Bay Area Air Quality Management District
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# APPROVED MINUTES

Advisory Council Regular Meeting
9:00 a.m., Wednesday, June 9, 2010

## CALL TO ORDER

**Opening Comment:** Chairperson Bramlett called the meeting to order at 9:00 a.m.

**Roll Call:** Chairperson Jeffrey Bramlett, M.S., Vice Chairperson Ken Blonski, M.S.; Secretary Stan Hayes; Council Members Jennifer Bard, Louise Bedsworth, Ph.D., Benjamin Bolles, Robert Bornstein, Ph.D., Harold Brazil, Alexandra Desautels, John Holtzclaw, Ph.D., Robert Huang, Ph.D., Kraig Kurucz, M.S., Gary Lucks, JD, CPEA, REA I, Jane Martin, Dr.Ph.D., Debbie Mytels, Kendall Oku, Michael Sandler, Jonathan Ruel and Dorothy Vura-Weis, M.D., M.P.H.

**Absent:** Council Member Rosanna Lerma, P.E.

**Public Comment Period**: There were no public comments.

**Consent Calendar**:

1. Approval of Minutes of the May 12, 2010 Advisory Council Meeting

**Advisory Council Action:** Member Hayes made a motion to approve the minutes of May 12, 2010; Member Blonski seconded the motion; unanimously carried without objection.

## PRESENTATION: CALIFORNIA'S 2050 GHG EMISSION REDUCTION TARGET – CONTROL TECHNOLOGIES & STRATEGIES FOR INDUSTRIAL & ELECTRIC POWER SECTORS

2. California's 2050 GHG Emission Reduction Target of 80% Below 1990 Levels – Control Technologies and Strategies for the Industrial and electric Power Sectors

   A. **Mineralization via Aqueous Precipitation (MAP) for Carbon Capture & Sequestration**
   Tom Carter
   Vice President, Government Affairs
   Calera Corporation

Deputy APCO Jeffrey McKay provided a brief introduction of Tom Carter, Vice President, Government Affairs, Calera Corporation.

Dr. Carter gave a PowerPoint presentation, stating that rather than separating $CO_2$ gas and storing it in a carbon dioxide form, Calera's technology converts $CO_2$ to $CO_3$, combines it with minerals to make calcium magnesium carbonates that can then be used as carbon negative building materials. This process is mineralization via aqueous precipitation or MAP process. Mr. Carter discussed the ambient temperature

and pressure process, carbon absorption/conversion, and he stated there is a large built environment reservoir which is capable of converting 16 billion tons of $CO_2$ annually. Their cost structure is dramatically lower than Carbon Capture & Sequestration (CCS) for $CO_2$ capture, it reduces sulfur dioxides, mercury, and other pollutants, they have applied for many patents, and he noted he would discuss Calera's extensive proven technology development and demonstration.

Mr. Carter noted fossil fuel power plants emit 9.5 billion tonnes[1] of $CO_2$/year, and industrial plants, such as cement plants, steel and paper mills, aluminum plants emit an additional 6 billion tonnes. He stated Calera captures major stationary source emissions and for every tonne captured, they make two tonnes of product. They add in minerals and additional oxygen to provide a higher molecular weight. The global market for materials is roughly 32 billion tonnes and therefore, this provides a reservoir of 16 billion tonnes which is slightly more than all of the stationary sources. Mr. Carter described inputs of flue gas, fly ask, brines, waste waters, and manufactured alkalinity; mineralization by aqueous precipitation process; and outputs of clean flue gas, building pollutant encasing and fresh water. The third output is building materials themselves which have encased pollutants captured.

Mr. Carter presented beneficial reuse of $CO_2$ with revenue streams:

| Product Sales: | Service Fees: |
|---|---|
| Building Materials | $CO_2$ |
| -Aggregate | Criteria Pollutants |
| -SCM | -$SO_2$ |
| -Special Cements | $NO_2$ |
| Fresh Water | Mineral Waste Mitigation |
| | -Fly Ash |
| | -Red Mud |
| | -Mining Residuals |

He displayed a graph of how Calera can make a carbon negative green concrete with their product without replacing all cement in the product.

He displayed a graph of carbon reduction potential, stating that even if they are capturing 70% of $CO_2$ from a power plant they can still have a total negative carbon impact on the environment of over 100% of the plant's emissions by displacing cement and other materials.

He displayed a baseline of operating expenses and revenues for traditional gas separation and for Calera's process. He said Calera shows positive revenue for CCS assuming a price on carbon per tonne, but they have the significant additional revenues of selling the materials they make and capturing the other pollutants. The Earning Before Interest, Taxation, Depreciation and Amoritization (EBITDA) shows that because Calera's revenues are higher than lower costs, they end up with a positive margin.

He then displayed an energy demand comparison for a power plant, the fresh water production process starting with waste water/brine, stripping out minerals during the process, and then adhering to carbonate formed. If they want to take an additional step to make the water potable, they could purify it completely through a reverse osmosis process. The salt removed can be used in their electrochemistry process by which they manufacture alkalinity.

He displayed ways to reduce mining at a limestone quarry to make cement, and an aggregate quarry to make aggregate. Mr. Carter presented Calera's very talented Senior Executive Team and gave a brief background on their accomplishments and experience.

[1] *Tonne = Metric ton*

Mr. Carter then displayed their pilot plant Calera location at Moss Landing R&D Center, one-third of a megawatt coal fired capacity, where they built a co-boiler, can burn coal to see how their process works on various coals and arrive at building materials. He also presented an example of their 90 foot absorber tower where they mix the alkalinity, alkaline liquid and flue gas to create the carbonate at their 10 $MW_e$ Dynegy Moss Landing Power Plant.

Chair Bramlett suggested Mr. Carter address the three questions posed, as follows:

a. How could California's 2050 GHG reduction target be accomplished for the industrial and electric power sectors?

Mr. Carter stated the process has the capacity to capture most of the emissions from all major stationary sources in the state. Even though there are only a few small coal plants and most major power plants are natural gas, they still have emissions. In addition, they could capture emissions at cement plants in California which are coal fired and at other major stationary sources, which is significant.

b. What are the implications of California's 2050 GHG emission reduction target for the Air District's regulatory and legislative agendas?

Mr. Carter said his assumption is that the District's missions is to do what it can to ensure the Bay Area meets its share of the statewide reduction targets. To the extent that emissions in the Bay Area come from stationary sources rather than from vehicles, they can help capture them.

c. What are the implications of California's 2050 GHG emission reduction target for the Air District's Climate Protection and Grants & Incentives Programs?

