Low Carbon Transportation Fuels: Climate Change & Energy Security

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Jonathan Rubin, The University of Maine
Paul Leiby, Oak Ridge National Laboratory
Maxwell Brown, Colorado School of Mines

OAK RIDGE NATIONAL LABORATORY
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A National Low Carbon Fuel Standard (LCFS)

- ***Objective is to stimulate innovation in low-carbon alternative fuels***
- Performance based: "Carbon intensity" target for transport fuels
  - Technologically neutral
  - Does not pick specific winners and losers
- Lifecycle measurement of carbon intensity
- Includes biofuels, electricity, natural gas, hydrogen, more
- Harnesses market forces
  - Allows trading of low carbon fuel credits

Why focus on fuel carbon standards? Why Not just an economy-wide Carbon Tax?

- Theoretically economy-wide C-tax is “efficient”
- *But little effect on transportation emissions*, given
  - VMT demand inelasticity
  - High initial fuel substitution costs
- Detailed study of US C-Tax (Waxman-Markey, 2009)
  - 83% by 2050 (relative to a 2005 baseline)
- Analysis estimated *little* reduction in transportation emissions:
  - only 1% to 3.5% by 2020
  - and 2.6% to 8.5% by 2030
- Conclude: Carbon Tax (also called “cap & trade”) not effective to:
  - Reduce oil use in transportation (for energy security or GHG reduction)
  - Change transportation fuels (reducing petroleum or C intensity)

Many Regions and Countries are Considering a Low Carbon Fuel Standard (LCFS) Why?

- Reduces vehicle GHG emissions *and* promotes fuel/vehicle transformation and economic change/development
  - *If* the transport is to play a significant role in reducing GHG emissions, sector specific policies will be necessary
  - **In the absence of increased vehicle efficiency – the CI per kilometer will increase**
- Can enhance energy security

Region/Nation	Status/Comment
California LCFS	**Active**
North East & Mid-Atlantic LCFS	Preliminary studies complete, **waiting** for political decision
Oregon State LCFS	10 % below 2010 levels by 2020 In development, ***may sunset*** *in 2015*
British Columbia LCFS	5%/4% renewable content in gas & diesel 10% reduction in carbon intensity 2020 **Active**
EU Fuel Quality Directive	**Active**, transportation fuel suppliers must reduce fuel GHG emissions 6% 2010 to 2020, largely via biofuels

Regions and Nations Implementing or Considering a Carbon Standard for Fuels

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Research Question

- Recent work (Huang, Khanna et al. 2013; Leiby and Rubin 2013; Rubin and Leiby 2013) focused on *national* implications of an LCFS. Lade and Lin (2013) modeled CA LCFS.
- Our research asks: What implications would a national LCFS *implemented at the regional level* have on
  - regional supplies and trading of low carbon fuels
  - regional fuel CI
  - and regional prices of fuels?

Preliminary Results, Do Not Cite

LCFS Builds on RFS

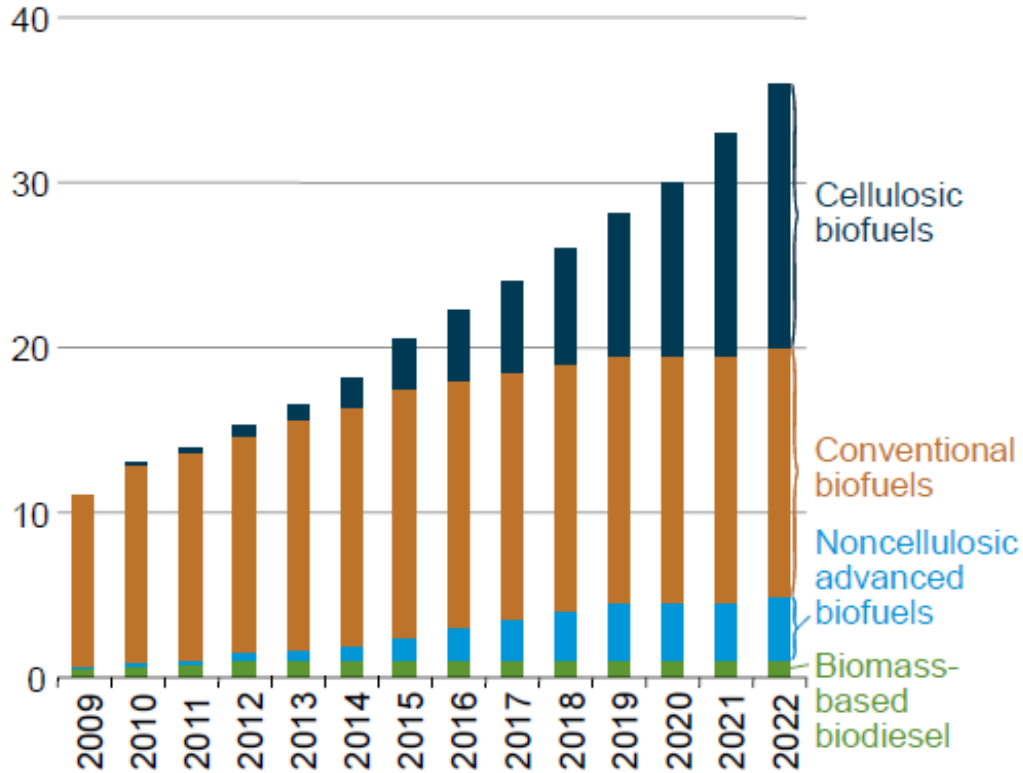
- A LCFS has advantages over a RFS
  - technologically neutral
  - Does not promote any specific type of fuel (i.e., biofuel)
    - Includes all transportation fuels: electricity, natural gas, hydrogen and biofuels
  - RFS2 **compliance** based on **volumes** by category
  - NLCFS **compliance** based on **carbon intensity**
- **Performance-based** standard (instead of fixed volumes)
  - Rewards cellulose at corn-ethanol facilities
  - Incentives to use waste materials
  - Incentives to reduce carbon footprint of oil sands
- Price caps, e.g., “safety valves” on credits
  - Protects companies and consumers from price spikes
- Flexibility and safety valves provide regulatory certainty and stability to companies

