Climate Policy and Future of LCFS in California and Elsewhere

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Industry Paradigm to a Low Carbon Economy?

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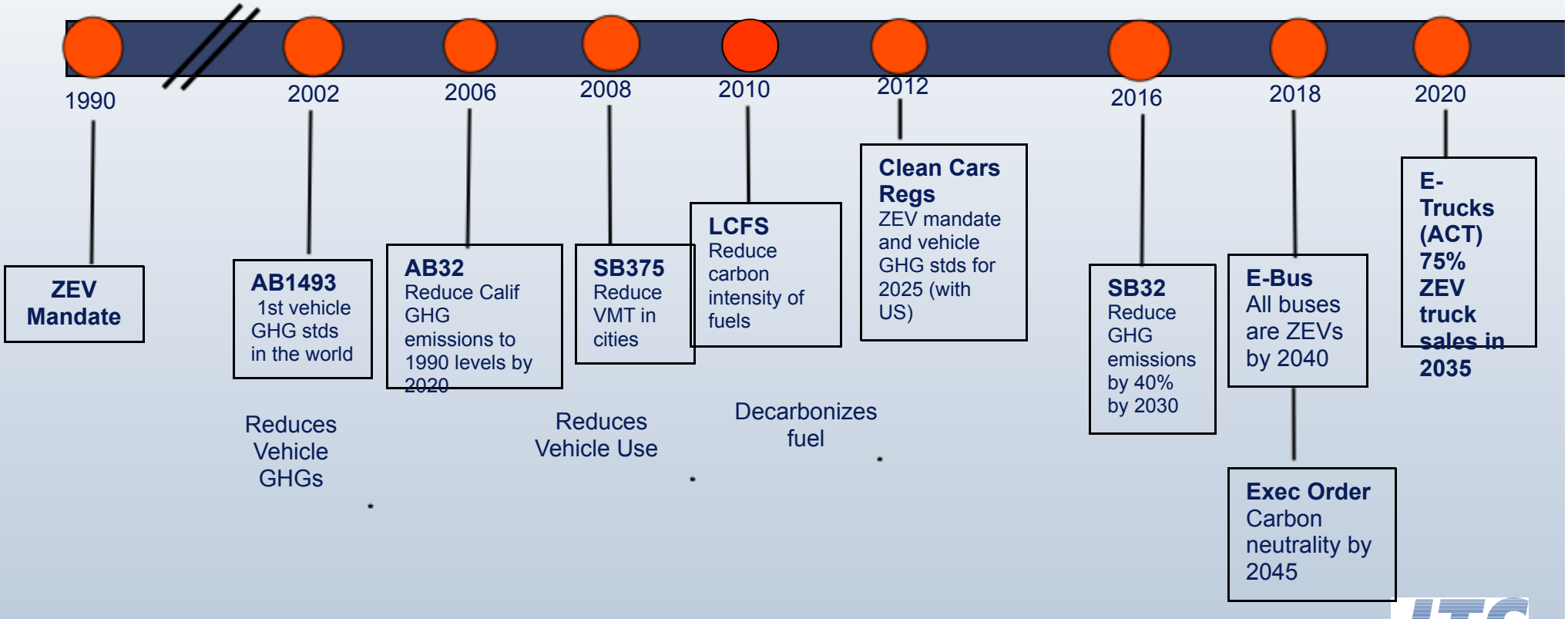
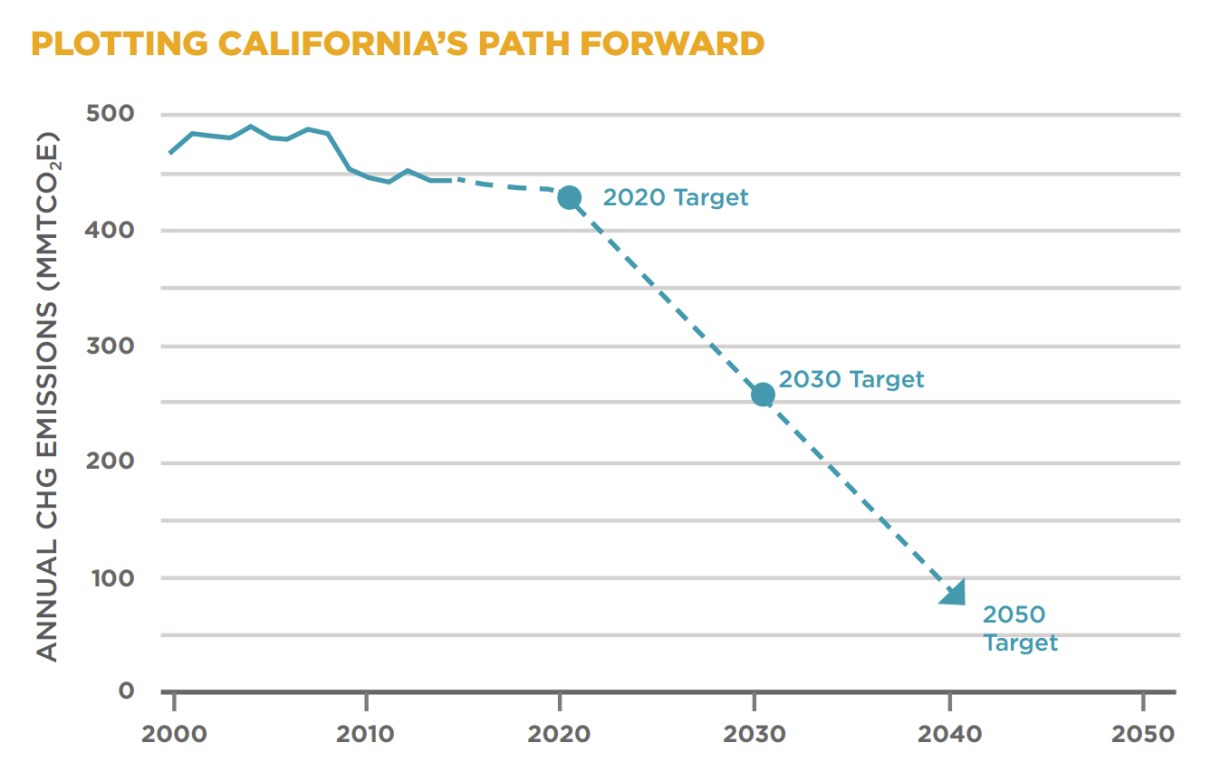
California Has Most Comprehensive Set of Laws and Regulations for Decarbonizing Transportation (though not most aggressive)…

