Ethanol - A Viable Alternative for Transportation Fuel in California

Ethanol Forum & Technical Roundtable

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South Coast Air Quality Management District

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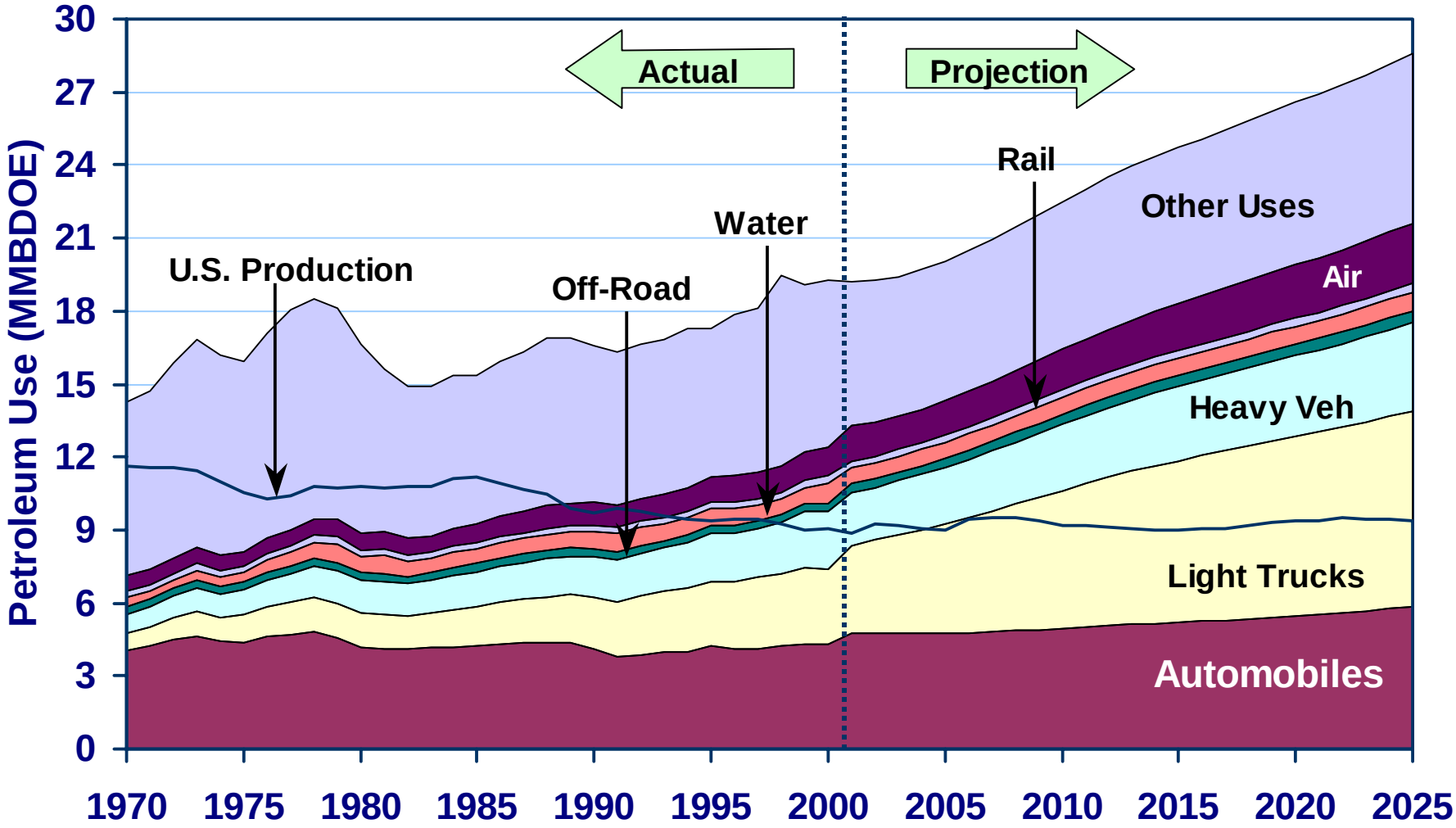
Viable Near Term Alternatives to Petroleum Based Fuels are Needed

- **40% growth in global energy demand is predicted by 2020 – transportation represents a major portion**
- **Petroleum based fuel supply needs to be supplemented to meet demand**
- **Alternative fuel sources are needed that can address continuing oil supply and price shocks**
- **The near term need suggests compatibility with the existing liquid fuel infrastructure and vehicle fleet**
- **Numerous alternative fuel policy initiatives are in play driven by concerns about petroleum fuel use and greenhouse gas emissions**

U.S. Now Consumes about 19 Million B/D of Oil, Transportation Accounts for ~75%



Data sources: ORNL (2003), the Transportation Energy Databook;
EIA (2003), Annual Energy Outlook; Annual Energy Review

