REPORT ON THE ADVISORY COUNCIL ACTIVITIES IN MAY-JULY CALIFORNIA'S ENERGY FUTURE AND THE MOVE TOWARDS THE 2050 GREENHOUSE GAS (GHG) GOAL

EXECUTIVE SUMMARY

This report summarizes the ongoing activities of the Advisory Council during May-July 2014, consolidating presentations received, and subsequent discussion and consideration by Council members during this period. This report is also informed by, and should be reviewed in tandem with, the Advisory Council's report on the February 2014 presentations.

The following presentations were made at the May 14, 2014 Advisory Council meeting:

1. *California's Energy Future* by Jane C.S. Long, Ph.D., Contributing Scientist at the Environmental Defense Fund, Former Principal Associate Director at Large and Director of Energy and Environment at the Lawrence Livermore National Laboratory. Dr. Long is co-chair of California's Energy Future Committee, which prepared the California Council on Science and Technology's *California's Energy Future- The View to 2050.*
2. *Reducing GHG Emissions though Energy and Innovation* by Emilio Camacho, Esq., Advisor to the California Energy Commissioner Hochschild and former Attorney with the Office of the Legislative Counsel.

A video recording of these presentations and the Council's discussion can be viewed at: http://baaqmd.granicus.com/MediaPlayer.php?publish_id=fa6bcfc1-2db6-1032-aaea-c81612194a28.

Dr. Long and Mr. Camacho concurred with earlier presenters who emphasized that an immediate multi-pronged strategy is required to reduce greenhouse gas (GHG) emissions to sustainable levels. Dr. Long suggested that California can reduce GHG emissions to about 60% of 1990 levels by 2050 if existing technology is used without regard to cost, and emerging technology is deployed at an 'unprecedented rate.' However, achieving the 80% reduction goal is unlikely without significant new technology innovation and deployment, such as grid-scale energy storage or climate engineering. Furthermore, there currently is no regional GHG action plan that could help advance these goals on a regional level in the Bay Area.

The recommendations to the Air District contained in this report: (1) emphasize the necessity for immediate action through all possible means; (2) promote regional coordination towards the shared goal of reduced GHG emissions; (3) seek to identify and close regulatory gaps; and (4) make progress in reducing GHG emissions through grant incentives and piloting of emerging technologies.

BACKGROUND

Professor Jane C.S. Long

1. Dr. Long explained the importance of stabilizing GHG emissions by highlighting the "bathtub effect," which is used to describe the addition of GHGs to the atmosphere at a higher rate than they decay or are absorbed, much like a bathtub with an open faucet and a partially clogged drain. But, even after equilibrium is achieved, atmospheric carbon dioxide (CO_2) concentrations will remain high because CO_2 remains in the atmosphere for centuries after it is emitted. Further, CO_2 in the ocean will come out of solution and enter the atmosphere even as atmospheric concentrations of CO_2 decrease.

2. Regional strategies are effective in meeting the State's long-term goal of reducing GHG emissions to 80% of 1990 levels. This is because the regional scale is large enough to achieve a meaningful impact, yet small enough to allow political consensus on a meaningful action plan. However, there does not appear to be an appropriate regulatory agency with authority in the San Francisco Bay Area to develop and implement all necessary actions that could be identified in a regional strategy.

3. Dr. Long identified three rules to follow to ensure that regional GHG action plans add up to achieve an effective solution:

    a. When accounting for GHG emissions, identify and quantify every emission source once and do not double-count emissions. For example, do not count GHG emissions from individual building electricity use and the power supplier's energy use.

    b. Action plans should reflect feasible technologies rather than unproven concepts that may never materialize.

    c. Ensure action plans do not result in "Leakage." Leakage is a term that denotes the increase in GHG emissions elsewhere as a direct result of one action plan's reduction measures. For example, action plans that limit growth as a strategy to reduce local GHG emissions could result in increased emissions outside of that plan's boundaries.

