

# The Low Carbon Fuel Standard Biofuel Implications

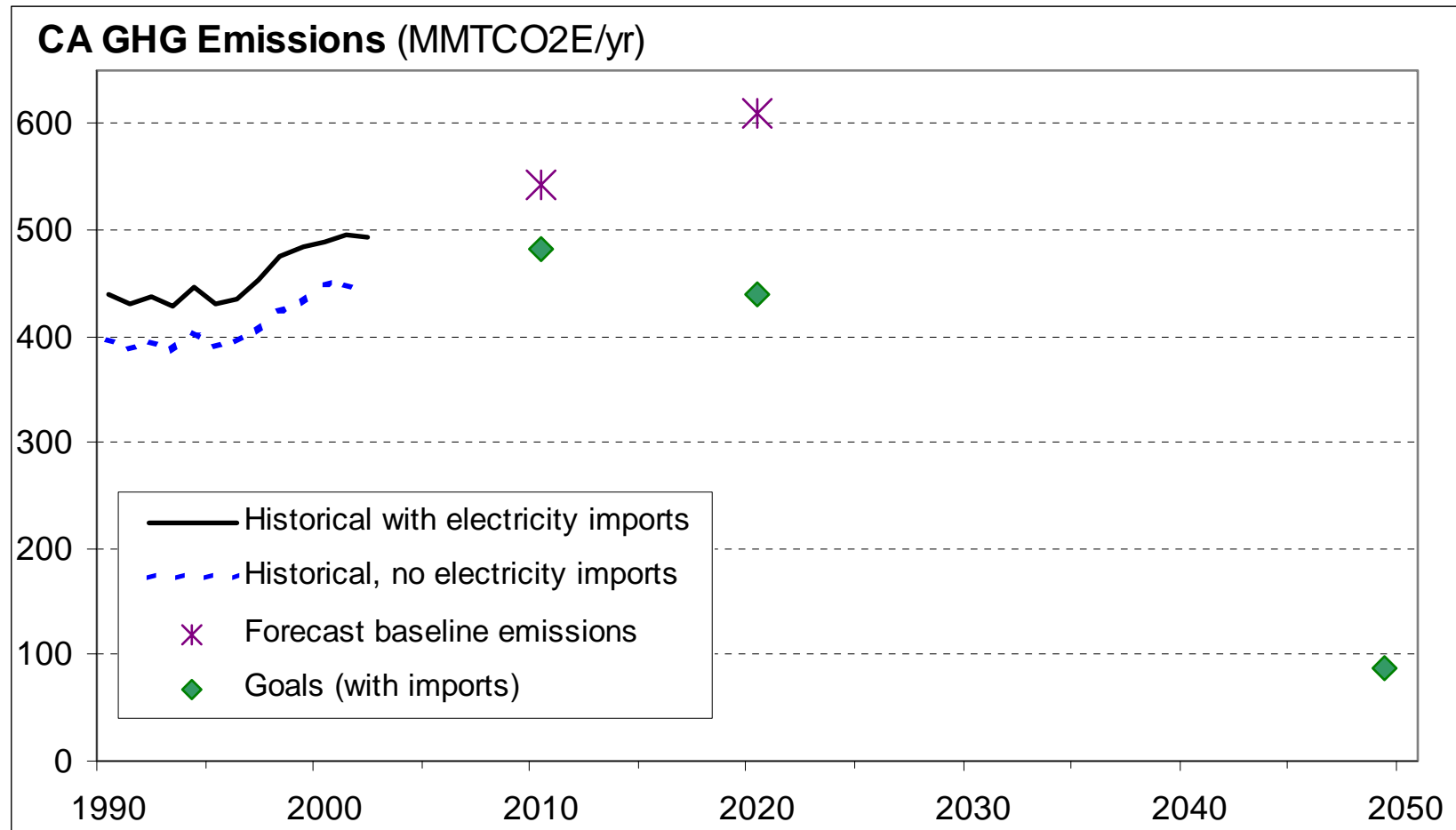
National Corn-To-Ethanol Research Center  
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# California has set ambitious targets



- **Executive Order S-3-05 GHG emission reduction targets**

- 2010: maintain 2000 levels (~10% reduction from baseline)
- 2020: return to 1990 levels (~25% reduction from baseline) → **AB32**
- 2050: attain 80% below 1990 levels

# California has developed a comprehensive, sectoral strategy to cut GHG emissions

- **Overall goals**
  - Executive Order S-3-05 (2005)
  - Global Warming Solutions Act 2006 (AB32)
- **Energy research portfolio**
- **Buildings and appliances**
  - Energy efficiency standards
- **Electricity (and large sources)**
  - Carbon Adder (CPUC)
  - Renewable portfolio standard for electricity (SB 107)
  - GHG performance standard and cap (CPUC decision, SB1368)
- **Transportation**
  - Vehicle GHG performance standard (AB 1493 Pavley)
  - Low Carbon Fuel Standard LCFS (AB32, Executive Order S-1-07)
  - Mass transit, smart growth, etc.
- **Other policies**



# Goals of the California climate change strategy

## **1. Short-term: Cut emissions by ~25% by 2020**

- Deploy existing and near-term technologies to lower GHG emissions.

