Potential Supply of Low Carbon Fuels from the Northeast

Michelle Manion and Allison Reilly
Climate and Energy Team

mmanion@nescaum.org *areilly@nescaum.org;*

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Presentation Overview

- Background on Land Use and Fuels
- Our Approach to LCF Supply Analysis:
  - Biomass Supply Analysis
  - Technology Assumptions
  - Electricity
- Estimates of Low Carbon Fuels
- Key Implications and Issues

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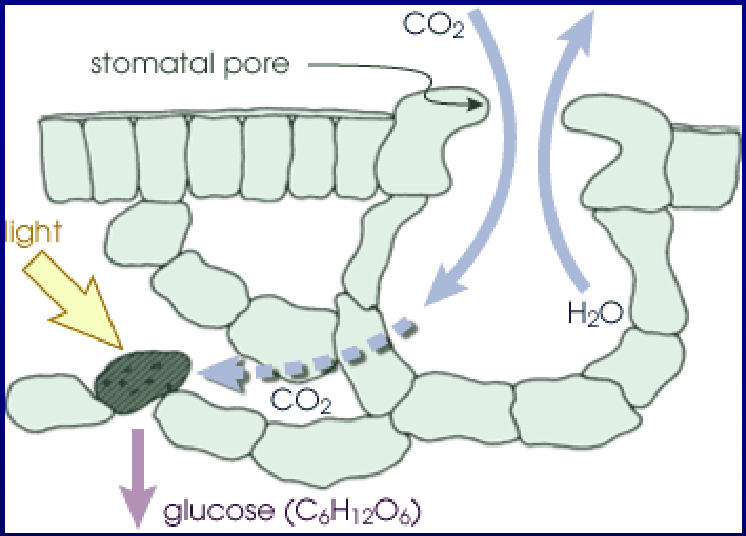
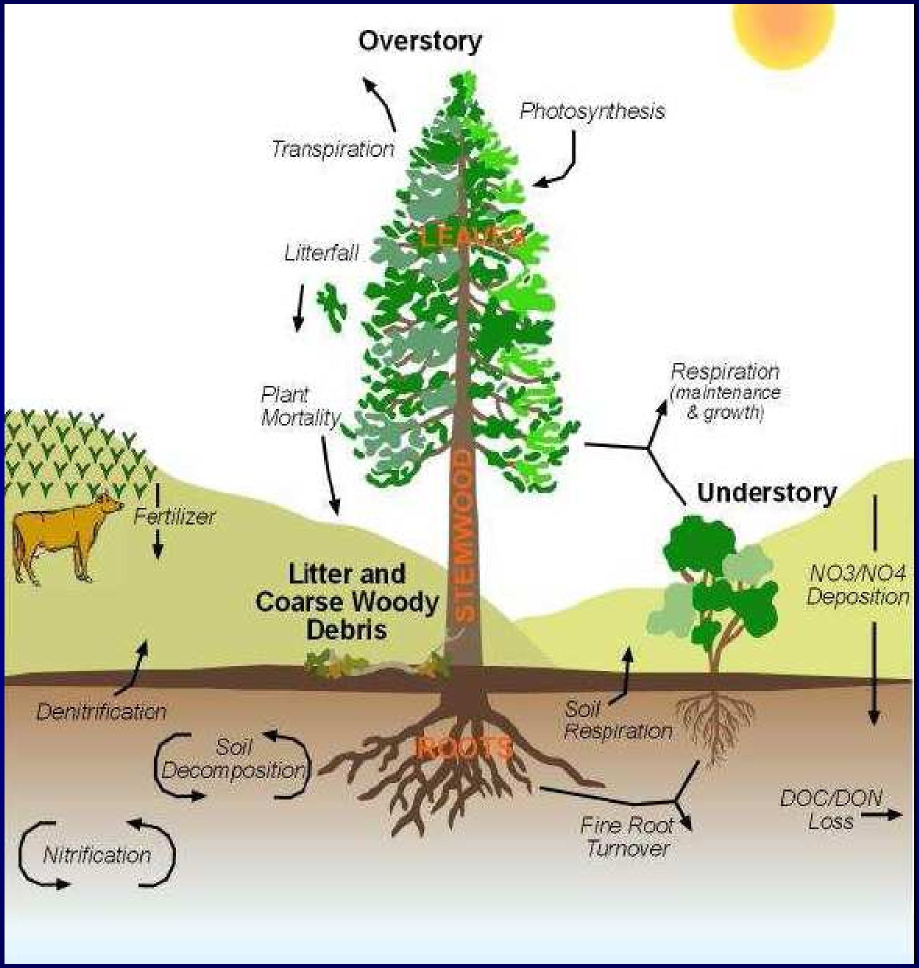
How Do Biofuels Mitigate GHGs?