4. Achieving the State's GHG reduction goal requires a four-part action plan that includes all of the following: (1) energy efficiency, particularly for end uses that cannot be easily electrified; (2) electrification of all feasible fossil fuel-based end uses; (3) decarbonization of the electricity supply; and (4) conversion to low-carbon combustion fuels (e.g., biofuels) for end uses that cannot easily be electrified (e.g., freight transportation, shipping, and air travel).

5. Dr. Long described several strategies to lower GHG emissions from energy use, for which she outlined advantages, disadvantages, and/or unknowns:

    a. Biomass/biofuels (e.g., woody energy crops, animal waste, municipal wastewater) were discussed as a potential energy source for decarbonizing fuels for end uses that cannot be converted to electricity. Other externalities need to be considered when formulating policy, including health effects of airborne pollutants, effects to food systems, availability of biomass resources to meet energy needs, etc. Long stated that it is unlikely that there would be enough available biomass to provide adequate load balancing for intermittent renewable energy supplies. The Advisory Council also points out that a lifecycle analysis of GHGs from biofuels should also be considered when formulating policy.

    b. According to Dr. Long, nuclear electricity is a safe form of electricity, the cost estimate is similar to either fossil fuel with Carbon Capture and Storage (CCS) or renewables, and there are no technical barriers to the technology; however, construction of new facilities is currently illegal in California until waste storage issues are resolved, and public acceptance is low.[1]

    c. Carbon Capture, Utilization, and Storage (CCUS) was identified as a technology to trap CO_2 produced during combustion and store it in old oil reservoirs. Long suggested that Carbon Capture and Storage (CCS) could be an important bridge strategy to reduce emissions while we develop zero-emissions generation and load balancing capabilities. The viability of CCS is enhanced by the economic value of captured CO_2 for enhanced oil recovery.

    d. Industrial Ecology is a potential strategy for reducing GHG emissions. Industrial ecology refers to a systems-based approach to managing industrial material flows so that one industry's waste can be repurposed as a resource for another industry's inputs.

    e. Wind and solar energy are largely intermittent and cannot currently be stored cost-effectively on a large scale; low capacity factors for wind and solar (30-40%) present tremendous load balancing challenges, requiring 3 times as much capacity to be built to meet needs, unless two-thirds of energy needs are provided by other sources. Energy storage for "load balancing" reduces intermittence and may be best suited for small-scale load balancing strategies, e.g., industrial users, as

[1] Cal.Pub.Res.Code § 25524.1, as cited by the National Council of State Legislatures (http://www.ncsl.org/research/environment-and-natural-resources/states-restrictions-on-new-nuclear-power-facility.aspx).

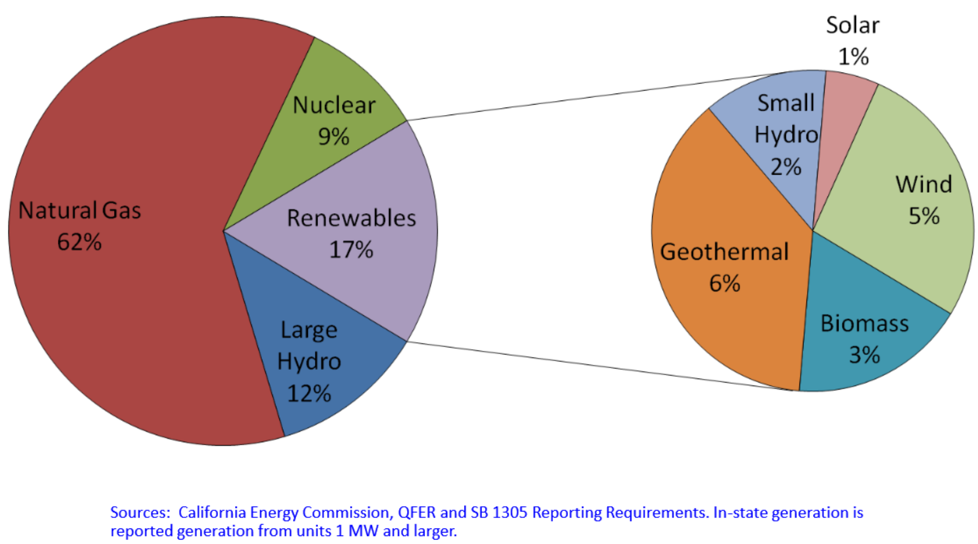
current storage technology is still largely experimental and not available for the entire grid.