## **2. Long-term: Stimulate innovation and investment in new technologies**

- Deeper cuts after 2020 will be needed to avoid dangerous climate change.

## **3. Contribute to related objectives as much as possible, including economic growth, air quality, affordable energy prices, and diverse energy sources**

- To avoid dangerous climate change, developed countries must demonstrate that emissions can be reduced while maintaining economic growth, in order to help obtain a global agreement.

# Main provisions of AB32

- **Broad authority to lower GHGs by 25% by 2020**
  - California Environmental Protection Agency (CalEPA)
  - California Air Resources Board (CARB)
  - Other agencies
- **Does not try to pick technological winners**
- **Early action plans to be in place by 2010**
  - Low Carbon Fuel Standard
  - *others*
- **Many regulatory programs underway or to be in place by 2012**
  - Energy efficiency standards
  - Port and truckstop electrification
  - Cap and trade on stationary sources
  - Afforestation
  - Manure management
  - etc.

# LCFS Timeline

- **January 2007** – Governor Schwarzenegger signs Executive Order S-01-07
- **May 2007** – University of California Berkeley/Davis study of the LCFS
- **July 2007** – CARB starts regulatory proceedings, including public workshops and notice and comment process
- **January 2009** – CARB adopts plan for achieving 2020 targets and completes regulatory proceedings for early actions
- **January 2010** – Early action regulations are enforceable

# Low Carbon Fuel Standard (LCFS) compliance

- **Compliance by blenders, refiners, and importers**
- **Separate from AB1493 (Pavley)**
- **Government sets performance standard and does not pick technological winners**
- **Global warming impact must be measured and go down over time**
  - Average Fuel Carbon Intensity (AFCI)
  - Measured in terms of impact per unit energy, gCO<sub>2</sub>e/MJ
  - At least 10% reduction by 2020
- **Default and opt-in approach**
- **Credit trading**

## Default and opt-in

- **All fuel inputs are assigned a default carbon intensity**
  - Conservative (high) value encourages opt-in
- **Suppliers with lower carbon intensity can get certified at a lower value**
  - CARB-approved protocols and 3<sup>rd</sup>-party certification
- **Producers**
  - Fertilizer and pesticide use
  - Tillage practice
  - Prior land use
  - Certification (for example Conservation Security Program)
- **Processors**
  - Fossil fuel inputs
  - Products
- **Could be included in Renewable Identification Number**

NOTE: This is our current thinking, we could use input here



# Credit trading

- **Overachievers generate credits that they can sell to underachievers**
  - Not a cap, no allowances to allocate
  - Actual emissions could increase
- **Fuel providers generate credits, but anyone could buy and sell them**
- **Flexibility allows companies to innovate and develop low-cost strategies that satisfy their customers**
- **Technologies compete, which speeds innovation and lowers costs**
- **Successful track record**
  - Lead phase-out from gasoline
  - Reformulated fuel standards
  - Criteria pollutants under the Clean Air Act (bubbles, banking)

## LCFS developments worldwide

- **California:** regulations to be in effect 2010
- **Other States:** Proposals in BC, WA, OR, AZ, NM, MN, and...IL?
- **United Kingdom:** Renewable Transportation Fuel Obligation requires GHG monitoring, pilot in 2007
- **United States:** Bills by Boxer (D-CA), Feinstein (D-CA), Obama (D-IL) Inslee (D-WA)
- **European Union:** monitoring in 2009, reductions start in 2011

# A Low-Carbon Fuel Standard for California

## Part 1: Technical Analysis

May 7, 2007

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# Study questions

Part 1: Is the 10% target technically feasible?

Part 2: What are the key policy choices?