Existing National Policy: EISA/RFS2

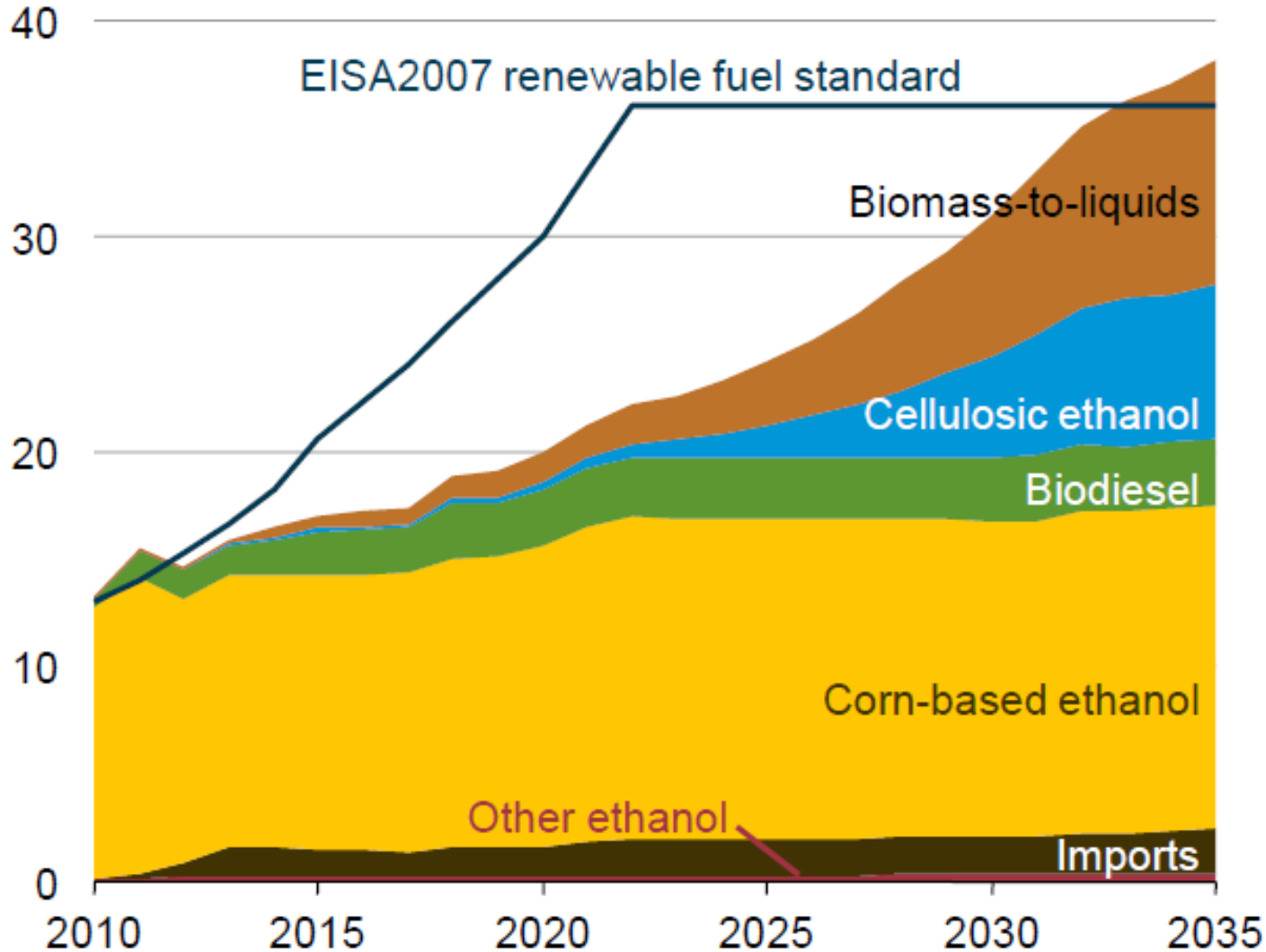
- Requires 36 billion gallons of renewable fuels by 2022
  - Each category of renewable fuels must meet *minimum* reductions in **greenhouse gas emissions** (GHGs) per GGE