6. GHG reduction strategies are in conflict with utility business considerations because low-cost natural gas is pushing alternative energy sources out of the market.

Emilio Camacho, JD

1. California is a leader in renewable energy deployment. California is home to the world's largest solar, wind, and geothermal projects. As shown in Figure 1, below, Renewable Portfolio Standard- eligible renewable energy sources account for approximately 17% (excluding large-scale hydroelectric) of all in-State electricity generated in 2012.

Figure 1. California In-State Electricity Generation in 2012[2]



2. Reducing GHGs in the energy sector is a goal of the California Energy Commission (CEC). Camacho highlighted multiple areas in which the CEC is providing leadership. The CEC sets energy efficiency standards for buildings and appliances; it permits new power plants greater than 50 MW, including large-scale photovoltaic (PV), solar thermal, wind, and geothermal power; it funds research and development of emerging technologies related to energy efficiency, renewable energy, energy storage, and load balancing (e.g., smart grid and demand response technologies).

3. Reducing GHGs in the energy sector requires altering consumer behavior, increasing the efficiency of energy production, electrification of end uses, encouraging renewable

[2] California Energy Commission defines Large Hydro as greater than 30 MW capacity (http://www.energy.ca.gov/hydroelectric/). While Hydro is a zero-emissions energy source, it is excluded as an eligible technology for meeting the State's Renewable Portfolio Standard targets.

energy sources, developing and increasing energy storage options, use of biofuels, research and development, integration of resources and new technologies and through grid alternatives (e.g., microgrids or smart grids). The way to achieve this is through policy change.

4. Integration of new technology offers opportunities for reducing GHG emissions. For example, microgrids are modern, small-scale versions of the centralized electricity system. Microgrids generate, distribute, and regulate the flow of electricity to consumers, but do so locally and can be used to integrate renewable energy into the electricity system at the community level.

KEY EMERGING ISSUES

1. The "bathtub effect" highlights the necessity to immediately implement all viable energy efficiency measures and low-GHG energy sources. It is essential to reduce emissions as much and as quickly as possible to achieve equilibrium. Success in attaining the 2050 GHG reduction goal hinges on quickly deciding on and implementing systems that eliminate emissions in the most cost-effective manner. Current research[3] indicates that California can reduce GHG emissions to about 60% of 1990 levels by 2050 if existing technology is used without regard to cost, and emerging technology is deployed at an 'unprecedented rate.' However, achieving the 80% reduction goal is unlikely without significant new technology innovation and deployment, such as grid-scale energy storage or climate engineering.
2. Dr. Long parts ways with Dr. Jacobson on the feasibility of relying solely on "WWS" – a combination of wind, hydropower (water), and solar – to meet our energy needs. Dr. Jacobson argued that virtually 100% of California's electricity needs can be met through WWS without over-sizing the capacity of the generation system. This finding enabled Dr. Jacobson to recommend for a multi-pollutant analysis approach and against transitional energy sources such as nuclear and CCUS that may produce significant negative externalities. Dr. Long, on the other hand, 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. The current load balancing strategy using gas turbines would produce emissions that far exceed 2050 targets. Currently available energy storage technologies may be cost-prohibitive. Dr. Long argues that the current technologies for load balancing a WWS-only generation system require investments in infrastructure that would then sit idle much of the time. Relying on wind, water, and solar sources also raises questions about how fast a replacement energy supply system could be built.

[3] *California's Energy Future- The View to 2050.* California Council on Science and Technology. May 2011. This document is available online at: http://www.ccst.us/publications/2011/CEF%20index.php. Accessed June 17, 2014.

