

California's Low Carbon Fuel Standard: Implications for Biofuel Development

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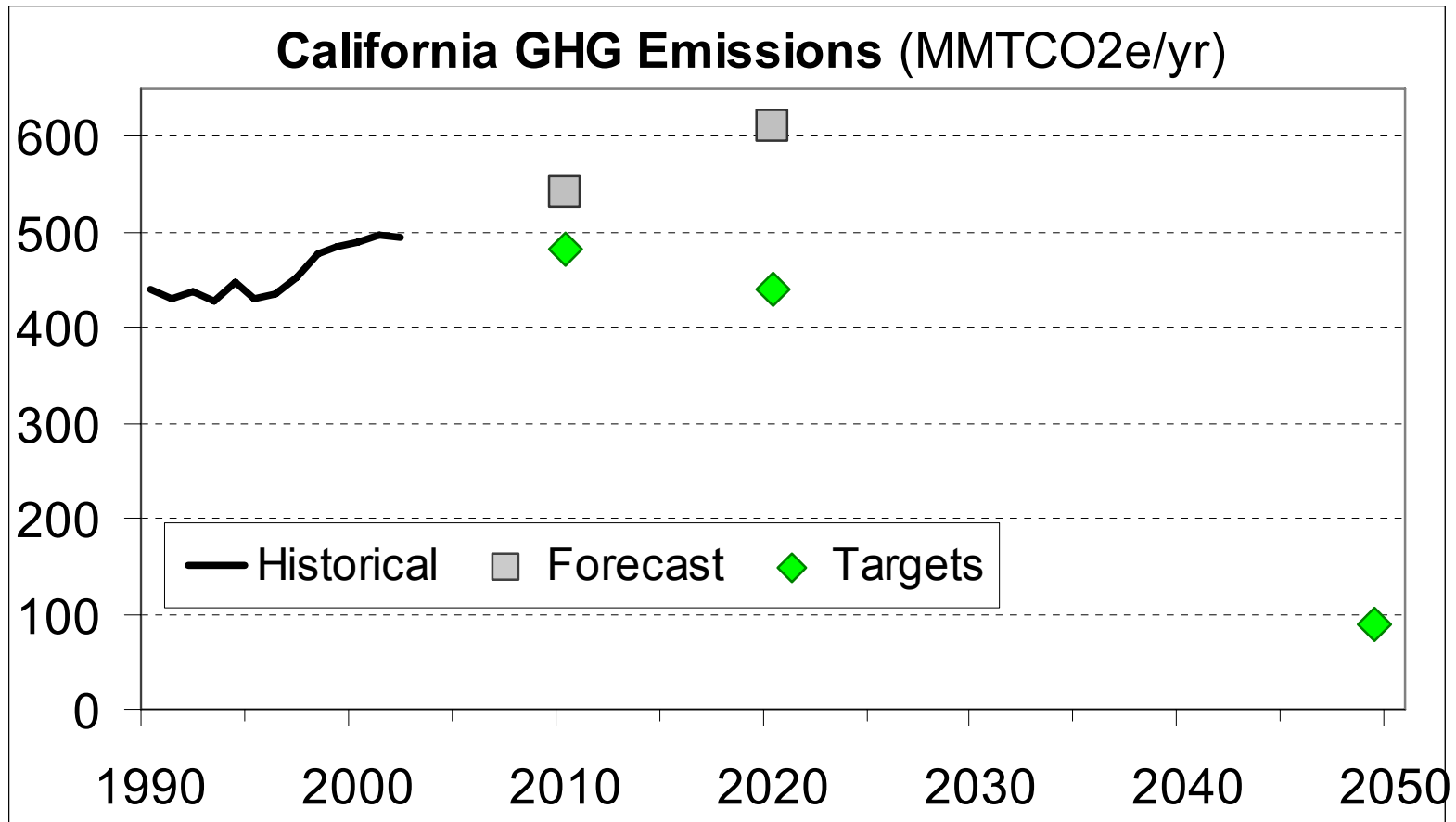


Presentation Summary

- Climate change policy and goals
- Why is a sectoral approach justified?
- Design and Implementation issues for the Low Carbon Fuel Standard (LCFS)
- What is next for biofuels?



