EXECUTIVE SUMMARY

This report summarizes ongoing activities of the Advisory Council during September-November 2014, consolidating presentations received, and subsequent discussion and consideration by Council members during this period. It is the intent of the Council to continue study of this topic during the early portion of 2015. As more information is received and evaluated by the Council, conclusions and recommendations are expected to evolve and will be documented in future reports.

The following presentation was made at the September 10, 2014 Advisory Council meeting:

> *Energy and Climate Opportunities for the Bay Area* by Daniel M. Kammen, Ph.D., Class of 1935 Distinguished Professor of Energy, Energy and Resources Group and Goldman School of Public Policy, and Founding Director of the Renewable and Appropriate Energy Laboratory, University of California, Berkeley

A video recording of these presentations and the Council's discussion can be reviewed at http://baaqmd.granicus.com/MediaPlayer.php?publish_id=2b960489-3929-11e4-bf9a-00219b9a9d7d

Building on the foundation of AB 32 and on the numerous policies implemented in California to meet its climate and clean energy goals, Dr. Kammen presented his "SWITCH" model, which analyzes the adequacy of energy generation, transmission, and storage systems to satisfy load requirements by allowing for the possibility of a variety of energy sources (including solar, wind, water, nuclear, geothermal, and fossil), as well as for energy conservation.

The model suggests that multiple pathways exist to achieve greenhouse gas (GHG) emissions reduction goals, while simultaneously ensuring grid reliability, so long as carbon pricing is integrated into the decision-making process. Each of these pathways is projected to be economically comparable to, or cheaper than, the business as usual strategy.

Some recommendations contained in this report are for the Air District to: (1) consider carbon analysis and accounting during decision making for major projects submitted as part of the permitting process; (2) provide education about the cost-effectiveness of shifting to a low-carbon energy future; (3) conduct future energy and climate change work in a manner consistent with principles of promoting equity and advancing both environmental and economic opportunities in disadvantaged communities; and (4) promote user-friendly tools to assist individuals, businesses, and local governments to reduce their carbon footprint.

BACKGROUND

Energy policy in CA

1. CA remains in a leadership position on climate change mitigation and clean energy development. Not only did the State adopt AB 32 in 2006, a bill that sets an aggregate climate pollution target for the year 2020, it has also adopted a series of integrated and complementary policies to address climate change and promote clean energy development across the economy. This "interlocking set of policies" guarantees that, even if one program fails, the others can remain intact and aim toward the same ambitious performance target.

2. While California's climate program sets ambitious targets, California represents only 2% of worldwide greenhouse gas (GHG) emissions. For maximum effectiveness in the effort to limit climate change, statewide efforts must work within and promote international actions to combat climate change. Moving forward, California's global leadership position on climate change policy will be as important, if not more so, than its effectiveness at reducing in-state emissions.

Dr. Kammen's SWITCH Model

3. The SWITCH model, developed by Dr. Kammen and collaborators, is a high-resolution energy-capacity-planning model based on a representation of the electric grid within the Western Electricity Coordinating Council (WECC) region. (Other regions in the world have also been modeled using SWITCH, yielding nearly identical results.) As described by Dr. Kammen, SWITCH explicitly models energy sources, sinks, storage, and transmission within the WECC region. Further, it accounts for changes within the WECC that are the result of policies that impact carbon prices and renewable portfolio standards. Other policies may also have impacts, but are not accounted for in the model, and the model does not take into account health costs, non-carbon environmental benefits, or other externalities, nor does it model electric-pricing demand response (since data in this area are sparse). Minimizing system costs to deliver power on an hourly basis and maintaining capacity reserve margins are explicit model constraints, and the model is run across a wide variety of seasons and times of day.

Model results and conclusions

4. The SWITCH model output allows Dr. Kammen to assert that many pathways exist to achieve AB 32 GHG reduction goals, while ensuring reliability of the electric grid. However, Dr. Kammen and SWITCH find that embedding a carbon price into relevant decision-making processes must also be implemented for this result to be reached.

5. Each pathway for AB 32 compliance is projected to have a lower cost than the business as usual (BAU) strategy. These findings are projected to hold even when SWITCH is run on a wide variety of days, including the least windy, hottest days in summer.

6. According to Dr. Kammen and the SWITCH model results, constraints on technology are not projected to be a limiting factor in meeting the goals embedded within AB 32 and other clean energy policies. Instead, policy and market forces will likely prevail, enabling investments in technological improvements that will cut emissions and deliver clean energy solutions.

