Carbon-negative renewable distillate fuel in New York State

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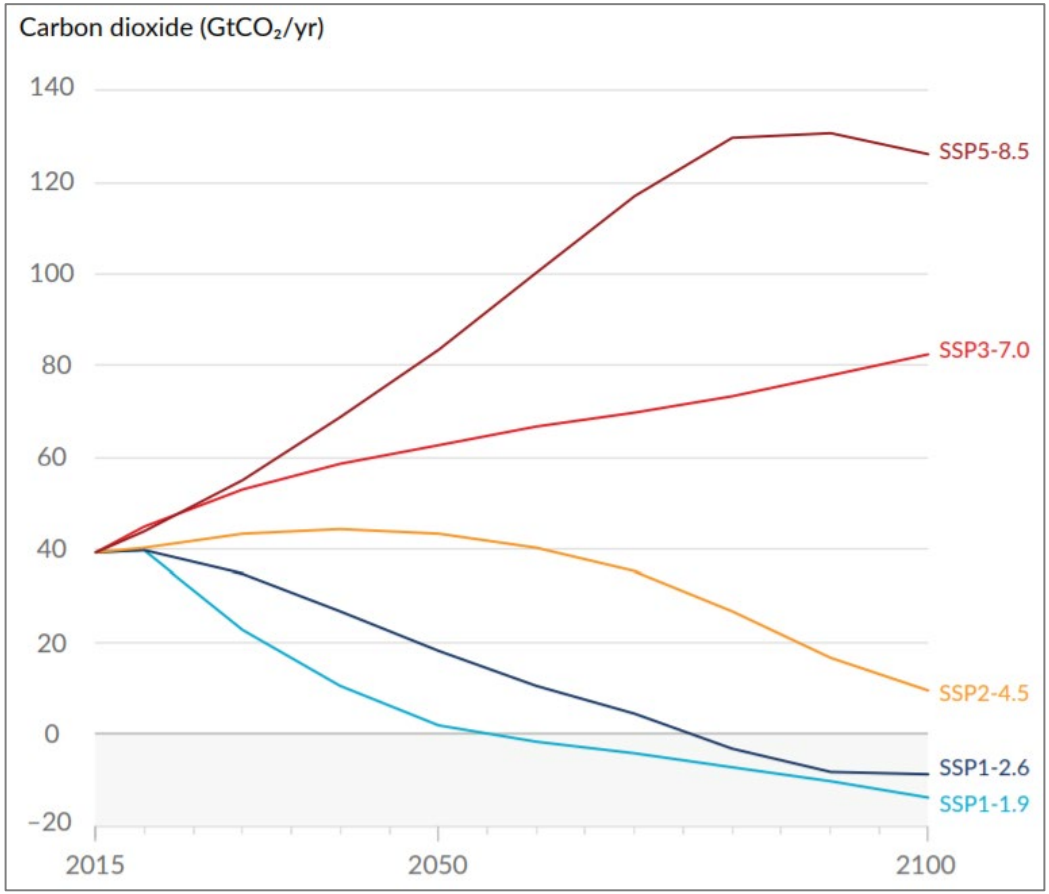
The critical role of CO2 removal