California has set ambitious targets



The 2020 target (~25% cut) is established by both Governor and Legislature.

Why a sectoral approach is needed

- An economy-wide approach would be efficient (static)
 - Possibly lowest cost approach to cutting near-term GHGs (goal #1)
- An economy-wide approach fails to meet other goals
 - At a “low” price (<\$25/tonne), little would happen
 - At \$25-\$50 per tonne, electricity would start to decarbonize significantly while little would happen in buildings and transport
 - Innovation would be narrowly focused (goal #2), maybe not dynamically efficient
 - The “side benefits” of cutting petroleum use are lost (goals #3, #4)
 - Prices high enough to cause transportation to decarbonize might force disruptive change in the electricity sector or be politically infeasible
- Compare costs and fuel-on-fuel competition (\$1/tonne CO₂)

– Nuclear + Renewables	\$0.0/MWh
– Integrated gasification combined cycle with carbon capture and storage (IGCC+CCS)	\$0.1/MWh
– Natural gas combined cycle (NGCC)	\$0.5/MWh
– Pulverized coal (PC)	\$0.8/MWh
– Gasoline	\$0.01/gallon ⁵

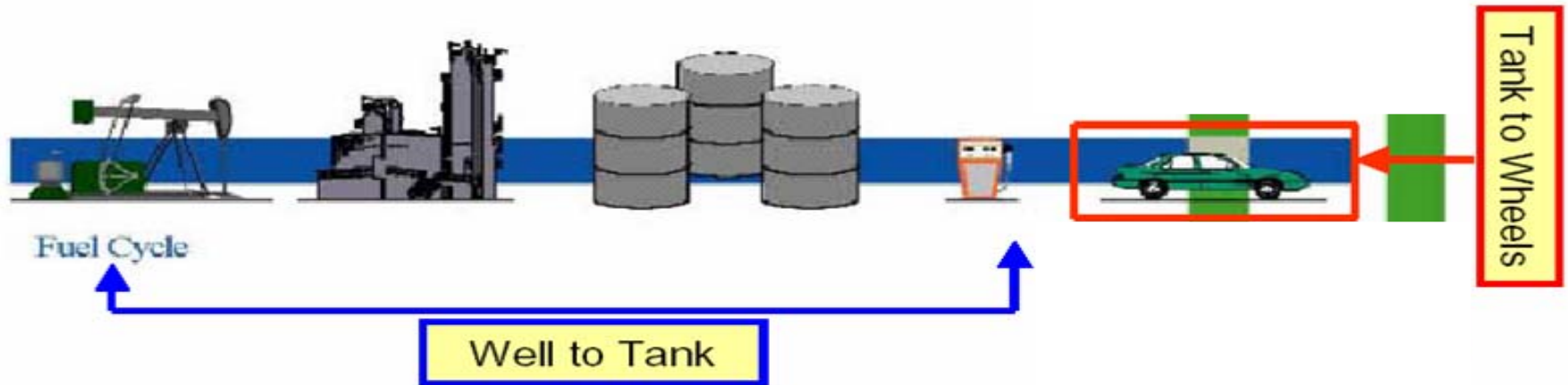
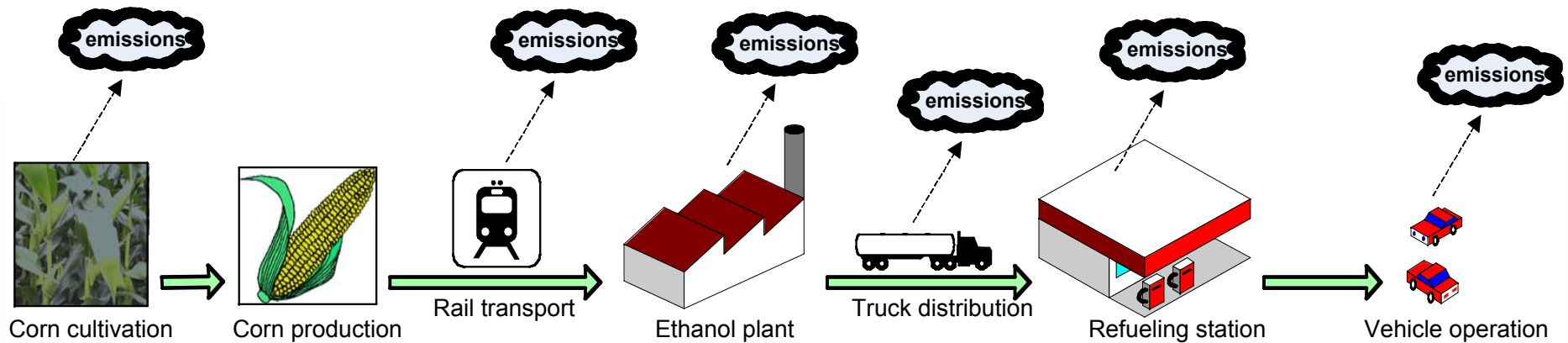
California's Low Carbon Fuel Standard