GHG includes emissions associated with *direct and indirect land use change*

AER 2012 Figure 44

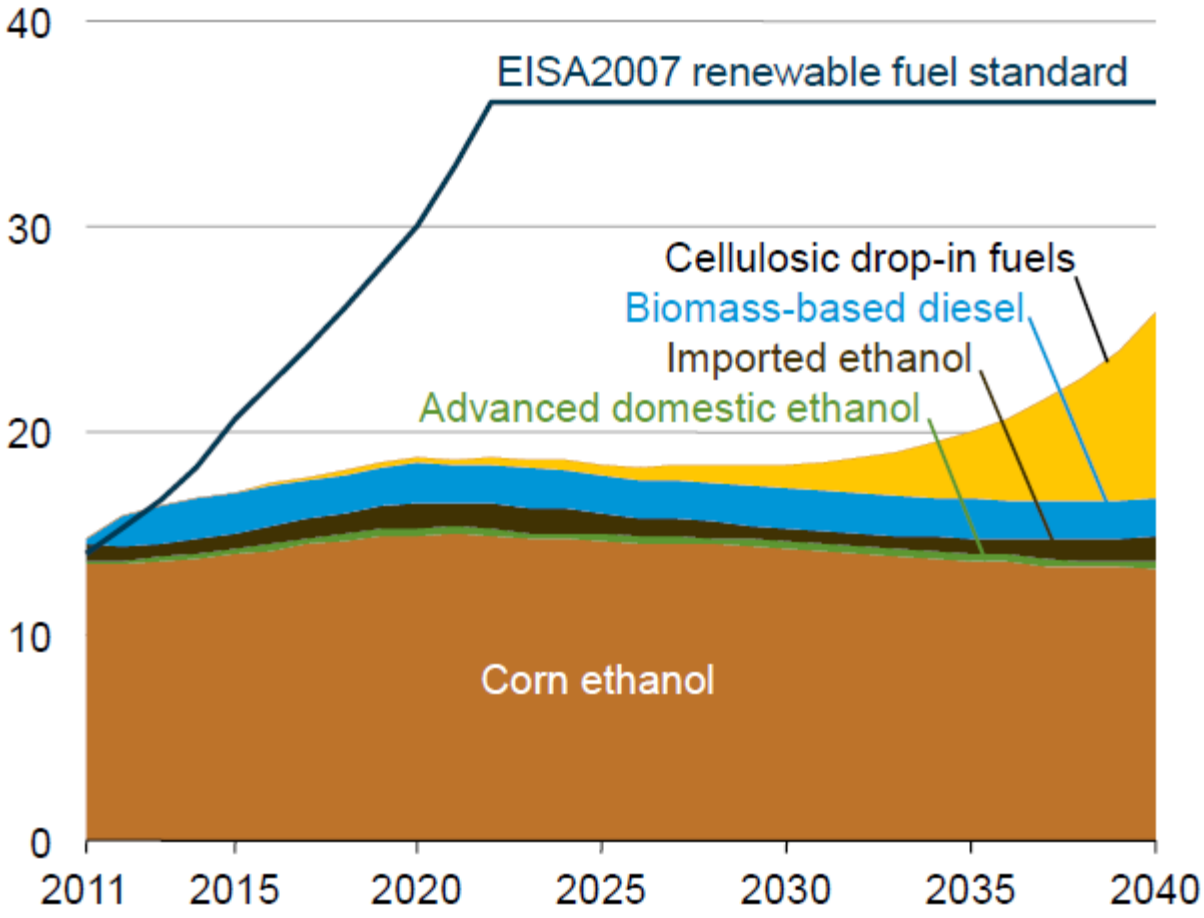


Actual & Projected RFS2 Credits, 2010-2035



AEO 2012, Figure 115

Actual & Projected RFS2 Credits, 2011-2040



AEO 2013, Figure 100

Estimating the Costs of a LCFS

- Estimate relative magnitude of potential costs and cost savings from a ***regional*** LCFS implementation with trading and banking
  - Identify key issues and tradeoffs of policy options for LCFS decision makers
    - Canadian oil sands
    - Ethanol imports
  - Guidance on credit system design
    - Ex: allow trading with other sectors
    - Banking credits/borrowings
- Examine energy security impacts (Leiby, P. J. Rubin, Energy Policy, 2013)