Global emissions thresholds and warming targets

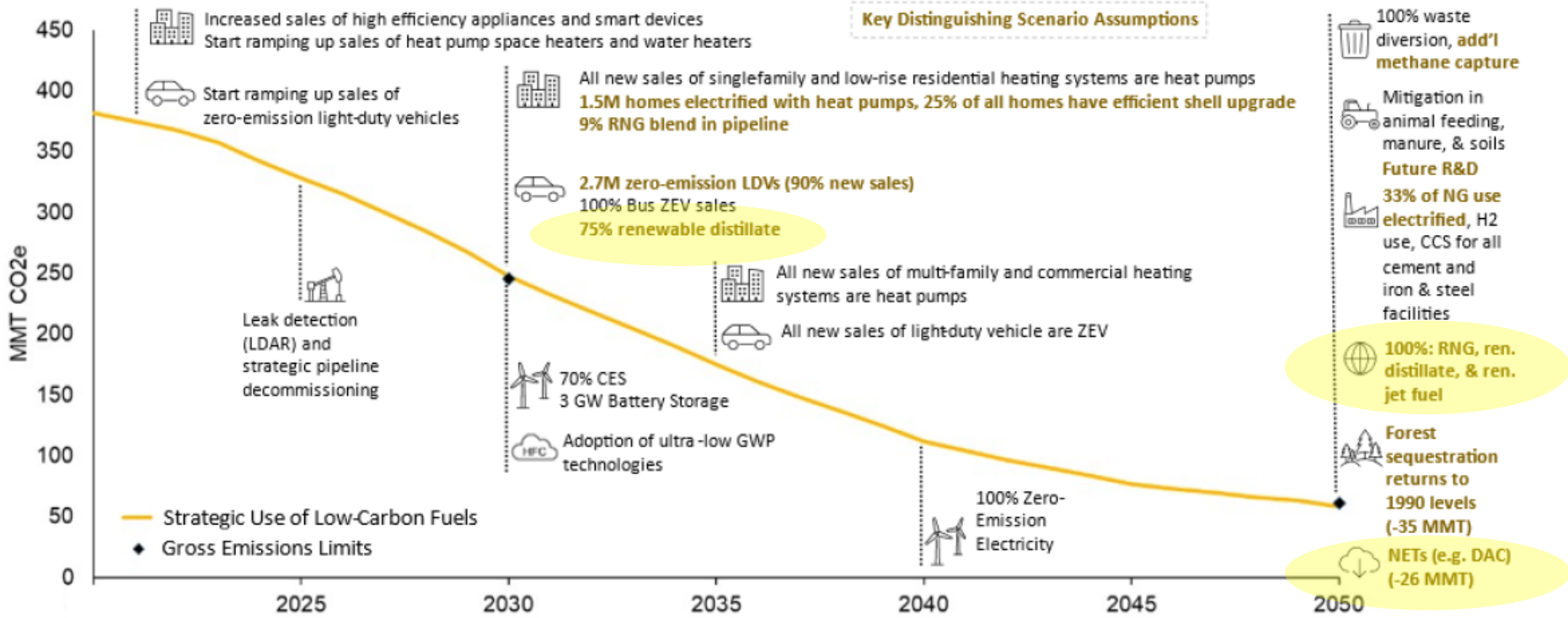


UN IPCC AR6: Catastrophic climate change will only be averted via the widespread deployment of Carbon Dioxide Removal (net sequestration) technologies.

Source: IPCC (2021)

New York State's response: The Climate-Focused Bioeconomy

Figure 7. Key Assumptions in Scenario 2: Strategic Use of Low-Carbon Fuels



https://climate.ny.gov/-/media/Project/Climate/Files/Draft-Scoping-Plan.ashx

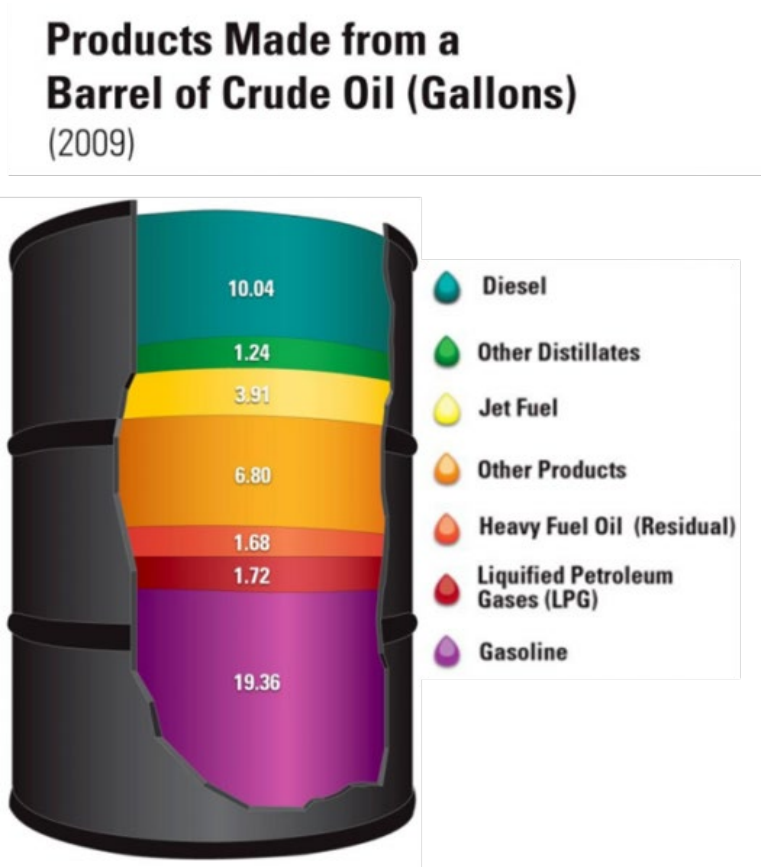
New York State's proposed plan

Climate-Focused Bioeconomy	AF18. Develop Forestry Training Programs to Support Expanding Workforce and Climate Knowledge AF19. Expand Markets for Sustainably Harvested Durable Wood Products AF20. Develop a Sustainable Biomass Feedstock Action Plan and Expand the Use of Bioenergy Products AF21. Increase Market Access for New York Low-Carbon Products AF22. Provide Financial and Technical Assistance for Low-Carbon Product Development AF23. Advance Bio-Based Products Research Development and Demonstration AF24. Advance Deployment of Net Negative CO_2 Removal

Climate-Focused Bioeconomy

The bioeconomy is the part of an economy that produces sustainable, renewable bio-based feedstocks, rather than fossil fuel-based feedstocks, to produce products that achieve the climate and social justice requirements of the Climate Act. New York's forest product industry produces a diverse range of products and jobs. New York's forests and wood products industries are directly responsible for nearly 40,000 well-paying jobs and more than $13 billion of economic output and are indirectly responsible for another 53,000 jobs and nearly $10 billion of economic activity.[209] In addition, there is an opportunity for enhanced carbon storage as long-term, durable wood products store carbon. Furthermore, substitution of wood products for fossil fuel based and fossil fuel-intensive products displaces GHG emissions, such as in housing construction[210] (see Figure 24).