- **Reduce the GHG intensity of transportation fuels (e.g., g-CO₂e/MJ) by 10% by 2020**
- **THE RULES ARE NOT YET DETERMINED**
- Compliance by blenders, refiners, and importers
- Global warming impact (not just CO₂) is measured and must decline over time
- Blend low-carbon fuels
 - Ethanol, biodiesel, etc. (if it is low carbon)
- Introduce low-GHG alternative fuels
 - Biofuels, electricity or hydrogen
- Buy credits...

Design and Implementation Issues

- Vehicle efficiency adjustments? (esp diesel, electricity, H2)
- Penalties?
- Imports? How to handle fuels produced outside CA? (eg, EtOH produced in CA from Midwest corn vs. EtOH produced in the Midwest and transported to CA)
- Baseline? When can credits start to accumulate (banked)?
- How to reward and certify best practices that reduce GHGs, such as better farming practices, using waste for process energy
- Who gets electricity (and H2) credits and how are they tracked and monitored?
- For expensive vehicles (e.g., PHEVs, FCVs), should vehicles purchasers get credit?
- Need consistent monitoring and tracking system. No double counting, clear incentives that point in the right direction.

“Well-to-wheel” emissions must be considered



Note: This is not as simple as it looks. Where do you draw the boundaries?

New fuels have potential for huge GHG reductions

GHGs per mile, Relative to Gasoline-Powered ICE, Full Energy Cycle

<u>Fuel/Feedstock</u>	<u>% Change</u>
Fuel cells, hydrogen with solar or nuclear	-90 to -80
Biofuels from cellulose	-90 to -40
Electric vehicles with natural gas	-60 to -40
Diesel	-20 to -10
Natural gas vehicle	-20 to -10
Gasoline, conventional oil	0

NOTE: Actual impacts could vary considerably. These estimates reflect a large number of assumptions and should be treated as illustrative.

Adapted from GREET, Farrell, and Delucchi

New fuels have potential for huge GHG reductions

– **OR NOT!**

GHGs per mile, Relative to Gasoline-Powered ICE, Full Energy Cycle

Fuel/Feedstock

% Change

Battery EVs (and PHEVs running on electricity)