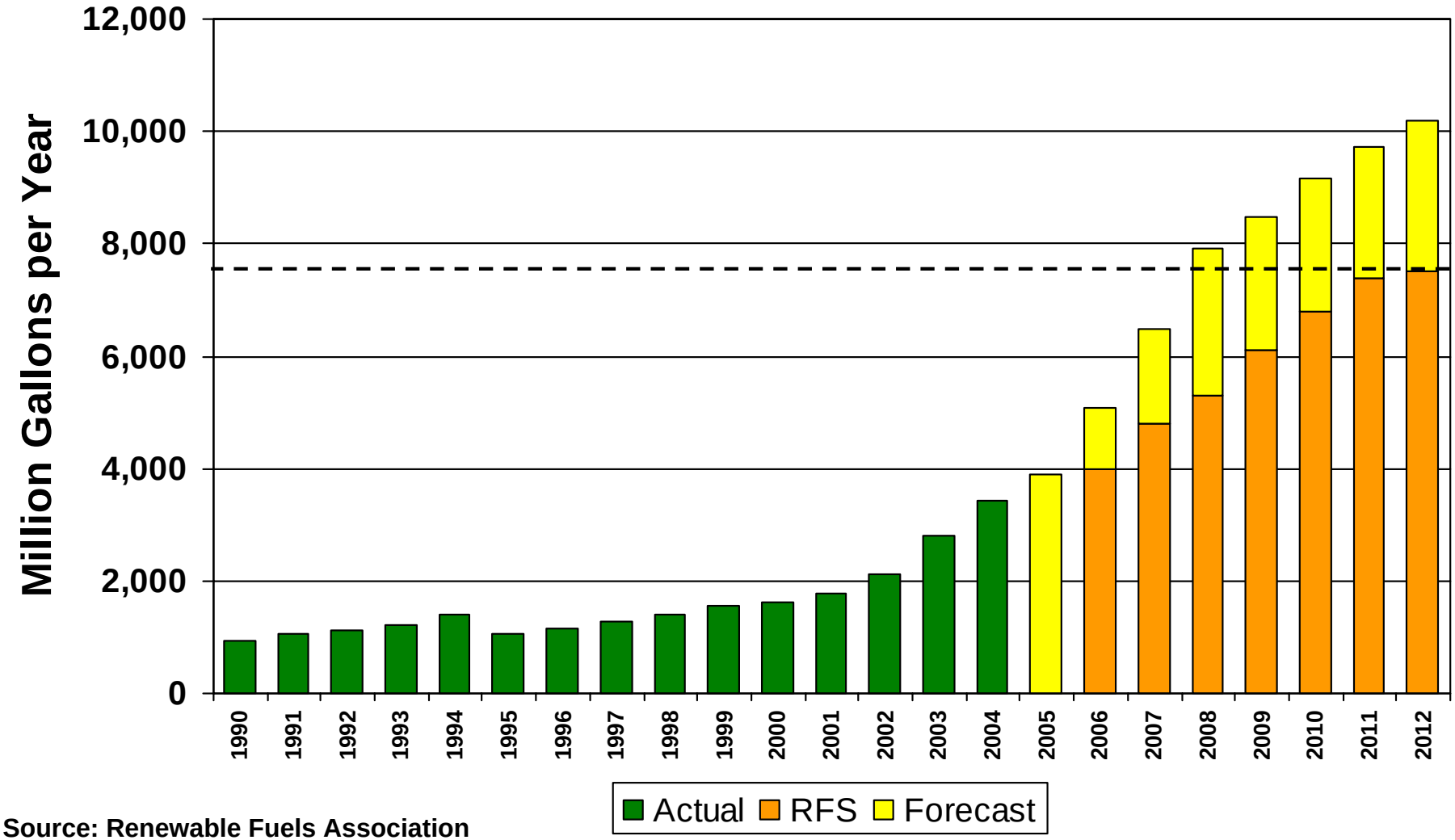
Ethanol - Opportunities

- **Renewable energy source**
- **“Home Grown” consumer alternative to gasoline**
- **Potential to supply significant amount of transportation fuel demand**
- **Significant greenhouse gas benefit – magnitude depends on production methods and raw materials employed**
- **Infrastructure issues simpler and less costly than gaseous alternative fuels (CNG, LPG, Hydrogen)**
- **Jobs creation**

