DOCKETED

Docket Number:	15-IEPR-11
Project Title:	Climate Change
TN #:	205532
Document Title:	Summary of the California State Agenciesâ€™ PATHWAYS Project:
Description:	E3's project overview
Filer:	Raquel Kravitz
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	7/28/2015 1:25:01 PM
Docketed Date:	7/28/2015

Energy+Environmental Economics
101 Montgomery Street | Suite 1600 | San Francisco, CA 94104 | 415.391.5100 | www.ethree.com

Summary of the California State Agencies' PATHWAYS Project: Long-term Greenhouse Gas Reduction Scenarios

January 26, 2015

Introduction

California statute requires a reduction in greenhouse gas (GHG) emissions to 1990 levels by 2020, with the further goal of reducing emissions 80% below 1990 levels by the year 2050.[1] Recently, Governor Brown stated his intention for the State to adopt a 2030 GHG emission target to inform policy setting and program development.[2] To support setting that target, several state agencies[3] and the California Independent System Operator (CAISO) engaged Energy + Environmental Economics (E3) to evaluate the feasibility and cost of a range of greenhouse gas reduction scenarios in California.

Modeling Tool

E3 conducted the analysis, with support from Lawrence Berkeley National Laboratory (LBNL), using the E3 California PATHWAYS model.[4] Enhanced specifically for this study, the model features detailed representations of the buildings, industry, transportation, and electricity sectors—including hourly electricity supply and demand. The stocks and replacement of buildings, vehicles, and appliances are modeled explicitly. Also represented, but with less detail, are non-energy GHG emissions, energy demand from the water sector and the agriculture sector. The model can represent a wide range of technologies and practices that may contribute to reducing GHG emissions, and incorporates interactions among sectors and key drivers of cost.

Scenarios Examined

With input from the agencies, E3 developed and evaluated scenarios of potential paths for reducing GHG emissions in California. The scenarios explore the potential pace at which emission reductions can be achieved as well as the mix of technologies and practices used to reduce GHG emissions 80% by 2050. The scenarios bracket a straight line emission reduction trajectory between today's GHG levels and the 2050 goal. Sensitivity cases examine the implications of policy choices and exogenous events,

[1] The Global Warming Solutions Act, California Assembly Bill 32 (AB32), 2006.
[2] United Nations Climate Summit, New York, NY, September 2014.
[3] The California Air Resources Board, California Energy Commission and the California Public Utilities Commission.
[4] An earlier version of the E3 California PATHWAYS model was summarized in: Williams, J.H. et al., "The Technology Path to Deep Greenhouse Gas Emissions Cuts by 2050: The Pivotal Role of Electricity," Science, Volume 335, January 6, 2012.

such as low gasoline and natural gas prices or limits on the availability of sustainable biofuels, on the technical feasibility and cost of reducing emissions. The core scenarios are described in Table 1 below.

Greenhouse Gas Emission Reductions

The scenarios evaluated result in a 25% to 36% reduction in greenhouse gases by 2030 relative to 1990 levels, as shown in Figure 1 below.[5] These scenarios result in 2025 proportional emission reductions that are similar to the recently-announced Obama administration goal of reducing U.S. net GHG emissions 26% to 28% by 2025, relative to 2005 levels, see Figure 2 below. On a *per capita* basis GHG emissions are much lower in California than the U.S. in both 2005 and 2025.

All scenarios incorporate energy efficiency and low-carbon technology and infrastructure, including:[6]

- **<u>Energy efficiency:</u>** double the amount of energy efficiency achieved in buildings and industry, relative to current policy, by 2030.
- **<u>Low-carbon electricity:</u>** 50% to 60% of electricity sales are supplied with renewable electricity by 2030, enabled by implementation of renewable integration solutions:
    - a relatively diverse renewable portfolio of wind and solar across geographies;
    - increased imports and exports of power across the state's transmission interties;
    - an increase in the flexibility and efficiency of natural gas generation and a phasing out of non-dispatchable fossil resources;
    - an increase in responsive loads including flexible loads in buildings and industry and smart charging of electric vehicles; and
    - either flexible production of low-carbon fuels from electricity or an increase in long-duration energy storage.
- **<u>Electric water heating and space conditioning or biogas in buildings:</u>** Over 50% of new sales of residential water heaters and HVAC systems for buildings are high efficiency electric heat pumps by 2030 ***<u>OR</u>*** over 50% of natural gas demand is supplied with biogas by 2030.
- **<u>Zero emission and hybrid vehicles:</u>** A rapid increase in near-zero and zero-emissions vehicles (ZEVs) by 2030; 6-7 million ZEVs and plug-in hybrid vehicles (PHEVs) on the road in 2030 in the Straight line scenario; the full range across all scenarios is 3 to 8 million ZEVs and PHEVs in 2030.
- **<u>Biofuels:</u>** A significant increase in the use of sustainable biofuels, with a large share likely to be imported from out of state. Biomass provides liquid transportation fuels (4 billion gallons of renewable diesel or gasoline in 2030) or biogas (over 50% of natural gas demand is supplied with biogas by 2030).
- **<u>Reductions in other GHGs:</u>** A significant reduction in high global warming potential gases including methane and F-gases. The base scenarios assume no net emissions from forests and working lands.