nuclear, hydro, solar, wind

coal

-90 to -80

+0 to +20

Corn ethanol

-50 to +20

Gasoline, conventional oil

0

Gasoline, tar sands

+30 to +50

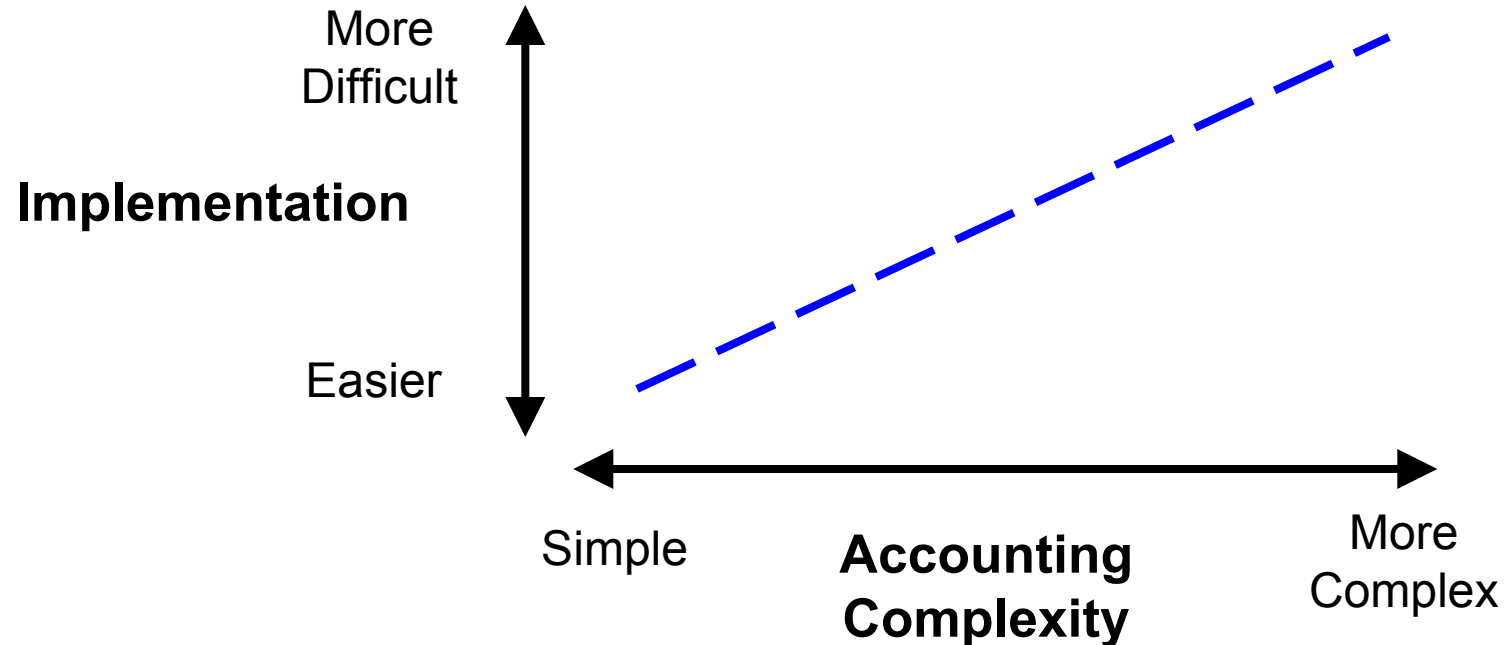
Gasoline, coal

+40 to +80

NOTE: Actual impacts could vary considerably. These estimates reflect a large number of assumptions and should be treated as illustrative.

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Implementation and Complexity



Possible approaches:

- **Default values with “opt in”**
- **Self certification with third party review**
- **Increase number of variables and/or certified fuels over time**