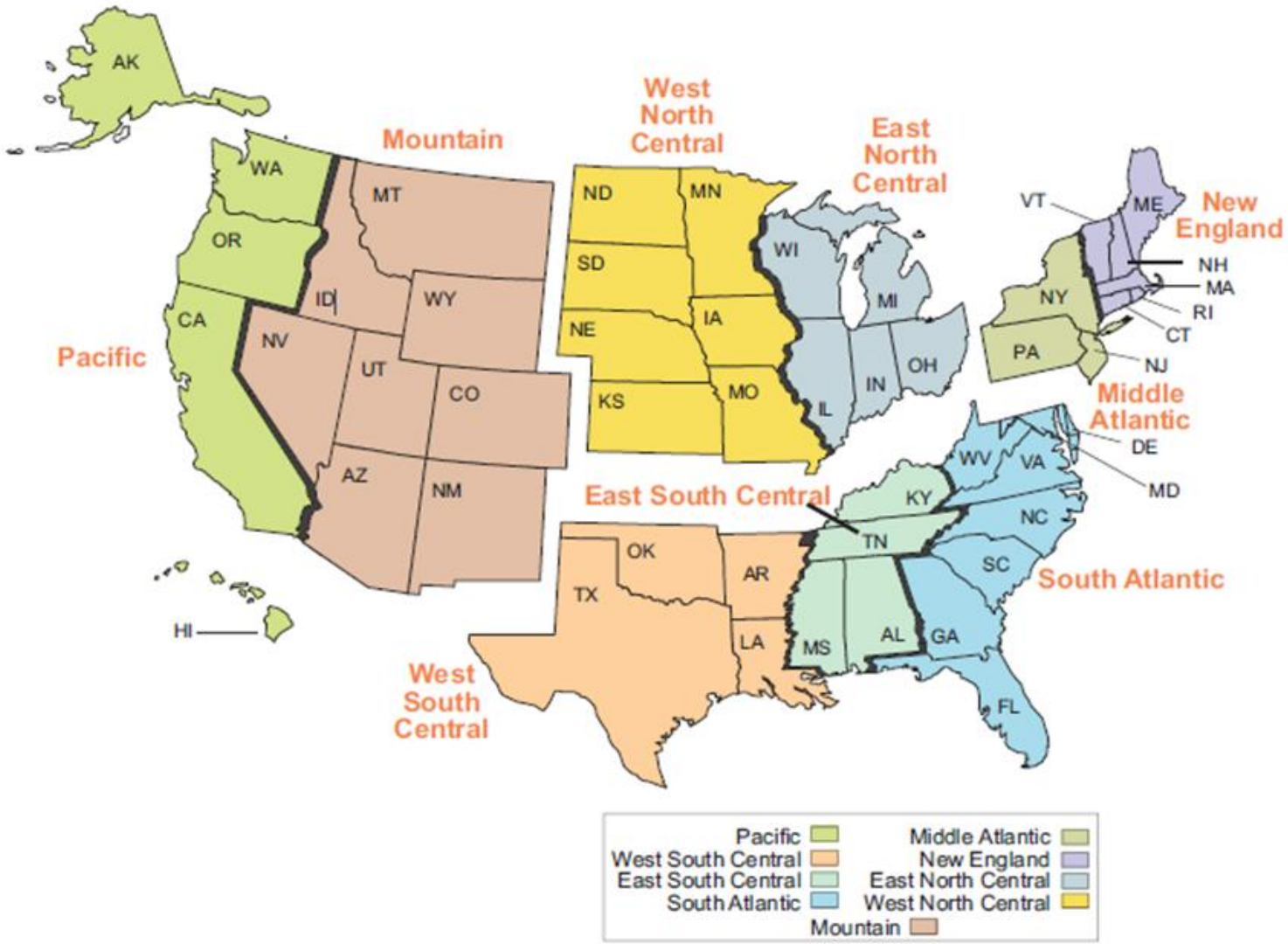
Transportation Regulation and Credit Trading – Regional (TRACTR) Model