Mr. Carter said part of his job is to gather public funds wherever available. They think their process holds a lot of promise, it is innovative, scalable, and has a wide variety of positive environmental impacts beyond $CO_2$ control. It can also help the state keep its domestic industries in place rather than import them from elsewhere. They do have one grant from the U.S. Department of Energy, another grant from the State of Victoria, Australia, and a matching fund offer from the Commonwealth Government in Australia. They also have a matching fund offer from the California Energy Commission from the DOE funds.

Because Mr. Carter had to leave after his presentation, Chairperson Bramlett invited Advisory Council comments and questions.

Mr. Ruel asked for clarification on calculations on estimates of the reservoir in buildable materials. Mr. Carter said they start with potential sources from which they could capture emissions. On a global level, they add up to about 15.5 billion tonnes of $CO_2$ per year from fossil fueled power plants and industrial sources. He said one would multiply that by 2 to get the amount of product they would make. This provides 31 billion tonnes. Fortunately, the 31 billion tonnes is just under the global market of 32 billion tonnes per year for all of the products they make, such as aggregate, cement, cinderblocks, concrete pipes.

Mr. Ruel asked that in adding up all of the products, is Mr. Carter assuming it was all 100% replaced by this product or used as a supplementary product at a level of 20%. Mr. Carter said this would assume the ultimate potential reservoir for Calera's products. He noted cement is a fairly small portion of the 32 billion tonnes, at about 2 billion tonnes, and even if they did everything else other than cement, it gets them close to the 31 billion tonnes.

Dr. Holtzclaw questioned how quickly could this be scaled up. Mr. Carter said they wanted to start the Australia project at about a 10-50 $MW_e$ scale within the next six months to a year. There is another coal-fired plant that they are in discussions with as well which they would like to get going before that at a 10-20 $MW_e$ scale. Once they prove out the scale, they could scale up fairly quickly. The numbers which are conservative show them getting up to 200-500 $MW_e$ scale by 2014. He said they want to be operating and absorbing $CO_2$ and producing products at a couple of coal-fired plants by the end of this year at the 10-50 $MW_e$ scale and from there, they could scale up once the technology is proven.

Dr. Holtzclaw questioned if Calera has spoken with industries in China. Mr. Carter said yes, but they have a resource issue and have only a certain number of people to ensure projects happen. He said obviously there is a big market in China, a lot of emissions, and they are also not particularly keen on geologic storage in China and even less keen in India. They are very confident Calera's technology can and will end up being a major part of the solution in China and India.

Dr. Holtzclaw questioned what the "C" was in SCM. Mr. Carter said this is Supplementary Cementicious Materials (SCM). He said "cementicious" means that when it gets wet, it gets sticky. Cement is actually an ingredient in concrete, which is made of sand, gravel and cement, and cement is the glue, and this is their cement replacement.

Dr. Holtzclaw referred to Slide 9; Carbon Negative Green Concrete and asked Mr. Carter to review it again. Mr. Carter said they start with a reference of ordinary concrete which has a 10%-15% Portland cement ratio and the rest, 80-85% being aggregate and 5% air, water, etc. This has a 537 lb. per cubic yard of concrete level. The grey bar shows a 60% cement component bar because they are putting two SCM's in there; 20% with fly ash or 2% of the concrete and 20% with Calera SCM. They are replacing all of the fine and course aggregate with Calera aggregates, or 85% of the concrete. So, even with the 200 lbs. of positive carbon footprint in the Calera concrete (green bar), the negatives of adding up the SCM, fine and course aggregate still make it into a concrete that is about twice as carbon negative as regular concrete is carbon positive. Dr. Holtzclaw confirmed they were still retaining some Portland cement, and Mr. Carter added they believe this could be realistic to sell in the next few years as a product salable on market.

Mr. Hayes said the basic chemistry of cement manufacturing is straight forward. It may be proprietary, but he asked for some additional information on how this works. Mr. Carter said they are making a stronger polymorph of calcium carbonate, and while he is not a scientist, their product people spend all their time doing this—making sure they can go to any facility and take inputs available there and turn it into a consistently, strong polymorph to meet the strength of Portland cement.

Mr. Hayes questioned the cost relative to a ton of cement produced. Mr. Carter said it is a difficult question; their cost depends on three factors—what the inputs are, whether they have natural sources or whether they need to manufacture them, it depends on the regulatory structure and the markets for various products. If they get paid enough to capture the $CO_2$, they will capture as much as they can and make as much product as they can even if they have to sell it in less expensive forms. Mr. Hayes questioned if a price for carbon was needed, and Mr. Carter said if they have the right inputs, they can still make cost-competitive cement materials at a profit.

Mr. Lucks referred to feed stocks including wastewater, and he knows the central valley has a limiting factor with salinity and concentrated total suspended solids are a big challenge and limiting factor. He questioned if this would be an opportunity to address that challenge. Mr. Carter said yes, it is. To the extent that waste waters have those minerals and/or the alkalinity they need, they are a prime input for Calera. Even to the extent they do not, there are items they could use waste waters, as long as they do not have things that will hurt their process.

Dr. Bedsworth asked if this is a process that can be centralized or does it need to be at each source. Mr. Carter said they could do it at a central plant with a network of pipelines to bring the flue gas to that central plant. But it might make more sense and be cheaper to exist at the brine source 50 miles away and bring the flue gas over. He said they do not need the gas to be hot when it comes in, and they envision co-existing with the power plant or other source, but it is not a requirement.

Dr. Bedsworth referred to the cost per ton of concrete, and she asked for a sense of cost for $CO_2$ captured, or questioned how it compares to other sequestration or other abatement strategies. Mr. Carter said it is a trade off between the products and the price on $CO_2$. If they couldn't sell their products at all, they would need a higher price on carbon to be profitable.

Dr. Vura-Weis said in looking at the local picture, she asked if there are toxic air contaminants released in the process into the atmosphere and/or to exposure to people working in the plants. Mr. Carter said they take this seriously, are doing a lot of testing the air in and out of their process, and they test the water in and out, and they test it with the slurry that comes out of that. They also want to be sure that mercury is captured and stays in the product. They are doing additional testing where they take solid material, crunch it up into a paste, and doing leeching studies on that to ensure metals stay in there. Those results have been very positive. For workers in the plant, they take safety very seriously. They have minimal exposure to any harmful materials, and they have to be most careful with alkalinity because it is caustic by nature. But, they do not produce any harmful chemicals in their process and they are testing all of the outputs to ensure they are not releasing any.

