A Low-Carbon Fuel Standard for the Northeast:
Inputs, Impacts and Policy Considerations

NESCAUM / NESCCAF

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What is a Low-Carbon Fuel Standard?

- Performance-based standard regulating “carbon intensity” or lifecycle carbon emissions from fuels
- Requires displacement of “high” carbon fuels with less carbon intense alternatives such as:
  - low carbon biofuels
  - electricity generated with renewable sources
  - hydrogen produced from renewable sources
- Penalizes carbon intensive fuels such as:
  - petroleum derived from tar sands
  - fuel derived from coal gasification
  - hydrogen derived from tar sands or coal gasification
  - electricity derived from carbon intensive processes

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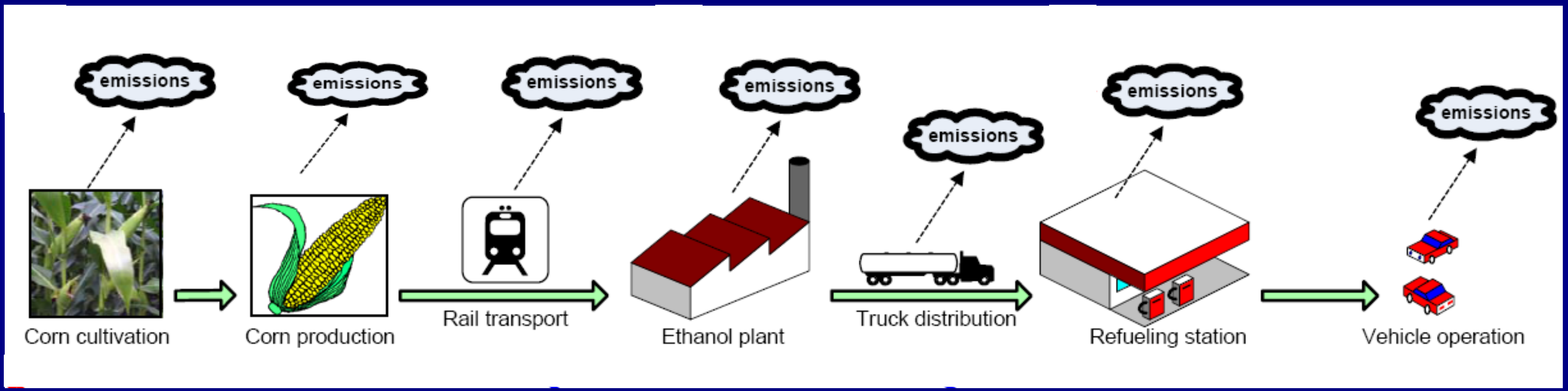
What is a Low-Carbon Fuel Standard? (continued)

- Requires reductions in carbon intensity from today's gasoline and diesel
- Based on lifecycle GHG accounting for gasoline, diesel, biofuels, unconventional fuels, and low carbon alternatives
- Heating oil could be included
- NOT A CAP ON TRANSPORTATION FUEL-RELATED EMISSIONS

Carbon Intensity (CI)

- A measure of the total CO_2-equivalent emissions produced throughout a fuel's **lifecycle**



(Source: Guihua Wang and Mark Delucchi, 2005. "Pathway Diagrams". Appendix X to the Report "*A Lifecycle Emissions Model (LEM): Lifecycle Emissions from Transportation Fuels, Motor Vehicles, Transportation Modes, Electricity Use, Heating and Cooking Fuels, and Materials." http://www.its.ucdavis.edu/publications/2003/UCD-ITS-RR-03-17X.pdf)*

- Measured in grams of CO2-equivalent GHG emissions per energy-unit of fuel

gCO_2e/MJ

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CI Values for Selected NE Fuel Pathways (*Draft Results*):

Pathway	Carbon Intensity (gCO2e/MJ)
Conventional Gasoline	**92.7**
Reformulated Gasoline Blendstock (RBOB)	**96.7**
Oilsand RBOB	**108**
Ultra-Low-Sulfur Diesel (ULSD)	**93**
Oilsand ULSD	**105**
Denatured Corn Ethanol	**72.6 ***
Soy Biodiesel	**35.1 ***
Forest-residue Ethanol: (Fermentation)	**-1.7 ****
Forest-residue Ethanol: (Gasification)	**11.5 ****