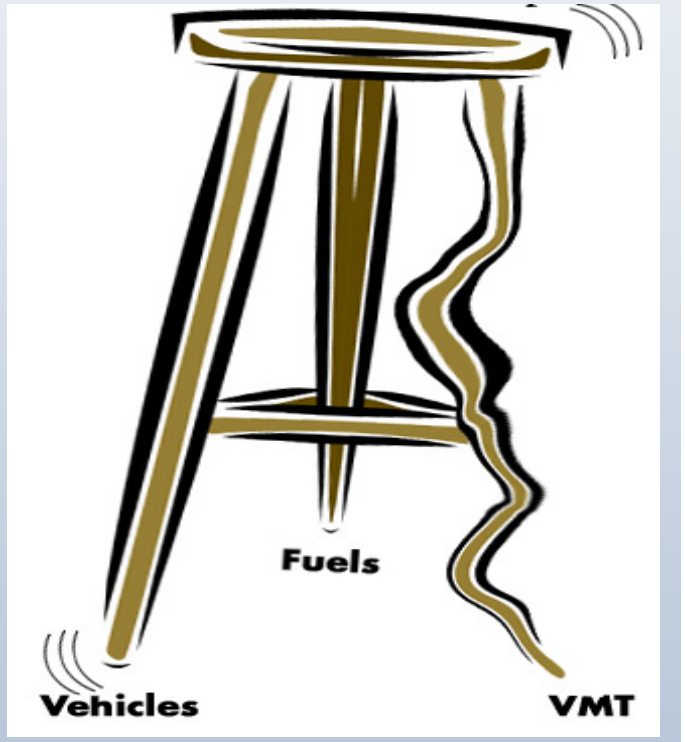


LCFS Plays Important Role in Meeting California's 2045 Net-Zero Target



LCFS Plays Important Role in Transportation GHG Reduction

- **Vehicles:**
  - **Light Duty**
    - GHG/mile performance standards
    - ZEV req'ts
    - Vehicle purchase subsidies
    - Charging and H2 station subsidies
  - **Heavy Duty**
    - GHG/bhp-hr performance stds for new trucks (US reqt)
    - ZEV reqt for buses (100% of sales in 2029)
    - ZEV reqt for trucks (up to 75% of sales by 2035)
    - Vehicle purchase incentives
  - **Goods Movement**:
    - Ship electrification at ports, misc other rules/incentives
- **Fuels**
  - **Low Carbon Fuel Standard**
- **Mobility**
  - VMT via SB375 (urban land use and mobility changes)