Ms. Bard said the technology is very promising to hear, and Mr. Carter said the more options there are for capturing $CO_2$ the better, and anything with potential should be explored. Ms. Bard said she did not see anything on PM 2.5 and she asked Mr. Carter to review the retrofit costs, stating one slide showed that this is a more efficient process for capturing all capital costs for all the separate retrofit processes required. Mr. Carter said most presumptions in graphs presented presume a retrofit situation. The one that in some cases that had an additional energy cost for SO2 control. This might have been developed for Australia where they have low sulfur coal and do not currently have sulfur controls. If they were going to try and separate that gas, they would have to install a sulfur control. In a brand new plant, their process is ideal because all the other units do not even have to be built. They are hoping PM controls also do not need to be installed. When they built their pilot with a coal boiler simulator on-site, they installed a bag house to capture the PM. They are now in the process of building the bypass of the bag house so they can test it without capturing the PM, and they feel confident that their process will capture the PM. He further explained the costs of maintaining bag houses, high energy costs, and even with PM controls, a lot of money can be saved in the long term by installing their process once they prove they also capture PM.

B. **Membrane Technology for Carbon Capture**
Richard Baker, for Tim Merkel, Ph.D.
Director of Research and Development
Membrane Technology & Research

Deputy APCO Jeffrey McKay provided a brief introduction of Richard Baker, Principal Scientist, Membrane Technology & Research.

Dr. Baker stated Membrane Technology and Research, Inc. (MTR) is a small firm in Menlo Park, California, making gas separation systems and he would discuss the nature of the problem, a brief review of membrane gas separation technology, how the technology would be used to capture $CO_2$ at a power station, and conclusions and answers.

He referred to the problem, stating that beginning in the industrial revolution the use of fossil fuels skyrocketed in the 1940's and it is now on the order of 25 billion tons per year of fossil fuels being

emitted. Each year it increases about 1 or 2 ppm every year. He stated about half of U.S. $CO_2$ emissions are produced during electricity generation, and the vast majority of this is coal. The next major source is transportation, which is oil and the rest is a mix of natural gas and oil. There are about 1100 coal-fired power plants in the United Stations and 5,000 worldwide, and 50-100 power plants are being built every year, which will continue.

Dr. Baker presented a graph showing the process of coal-fired power plants, stating that 600 $MW_e$ plants emit approximately 10,000 tons of $CO_2$ per day, which is enormous. Regarding whether the unconcentrated flue gas could be transported from one place to another, he said this cannot be done and the flue gas emitted from the stack contains about 10% to 13% $CO_2$. Even though it has gone through precipitation and desulfurization, it still has ash, SO2, NOx and other chemicals as well.

Several CCS technologies are being considered but it is very expensive and will double the price of electricity. Membrane Technology and Research makes membrane technology systems mostly for the petro-chemical industry and refineries. He presented examples of a petrochemical plant, a hydrogen refinery, a natural gas plant, and a listing of some of their customers. He presented types of membrane separations, which act as micro filters, separating molecules from gas or liquids by straight filtration. When the pores get extremely small, you get processes like reverse osmosis and gas separation. In those processes, the pores are the tiny gaps between the polymer chains that make up the film, or the membrane. The gaps are created by thermal motion, and this is a diffusion process. The one mentioned previously is reverse osmosis; a process to desalt water by filtering it through very tight membranes. Similar membranes could be made to separate gases.

Dr. Baker said the membranes for separating water and salt are tight and have relatively low permeabilities and the trick is to make the membrane extremely thin to provide useful fluxes. In 1960, two scientists developed the asymmetric membrane occurred at UCLA and he presented examples. Even with the best membrane material and the best membrane, a lot of membrane area is needed. MTR uses spiral-wound modules. Rolls of membrane are made, membrane envelopes are made, and they are wrapped around the porous pipe, the wrapping component goes into a pressure vessel, and one stream comes in and two streams come out. In their process, they have flue gas coming in, $CO_2$ permeates the membrane and goes out on one side, and the nitrogen and other components keep on going and are vented to the stack. He presented an example of its use in a power plant.

Dr. Baker then presented the permeation rate of the membrane, Polaris $^{TM}$ membranes which are 10 times more permeable to $CO_2$ than conventional membranes used for natural gas treatment; pure-gas data at 25°C and 50 psig feed pressure. He then presented and described MTR's $CO_2$ capture process and noted that 90% capture is approximately \$25-\$30/ton $CO_2$ and they will use about 15-20% of the plant energy, which is about a 45% increase in the cost of electricity. They calculated the amount of energy and membrane area needed. As they increase the pressure of the compressor the energy cost goes up but the membrane area goes down. Therefore, there is a trade-off between compression power and the membrane area required.

Dr. Baker then presented the Ashkelon desalination plant, a membrane plant of the required size that exists today. He said there are about 25 plants of this order of magnitude installed around the world, mostly in Saudi Arabia, 1 or 2 in Spain, or places where water is at a premium. He presented the current status of MTR technology, presented one of MTR's first test systems which was put in Red Haw, a 1060 $MW_e$ natural gas-fired power plant in Phoenix for the Arizona Public Service (APS) power plant, a larger APS Cholla Power Plant which conducted a six month test with coal-fired flue gas in April 2010 and the Polaris TM membrane system captures 1 ton $CO_2$/day.

Dr. Baker described remaining challenges for membrane post-combustion $CO_2$ capture, as follows:

- Particulate matter/other minor contaminants and their potential impact on membrane life, module life and module pressure drop
- Integration with power plants and effect of $CO_2$ recycle on boiler efficiency
- Vacuum blower operation and materials challenges
- Cleanup of SOx and NOx in $CO_2$-rich permeate
- Gas flow distribution
- Water recovery and handling
- Cost reduction and scale-up issues

He presented the Cholla II skid which is proposed to begin operation in late 2011. It will be a 20 fold scale up from the Cholla I unit and will treat about 20 tons of $CO_2$ per day which is the equivalent of about 1 $MW_e$.

Dr. Baker then presented a Department of Energy Post-Combustion $CO_2$ capture timeline outlining a variety of field testing projects, pilot-scale field testing projects, large demonstrations, with their hopes of having a commercial deployment by 2020.

