California’s GHG Research and Mitigation Programs

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California Global Warming Solutions Act (Assembly Bill 32)

AB 32 charged Air Resources Board (ARB) to:

- Reduce 2020 GHG emissions to 1990 levels
- Monitor, report, and regulate sources of GHG emissions
- Rigorous and consistent inventory of emissions
- Monitor compliance with any rule, regulation, order, emission limitation, emissions reduction measure, or market-based compliance mechanism
GHG Emission Reduction Goals

* Executive Order B-30-15 and Senate Bill 350
** Executive Order S-3-05
Existing Regulations and Policies

- Cap and trade program for all large sources (cap drops 2-3% per year)
  - Offset protocols for ODS, forestry, urban forestry, dairy digesters, mine methane
  - 25% of revenue goes to disadvantaged communities
- Transportation
  - 54.5 mpg fleet average by 2025
  - 1.5 million zero emission vehicles by 2025
  - 10% lower carbon intensity for fuels by 2020
  - ~7.6% per capita VMT reduction by 2020, ~12% by 2035 (SB 375)
- Electricity generation and energy efficiency
  - 33% renewable by 2020, energy efficiency audits
  - No imported coal power after 2025 (SB 1368)
  - 12,000 MW renewable self-generation by 2025
  - Appliance standards
  - $2.5B for school retrofits (Prop 39), retrofit existing buildings (AB 758)
  - Zero energy new residential buildings by 2020, commercial by 2030
- Short-lived climate pollutants
  - Six regulations covering all F-gases (CFC, HCFC, HFC, SF₆, PFC, NF₃)
  - Methane controls on landfills, oil and gas production (pending)
  - Diesel retrofit/repower requirements, local fireplace controls
- Water and waste
  - 20% per capita water consumption reduction by 2020
  - 75% waste diversion by 2020 (AB 341)
Short-Lived Climate Pollutant Plan

Senate Bill 605 – Develop SLCP strategy by 1/1/16
- Concept paper released 5/7/2015, draft strategy 9/30/15
- Board consideration in December 2015
- Final in spring 2016

(a) 100-year and (b) 20-Year Global Warming Potential values
SLCP Targets

From current (2013) levels:

• Reduce black carbon emissions (non-forest) 50% by 2030
• Reduce methane emissions 40% by 2030
• Reduce F-gas emissions 40% by 2030
Governor Brown “5 Pillars”

* Set in 4th Term Inaugural Address – January 5, 2015
* By 2030:
  * Increase renewable electricity to 50%
  * Double energy efficiency of existing buildings and make heating fuels cleaner
  * Reduce petroleum use in cars and trucks by 50%
  * Reduce methane, black carbon, and other potent pollutants (short-lived climate pollutants)
  * Increase carbon sequestration in farms and rangelands, forests and wetlands
Assembly Bill 1496

- Measurements of high emission methane "hot spots" in California using aerial surveys and ground-based measurements
- Life-cycle greenhouse gas emissions analysis of natural gas produced and imported into California
- Review atmospheric reactivity of methane as a precursor to the formation of photochemical oxidant
- Update relevant policies and programs to incorporate the information
While California's economy and GDP continued to grow in 2013, the GHG carbon intensity of the economy (emissions per GDP $) continued to decline.

The total GHG emissions decreased by 0.3% while GHG emissions per capita decreased by 1%.
Challenge of meeting 2050 target

Pre-2020 and Post-2020 emissions trajectories

-4.7 MMT CO$_2$e per year
-1.0 percent per year
-5.2 percent per year
-11.4 MMT CO$_2$e per year

Constant percentage reduction
Constant MMT reduction
ARB’s greenhose gas measurement program is designed to support California’s GHG reduction efforts.
California Research Collaborators

Satellite Measurements (700 km)

Aerial Measurements (<1 km)

Ground-level Measurements

Towers
- ARB, Caltech
- LBNL, LLNL
- Scripps

Mobile
- ARB
- LBNL, Picarro
- UC Irvine

Field Studies
- UC Berkeley
- UC Davis
- Other UCs

Remote Sensing
- Caltech
- JPL

Laboratory
- Caltech
- NOAA
- UC Irvine

CEC
California’s GHG Monitoring Network
Current Progress

- Identify Specific Sources
- Evaluate Source Emissions
- Identify GHG Reduction Opportunities
- Track Emission Reductions

- Carbon Dioxide (CO₂)
- Black Carbon (BC)
- Hydrofluorocarbons (HFC)
- Methane (CH₄)
- Nitrous Oxide (N₂O)
45 Years of Progress on Black Carbon

Reference: Ramanathan, Kirchstetter, et al. (2013) Black Carbon and the Regional Climate of California, CARB Contract No. 08-323
Hydrofluorocarbon Findings
Los Angeles Basin

* Results from national EPA-based method differed significantly from 2007 Mt. Wilson measurements
* New California-specific emissions inventory consistent with measurements

Statewide Methane Findings

- Estimated methane emissions 1.3 - 1.6 times the ARB inventory
- AB 1496 requires investigation of methane hotspots/super-emitters to inform policies and programs

Fischer and Jeong (2012) Inverse Modeling to Verify California’s Greenhouse Gas Emission Inventory, ARB Contract No. 09-348
Statewide Nitrous Oxide Findings

- Estimated $\text{N}_2\text{O}$ emissions 1.7 - 2.2 times the ARB inventory
- Ongoing research to better characterize agricultural and mobile source emissions

Estimated annual anthropogenic $\text{N}_2\text{O}$ emissions (Gg $\text{N}_2\text{O}$/yr)

*Draft – Do not cite*

Nitrous Oxide Findings
Los Angeles Basin

* Estimate based on Mt. Wilson N$_2$O:CO correlation 130±24% greater than earlier ARB emission inventory

* Recent ARB inventory update reduces discrepancy to 49±15%

* Annual emission trends (2012-2015) stable at 1.68±0.16 MMT CO$_2$e/year.

Draft – Do not cite
Kuwayama, et al. (in preparation)
California Data Needs

Meeting Air Quality Standards
* Role and source of ozone aloft (2016 field study)
* Role of stratospheric intrusions and transport from East Asia

Meeting Greenhouse Gas Targets
* Track Statewide and sector/source-specific GHG mitigation
* Track co-pollutant trends in disadvantaged communities
* Highly resolved CO and GHG inventories for inverse modeling
* Quantify CH₄ emissions from dairies, landfills, oil/gas sector
* Quantify N₂O emissions from fertilized fields/lawns, dairies, other sources
* Identify remaining sources of BC and BrC
* Land-use changes (urban, working, natural)

Forest Carbon Stock
* Statewide inventories of carbon stocks for forests and other lands
* Screening for carbon-depleted or high carbon-containing natural areas for priority management
Data Product Considerations

Spatial Resolution
- Geographic specificity to target reductions and convince stakeholders
- Role of super-emitters to design regulation/enforcement
- Proper accounting of natural sources (e.g., oil seeps)
- Ability to track individual facilities for compliance and upset conditions
- Landscape carbon accounting at the scale of offset projects

Timeliness
- Regulatory development phase takes 1-3 years
- Decisions on funding for working and natural lands year-to-year

Continuity
- Long-term commitment to measurements and analysis products
  - Inform mitigation program over next few years
  - Help track compliance and effectiveness to 2020, 2030, and beyond
California GHG Research Program critical for success of AB 32 programs
- Evaluate and inform ARB GHG inventory
- Identify, implement, and validate effective emission mitigation strategies
- Track GHG emission trends in the state

Current efforts are helping improve emission inventories and source attribution

Continued research collaborations invaluable to help California meet its short- and long-term climate goals