California LCFS-Related History

- 2005: National RFS: 7.5B gallons by 2012
- 2006: California AB32 (Reduce GHG to 1990 levels by 2020)
- LCFS selected by CARB as "early action" item
- 2007: RFS: 36B gallons by 2022
- 2009: LCFS adopted by CARB: 10% CI reductio by 2020
- Lawsuits …
- 2018: LCFS target increased to 20% CI reductio 2030

Governor Schwarzenegger signing LCFS executive order

Key Attributes of Low Carbon Fuel Standard

Design Features

- Based on lifecycle measurements; performance/intensity standards
- Imposed on oil refiners
- Tradeable credits (companies can buy/sell credits)

Advantages of LCFS concept

- Inspires innovation
- Robust/durable
- Life-cycle oriented
- Doesn't pick winners;
- Encompasses all fuels: NG, petroleum, unconventional oil, biofuels, electricity, H2

Disadvantages

- Limiting leakage and gaming
- LU impacts of biofuels not yet well understood

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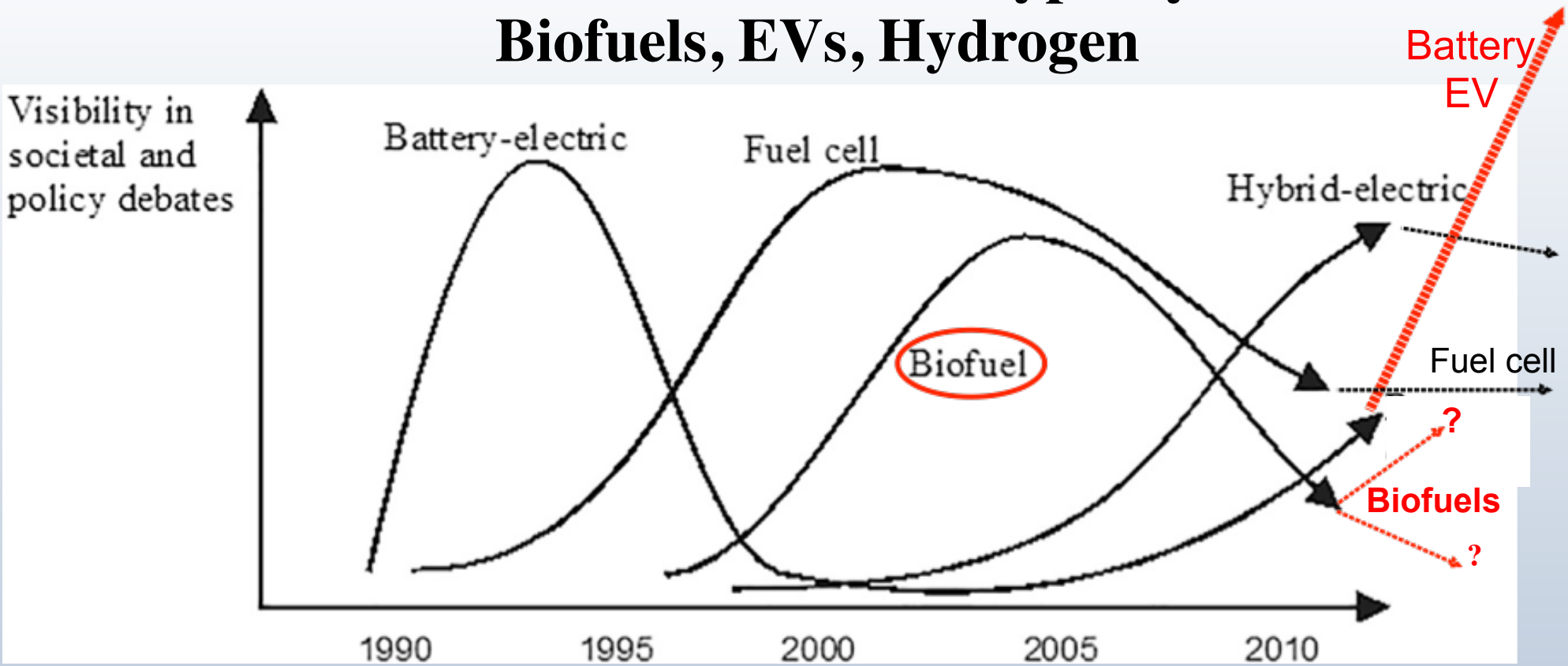
Fuels in the LCFS … the Hype Cycle of Biofuels, EVs, Hydrogen