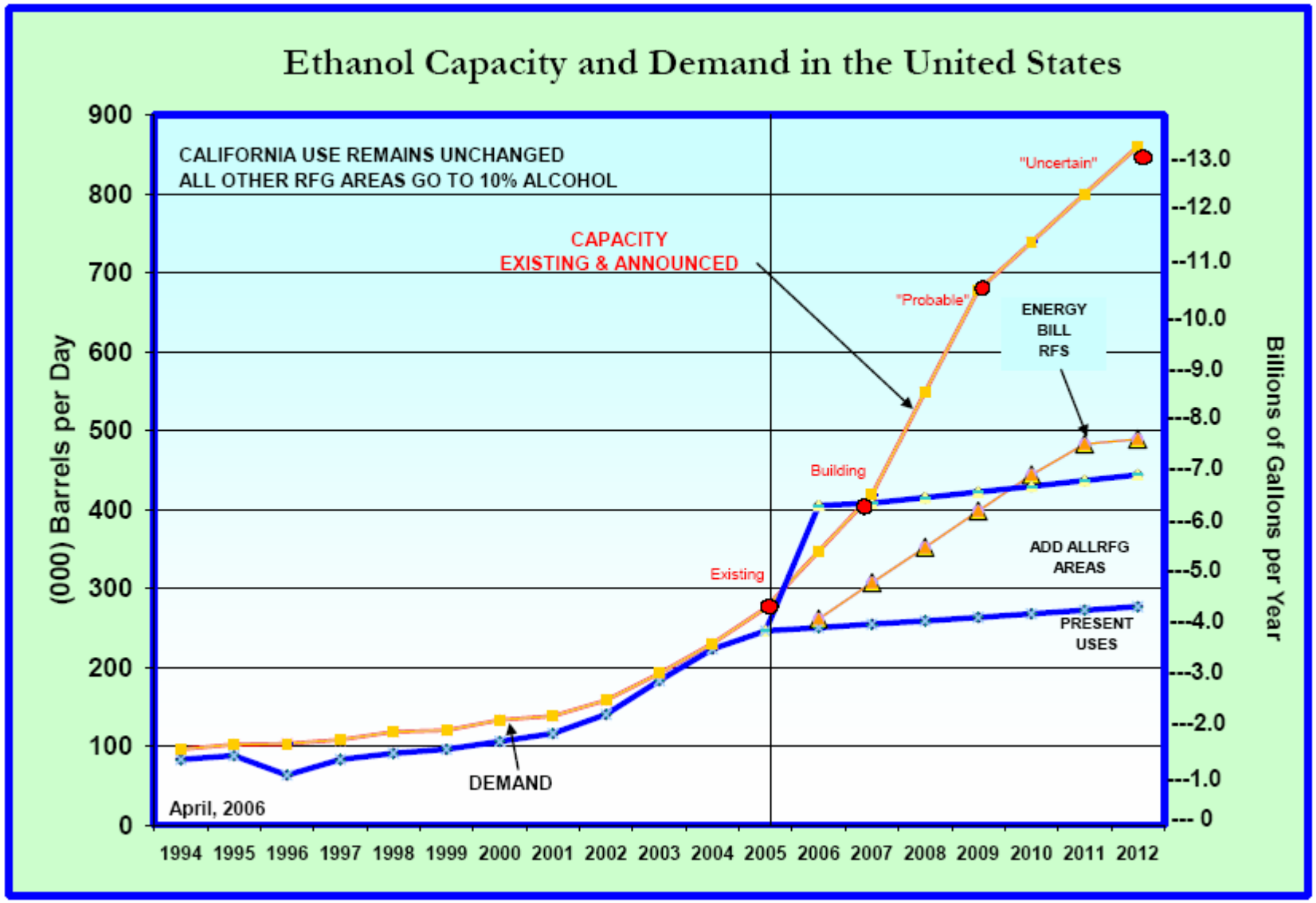
California is Moving Toward Specific Objectives

- **Non-petroleum fuel use: 20/30% in 2020/2030**
  - **Energy Commission 2005 Integrated Energy Policy Report**
  - **Calls for simultaneous emission and GHG reduction**
  - **Long term transport plan to Governor on March 31, 2006 including bio-energy use**
  - **AB 1007 "Pavley" requires plan by June 2007**
  - **Ethanol is likely to play a major role**
- **GHG reductions: 17/27% in 2020/2030 in the vehicle fleet, 22/27% in 2012/2016 in new vehicles**
  - **AB 1493**
  - **Ethanol can play an important role**

