Bay Area Air Quality Management District
939 Ellis Street
San Francisco, CA 94109
(415) 749-5000

APPROVED MINUTES

Advisory Council Regular Meeting
9:00 a.m., Wednesday, March 10, 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, Benjamin Bolles, Harold Brazil, John Holtzclaw, Ph.D., Robert Huang, Ph.D., Kraig Kurucz, M.S., Rosanna Lerma, P.E., Gary Lucks, JD, CPEA, REA I, Jane Martin, Dr.Ph.H., Debbie Mytels, Jonathan Ruel, Dorothy Vura-Weis, M.D., M.P.H.

Absent: Louise Bedsworth, Ph.D., Robert Bornstein, Ph.D. and Kendal Oku

Introduction of New Advisory Council Member
Chairperson Bramlett introduced new Council Member, Gary Lucks, and provided a brief description of his background and experience.

Oath of Office
The Oath of Office was given to Council Member Gary Lucks.

Public Comment Period: There were no public comments.

Consent Calendar:

1. **Approval of Minutes of the February 10, 2010 Advisory Council Meeting**

Advisory Council Action: Member Blonski made a motion to approve the minutes of February 10, 2010; Member Vura-Weis seconded the motion; unanimously carried without objection.

PRESENTATION: CALIFORNIA'S 2050 GHG EMISSION REDUCTION TARGET – INDUSTRIAL SECTOR

2. **California's 2050 GHG Emission Reduction Target of 80% Below 1990 Levels – Industrial Sector**

   A. **GHG Emission Reduction Strategies for Oil/Gas Production & Refining**
   Joe Sparano, Executive Advisor to the Chairman
   Western States Petroleum Association

Deputy APCO, Jean Roggenkamp, introduced Joe Sparano, Executive Advisor to the Chairman, Western States Petroleum Association, and provided a brief description of his background.

Mr. Sparano gave a PowerPoint presentation regarding meeting California's 2050 GHG emission targets, reviewed AB 32 Global Warming Solutions Act to reduce CO_2 to 1990 levels by 2020 – a 30% reduction, to reduce CO_2 to 80% of 1990 levels by 2050, and the low carbon fuel standard which reduces the "carbon intensity" of transportation fuels at least 10% by 2020.

Mr. Sparano discussed challenges of reducing carbon content of fuels, complementary measures for stationary sources, timing of market opening, fuels under cap and trade, offsets, environmental justice issues and cost containment. He believed the program must:

- Be the product of a transparent, technically sound rulemaking
- Be fuel and process neutral; innovation is key
- Start simple and ramp up to meet 2020 & 2050 goals
- Prevent leakage of emissions out of state or country
- Contain regular milestone reviews to assure program is on track
- Rely on markets; assure fair competition for at-risk investments
- Promote the development and introduction of advanced, not-now-commercially available low carbon intensity fuels
- Be compatible with federal renewable fuels standard and other federal and international programs

The program needs comprehensive energy policies:

- Needs to be realistic about green energy costs and in the time it takes to develop technologies
- Economy requires readily available energy today, not just the promise of it 10-20 years from now
- Avoids inadvertently creating unattainable public expectations
- Public will not allow energy development unless resulting carbon impact is addressed
- Public will not favor reductions in carbon emissions if, as a result, energy prices are forced upward too much, too fast
- An energy transition will not occur overnight, at little cost, and with no inconvenience

He noted that California produces and sells approximately 43 million gallons a day of gasoline and is the third largest consuming entity. He said the stakes are high, volumes are extraordinary and to replace the volume will require some real innovation, creativity, and cost effective processes and fuels in the future.

Mr. Sparano presented a chart developed by the Energy Information Administration of future U.S. energy supply projections. The chart shows U.S. energy demand will increase by 14% between 2008 and 2035 and that close to 80% of the energy used in the United States comes from fossil fuels: coal, gas and oil.

He presented California's GHG footprint and reduction goals, stating that a 20 to 30% reduction will need be needed to reach AB 32's target of reducing GHG emissions to 1990 levels by 2020.

Mr. Sparano presented a low, moderate and high growth chart and the related emission reductions required to get to the 1990 baseline by 2020.

He said regulators have made it clear that their goal is to see the reduction or elimination of the use of petroleum in California. If this is the future, business strategies will be adapted to look at what else is out there, but until then, they cannot afford a gap in energy supply. Sequestration needs to be seriously considered and results will require innovation. The level of state GHG reductions required to meet the goal are "massive" and imply:

- Essentially eliminating carbon from virtually all electricity production and non-aviation transportation;
- Eliminating about 2/3 or more of the carbon from all other applications

California refineries are some of the most energy efficient in the world. Additional energy efficiency improvements in California may be very limited, and California refineries are already highly regulated.

Mr. Sparano reviewed hurdles and barriers to GHG reductions, as follows:

- Technologies needed (i.e., carbon capture and storage - CCS) not currently commercially viable
- Permitting hurdles will be significant
- Combined Heat and Power (CHP) has numerous permitting and market barriers
    - Increases, rather than decreases, net GHG emissions on site
    - Regulatory driven economic impediments in the form of exit fees for departing load are major hurdles for any potential project
- Refinery configurations, layout, space restraints, operating restraints, and capital restraints complicate matters
- Must consider local community inputs for major modifications
- Must consider competing goals

Carbon Capture and Storage (CCS) will help California meets its GHG reduction goals. Over 1 billion tons of CO_2 storage capacity is available in local California oilfields and approximately 57 billion barrels of 'stranded oil resource'.

Mr. Sparano then presented a map showing CO_2 sources & potential storage. He said saline aquifers have a tremendous potential to store 80-300 billion tons of CO_2. When the first commercial scale carbon capture project moves forward, such as a hydrogen energy project, it will take coal and coke available in the valley area, put it through a process, and create clean hydrogen.

