it is really necessary, you can have a hybrid
8 system where you can reduce water demand, but still avoid
9 that energy penalty. And this is a picture of a hybrid
10 system in Goldendale, Colorado, I think it is about a 235
11 Megawatt plant, and you can see in the lower right-hand
12 corner, there is a two cell cooling tower, and then there is
13 about a 10 cell ACC, so I am not exactly sure of the ratio
14 of dry to wet, but I would say it is probably about 50
15 percent, so you can -- you will see, I think, with more
16 years of experience with this technology, and at this
17 facility and others, that you will start to see people
18 adopting this a lot more. Another issue facing us in the
19 future is carbon dioxide reduction. You know, if we go and
20 we retrofit existing gas-fired power plants here in
21 California, there is an energy fitness penalty associated
22 with the technologies to capture that. They also require
23 water for the steam processes to cool the compressors and
24 that sort of thing, so you will see that actually the power
25 plants' water demands will go up with that technology. For

1 coal, the integrated gas combined cycle facilities would
2 use more water than a straightforward pulverized coal power
3 plant, that is not counting slurry delivery of the coal, or
4 water use associated with the mining, but just the power
5 plant itself. So, to deal with our CO₂ sequestration issues,
6 there may be additional pressure on water use within the
7 state, as well as for the energy that we import from out of
8 state. So, thank you, and if there are any questions?

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

18 MR. O'HAGAN: Well, ideally a hybrid system, as
19 long as you are not more than 80 percent dry, a rule of
20 thumb is it is probably still going to cost less than 100
21 percent dry system. I think we are seeing a lot more dries
22 because people have more experience with it, it does resolve
23 the water use issue. I mean, that 500 Megawatt power plant
24 that is going to use, you know 3 million gallons of water
25 per day is going to use only a few hundred gallons of water

1 for hotel load, for steam make-up, so it really resolves a
2 lot of issues. I would say that graph that showed the
3 comparisons of cost did not factor in the costs of water, or
4 the costs of transporting the water to the power plant,
5 treating the water, nor disposal, so in some cases the water
6 is just not available, some cases, you know, it is not
7 reliable, so a number of power plant operators have opted
8 for dry cooling just to avoid these issues, and I think we
9 will see more and more of that. I think the hybrid, though,
10 in certain situations, it will be adopted and embraced, and
11 that we will see a lot more of that.

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

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

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

1 California --

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

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

8 MR. O'HAGAN: Thank you.

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

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

24 So let's start with background information. So
25 let's look at historical generation and CO₂ emissions from

1 the combustion of fossil fuels in California. The graph on
2 the upper right left shows that total energy from the
3 combustion of fossil fuel has more or less doubled in the
4 last 60 years. This is a graph that goes from 1960 to 2005.
5 And the same is true for the amount of energy that has been
6 combusting in power plants in California that has been going
7 for about 1,000 Btu to about 2,000 Btu. Now, let's look at
8 carbon dioxide emissions from the combustion of fossil
9 fuels. The emissions for the combustion of all the fossil
10 fuels in California to generate energy, not only
11 electricity, is also going up significantly. However, CO₂
12 emissions from the combustion of fossil fuels in the state
13 power plants, only power plants located in California, has
14 actually more or less remained the same. There was a big --
15 in the late 1990s, it was mostly because during that time we
16 were burning a lot of our residual fuel oil, if you can
17 believe it, and we also -- I mean, for example, for enhanced
18 [inaudible], we were burning actually crude oil. So at that
19 time, natural gas became less expensive than residual fuel
20 oils, and there was a big switch from residual fuel oil in
21 power plants in California to natural gas, and later the
22 natural gas became more expensive in terms of the oil, but,
23 of course, the air quality regulators decided to impose
24 restrictions with respect to the amount of NO_x emissions, and
25 natural oxides of nitrogens that could be a medium for power

1 plants, and that impeded the return of the burning of
2 residual fuel oil. Now, with respect to CO₂ emissions
3 associated with electricity imports, this is a very
4 controversial issue, I think a prior speaker talked about
5 this. The only thing that I would like to say is that, in
6 AB 32, it is required to take into account the CO₂ emissions
7 associated with our state power plants in California.

8 Now a little more information about climate
9 projections for California. As you may know, the public
10 interest in the Air Resource Program has a relatively robust
11 regional climate change program in California. It created
12 what we call the California Climate Zone Center. That was
13 the first state sponsored research initiative in the United
14 States, now there are two more that I know, and more are
15 being created. The Climate Zone Center went into business
16 in 2003. And one of the things that we have been doing is
17 to develop regional climate projections for California, not
18 only for research, but also for long-term planning. Some of
19 these regional climate projections are being used, for
20 example, for the State Water Plan and for the State Forestry
21 Plan. So what the global climate modelers -- there used to
22 be about 16 climate modelers around the world, and now there
23 are about 20 -- they used the estimated, well, the different
24 scenarios, global emissions scenarios, used in cash and
25 import to the global climate models, and this is a real

1 example of an output, generate projections of how climate
2 will change around the world. Of course, the grid sizes
3 that are used are too coarse for California, I mean, here
4 you have, assuming the outputs of the region that we
5 consider California, the grid sizes for the global climate
6 models is on the order of 150 to 300 Kilometers, that is too
7 coarse for California. For example, the San Francisco Bay
8 Area and, more or less, Sacramento will be considered to be
9 one big region having the same temperature, and we know that
10 is not the case. So what we have done in the last few years
11 is to develop actually different groups in California,
12 research groups in California have developed what we call
13 statistical down-screen techniques. What you do is to use
14 the outputs from the global climate models that are more
15 believable, for example, high level pressures, atmospheric
16 pressures, to develop a statistical relationship between
17 those features of the global climate models that are
18 credible with local conditions. And doing that, they are
19 able to develop projections for California when grid size is
20 on the order of 7 X 7 miles. The role of this is that this
21 is a statistical down-screen technique that only -- that can
22 only be used for certain parameters, for example,
23 temperature and precipitation, but we do not have
24 information about how, for example, solar radiation reaching
25 the ground level would change, or how wind patterns could

1 change under climate change.

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

25 Now, with respect to precipitation, most of the

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

18 With respect to sea level projections, the last
19 Integrated Panel on Climate Change Report suggested that sea
20 levels would go up by about -- I think it is about 30
21 inches. But that finding has been very controversial, in
22 part because they rely on old information. There have been
23 new papers that have been released in the last two years
24 suggesting that sea level rise could be much higher. For
25 the work that we are doing here in the Energy Commission and

1 it is being now used by other agencies, we estimate that
2 sea level rise in California could go up to 1.4 meters,
3 about 55 inches, by the end of the century, with very steep
4 trajectories that, again, depend -- the actual estimated
5 rise depends on the global emissions. But one thing that is
6 important to understand is that, even if we reduce global
7 emissions right now, and very dramatic reductions, sea
8 levels will continue to go up. I did put a graphic here
9 showing the big one is an area where [inaudible] and we will
10 have scenes that will be almost undistinguishable sea level
11 rise for both scenarios. So the sea level rise will
12 continue for the next 90 years and continue in the following
13 centuries because of the thermal condition of the ocean and
14 the fact that the greenhouse gasses stay in the atmosphere
15 for long periods of time.

16 So what are the implications of climate change to
17 advanced energy -- I put here electricity technologies --
18 actually, I do not have too much to say. But I just want to
19 tell you that there are groups that have been funded by the
20 U.S. Global Climate Change Program, and what they have been
21 doing is to look at how technologies would have to change in
22 the future under policies restricting the emissions of
23 greenhouse gas in California. So this is the result for one
24 of those models, the MiniCAM model, that is supported by the
25 Pacific Northwest National Laboratory. So this is just for

1 the electricity sector at the U.S. level. So this is the
2 reference scenario, we see, you know, there is a lot of
3 natural gas, the blue bars, we have a significant amount of
4 renewables, some nuclear, even some commercial biomass. But
5 this is the reference scenario. And under the more
6 restrictive scenario, we have, you know, a huge increase in
7 nuclear. According to this model, they are all scenarios
8 without nuclear, or with restricted use of nuclear, you
9 know, we have lot of renewables, and the rest is carbon
10 capture and sequestration. So even, you know, coal, natural
11 gas, everything is captured and sequestered, and it starts
12 by the middle of the century. So the other thing this graph
13 does not show is that these assimilations would suggest that
14 there would be a rapid electrification of the energy system.
15 And here I am not talking about just the electricity, of
16 course, but I am talking about transportation, whatever uses
17 energy. So there will be a rapid electrification of the
18 energy system and an 80 percent reduction from developed
19 countries, and that has been -- I think the scientists would
20 suggest that is the level that we should aim for, means that
21 the deployment of zero or close to zero greenhouse gas
22 emitting technologies actually seems to be far away, but
23 actually it is around the corner, you know, in 20 to 30
24 years from now.