- Energy firms maximize profit subject to meeting LCFS
  - Reduce carbon intensity of conventional fuels
    - Refinery improvements
    - Possible “shuffle” of fuels
  - Choice of alternative fuels to produce/import
    - Blending alternative with conventional fuels
    - Sale of “neat” alternative fuels (electricity, E85, CNG, …)
  - Use of LCFS credits (purchased or banked)
  - Exceed target, pay “safety valve” credit price

$$\underset{E,N,B,S}{Max} \sum_{t=1}^{T} \delta_t \sum_{v=1}^{2} \sum_{f \in F} \sum_{r \in R} [P_f E_f - C(E_f)] - \pi_{vmrt} N_{vmt} - P_s S_{vmt}$$

TRACT Model Implementation and Scope

- Light- and heavy-duty vehicles for the US from 2012 - 2025
  - Primary fuels supplied
    - Petro-gasoline
    - Petro-diesel
    - Ethanol
      - Corn, Cellulosic, Sugarcane
    - Bio-diesel
    - FT-diesel
    - Electricity
    - CNG
    - H2
  - Fuel Blends
    - Gasoline-ethanol
    - Ethanol
    - Diesel (B5) *or* FT (any)
  - Fuel-Vehicle Systems with final fuels
    - Gasoline (E10)
    - Diesel
    - CNG
    - FFV (E85)
    - BEV
    - PHEV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Data – Fuel Usage

- The primary sources of reference data for TRACTR are from AEO 2012
  - Provides reference fuel usage by census division, with the limitation of non-specific biodiesel and cellulosic ethanol sources
- BioTrans (ORNL - Uría-Martínez and Leiby 2012)
  - Fills a gap by providing biofuel reference usage and full supply curve estimates by feedstock and region.
- Regional petroleum CI information by PADD generated from a study on petroleum CI variability (Venkatesh 2010; Kocoloski, Kimberley A. Mullins et al. 2011)