He said GHG emission reductions must be achieved at the lowest cost possible while maintaining the competitiveness of California businesses and protecting the interests of consumers and workers. To do this, they must:

- Provide regulatory certainly through use of sound scientific methods to develop, implement and review programs
- Adopt policies that keep jobs in California and achieve global emission reductions to address leakage (use of unlimited offsets)
- Impose only cost-effective & technologically feasible regulations
- Promote innovation and market-based strategies

- Minimize and fairly allocate compliance costs across all sectors of the economy (minimize auctions and limit fees to administrative costs)
- Link to national and international climate programs
- Encourage CCS and CHP
- Minimize direct command and control regulations on facilities
- Coordinate with existing air quality and environmental programs

Key issues for implementing AB 32/LCFS: Fully evaluate the pros and cons before incorporating fuels into Cap and Trade program:

- How would the inclusion of transportation emissions in a market integrate with, affect the design of, obviate the need for, or duplicate other transportation sector policies (i.e., LCFS)?
- What effect would it have on fuel supply and fuel infrastructure?
- What effect could it have on the cost of fuel to consumers?
- How could the allocation process mitigate or exacerbate either fuel supply or cost to consumers?
- How would inclusion of transportation sector emissions in a cap and trade program impact the rest of the market?

LCFS – ensure adequate, reliable, affordable fuels:

- Require adequate, thorough analysis of impacts
    - Demonstrate feasibility of supply and economics of sufficient lower carbon fuels to meet targets using existing technologies
    - Identify the degree to which meeting the standard will depend upon development and commercialization of new technologies
    - Limit adverse impacts on fuel supplies or consumers
- Build appropriate review period and public review process into the regulations
    - Full public process
    - Evaluation of technology advances
    - Assessment of supply and rate of commercialization of fuels and vehicles
    - Program impact on fuel supplies
    - Program impact on state revenues and consumers
    - Identification of hurdles or barriers
    - Compliance schedule adjustment as necessary

Mr. Sparano reviewed the estimated cost/benefits of AB 32 estimated by CARB as well as by a Sacramento State University study, which greatly differ:

- CARB: $24.9 billion in direct costs and $40.4 billion in savings
- CA State University Sacramento: $63.9 billion direct costs on small businesses, $52 billion on consumers, and $49,691 annual cost per small business.

He presented an outline of impacts on consumers of AB 32 which estimates an additional $3,858 annual cost for households, $49,691 average cost to California small business, $183 billion in lost gross state output, 1.1 million jobs lost; $76.8 billion reduction in labor income, and $5.8 billion in lost indirect business taxes. The following is estimated costs/benefits of low carbon fuel standard by CARB and Sierra Research:

CARB:

- $3.4 billion in annual cost savings by 2020;
- Net reduction in criteria pollutants;
- Significant reduction in greenhouse gas (GHG) emissions

Sierra Research:

- Fuel costs increase by $3.7 billion per year in 2020
- NOx emissions increase by more than 5 tons per day
- No detectable change in climate

Mr. Sparano concluded by stating WSPA understands their responsibility, are determined to be successful in meeting AB 32 requirements and the low carbon fuel standard, and described WSPA's Petroleum Plus, which makes for more cleaner burning, investments in wind and solar. He said WSPA has been a founding partner of hydrogen research and development efforts in California, they know how to turn coal into clean burning gas, and said Exxon Mobile has a chemicals company which spent $100 million on environmental compliance. He thanked the Advisory Council for the opportunity to provide the presentation.

B. GHG Emission Reduction Strategies for Industrial Energy Use

Dr. Eric Masanet
Principal Investigator, Energy Analysis Department, Environmental Energy Technologies Division
Lawrence Berkeley National Laboratory

Deputy APCO, Jean Roggenkamp, introduced Dr. Eric Masanet, Principal Investigator, Energy Analysis Department, Environmental Energy Technologies Division at Lawrence Berkeley National Laboratory, and gave a brief description of his background.

Dr. Masanet noted that the project to be presented was funded by the California Energy Commission to estimate what the potential is for energy efficiency in California's industry. He said they are not advocating any technology but, if they were to max out their efficiency potential based on known technologies and what can be envisioned, they looked at how far this would get them toward the GHG emission reductions required for California industry. Clearly, however, this will not be enough to meet the aggressive targets set for the State.

He said the project focused on electricity and gas efficiency for California's industrial sector, which accounts for a large fraction of the state's GHG emissions. The study provided projections for residential and commercial. Electricity use in manufacturing accounted for about 16% of California's total electricity use and 13% of the state's natural gas use. The upshot is that these two fuels combined account for 10% of California's net GHG emissions annually, so they were not able to capture the full range of opportunities available for this industry, and really focused on the 10% they were charged with assessing.

Dr. Masanet presented a chart of trends in California industrial GHG emissions from 1990-2004. He described the legend, stating that purchased electricity and natural gas emissions account for roughly half of California's GHG emissions. The other large contributor is refinery gas. They were not looking for opportunities with refinery gas, although some natural gas measures could be applied to some operations that fire refinery gas, such as boilers or combustion units. They also did not look at coal or clinker production because they were out of scope. Therefore, information presented only got at about half of the emissions attributed to the State's manufacturing sector.