U.S. Fuel Ethanol Production is Forecast to Exceed RFS by a Substantial Amount

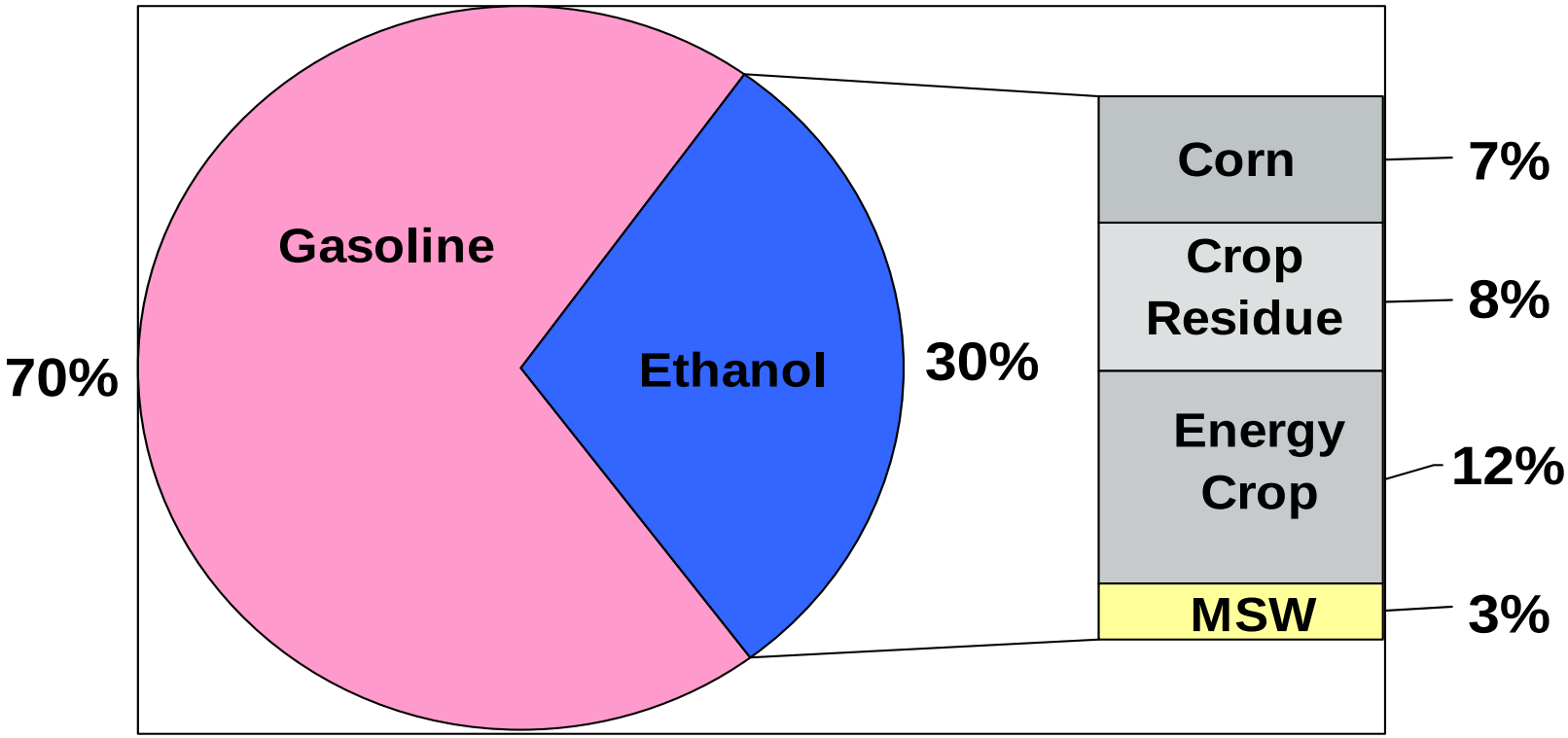


Source: Renewable Fuels Association



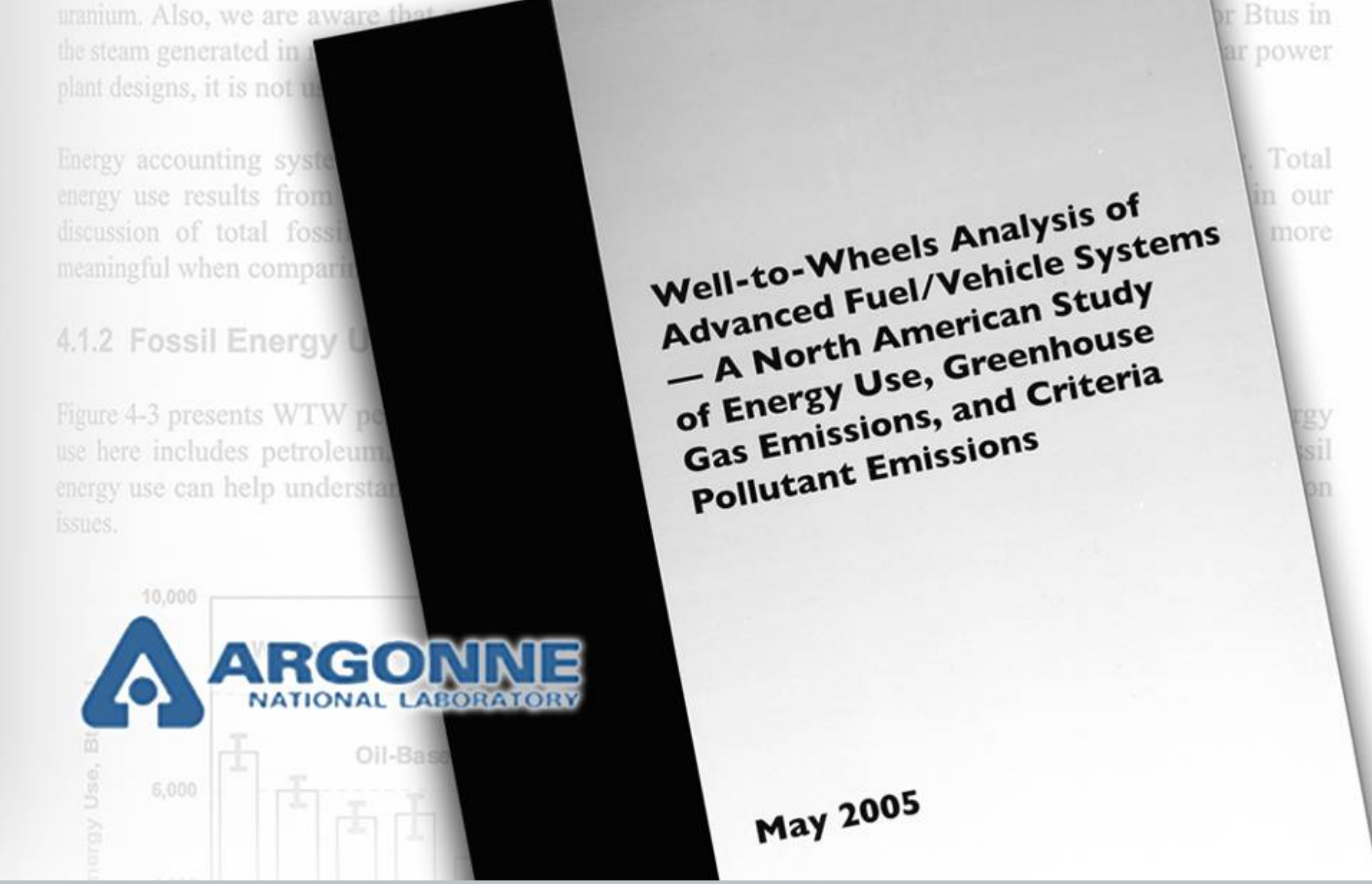
Source: JJ&A Fuels Consulting April 14, 2006

Practical Estimate of Potential U.S. Ethanol Portion of U.S. Light-Duty Fuels (Year 2020)