Regarding the three questions,

a. How could California's 2050 GHG reduction target be accomplished for the industrial and electric power sectors?

He said for the last hundred years, $CO_2$ has been on a steady increase as referenced in his Slide #3, and getting them reduced is a difficult target. He thinks electricity and gasoline are the big things to work on, there are not one or two processes that will do it, everything will need to change and to meet the target, the total economy of the country has to change; solar, wind, nuclear, biofuels, electric cars, hybrids, IGCC, oxycombustion, and carbon capture and sequestration.

a. What are the implications of California's 2050 GHG emission reduction target for the Air District's regulatory and legislative agendas?

Nothing will happen without regulation or tax. A $CO_2$ tax would change electricity production fairly significantly, but it will do nothing to gasoline consumption. It changes the price of oil by $8 a gallon which will do nothing, but it doubles the price of coal and it increases the price of electricity by 30% to 40%. It would be a driver to convert or change the balance between coal and natural gas, which would happen within a few years of implementing such a tax, and it could possibly encourage some sort of sequestration.

b. What are the implications of California's 2050 GHG emission reduction target for the Air District's Climate Protection and Grants & Incentives Programs?

Dr. Baker said he was unfamiliar with the District's program, but he said the Cholla II unit is a $20 million program. They are getting 80% of the money for the program from the federal DOE, and they are putting up about $4 million. The next stage is a plant that might be a $50 million plant and he hopes DOE would give them the bulk of that money too. But even a 20% cost share would be significant for them. Therefore, he said MTR would be happy to be apprised of any available District grants and incentives.

**C. Dr. John Beyer**
**Staff Scientist**
**Geophysics Department**
**Earth Sciences Division**
**Lawrence Berkeley National Laboratory**

Deputy APCO Jeffrey McKay provided a brief introduction of Dr. John Beyer, Staff Scientist, Geophysics Department, Earth Sciences Division, Lawrence Berkeley National Laboratory

Dr. Beyer thanked the Advisory Council for the opportunity to speak, discussed the basics of what and where is carbon dioxide, reviewed sources of $CO_2$ which includes combustion of fossil fuels, electricity generation at coal and gas-fired power plants, cars, trucks, oil refineries, and cement plants.

The problem is that the carbon cycle is out of balance. The amount of $CO_2$ in the atmosphere is increasing. Working in our favor is that the ocean is absorbing $CO_2$, plants absorb it and produce oxygen, but humans are producing more $CO_2$ that can be absorbed, and as a result, seal level is rising and glaciers are melting, weather patterns are changing, and the oceans are becoming more acidic and destroying marine ecosystems. He reviewed the scale of $CO_2$ emissions from people burning gasoline, coal-fired power plants, gas-fired power plants, U.S. fossil fuel and global fossil fuel $CO_2$ emissions.

Dr. Beyer noted that 48.5% of electricity is generated with coal, and 1,820 million tons of $CO_2$ is emitted per year. 21.3% is generated with natural gas which produces 400 million tons of $CO_2$ per year, 19.6% is generated with nuclear and 6.0% with hydro, 1.6% wind, solar and geothermal, and 1.4% with biomass, which is considered neutral. The U.S. power sector produces 2,200 million tons of $CO_2$ a year.

Dr. Beyer presented a graph from the Air Resources Board showing a breakdown of California GHG emissions in 2006. Transportation accounts for 39%, industrial at 21%, electricity generation in state at 12% and electricity generation imports at 10%. He presented a 2008 Atlas Sources Map of the Bay Area stationary source $CO_2$ emitters which can be located at http://www.natcarb.org/Atlas/ims_map.html which highlights most of the Bay Area refineries.

Carbon Capture and Storage (CCS) involves three processes: $CO_2$ capture and separation, $CO_2$ compression and transportation, and $CO_2$ injection. Geologic $CO_2$ storage is used to buy time to convert to renewable energy sources to address the problem of global warming.

He stated oil companies have been safely injecting large quantities of $CO_2$ into the ground for decades for enhanced oil recovery. $CO_2$ injection started in 1972 and is responsible for more than 1 billion barrels of oil from the Permian Basin in Texas and New Mexico. There are more than 72 U.S. oil fields where a total of 50 million tons/year of $CO_2$ is being injected into the ground which has produced over 1 billion barrels of domestic oil, and they are currently producing more than 300,000 barrels per day which accounts for 12% of lower U.S. oil production. He noted the $CO_2$ does not come from man made sources, but naturally existing deep reservoirs of $CO_2$ in the ground, and it has been there thousands of years. There are 3,100 miles of high pressure pipelines delivering $CO_2$ for enhanced oil recovery in the Permian Basin in West Texas and Eastern New Mexico.

Regarding reducing $CO_2$ emissions, Dr. Beyer said the goal is to reduce emissions by 7 Gigatons (Gt) of carbon/year by 2050. He presented a graph which indicates that by 2050, with a business as usual model, the United States will be producing twice as much $CO_2$ as now. Even if we try to stabilize the Earth's atmospheric concentration of $CO_2$ at 500 ppm, to do this, we will have to not emit an amount equal to the amount we are already emitting. He said there is no silver bullet, it is too early to pick winners and losers in terms of technologies, and at this point, all technologies must be worked on. He referred to the diagram on Slide 11 and noted 9 possible wedges/technologies are represented which include:

- Carbon capture and geologic storage (from power generation, cement manufacturing, oil refining, natural gas processing, hydrogen plants)
- Nuclear power generation replacing coal
- Renewables (wind, solar, geothermal, biomass)
- Switch from coal to gas generation

- End use electricity efficiency (buildings, industry)
- End use fuel efficiency (power plants, vehicles)
- Reduced use of vehicles
- Biomass fuel
- Terrestrial sequestration (reforestation, agricultural)

He discussed Slide 12, which represents the first wedge, or 3.7 Gt of $CO_2$/year. Within 50 years, this much should be put into geologic storage into the ground, which he said can be done. He presented the types of geologic reservoirs and their estimated storage capacity, which includes depleted oil and gas fields, unminable coal seams or deep saline formations.

Dr. Beyer then presented California's major geologic storage areas by natural gas fields and oil fields and their estimated storage capabilities. Regarding cost of CCS for various scenarios, he presented a chart showing the cost for capturing $CO_2$, compressing it, transporting it and injecting it which includes monitoring of it in Slide 14.