Dr. Masanet presented the following project goals:

- To develop an analytical framework for estimating the potential electricity and natural gas savings associated with efficiency improvements in California's industrial sector over the long-term (i.e., through 2050) that considers:
    - ➢ Structural changes in California (e.g., changes industrial makeup and output)
    - ➢ End use technology changes (e.g., efficiency improvements) and uptake
    - ➢ Future technology and energy costs
- To strike a balance between modeling detail, available resources, and inherent (and significant) uncertainties associated with long-term projections
    - ➢ Focus on key end uses
    - ➢ Cumulative changes (2025 and 2050) versus year-by-year granularity
- To explore data and modeling uncertainties to improve the robustness of decision making
- To provide results that can serve as useful inputs to other state energy and econometric models for policy evaluation (e.g., supply curves)

His discussed his research plan, stating that projections are based on an economic metric the real output of each industry in California, and how that output is expected to change through the year 2050.

Regarding the industrial modeling detail for electricity and natural gas, for electricity, most can be attributed to motor systems which include drives, pumps, compressed air and fans (52%), HVAC units (12%), Refrigeration (9%) and lighting (8%). There are fewer broad categories for natural gas energy use, which include steam systems (26%), process heating or CHP (10%), and HVAC (8%).

Dr. Masanet said they wanted to focus on the industrial sectors that are clearly the largest energy users currently and would likely be some of the largest moving forward. He presented a model for industrial natural gas use and electricity use, showing that for natural gas, about half (or 55%) is attributed to food and beverages and petroleum. The caveat for petroleum is that it is natural gas for combustion purposes. The top 80% boils down to 5 sectors which also include cement and glass, chemicals, paper.

Similarly, for electric energy use, there are more industries at the top 80%; petroleum refineries, food and beverage, and electronics are at 47%. They also looked at chemicals, cement and glass, paper, fabricated metals, plastics and rubber, which are major electricity users.

Most uncertain in their analyses is that projecting what industry will look like 20-40 years out into the future. They found projections developed at the California Energy Commission which they used to generate their industrial energy demand forecast. There is no telling which industries will grow by leaps and bounds and which ones will shrink, but they based their analyses on best available economic projections and projections for services and demand by growing population. The graph shows that plastics and rubber is projected to grow the most by about 400% by year 2050. Chemicals manufacturing (275%), electrical equipment (220%), and machinery (120%) are prime growth sectors, and interesting, petroleum is only projected to grow by 25%. This is mostly due to renewable fuel standards which may offset product outputs and the fact that no new refineries will be added. He noted that glass and cement are reflected under nonmetallic minerals (70%).

Dr. Masanet discussed where they got their data from, how they are making estimates and types of technologies they looked at. Three tiers of technology they considered include:

- Commercially-available best practice technologies
- Emerging technologies currently at the introduction or R&D stage
- Stylistic representation of future advanced technologies from thermodynamic limits, DOE "bandwidth" studies, and technological learning rates

He presented a best practice case study for an existing technology: blanching, which is a key end use of steam in the food industry. Steam accounts for the majority of energy use currently in the food sector. For each of the end uses, they tried to find credible technologies which drew benefits of energy-efficiency. They saw blanching as one of the promising technologies for reducing energy demand in the food industry, which could be a factor of 6 or more than the least efficient blanchers.

He presented under-utilized technologies which were considered and said there is a surprising array of some technologies, given that the State is focusing on energy efficiency GHG mitigation. The following have a less than 5% market share:

- Under-utilized technologies defined as those with less than 5% present day market share
- Under-utilized technologies considered for motor systems, steam systems, process heating systems, and lighting systems
    - Examples: food processing steam
        - Super boiler = 15% fuel savings

In the future, emerging technologies will be paramount:

- Solar thermal concentration can replace up to 100% of steam system fuel demand

Dr. Masanet presented projections for 2050 industrial electricity demand and savings, which reveals a 21% achievable reduction, given growth and technology assumptions. The 2050 industrial natural gas demand reveals an achievable reduction of 30%, a lot of which has to do with improving process heating efficiency. The big savings industries are refining, chemicals, cement and glass.

In showing where savings are attributable in terms of end use technologies, Dr. Masanet provided a graph of the total magnitude of savings projected for electricity. They looked at motors, lighting, HVAC, process heating and refrigeration and found that most of the savings are from improvements in motor systems as a whole. He provided a similar breakdown for gas savings estimates.

For petroleum refining which is the second largest bar, most of it is wrapped up in assumptions for process heating or non-thermal separation technologies in refining processes. They also saw a lot of savings potential in the food industry because there is still a lot of efficiency in steam systems and process heating systems which has to do with the nature of industry in California. There are many large plants that use advanced equipment with higher capital investment type operations, but still many smaller plants that may not be able to afford the most efficient boiler, latest combustion technologies and controls.

Dr. Masanet presented a graph which showed what the 2050 natural gas demand may look like in the absence of any efficiency improvements when considering population growth, projected growth in industry, residential, and in the commercial sector. Given the technologies available in each of the three sectors, the absolute demand can be reduced below current levels for natural gas, but the real issue is population growth and services demanded by society. For electricity, it is a break even scenario under the three sectors.

He said there are many uncertainties in assumptions in projecting future technologies and growth for industry, commercial, population and homes, and they have tried to construct high and low bounds. They looked at a benchmark growth to almost 60 million people in California which was based on Department of Finance projections. For both electricity and natural gas projections, they look at how far they can get for efficiency. He presented a graph showing where demand would go in the absence of efficiency, or a "frozen efficiency" scenario and the lower demand in the same color. The high scenario assumes low penetration of efficient technologies and high growth in industrial output. Conversely, the low scenario assumes low growth in industrial output or structural changes that would help produce energy demand, coupled with very high uptake of efficient technologies. The differences between the high and low cases, is a range where projections would fall into. The key is that they plotted 2006, 2025, and 2050. Even under the low scenario, they are looking at still flat-lining for electricity use on just the efficiency side of the equation. For natural gas it is better because more thermal intensive industries are assumed to drop off if they have cap and trade, high energy prices, and if they look at a more aggressive efficiency scenario and more optimistic growth scenario from an energy use perspective, there is potential to reduce natural demand from industrial uses by a meaningful fraction, or maybe by half in 2050.

