The CA-TIMES Model

- TIMES (The Integrated MARKAL-EFOM1 System) model is an Energy-Economy-Environment (E3) model.
- 4E models are widely used for transition scenarios for multidisciplinary subjects.
- Identifies most cost-effective pattern of resource use and technology deployment over time under various technological, behavioral, resonant.
- Powerful tool for policy analysis for the energy system:
  - Policy scenarios
  - "If-Then" scenarios
  - Sensitivity analysis
- Rich in "bottom-up" technological detail – describes in detail technology operation, efficiency, availability, fuel production/demand, retrofit, and resource in flexible time slices.
- Model covers all sectors of the California energy system (not Rest of World).

Schematic Representation of the CA-TIMES

Reference Case Scenario Policies

- Current biofuel tax credits
- Current biofuel import tariffs
- Current transportation fuels
costs
tax credits
- CAFE standards to 2016 and 2025
- Federal and California electric vehicle subsidies
- Low carbon fuel standard (LCFS) biofuel volume scenario to 2022
- Power plant electricity GHG standard
- Renewable portfolio standard (33%) by 2020 and remains until 2050
- Renewable electricity production tax credit, solar investment tax credit
- Zero Emission Vehicle (ZEV) mandate policy constraint to 2025

GHG/Step% vs. %BAU/LoVMT%

Greenhouse Gas Scenarios

- GHG scenarios include all policies that are represented in the Reference Case are, as well as additional policies that would also need to be enacted.
- There are two types of caps: "Step" cap which is held at the 2020 target (1990 levels) between 2020 and 2050 but then dropped to 80% below 1990 emissions in 2050.
- "Line" cap that is a declining carbon cap – specifically, a straight-line trajectory from 2020 to 2050 is assumed.

Results: Emissions by Sector

- In the Reference case, in 2050, instate GHG emissions are approximately 1% lower than 1990 levels.
- Both GHG scenarios are able to reduce included instate emissions below 1990 levels by 74.6% falling just short (5.4%) of the 80% target.
- Emissions and fuel use from cross-boundary aviation and marine trips international are not included in the GHG target, consistent with the state’s treatment of emissions categories.
- The emission levels in 2030 range from 286 MMTCO2e in the GHG-Line scenario to 341 MMTCO2e in the GHG-S-Elas2 scenario.

Transportation Sector

- Gasoline is entirely gone as light-duty vehicles shift to electric drive vehicles.
- Diesel declines slightly but is still needed in heavy and medium duty trucks.
- Biofuels drop significantly to make up 37% of fuel use in 2050, while petroleum-based fuels account for approximately 41% of 2050 fuel use.
- The remainder comes from natural gas (5%), hydrogen (9%) and electricity (9%).

Electricity Sector

- Electricity generation in GHG scenarios is approximately 600 TWh in 2050, approximately 50% more than the Reference case.
- Geothermal and tidal generation expand as much as the economically feasible resource allows in 2050 to 28 TWh and 22 TWh respectively.
- Solar and wind power make up the bulk of the generation in 2050, with utility scale solar thermal, solar PV and wind contributing 107 TWh, 110 TWh and 221 TWh, respectively.
- The carbon intensity of the Reference scenario declines to around 200 gCO2e/kWh in 2040 and stays constant to 2050 (184 g/kWh), whereas in GHG scenarios eventually decline to below 30 gCO2e/kWh.

Key Conclusions

- Nuclear power and CCS are not available in the primary scenarios, and without these options, it is more difficult to meet the 80% GHG reduction target.
- Among all GHG scenarios, emission in 2035 range from 235 to 320 MMTCO2e.
- Wind and solar produce 54% to 80% of generation in most GHG scenarios, which requires very large investments and a fast ramp up of capacity.
- Electricity must be decarbonized if GHG goals are to be met.
- Battery and fuel cell powered vehicles are important and make up between 50% and 90% of light-duty vehicles in 2050.
- If CCS is available, biofuels production with CCS can provide significant negative emissions and offset petroleum usage.

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