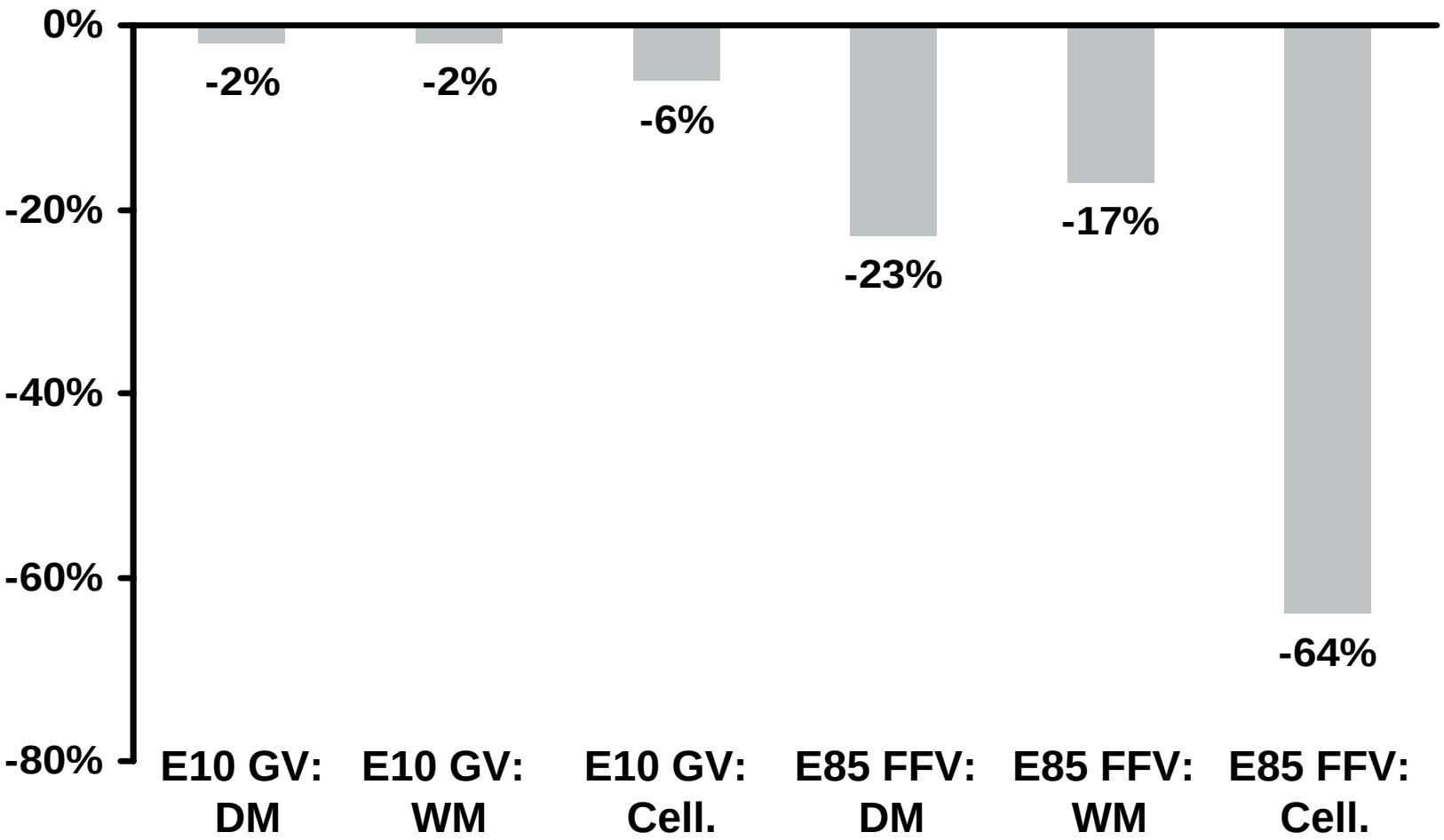


All percentages are on an energy equivalent basis

Source: GM/University of Toronto research on cellulose ethanol supply


Well-to-Wheels Analysis of Advanced Fuel/Vehicle Systems — A North American Study of Energy Use, Greenhouse Gas Emissions, and Criteria Pollutant Emissions
May 2005
ARGONNE
NATIONAL LABORATORY
GM

Ethanol Blends, Especially E85 Made from Cellulosic Ethanol, Can Significantly Reduce GHG Emissions



Reductions in Per-Mile GHG Emissions by Ethanol Blend - Source: Argonne National Laboratory

Ethanol - Challenges

- **Low concentration ethanol blends (E10, E6) present evaporative emissions challenges**
- **High concentration blend (E85) consumer availability is limited, infrastructure needed**
- **Near term spot market prices influenced by tight short term supply, contract prices remain competitive**
- **“Energy balance” of ethanol production continues to be raised.**