## Part 1 report outline

1. Introduction
2. Methods
3. Fuel characterization
4. Resources for low-carbon fuels
5. Scenarios

# Scenarios examine the technological change needed to meet climate change goals

- Balance of innovation and investment
- Fuels
  - Mid-GHG biofuels – best current technologies
  - Low-GHG biofuels – technologies in development and pilot phase
- Vehicles
  - Flex-fuel
  - Diesel
  - Hybrid
  - Plug-in hybrid
  - Battery electric
  - Hydrogen

# Representative Fuels

Fuel type	Description	AFCI gCO <sub>2</sub> e/MJ
Gasoline	California average	92
Average Midwest corn ethanol	Current	76
Mid-GHG ethanol	Corn feedstock, modern dry mills Natural gas, natural gas (wet DGs), stover	58
Low-GHG ethanol	Poplar, switchgrass, prairie grasses Cellulosic production	4
Mid-GHG biodiesel	Soy feedstock	38
Low-GHG biodiesel	California poplar Gasification and Fischer-Tropsch	-6
Electricity	California average	27
Hydrogen	Steam methane reforming	48

# Scenario Analysis

- VISION-CA model (based on Argonne National Lab)
- Smooth transition from 2008 to 2020
- Changes in vehicle and fuel sales
  - Example: transition from average Midwest ethanol to low-GHG ethanol
  - Example: introduction of plug-in hybrid electric vehicles
- Key assumptions:
  - Population and economic growth
  - Vehicle stock turnover
  - AB1493 (Pavley)
  - Diesels and other technologies change
- Scenarios
  - Low-carbon fuel and vehicle introduction rates
- Results
  - Estimates of AFCI and market size, but not prices

# Light Duty Vehicle Scenarios

Scenario name	Description (beyond BAU)
Business as Usual (BAU)	
Electric Drive	Battery, plug-in hybrid, and hydrogen vehicles
Existing Vehicles and Advanced Biofuels	Diesel vehicles Low-GHG ethanol, low-GHG diesel
Evolving Biofuels and Advanced Batteries	Battery, plug-in hybrid vehicles and FFVs Mid-GHG ethanol, mid-GHG diesel, Electricity
Biofuel Intensive	Diesel, flex-fuel, flex-fuel hybrid vehicles Mid- and low-GHG ethanol, mid- and low-GHG diesel
Multiple Vehicles and Fuels	CNG, plug-in hybrid, battery, fuel cell, flex-fuel, diesel Low-GHG ethanol & diesel, CNG, electricity, hydrogen,

