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Potential for Producing Liquid Fuels from Coal and Biomass

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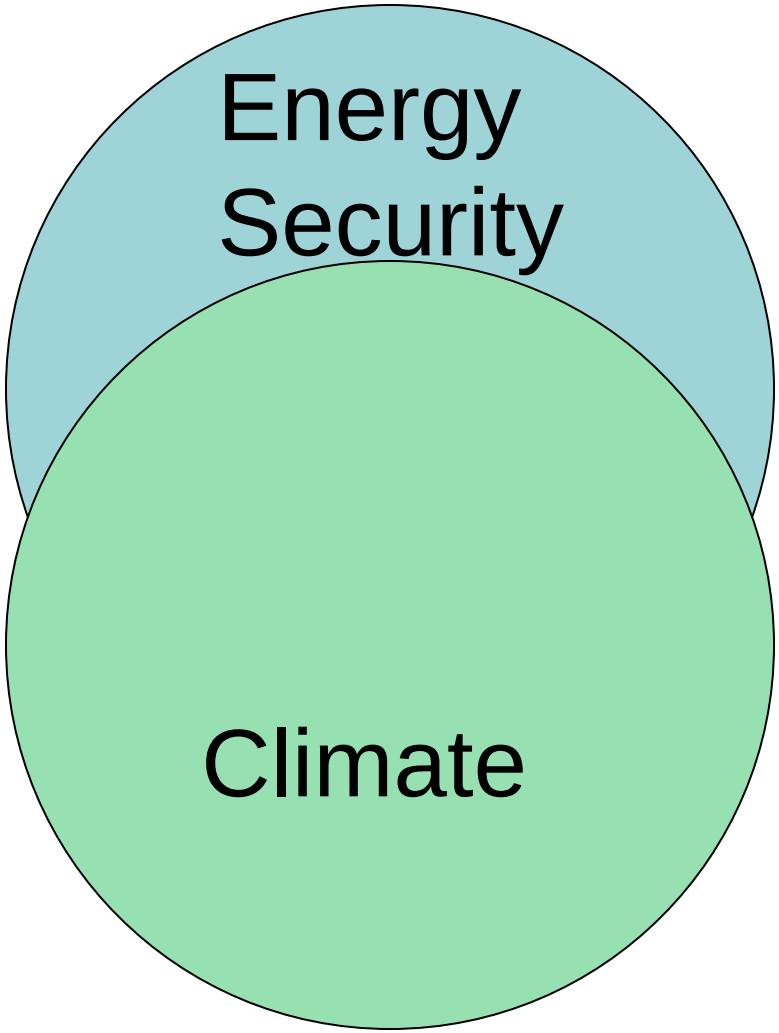
National Energy Objectives

- **Energy security** – we import over 60% of our oil, much of it from sources that are not necessarily friendly, stable, or reliable.
- **Reducing GHG emissions** – climate change and energy policy are inextricably intertwined.

To what extent do the objectives overlap?



Technology	ES	C
Coal with CCS		■
Coal liquids	■	■
PHEV	■	■
Biofuels	■	■
Renewable energy		■
Energy efficiency	■	■
Offshore drilling	■	
Nuclear		■

Coal and Biomass Liquid Fuels

- A 2009 NAS study entitled *Liquid Transportation Fuels from Coal and Biomass* covered these options in detail.
- We are doing work at Purdue on combined coal and liquid fuels using MARKAL, a detailed energy model.

NAS Study Findings

- Technologies for the indirect liquefaction of coal to transportation fuels are commercially deployable today; but without CCS, GHG emissions would be about twice that of petroleum-based fuels.

NAS Study Findings

- Indirect liquefaction of combined coal and biomass to transportation fuels is close to being commercially deployable today. Coal can be combined with biomass at a 60:40 ratio on an energy basis to produce liquid fuels that have GHG emissions comparable with those of petroleum based fuels if CCS is not used, and carbon neutral with CCS,

NAS Quantitative Results

	CTL FT wo CCS	CBTL wo CCS	CTL w CCS	CBTL w CCS
Production (mil gal/yr)	756	151	756	151
Capital cost (bil $)	4.88	1.32	4.95	1.34
Breakeven oil price ($/bbl)	56	93	68	103
Fuel cost ($/gal)	1.50	2.31	1.64	2.52
GHG emissions (kg CO2 eq/gal)	205	118	98	-2.3
Fuel cost w $50/ton CO2	2.58	2.86	2.12	2.41