He described how the process of CCS works, stating $CO_2$ compresses by a factor up to 370 from its volume at the surface. The hydrostatic (water) pressure in the rocks increases by about ½ psi per foot of depth. Therefore, the $CO_2$ stays compressed by the pressure that naturally exists deep in the earth. The compressed $CO_2$ is liquid-like, with about 2/3 the density of water.

$CO_2$ is trapped deep in the earth by the following:

1. Stratigraphic – Impermeable cap rock over permeable reservoir rock
2. Structural – e.g., dome-shaped structures or sealed faults (the way oil and gas are trapped)
3. Solubility – $CO_2$ dissolves in saline water in the reservoir rock (like $CO_2$ dissolved in soda) and makes the water 8% more dense.
4. Residual (capillary) – If the plume moves from buoyancy, water fills in behind it, trapping bits of $CO_2$ in tiny spaces in pores of the reservoir rock.
5. Mineral – Chemical combination with minerals dissolved in the formation brine to form new rock.

He then presented a chart of $CO_2$ trapping mechanisms over time, stating that over a number of years, new minerals are created below the ground. He noted there are concerns about geologic $CO_2$ storage such as induced seismicity, drinking water contamination and leakage of $CO_2$ to the surface. He briefly provided an analysis of each and discussed control and monitoring mechanisms, and mitigation.

Dr. Beyer discussed the project he is working on with Shell Oil Company, noted the site for it is in the Montezuma Hills, about 10 miles west of Rio Vista where the wind mills are. They hope before the end of the year to start drilling the first of two wells 2 miles deep and 150 feet apart where $CO_2$ will be injected into a permeable sandstone layer beneath multiple impermeable shale layers. He noted a few miles away from this site lies the Rio Vista Gas Field which has been significantly drilled and they have huge amounts of data. He presented examples of a well head and a $CO_2$ valve opened up. Dr. Beyer presented $CO_2$ geologic storage projects around the world grouped by small, medium and large scale operations: 1) A storage project in Alberta and its pipeline, 2) a storage project from an off shore oil rig in the North Sea, Norway with seismic data, and 3) a storage project in Krechba, Algeria which is monitored by satellite data.

Dr. Beyer gave the following conclusions:

1. There are large point sources where $CO_2$ can be captured
2. There are geologic formations where $CO_2$ can be stored
3. Processes and mechanism are understood

4. Capacity exists for hundreds of years of injection
5. Impacts of geologic storage will be limited at well-chosen sites
6. Monitoring and mitigation technologies are well-developed
7. $CO_2$ EOR and natural gas storage provide analogs and experience
8. CCS is an effective way of reducing $CO_2$ emissions

Regarding why CCS is not done:

1. It is expensive, particularly the capture part
2. No value placed on $CO_2$ emissions (or other GHGs)
3. Legal and regulatory framework in early stages
   a. Pore space ownership
   b. Long term liability
   c. Permitting
   d. Accounting of stored $CO_2$
4. Need public outreach and education
5. Need Political will

Regarding the cost of inaction, sea levels are rising, weather patterns are changing, people will get flooded out of some of the most populous areas of the world, it may cause major wars globally as people get displaced, and croplands will turn to dust bowls.

Chairperson Bramlett thanked Dr. Beyer for his presentation and noted questions would be taken at the end of the meeting.

**D. Jan Mazurek**
**Advisor for Science and Technology Policy**
**Air Resources Board**

Deputy APCO Jean Roggenkamp introduced Jan Mazurek, Advisory for Science and Technology Policy, Air Resources Board.

Ms. Mazurek thanked the Advisory Council and said she would be talking about policy and putting a price on carbon, which may drive some of the technologies described today. In 2020, their economic modeling shows at the low range getting a price of about $30 per ton of $CO_2e$, which sounds like the low end of what it would take to get some of the technologies going. In the near term, with AB 32, a cap-and-trade is driving much more conventional approaches, including energy efficiency and renewables. Since cap-and-trade does not dictate which technology to install or use to reduce GHGs, it also provides a powerful incentive to drive rules, tools and processes and technologies.

She reported that ARB's Board Chair, Mary Nichols, along with colleagues from the CPC and CPUC several months ago established a Blue Ribbon Advisory Panel on geologic sequestration and appointed her as the point at ARB to monitor those efforts. The panel should be delivering a report with recommendations on geologic sequestration in the coming months.

She congratulated the Air District on its climate initiatives and adoption of CEQA guidelines, which have given industries a competitive edge in the cap and trade program. She described how cap and trade complements the other components of AB 32 implementation plan, or scoping plan, how it takes a different approach to curbing GHG emissions under conventional Clean Air Act approaches.

She recapped AB 32, which seeks to return GHG emissions to 1990 levels by 2020 and to get 25% below that target. While the group has been talking about 2050 targets, their Scoping Plan runs to 2020 as well as the cap and trade program.

The ARB has proposed cap and trade as one in a suite of policies and strategies to reduce GHG emissions and other $CO_2$ climate warming gases. Transportation makes up about 40% of GHGs, and most regulations target vehicle emissions, such as the low carbon fuel standard and the clean car law or the Pavely bill, which are referred to as complimentary to cap and trade. She said this date, ARB has approved 14 of the 30 complimentary measures in the Scoping Plan.

ARB's recent updated economic analysis of the cost associated with the Scoping Plan to make technologies viable requires a very high price for carbon and to make the program palatable to Californians during the economic crisis. Their updated analysis shows complimentary measures along with the carbon cap will drive energy efficiency improvements and save Californians money on their electric and gas bills.

Ms. Mazurek said they realized going with status quo or performance standards would not achieve the GHG reductions they were seeking in a way that is both administratively feasible and economically feasible. There are so many potential pathways to emit $CO_2$ in day to day activities, it poses a challenge for the regulator to know what those are and specify how they need to be reduced. They selected cap and trade for industrial sources because there are so few technological options in the immediate term to address them. EPA's modeling at the federal level turns on the ability to deploy nuclear as well as CCS for coal, which are options in California that are not technologically ready or politically acceptable. For those reasons, those technologies were not included in their modeling in the Scoping Plan. Included are a combination of regulations, market and voluntary measures, as follows:

- Advanced Clean Cars
- Renewable Electricity Standard
- Low Carbon Fuel Standard
- High SWP (Self Contained, Water Cooled, Plenum Discharge) Refrigerant Management Program
- Regional Targets for transportation-related emissions
- Cap-and-trade program.