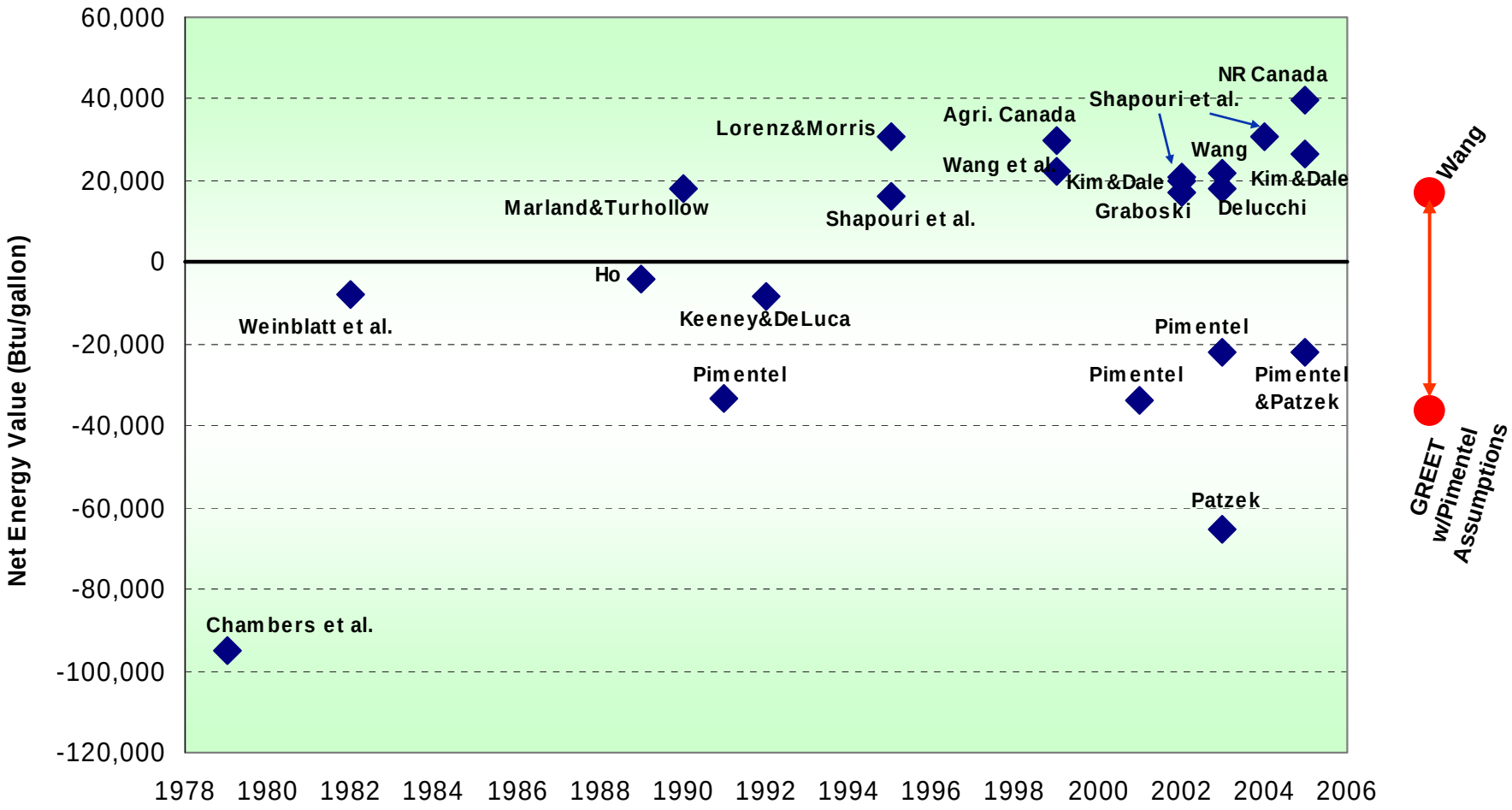
Evaporative Emissions and Ethanol Blends

- **Evaluation of available offset mitigation strategies in process**
- **Near Term**
  - **Adjustment of base gasoline properties including RVP and T50**
  - **Update of the models with recent data including CRC studies and Alliance Zero Sulfur Test Program**
  - **Evaluation of equivalent VOC reduction from ethanol related CO reductions**
  - **Exhaust emission benefits to off-road inventories**
  - **Consideration of offset opportunities from other sources**

Emissions and Ethanol Blends

- **Longer term**
  - **Increased use of E85**
  - **Fleet turnover to "zero" and near zero evaporative emission vehicles**
- **Other factors**
  - **Integrate impact on petroleum fuel use and greenhouse gas emission goals into the overall assessment of ethanol use**
  - **Consider supply implications**

Most of the Recent Corn EtOH Studies Show a Positive Net Energy Balance



Energy balance is defined as Btu content a gallon of ethanol minus fossil energy used to produce a gallon of ethanol

Next Steps

- **Stakeholders and ARB are currently working through the process of the Predictive Model and EMFAC inventory model updates**
- **Several issues have been raised concerning modeling methodology and assumptions that could have an important impact on the outcome**
  - **Untested modeling assumptions**
  - **Application of modeling methodology to permeation emissions**
- **It's too early to predict the impact on inventories**
- **A disconnect between the Predictive Model and EMFAC model update timing should be resolved**
- **Adequate time should be allowed to address all issues to permit the most accurate model assessment**

Modeling Issues

- **Untested assumptions**
  - **Augmentation ratio**
  - **Permeation fraction of evap emission components**
  - **Tank temperatures**
- **Preliminary modeling results raise issues**
  - **Ethanol contribution doubles at higher temperature profile when "augmentation ratio" remains constant**
  - **Permeation fraction may not increase with temperature**
- **Adequate time should be allowed to address stakeholder issues and produce the most accurate model**