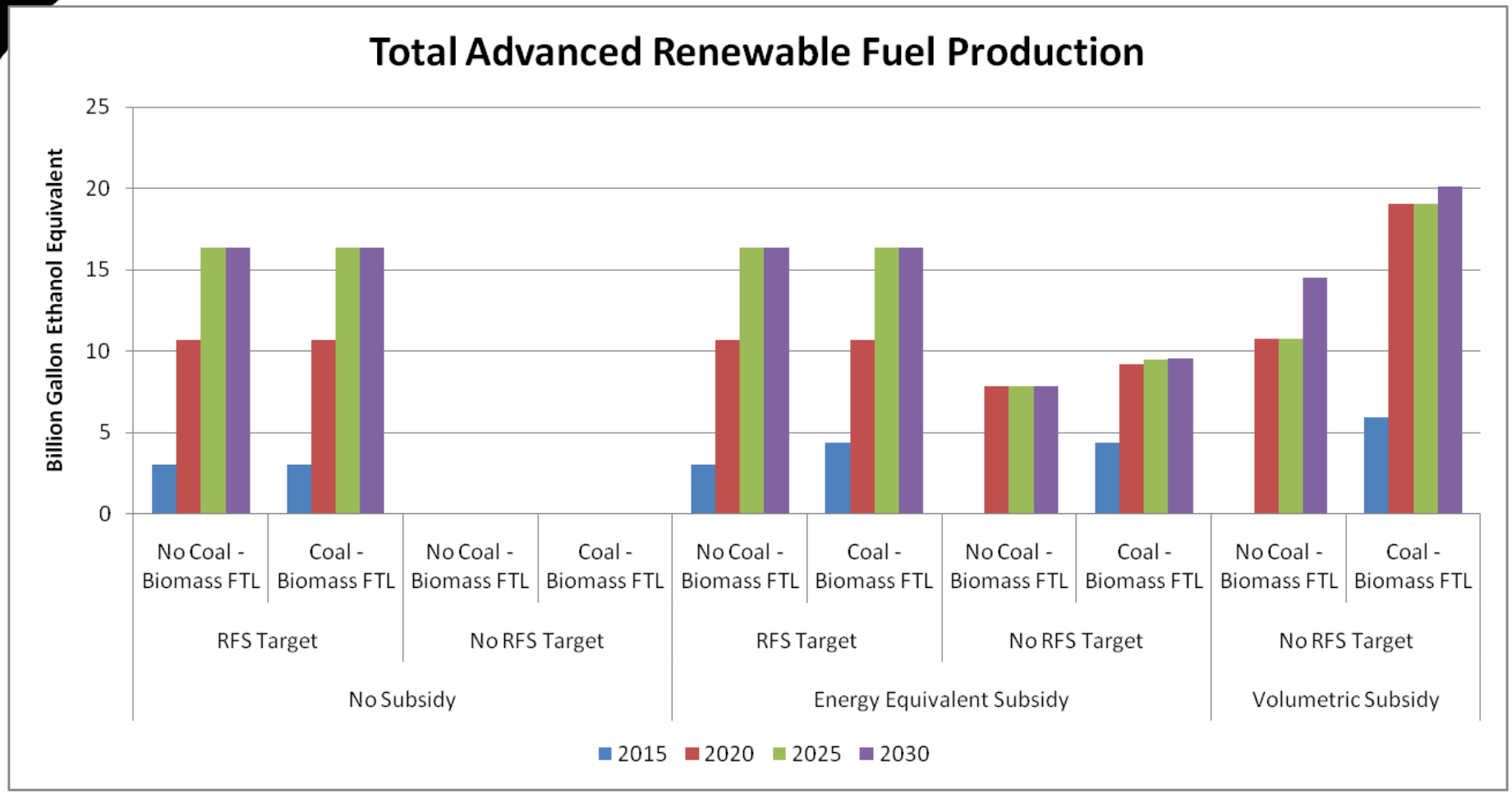
Gasoline wholesale Dec. 7 - $2.31

MARKAL-GTAP Analysis

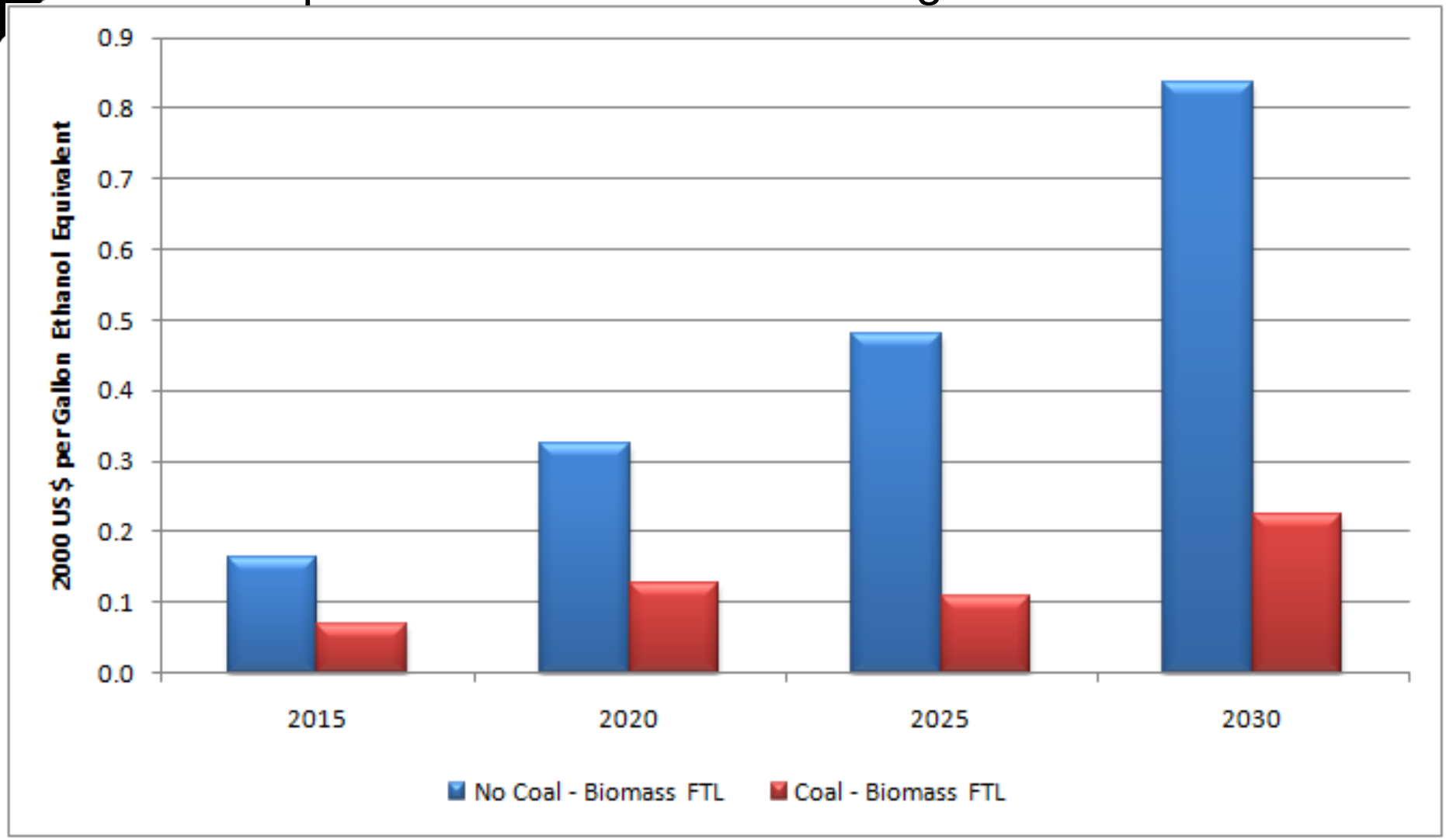
- We are now doing economic and policy analysis using MARKAL and GTAP.
  - MARKAL is a bottom up energy model, with 1000s of energy technologies. Users specify a demand to be met, and the model develops the optimum (least cost) pathway to meet the demand.
  - GTAP is a top down CGE global model that is used for a wide range of policy analyses.

Analytical Procedure

- Essentially we are using GTAP to develop land supply curves for corn ethanol and cellulosic biomass.
- The GTAP land data base has been incorporated in MARKAL so that MARKAL now can be used realistically for economic and policy analysis of biofuels and coal-biomass combinations.
- We now are at the stage of having some preliminary results.


Total Advanced Renewable Fuel Production
Billion Gallon Ethanol Equivalent
25
20
15
10
5
0
No Coal - Biomass FTL
Coal - Biomass FTL
No Coal - Biomass FTL
Coal - Biomass FTL
No Coal - Biomass FTL
Coal - Biomass FTL
No Coal - Biomass FTL
Coal - Biomass FTL
No Coal - Biomass FTL
Coal - Biomass FTL
RFS Target
No RFS Target
RFS Target
No RFS Target
No RFS Target
No Subsidy
Energy Equivalent Subsidy
Volumetric Subsidy
2015
2020
2025
2030

Total system cost increase per gallon ethanol equivalent fuel due to RFS targets



Policy Issues

- There are complicated policy issues:
  - There is a RFS for biofuels but not for CTL.
  - Would need to allocate the portion of total fuel that is from biomass so that could be counted towards the RFS.
  - Similarly, there are subsidies, loan guarantees, and other incentives for biofuels that would not apply to the coal portion.
  - However, there is increasing interest in coal/biomass combinations.

Lugar Energy and Climate Plan

- Increased fuel efficiency standards for both passenger cars and trucks with CH_4 use for trucks encouraged
- Reverse auction for biofuels
- Flex fuel vehicle mandate
- Building energy efficiency standards and incentives
- Appliance energy efficiency standards
- Diverse energy standard – replacing coal with renewables, nuclear, and coal with CCS and using market trading mechanisms
- Retire inefficient coal plants
- Loan guarantees for nuclear power
- Mandatory measurement of progress

Thank you!
Questions and Comments

For more information:

http://www.ces.purdue.edu/bioenergy

http://www.agecon.purdue.edu/directory/details.asp?username=wtyner