25 The only thing with these things is that we have

1 to be cautious with [inaudible]. In this case, it seems
2 that the carbon capture and sequestration is the silver
3 bullet that would allow us to continue burning, however,
4 there are older assessments that they are more realistic
5 with respect to renewable technologies that assumed that it
6 would be more renewables and also carbon capture and
7 sequestration still remains an improved technology. So that
8 was the good news. So now let's go to -- no, no, I am
9 sorry, now let's go to the good news. So the good news is
10 that we are working already on this issue, for example, we
11 have a project with LBNL and UC Berkeley and UC Davis to
12 study potential energy pathways for California by 2050,
13 integrating the knowledge that we already have about energy
14 efficiency, renewables, etc. etc., including advanced energy
15 technologies. This is a bottom up type of exercise that
16 will improve from the Pacala-Socolow Study that was
17 published in 2005 in *Science* magazine. We will do a much
18 better job, of course. So that is a bottom up type of a
19 study. But we also are funding the developing of a new
20 version of the MiniCAM model for California that will be
21 embedded into the U.S. and global model to train, to
22 account, interactions between what California may do and
23 what may happen in the U.S. as a whole, and in the rest of
24 the world. We also -- I mean, one thing is that we always
25 talk about how restrictions in the amount of greenhouse gas

1 emissions, that that can be [inaudible] will affect the
2 energy system, but also we do not think about the fact that
3 climate change, itself, will affect the energy system. And
4 here just, again, two examples, I mean, of course, higher
5 temperatures will change the amount for energy, especially
6 for air-conditioning, but also the energy infrastructure in
7 California will be affected, so we just studied a new
8 project with LBNL on this topic, you know, looking for
9 example of how coastal power plants could be affected. This
10 is a map showing about -- I think it is about 30 power
11 plants in California that are having initial assessments
12 that are a risk, or something has to be done to study the
13 potential impacts of civil rights in this case, to these
14 coastal power plants. We are working very closely with the
15 utilities on this and we welcome the participation, all that
16 would like to join us, on this study. As always, the
17 science will be evolving with time, so this type of study
18 will have to be updated periodically. The other issue has
19 to do with the potential impact of climate change on
20 renewable sources of energy. As I said before, the studies
21 that we have already on the considered temperatures and
22 precipitation, but the wind patterns could also change, the
23 amount of clouds that we will have, I am told, our
24 atmosphere could change, and that would impact the
25 photovoltaic solar technologies, for example. So we have

1 with Scripps some funding from the RD&D Committee here at
2 the Commission to do a study about the potential impacts of
3 climate change on renewable sources of energy. In part, we
4 have already started the project. There is a group of
5 researchers at Scripps, LLNL, that is Lawrence Livermore
6 National Lab, U.C. Santa Cruz, and Santa Clara University,
7 they are developing new probabilistic climate studies for
8 California. And for the first time, we are using dynamic
9 models, these are the same type of models that you use to
10 forecast how weather conditions will change, they assume the
11 Physics involved, so those models are highly -- I mean, we
12 need huge computation resources, so they are being drawn
13 using super computers, so this is the model domain that we
14 are using, model Domain A is we are using a resolution of 30
15 X 30 Kilometers, and the model in Domain B, that is
16 California, we will be using a resolution of 10 X 10
17 Kilometers. This model will provide information to us about
18 how wind patterns make change, how solar radiation reaching
19 the ground would change, and that information will be used
20 to estimate how climate change itself will affect renewables
21 energy resources in California.

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

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

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

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

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

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

15 COMMISSIONER BYRON: Thank you.

16 MS. KOROSEC: Thank you.

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

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

19 MS. KOROSEC: We are going to go ahead and resume.
20 Commissioner Byron apologized, but he had to leave for
21 another meeting, but we are going to go ahead and hear from
22 our last speaker on this morning's session; however, just a
23 little bit of a change in the agenda. We will be starting
24 our afternoon presentation a little bit earlier, since we
25 are so far ahead of schedule, have some introductory

1 remarks, and then break for lunch and continue with the
2 presentation after lunch. Alright, with that, I will turn
3 it over to Elizabeth Burton.

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

13 I do want to clarify one thing. Guido made the
14 point that, in some circles, CCS is often looked upon as a
15 silver bullet type of technology, and I do not think that we
16 ever really view it that way, it is not a silver bullet, but
17 it certainly is a technology that can increase the
18 likelihood substantially that we will meet our 2050 goals
19 that climate change scientists say are absolutely necessary
20 for us to meet in order to avoid particularly severe
21 consequences of continuing to emit large amounts of carbon
22 into the atmosphere. So the premise that we are moving
23 ahead on is that this is an enabling technology to move us
24 through a short to medium transition period, to get our
25 heavily dependent economy off the fossil fuels, but is not a

1 silver bullet technology that will just allow us to
2 continue to burn fossil fuel and do business as usual, and
3 just assume we can stick it in the ground and sequester it.

4 Carbon Capture and Sequestration technology
5 basically means that we take large industrial point sources
6 of CO₂, we capture the CO₂ emissions from the stacks, and
7 then we sequester it underground in a geologic formation
8 that is highly likely to retain it at 99 plus percent over
9 hundreds of years, to get us out of this sort of short to
10 medium-term difficulty we have, being a fossil fuel economy.

11 The main points that I want to make today are
12 really three-fold. The enabling, or key piece of
13 legislation related to CCS in California is Assembly Bill
14 1925, to date. And this required simply a report by the
15 Energy Commission and the Department of Conservation, making
16 recommendations to policy makers on how to accelerate CCS
17 adoption. So there is definitely a legislative mandate here
18 to include this technology in future considerations of how
19 we meet our climate change goals. Now, for California, the
20 whole CCS debate is, in fact, somewhat different because we
21 do not have a lot of in-state coal use, and CCS has
22 traditionally been viewed as sort of a coal associated
23 technology, not something you would slap on a natural gas
24 plant, or something else. The process to develop the
25 policies and regulations and statutes has to rely on early

1 demonstration projects that involve multiple agencies and
2 will need to be regional, these are the basic conclusions
3 out of the first Assembly Bill 1925 Report that was
4 completed in 2007 as part of the IEPR. We are going to
5 deliver another report in the time frame of about the end of
6 2010 because the technology right now is just taking off for
7 a number of reasons. There are a few early projects going
8 forward in California and there is quite a bit of stuff
9 going on at the International and at the National level in
10 CCS that we wanted to take advantage of before we made the
11 final recommendations to the Legislature, so there will be a
12 second follow-on report after the 2007 report that was
13 completed.

14 Just a review. I think you have heard a lot about
15 this already this morning, but very quickly, the Executive
16 Order S305, established three target reduction levels for
17 greenhouse gas emissions in California, to 2000 levels by
18 2010, 1990 levels by 2020, and then 80 percent below 1990
19 levels by 2050. And AB 32 codified the second bullet into
20 law, so the 1990 levels are supposed to be achieved by 2020.
21 The Air Board, as you know, is in charge of that. AB 1368
22 is another relevant piece of legislation that is related to
23 the whole concept of putting CCS on line in the state; this
24 is the emissions standards to prohibit long-term power
25 purchase agreements for base load power, with emissions

1 greater than that standard. And CCS is one way that some
2 facilities may, in fact, be able to meet the standard.

3 Just to kind of put these climate change goals in
4 a context, we are sort of a pinnacle progression here, if
5 you want, with some numbers on the left side. Right now,
6 2000 levels would be 484 million metric tons in 2004 down to
7 457 million metric tons. By AB 32, that has to be reduced
8 somewhat, it is not a huge difference, and it is something
9 that the Air Board believes that we can actually achieve
10 without a great deal of pain and change. But when we start
11 looking at 2050, we see a huge reduction in the amount of
12 carbon and, based on projections of population and fuel use,
13 we are looking at about 800 million metric tons if we did
14 business at normal, and that has to be reduced by nearly
15 ten-fold to get us where we need to be, to meet our climate
16 change goals. And it is very difficult to see how we can
17 get there without some kind of stopgap technology like CCS
18 to allow us to continue to not freeze in the dark, so to
19 speak, and tank the economy that depends so much on fossil
20 fuel right now.

21 Just to kind of review again, these are out of the
22 '07 IEPR. CCS is a potential application for up to about 45
23 percent of California's emissions. These are just some
24 simple pie charts that show what California's break-out of
25 energy sources is. On the left, again, it is mostly natural

1 gas for power, but also the large transportation sector
2 gives us a lot of petroleum use and, again, through
3 refineries or switchovers to electric fuel cars, we can
4 think about CCS even for some of those other sectors. By
5 sector, again, you have probably all seen these before,
6 transportation is the largest thing, and then the graph to
7 the far right, greenhouse gas emissions by sector, the three
8 sectors where CCS has potential application, the industrial
9 sector, in-state electricity and, of course, electricity
10 imports, which we get, still, a lot of our electricity from
11 coal-fired plants out of state. So overall, about half the
12 pie could really benefit from CCS technology.

13 Again, from the 2007 IEPR, the way that California
14 has thought to get to the 2020 goal breaks out something
15 like this. This is a wedge diagram specific for California,
16 along the idea of the things that Socolow first spun out a
17 few years ago in his *Science* article of using wedges to meet
18 emission level targets, and here we see the pink wedge would
19 be transportation reductions, electricity and natural gas
20 reductions in the yellow, through efficiency standards,
21 without CCS included, other known reductions like forest
22 conservation, land use change shown in the blue, and then
23 this big white wedge as of 2007. My understanding is that
24 people are feeling better about how to remove this white
25 unknown wedge, which is the needed additional reductions

1 just to meet 2020 goals, and there is some confidence that
2 we can get there without a huge deployment of CCS, which is
3 good, however, when you start extrapolating this again to
4 getting down to 85.5 million metric tons of that huge --
5 that white space gets to be quite huge, and it is hard to
6 understand how we can get to 2050 goals without CCS. And,
7 in fact, there are a few early projects that are ramping up
8 right now in California that can even help us get to the
9 2020 goals, and should be studied heavily right now, just
10 because this is a technology with a fairly long term because
11 of infrastructure issues to get off the ground, so we need
12 to start now to be ready for 2050.