**Does not include effects of land-use change*

***Includes new forest growth*

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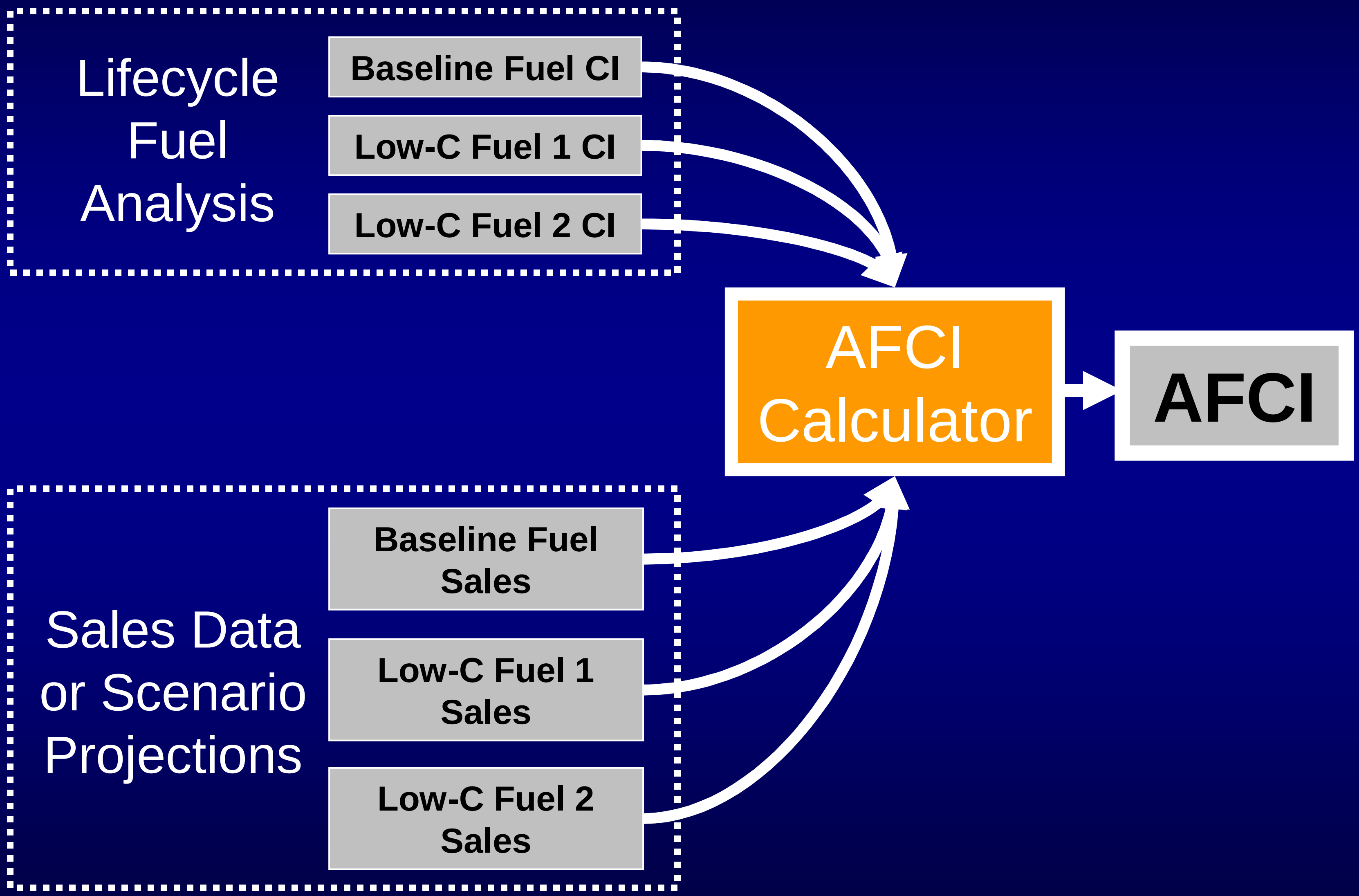
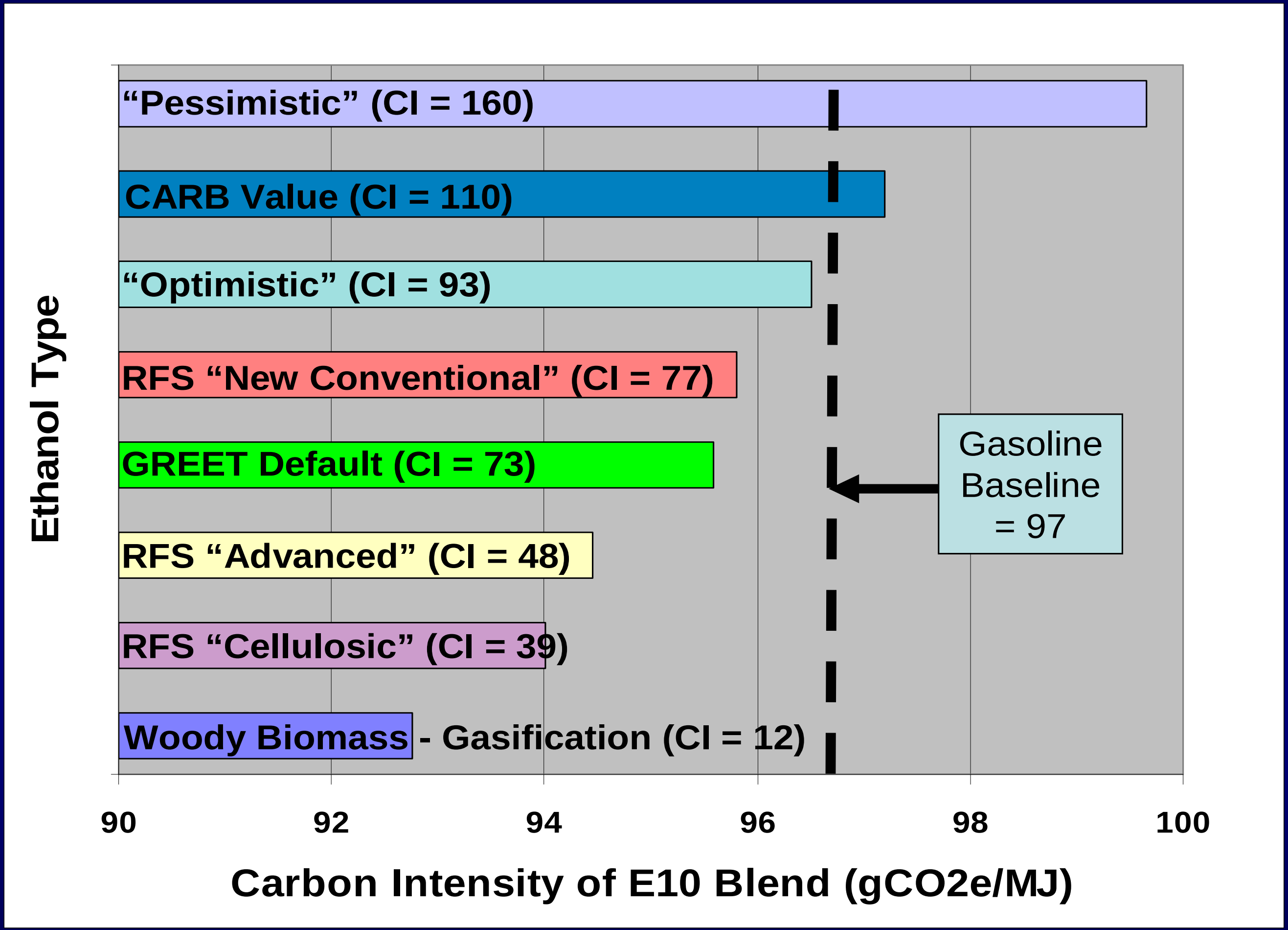
Average Fuel Carbon Intensity (AFCI):



Effect of Ethanol CI on Gasoline AFCI: E10 (Draft Results)



Assumes 10% ethanol by volume in all gasoline, and no other fuels contribute to gasoline AFCI

"Optimistic" and "Pessimistic" estimates of land-use change based on CARB's 10-16-08 presentation "Life Cycle Analysis and Land Use Effects" (www.arb.ca.gov/fuels/lcfs/101608lcfsluc_prstn.pdf).