- Terrestrial Carbon Cycle, i.e. "the Miracle of Photosynthesis"



Source: NASA



Source: Univ. of California, Santa Barbara

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

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Recent Science on Indirect LUC Suggests A Precautionary Approach

Grams of GHG emissions (CO_2 equiv.) per MJ (Source: Searchinger *et al.*)

Source of Fuel*	Making Feed-stock	Refining Fuel	Vehicle Operation (Burning Fuel)	Net Land Use Effects: Feedstock Uptake from Atmosphere (GREET)	Net Land Use Effects: Land Use Change	Total GHGs*	% Change in Net GHGs vs. Gasoline
Gasoline	**+4**	**+15**	**+72**	**0**		**+92**	
Corn Ethanol (GREET)	**+24**	**+40**	**+71**	**-62**	–	**+74** **+135** without feedstock credit	-20% **+47%** without feedstock credit
Corn Ethanol + Land Use Change	**+24**	**+40**	**+71**	**-62**	**+104**	**+177**	**+93%**
Biomass Ethanol (GREET)	**+10**	**+9**	**+71**	**-62**	–	**+27**	-70%
Biomass Ethanol + Land Use Change	**+10**	**+9**	**+71**	**-62**	**+111**	**+138**	**+50%**

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 <u>maximum</u> versus <u>likely</u> biomass supply.

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Key Assumptions and Methods: Woody and Ag. Biomass Estimates

- Estimates of supply based on INRS analysis of county-level data from USDA Forest Service, Dept. of Energy, and state and private data sources.
- From the county-level data, INRS subtracted some portion to account for:
  - Existing woody biomass markets
  - Legal restrictions on resource availability (e.g., National Forest ownership)
  - Other county-level factors
- We conservatively assume only a fraction (10% to 40%) of the maximum estimated of each category of woody/ag biomass is likely to be available to the market, due to a variety of economic and environmental factors.

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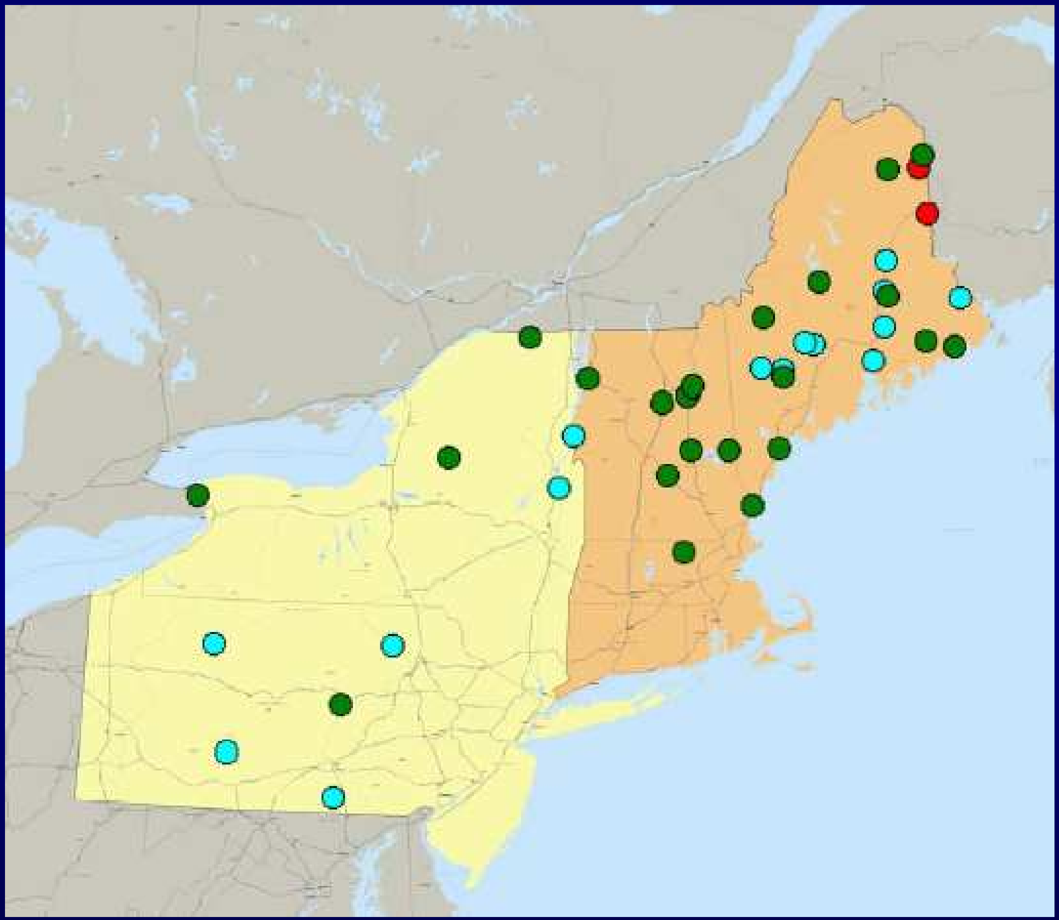
Considering Current Biomass Demand: Existing Biomass Facilities in the Northeast