13 The first report, in fact, basically went over
14 kind of what we would have to do technically and
15 economically to make CCS feasible in California, and I just
16 want to very quickly review what was in that report and the
17 conclusions and recommendations that were made in that.
18 First, the role of CCS in California, this is basically a
19 list of the chapter titles, was a review of how CCS might
20 fit into California's policy legislation and its climate
21 change emissions reduction goals, a review of the key
22 implementation issues and, again, it was found that these
23 were not by and large technical issues, but regulatory and
24 statutory issues. And this actually echoes what a lot of
25 other states are finding and, in fact, at this point in

1 time, 32 other states have taken legislative action of some
2 kind to try to promote CCS adoption in their states.
3 Chapter 3 was a review done by the Department of
4 Conservation, the Geological Survey looked at basins
5 throughout California and where sources were located, and
6 the geology of California actually lends itself quite well
7 to carbon sequestration, there are lots of places in the
8 subsurface that make secure traps, and the capacity is more
9 than sufficient to put California's CO₂ emissions away for
10 hundreds of years. Chapters 4 through 9 basically looked at
11 -- well, actually 4 through 8 -- looked at the different
12 aspects of the technology for CCS and basically we can
13 borrow a lot of existing technologies, we do not have to
14 invent anything new to make CCS happen. Capture
15 technologies are certainly expensive, but they do exist, and
16 they do work quite well. Site characterization and
17 certification, while we need protocols to be in place, so
18 there is some rational framework across agencies to certify
19 sites, we know how to do that and a lot of the technology to
20 do this sort of geologic site characterization comes out of
21 the oil industry and is quite well adaptable to CCS issues.
22 Likewise, monitoring and verification and risks, and risk
23 management, the technologies that are necessary are existing
24 and are in place, and need maybe some adaption to work for
25 CCS. And likewise, remediation and mitigation, if one of

1 these sites should leak, we do know how to do that. So the
2 bottom line here is that, really, the barriers are not
3 technological here, but they are more statutory and
4 regulatory, and right now economic. It is not cheap to
5 start thinking about capturing the CO₂. The capture costs
6 are high. It does not cost that much to actually sequester
7 it, but we have to think about the cost of doing this as we
8 move forward. Statutory and regulatory frameworks are
9 ambiguous and messy and could actually end up increasing the
10 costs, as well, if we do not move forward in a rational way.

11 And then, finally, recommendations. And these
12 were adopted both by the Commission and the Department of
13 Conservation. Basically there is a lot going on right now,
14 worldwide, and the Department of Energy has seven
15 partnerships going on across the country. WESTCARB is the
16 partnership to which California belongs and that partnership
17 is directed by the Energy Commission. These are the
18 regional carbon sequestration partnership programs and DOE
19 is putting a significant amount of energy and money into
20 these to try and make carbon sequestration happen at a large
21 scale. The goal for the Phase 3 program of the DOE
22 partnerships is to put a million metric tons of CO₂ in the
23 ground over five years, for each partnership to have a
24 project like that.

25 A second recommendation is to consider geologic

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

8 Further examination of early opportunities within
9 the state, we are already starting this. One big
10 opportunity is going to be looking at EOR, which is enhanced
11 oil recovery with CO₂, which actually gives us a value for
12 the carbon and is a big component in some of the early
13 projects that are just now starting up and are in the
14 permitting phase within the state. There is a very great
15 need to develop and improve cost estimates and to include
16 CCS as a greenhouse gas reduction strategy in state
17 planning; I am happy to say that that is actually happening
18 since the 2007 report. And then, again, we have to get
19 together with the other agencies and start looking at
20 existing statutes and the ambiguities that exist, and then
21 figuring out how to either advocate for legislation, or
22 develop some kind of a framework that has continuity of
23 protocols in order that industry can move forward with
24 projects as they become viable.

25 Recommendation 1, learning from pilot projects is

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

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

23 Another thing that I think that has to be into the
24 mix, transportation fuels are exported, so we have a lot of
25 refinery emissions that are actually, if you want, belong to

1 fuels that get used out of state, so how does that go into
2 the mix? So does carbon actually flow with the energy? And
3 I think having some kind of regional policy agreement,
4 understanding, with our neighboring states is going to be
5 key to properly deploying CCS in the future, for optimally
6 deploying it, anyway.

7 Recommendation 3, again, this is looking at these
8 early in-state opportunities. There is a big opportunity to
9 offset this huge cost of CCS through advancing EOR
10 opportunities; this is not a trivial thing to do, however,
11 because you have got to have a pipeline infrastructure to
12 get the CO₂ from the sources to the EOR sites. There are
13 lots of oil fields, certainly, in California which are just
14 chomping at the bit to use the CO₂ should it become available
15 at a reasonable price. And 80 percent of the emission
16 sources, in fact, are within 50 Kilometers, so we are not
17 talking about hugely long pipelines, but we still need to
18 have that infrastructure in place for this to become a
19 viable way to enable CCS. There are some regulatory
20 challenges and, certainly, in terms of carbon credits for a
21 source that feeds its CO₂ into a pipeline that may feed a
22 number of different EOR operators, it is not at all clear
23 how we are going to give them credit for meeting some kind
24 of a cap limit like SB 1368, or even a more stringent
25 requirement that may come up in the future.

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

13 And then, finally, Recommendation 5. There are
14 various agencies that are going to have jurisdiction
15 because, now, all of a sudden, when we think about doing a
16 power plant siting, it is not just the surface site, but it
17 is also the subsurface site that may have to be considered.
18 The California Department of Conservation, Division of Oil
19 and Gas right now permit underground injection for EOR. The
20 EPA Region IX permits underground injection if we are
21 looking at a saline formation, so we have a split authority
22 for the subsurface right now. California Air Resources
23 Board may have a role to play in terms of certifying that
24 these sites meet their climate change mitigation goals, and
25 in giving sources of CO₂ that sequester credit for meeting

1 their mitigation requirements. The Office of the State
2 Fire Marshall right now would permit and regulate CO₂
3 pipelines, and then the Energy Commission itself does the
4 power plant siting and the CEQA permitting. And then, of
5 course, there is a host of local agencies that would also be
6 involved. And, again, a lot of other states have already
7 started tackling these issues and some have even introduced
8 legislation to streamline this process.

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

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

23 MR. BINING: There is a little change in plan
24 because we are ahead of schedule, so we thought that we can
25 start with our afternoon presentation now, so that we can

1 cover as much of a portion of that presentation as we can
2 before we break for lunch. And before we do that, I would
3 like to introduce a team of Navigant Consulting, Inc., who
4 has been helping us in putting together this roadmap. We
5 started on this roadmap project in around May, and then
6 continued with a few of the tasks in that project, and today
7 we have completed two major tasks of that project. The
8 first one was to put together a background paper which will
9 give us the current status of the technologies for advanced
10 generation, so that we can fully understand where do we
11 stand now on advanced generation technologies. And the
12 second part is to set a roadmap framework. So the
13 information that Navigant will be presenting will be mostly
14 on two aspects, a background paper of the current status of
15 advanced generation technologies, and the roadmap framework.
16 The presentation will be made by David Walls, and he is
17 pretty knowledgeable about advanced generation technologies
18 and has worked on a number of projects with the National
19 Energy Technology Lab from the Department of Energy, and has
20 been focusing on advanced generation technologies. His
21 colleague is Jose Luis Contreras. He is the Project Manager
22 on this project. And then we have Erin Palermo, and I do
23 not have the full name for Hiro, but we will get that name.
24 So it is a four-person team that has been helping us to put
25 together this background paper, roadmap framework, and we

1 will continue with that over the next couple of months to
2 finish the roadmap and the implementation plan. So with
3 that, I request David to start his presentation.

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

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

25 So I am going to start with just an overview of

1 the guiding policy framework, and discuss an overview of
2 that. Much of the policy framework has been reviewed by
3 other presenters this morning, so much of the issues that I
4 will be mentioning are issues others have been discussing in
5 more detail, and then we will continue, as I said, later
6 with discussion of the technologies and key issues, and
7 conclude with development of the roadmap framework that we
8 will then get your comments on.

9 The energy policy goals that impact advanced
10 generation in California, there are many of them. Some of
11 the more important ones are AB 32, limiting greenhouse gas
12 emissions to 1990 equivalent levels by 2020. The Governor's
13 Executive Order S305, to reduce greenhouse gas emissions to
14 2000 by 2010, to 1990 levels by 2020, and 80 percent below
15 the 1990 levels by 2050, the AB 32 Scoping Plan, with the
16 objective of developing 4,000 Megawatts of additional CHP
17 capacity in the state by 2020, then we have some of the past
18 IEPR studies that were done with specific goals outlined.
19 Some of the more important ones are the IEPR 2007 net zero
20 energy for new construction through the use of CHP, which is
21 2020 for residential applications of CHP, and 2030 for
22 commercial applications of CHP. So zero net energy through
23 the use of CHP.