Dr. Masanet said the message he conveys is that efficiency is very important; it is one of the first steps they should take because there are cost effective efficiency improvements that can achieve real savings today. However, it is probably not enough to get to large reductions in GHG from California's industrial sector. Although, they did not look at a few key strategies that could be very important for reducing GHG emissions, such as switching of fuels—going from a thermal process to an electric process. They did look at membrane separation as one of the core technologies, but there are other technologies out there that they did not have good data on to consider. They did not look at electric boilers, electrified emerging technologies for the food processing sector for lack of data. However, there are technologies that could move from a gas fired oven to a microwave or an RF frequency oven. The key caveat is that they really only work for GHG's when there is a low carbon energy source. If we have a carbon-free grid, these make a lot of sense. They did not look at carbon capture and sequestration, but clearly a lot of industrial analysts are saying this is likely part of the solution, and they need to better understand the ramifications of this due to water and energy investments to make it work.

Lastly, there is growing attention to look at how we can change the demand side of industrial output, so if we can de-materialize products, produce longer lasting products, and shift from products to services, those may be viable models for having a viable and vibrant industrial sector while providing the same services to end use customers. Dr. Masanet ended his presentation by discussing a successful business model used by Xerox involving leased, versus purchased, products. Leasing provided Xerox profits without producing as much equipment.

C. GHG Emission Reduction Strategies for Cement Industry
Gregory Knapp
Director, Environmental Safety & Health West Region, Lehigh Hanson

Deputy APCO, Jean Roggenkamp, introduced Mr. Gregory Knapp, Director, Environmental Safety & Health West Region, Lehigh Hanson, and provided a brief description of his background.

Mr. Knapp stated that in 2008 G8 leaders asked the International Energy Agency (IEA) to prepare "technology roadmaps" for various industries to identify carbon emission reduction opportunities. IEA worked with the World Business Council for Sustainable Development's Cement Sustainability Initiative to develop a roadmap for the cement industry.

He reviewed cement demand:

- Cement is the "glue" in concrete
- Concrete is second only to water in total volumes consumed by society
- California has specific standards for cement based on ASTM C-150
- California consumes 0.33 tons of cement per person per year, or, an average of 12 Million Tons (MT) per year
- This demand has ranged from 9 MT (today) to 16 MT (2005) per year
- California has 10 cement plants that can nominally produce 12-14 MT per year
- At the peak of the curve, 30-40% of California demand was provided by international imports, as California plants were exporting to neighboring states

Cement Greenhouse Gas Emissions:

- California cement plants account for roughly 2% of the 1990 CARB Inventory

Cement manufacturing stationary GHG emissions come from 3 main categories:

1. Process $CaCO3 \rightarrow CaO + CO_2\uparrow$

Calcination - a necessary chemical reaction to form "clinker" in the kiln

1. Fuel

Principal fuels are coal, petroleum coke, tires, biomass fuels

1. Electricity Use (aka Indirect Emissions)
    - Large demands for crushing, milling, and other equipment
    - Not included in emissions inventory
    - About 8-10% of overall energy use in a cement plant

Mr. Knapp presented a graph and discussed how cement is manufactured, displayed examples of Lehigh Hanson's Redding Plant, a pre-heater and pre-calciner and the kiln which makes clinker. He discussed the following carbon emission reductions in the cement industry:

Potential Sources – Fuel and Electricity:

1. Thermal and Electric Efficiency
    - Further efficiency gains in fuel burning and electric equipment

- Primary current focus of operations – main opportunity for efficiency
- Small gains are expensive – millions of dollars
- The only reduction managed by the industry itself

2. <u>Alternative Lower Carbon Fuels</u>
   - Biomass / carbon-neutral fuels
   - Tires which include 25-30% natural rubber (carbon neutral)
   - Bio solids

Potential Sources – Process:

3. <u>Carbon Capture and Storage</u>
   - Collecting CO_2 before it leaves the stack, converting it to a stable form, and storing it securely
4. <u>Clinker Substitution</u>
   - The manufacture of clinker is the most emissions intensive segment of making cement. Typically, California cement contains 91-93% clinker.
   - Other less GHG-intensive materials can replace clinker in cement including: fly ash, silica fume, steel slag, natural minerals.
5. <u>Low Carbon cements</u>
   - Experimental and not comparable in performance to Portland cement at this time
   - Not made in kilns, but they are processed

Thermal Efficiency:

- Thermal efficiency improvements occur with the replacement of old technology. For example, wet kilns replaced by dry kilns and now, the use of "pre-heater / pre-calciner (PH/PC)" systems.
- Recent global industry-wide average for PH/PC: 6% improvement
- Recent California industry-wide average: 13% improvement (includes changes from older technology to PH/PC)
- Global Industry-wide projection of an additional 5% improvement by 2050 (PH/PC only)

Obstacles for Thermal Efficiency Gains:

- 1.65 to 1.8 gigajoule (GJ)/ton is the theoretical requirement not including conductive heat loss and other inherent physical inefficiencies
- Significant improvements require major ($100s million) investments
- Business uncertainty inhibits these major retrofits
- Research & Development potentials
  1. Fluidized bed technology
  2. Others?