Frank W. Geels, Benjamin K. Sovacool, Tim Schwanen, Steve Sorrell, The Socio-Technical Dynamics of Low-Carbon Transitions https://www.cell.com/joule/fulltext/S2542-4351(17)30092-2

Why Biofuels Faded

- Perception of large environmental impacts (palm oil, ILUC, high LCA for corn ethanol)
- DOE's premature declaration of success with cellulosic biofuels … resulting in less R&D
- Failure of cellulosic fuel biorefineries
- Rise of EVs (and dropping battery costs)
- Rise of shale oil (undermining energy security concerns)

Will EVs Push Aside Biofuels?

Governor Newsom Executive Order (9/23/20)

- 100% sales of LDVs are ZEVs by 2035
- 100% of all trucks (not just sales) are ZEVs by 2045 (“where feasible”)
- 100% of all off-road equipment/vehicles (not just sales) are ZEVs by 2035 (“where feasible”)

- ZEVs = BEVs, PHEVs, FCVs

…Now CARB must adopt regulations to implement these targets

California Requires Most Trucks to be Zero Emissions by 2035

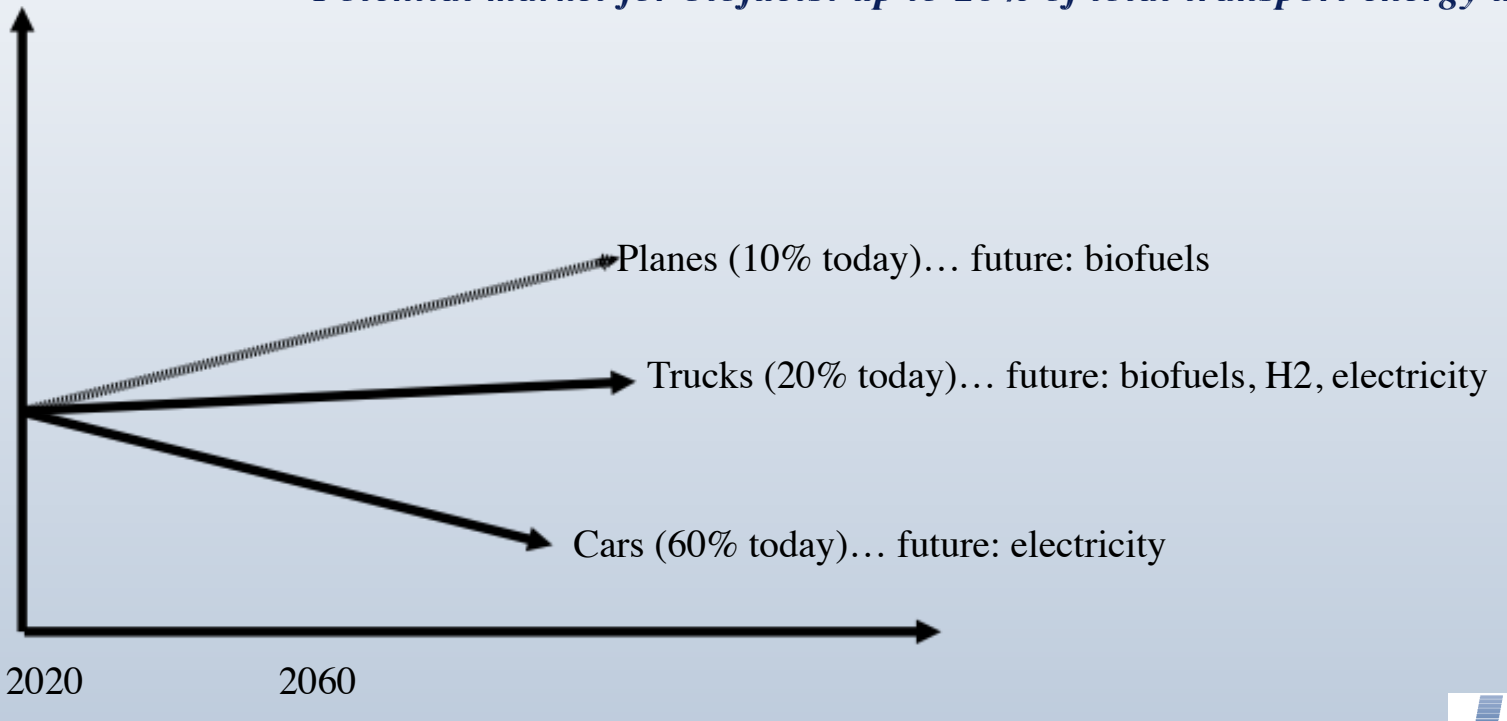
- Adopted June 2020, effective 2024
- Applies to large truck manufacturers who sell trucks in California
- Credit trading allowed
- Applies to manufacturers with >500 annual California sales
- ~100,000 ZEVs by 2030
- ~300,000 ZEVs by 2035
- Partial credits allowed for PHEVs (based on all-electric miles)