24 The IEPR 2008 update discussed the elimination of
25 once-through cooling between 2015 and 2021. That has an

1 impact, of course, on cooling technologies and the choice
2 of power generation technologies. And the additional
3 objective of repowering and retiring, replacing aging power
4 plants by 2012. Additional policy that should be mentioned
5 is SB 1368, which is the emissions standard that impacts
6 imported electricity from out of state.

7 MR. WILLIAMS: Just a brief clarification. Is the
8 2010 standard four months from now? Or --

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

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

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

1 considering technology options for R&D.

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

1 impacting each of those technologies are different.

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

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

1 energy efficiency, storage, or integration with fossil and
2 conventional technologies.

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

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

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

6 Just going through these quickly and, then, as I
7 said earlier, what we will do is we will break for lunch and
8 then come back and discuss each of these categories
9 individually. The primary focused technologies include
10 distributed generation and combined heat and power, as I
11 mentioned earlier. The prime movers that we looked at were
12 fuel cells, the four primary fuel cell technologies of
13 molten carbonate, solid oxide, protonic exchange membrane,
14 and foss acid, and the activities going on to further
15 develop those fuel cell technologies for distributed
16 generation, stationary power. Hybrid fuel cell gas turbine
17 cycles, the integration using various approaches to
18 integrate fuel cells in gas turbine, taking advantage of the
19 waste heat recovery either for fuel reforming or for
20 additional integration efficiency improvement opportunities.
21 There are a few companies and research initiatives going on
22 in that area. Some of the highest efficiencies are
23 potentially obtained through these types of cycle options.
24 Reciprocating engines, kind of the work horse of the
25 distributed generation field, which is most of the market

1 today; there are significant opportunities there for
2 efficiency improvement, emissions reductions, and packaging
3 for CHP applications. Stirling engines, indirect heat
4 engines that have a wide application in both the renewables
5 area through direct use with solar energy, but can be used
6 with many different alternative and low value fuels in heat
7 engine type applications, there are several research
8 initiatives going on in that area. Micro turbines, the
9 primary focus of micro turbines or primary interest is for
10 combined heat and power applications. There are a few
11 companies developing those technologies, a couple here in
12 California. Gas turbines, primarily here. We are talking
13 about small gas turbines for distributed generation, but for
14 advanced co-generation or CHP applications.

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

23 The next category is advanced gas turbine cycles.
24 Again, because of the importance of natural gas to the
25 California advanced generation portfolio, there are a number

1 of opportunities here to improve efficiency, and improving
2 efficiency has the benefit of, of course, reducing emissions
3 and reducing carbon emissions. Advanced generations in the
4 application for industrial co-generation is a fairly basic
5 application. Inlet cooling to reduce the inlet
6 temperatures, especially in areas with warmer climate, it is
7 done a number of ways. Many of these technologies here are
8 what we might call incremental improvements in efficiency
9 and emissions, but nevertheless can be important in terms of
10 looking at the total portfolio. Recuperation is the
11 capturing of waste heat for heating inlet air temperature
12 before it goes into a combustor for net efficiency
13 improvements in gas turbine cycles. Inter-cooling and
14 recuperating is the combination of a couple of different
15 steps here, which can have benefits for flexible turbines
16 that could be used for renewable integration, potentially
17 used in more peaking and cycling application. Heat
18 recovery, one of the basic technologies used for combined
19 cycle applications. Advanced simple cycle for peaking is
20 the development of advanced gas turbines that are more
21 flexible, start up more quickly, require less maintenance
22 for use to firm -- potentially firm renewable capacity.
23 Hybrid renewable cycles, hybrid renewable cycles really
24 first to a number of different combinations of gas turbine
25 cycles with renewables, such as solar thermal for either

1 some type of inlet cooling, potentially, or recuperation
2 type application to improve the overall heat rate of the gas
3 turbine cycle; again, a way to incorporate renewables
4 together with advanced gas technologies. Integrated
5 gasification simple cycle, the California Energy Commission
6 has done work in this area in the past, potentially
7 important technology for basically recovering energy and
8 reforming natural gas to make hydrogen to improve the
9 overall efficiency of a simple cycle gas turbine could be
10 applied to biomass, for example, alternative fuels, as well,
11 but a potentially interesting technology for further
12 development.

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

18 And then carbon reduction, we have specifically
19 here broken up pre-combustion capture of carbon, and the
20 application of this technology to natural gas would be an
21 opportunity to remove carbon for application and combined
22 cycle, or simple cycle gas turbine running the turbine on
23 hydrogen rich stream and then sequestering the carbon in
24 some type of a potentially enhanced soil recovery or
25 something, some application like that. So those are some of

1 the technologies that we focused on in more detail.

2 Various opportunities exist there for R&D to become part of
3 the future roadmap for the advanced generation portfolio.

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

1 at some of the technology developments there.

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

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

17 MS. KOROSK: Yes, we will return at 1:00. Thank
18 you.

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

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

21 MS. KOROSK: We left off before lunch with the
22 presentation from Navigant.

23 MR. WALLS: Good afternoon, David Walls again. I
24 am going to continue where we left off before lunch. We
25 were going through the primary and secondary technologies

1 that were profiled in the background paper, and we will
2 start with distributed generation and combined heat and
3 power takeaways. In each area, we look at some of the take-
4 aways and some of the research issues.

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

23 Rule 21 has been successful in removing some of
24 the fundamental barriers to interconnection. Now, we can
25 focus on more of the technical issues associated with

1 communication and control. The highest efficiencies are
2 achieved with hybrid cycles, using typically fuel cells and
3 gas turbines, efficiencies of 60-70 percent are achievable,
4 and have been demonstrated, some of the technologies under
5 development. Now, there is considerable funding that has
6 been applied to transportation applications in technology
7 development for fuel cells. There has been more limited
8 funding for stationary power applications. This has been a
9 general trend over the past few years, specifically driven
10 by some of the DOE initiatives to invest more in
11 transportation applications and the hydrogen economy. And
12 the stationary applications and benefits have been achieved
13 through that, or benefits in terms of the research in
14 transportation fuel cells, but the target in many cases has
15 been the transportation application, first.

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

22 Avtar presented this slide earlier, he had a
23 little more detail in terms of some specific thinking about
24 the stage of development of some of these technologies, but
25 this is a snapshot that shows what some of the various

1 distributed generation technologies and applications and
2 the relative strengths and weaknesses of some of the
3 technologies, a check meaning it is a good application, and
4 "x" meaning it is a less favorable application of the
5 technology. Fuel cells, for example, are applicable;
6 depending on the specific technology, some have higher
7 temperature and are actually better for CHP like the higher
8 temperature solid oxide and molten carbonate. They are
9 better for base load applications. They can be used for a
10 back-up in peak shaving, and specifically some of the PEM
11 technologies, they are less attractive for strictly cycling
12 applications. Hybrid fuel cell gas turbine cycles, similar
13 applications, similar in terms of their strengths and
14 weaknesses. They are less attractive for cycling, but more
15 attractive for the CHP or base load, probably base load
16 being one of the stronger applications for hybrid fuel cell
17 gas turbine cycles. Reciprocating engines are applied
18 across the board. The specific technology is slightly
19 different in terms of the details in how they are applied;
20 the higher speed engines used for cycling, lower cost, some
21 of the medium speed engines are used more for base load or
22 CHP. But there are applications across the board. Stirling
23 engines are most attractive for CHP and base load. Micro
24 turbines most attractive for CHP and for cycling. They are
25 more flexible in terms of the ability to start and stop many

1 of the smaller micro turbines being developed from the
2 turbo charger family of technologies. Gas turbines, really
3 here focusing on what we would call small gas turbines up to
4 5 or 10 Megawatts, are applied across the board in terms of
5 CHP, or base load, or for cycling.

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

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

1 develop the market, to help fuel cell companies lower cost.

2 High temperature fuel cells offer advantages in

3 terms of efficiencies, efficiencies of greater than 40

4 percent and higher are achievable with some of the solid

5 oxide and molten carbonate fuel cells. But that technology

6 is generally considered to be receiving less funding.

7 Research opportunities that we identified would be

8 increasing fuel flexibility and increasing stack life. One

9 of the issues facing fuel cells is the stack life is

10 typically limited to about five years or less, and that is

11 significantly limiting application. Until stack life can be

12 more consistent with other distributed generation

13 technologies, they probably will be less accepted and the

14 life cycle cost will continue to be high because of that

15 maintenance requirement. Improving the reliability, fuel

16 reformer design, the fuel reformer being what is used to

17 convert the fuel to hydrogen, whether it be a natural gas,

18 or some type of a liquid fuel, renewable fuel, reducing the

19 size and system complexity to lower cost is an opportunity.

20 Again, standardization is a key need for reducing fuel cell

21 cost and efforts could be applied there. Then, longer term

22 research issues do focus on lower cost materials, membrane

23 technologies, and those types of opportunities. Many of

24 those issues are probably more expensive research

25 initiatives.

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

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

1 require new designs and new development.