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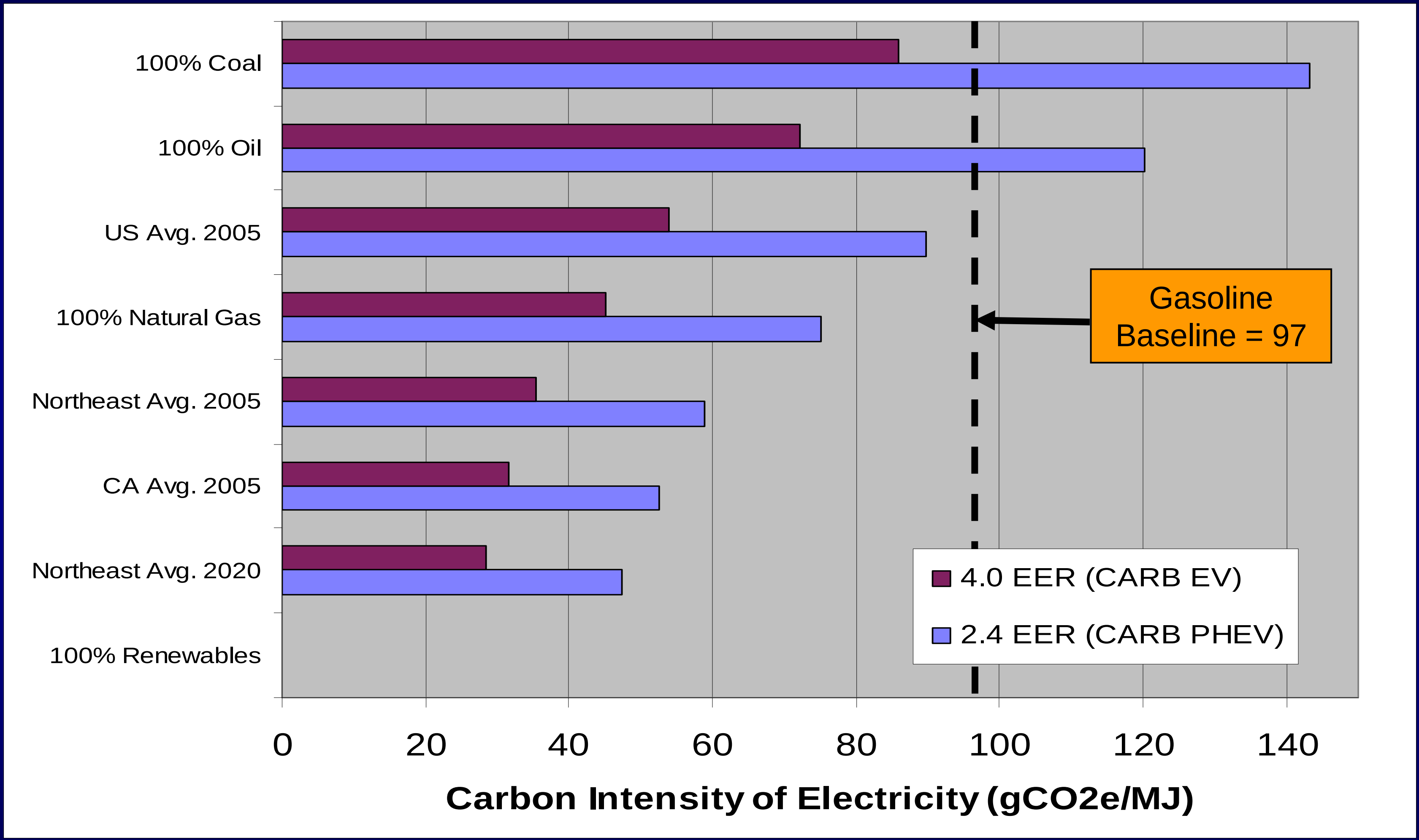
Effect of Grid Resource Mix on Electricity CI (Draft Results)



US & CA technology shards based on GREET default; Northeast technology shares based on MARKAL

	Oil	NG	Coal	Nuke	Bio	Other
US Avg	3%	19%	51%	19%	1%	8%
CA Avg	1%	41%	15%	19%	2%	23%
NE 2005	10%	31%	16%	31%	0%	12%
NE 2020	4%	41%	8%	18%	2%	27%

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Example Compliance Scenarios:

- The following scenarios are *illustrative purposes only.*
- Illustrate the AFCI impacts of various sets of assumptions.
- NESCAUM / NESCCAF is not advocating for any one or group of fuels or fuel pathways.
- LCFS is intended to promote competition, not dictate specific fuel choices

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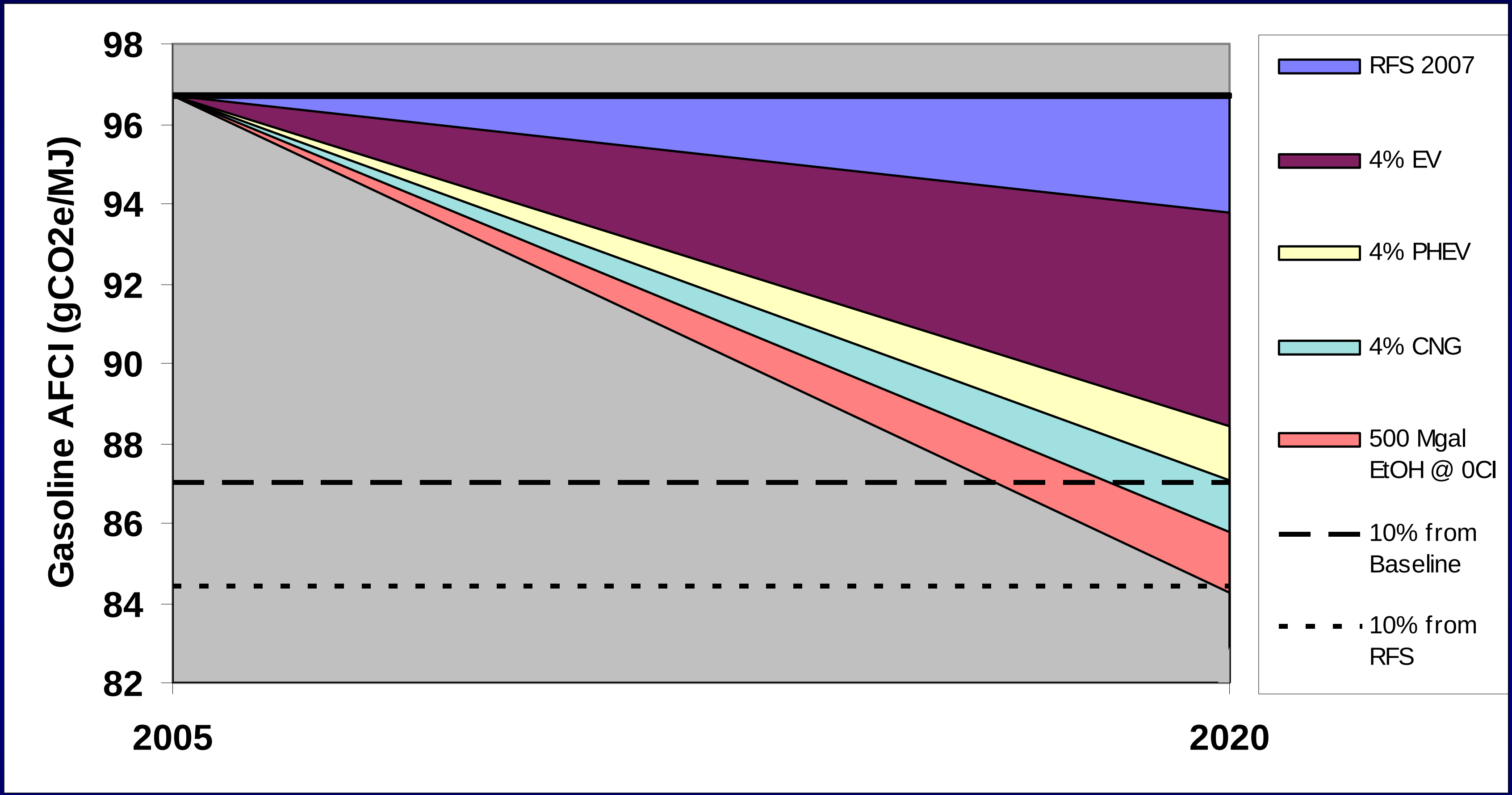
Example Compliance Scenario (Draft Results): 100% Renewables for EV and PHEV



Assumptions:

- **EER = 4.1**
- **4% fleet penetration in 2020; new vehicle sales increase linearly from 1.2% in 2011 to 12% in 2020.**
- **CI values (gCO2e/MJ): Electricity for BEVs and PHEVs: 0; CNG: 73.1; FR-F EtOH = 0**

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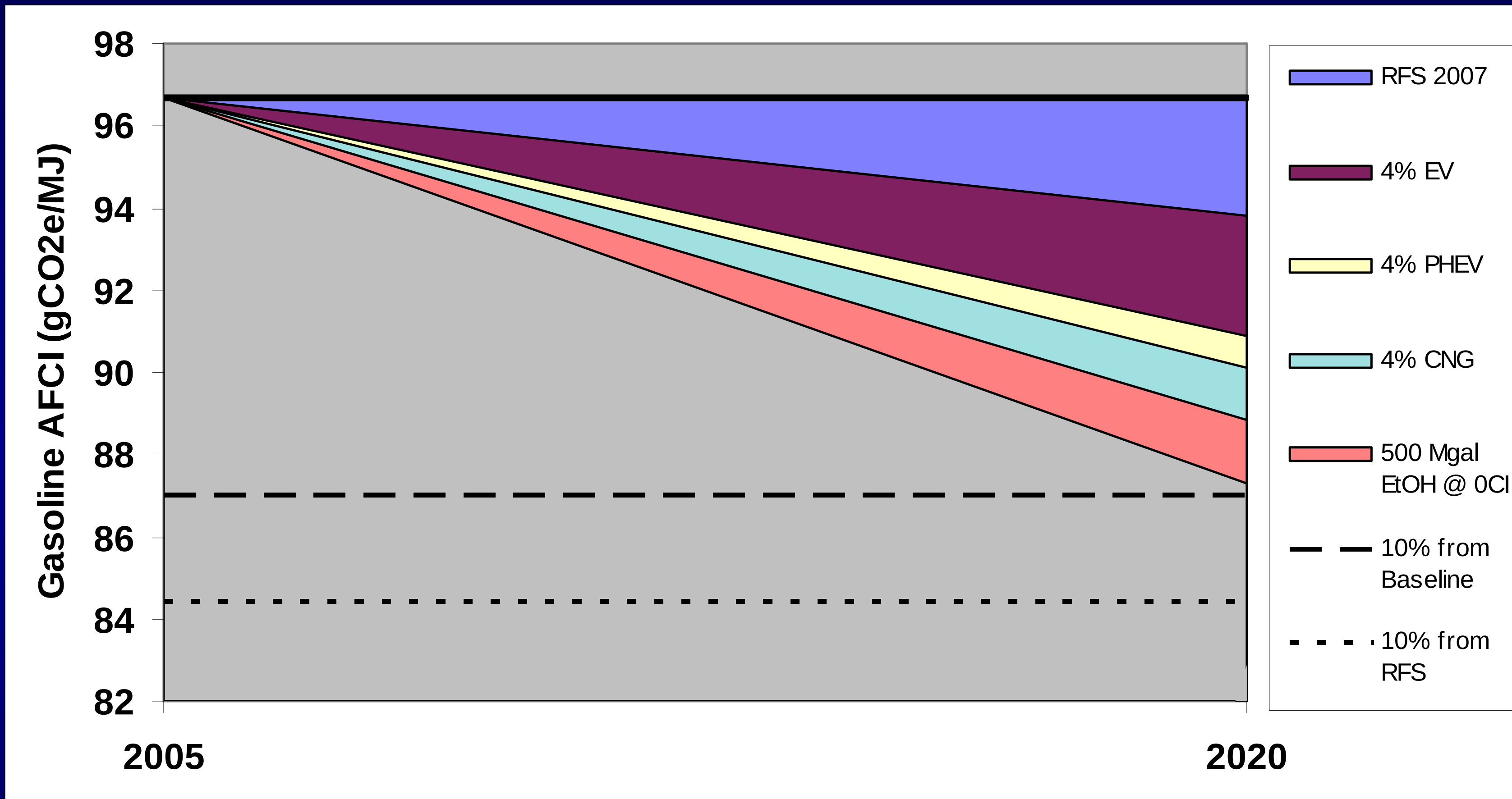
Example Compliance Scenario (Draft Results): 100% NG Electricity for EV and PHEV



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- **EER = 4.1**
- **4% fleet penetration in 2020; new vehicle sales increase linearly from 1.2% in 2011 to 12% in 2020.**
- **CI values (gCO2e/MJ): Electricity for BEVs and PHEVs: 44; CNG: 73.1; EtOH = 0**

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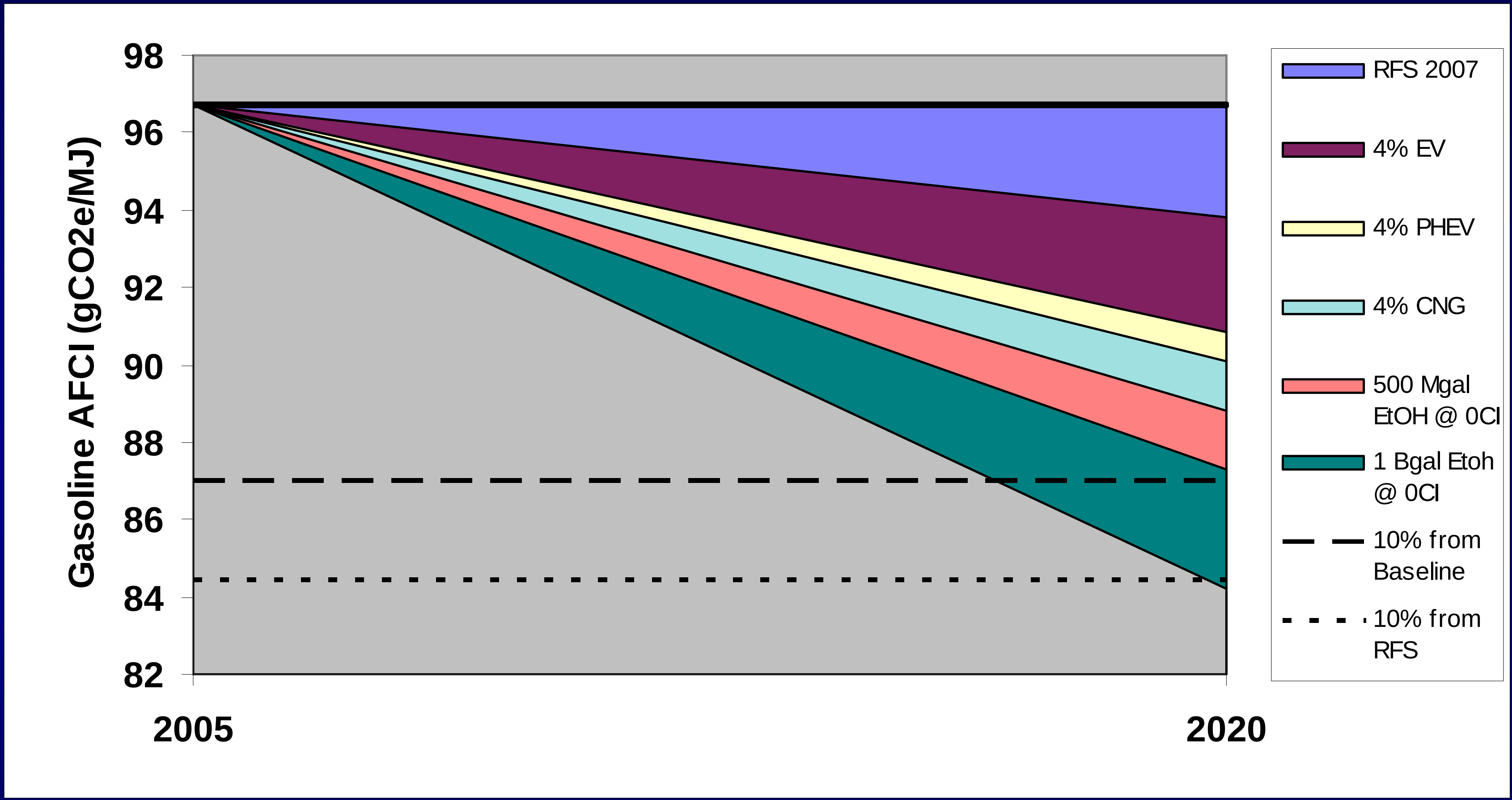
Example Compliance Scenario (Draft Results): 100% NG Electricity for EV and PHEV