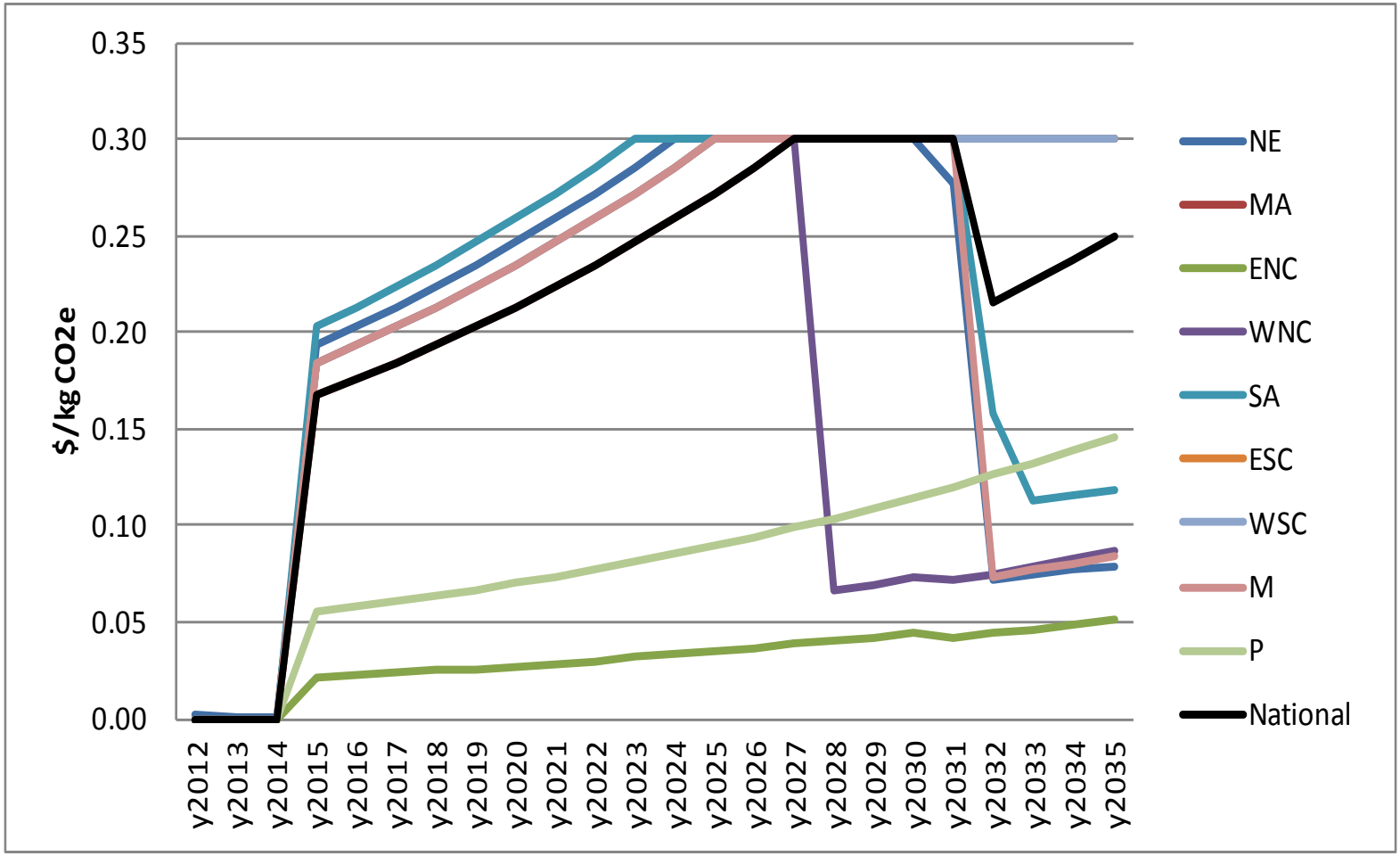
Data – EVs and GHGs

- EV Characteristics: VISION (ANL, 2012)
  - Regional usage by PHEVs and BEVs is not available directly in AEO 2012. However, regional vehicle stock, VMT and MPG schedules are available from VISION (ANL 2012). This allows us to calibrate regional usage to national AEO 2012 electricity usage data.
- Carbon Intensities (CI) from GREET (ANL, 2012)
  - Regional cellulosic ethanol CI is computed using GREET cellulosic ethanol CIs weighted by the regional feedstock sources as estimated in the BioTrans model.
  - Regional electricity CI is computed using average of electricity CI by source from GREET weighted by electricity generation by source from AEO 2012.

Results

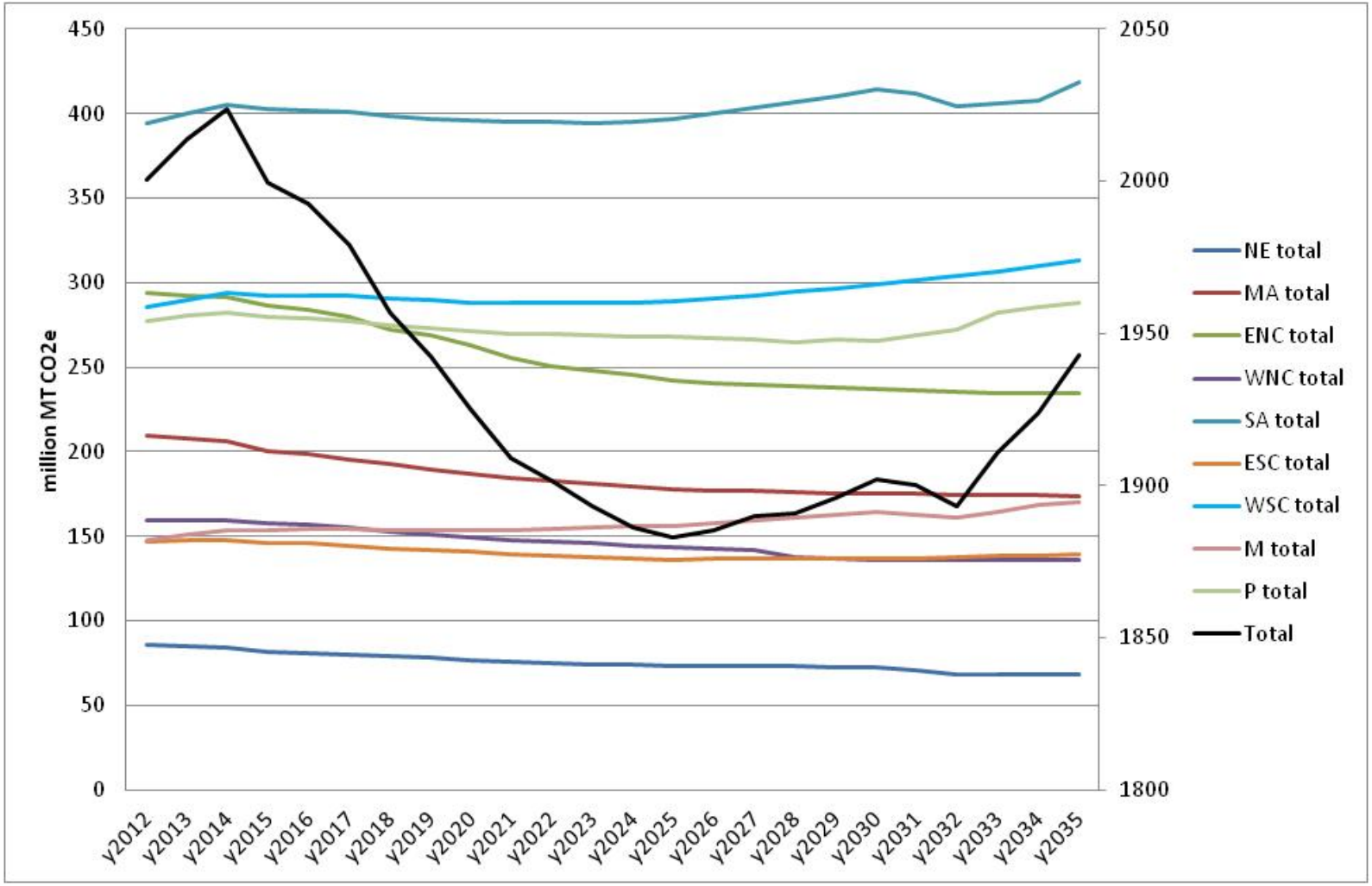
- Wide Range of Credit Costs (Marginal Compliance Costs)
- For a 10% phase-down by 2025
  - Credit prices **$21 - $300/t CO_2**
    - NOTE: apply this charge to only 10% of petro-fuel CO2
    - $300/t CO2 (on 10%) ~ $0.38/gallon
- Range of costs reflects
  - Regional biofuel supply costs and quantities
  - Achievable CI of biofuels supplied
  - Regulatory stringency
    - CI Phase-down path
  - CI of national fuel supply