2 Reciprocating engines are -- one of the
3 significant advantages they have is low first cost, proven
4 reliability, significant potential for heat recovery,
5 although it is a lower quality heat, meaning lower
6 temperature, less potential to produce steam, more potential
7 for hot water in co-generation using reciprocated engines.
8 Emissions on a relative basis to the other distributed
9 generation technology are higher, and so that leads to some
10 of the opportunities. Some of the major barriers to broader
11 application have been higher maintenance costs, and the
12 frequency of maintenance intervals, oil changes, overhaul
13 requirements due to wear, mechanical parts, vibration, those
14 types of problems. Current research is exploring the
15 operating and maintenance cost reductions and focused on
16 reducing emissions. In terms of research opportunities,
17 there is more opportunity to look at full waste heat
18 recovery and taking advantage of more of the low temperature
19 waste heat from reciprocating engines. Also, increase in
20 the application of use of alternatives fuels, such as
21 landfill gas or digester biogas and other fuels,
22 reciprocating engines have been applied in many of those
23 cases, but there is further opportunity for development
24 there. And achievement of U.S. DOE's fuel to electricity
25 efficiency target of 50 percent on a lower heating value

1 basis by 2010, that would be a 30 percent increase over
2 today's average, and so that is just around the corner; I
3 would say there is maybe opportunity for improving
4 efficiency overall, though, is an opportunity.

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

25 Microturbine research and development is fairly

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

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

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

1 heat and power, or co-generation.

2 The next category is cooling combined heating and
3 power. Generally, we are talking about applications that
4 incorporate absorption chillers into the cycle as a way to
5 make higher utilization of waste heat. In California, there
6 is less opportunity to use waste heat in all co-generation
7 applications, so broader development of the combined heat
8 and power and cooling market will require emphasis on
9 absorption chillers. Electric chillers are another
10 opportunity, however, more difficult to take advantage of
11 the waste heat in some of the technologies that we talked
12 about, such as the gas turbine technologies, or
13 reciprocating engines. The issues are relatively high cost,
14 relative to the efficiency benefits, so while the efficiency
15 can be high, from a financial standpoint, the pay-back in
16 many cases is not as attractive as it needs to be. The
17 overall efficiency is lower for systems that are paired with
18 absorption chillers, compared to other straight CHP systems
19 that can take more advantage of all the waste heat, the
20 issue being generally that absorption chilling has an
21 additional efficiency loss associated with it, hence the net
22 cycle efficiency is slightly lower. As I said, the primary
23 benefits of the technology are broader application of CHP in
24 areas of warmer climate. Currently, an issue is cost. We
25 are talking about greater than \$600 per ton for a double-

1 effect absorption chiller; that cost needs to be reduced
2 for broader application. Current research focuses on
3 pairing absorption chillers with reciprocating engines and
4 microturbines to capture some of the smaller packaged
5 applications. So some of the research opportunities would
6 be further reducing cost and improving efficiencies with CHP
7 and absorption chillers, also associated with pre-packaging
8 systems to reduce cost.

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

24 Recent emphasis of the Original Equipment
25 Manufacturers, the OEMs, has focused on materials, higher

1 temperature combustion, higher pressure cycle development
2 associated with some of the aero derivative engines,
3 companies like GE, Pratt & Whitney, Rolls Royce, working
4 more on applying technology developed in the aerospace
5 industry to power generation.

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

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

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

1 21 that helped to facilitate interconnection issues helped
2 DG applications up to 10 Megawatts, but for applications
3 greater than 10 Megawatts, has not been as helpful. An
4 additional issue or barrier for industrial co-generation has
5 been tax depreciation policies which generally have not, I
6 would say, encouraged, they somewhat discouraged, industrial
7 co-gen more broadly, and impact the financing. Financing
8 for these types of applications is a significant issue and
9 one of the areas currently being addressed by the U.S.
10 Department of Energy Loan Guarantees, which may help to some
11 degree.

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

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

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

22 Recuperated gas turbine cycles is the recovery of
23 waste heat for improving the overall efficiency by boosting
24 the inlet temperature to combustor. This has been applied
25 to smaller gas turbines, it has not been applied more

1 broadly, generally because of retrofit issues, changes in -
2 - it does have an impact on pressure ratio and other
3 technical issues associated with the turbine. Larger gas
4 turbines are less well-suited to recuperation due to higher
5 pressure ratios, so there tends to be less of an opportunity
6 for larger gas turbines, say, greater than 20 Megawatts, or
7 so. Cycle produces less power, generally when it is
8 recuperated, and results in less waste heat available for
9 combined heat and power. So you have to look at the overall
10 application to decide if this is the right technology for a
11 particular application. In general, the research
12 opportunities, this is an area that has not had as much
13 research associated with understanding the complexities of
14 the cycles and the overall impacts; there is an opportunity
15 for more cycle research. There is the success of the cycle
16 also will depend on the cost and the durability and
17 reliability of the recuperator section, and so there is an
18 opportunity there for a better understanding of some of
19 those issues.

20 Related technology is the Inter-Cooled Recuperated
21 gas turbine cycle, the ICR cycle. There was quite a bit of
22 work done on this technology during the '90s. A couple of
23 companies were working on this technology, Westinghouse,
24 Rolls Royce, and others, and had developed prototypes for
25 designs in marine propulsion, initially, not for stationary

1 power. Again, this is an overall cycle improvement. It
2 would have an impact and make the technology less attractive
3 for co-generation, but it could be an attractive way to
4 improve gas turbine efficiency. It is most applicable to
5 small to medium size gas turbines in the 5-25 Megawatt size
6 range. A cycle life, this is being developed for
7 microturbines for vehicular applications that could be
8 applied to stationary power, the Recuperator and the Inter-
9 Cooler add significant cost and complexity, that is an area
10 where there is additional research opportunity, both in
11 terms of the life of the parts, and the cost, again, the
12 recuperator being a heat-exchanger that needs to have
13 significant durability and be able to run through cycles,
14 long lifetime cycles without cracking or deteriorating. So
15 reliability is an issue.

16 General category of heat recovery, this is a broad
17 category here, we have not really attempted to break it down
18 into a lot of different sub-technologies, but heat recovery,
19 in general, is a broad opportunity for power generation
20 improvement, you know, applied. It can be applied to many
21 cycles where there is waste heat available, fundamentally
22 from an industrial process. One of the sub-technologies are
23 organic ranking cycles and other types of cycles that are
24 really focused on recovering lower temperature waste heat.
25 The economics and operation somewhat are similar to

1 renewables in the fact that there is no fuel cost
2 associated with the heat recovery project, but there is a
3 significant upfront capital cost. Some have tried to put
4 heat recovery in the category of renewables for this reason.
5 There is, you know, based again on the analysis that has
6 been done in the CHP market, a significant unrealized market
7 potential for heat recovery in industrial and commercial
8 applications in California.

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

23 The next technology we looked at was advanced
24 simple cycle technology applied to peaking, or cycling
25 application. The advantage of the technology is high

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

22 Hybrid renewable cycles, again, that is a broad
23 category of different types of technologies focused on
24 helping renewables overcome some of the intermittency
25 issues. We categorize it as an emerging technology, just

1 entering commercial development in some areas. Focus has
2 been on small scale demonstrations; large scale
3 demonstrations are still in planning. But more of the
4 investment and demonstration of these technologies has been
5 done internationally because there is less funding and less
6 incentives available for the technology in the U.S. So
7 there is research opportunities here associated with looking
8 at ways to incorporate turbines with concentrating solar, to
9 facilitate the development of some of those projects, or
10 research on small scale demonstrations to fully understand
11 the optimization integration issues. There are a number of
12 different ways that solar, for example, solar heat could be
13 used to integrate with the gas turbine cycle to improve
14 efficiency. So there are opportunities for further analysis
15 of some of those cycles, and opportunities to look at how
16 solar, for example, could be integrated with combined cycle
17 plants that might require scales of 50 Megawatts or larger.
18 So there are a number of different demonstration
19 opportunities that might be available, as well as studies
20 associated with cycles to understand some of the
21 optimization and integration issues.

22 Integrated Gasification Simple Cycle is a
23 technology that has been investigated in the past by the
24 California Energy Commission, it could be a way to reduce
25 emissions and improve efficiency of either internal

1 combustion engines or gas turbines for DG applications.
2 So it has been applied. This says "Integrated Gasification
3 Simple Cycle," but it could be applied to both gas turbines
4 or internal combustion engine cycles. It does require extra
5 components and complexity. Basically you are doing fuel
6 reforming of the natural gas and using the hydrogen as the
7 primary fuel for the turbine. It has benefit of potentially
8 improving the cycle efficiency, however, it does require
9 significant modification to the turbine design to
10 incorporate the technology. This is one of the barriers for
11 development of this, is the cost associated with the
12 technology development, and the turbine equipment
13 manufacturers would need to be involved in this type of
14 development. So it requires significant demonstrations and
15 verification of the components, both for internal combustion
16 engines and gas turbines. Research on the combustion of
17 hydrogen rich fuels needs to be done for both gas turbine
18 and IC engines, to the extent they would be applied to the
19 cycle. So there is some initial component testing and
20 analysis that would need to be done before full cycle
21 demonstrations really would be a potential.