Summary and Recommendations

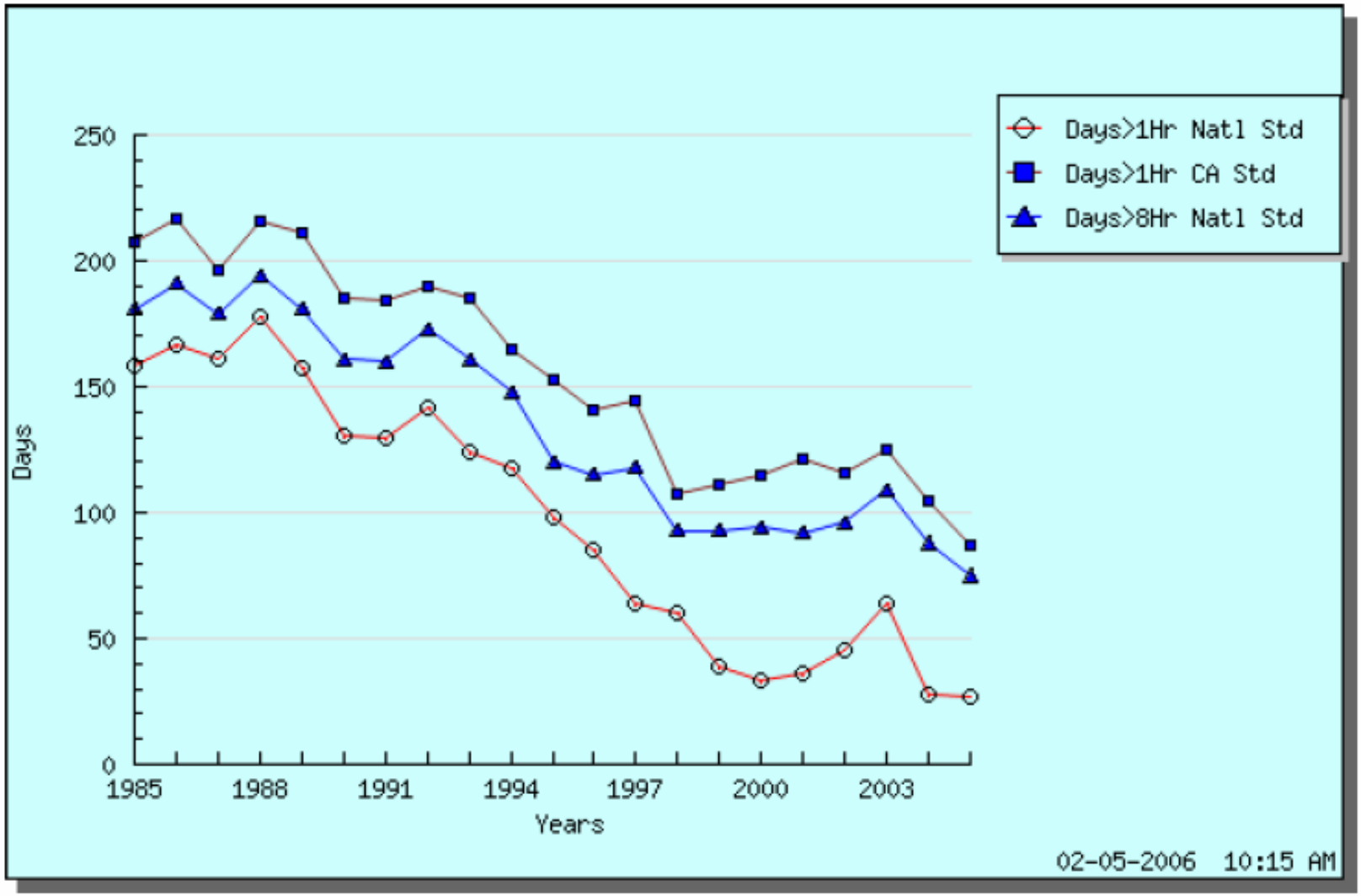
- **A growing body of research suggests that ethanol represents the best near term opportunity to add significantly to the fuel supply, and address greenhouse gas emissions concerns as well.**
- **Ethanol's unique ability to address these issues aligns with California's goals for transportation fuel allocation and greenhouse gas emission reductions, and expressed desire to increase production and use of ethanol.**
- **Ethanol supply is expected to be adequate to meet California's needs. Longer term, ethanol production represents an opportunity for new jobs and economic growth in the state.**
- **Current ethanol spot prices are driven by tight short term supply that is expected to be alleviated within the next year.**

Summary and Recommendations

- **To avoid undesirable impacts on fuel supply and market disruptions, practical plans for increased use of ethanol should include continuing and maximizing the use of ethanol blends such as E5.7 and E10.**
- **Emission inventory impacts must be fully evaluated including permeation evaporative emissions and offset mitigation strategies.**
- **It is the best interests of the State and the South Coast to take the necessary time to develop a technically sound modeling methodology to determine the most accurate inventory prediction.**

Backup Material

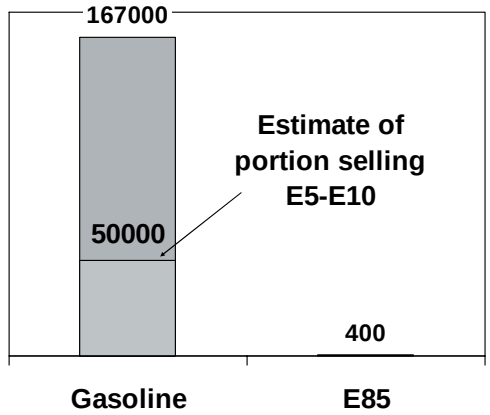
Air Resources Board Ozone Trends Data
South Coast Air Basin