Ms. Mazurek said cap and trade is a flexible market-based approach to reducing GHG pollution. It harnesses the power of supply and demand to taper down emissions, and it is a relatively new alternative to command and control approaches such as Best Available Control Technology (BACT) to performance standards like a low carbon fuel standard, to market standards of cap-and-trade. She said command and control is ARB's trademark, the State's technology forcing standards on engines, fuels and emissions have driven remarkable advancements in the automotive industry. Between 1990 and 2000 the tailpipe limits helped them cut smog forming emissions by 200,000 tons a year. She underscored the point that we would not be where we are nationwide without the traditional BACT standard approaches enshrined in the Clean Air Act.

She said under a market approach, regulators would set a single limit or cap on large emitters throughout a large area, or ideally, the entire nation. She said they will be setting a cap over the next year based on historic emissions at some number that is slightly below the actual emissions reported to them. The cap is set to decline gradually over time until the 2020 goal is met. Generators and importers of electricity and the largest industrial sources would be the first to come under a cap in 2012. The trend line in 2015 increases when transportation fuels will be brought in. They would tighten the cap gradually at first so that regulated industries have time to acclimate to an emissions cap and to become familiar with rules of trading, and to invest in cleaner energy, fuels and technologies that will gradually lower their upfront costs.

ARB would either auction or give to regulated industries and electricity generators and importers emissions allowances. They add up to the total limit under the cap, and ARB would then divide the cap

into annual budgets, which would specify the number of allowances created each year. The allowances allocated would add up to the total emissions numbers set up under the cap.

The emissions allowances hold monetary value and they become a tradable commodity. Companies that can cost-effectively go beyond their obliged emission reductions, can sell their allowances to businesses. This cap provides an incentive for companies to become more efficient. The less energy they use, the more they save and more allowances they have to sell to other companies that may not be able to cost effectively meet their obligation under the cap.

Ms. Mazurek said cap and trade is less costly than command and control because different companies face different pollution control costs. A company that burns carbon intensive coal would find it more expensive to reduce emissions than one using natural gas. The beauty of the cap and trade compared to a BACT approach is that it gives companies under the cap flexibility. She said the gradual flexible nature of a cap reflects ARB's commitment to protect public health and consumers' pocketbooks. It is well suited to address climate change; it rewards those who have invested in energy efficiency and GHG reduction, and encourages continued investment in efficiency and clean energy.

She noted that the ARB will most likely issue their first protocols later this year regarding forestry. Trees absorb vast amounts of carbon dioxide and industries covered by a cap would be allowed to offset a certain portion of their GHG emissions by paying forest land owners in California to preserve stands that otherwise would have fell for wood products or cleared for subdivisions. The ARB is developing rigorous standards so that offset projects such as forest preservation can be verified as emissions reductions that would not otherwise have occurred, and they will be holding a workshop in Sacramento at ARB headquarters on June 23rd to examine how to develop rigorous protocols for offsets and examine the application of other cost containment mechanisms to also serve as a break if they do not have a sufficient supply of offsets in California.

She underscored the point that cap and trade is rigorously enforced and the system cannot function without complete transparency and accountability. Emissions cannot be cut that cannot first be counted. Capped industries will first be required to register with the Air District and report their GHG emissions annually. The ARB is just now compiling data and working to align their mandatory reporting rules with those adopted last year by the U.S. EPA. Once registered, the regulated entity can either reduce emissions and buy or sell trading allowances and offsets. They are working on an allowance tracking system as well as compliance monitoring programs to protect against market manipulation. In theory, once the program is up and running, at the end of the compliance period, the capped entity must do a true up. If they do not match up, enforcement will occur. When fully implemented, the cap and trade system would cover about 85% of the state's GHG emissions.

Ms. Mazurek said very important to understand is that their market would not be limited to California and they developed their program in partnership with seven (7) western states and four (4) Canadian provinces, otherwise known as the Western Climate Initiative. They have worked closely with the California Attorney General's Office and the Federal Commodities Futures and Exchange Commissions which oversees trading of commodities such as allowances and offsets. They have also worked with drafters of federal climate legislation. She said the climate bill proposed by Senators Kerry and Lieberman takes a similar approach to theirs, and their economic modeling shows that the more states, regions and provinces the ARB partners with, the lower the cost of reducing GHG emissions. Assuming Congress passes a federal cap in 2011, their costs under a federal system to achieve the 2020 goal would be half the expense versus going it alone. There are still issues to work out on proposed regulation, and most debate centers on whether to auction or give away emissions allowances, and their dialogue with stakeholders will continue.

**PANEL DISCUSSION**

Ms. Bard questioned what the most important policies that can help the region and also serve as a model for California as a nation. She said after hearing the first presentation and seeing the co-benefits of carbon capture and sequestration and alternative building materials manufacturing, she questioned the downside to the technology, and why wouldn't it be adopted right away. Ms. Mazurek said the only downside she could see is the current state of the California economy and not a demand for cement made by conventional practices as well as alternative approaches.

Mr. Brazil questioned Dr. Beyer and referred to the storage capacity numbers and questioned what California's share of the worldwide storage capacity would be. Dr. Beyer stated the lower estimate worldwide is a couple of thousand Gts, so California's would be about 75-300 billion tonnes, or $1/10^{th}$ of the worldwide numbers. However, he said $CO_2$ will not be distributed around the world because long pipelines will not be built, but rather geologically store the $CO_2$ fairly close to the source or group of sources. He said while there is 3,100 miles of pipeline, this is for $CO_2$ which has economic value for enhanced oil recovery, and they sell that $CO_2$. The point is, though, California has tremendous capacity to store CO2, and much more than it would need to store California's $CO_2$ emissions from point sources and beyond.

Mr. Lucks noted that Dr. Beyer was suggesting that there is a relatively low probably of a severe seismic risk associated with carbon sequestration. He asked for comment about the recent events in Switzerland and northern California that suggests possibly more risk. Dr. Beyer said seismic risk has become a big issue and has been in the headlines. In these cases, they deliberately injected fluids at pressures to fracture the rock, which is the intent. It is done for various oil and gas enhancement processes to increase flow of fluids in the ground. This was part of the intent for the geothermal systems, as well, and he agreed, they did set off some sizeable earthquakes.

For geologic storage of $CO_2$, they do not intend to inject at those pressures. The pressure is very monitored and regulated highly. EPA has a group where they must get what is called an Underground Injection Control permit (UIC) from EPA. So, they do some very small scale testing first and slowly bring up the pressure to see where they get the tiniest fracturing, and then the pressure drops. The EPA then mandates that they only inject at 60% of that number. So, pressure is something that becomes the issue, but it is monitored all the time and if low levels of seismic activity are seen, they monitor that, as well.