Model Year (MY)	Class 2b-3	Class 4-8	Class 7-8 Tractors
2024	5%	9%	5%
2025	7%	11%	7%
2026	10%	13%	10%
2027	15%	20%	15%
2028	20%	30%	20%
2029	25%	40%	25%
2030	30%	50%	30%
2031	35%	55%	35%
2032	40%	60%	40%
2033	45%	65%	40%
2034	50%	70%	40%
2035	**55%**	**75%**	**40%**

Future of Biofuels (USA)??

More for Trucks, Planes, and Ships; Less for Cars

Potential market for biofuels: up to 20% of total transport energy use



LCFS Impact on Investments and Innovation

- Incremental (carbon) improvements in corn ethanol production
  - Corn oil extraction
  - Greater efficiencies
  - Lower-carbon energy inputs
  - Bolt-on cellulosic
  - ➢ *15-25% lower carbon "footprint"*
- Upsurge in Renewable Diesel
- (Small) investments in cellulosic production (bolt-on)
- Investments in low-carbon biogas (RNG)
- Reduced carbon footprint for oil sands and some oil

New Provisions in 2019

- Program extended to 2030 with 20% CI reduction target.
- Significant new provisions for EVs.
- Extra (capacity) credit for DC fast chargers and hydrogen fueling stations
  - ➢ Stimulating large new investments in H2 stations (by Shell and others)
- EV consumer rebates from bundling of electric utility credits
  - ➢ ~$1500/EV
- Additional credit for using renewable energy, or charging at off-peak times
- Credits for carbon capture and sequestration in oil fields
- Sustainable aviation fuels (biofuels) credit