Electric Efficiency

- Electric Efficiency improvements are also made by replacement with more efficient motors and electricity-demand equipment
- Largest users in a cement plant are typically mills and crushers
- California shows 4.6% improvement between 1990 and 2005 (Global 3.5%)

Global projections have high uncertainty due to:

- High investment cost vs. return

- Strengthened environmental requirements increase electricity demand for control equipment
- Demand for high strength cement performance requires finer grinding and thus more electricity
- Carbon Capture and Storage can increase plant electricity use by 50-120%
- Some modeled scenarios show 10% improvements by 2050

Mr. Knapp provided an example of a 2005 California Plant:

Clinker Produced: 1,000,000 tons Thermal Efficiency; 4.07 GJ/ton clinker

Fuel mix: Coal 107,917 70% - Coke 38,850 25% - Tires 7,216 5% - Biomass 0 0%
Fuel CO_2: 379,612 - Process CO_2: 525,000 - Total Direct CO_2: 904,612 Tons

Cement Produced: 1,080,000 tons Electric Efficiency: 144 KwH/ton cement
MwH used: 155,520 Total Indirect CO_2: 62,200 Tons

CO_2 e = 966,812 Tons

Mr. Knapp then provided an example of a 2030 California Plant:

Clinker Produced: 1,000,000 tons Thermal Efficiency; 3.97 GJ/ton clinker (↓2.5%)

Fuel mix: Coal 90,227 60% - Coke 30,317 20% - Tires 21,112 15% - Biomass 12,250 5% Carbon Neutral - Fuel CO_2: 313,050 - Process CO_2: 525,000 - Total Direct CO_2: 838,050 Tons

Cement Produced: 1,080,000 Electric Efficiency: 137 KwH/ton cement (↓5%)
MwH used: 147,960 Total Indirect CO_2: 59,180 Tons

CO_2 e = 897,230 Tons

Mr. Knapp then provided an example of a 2050 California Plant:

Clinker Produced: 1,000,000 tons Thermal Efficiency; 3.87 GJ/ton clinker (↓2.5%)

Fuel mix: Coal 79,305 54% - Coke 30,317 21% - Tires 21,112 15% - Biomass 23,890 10% Carbon Neutral - Fuel CO_2: 284,670 - Process CO_2: 525,000 - Total Direct CO_2: 809,670 Tons

Cement Produced: 1,080,000 Electric Efficiency: 130 KwH/ton cement (↓5%)
MwH used: 140,400 Total Indirect CO_2: 56,160 Tons

CO_2 e = 865,830 Tons

Example California Plant Progress toward 2050 - 10% CO_2 e Emissions Decrease

<u>Carbon Capture and Storage</u>

- A developing technology that uses chemical collection processes to remove CO_2

- Current approaches would liquefy the gas and inject it deep underground after pipeline transport to a suitable location
- Transportation and storage networks currently do not exist
- Storage pressures of injected CO_2 > 1500 psia
- Post-combustion approaches include chemical absorption, membrane technologies, and adsorption carbonate looping
- Not expected prior to 2020 after which it would be expensive and only affordable by larger plants, greater than 1,500,000 tons per year
- An estimated cost for a 2,000,000 ton per year plant in 2030 is:
- 150 - 450 $ Million for installation
- 30 – 150 $ Million per year operating cost
- Not including transportation and storage

<u>Chemical Absorption – Desorption</u>

- Currently used in other industries such as natural gas processing
- Cement and other flue gases are quite different having much lower CO_2 partial pressures (< 2 psia) and higher volumes to treat
- The low CO_2 partial pressures create very slow absorption rates and thus complicate a large-scale process
- Significant energy is used for regeneration of solutions, purification of CO_2 stream, compression to 1500 psia from atmospheric, transportation via pipeline, other storage needs
- CO_2 emissions could actually increase without proper design

<u>Membrane Separation</u>

- Currently experimental for CO_2 from flue gas
- Membranes selectively let CO_2 from flue gas pass through, or
- Absorbing solution attracts CO_2 from flue gas through the membrane
- Enriched gas is then sent on to compression
- Membrane systems can be low maintenance and use low energy
- Significant Research and Design is needed for
- Membrane systems at the huge scale needed for flue gas
- (current systems are very small scale)
- Compatibility with flue gas impurities
- Compatibility with high flue gas temperatures

<u>Solid Adsorption</u>

- Adsorbs CO_2 onto or forms into a solid for later desorption
- A special case is "Carbonate Looping" which seems applicable to cement

  $CaO + CO_2 \rightarrow CaCO3$ occurs from the flue gas
  $CaCO3 \rightarrow CaO + CO_2$ is then performed in a calciner

- A portion of the CaO must be discarded due to deactivation, but, it can be used as a cement kiln feedstock
- This process is currently being researched in the industry

He presented the process of CO_2 absorption with carbonate looping.

Storage
Perhaps the biggest uncertainty, how much of the CO_2 injected into an oil and gas reservoir actually stays there permanently?
Same question for other geological formations such as saline aquifers. The ocean? "Carbon Looping" -- can it ever decrease or just stay even?

Summary
IEA: "The roadmap's technology mitigation options are outlined in a set of 38 technology papers developed by the European Cement Research Academy (ECRA) sponsored by the CSI."

"The papers do not envisage a major breakthrough technology in cement manufacture, so the importance of CCS is critical if the industry is going to reduce its emissions significantly. But even with CCS development and implementation, the cement industry could not be carbon neutral within its existing technology, financing, and innovation framework. No alternative for concrete exists that can be applied at sufficient scale."

(Technology papers can be found at www.wbcsdcement.org/technology)

- Cement manufacturing can achieve modest reductions focusing on lower-carbon and/or carbon-neutral fuels such as tires and biomass fuels
- Electricity demand can be an additional, though much lower reduction
- A 10% decrease in cement manufacturing CO_2 e reduces the California 1990 inventory by 0.2 %
- The CO_2 e emissions reductions due to the fuel efficiencies gained by wider use of concrete as a building material exceed these reductions

Regarding questions asked of speakers, Mr. Knapp provided the following answers:

Question 1: How could California's 2050 GHG reduction target (80% reduction) be accomplished for the industrial sector?