22 The next category is the replacement for once-
23 through cooling technologies. As we discussed this morning,
24 there are a number of opportunities there, but some of the
25 issues are incorporating the plants with any alternative

1 technologies is expensive and will impact efficiency. So
2 that is always going to be a barrier. Some of the older
3 plants, the older ranking cycle thermal plants, are more
4 likely to shut down due to this policy than to eliminate the
5 once-through cooling, so that is a barrier again to some of
6 the retrofit. And the costs are highly dependent on the
7 site and what is available in terms of space and alternative
8 water. Typically, dry cooling is most expensive, followed
9 by hybrid cooling, then closed wet cooling towers. Wet
10 cooling towers utilized in sea water still represent a
11 significant improvement, however, over once-through cooling.
12 It could be a retrofit opportunity in some cases. Space is
13 an issue, as I said, due to the space required for cooling
14 towers, so many of these coastal applications, that is a
15 limiting issue for retrofitting.

16 The next category we touched on, and I think I
17 have mentioned this, but if you go to our report, there is a
18 significant detail on each of these technologies and a
19 summary of the research going on in other areas in the
20 world, including the U.S., but other areas, as well, that we
21 have summarized, if you want to refer to that. Pre-
22 combustion carbon capture is an area that has not had as
23 much attention as one of the ways for carbon capture and
24 sequestration. Typically, the costs are going to vary
25 widely and the cost of retrofitting plants is prohibitive,

1 however, it could be an attractive option and applicable
2 here in California. There has been a lack of utility scale
3 demonstrations, and that is limiting development adoption.
4 The Recovery Act funding could assist this, but I do not
5 believe there will be many of the demonstrations focused on
6 pre-combustion capture. The most likely demonstration that
7 would fall into that category would be integrated
8 gasification combined cycle. I do not believe there is any
9 proposed pre-combustion capture of natural gas that is being
10 proposed. The IGCC plants generally, with pre-combustion
11 capture, have the lowest energy requirements, if you look at
12 carbon capture. And, as I said, there has been little
13 research on pre-combustion capture for natural gas plants,
14 and that would be an opportunity.

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

1 maybe less likely.

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

19 The success of enhanced oil recovery sequestration
20 depends on alignment, really, of interests between the oil
21 producer and the society's need to reduce carbon, so there
22 is an opportunity here to align those needs and really take
23 advantage of the need for carbon for CO₂ to be used for
24 enhanced oil recovery. That could create an opportunity
25 here.

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

20 So now we have covered a lot of the technologies
21 that we have looked at. There are a series of trends and
22 issues that we have identified, that could have a
23 significant impact on advanced generation technologies in
24 California. Recent studies have found that generation from
25 natural gas could be reduced by 15 percent by 2020. Under

1 current policy, the state will need to replace or repower
2 66 aging natural gas plants by 2010. That would be a
3 combined capacity of about 17,000 Megawatts, 40 percent of
4 the gas-fired plants, and it represents about 40 percent of
5 the natural gas-fired plants, and 25 percent of all power
6 generation capacity. However, the scope and time frame of
7 this goal is still under review. Another issue is, despite
8 improvements, energy intensity from desalination remains
9 high. Energy and greenhouse gas impacts will need to be
10 considered when assessing desalination projects. We bring
11 this up because there are a number of desalination projects
12 being proposed that could be a significant demand for power
13 generation capacity, and also represent opportunity for
14 research and development.

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

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

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

19 We have worked together with the California Energy
20 Commission, with Avtar, to develop a preliminary vision for
21 the 2020 PIER Advanced Generation Vision. I will just read
22 it to you. "The PIER Advanced Generation Program provides
23 key RD&D that enables California to generate energy
24 efficient, abundant, affordable, reliable, and
25 environmentally friendly electricity, and other forms of

1 power from small to large power plants, including
2 distributed generation and combined heat and power, using
3 clean, non-renewable fuels and fuel flexibility capability
4 in order to help reach the greenhouse gas emission reduction
5 targets." Kind of a long paragraph, but represents a lot of
6 things that we are trying to incorporate into the vision for
7 the Advanced Generation Program. I will just leave that for
8 a second for you to take a look at.

9 MR. WILLIAMS: May I ask a question while we are
10 --

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

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

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

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

1 rather than a need for district heating.

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

23 The PIER Program has limited resources, PIER
24 advanced generation has limited resources, and so it needs
25 to focus those resources in a few key areas, and it needs to

1 avoid duplicating efforts with funding and other research
2 going on in other program areas. As such, it needs to work
3 closely with those areas to leverage investment and activity
4 across the PIER organization. Some of those areas are the
5 residential single family CHP, as discussed. The
6 technologies there are currently not cost-effective, as the
7 thermal load is too small relative to the electricity load.
8 So we recommend continuing to monitor technology progress in
9 this area due to the high technical potential for
10 residential CHP and CCHP.

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

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

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

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

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

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

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

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

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

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

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

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

21 MR. SAYRE: I realize you are right to do your
22 study based on what our Legislature has been providing for
23 you, however, you talk about the moratorium for nuclear.
24 What the tests of the population of California, 82 percent
25 are in favor of California going ahead with nuclear power

1 plants, yet the Legislature will not let that happen. Can
2 you go on beyond what the legislation wants because of what
3 the people in California want?

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

6 MR. SAYRE: Higher than your pay grade.

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

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

25 MR. WILLIAMS: It might be nice in the final

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

9 MR. WALLS: Yeah, thank you.

10 MR. WILLIAMS: Thank you.

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

13 MR. THEROUX: Good afternoon, excellent report and
14 coverage of the report, as well. Two pieces of the puzzle
15 that I was listening for and did not find -- Michael
16 Theroux, Theroux Environmental -- and I would not ask so
17 much for a detailed response on this, but perhaps
18 consideration as to where they would fit. First is the
19 development, the parallel development, of use of algae as a
20 mechanism for capturing CO₂ and how that fits into this whole
21 puzzle, CCS and Advanced Generation. The second, a
22 development that I have been watching in solid oxide fuel
23 cells, cylindrical framework solid oxide fuel cells, for
24 both down hole redevelopment, and also to use those curious
25 little cylinders for the 600 degrees C. heat that they

1 generate to provide a thermal source inside of retorts for
2 paralysis and gasification. Those two paths seem to be both
3 showing some very nice progress recently in this arena of
4 ancillary systems to advanced generation. The question that
5 I actually have, though, has to do with integration. It
6 appears that one of the steps that I am seeing in project
7 development is not really addressed here, and that is, all
8 right, we have got a lot of different systems, and we
9 understand that integrated packages make the most sense, we
10 are talking on one side of sustainable community development
11 and we have the questions of Smart Grid and all its
12 intricacies; it seems that our focus has almost leaped in
13 front of what the agencies' attention is, in that we need to
14 be concerning ourselves with community scale integration,
15 not just power generation, but the fuels and the waste
16 management and the air quality and the rest of it, once
17 again, but how do these new tools and our ability to lace
18 them together fit within our community specifically? So
19 that would be the question that I would ask, as to what you
20 might put your finger on. So, thank you.

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

1 would you like to address it?

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

8 MR. THEROUX: Okay, thank you.

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

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

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

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

13 MR. WALTER: Good. Both of these documents
14 address the need for nuclear power in California. But
15 apparently their valuable content has fallen on deaf ears
16 because nothing has happened as a result of these documents.
17 Basically, my position is that California needs to be
18 putting in considerably more nuclear power plants if it is
19 to meet its needs for electricity in the future that is
20 safe, clean, reliable, and economical. Nuclear power can be
21 sustainable for centuries by utilizing advanced design
22 concepts. In order for California to be a leading proponent
23 of this new technology, the Warren-Alquist Act of the 1970s
24 must be repealed to allow the construction of new nuclear
25 power plants within the state, and justify research in the

1 area of advanced designs. This current workshop on
2 advanced generation and public interest energy research must
3 include three recommendations, 1) to repeal the Warren-
4 Alquist Act, 2) to support deployment in our state of
5 existing designed nuclear electric power plants, and 3) to
6 support research of advanced multi-purpose nuclear power
7 plants that can provide electricity, heat, hydrogen
8 production, and sea water desalination. Thank you.

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

11 MR. SAYRE: Sayre.

12 COMMISSIONER BYRON: Sayre, forgive me.

13 MR. SAYRE: I am also here representing ACRE,
14 retired engineer who has built nuclear power plants and
15 maintained them all around the world. What I want to talk
16 about is smaller nuclear power plants, 10-200 Megawatts that
17 are ideal for California's future. So nuclear power plants
18 are under development that may have the potential for being
19 throttleable and still maintain efficiency and be
20 economical. The ideal design is from 30-100 Megawatts
21 capacity and to be able to turn it on in minutes' time and
22 pick up the load in the Grid and to be turned off when they
23 are not needed, with solar and wind power prevailing. Some
24 of the small nuclear power plant designs can be turned on in
25 a few minutes, but they can be collected in groups and

1 operated in varying percentages of outputs of the grid in
2 order to keep the grid stabilized and to take care of the
3 off and on problems with your renewables. One of those is a
4 -- and this is kind of an old system, this is a small gas
5 cooled, throttleable nuclear power plant that was developed
6 back in the Aircraft Nuclear Plant Program during the 1950s,
7 and these concepts can probably fulfill these needs with the
8 improved performance gained in advanced technology over the
9 past 50 years. I have figures in here that people can see,
10 that have these. There is a sketch of a small fast nuclear
11 reactor power plant with total cycle of noble gas going from
12 the compressor through the electrical heater, fast reactor,
13 and through the turbine, and it is used to start the power
14 in just a few seconds, which can be used and destabilized
15 when you are working with the wind and solar power. Another
16 one that is being developed by a company now is the New
17 Scale nuclear power plant, another possible small nuclear
18 plant that can fulfill the variable needs in the power -- 40
19 Megawatt water cooled reactor. While it will not be
20 efficient to turn on and off in a very few minutes, a group
21 of them can be put to the grid and operated on a percentage
22 basis to regulate the input variations on the renewables.
23 Another one is the Hyperion nuclear power plant and it was
24 actually developed at Los Alamos Nuclear Lab and it is being
25 done now by a commercial group, and the Hyperion nuclear