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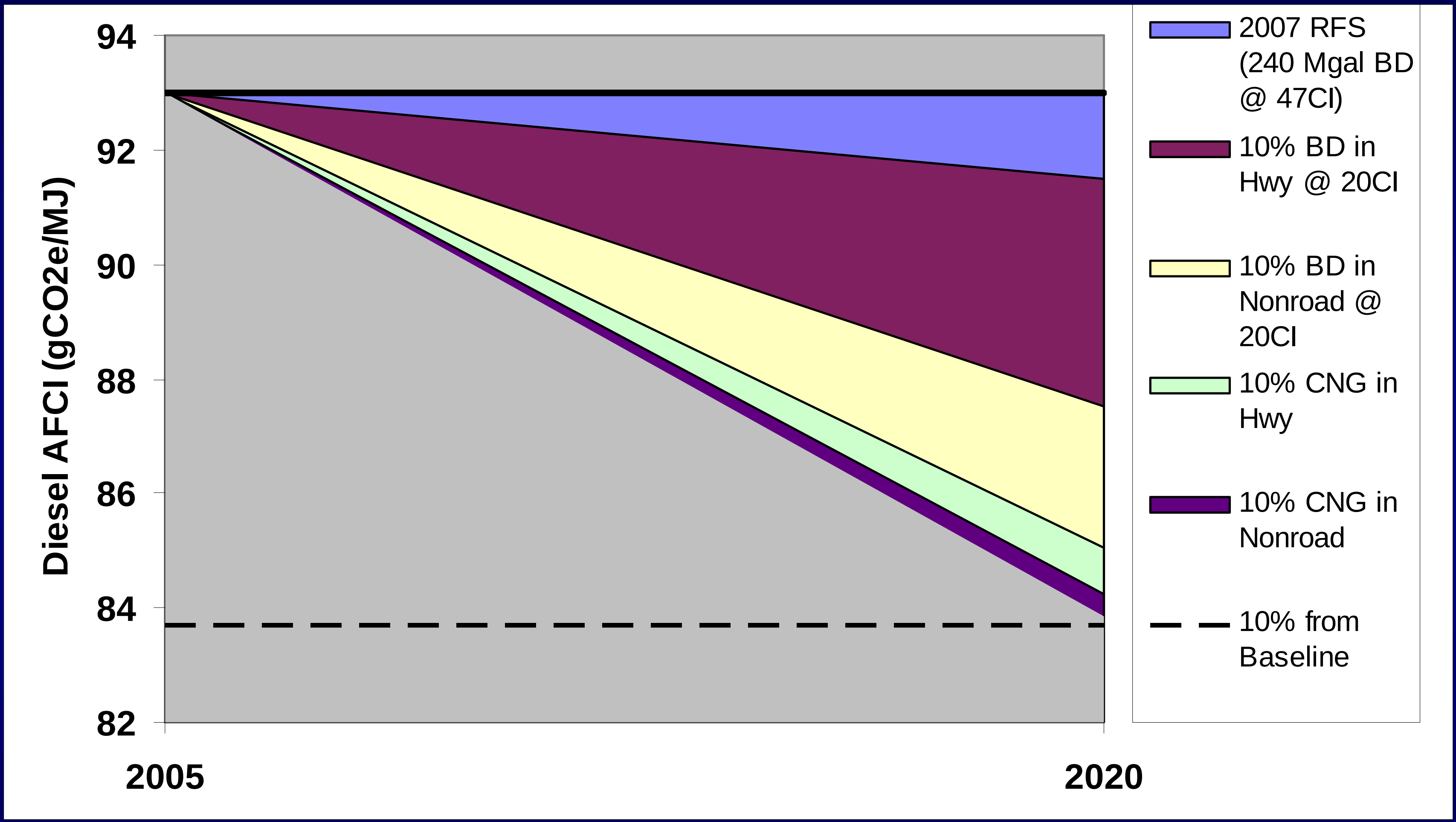
Example Compliance Scenario: Diesel AFCI (Draft Results)



- Baseline includes highway and nonroad diesel only.
- RFS: 240Mgal BD in 2020; 50% CI reduction compared to ULSD.
- 10% BD in highway diesel = 410 Mgal, displacing 380 Mgal in 2020
- 10% BD in noroad diesel = 250 Mgal, displacing 230 Mgal diesel in 2020
- 10% CNG in highway diesel = 52 quadrillion BTU, displacing 380 Mgal diesel in 2020
- 10% CNG in nonroad diesel = 24 quadrillion BTU, displacing 170 Mgal diesel in 2020