Credit Prices: Gasoline Market with & without Credit Trading Among Divisions (10% 2015 – 2025 phase down)



New England (NE), Middle Atlantic (MA), East North Central (ENC), West North Central (WNC), South Atlantic (SA), East South Central (ESC), West S. Central (WSC), Mountain (M), Pacific (P)

GHG Emissions by Census Division and Nation, 10% CI reduction with Trading and Banking



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Value of Regulatory Flexibility (reduction in compliance costs)

Fuel Category Trading (Gasoline and Diesel)	Inter-Regional Trading	Banking	Regulatory Baseline is 2012 Petroleum CI*	Regulatory Baseline is 2012 Average Fuel CI*
Yes	No	No	21%	11%
No	Yes	No	13%	9%
No	No	Yes	26%	13%
Yes	Yes	Yes	42%	26%

*Percent Lower Cost Compared to No Credit Trading or Borrowing

Starting from the AFCI baseline, a NLCFS on top of RFS2 (2012 fuel use) increases compliance costs an additional 20% - 40%

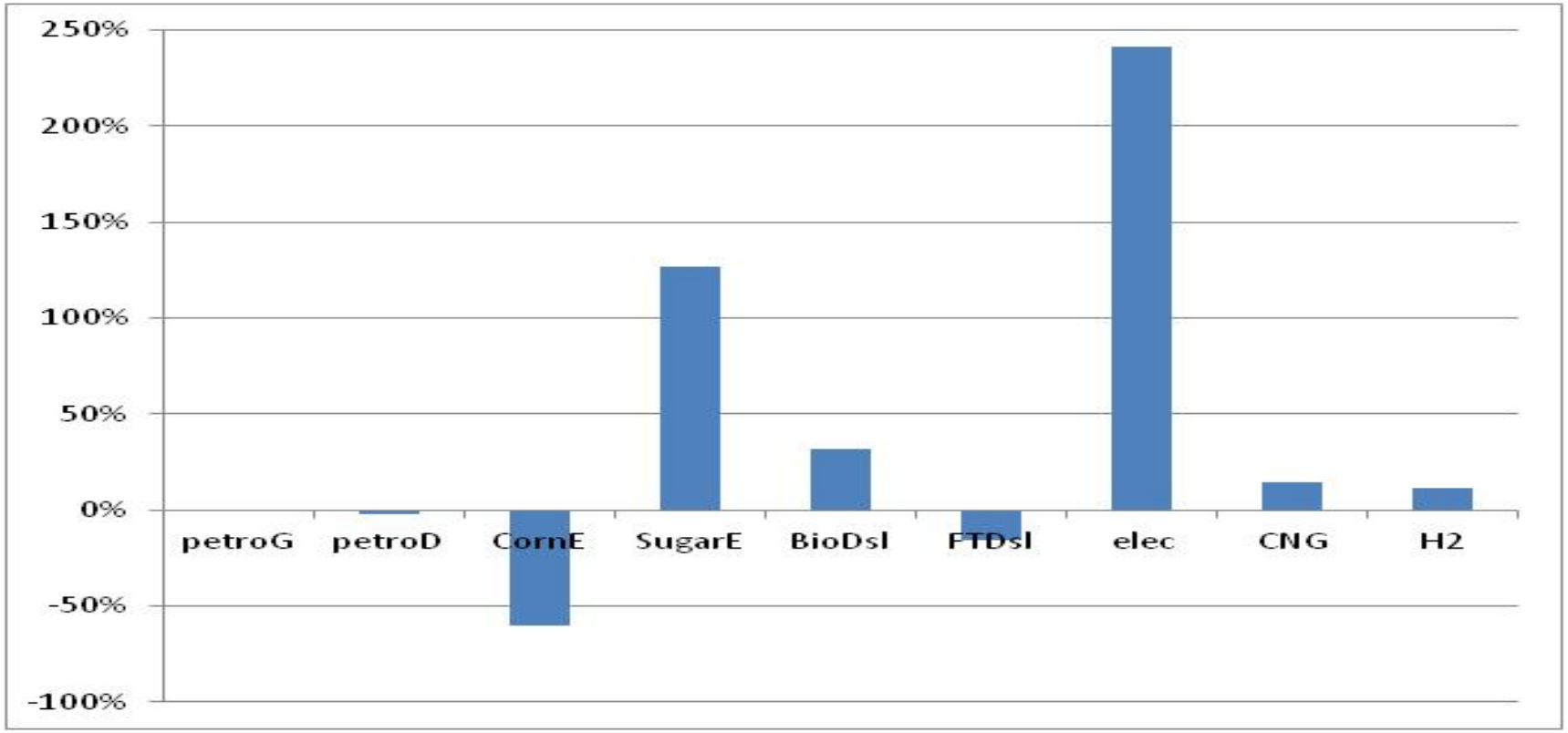
Complementary Regulations: California LCFS