1 reactor is a new unique design with Uranium hydride fuel,
2 with the hydride fuel and a hydrogen atmosphere inside a hot
3 chamber, the reaction is automatically controlled and a very
4 safe system. The heat is generated to an extent so a heat
5 exchanger can provide steam for a steam turbo generator
6 system. The fuel in this reactor is a performance of eight
7 to 10 years, and it makes it possible for the reactor to be
8 placed in a chamber, underground, for a very safe
9 environment, and instead of refueling on-site like most
10 nuclear reactors, this reactor is replaced after it runs low
11 on energy and they take the reactor out, back into the
12 factory, and re-do it to go into another new plant. The
13 last one to talk about is one that is being developed at
14 Lawrence Livermore Laboratory. You may have heard of that,
15 it is called LIFE, it is a Labor Initiated Fusion Fission
16 Energy nuclear power plant. This kind of power is under
17 development there and the concept is fission and fusion
18 combined. What you have is -- it will be a long time in
19 development, but it will have many advantages in the future
20 because it does have major safety situation, you never have
21 complete fusion, it never has a possible meltdown of a
22 fission plant, and it has a possibility of being
23 throttleable and to be turned on and turned off. All of
24 these types of plants, there are major sources of
25 throttleable electric power to integrate with our renewables

1 that we are pushing for California, and they are gas
2 turbines and small hydro plants, and even some small coal
3 power plants. But the thing about it is, with the nuclear,
4 you can integrate these small nuclear plants with the
5 renewables and have a good stable grid situation.

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

8 MR. JOHNSON: Thank you. I will be speaking on
9 behalf of myself, as well as ACRE. I am a retired nuclear
10 engineer with 47 years experience in this field. That makes
11 me prejudiced toward nuclear energy, but prejudiced does not
12 equate to being wrong anymore than lack thereof equates to
13 being right. When choosing energy sources, it is necessary
14 to consider a few attributes such as longevity, which is the
15 amount of the source, cost, energy efficiency, and safety
16 are also paramount. It is difficult to determine the order
17 of importance of these attributes because they are all
18 interrelated. I will also discuss a subset of safety which
19 is the lack of harmful emissions, since it is specifically
20 treated because of the current national obsession with
21 greenhouse gasses and global warming. Only solar and wind
22 energy of the renewable sources will be discussed here
23 because these are the cornerstone of the CEC Energy Policy,
24 and because they have the greatest potential for expansion.
25 In terms of longevity, wind and solar are forever, so they

1 easily claim the prize in that attribute. U.S. Coal is
2 estimated to last 250 years; oil is but a few decades away,
3 at best, from becoming prohibitively expensive, even though
4 not entirely extinct. Natural gas has been recently
5 augmented by the development of horizontal drilling and
6 fracturing its shell deposits to bring new source back from
7 the brink of extinction. This is fortunate, in part,
8 because natural gas can replace oil readily, as a fuel for
9 internal combustion engines, which are essential for
10 maintaining our current civilization. But this silver
11 lining has a cloud. These wells have significantly less gas
12 than the traditional gas well and they have greatly
13 increased the number of wells required per unit of gas
14 production. These facts do not bode well for sustained
15 natural gas supplies, but they may still provide a bridge
16 from the inevitable oil shortfall to a more sustainable
17 means of maintaining our life preserving internal combustion
18 engines. In contrast to oil and gas, nuclear energy sources
19 are so huge that they can actually be treated as renewable.
20 Both Thorium and Uranium, which are abundant elements in the
21 earth's crust, can reproduce a staggering amount of energy
22 per unit weight, typically 2 to 3 million times as much as
23 that of fossil fuels. However, in the current power
24 reactors, only five-tenths of one percent of the mined
25 Uranium readily undergoes fusion. That still amounts to a

1 15,000:1 energy production advantage over fossil fuels.
2 Advanced reactors have been developed primarily in the
3 United States that convert the initially non-fissile portion
4 of the Uranium, which is U238, to that which can fission and
5 thereby increase energy production by one hundred fold. And
6 the United States has sufficient U238 that is already mined
7 and separated to supply its entire energy needs for over 700
8 years in these advanced reactors. Unfortunately, it is our
9 Government's policy not to deploy these reactors. Well,
10 France, Russia, and Japan utilized the technology developed
11 in the United States to vastly multiply their energy
12 resources. Energy efficiency is measured by the energy
13 payback ratio, that is, the ratio of energy output to the
14 energy input required to produce this output. Its common
15 measure is called "energy payback ratio." EROEI, hard to
16 get that straight, is another common term for it, and it can
17 vary from nearly zero to very large numbers. It
18 significantly impacts the cost and longevity of the source.
19 While the EPR is simple in concept, its determination is
20 difficult because of the great many factors contributing to
21 energy input and the difficulty in determining appropriate
22 values for these. These problems create a wide range of
23 individual EPR estimates and provide ample opportunity for
24 biasing the results. Typical EPR values for our common
25 energy sources are as follows: for the advanced nuclear fuel

1 cycles, an energy production ratio of greater than 1,000
2 can be attained. Next comes hydroelectricity, which is
3 generally in the range of the low 100s, current once-through
4 nuclear cycles using centrifuge enrichment comes in at 51,
5 coal is 19, current once-through nuclear fuel cycle with
6 diffusion enrichment is 19. The reason for the difference
7 between these two types of nuclear cycles is that the fusion
8 and enrichment is an extremely energy intensive process.
9 When --

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

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

1 Hydro get less than one. Similarly, we have cost numbers.
2 These numbers are from Europe. It seems that the United
3 States energy organizations are determined not to commit to
4 a side-by-side comparison. The numbers represent an average
5 of between 2005 and projections to 2030. Gas is 4.325,
6 which is in terms of hundredths of a Euro, which is about a
7 penny, coal is 5.3, nuclear is 4.75, wind is 7.8. There is
8 no reason to expect the United States or California to
9 differ so significantly from these figures. Gas, coal and
10 nuclear are all within a few percent of one another, but
11 wind is almost double any of these, California's latest
12 public show of electricity cost is with \$.22 per Kilowatt
13 hour. It is claimed, however, that it can be reduced to
14 \$.13. If we give it credit for reducing by at least half
15 that amount, we find that wind is more than twice -- solar
16 is more than twice the cost of wind, and more than three
17 times the cost of nuclear or fossil fuel. California is
18 basing its electric future on the world's two most costly
19 sources, and the state is paying an exorbitant subsidy for
20 these sources when it is already up to its eyeballs in debt.
21 Below, as a means of addressing the emissions thing, we have
22 the amount of carbon released per Kilowatt hour developed in
23 Japan. Coal has 950 grams per Kilowatt hour, gas for
24 thermal purposes has 882, gas for combined cycle electricity
25 has 480, solar voltaic has 66, wind has 16.2, and nuclear

1 has 15.3, and hydro has 7. Gas is not significantly
2 different than coal in carbon emissions, and even by CEC's
3 projection, we will be mostly using gas for decades to come.
4 Nuclear matches exceed all other items in sustainability,
5 efficiency, and cost, and hydro and nuclear are the best
6 relative to carbon emission. But the state government
7 maintains a law against nuclear power and hydro sites are
8 all used up. So we are stuck with wind, solar and natural
9 gas for the future. The only thing wrong with this
10 limitation is that it is inadequate for our future energy
11 needs. The sustainability of natural gas is by no means
12 assured, and the conventional wisdom among energy experts,
13 including the President of the American Wind Energy
14 Association is that renewables of wind and solar can never
15 exceed 20 percent of our energy needs. Beyond that level,
16 the intermittency imposes impossible restrictions. The CEC
17 calls for us to achieve 30 percent in 10 years, the same
18 president of AWEA, the American Wind Energy Association, has
19 said that it will require 30 years to achieve even 10
20 percent. The CEC plan is totally devoid of any realism.
21 The state currently bans nuclear energy because a waste
22 repository must be licensed and reprocessing of used nuclear
23 fuel has to be achieved. Since the national government has
24 cancelled both of these projects, permanence of this ban
25 seems assured. But without reprocessing, we will never

1 achieve the closing of the fuel cycle, and we will never
2 expand our energy capacity by the factor of 100 that this
3 enables. Further, the irrational fear of nuclear waste that
4 has been allowed to invade the national psyche is probably
5 the greatest hoax that has ever been perpetrated on a large
6 group of people. Nuclear waste has never been and never
7 will be an issue. Used nuclear fuel has been safely handled
8 for over 50 years in this country with no incident and no
9 one being harmed because of the effectiveness of those
10 procedures that are in place. Due to its radioactive decay,
11 the used fuel can be safely handled within 15 to 20 years of
12 removal from the reactor. There is no necessity for
13 millions, tens of thousands, or even many hundred years of
14 storage, and it does not have to be stored underground. We
15 routinely deal with hazards that are hundreds of times more
16 likely to harm us than nuclear waste, and we completely
17 ignore them. But I have digressed from the CEC Energy Plan.
18 I did that because nuclear power is the only means of
19 solving California's energy problem, and I wanted to explain
20 the folly of holding it hostage to reprocessing and the
21 nuclear waste issue. I would like to summarize our current
22 CEC Energy Plan as a means to guarantee that California will
23 be the first political entity to suffer the cataclysm of an
24 energy shortfall and also to assure that we pay the world's
25 highest price for energy that we could manage to produce on

1 our way to this economic oblivion. Thank you.