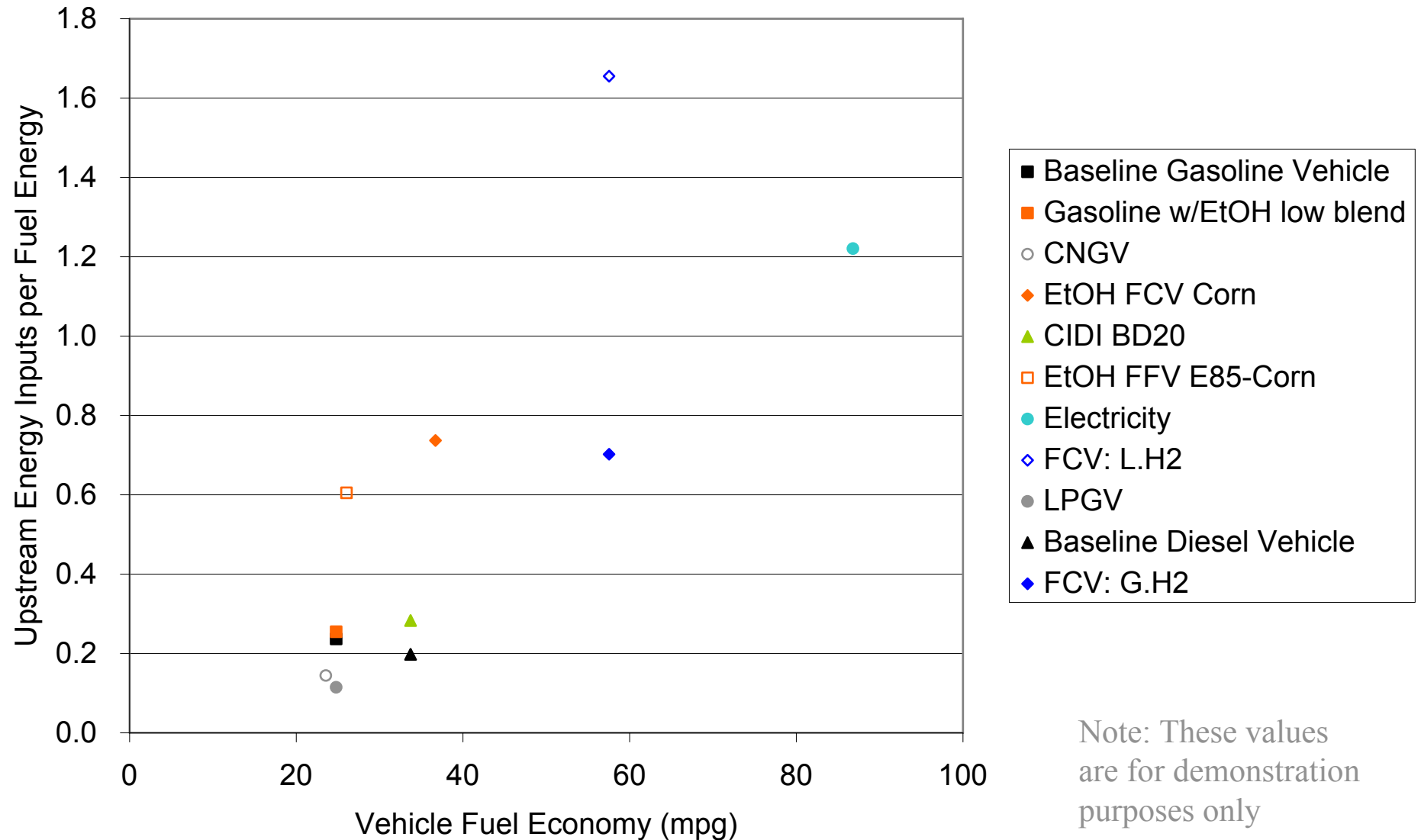


Definition of Intensity: What is being Reduced?