For the cement industry to significantly contribute towards reaching this goal, the only possibility is through Carbon Capture and Storage.

Question 2: What are the implications of California's 2050 GHG emission reduction target for the Air District's regulatory and legislative agendas?

Encourage consumer-based GHG reductions:

a) Promote products and materials with higher fuel and energy efficiencies and/or lower overall CO_2 e intensities based on total life cycle analyses. Examples include: concrete pavements; concrete components in commercial & residential buildings; cement with less clinker; concrete with less cement
b) Promote the reuse of the associated carbon of materials for fuel and/or material replacement. Examples include: bio-solid fuels; waste fuels; recycled concrete for aggregate

Question 3: What are the implications of California's 2050 GHG emission reduction target for the Air District's Climate Protection and Grants & Incentives Programs?

Promote research and outreach to further the above societal goals. These can be fundamental changes in the lives and purchasing habits of Californians. Their acceptance needs fostering. Examples include: acceptance of lower CO_2 e concrete through outreach to architects, engineers, and builders; "credits" for lower CO_2 e intensive buildings.
Promote research in Carbon Capture and Storage. This can include synergies between "producers" (e.g. power plants) and consumers (e.g. cement plants)

<u>Public Comments:</u>
Sam Altshuler discussed the debate and argument surrounding costs and affordability back in the 1970's and again now in addressing air quality, noting that industry provided alternative products. He said not discussed is a source of pure oxygen which would make the whole process of carbon sequestration easier. He also referred to and briefly discussed the Blume Box, aired on 60 Minutes, which uses methane to extract energy.

PANEL DISCUSSION

3. Industrial Sector GHG Emission Reduction Strategies for California and the Bay Area

Chairperson Bramlett asked Mr. Sparano and Dr. Masanet to address the three questions posed, and thereafter, questions would be taken from Advisory Council members.

Mr. Sparano responded to the following questions:

1. How could California's 2050 GHG reduction target (80% reduction) be accomplished for the industrial sector?

Mr. Sparano said most important is carbon capture and sequestration which is a process tested and used in their industry and has a nice complimentary effect if one is in the business of producing more oil. The other is offsets, which has complicated issues, the least of which is a desire in regulatory agencies to make improvements to air quality locally. At the same time, WSPA is dealing with a global issue where having the use of offsets could make material and verifiable reductions in GHGs that do not happen to be right inside the plant. They can make investments that honor the premise of reduction in global warming. He acknowledged that industry must be sensitive to cost, does not know whether cost will drive them out of business, and said regulations are the most transforming he has seen.

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

Mr. Sparano said one of the areas they have been challenged by is the issue of local regulation and fees compared to whatever structure they have on a state basis. BAAQMD has gotten out in front of this. It is a challenge to his members, but he feels there needs to be a good balance between the agendas on a district-by-district basis and what the state has set up as an overall framework, as well as balance if a federal program is put into place. If there are 18 different specifications around the country, this makes it hard if they have a disruption in fuel supply in one high volume market to bring supplies from another market place. With low carbon fuels, they are seeing state and city regulations and substitutions, and he believes a great deal of care needs to be exercised in this area.

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

Mr. Sparano said he does not have an answer to this question. WSPA works closely with the District and if there are ways to cooperate and support efforts, they will if they can.

Dr. Masanet responded to the following questions:

1. How could California's 2050 GHG reduction target (80% reduction) be accomplished for the industrial sector?

He echoed his colleagues' statements and is an efficient-first proponent, but there are many barriers to efficiency—cost and perceived risk about new technologies. However, he stated that a lot of benefit can be had in low cost in the industrial sector through the promotion of energy efficiency, but results suggest that it will only get us so far.

The second is lower carbon supply. Electricity used by California's industrial sector is a large component for many industries, and to some extent, industry can reduce the footprint of its use by use of combined heat and power (CHP). However, there is a perverse outcome when a site is penalized for increased fuel use where society benefits from a lower carbon intensity kilowatt hour. The supply side is equally important to the demand side. The success of California manufacturing companies getting close to the target is really dependent on what is available in terms of low carbon electricity generation.

He said carbon capture and sequestration will likely need to happen, but should only be done as a last resort. There seems to be a lot of unknowns and energy and water investments in the carbon capture technologies are not fully understood. He said the system is not fully understood in concentrating the CO_2, transporting it, and ultimately sequestering it safely and securely. Therefore, more research and investment needs to be in place.

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

Dr. Masanet said he is a novice at understanding the Board's regulatory and legislative powers and priorities, but more research is definitely needed to better understand carbon capture and sequestration. Also, taking a broader and more holistic approach to providing incentives, if we draw the box solely around industry, we may miss some greater system level benefits and not capture benefits, i.e., societal level benefits of concrete for buildings and pavements such as reducing rolling resistance, improving fuel economy in pavements and in buildings, providing greater thermal mass to reduce cooling and heating requirements, and he said some sort of holistic perspective in providing incentives is needed.

He recommended starting to explore issues through life cycle assessment that tries to get at big picture net benefits associated with materials and products. If we get our arms around this, we can provide the right incentives into the market place through voluntary programs and through standards and regulations. Again, more research is needed on those questions.

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

Dr. Masanet said he does not have much experience with grants and incentives, but if strategies and investments can be incentivized that will minimize system level emissions, this is the right course of action. It will take research, and he has noticed that what goes a long way in efficient technologies are demonstration projects. Many companies are hesitant to adopt new technologies until they see it proven out somewhere. Barriers they see are that there is not a lot of information that can address perceived risk. Most companies are not amenable to trying out something new unless it is proven.

Ms. Bard cited recent arguments to roll back AB 32 and referred to Mr. Sparano's presentation. She said the Varshney Report has been criticized by economists in California, including Stanford University Economist Jim Sweeney, who states the costs have been over-estimated by a factor of ten. He found the report to be highly biased based on poor logic and unfounded economic analysis. It only looked at the cost of implementing AB 32 purposely omitting any of the savings it would generate, which is $40 billion.