Different types and levels of technological innovation occur in each scenario

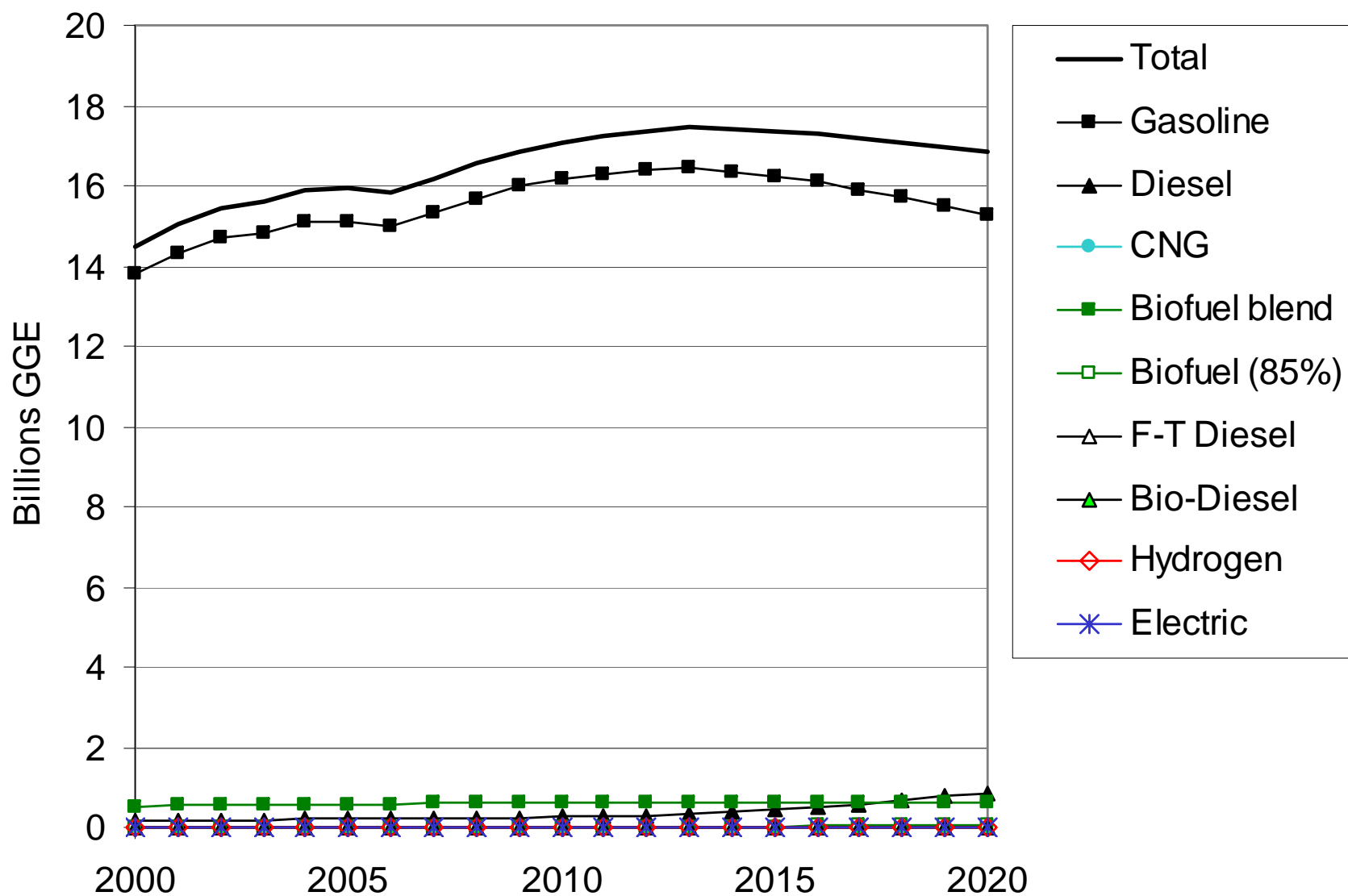


## LDV Scenario Results (-10% AFCI)

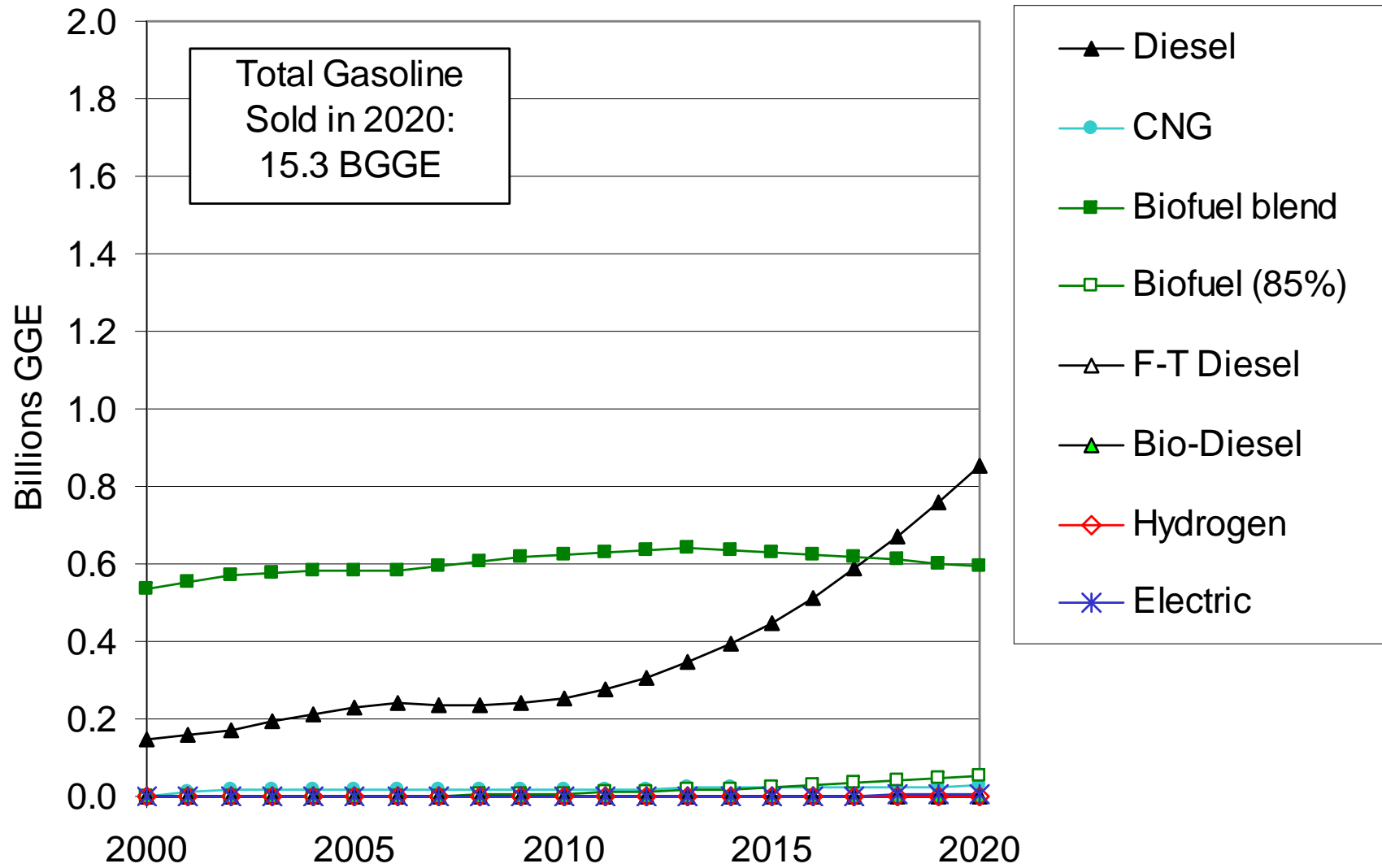
Scenario name	Volume in 2020 (million GGE/yr)*
Business as Usual (BAU)	Gasoline: 15,300 (of which ~900 are ethanol) Diesel: 850
Existing Vehicles and Advanced Biofuels	Low-GHG ethanol: 957 Low-GHG diesel: 709
Biofuel Intensive	Mid-GHG ethanol: 3,293 Mid-GHG diesel: 423
Multiple Vehicles and Fuels	Low-GHG ethanol: 1,262 Low-GHG diesel: 171 CNG: 289 Electricity: 69 Hydrogen: 59