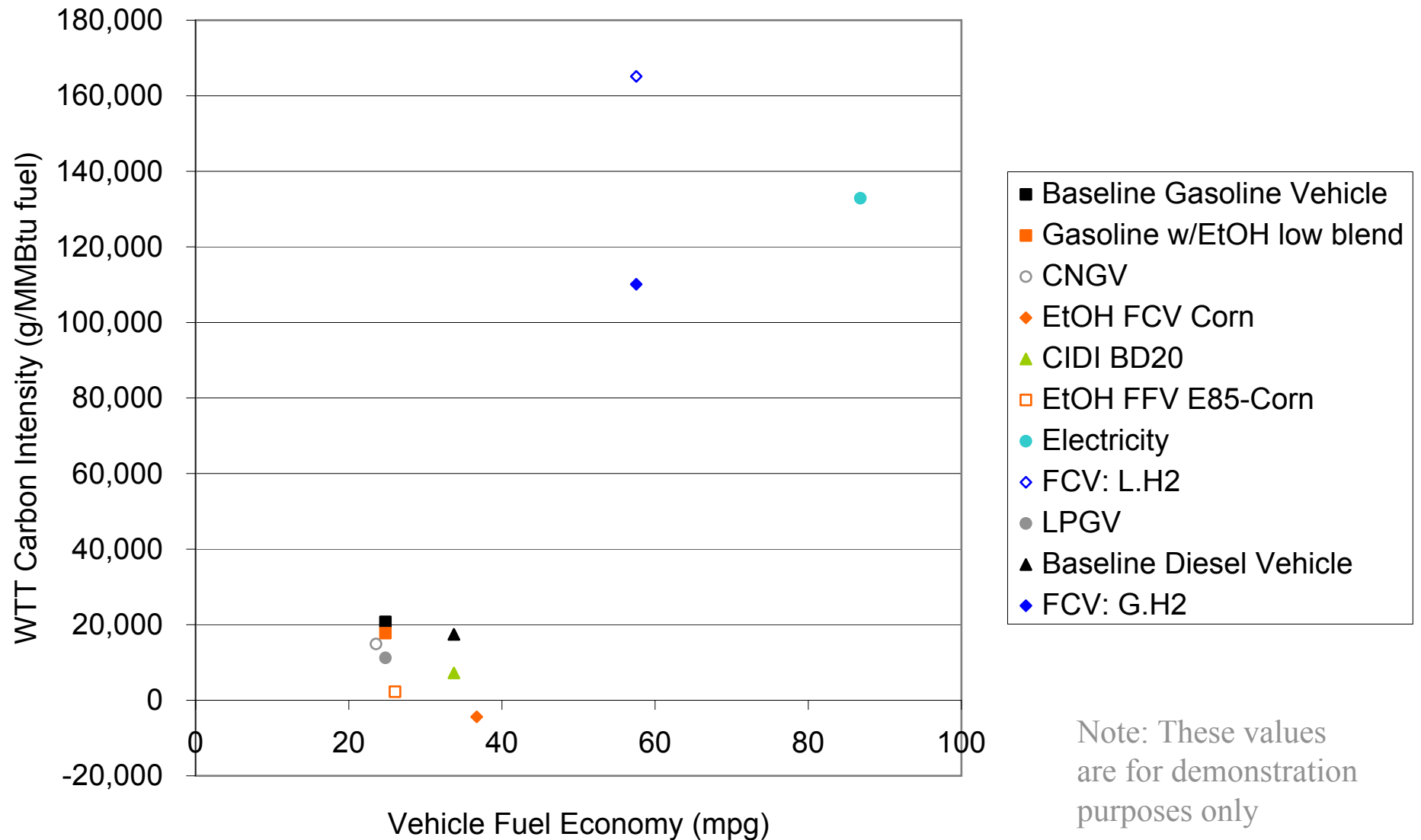
- Carbon intensity can be defined in various ways
- Our current thinking would include:
 - All GHG emission upstream from the vehicle
 - The carbon content of the fuel
 - A vehicle drivetrain efficiency adjustment factor
- Higher quality fuels are more energy-intensive but can be used more efficiently in vehicles