Type of Facility:

- **Pulp Mills**
- **Biomass Electric Plants**
- **Oriented Strand Board Plants**

Source: INRS, 2007.

Existing biomass markets use 28 million green tons per year of low-grade wood.

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Estimated Maximum Woody Biomass, By State

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; we conservatively estimate "likely availability" to be 8 to 9 million dry tons. Note that NY and PA combine for approximately two-thirds of total supply.

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Estimates of Agricultural Biomass

- Key agricultural resources for our region include:
  - Agricultural residues from food crops; and
  - Energy crops (e.g., switchgrass and short-rotation woody crops)
- Ag-based resources are not nearly as plentiful in our region as woody biomass (i.e., approximately 10 percent of total forest-based resources).
- Estimates range from a maximum availability of 3.6 to 6.8 million dry tons, which means likely availability of 0.5 to 1 million dry tons.
- NY and PA dominate again—approximately 75 to 90 percent of agricultural biomass resources are concentrated in these two states.

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Key Assumptions and Methods: Waste-based Biomass Estimates

U.S. Census population projections used to determine waste (by type) per person & forecast years 2010 - 2020

- 2005 MSW averages by state estimated from Biocycle, 2004, and state data from years 2005 and 2006 and EPA Waste Characterization Percentages (2006) applied
- Used cooking oils retrieved from Northeast Regional Biomass Program database
- Livestock waste calculated using U.S. Census data (2007/2008) and USDA assumptions regarding waste per animal (by type)
- WWTF biosolids and biogas per person estimates taken from EPA CHP partnership (2007).

Counted only 50% of potential biowaste- assumed remainder was candidate for source reduction/recycling--due to competing markets, we include only 25% of corrugated cardboard and office paper and only 10% of waste oils.

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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	tons	62,049	63,552
Livestock Waste	tons	5,215,063	5,355,422
WWTF Biosolids	tons	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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Biomass Conversion Technologies

- Energy and fuel technologies are currently undergoing significant RD&D and rapid transformation.
- Given rate of anticipated technological innovation, we assumed that:
  - Existing, commercially viable technologies (e.g., biomass electricity plants/co-firing, wood pellet boilers) dominate regional production of low carbon fuels in the near-term (~up to 2015).
  - Developing technologies (e.g., gasification) will be commercially relevant by 2020.