---

[5] This is equivalent to a 33% to 43% reduction in emissions by 2030 relative to 2005 greenhouse gas levels.
[6] These scenarios should be considered indicative corner cases. The policy mechanisms to achieve these transformations are not evaluated in this study, nor are all possible combinations of low-carbon technologies.

All scenarios rely on existing technologies and assume a continuation of current lifestyles and economic growth. The pace of emission reductions requires that key technologies are commercialized, produced at scale, and achieve broad market adoption in the next 10 - 15 years.

Costs

E3 also developed economic metrics to assess and compare the implications of different 2030 GHG targets for households, evaluating a range of potential future technology costs and fossil fuel prices. As shown in Figure 3, under base-case cost assumptions, the average household direct cost of the Straight Line scenario is found to be $8 per month in 2030 (reported in 2012 year dollars), relative to current policy (Reference scenario). This estimate includes all direct effects including changes in the average household's cost of transportation fuel, electricity and natural gas bills as well as the incremental capital outlays on energy efficiency and low-carbon vehicles. If all commercial and industrial costs are assumed to be passed on to households, the average household cost impact is $12 per month in 2030 relative to current policy.

In light of significant uncertainties in fossil fuel prices and low-carbon technology costs, a wide range of possible cost outcomes was evaluated. Under high fossil fuel prices ($4.75 per gallon gasoline in 2030) and rapid technology cost reductions, the average direct household cost is found to be up to $13 per month *lower* than the Reference scenario in 2030. Under low fossil fuel prices (below $3 per gallon of gasoline in 2030), the average direct household cost is found to be up to $18 per month higher than the Reference scenario.

Conclusion

This study finds that successfully reducing California's greenhouse gas emissions requires significant progress on all of the following:

1. Increasing the achievement of energy efficiency in buildings and transportation;
2. Switching to lower carbon fuel sources in buildings and transportation;
3. Producing lower carbon electricity;
4. Producing lower carbon liquid or gaseous fuels; and
5. Reducing non-energy greenhouse gases.

These results are broadly consistent with other studies of low-carbon futures in the United States and the rest of the world.[7] In the long-run, actions from other states, the federal government, and the international community are needed in order to achieve the levels of carbon reductions evaluated in these scenarios, both in terms of creating markets and economies of scale for low-carbon technologies, and in terms of mitigating the risks of global climate change.

[7] See for example, Sustainable Development Solutions Network's "Pathways to Deep Decarbonization"(2014): http://unsdsn.org/what-we-do/deep-decarbonization-pathways/; the United Kingdom's "2050 Pathways Analysis" (2010): https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/68816/216-2050-pathways-analysis-report.pdf; The European Union's, "Roadmap for moving to a low-carbon economy in 2050," (2011): http://ec.europa.eu/clima/policies/roadmap/documentation_en.htm; and California Council on Science and Technology, "California's Energy Future – the View to 2050," (2011).