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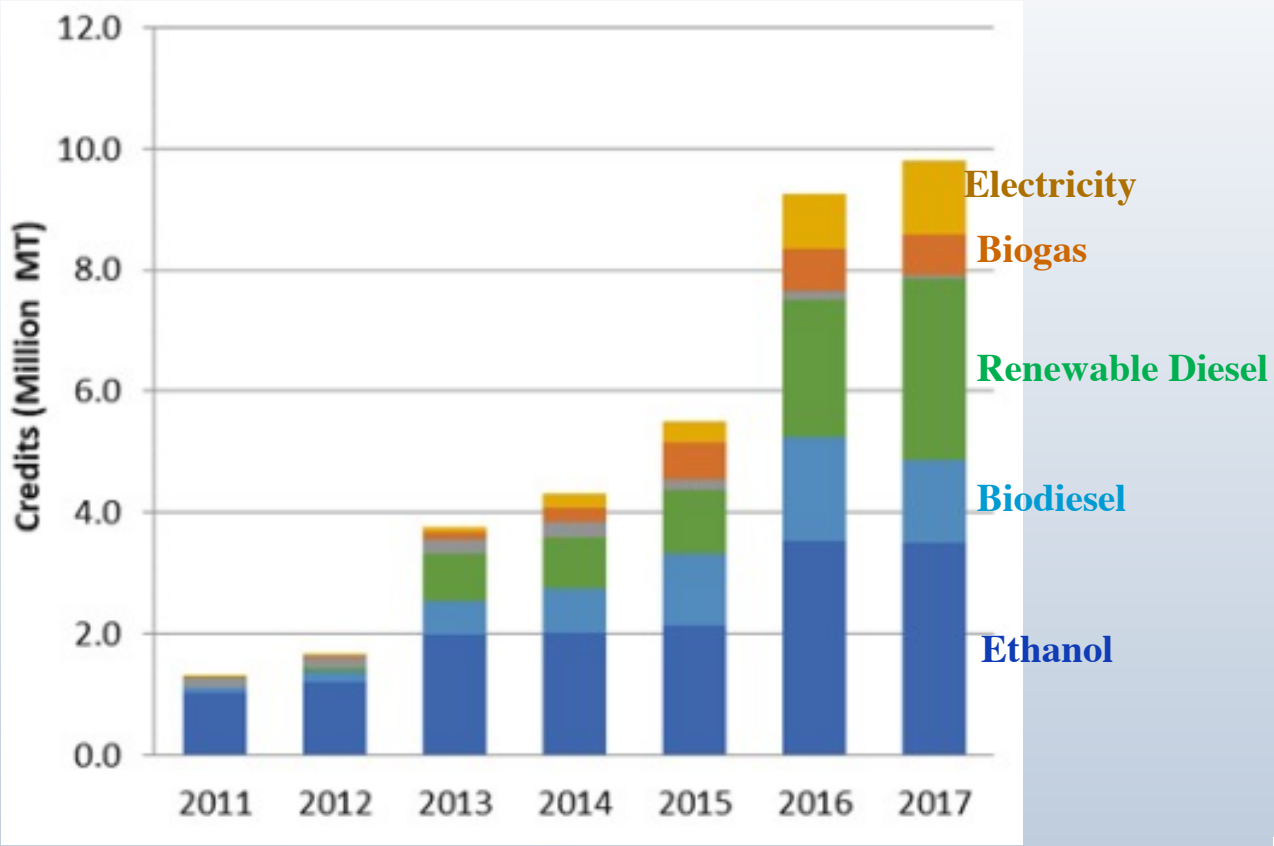
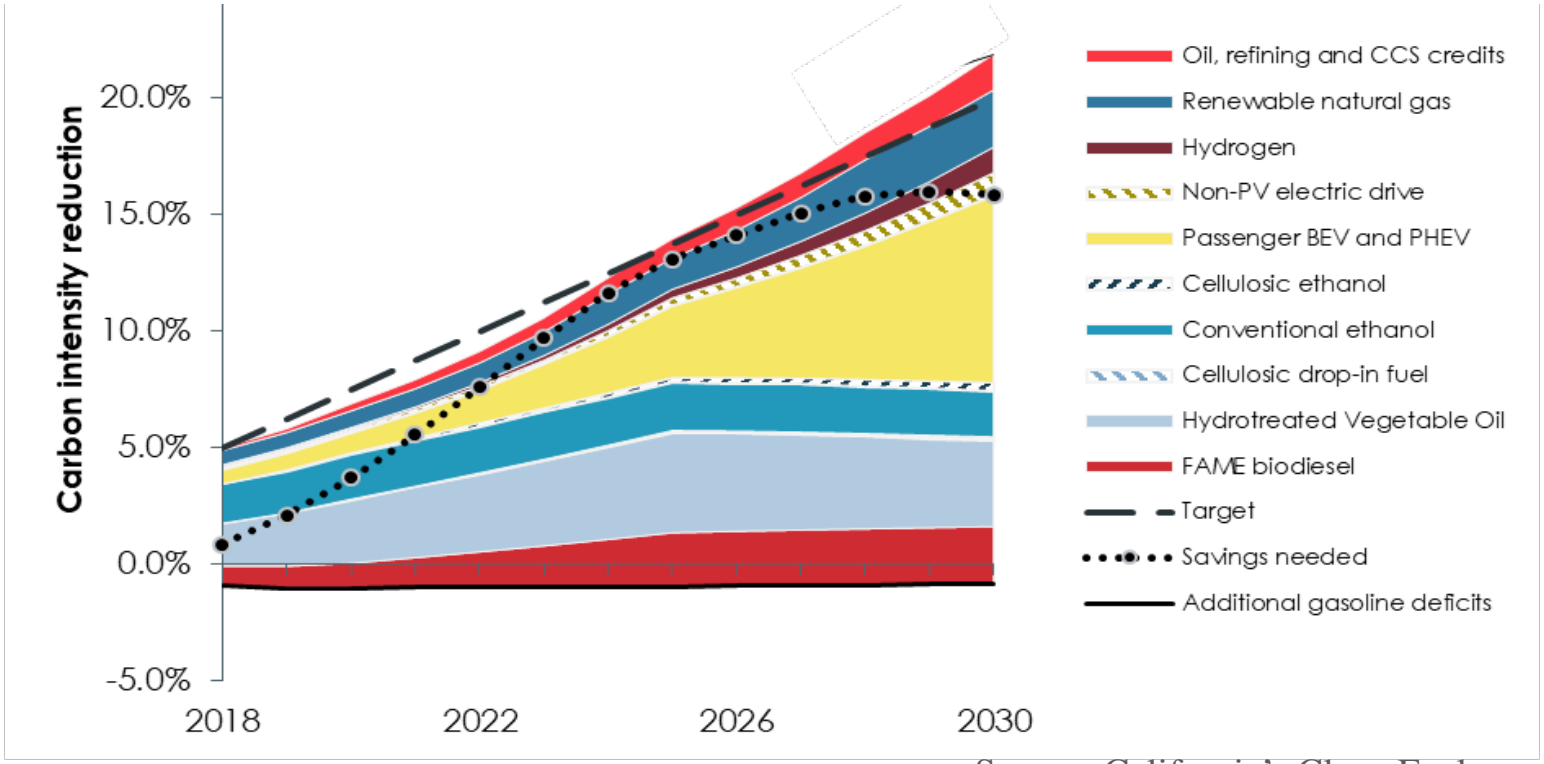
LCFS's Political History … From Ambivalence to Hostility to Love