\* GGE = gallons of gasoline equivalent

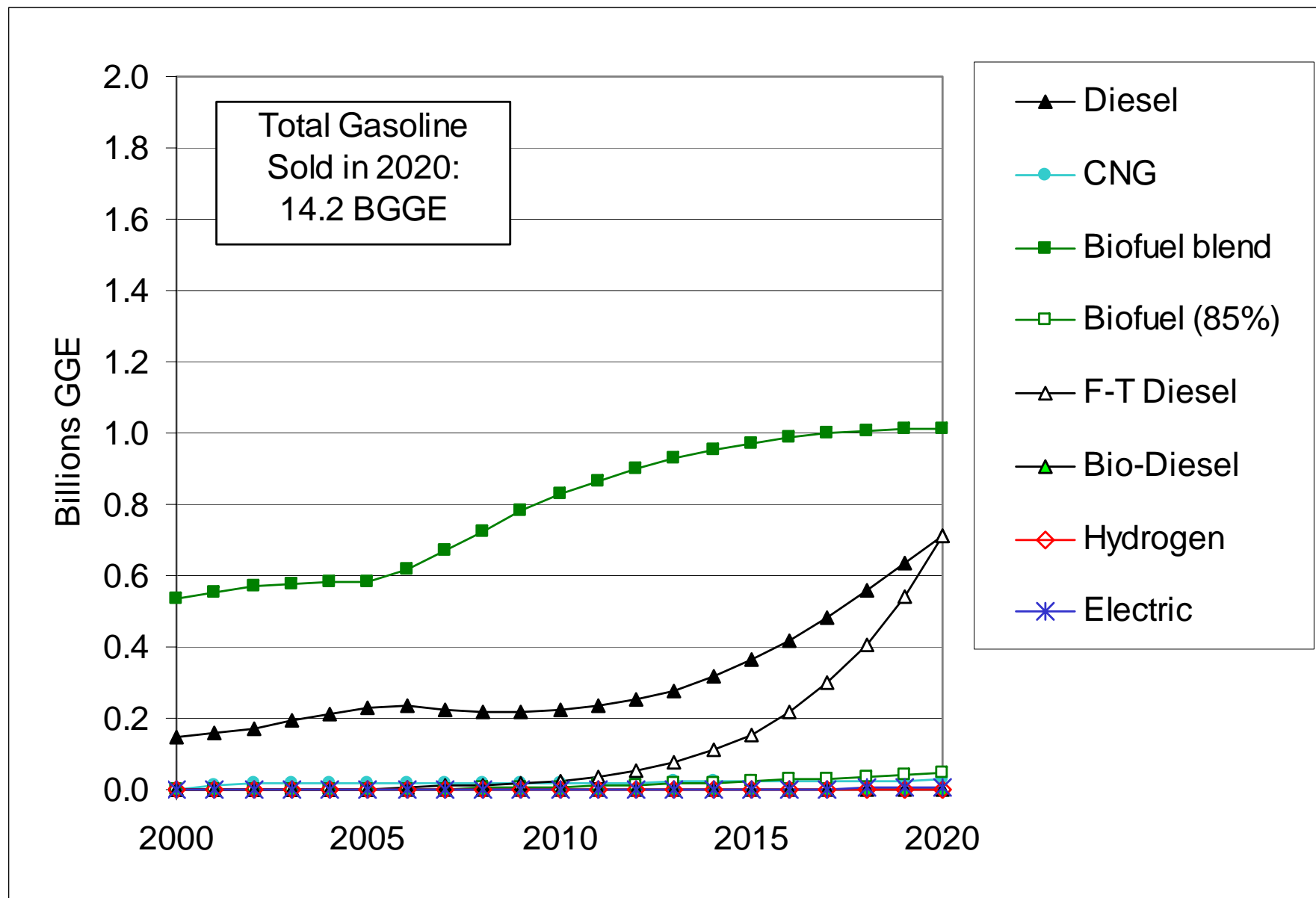
# BAU fuel market



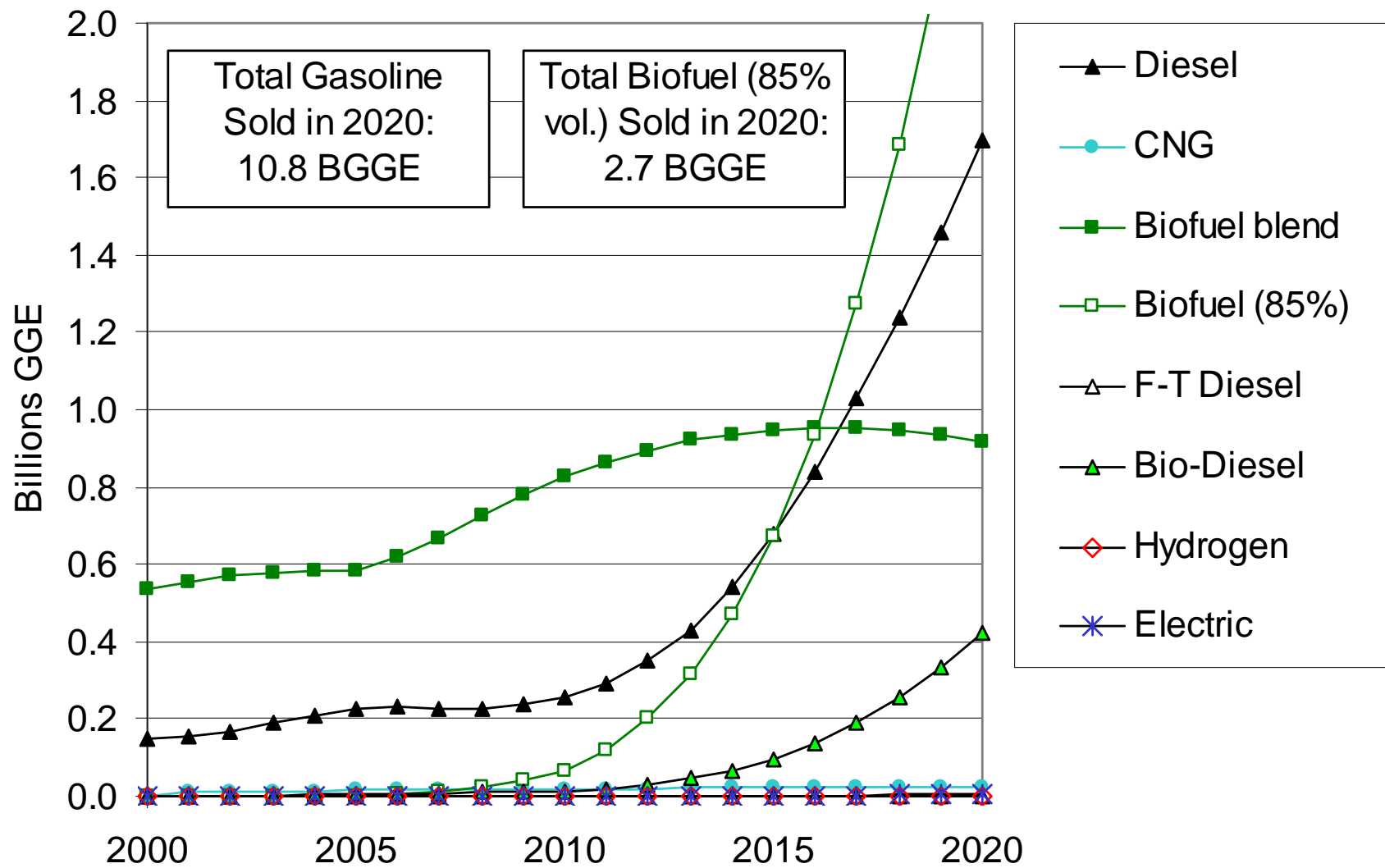