   For example, large-scale renewables have historically proven difficult to bring on-line without substantial new transmission capacity and sufficient backup power while new transmission lines and large-scale energy generation facilities have proven challenging to site. Recent policy developments that enhance the permitting process for siting renewable energy sources and transmission capacity have been promising, but further long-term policy support will still be needed "to ensure coordinated investment in research and development and infrastructure, and efficient deployment of enabling technologies such as storage, demand response, flexible transmission, and active controls."[1]

   Furthermore, according Dr. Kammen's SWITCH model, a carbon price point of approximately $40 per ton is forecast for 2030 to create an economic incentive to decarbonize economies across the planet. At present, the California carbon price is about $12/ton, and it is $20/ton in China.

7. In all iterations of SWITCH, the "duck curve" problem, which utility companies use to illustrate concerns about mismatched renewable generation and demand (i.e., time-of-day availability of solar energy), is not projected to be problematic. Other energy sources in the near term, and a better distribution of energy assets (including improved energy storage) in the long term provide solutions to this so-called problem.

Climate change mitigation and social equity

8. According to Dr. Kammen, if climate change efforts proceed without regard to equity, issues of environmental and social injustice will remain, and are likely to be exacerbated. For example, without a focus on equity, energy efficiency programs may leave homeowners who cannot afford efficiency upgrades with higher energy bills as compared to homeowners who can afford the upgrades. Similarly, low-income renters may become priced out of

[1] Mileva A, JH Nelson, J Johnston, and DM Kammen. "SunShot Solar Power Reduces Costs and Uncertainty in Future Low-Carbon Electricity Systems." *Environ Sci Technol,* **2013,** 47, 9053-9060.

upgraded, energy efficient housing in transit-rich, mixed use, low-carbon intensive urban cores and be forced into higher-carbon intensive and transit-deficient suburbs. For these and similar reasons, when working on climate issues, it is crucial that consideration of environmental and social justice be at the forefront.

Reconciling with other speakers

9. Four previous speakers have presented to the Advisory Council in 2014 on the topic of the Bay Area's Energy Future (i.e., Dr. Mark Jacobson of Stanford University, Dr. Jim Williams of Energy + Environmental Economics, Dr. Jane Long of Lawrence Livermore National Lab, and Emilio Camacho, Esq., Advisor to California Energy Commissioner Hochschild). While each speaker presented a somewhat different approach to achieving AB 32's 2050 GHG reduction goal, all four concurred that three essential areas exist for action: (1) continued focus on energy efficiency, (2) electrification of end-uses, and (3) decarbonization of the energy supply.

10. Drs. Long and Jacobson differed on their assessment of the feasibility of relying solely on wind, hydropower, and solar (WWS) to meet California's energy future needs. Dr. Jacobson argued that virtually 100% of energy needs could be met through WWS without over-sizing the capacity of the generation system, while Dr. Long argued that the low load factors for wind and solar (30-40%) present tremendous load balancing challenges that cannot be met with a WWS-only strategy. Instead, according to Dr. Long, California will need to rely on an "all of the above" approach.

11. According to Dr. Kammen, an approach intermediate between Drs. Long and Jacobson may be needed, though his view of long-term (i.e., 2050) climate goals aligns more closely with Dr. Jacobson.
    a. Dr. Kammen expressed that, while Dr. Long's vision seems to be that the future will largely resemble the present, he is much more optimistic that the future of storage technologies and other technological innovations will radically transform energy possibilities.
    b. At the same time, Dr. Kammen noted issues with Dr. Jacobson's approach of re-starting our entire energy system from scratch, and he feels that significant expansion of existing energy infrastructure is needed for the energy future.
    c. The models employed by Drs. Jacobson and Kammen also differed, with the former matching supply with demand and the latter adding an economic component that accounts for costs of necessary developments in infrastructure.

12. Dr. Williams stressed the importance of the electrification of all end-uses. Dr. Kammen agreed that electrification is extremely important, but he went further to identify lifecycle analysis of carbon intensity as the key

methodology to guide decisions about whether and when to electrify any given end use.

KEY EMERGING ISSUES RELEVANT TO THE BAY AREA

The key emerging issues identified below represent a synthesis of the information contained in the presentations given to the Advisory Council in the 2014 by speakers, as well as an analysis of these presentations by the Advisory Council.

1. Business objectives that meet and even go beyond the AB 32 goal can be cost-effective, i.e., they can make or save money for utilities and many other types of businesses. Storage, grid infrastructure, and developing renewable energy sources all represent opportunities, albeit challenging, for utility companies to generate revenue. Further, investment in fossil fuels may, in the long-term, be a poor economic choice given increasing carbon prices, and divestiture from fossil fuels may represent a financially prudent decision.