- Initial acceptance by most of oil industry and other "stakeholders" (2007)
  - Given climate policy imperative, seemed "good" policy
- Deepening hostility in following years
  - ILUC factor (reduced CI of corn etoh)
  - Climate policy receded nationally
    - Lawsuits by ethanol and oil industries
- Growing support 2017+
  - Natural gas utilities
  - Electric utilities
  - Auto industry
  - Corn ethanol industry
  - Airlines (post 2019)

Looking Forward … Increasing Share of Credits From Electricity



What Do More ZEVs Mean for the LCFS?



Source: California's Clean Fuel Future

Canada's Clean Fuel Standard is Very Similar, Except for…

- 13% CI reduction in 2030 (vs 20% in California)
- Credits for displacing natural gas and pet coke outside transportation (not possible in California)
- No special capacity credits for H2 stations and EV fast chargers
- No iLUC factor ("indirect land use change) (instead, uses land use/biodiversity criteria and only disfavors palm oil)
- Everything else similar: lifecycle analysis, credit price "ceilings", special credits for upstream oil industry innovations, credits for fleets and charging networks

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What About Rest of the World?

- **Other States/Provinces**
  Now: Oregon, BC, EU (weak FQD)
  Soon: Colorado, Minnesota, other??
- **Canadian CFS**
- **US Nationwide LCFS?**
  - Replace or complement RFS?
- **International Aviation LCFS?**

LCFS-type Policy is "Best" for Decarbonizing Transport Energy
(considering politics, markets, consumers)

- Stimulates innovation and investment
- Doesn't pick winners
- Harnesses market forces (via credit trading) (engages industry productively)
- Creates strong stakeholders
- High carbon price helps overcome market barriers

➢ *Beyond vehicle emission performance stds, LCFS is most robust and effective policy instrument for reducing carbon footprint of transportation*

“We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten. Don't let yourself be lulled into inaction.”

Bill Gates