Table 1. Description of scenarios evaluated in California PATHWAYS analysis

Comparison Scenario	
1. Reference	Current GHG policies are continued through 2020 only
Timing Scenarios (achieve 80% below 1990 by 2050)	
2. Straight Line	Suite of low-carbon technologies including energy efficiency, building electrification, renewable electricity, zero emission vehicles, and renewable liquid fuels
3. Early Deployment (Faster)	Same technology focus as the Straight Line Scenario, but with faster deployment of renewable electricity and near-term measures with air quality benefits, including zero emission vehicles and electric heat pumps
4. Slower Commercial Adoption (Slower)	Same technology focus as the Straight Line Scenario, but with delayed implementation of higher-cost measures, primarily zero emission vehicles and electric heat pumps in the commercial sector; adoption is accelerated post-2030 to hit 2050 goal
Alternate Technology Scenarios (achieve 80% below 1990 by 2050)	
5. Low Carbon Gas	Focus on decarbonized pipeline gas, no renewable liquid fuels and no building electrification
6. Distributed Energy	Focus on distributed PV and grid storage
7. CCS	Phase-in of natural gas carbon capture and sequestration (CCS) in electricity generation and hydrogen production post-2030
8. High BEV	Focus on battery electric vehicles instead of fuel cell vehicles
All scenarios rely on existing technologies and assume a continuation of current lifestyles and economic growth. The pace of emission reductions requires that key technologies are commercialized, produced at scale, and achieve broad market adoption in the next 10 - 15 years.	

Figure 1. 2030 California greenhouse gas ranges were evaluated in the E3 PATHWAYS scenarios (slower commercial adoption ("slower"), straight line, and early deployment ("faster")), all of which are consistent with meeting California's 2050 greenhouse gas reduction goals.

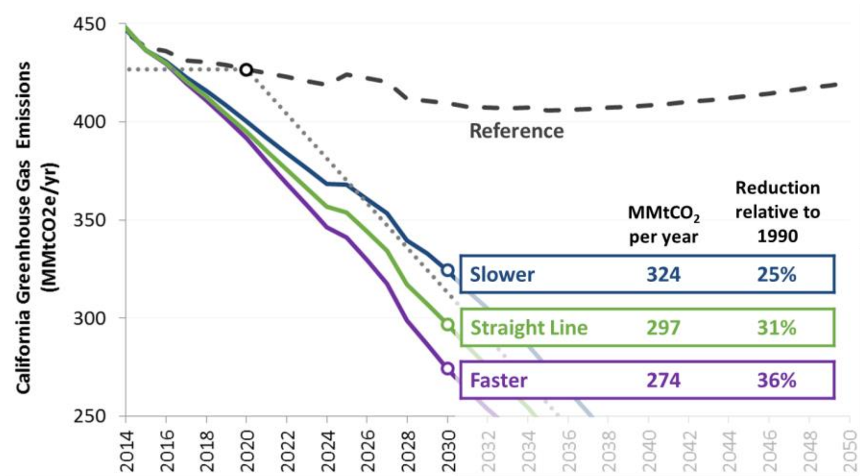

Figure 2. 2025 California greenhouse gas emissions in the low-carbon scenarios are similar to the Obama administration 2025 goal for the U.S. on a percentage reduction basis, but lower on a CO2 per capita basis.

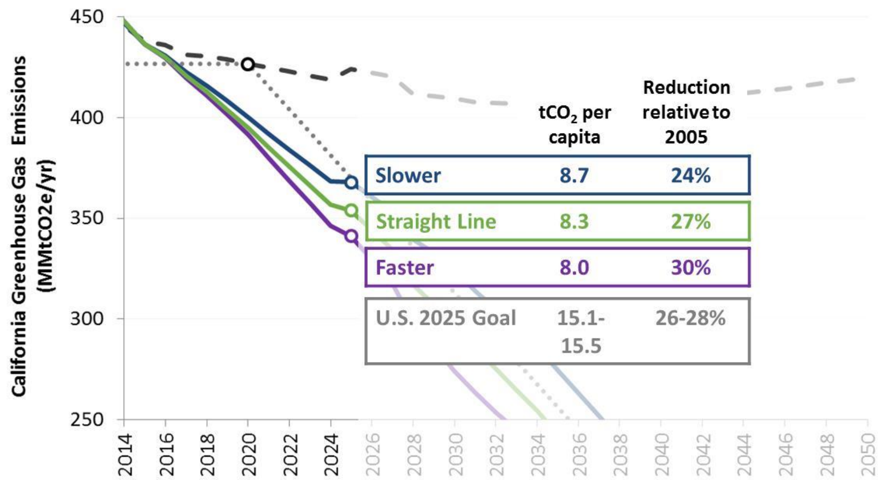

Figure 3. 2030 household direct costs – Straight Line scenario. The average household sees significant savings in gasoline/diesel and natural gas costs, offset by increases in the electric bill, car payments and cost of ZEV fuel. Net total cost impact in 2030 is $8 per month per household. Ranges reflect cost sensitivity cases.