2. Equity and environmental justice are important considerations associated with climate change mitigation because the adverse effects of climate change will disproportionately affect disadvantaged communities. Policies put into place to mitigate climate change must not exacerbate existing equity issues. Strong public policy will needed to balance the need for considerations of equity in all projects with the simultaneous requirement that all projects be pro-business.

3. An urgent need exists to improve upon existing, and to develop new technologies, for storing cleanly-produced energy. Through laws, such as AB 2514, the California Public Utilities Commission (CPUC) has endorsed a target of having at least an additional 2% of California's 2020 energy mix provided by storage during peak demand times and when renewable sources like WWS are low.
    a. Several energy storage technologies and designs currently exist, including compressed air, batteries, hydrogen, and pumped hydroelectric.
    b. Energy storage elements are optimal when co-located with renewable energy generation elements, especially in those areas most in need of storage support. A so-called "locational feed-in tariff" would create a price signal from utilities to incentive placement of renewable generation and storage in locations most in need of energy.

4. When observed on a carbon intensity basis, metropolitan cities exhibit a carbon emissions doughnut pattern, with lower-emission urban cores and higher emission suburbs. Some of this is due to commute patterns, but it is also due to larger homes and greater reliance on vehicles to procure and transport goods and services (versus dense, "complete" neighborhoods, that are mixed-use, walkable, bikable, and transit-rich). Taking this pattern into account in environmental permitting and investment planning in suburban areas can alleviate some of these concerns, as can improvements in walking and cycling infrastructure and innovations in the mass

transit of both people and goods. Further, the large square footage of homes and open land in suburban areas provides important opportunities for energy generation, such as the installation of solar panels.

5. Individuals and local jurisdictions (urban and suburban) can be empowered to make the best choices that benefit the environment and save money through user-friendly tools like CoolCalifornia.org, developed to assess and provide tips on how to reduce the carbon footprint of individuals, businesses, and jurisdictions.

6. A need exists to better understand demand response among Bay Area residents. The CPUC defines demand response as "end-use electric customers reducing their electricity usage in a given time period, or shifting that usage to another time period, in response to a price signal, a financial incentive, an environmental condition or a reliability signal."

RECOMMENDATIONS

1. The Air District should make carbon analysis and accounting a business requirement for all institutions and activities above a certain threshold (to be defined) as part of the initial permitting and renewal processes.
    a. Do not charge businesses for their carbon emissions (yet), but require this accounting for all permits issued.
    b. The analysis should take into account lifecycle emissions and address the full carbon exposure from direct and indirect business activities.
    c. Pay particular attention to the permitting of back-up diesel engines and generators, including requiring analyses of both the proposed and alternative fuels and systems.

2. The Air District should work with utilities to ensure a mutual exchange to understand future energy strategies, as well as their respective costs and benefits. The Air District should also work with utilities to promote public outreach and understanding. In particular, emphasize the message that "green" energy strategies are actually cost-effective and can save both utilities and consumers money.

3. The Air District should examine its own internal investments, including holdings in employee retirement accounts, and consider full divestiture from fossil-fuel holdings. Externally, the Air District should educate businesses in the region about fossil-fuel divestment and potential long-term cost-savings.

4. The Air District should develop mechanisms, both internally and externally, to incentivize projects that promote environmental, public health, and economic advancement, especially in areas most heavily burdened by air pollution or in areas projected to be most affected by the adverse effects of climate change.

Examples that might meet these three criteria and could be further investigated by Air District staff are to:

a. Provide permitting incentives for projects that can demonstrate positive results in a lifecycle carbon analysis, especially if they also serve disadvantaged communities (e.g., such projects should go to front of the line for review).
b. Expedite the permitting of clean energy projects in the Bay Area for those projects demonstrating that issues of equity have been considered in siting decisions.
c. Encourage local governments to facilitate use of creative and collaborative partnerships with businesses towards sustainable goals and shared resources. For example, encourage local governments to facilitate arrangements in which excess heat produced by one site, such a fuel cell combined heat and power installation, is used for heating needs by a second, geographically close site, such as a dry cleaning facility.
d. Promote the advancement of innovative technologies and business models to reduce GHG pollution, while improving citizen mobility. For example, work with car-sharing companies to develop sliding scale rates for electric vehicle (EV) car-share rental, or work with public and/or private entities to develop fuel-cell public transportation projects (buses or ferries) that reduce vehicle miles travelled (VMT) and employ mass transit in disadvantaged communities using low-carbon, clean energy.
e. Working with commercial lending and advocacy organizations to improve the purchase of EVs through traditional home mortgage tools.

5. The Air District should promote CoolCalifornia.org for individual, business, and local government use.
    a. This assessment tool could be provided as a mechanism for projects and their alternatives.
    b. Work with Association of Bay Area Governments (ABAG) to use this tool for assessing alternative Sustainable Communities Strategies in future planning iterations.