Ms. Bard said it would be helpful to the Advisory Council to know what the industry best practices are and whether this is in California, nationally, or globally. She acknowledged BP's groundbreaking work, voiced interest in knowing those state-of-the-art facilities' control of GHGs and other emissions around the globe which she said would help advise the Council on what can be achieved in California. She also questioned whether WSPA was actively supporting efforts to rescind AB 32 in California.

Mr. Sparano said WSPA has been a group actively involved in offering its opinion on AB 32, which everyone has a right and obligation to do. They have some legitimate concerns and there are costs which cannot be ignored. For this panel, he offered the need to embrace balance and ensure we do not overlook costs. He said WSPA is not trying to roll back AB 32, but they are vigorously discussing their concerns.

Mr. Kurucz referred to Mr. Sparano's statement and questioned CO_2 as part of the tertiary production. Mr. Sparano said a reservoir of oil is fractured rock. At the end of secondary recovery after a water flood, you might be around 30% of recovery from resources in the well. Some of their members, particularly in Texas, have been using CO_2 for years. The irony is they have been buying food grade CO_2 and putting it in liquid form down the well, helping to further extend the life of the well and recovery of resources. In California, this has not been done much. He discussed a joint venture test project in Bakersfield where the end product is clean hydrogen used to make electricity. That CO_2 would eventually find its way down into a reservoir in Kern County, and over a period of time, push the oil out and remain under the surface. In Texas, this has been done for 40-50 years with good results and no escape of material. The process is not yet perfected, but it is important and there are opportunities they may not have fully engaged in.

Mr. Kurucz questioned how refineries measure efficiency. Mr. Sparano stated they have standards that look at how much energy they have used in a point of time and reductions in that use, whether it is by buying more energy efficient equipment or looking at how hard the equipment is being run.

Mr. Kurucz questioned whether it was a percentage of the potential energy of the crude oil you bring in or a percentage of utilization of the electrical power you buy. Mr. Sparano said it is more the utilization of electric power and he noted processing that does a great job of advancing octane quality, energy of gasoline, or de-sulfurizing or removing contaminants from the diesel, which is all energy intensive and an area where they have made great improvements in energy reduction.

Regarding technology in terms of the non-thermal separation or membrane instead of a distillation column, Mr. Sparano said he wishes he was more familiar with it. It is a breakthrough technology they can deal with in terms of its applicability to their industry and they will be very interested in it.

Mr. Kurucz asked Mr. Knapp if biomass is in use at any large facilities in California. Mr. Knapp said he knows one plant in southern California is using bio solids, however, he did not know the percentage of fuel replacement they get, but said it is fairly small. Other cement plants in California have looked at the vegetative type of biomass. Their plant in Redding was making 5%-10% replacement. He said there are practical limitations on these types of fuels that must be overcome with engineering and systems. These plants are different in how they handle materials because they ultimately have to get them into the kiln and tower similar to the way you would inject petroleum coke or coal. There is a lot of handling upstream of this and limitations as to how fast you can get the material processed and into the kiln at the right rate to deliver the energy you need. But, they have seen that somewhere between 60% and 70% replacement of fuel is possible, but not easy. To look at California as an example of what it would take to use bio solids that need a home, it will take a partnership between the waste treatment plant operating the utility sections that operate waste treatment plants and the transportation to get that to a suitable user. It will not be driven by one industry. It will take some partnerships and to also find the right use for these. There are certain restrictions as to what can be put in landfills and it will take interaction between government and producers and users of these types of materials to get that into our industrial system.

Mr. Kurucz asked if using fly ash was a viable option. Mr. Knapp said it is being used now and is prescribed by certain concrete mixes. He said it is 7% to 15% usage in the concrete delivered, but there is opportunity for that material to be used on a wider scale and it can produce better performing concrete over time than some applications, but it has some restrictions. Where it is coming from presents the transportation issue, as most of it is in the mid-west and further east.

Mr. Kurucz clarified that operating California plants are using a pre-calciner, except for one plant in southern California which is currently idle.

Mr. Kurucz questioned where the calcium oxide (CAO) used in the carbonated looping was coming from. Mr. Knapp said this is generated by a kiln type process; heating limestone and making calcium oxide by driving off CO_2.

Mr. Kurucz questioned if there were any problems with seismic standards or engineer/architectural tests when making major changes in cement products. Mr. Knapp said there will be challenges to see if blends can meet the specifications of design engineers, architects and building codes. There are locations in California where building codes are outdated and cement is typically high clinker percentages, but there are also global applications where different replacement cements can work.

Dr. Holtzclaw thanked all three speakers for their presentation and for Mr. Altshuler in his statement that we should not be limited by what we know now in predicting what will occur 40 years into the future. He said already occurring is cloud computing, which was discussed 15 years ago. Google is in the lead on it, and it reduces the amount of manufacturing and energy in manufacturing for computers. It requires more radio wifi and connection for telephones. He asked how much electrical energy or CO_2 cost goes into communications with large computers and how much it might increase in the future.

Dr. Masanet said he was involved in a study two years ago commissioned by the U.S. Congress to look at data center energy demand in the U.S. and efficiency opportunities for data centers. He submitted a manuscript for publication where they modeled trends in energy demand. Currently, data centers account for about 1.6% of national electricity demand. If we move to cloud computing, this is likely to go up. Efficiency opportunities are prevalent for data centers, as well. A data center could reduce its electricity consumption in the U.S., on average, about 80% through some of the advanced server management strategies and more efficient equipment. Even if this sector is grown which speaks to the holistic systems view, they may be manufacturing less energy-intensive PCs accessing the cloud, rather than a large, powerful hard drive or processor in every house. He said this is something that could transform the way we communicate home energy use.