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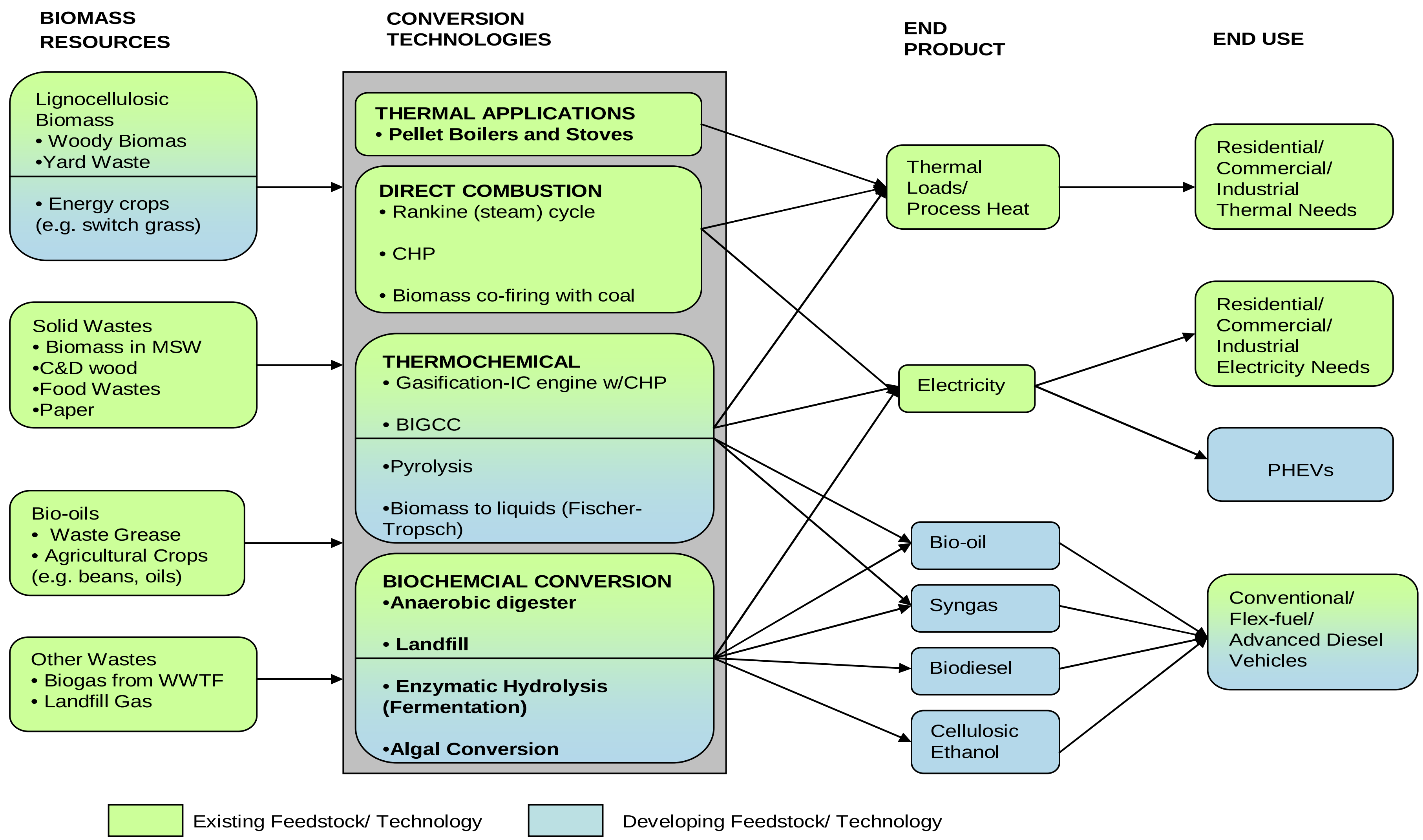
Existing and Developing Fuel Conversion Technologies



Estimated Low Carbon Fuel Production, 2010 and 2020

- *Estimates are under revision…*

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Electricity for PHEVs: Preliminary Findings

- Plug-in hybrid vehicles are intriguing because of the efficiency with which they use their fuel (electricity);
- PHEVs are a rapidly developing technology, so we have little empirical knowledge of how consumers will use them;
- Due to uncertainty, we did a boundary analysis to explore the range of possible impacts of PHEV use on electricity and GHGs:
  - Assumed PHEVs penetrate the market at very low and high levels over 2010 to 2020
  - Assumed PHEVs with 20- and 40-mi. ranges, plugged in at different times (e.g., 9am, 5pm, midnight) and for varying duration (e.g., 2, 4, 6 hours)
- Preliminary results suggest timing matters—if charging takes advantage of existing capacity, little incremental generation capacity will be needed
- GHG intensity of electricity should decline due to RPSs and EE investments; CO_2 capped by RGGI regardless

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Key Insights on Low Carbon Fuel Supply Analysis (1)

- 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 (2)

- 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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