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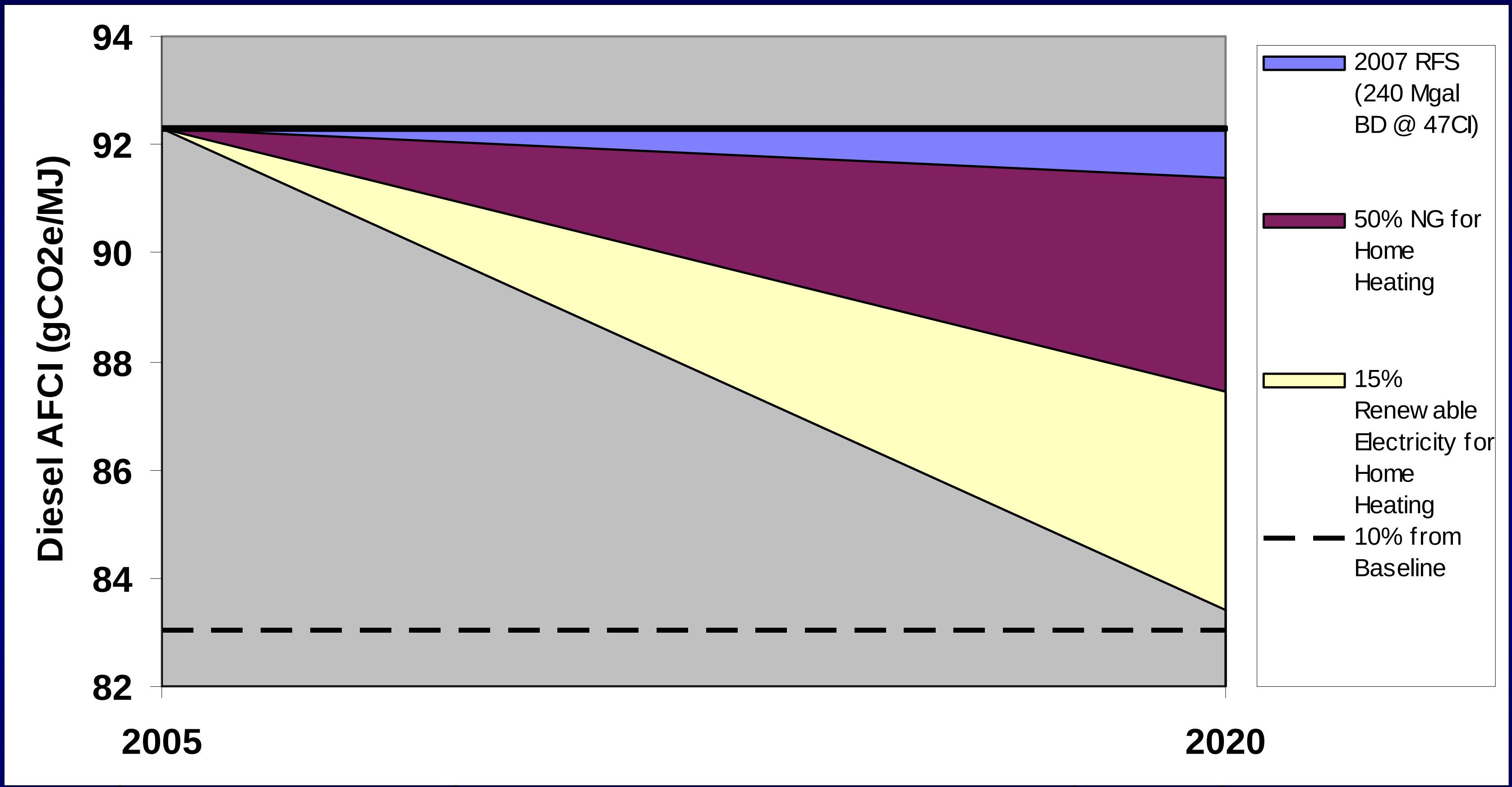
Example Compliance Scenario: Diesel AFCI (Draft Results)



- Baseline includes highway, nonroad and home heating distillate fuels.
- 1.64 Bgal distillate oil displaced by 212 quadrillion BTUs of NG
- 530 Mgal distillate oil displaced by 17000 GWH renewable electricity

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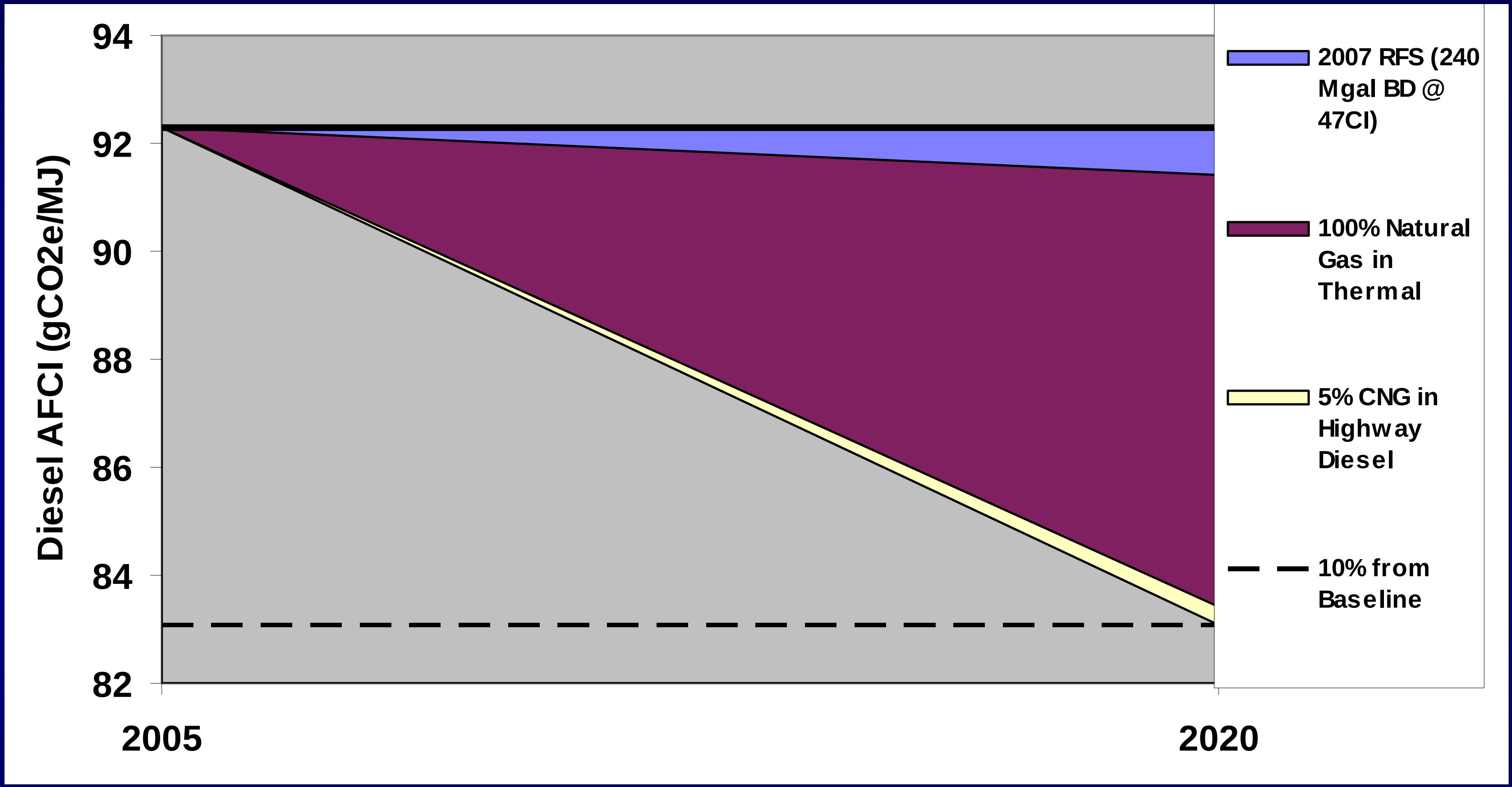
Example Compliance Scenario: Diesel AFCI (Draft Results)



- Baseline includes highway, nonroad and home heating distillate fuels.
- 3.5 Bgal distillate oil displaced by 430 quadrillion BTU of NG
- 200 Mgal highway diesel displaced by 25 quadrillion BTU of CNG