Dr. Holtzclaw questioned how much energy goes into radio communication. Dr. Masanet said they did look at the transmissions to and from the data center as well, but he did not have estimates.

Mr. Hayes thanked the three speakers and stated that industrial emissions represented about 20% of total 2006 GHG emissions; refineries represented about 8%; oil and gas from facilities represented about 12%; and cement represented about 2%. It seems that the large piece is the transportation sector, which represents about 40% of the total. He thinks it is important to understand what is in the scoping plan, what additionally will be needed to be done beyond the 2020 measures, and what is being asked of industry. He reviewed the 72 measures to determine which apply to industry and it seems that a couple of measures really matter—Pavley I and II is 20%, low carbon fuel is 10%, and another 10% for cap and trade. Those together represent almost half of total GHG emissions and the rest is an assortment of smaller reductions.

The message he is taking away is carbon capture and sequestration, and it does not sound as if there is any other realistic avenue to an 80% reduction. With the cement industry, there is a chemical reaction to make the end product to reduce CO_2 formed, but by and large, it is a task of managing CO_2 and disposing of it someplace.

Regarding the oil and gas industry, it seems there are additional efficiencies that can be obtained in refinery operations. There is participation in cap and trade which will be a major activity, and he is not quite sure he understands how the petroleum industry is thinking about low carbon fuels, the implications of Pavley-compliant vehicles on the road and how it sees their role in meeting the goals of Pavley and low carbon fuels.

Mr. Sparano said he mentioned earlier that one of the things WSPA sees is that the state is looking to minimize or eliminate use of fuels in the future and replace them and vehicles with an electrified system, which is tough for their industry. And, with a cap and trade system, they end up paying for the electrification of the system. In looking at the product opportunities to meet the low carbon fuel standard, in the first few years from 2011 through 2015, there is probably lower carbon materials that are bio-fuel in nature but later on, they will be challenged. He said they have a great deal of money invested in California in adapting their operations to create usable fuels that meet standards, and he is fearful about having the right kinds of fuels to meet the low carbon fuel standard.

Mr. Hayes questioned and confirmed that Dr. Masanet did not include refinery gas in the study's analysis, although some of the findings could be extended to refinery gas. Mr. Sparano noted that if they do not sell it, they typically use it in their operations. Also, many members in California have built co-generation plants so they can use it in an energy efficient way.

Dr. Masanet said the savings they have to natural gas could go higher if some of the refinery gas measures are applied, and therefore, they most likely under-estimated the GHG savings by just focusing on natural gas.

Dr. Vura-Weis noted the huge challenge, and said it is illogical to take carbon that is sequestered, de-sequester it, burn it, capture the carbon, and then put it back into the earth. She believed in other ways of capturing energy such as de-materializing society, changing the way people live their lives, decreasing demand, and she cited nutrition labels, energy star ratings with appliances, and questioned the use of metrics labeling of how much embedded energy is used on a per year basis.

Mr. Knapp said two large global retailers; Tesco and Wal-Mart, are moving in the direction of carbon labeling standards, but there are all sorts of technical challenges doing this. They are working with testing the idea to see what gains could be realized if labels were successful and they drove the market down to a lower carbon operating point. The one big challenge is that it is difficult to come up with a metric that is robust. He gave the example of buying shoes that fall apart sooner; you end up buying more of the same shoes, compared to a higher carbon pair of shoes that last longer, therefore, buying less.

Mr. Lucks said he serves on the California State Bar Legislation Committee, and noted last week they met in the Capitol with Senate and legislative leaders to get a forecast for environmental policy this year. One policy they will focus on is tax incentives and other financial strategies to promote research and innovation in green and clean technology. However, he did not hear anything about carbon capture, so he hoped there is an opportunity to morph some bills into policy. He referred to an innovative technology out of Santa Cruz using sea water that would result in a lower carbon footprint for a whole new focus on cement. Mr. Knapp said he heard a presentation last year sponsored by the Department of Energy on an experimental power plant, but was not exactly sure it was the same example.

Mr. Lucks said there are one or two lawsuits challenging the low carbon fuel standard, and he questioned if WSPA was part of the lawsuit. Mr. Sparano said WSPA is not; there are national associations which are and they have some common members, but their membership is not supportive of this. He said WSPA has worked very hard with CARB for many years on both AB 32 and the low carbon fuel standard to create ways to successfully implement both, and acknowledged their concerns.

Chairperson Bramlett thanked all speakers and panel members. He requested members send comments to Mr. Kurucz, the principal author of the group, by March 17, 2010 and to have the first draft report back to the author by April 6, 2010.

OLD BUSINESS

4. Council Member Comments/Other Business

Chairperson Bramlett asked members to email him as to their interest in attending the Air and Waste Management Conference June 22-25, 2010. Dr. Holtzclaw reminded members that ethics training will be held at the District on March 18, 2010 at 1:00 p.m.

Ms. Bard said MTC and ABAG are hosting a public workshop today from 2:00 to 4:00 p.m. to solicit public input on region-setting of GHG reduction targets from land use and transportation planning, as part of SB 375 implementation. She is attending and representing the public health community. She will submit a letter on behalf of 20 public health organizations to bring the message of urgency to address GHG reductions and health benefits from transportation and land use planning which can improve public health and promote active transportation.

5. Time and Place of Next Meeting - 9:00 a.m. – 12:00 noon, Wednesday, April 14, 2010, 939 Ellis Street, San Francisco, CA 94109.

6. Adjournment: The meeting adjourned at 12:00 p.m.

/S/ Lisa Harper
Lisa Harper
Clerk of the Boards