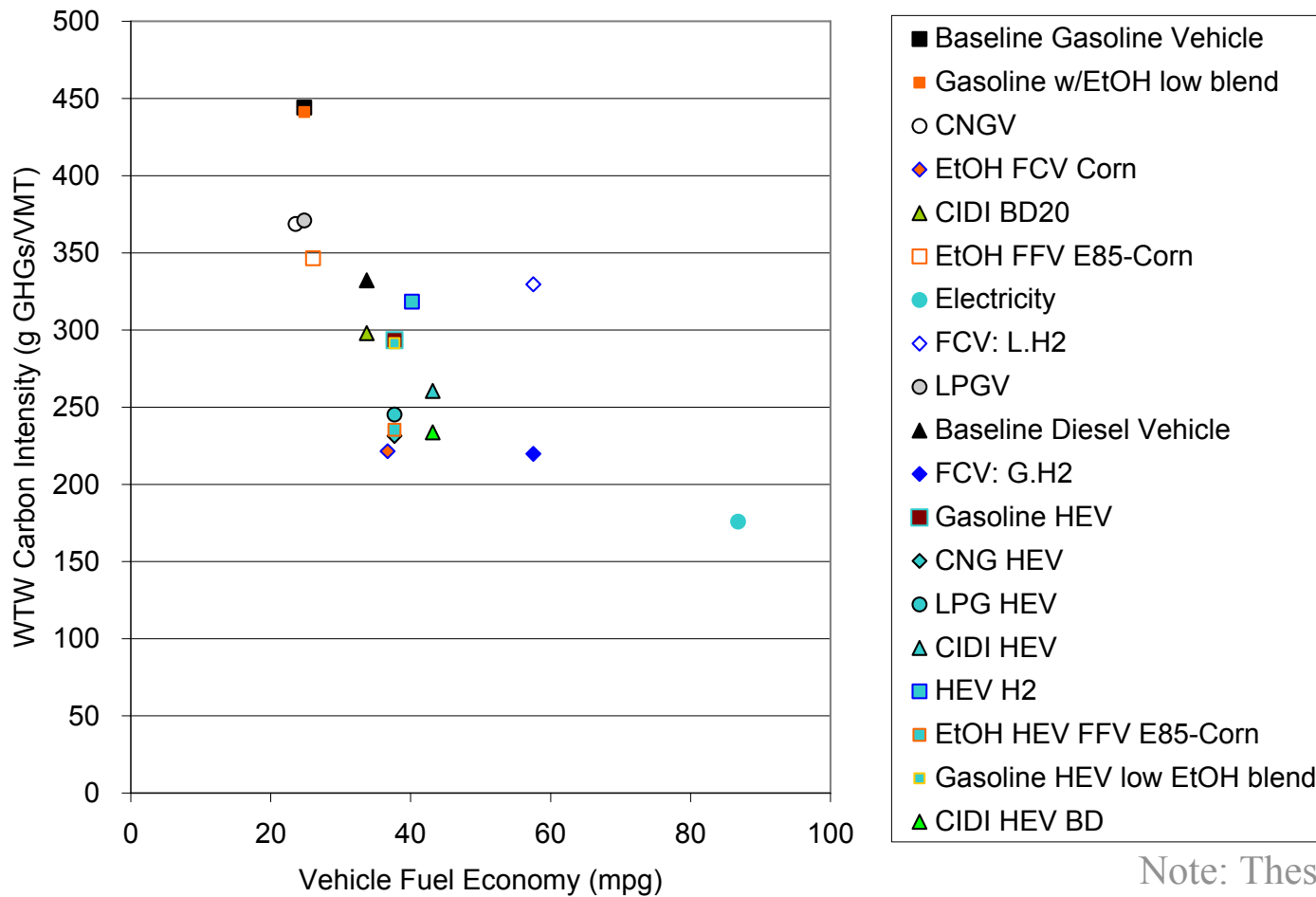
Upstream energy per fuel energy vs. Fuel Economy



GHG Emissions per Fuel Energy vs. Fuel Economy



WTW C/VMT vs. Fuel Economy



Note: These values are for demonstration purposes only

What's next for biofuels opportunities?

- New technologies
- A transformation is underway – Markets for Green Biofuels
 - Low Carbon Fuel Standard in California, Europe, and...?
 - A subsidy-free market for value-added commodities
- Performance standards and market forces will transform vehicle technology and fuel supply
 - Government should not try to pick winners
 - Provide industry with the flexibility and incentives to find least cost technologies and strategies
 - Indices for broader sustainability metrics (not just GHGs)
- California is not an island – we are pioneering with the expectation that others will join
 - The University of California (Berkeley and Davis campuses) is helping the state evaluate low-carbon fuel options.



Thank You!

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Study Website
<http://www.its.berkeley.edu/sustainabilitycenter/carbonstandards.html>