Mr. Lucks said the Safe Drinking Water Act acknowledged federal regulation would likely govern carbon capture moving forward at the federal level, and he questioned if fracturing per the permit was something not typical. Dr. Beyer said in some processes this is done, but for $CO_2$ injection it is not anticipated at all. They can test what pressure will fracture rock and simply do not inject it anywhere near those pressures. If there are existing faults stressed ready to go off and the core pressure is increased, slippage can be produced. He noted they will be putting out seismic monitoring stations to look at all activity, but a critically stressed fault can also go off by itself.

Mr. Kurucz referred to membrane separation technology and asked if one of the other technologies would be used to sequester or put the carbon into another form, noting that one project was with an algae plant and he questioned how this worked. Dr. Baker said in this process, it was biodiesel production, so the $CO_2$ is metabolized by the algae and turned into biodiesel. The reason they were doing it is algae farms are using photosynthesis from the sun so they are fairly spread out. The mechanics from pumping flue gas and pumping 6% $CO_2$ and 94% nitrogen 5 miles around a huge algae farm it is not tenable. So they need to concentrate the $CO_2$ and the flue gas just to pump it the distance they need to get it to the algae farm where this is metabolized. They didn't need to get it pure enough to get it into the ground to turn into a liquid, but did need to get it more concentrated than 6%.

Mr. Hayes acknowledged the amount of work that needs to be done. The Advisory Council has talked about membrane technology which is a capture example, storage and sequestration needs to be the destination of those things captured, and with the cement presentation, how is it that reformulation is done which offers real promises to reducing emissions, and there are many connectors here. You must get carbon after captured to the places shown on this map with a lot of pipeline pumping, technology problems, seismic problems, and other issues. All of it is in a stage of trying to show that there is some hope for the future. The Advisory Council's focus is on 2050 and this is long enough for all of this to prove testing and concepts to be done and infrastructure to be constructed. One of the key pieces that need to happen is establishing a price of carbon through the cap and trade program in California. He asked if Dr. Beyer had thoughts about the timing of this, and how it looks like it will unfold over the next couple of decades.

Dr. Beyer said it could lean upon the District's grants and incentives program, but he talks to the public, to regulators, local political people, and public education and outreach is needed about the whole issue. People must understand the problem and the need to take action. He said perhaps money could be put into programs that try to do this. In explaining geologic sequestration, he runs into "Not Under My Backyard" or NUMBYs, and it is interesting that Californians are more in tune with environmental issues. He worked on a project in Arizona, where they don't believe in global warming and climate change is real, and they found an approach that, because they were next to a major coal fired power plant, promoting jobs was the way of making it more understandable.

Ms. Mazurek said ARB's intention is to flip the switch and put a price on carbon in 2012. Their modeling shows that given the gradually declining nature of the cap it would start low at about $12-$18 per ton of $CO_2$ or lower given the prices carbon is trading. She said there is uncertainty at the global levels, at the federal level uncertainties as to passing a nationwide cap, and political challenges facing California in November as to whether or not cap and trade and AB 32 will go forward. While a price on carbon might be the stick or carrot, and to some degree, the technology of whether it is geologic sequestration or other forms of storing carbon, it is already underway and moving ahead. However, the public sector is somewhat stalled now due to political stoppages.

Mr. Hayes questioned if $12-$18 a ton was enough to make technologies work. Ms. Mazurek said the thresholds for technologies discussed would start at a minimum of $30 per ton and more in the 2030 to 2050 horizon. She said as the cap declines and carbons becomes more constrained, the price per ton for carbon increases, so between now and 2020 if the $30 per ton mark is hit, in the next 8-10 years, other price incentive mechanisms would be needed to augment the signal sent by the carbon cap.

Ms. Desautels referred to cap and trade, and she questioned how ARB will prevent the concentration of certain cap industries in certain areas, and is this being factored into how allowances are going to be distributed. Ms. Mazurek said AB 32 contains specific language that they evaluate for environmental health impacts. ARB and the California Health Department are undertaking a health impact study to see whether or not a cap and trade program would release any co-pollutants which would be of concern in communities. We are making sure that analysis is in place, but she did not yet have any preliminary reports.

In terms of the allocation piece of the question, Ms. Mazurek said it would follow that the health assessment would help to steer ARB's considerations about allocations and offsets, as well.

Dr. Bedsworth said as ARB expands sectors included under the cap, she asked how this integrates with GHG standards for passenger vehicles, to ensure it provides additional reductions. Ms. Mazurek said stakeholders in the transportation sector are asking this, as well, because they are faced with three different policies. Because the low carbon fuel standard and the Pavely performance standard for vehicles are already in place, this is one reason they have made a decision not to bring the transportation fuel

sector into the cap until 2015 because so many reductions are driven by measures that are complimentary to a cap and trade system. Refineries are in 2012 because they are large stationary sources, but indirect emissions associated with combustion fuels will come in 2015. This is a decision still up in the air and their thinking is that if they both don't drive all reductions by 2020 under the cap, the 2015 inclusion of indirect sources would then give ARB the incremental reductions they are seeking. So, it is staged.

Mr. Sandler said he knows the history of cap and trade included the Reclaim Program developed by the South Coast AQMD. This program was one of the early attempts as a learning process in how cap and trade worked and some of the intended or unintended consequences of such a system. He questioned lessons learned from the reclaimed system. His understanding is that reclaim did administrative allocation to sources of emission which resulted in some over-allocation. There were also some concerns about hot spots from an environmental justice component, and a lack of a price collar on the price of emissions. During the California energy crisis, they had a real price spike. The European system had a price drop when they found out about over-allocation. He wondered if those lessons learned will be incorporated into the California AB 32 program.

Ms. Mazurek said EPA's acid rain program that came out of the 1990 Clean Air Act amendments was a very different approach than Regional Clean Air Incentives Market (RECLAIM), which was a credit based trading approach rather than Congress going into the Clean Air Act and creating allowance trading system out of whole cloth. Every time they take a run at designing a cap and trade program, built into that are lessons learned from the earlier programs. One of the problems that EUETS (European Energy Auction and New Values) has that our system does not have is that they did not have any underlying GHG mandatory reporting data. This is something the ARB has been collecting for several years now, so there is a good basis on which to allocate emissions. In contrast to the RECLAIM program, they are not using a crediting system that piggybacks off of existing laws. Regarding attention to the cost containment mechanisms, they are holding a workshop on June 22, 2010 where they will talk about the importance of cost containment mechanisms beyond offsets, and then roll out what staff is thinking of using in terms of prices spiking too high as well as falling too low. She invited Council Members to attend the workshop or tune into the webinar.