6. There remains disagreement among experts about several issues relating to full reliance on renewable energy sources. To better understand the Bay Area's energy future, we recommend that the Air District staff and Advisory Council gain a better understanding of the air quality and climate change mitigation issues related to energy storage potential, grid infrastructure, and the so-called "duck curve" problem.

7. Support CPUC work on the following:
    a. Developing incentives to subsidize programs that finance the deployment of electricity storage systems
    b. Providing incentives for utility companies to identify locations where the grid system is currently (and is projected to be) in the most need of

support and energy storage, and then co-locate renewable energy generation facilities in those locations.

c. Mandating that utilities establish net metering at all residences and businesses (i.e., every electricity meter should function in a two-way communication pathway between consumers and utilities).

GLOSSARY

Air District – Bay Area Air Quality Management District

BAU – Business as usual

Carbon pricing – A method of reducing GHG emissions by charging those who emit carbon dioxide (CO_2) for their emissions. That charge, called a carbon price, is the amount that must be paid for the right to emit one ton of CO_2 into the atmosphere. Carbon pricing usually takes the form of a carbon tax or a requirement to purchase permits to emit (also called "allowances"). Because such permits are privately tradable and emissions are limited by the total number of available permits (the cap), this system is known as cap-and-trade.

Combined heat and power – The use of a single fuel source to simultaneously generate electricity and useful heat, also known as “cogeneration.”

CPUC – California Public Utilities Commission

Decarbonization – The declining average fossil carbon footprint from primary energy over time.

Demand response – End-use electric customers reducing their electricity usage in a given time period, or shifting that usage to another time period, in response to a price signal, a financial incentive, an environmental condition, or a reliability signal

Divestment – The reduction of some kind of asset by an individual or business for financial, ethical, or political objectives.

Duck curve – A graph that utility companies use to illustrate concerns about mismatched renewable generation and demand (i.e., lack of availability of solar energy during high use early evening hours).

Electrification – To supply (a region, community, building, etc.) with electric power.

Environmental justice – The idea that all people, regardless of race, color, national origin, or income, are able to enjoy equally high levels of environmental protection. Environmental justice communities are commonly identified as those where residents: are predominantly minorities or low-income; have been excluded from the environmental policy setting or decision-making process; are subject to a

disproportionate impact from one or more environmental hazards; and/or experience disparate implementation of environmental regulations, requirements, practices and activities in their communities. Environmental justice efforts attempt to address the inequities of environmental protection in these communities.

EV – Electric Vehicle

Externalities – External effects, often unforeseen or unintended, accompanying a process or activity.

Flexible transmission – A system composed of static equipment used for the transmission of electrical energy. Flexible transmission is meant to increase the reliability of energy grids and reduce power delivery costs. These systems improve transmission quality and efficiency of power transmission by supplying reactive power to the grid.

GHG (Greenhouse Gases) – A gas in the atmosphere that absorbs and emits radiation within the solar or thermal infrared range. This process is the fundamental cause of the greenhouse effect. The primary greenhouse gases in the Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone. Other greenhouse gases include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). Black carbon, or soot, is not an actual greenhouse gas, as it is a solid, and warms the atmosphere differently to a gas. However, it may be responsible for as much as 25 percent of observed global warming.[2]

Lifecycle analysis - A technique to assess environmental impacts associated with all stages of a product's life, from-cradle-to-grave (i.e., from raw material extraction, through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling).

Load - The amount of electric power delivered or required over a given period at a constant rate.

Load balancing – The use of various techniques by electrical power stations to store excess electrical power during low demand periods for release as demand rises.

Locational feed-in tariff – A policy designed to accelerate investment in location-specific energy storage projects and in distributed energy resource projects that feed energy into the grid. Prices offered by utilities for these resources differ by location to maximize benefit to the grid, by placing such resources at energy bottlenecks and in sensitive areas.

Net metering – A service to an electric consumer under which electric energy generated by that electric consumer from an eligible on-site generating facility and

[2] See http://oceana.org/en/our-work/climate-energy/climate-change/learn-act/greenhouse-gases

delivered to the local distribution facilities may be used to offset electric energy provided by the electric utility to the electric consumer during the applicable billing period.

VMT – Vehicle miles travelled

WECC (Western Electricity Coordinating Council) – The WECC region encompasses the states of Washington, Oregon, California, Idaho, Nevada, Utah, Arizona, Colorado, Wyoming, portions of Montana, South Dakota, New Mexico, and Texas in the United States, the Provinces of British Columbia and Alberta in Canada, and a portion of CFE's system in Baja California in Mexico.

WWS – Wind, water, solar