# BAU alternative fuel markets



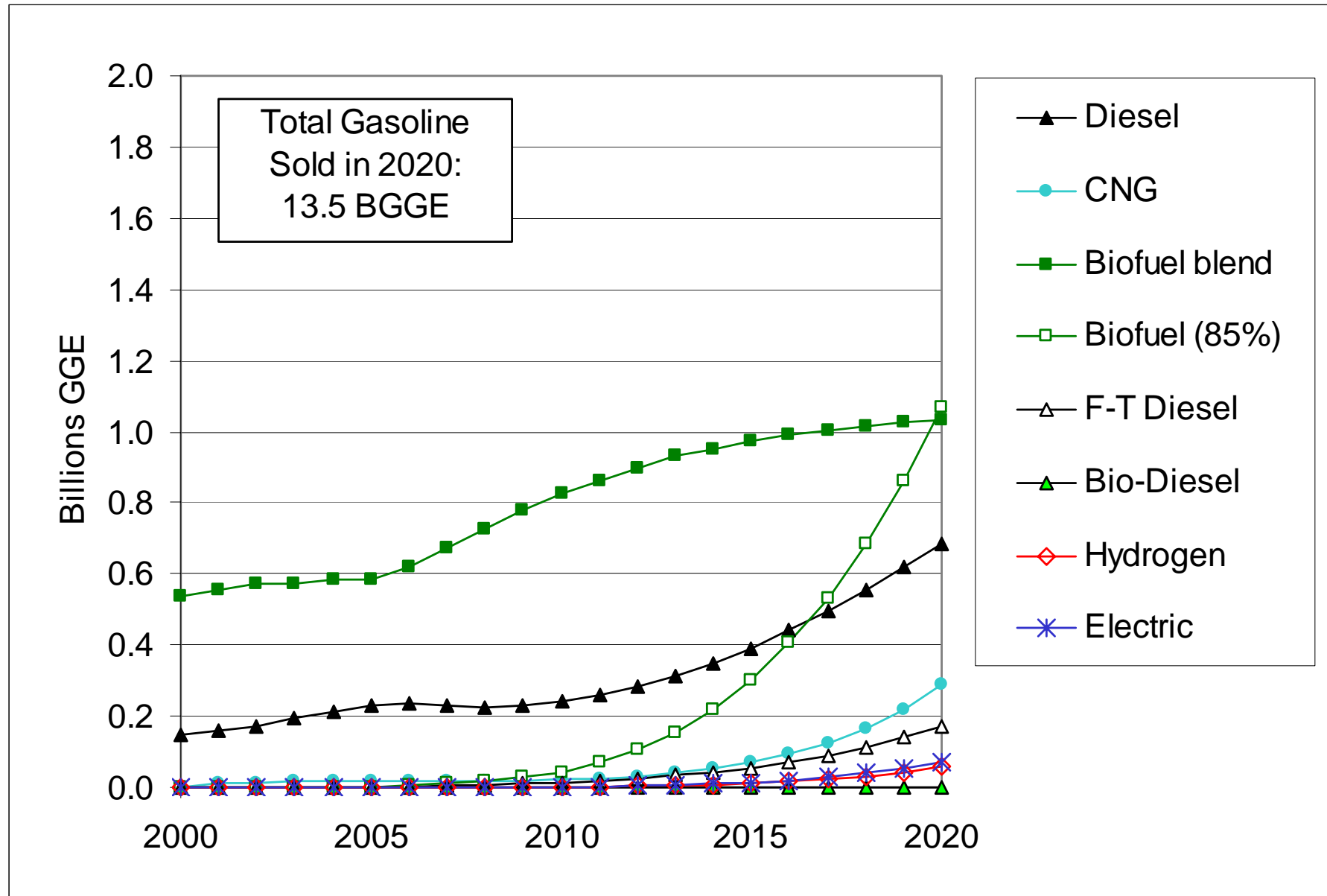
# Existing Vehicles and Advanced Biofuels