Dr. Bornstein voiced concern with the dismissal for the possibility of earthquakes due to the role of human error in putting in too much gas and getting above recommended pressures. Dr. Beyer said while not dismissing it, the risk is low for creating an earthquake that will do any damage. However, it is something that the DOE has determined to be a big issue for gas processes, geothermal, and $CO_2$ sequestration. One of his colleagues at Lawrence Berkeley National Laboratory is a very noted authority on induced seismicity that has done monitoring at the geysers geothermal area for decades. They produce a lot of small earthquakes and have seismic networks in place to get more water back into the geysers geothermal systems. Sometimes they are big enough to feel, but he does not think they have done any serious damage. They have also used micro seismicity to track where the water is going. Injection pressures are monitored all the time for processes, but his point is that they have been doing it for a long time in Texas, and both California and Texas have many micro-earthquakes, it is very manageable and controllable, and not something to derail any efforts to do $CO_2$ sequestration.

Dr. Bornstein questioned the effects from a severe earthquake. Dr. Beyer said he did not believe a severe earthquake would happen, and inducing very tiny micro-earthquakes would not necessarily mean anything is being released. He referred to the long geological column in the Montezuma Hills, which they made to scale to provide some concept of the many, many thick layers of sandstones and shale formations which they have tested.

Dr. Vura-Weis thanked speakers and said in stepping back and looking at it on the larger scale, as the group writes its recommendations to the District Board of Directors, conservation and decreasing energy usage must really be present and in the framework of what people do. Regarding cap and trade of how it

would work to have an impact, if allowances are set lower to begin with or the drop in the curve of allowances goes down more steeply would have a greater impact, she asked if it was political issues of acceptability, was it economic, or something else. Ms. Mazurek said it was primarily economic; if the cap is set tighter than warranted or declines too steeply, when you cause an emitter to make reductions that are very steep very quickly, it gets very expensive for them and they will pass those prices on throughout the economy. So, what could happen are price spikes in energy or prolonged high energy prices. This is one of the reasons ARB is exercising so much caution in terms of how to introduce a price signal in carbon, yet they are fully committed in meeting their 2020 goals.

Dr. Vura-Weis commented that the price spikes in energy could lead to greater conservation. Ms. Mazurek said yes, this is the grand dilemma in carbon containment politics and policy, which, on the one hand a high price is needed to stimulate CCS and other technologies, and a long price signal companies can look at beyond 2020 to make investments today. The problem is that they want a high price so that it pencils out for their investment, and at the same time, given the economic crisis, they do not want to impose such a high energy price that could arrest growth from starting out.

Mr. Ruel referred to forestry as a potential source of offsets and ARB is issuing some goals for this soon. He questioned how ARB would portray the connection of the cap and trade program to agriculture, particularly in regards to offsets. Ms. Mazurek said at the federal level, offsets from agriculture are one of the central sources that EPA and the Department of Agriculture sees as bring offsets into a national system. ARB recognizes the importance of them, but unfortunately, we do not harness some of the farming practices that other farm states use that would lend themselves to a readily available supply of offsets, such as no-till[2] agriculture which is not used in California. Their efforts to develop protocols for agriculture, the California Carbon Action Registry has been scouring the state to look for inexpensive sources of uncapped reductions from the agricultural sector, which are tough to come by. They have explored methane, but there was an unanticipated NOx consequence. They recognize how important it is to develop protocols for agriculture, but the ARB and others are still scouring for those sources. One area they are starting to look at that might provide a nice overlay is that there may be a large potential in wetlands. There is some work underway to examine the scientific feasibility of developing a protocol for offsets from wetlands sources.

Mr. Ruel said he did not think it was that California does not practice no-till, but it is not a lot of soybeans and corn that could be adapted to no till. He comes from a vineyard operation and they actually do practice no-till, which is common throughout vineyard and orchards. He thinks it is just an area where there is not significant gain.

Mr. Kurucz said in California, they had a spike in gasoline prices. He questioned if ARB has studied the amount of conservation versus pricing. Ms. Mazurek said yes; in their economic analysis they incorporated not just a statewide but national level real energy price data as well as projected data from the U.S. Department of Energy. She does not have the numbers specifically, but they did see an inverse relationship between demand for gas and prices, as well as a pronounced reduction in attendant $CO_2$ emissions and they are presently working to update our underlying GHG projection inventory data based not only on those fluctuations in fuel prices, but the decrease in demand for energy and the intended reduction of $CO_2$ from the current economic downturn.

Mr. Kurucz questioned if Europe has done more funding for CCS or others. He asked if they are using a higher carbon price as a way to get demonstration projects underway. Ms. Mazurek said she has not followed the European case closely, but under the European ETS trading system, the price of carbon has

[2] (*Wikipedia): No-till farming (sometimes called zero tillage) is a way of growing crops from year to year without disturbing the soil through tillage. No-till is an emergent agricultural technique which can increase the amount of water in the soil and decrease erosion. It may also increase the amount and variety of life in and on the soil but may require increased herbicide usage.*

been too low to see any investment effects. However, looking backwards at the book she wrote in 1998 with Terry Davies, they did a comparative study between the U.S. and Europe and found that the much relatively higher price of fuel in Europe owing to the tax structure that is placed on fuels there had a strong correlation with reduced conventional pollutants and lower VMT, but they we did not look at how revenues from higher fuels in Europe were being directed.

**OTHER BUSINESS**

**3. Council Member Comments/Other Business**

Chairperson Bramlett noted that he and Mr. Kurucz would make a presentation to the Board on June 16, 2010 on the Final Report of the Control Technologies and Strategies for the Industrial and electric Power sectors, and on behalf of the entire Advisory Council, thanked speakers for their presentations.

**4. Time and Place of Next Meeting -** 9:00 a.m. – 12:00 p.m., Wednesday, July 14, 2010, 939 Ellis Street, San Francisco, CA 94109.

**5. Adjournment:** The meeting adjourned at 12:21 p.m.

/s/ Lisa Harper
Lisa Harper
Clerk of the Boards