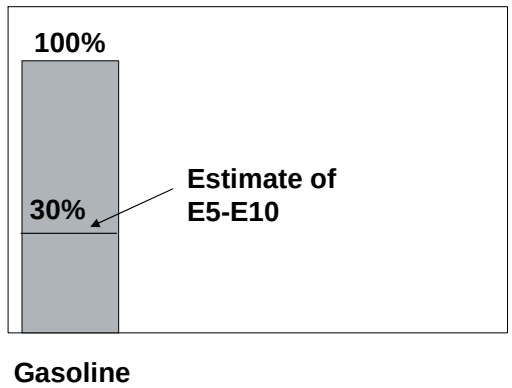
National Perspective - The Renewable Fuel Standard is a Good Start, But Far Short of the Potential for Ethanol

- **Research indicates 30% of current US annual gasoline use could be displaced by ethanol (55B gallons of ethanol)**
- **Maximize the use of ethanol blends**
- **Expand E85 infrastructure**
- **Support research and develop cellulose ethanol production**
- **Provide incentives to replace the entire fleet with flex fuel vehicles**
  - **Flex fuel technology supports the full range of blends from 0 to 85%**

Number of U.S. Stations



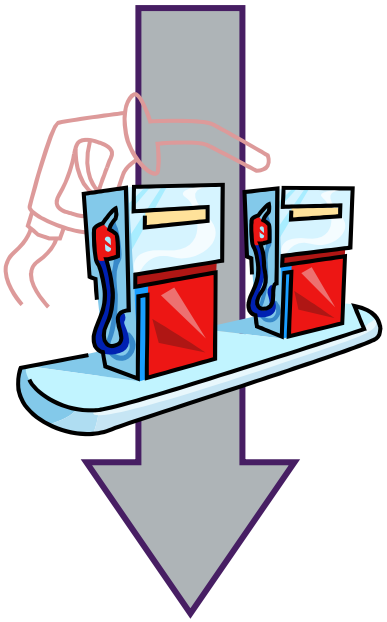
Percent of U.S. Gasoline



Gasoline vs. E85 Energy Content and Vehicle Range

Typical Gasoline Properties:

- **Energy density ~115K BTU/gallon**
- **Regular grade octane 87 (R+M)/2**



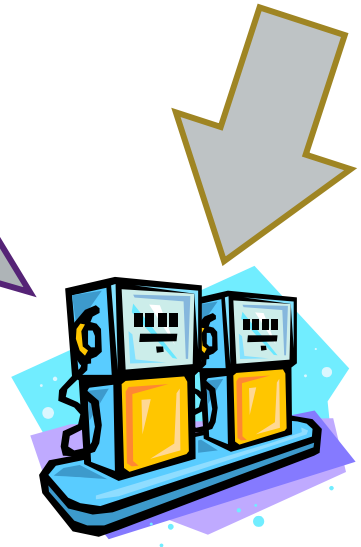
Gasoline fueled MPG and range are higher than E85 by about 25%

- **Slightly better than fuel**

  Δ energy (for normally aspirated S.I.)

Pure Ethanol Properties:

- **Energy density 76K BTU/gallon**
- **Octane – about 100 (R+M)/2**

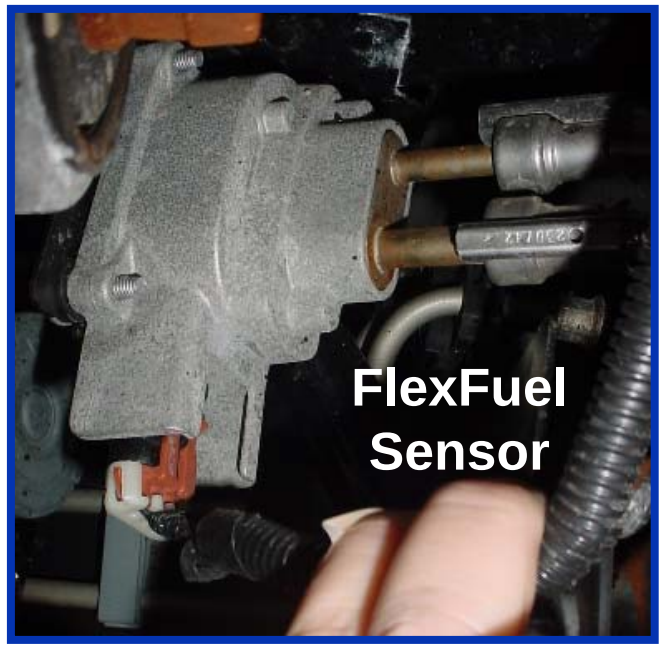


E85 blend properties:

- **Energy density ~83K BTU/gallon**
- **28% lower than gasoline**
- **Regular grade octane 96 (R+M)/2**

E85 FFV Vehicle Content

- **Fuel system materials improved for corrosion resistance**
  - **Pump, level sender, OBD pressure sensor, fuel injectors**
- **Higher fuel pump and injector flow capacity compensates for E85 energy density**
- **Cylinder head and valve materials**
- **Software/calibration to detect fuel blend and optimize operation**
  - **Virtual fuel sensor (software algorithm) identifies blend (or FlexFuel sensor)**
  - **Fueling and spark tailored to fuel characteristic**




Saab
WXE 157

Evolving Emission Picture for FFVs

Today → **Tomorrow**

- Current FFV Evap Certification
  - **Whole vehicle**
  - **Certify on E10 (worst case)**
  - **Standard 0.90 g (CA near-zero)**
    - **E0 evap = 0.36 g**
    - **E85 evap = 0.31 g**

Pictured: 2007 Tahoe LTZ

California PZEV Evap Certification:

- **Fuel system "rig" replaces vehicle**
  - **Standard 0.054 g**
  - **Vehicle non-fuel emissions much greater than standard**
  - **Significant challenge ahead is FFV PZEV**