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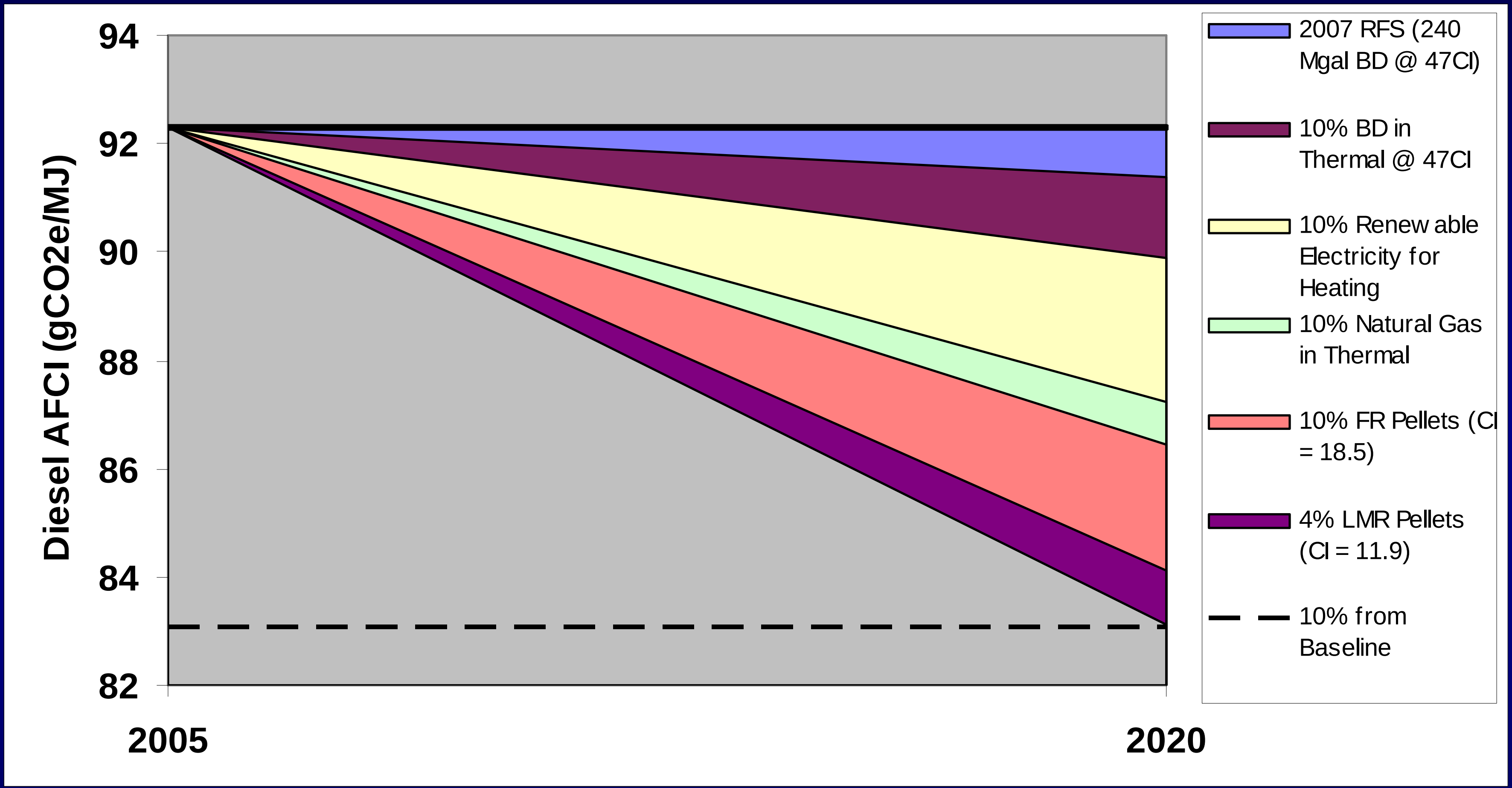
Example Compliance Scenario: Diesel AFCI (Draft Results)



- Baseline includes highway, nonroad and home heating distillate fuels.
- 350 Mgal distillate oil displaced by 380 Mgal biodiesel @ CI = 47 gCO2e/MJ
- 350 Mgal distillate oil displaced by 11000 GWh renewable electricity @ CI = 0 gCO2e/MJ
- 350 Mgal distillate oil displaced by 43 quadrillion BTU of NG @ CI = 71 gCO2e/MJ
- 350 Mgal distillate oil displaced by 3.1 million tons FR pellets @ CI = 18.5 gCO2e/MJ
- 130 Mgal distillate oil displaced by 1.3 million tons LMR pellets @ CI = 11.9gCO2e/MJ

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Potential Supply of Low Carbon Fuels from the Northeast

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Incorporating Land Use Change (LUC) into GHG Lifecycle Analysis

Direct LUC emissions can be measured and incorporated in modeling:

- Measure changes in soil C
- Measure changes in above-ground C (trees)
- Measure changes in other GHG emissions
- Account for GHG emissions from harvesting, processing

Indirect LUC emissions are difficult to estimate, almost impossible to measure directly:

- Food, ag and forestry products are globally traded commodities
- Not easy to assign changes in land use to any one factor
- To address concerns over indirect LUC, EU is developing sustainability standards, modifying their Renewable Energy Directive

Woody biomass can be carbon-neutral, but it needs to be sustainably managed to maintain the C stock over time.

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Our Approach to Low Carbon Fuel Supply Analysis

- Because of the concerns about indirect GHG emissions, we considered only those regional biomass resources that are most likely to avoid inducing additional land use change:
  - Regionally available and measurable
  - Supply that is incremental to that which serves current markets
  - Waste resources (e.g., oils, MSW)
- Because fuel and energy technologies are undergoing major transformation, we estimated quantities of low carbon fuels assuming that:
  - In the near-term (2010-2015), existing fuel technologies (e.g., biomass electric) dominate production;
  - Over the longer-term (by 2020), developing technologies and fuels (e.g., cellulosic EtOH) come into play.
- We weren't able to conduct a formal sustainability analysis (e.g., impacts on C sequestration, biodiversity, water quality, etc.); instead we made relatively conservative assumptions about maximum versus likely biomass supply.

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Estimated Maximum Woody Biomass

State	Dry Ton Equivalent	Area (Land) Sq. Miles	Dry Tons / Sq. Mile
Connecticut	1,072,000	4,844	221
Massachusetts	1,698,000	7,80	217
Rhode Island	193,000	1,045	185
Vermont	2,488,000	9,250	269
Maine	2,288,000	30,862	74
New Hampshire	2,761,000	8,968	308
New York	12,561,000	47,213	266
New Jersey	1,980,000	7,417	267
Pennsylvania	11,689,000	44,816	261

Maximum is 33 to 37 million dry tons.

Conservative estimate of 8 to 9 million dry tons “likely available”.