3. In contrast to Jacobson's WWS-only approach, the load balancing challenge leads Dr. Long to argue for an "all of the above" approach that gives serious consideration to all viable low-GHG energy sources including using natural gas with CCUS, biomass, nuclear, and renewable energy. Biofuels and energy efficiency are particularly important as a strategy for end uses such as transportation that cannot economically be electrified. When paired with biofuels, CCUS offers the advantage of being GHG-negative. Although nuclear energy may be politically infeasible, Dr. Long argues that proven nuclear waste storage technologies are already available. Storage and related safety issues might also become less of a concern with Generation IV[4] reactors under development.
4. Mr. Camacho's presentation highlights the CEC's leadership role in energy efficiency, decarbonization of the energy supply, and load balancing. Mr. Camacho identified electric vehicles and California's High Speed Rail as efforts to electrify transportation, but did not discuss the issue of electrifying fossil fuel-based end uses in homes (e.g., gas furnaces, water heaters, and clothes dryers).

<u>RECOMMENDATIONS</u>

The Advisory Council recommends the following updates and additions to the recommendations in the report covering the February 2014 presentations:

1. <u>Research.</u> Experts disagree about the potential for 100% renewable electricity – wind, water and solar – to supply all energy end-uses within the region or state, due to their intermittent nature, the number of new facilities that would be required to meet loads, and the need for load-balancing and storage. Therefore, we recommend that the District investigate the feasibility of meeting the region's energy needs through wind, water, and solar, considering load balancing and grid reliability constraints.

2. <u>Planning</u>. Given the growing accumulation of GHG emissions into the atmosphere, it is urgent to significantly reduce GHGs by mid-century or sooner. We recommend that the District, through regulations, permitting, guidelines, and other planning approaches, support decarbonization of energy supplies, energy efficiency, and electrification of energy use across all sectors while considering life-cycle impacts. For those end uses where fossil fuel substitutes are not feasible or reasonably cost-effective, lower-carbon

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[4] Generation IV refers to the development of innovative nuclear systems (reactors and fuel cycles) likely to reach technical maturity by 2030. Under the Generation IV International Forum (GIF), six nuclear systems were selected with the aim of making considerable improvements in economic competitiveness, safety, uranium resource economy and in reducing long-life radioactive waste.

energy sources (such as biofuels) should be encouraged, ideally paired with other strategies for reducing the GHG impacts of energy use, such as reducing vehicle miles traveled, optimizing and enforcing speed limits, natural gas with CCUS, and more. The District should adhere to its multi-pollutant approach that seeks to reduce GHG emissions while also limiting health impacts and other negative effects from airborne pollutants. The District should work with State, local, and other entities of regional government to develop a long-term strategic plan including regional GHG reduction goals and a roadmap for meeting them by 2050.

3. Control of Small Sources. We recommend that the District explore ways to reduce GHG emissions from small stationary sources of CO_2, such as backup generators, furnaces, water heaters, and boilers. Emissions from these fossil-fuel-based end uses are unlikely to be decarbonized on a large scale unless rules, requirements, incentives, or other policy mechanisms dictate a steady reduction in CO_2 emissions from these sources.

4. Regional Coordination. Because of the efficacy of climate action planning at the regional scale, we recommend that the District use the full extent of its statutory and regulatory authorities and resources to coordinate and implement Bay Area energy-related response actions, and to execute its long-term strategic plan. We recommend that the District collaborate with other government agencies to identify barriers that prevent effective and meaningful regional action, including identifying additional authority or powers that may be needed. To ensure successful implementation of the District's long-term GHG plan, we recommend the District solicit support from partners (e.g., Planning Departments, Offices of Sustainability, energy and water utilities, and other local government officials) and support local government climate action planning that incorporates a multi-pollutant approach.

5. Grants. The District has grant funding that is currently restricted to reducing emissions from mobile sources that are outside of its regulatory control. The District should attempt to identify new funding sources to expand its grant program to stationary sources in light of its goal to significantly reduce regional GHGs. Following that, the District should prioritize the following within its grant programs:
    a. Development of infrastructure to support electrification (e.g., electric vehicle charging stations, solar PVs, heat pumps, solar hot water), including enhancement of incentives for residents and building owners.
    b. Clean-energy backup emergency power systems at both individual building and community levels.
    c. Promotion of energy efficiency measures in buildings, appliances, and processes, including measures to enhance indoor air quality while improving building performance.

   d. Efficiencies beyond VMT reductions through ‘smarter’, high-performance vehicles and technologies that optimize operations, particularly industrial and farming operations.