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

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

6 COMMISSIONER BYRON: I do.

7 MR. WILLIAMS: And I am willing to try to depart
8 from them in order to adhere to the time line. I, too, am a
9 retiree first from the U.S. Navy, then from General
10 Electric, where I designed water reactors, and then for
11 Electric Power Research where I was a Program Manager in the
12 Fuel Cycle area, specializing in high level waste disposal
13 and spent fuel storage, and finally, a consultant to the DOE
14 on a part-time basis after my retirement in 1994. I am
15 trying to -- I have testified the last three years to the
16 CEC about how the essence of the Warren-Alquist Act has been
17 achieved, and my prepared remarks do address that. I am
18 searching for a political compromise, some way that the CEC
19 staff can start to include nuclear power in their studies,
20 so that some of the advantages, the cost advantages, the
21 siting disadvantages if there are any, can be addressed. It
22 strikes me that somebody like yourself and like the manager
23 of this program could propose to the Legislature that you
24 begin some studies on the basis not that the Warren Alquist
25 Act be repealed, but that a bypass, an exception for two

1 plants to be a demonstration plant of some sort would be
2 advanced and the loophole, then, would be to study the type
3 of two plants. The two plants might lead to four plants,
4 with one being -- or with two of them being desalinization
5 demos and two of them being power demos, and you might even
6 get it up to six plants if you said one of them, or two of
7 them need to be high temperature reactors that produce
8 hydrogen for this clean fuel economy. So my prepared
9 remarks outline why I think the requirements for
10 reprocessing and waste disposal have been adequately
11 demonstrated, that they might justify this demonstration
12 amendment to the Warren-Alquist Act. One of the main
13 reasons for doing that is we are on the verge of conceding a
14 trillion dollar industry. It would be like deciding that we
15 are not going to make jet airplanes, even though we
16 pioneered them and have the Boeing Company. We are
17 conceding a trillion dollar industry, which is the nuclear
18 power industry, to the French, and the Japanese, and pretty
19 soon the Chinese, who are in the process of building 50 of
20 them over the next 20 years. I hate to see our kids lose
21 that job opportunity. I also believe that the United States
22 requires some effort to reindustrialize. So that brings me
23 to point 2. The solar energy and wind energy technologies
24 are very modular and relatively small. My understanding,
25 from talking to my stockbroker, is that the best solar

1 energy company on the market today is a Chinese company
2 that already has 50 percent of the market in a particular
3 kind of solar panel. General Electric is doing worldwide
4 sourcing of its wind turbines. So the bottom line is that
5 we will have almost as big a balance of payment, deficit,
6 buying these green energies, even though Nancy Pelosi says
7 the main reason for wind and solar is jobs, jobs, and jobs.
8 The thing that will really lead to jobs in the United States
9 is big nuclear plants that have got a lot of concrete and
10 Rebar and heavy section pressure vessels that are not as
11 practical to build overseas as they are here. So these will
12 lead to good manufacturing jobs, good construction jobs, and
13 jobs in the United States. In my view, the United States
14 desperately requires reindustrialization. The third point,
15 very briefly, has to do with water. I think water will be
16 as big a crisis as energy if there is global warming, and
17 some of your remarks by the staff here, I think, bear that
18 out. The point I would make is two-fold. I would have the
19 staff study canals from British Columbia and Alberta, Lake
20 Kootney is a long lake on the Canadian-U.S. border, and it
21 is in a perfect elevation to have an inland canal from
22 Canada down to Nevada and even approach in California. But
23 the second thing we need to do is consider desalting plants
24 that are powered by nuclear power, and the reason for doing
25 that is that the thermal energy which is the cost driver for

1 these things, is by far the least expensive of any of the
2 energy options that we can consider that are not very
3 intermittent. So as an expert on the fuel cycle, I can tell
4 you that nuclear energy, even if we triple the price of
5 Uranium, will still stay under a dollar per million Btu's
6 and this will compare to natural gas, you know, in the last
7 few years it is has been \$4.00 per million Btu's, and oil is
8 at \$6.00 per million Btu's, headed higher. So I think a
9 good case could be made for two, or four, or six
10 demonstration nuclear plants, and that is not woven into my
11 argument here in the written papers, but that might be the
12 vehicle for the compromise that we need, first for the
13 studies to start considering nuclear power, and then,
14 second, for the state to really start to get on the
15 bandwagon before the ship leaves the station. Thank you.

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

18 MR. BURT: I am Bob Burt, Insulation Contract
19 Association, and you might gather from my association, my
20 principal concern is the commercial side of energy
21 efficiency. I would add that I have been greatly impressed
22 by the comments I have already heard. I have two very brief
23 comments, one, apparently the people who make decisions on
24 money are under the impression that the much maligned
25 deniers will turn out to be right because there seems to be

1 very little action on this program when it comes to
2 spending money. My second point is that, in view of the
3 large numbers of dollars that people are talking about
4 spending in this program, even though near term there may
5 not be that much, since this is an IEPR meeting, let me
6 suggest that the people -- some of the people -- tasked with
7 this workshop be further tasked to try to make a guess as to
8 the near term expenditures in this program, so that the
9 avoided cost menus that we have could be updated. The
10 reason for that is that there are a number of presently
11 marginal energy efficiency measures which would suddenly
12 become very effective, and the value, as the IEPR points
13 out, of managed efficiency is that Kilowatt hour which is
14 not doing it at all, does not send out any greenhouse
15 emissions. That closes my comments. I welcome questions.

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

21 Once again, I think this subject, the advanced
22 generation technology, at least to me, indicates again how
23 energy and environment issues always seem to intersect.
24 California has set the highest environmental standards than
25 the rest of the United States with regard to CO₂ air

1 emissions, water use impact on marine biology, and of
2 course we recognize that energy efficiency is the key -- the
3 first key that we use prior to trying to generate additional
4 electricity, and there is some recent studies that indicate
5 from the Department of Energy that there is a great deal
6 more energy efficiency to be had, and this Commission will
7 pursue that, and is doing so with its goals. But we need
8 and depend upon technology advancement and generation in
9 order to pick up the shortfall, if you will, the necessary
10 generation that we need to run our economy.

11 I think the input that we received today is
12 extremely valuable. I particularly appreciate the comments
13 of all of the folks that commented from ACRE and on behalf
14 of themselves on behalf of nuclear. In my mind, it is clear
15 that nuclear is going to continue to play a role in reducing
16 CO₂ throughout the world. Gentlemen, I was at a meeting last
17 week of the Electric Power Research Institute's Annual
18 Summer Meeting and a number of utility executives from
19 around the country, and they did some real time polling, and
20 it is interesting, when asked the question, how will they --
21 in what way do they see reducing CO₂ to be most effective, it
22 was not renewables, it was not energy efficiency, it was not
23 carbon capture and sequestration, more than 80 percent of
24 them said nuclear. So, in all likelihood, nuclear will
25 continue in some way in this country, but as many of you

1 indicated, we do have a limitation here in California,
2 namely the laws as currently written. Oh, and I should add,
3 there were some other really interesting examples. South
4 Korea has an incredibly successful program in this regard,
5 and they are headed down the nuclear path, and some of you
6 mentioned obviously the French and the Chinese. But we have
7 had this moratorium on nuclear in the State of California
8 for over 30 years, primarily based upon the closing of the
9 fuel cycle. We have had workshops in this Commission in
10 attempts to try and make findings that we think would stand
11 up in the Legislature and have not been able to do so. I
12 would only offer -- and it is off topic, somewhat to what we
13 are trying to do in today's workshop -- but I would only
14 offer that any changes towards an attitude in nuclear in
15 this Commission and in this Legislature would have to start
16 in the Legislature. As you know, there are individuals that
17 have attempted to put forth legislation, that have not been
18 successful getting it out of committee, but that is really
19 where that change will need to take place. I appreciate
20 your being here and for your comments. I read them in
21 entirety and will of course consider them, but I think you
22 understand the limitations that we are facing under the law.
23 If there is nothing else to add at this point --

24 MS. KOROSEC: I just wanted to remind people that
25 written comments are due on August 17th and also for those on

1 the WebEx who are callers and are not identified by name,
2 if you do want to have any additional information, please
3 contact Avtar Bining and his contact information is on his
4 presentation that was given at the beginning of the day
5 today.

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

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

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CERTIFICATE OF REPORTER

I, TAHSHA SANBRAILO, an Electronic Reporter, do hereby certify that I am a disinterested person herein; that I recorded the foregoing California Energy Commission Workshop; that it was thereafter transcribed into typewriting.

I further certify that I am not of counsel or attorney for any of the parties to said meeting, nor in any way interested in outcome of said meeting.

IN WITNESS WHEREOF, I have hereunto set my hand this _____ day of August, 2009.

Tahsha Sanbrailo