- Regional models consider quantities of low CI fuels produced/consumed in each region
  - One expects that low CI biofuels would be shuffled in the US to meet both national (RFS2) and regional obligations.
  - California is consuming 19% of all US imports of Brazilian sugarcane ethanol (Yeh, Witcover et al. 2013, p. 7), market share alone CA would consume 10%
- Northeast: if LCFS scope includes No. 2 distillate fuel oil (used for heating), low cost credits from fuel substitution (pellets).

Impact of California LCFS on NLCFS Compliance

- We implemented a separate LCFS for the Pacific Division 9, equivalent to the CA LCFS
  - Alaska, California, Hawaii, Oregon, Washington, starting in 2012 (consistent with current law)
  - California represents about 75% of fuel consumption in this Division
  - Oregon is considering adopting a LCFS of its own.
- Rest of the nation either has no new regulation or faces a NLCFS in 2015

CA LCFS Alone with no New National Policy: % Change in Fuel Supply for Pacific Division from California LCFS



The Pacific Division uses 12% of national transportation fuel. Our results show that implementing a NLCFS on top of the CLCFS would be 10% lower in costs than without the CLCFS.

Policy Insights: Complementary Policies

- The LCFS targets the fuel portion of the fuel-vehicle system
  - Sale of credits by low CI fuel suppliers
  - Can be built on top of RFS2 by modifying rules & compliance pathways
- Does *not* directly provide revenues to producers or consumers of infrastructure or vehicles
- There is a need to *harmonize fuel and vehicle policies* to facilitate coordination of fuels, fuel infrastructure, and vehicle systems.

Conclusions: National LCFS - Regional

- Reduces vehicle GHG emissions and promotes fuel/vehicle transformation and economic change/development
- For a 10% phase-down by 2025, credit prices (with trading, banking) $160 - $300/t CO2 ~ $0.19 - $0.37/gallon fuel.
- Biofuels are the largest source of petroleum replacement fuel in the 2025 timeframe
  - Biofuels can enhance energy security
- Compliance costs strongly affected by chosen baseline
  - Average petroleum CI or average fuel CI (e.g., RFS2 baseline)

Limitations

- Our research does not address the net costs or consequences of changing the final demand for various fuels or fuel-vehicle technology combinations.
  - For example, the quantity of electric vehicles is assumed to be determined in the vehicle market as predicted by the US EIA.

- Our data reflect historic CI of petroleum fuels in each census district. New pipelines and rail shipments may provide a less expensive option for a NLCFS implemented at the regional level via fuel shuffling.

- Results are based on AEO 2012 data, which were the latest available for the various subcomponent models. AEO 2013 is less optimistic about biofuel availability. To the extent that AEO 2013 is correct our compliance costs are understated.

- Our NLCFS phase down schedule requires equal percentage change reductions each year. In contrast, California LCFS is phased in more slowly, requiring very little emission reduction in early years with more sharply increasing reduction in later years. This allows regulated parties to build up stocks of banked emissions for later compliance. This should reduce compliance costs.

Thanks!

Further Resources

Rubin, Jonathan and Paul Leiby, “Savings for A National Low Carbon Fuel Standard for Road Transport,” *Energy Policy* (2012), http://dx.doi.org/10.1016/j.enpol.2012.05.031.

Leiby, Paul and Jonathan Rubin, “Energy Security Implications of a National Low Carbon Tradable Credits System Design and Cost Fuel Standard, *Energy Policy* (2012), http://dx.doi.org/10.1016/j.enpol.2012.06.058