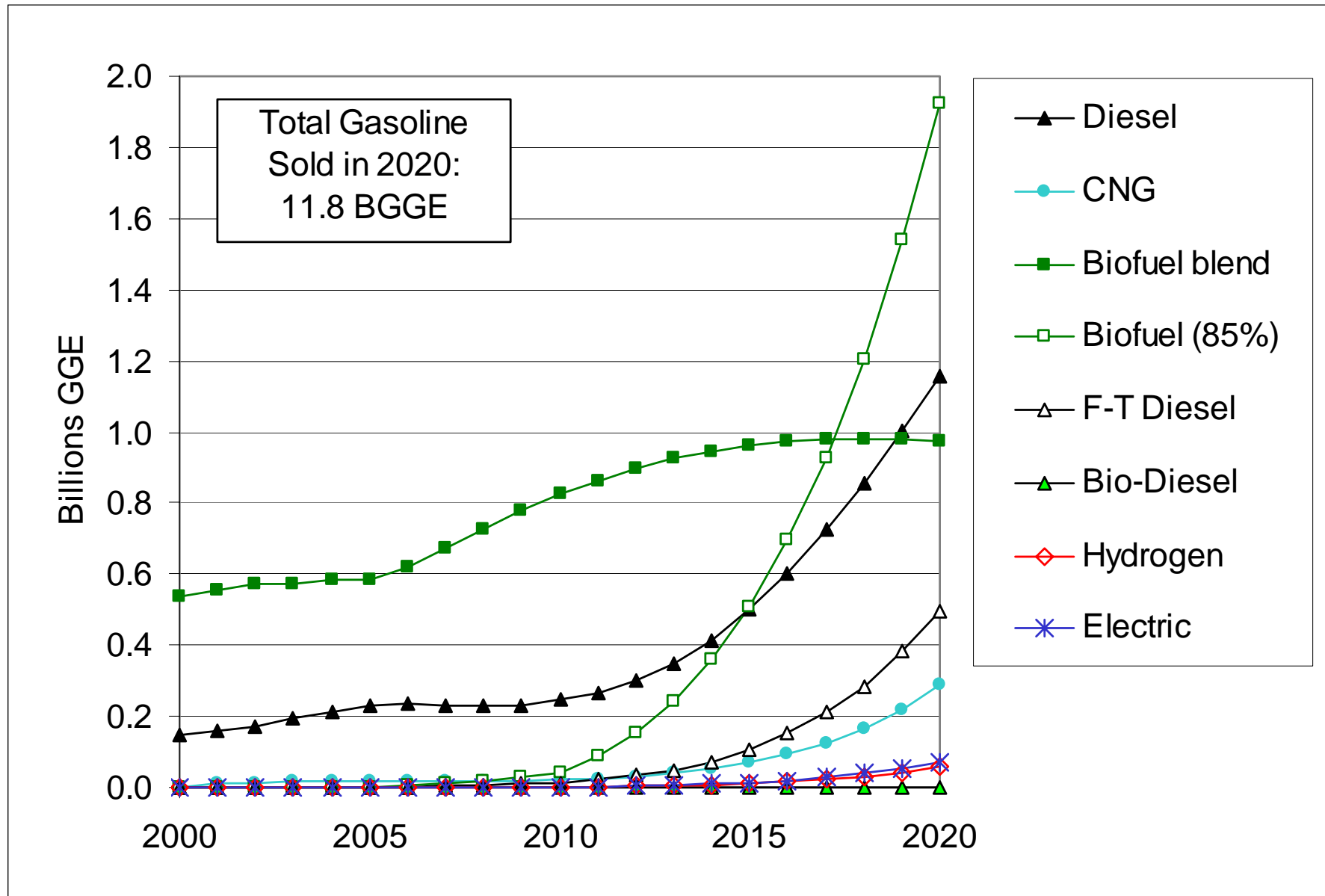
# Biofuel Intensive



# Multiple vehicles and fuels



# Multiple vehicles and fuels (-15% AFCI)



## Resources for low-GHG fuels

<b>In-state feedstocks</b>	<b>Potential (million GGE / yr)</b>
California starch and sugar crops*	360 to 1,250
California cellulosic agricultural residues	188
California forest thinnings	660
California waste otherwise sent to landfills	360
Cellulosic energy crops on 1.5 million acres in California*	2,400 to 3,200
California corn imports	130 to 300
<b>Forecasted 2012 nationwide production capacity</b>	<b>Potential (million GGE / yr)</b>
National mid-GHG ethanol	776 to 969
National low-GHG ethanol	288
National mid-GHG diesel	1,400
National low-GHG diesel	175

\* Requires significant changes



# Conclusions

Is the 10% target technically feasible?

**Yes, but more research is needed**

**There are multiple ways to lower AFCI**

**California and nationwide resources seem adequate**

**Technological change is required**

What are the key policy choices?

**Coming soon**

International Symposium on the Low Carbon Fuel Standard

May 18, 2007

Lawrence Berkeley National Laboratory

What are the implications for biofuel producers?

**New, value-added market**

**Probable increase in market size**

**New record-keeping requirements**

**New incentives to lower GHG emissions**

**Increased variety of fuel sources and competition**

# Thank You

- S.M. Arons, A.R. Brandt, M.A. Delucchi, A. Eggert, A.E. Farrell, B.K. Haya, J. Hughes, B.M. Jenkins, A.D. Jones, D.M. Kammen, S.R. Kaffka, C.R. Knittel, D.M. Lemoine, E.W. Martin, M.W. Melaina, J.M. Ogden, R.J. Plevin, D. Sperling, B.T. Turner, R.B. Williams, C. Yang
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