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Estimates of Waste-Based Biomass

Biomass Category	Units	Biomass Quantity	
		2010	2020
MSW (Yard Waste, Paper, Food Scraps, Wood)	tons	20,390,809	20,978,928
Used Cooking Oil		62,049	63,552
Livestock Waste		5,215,063	5,355,422
WWTF Biosolids		725,208	742,761
Total	**tons**	**33,568,794**	**34,458,118**
WWTF Biogas	cubic feet	27,892,590	28,567,719
Total Electricity Potential	**MW**	**471**	**484**
Total Biodiesel Potential- B5 (from used cooking oil)	**million gallons**	**42**	**46**

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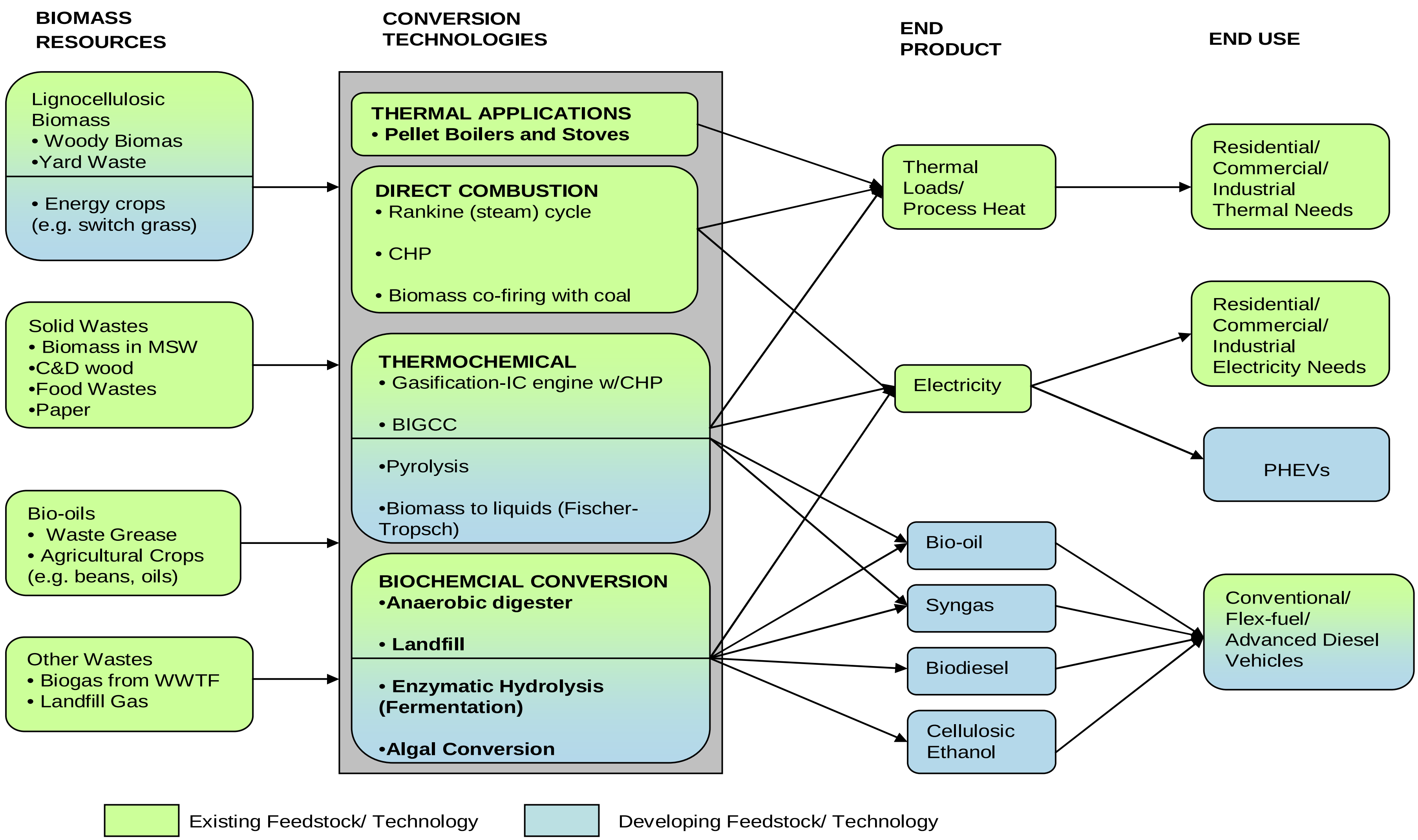
Existing and Developing Fuel Conversion Technologies



Estimated Low Carbon Fuel Production from NE Feedstocks

Resource	2010			2020		
	Electricity Generation (MW)	Thermal Uses (No. of Homes)	Liquid Fuels (million gallons)	Electricity Generation (MW)	Thermal Uses (No. of Homes)	Liquid Fuels (million gallons)
Woody and Ag. Biomass	368	400,000	--	1,000	970,000	315
	40	--	--	40	--	124
Waste-based Resources	471	-- --	42	484		46
TOTALS	879 MW	400,000 homes	42 (B5)	1,524 MW	970,000 homes	439 (Cell EtOH) 46 (B5)

Electricity for Plug-in Hybrids (PHEVs)

- PHEVs are far more efficient than ICE vehicles
- PHEVs are an emerging technology; how consumers might use them is unknown
- Preliminary results suggest timing matters—if charging takes advantage of existing capacity, little incremental capacity will be needed
- Theoretically, PHEVS can be used to enable intermittent renewables (“RE-following”) and provide power TO the grid (V2G) for peaking and back-up power
- Smart metering would benefit PHEV deployment

Chris Yang and PHEV. Source: Chris Yang and Ryan McCarthy, “Carbon Emissions and Grid Impacts of of Using Electricity to Charge PHEVs in California” presentation to Plug-In 2008 Conference, San Jose, CA, July, 2008. http://steps.ucdavis.edu/research/Thread_2/fuels_electricity/3B_Yang_UCD-PHEV-Final.ppt/view

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Key Insights on Low Carbon Fuel Supply Analysis

- Waste-based biomass (MSW, waste oils, ag and WW solids) is the Northeast's most significant resource for low carbon fuel production, and one most likely to avoid LUC-related emissions;
- New York and Pennsylvania dominate the available supply of ag and forestry feedstocks; New England has substantial woody biomass but also many existing markets (e.g., pulp and paper);
- In the near-term, fuel production will continue to rely on current technologies and focus on electricity production and thermal applications.

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Key Insights on Low Carbon Fuel Supply Analysis

- Electricity is probably the most viable low carbon fuel for transportation in the near-term;
- Over longer-run, developing fuel technologies and advanced biofuels will come into play, but there are large uncertainties over the potential for liquid fuel production in region.
- The Northeast can be a significant producer of low carbon fuels, but states should be proactive in addressing sustainability issues (especially forest health, air emissions, and water demand) within LCFS framework.

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Regional Initiative

- June 2008, Governor Patrick sent a letter to all 10 RGGI state governors inviting them to participate
- November 2008, Commissioner Burt circulated a LOI for environmental commissioner to sign
- MN, WA and Quebec/ECP have been invited as observers
- Held state briefing at Yale University in October 2008
- Conference call briefing in November 2008
- Regular monthly calls
- Goal is to have an MOU by December 31, 2009

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