6. Emerging technologies. We recommend that the District research the feasibility of emerging technologies and partnerships that could accelerate efforts toward GHG reduction, and which the Bay Area could pilot and eventually implement, such as: industrial ecology, use of biofuel resources such as landfill gas and agricultural waste, municipal solid waste gasification, utilization of CO_2 from CCUS, local climate engineering, ‘smart grid’/ ‘microgrid’ technologies and zero-emission load-balancing strategies to better accommodate renewable energy sources.

GLOSSARY

Bathtub effect –The bathtub effect is an analogy used to describe GHGs being added to the atmosphere at a much higher rate than they are decaying or being absorbed, much like a partially full bathtub with an open faucet and a partially clogged drain.

Biofuel – A biofuel is a fuel that contains energy from geologically recent carbon fixation. These fuels are produced from living organisms. These fuels are made by a biomass conversion (biomass refers to recently living organisms, most often referring to plants or plant-derived materials). This biomass conversion can result in fuel in solid, liquid, or gas form.

Carbon fixation – The conversion of inorganic carbon (carbon dioxide) to organic compounds by living organisms.

CCS – (Carbon Capture and Storage or sometimes Carbon Capture and Sequestration) – The process of trapping carbon dioxide, transporting it to a usually underground storage location, and isolating it there.

CCUS – (Carbon Capture, Utilization, and Storage) combines CCS with CO_2 utilization strategies such as enhanced oil recovery.

CEC – California Energy Commission

Climate Engineering – also referred to as “geoengineering,” is the deliberate and large-scale intervention in the Earth’s climatic system with the aim of reducing global warming. Climate engineering has two categories of technologies- carbon dioxide removal and solar radiation management. Carbon dioxide removal addresses a cause of climate change by removing one of the greenhouse gases from the atmosphere. Solar radiation management attempts to offset effects of greenhouse gases by causing the Earth to absorb less solar radiation.

CO_2 – Carbon dioxide

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

District – Bay Area Air Quality Management District

GHG – (Greenhouse Gases) – A gas in the atmosphere that absorbs and emits radiation within the 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 (SF_6). 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.[5]

Generation IV nuclear reactors – Generation IV refers to the development of innovative nuclear systems (reactors and fuel cycles) likely to reach technical maturity by 2030. Under the Generation IV International Forum (GIF), six nuclear systems were selected with the aim of making considerable improvements in economic competitiveness, safety, uranium resource economy and in reducing long-life radioactive waste.

Industrial Ecology – Industrial ecology refers to a systems-based approach to managing industrial material flows so that one industry's waste can be repurposed as a resource for another industry's inputs.

Leakage – Leakage is a term that denotes the increase in GHG emissions elsewhere as a direct result of one action plan's reduction measures.

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

Low-carbon – Minimal output of greenhouse gas emissions.

Microgrid – A modern small-scale version of the centralized electricity system.

PV – (Photovoltaic) – Producing electric current or voltage caused by electromagnetic radiation, especially visible light from the sun.

Renewables Portfolio Standard – California's Renewables Portfolio Standard requires the state's utilities and other electricity providers to increase the amount of renewable energy they procure until 33 percent of their retail sales are served with renewable energy by the end of 2020. Facilities eligible under the RPS must meet certain requirements and be one of the following technologies: biomass, solar thermal, photovoltaic, wind, geothermal, fuel cells

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

using renewable fuels, small hydroelectric generation (less than 30 MW), digester gas, municipal solid waste conversion, landfill gas, ocean wave, ocean thermal, or tidal current.

Solar thermal –The use of solar energy to produce heat.

VMT– Vehicle miles travelled

WWS – Wind, Water, Solar