The limitations of vehicle electrification



https://www.energy.gov/articles/hows-and-whys-replacing-whole-barrel

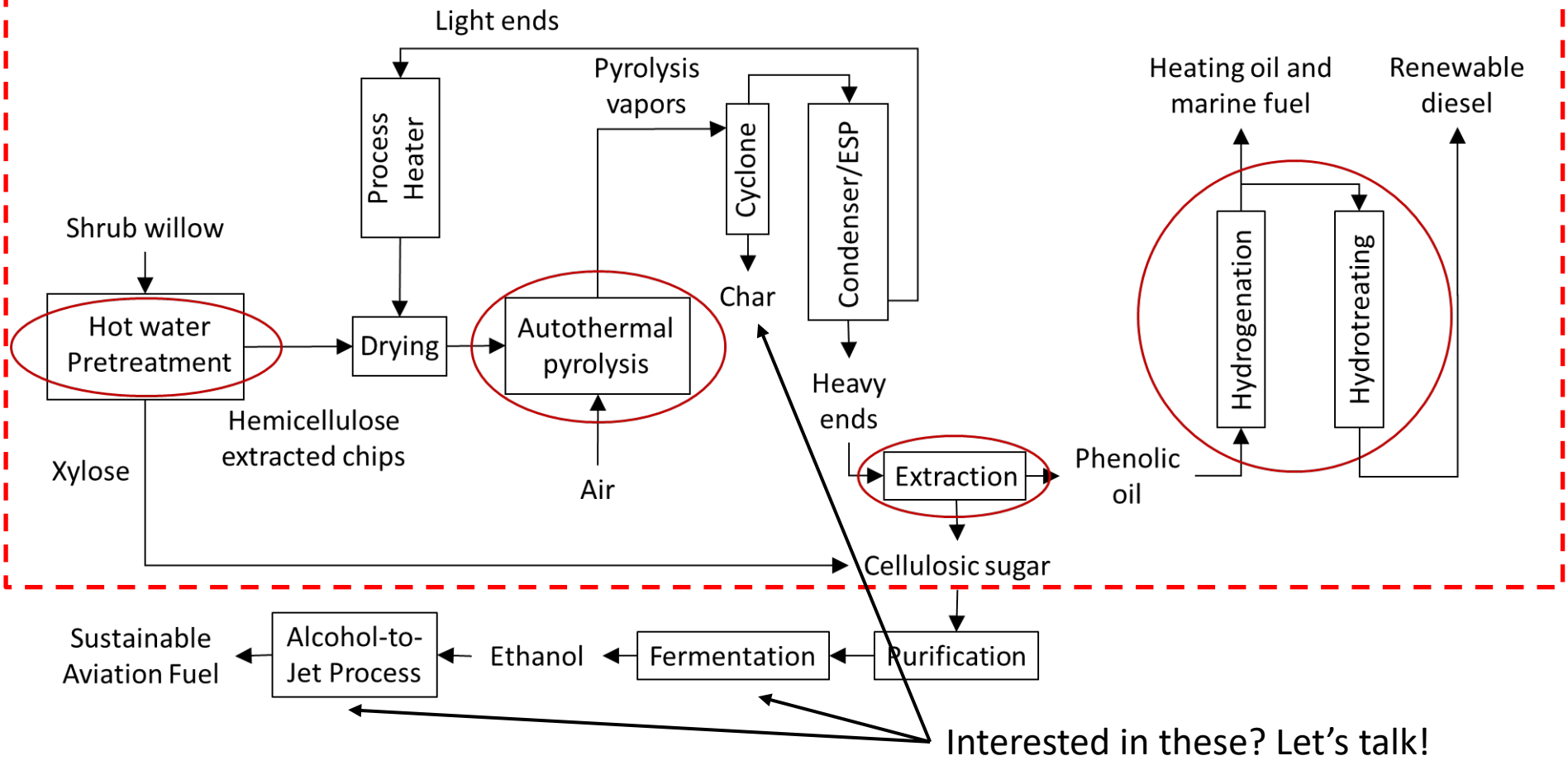
- 2020s vehicle technologies will largely limit electrification to gasoline vehicles
  - Only 43% of every barrel of petroleum produces gasoline
  - Only 67% of NYS's transportation sector GHG emissions come from gasoline vehicles
  - Diesel fuel, residual fuel, and jet fuel are unlikely to be replaced by electricity before the 2040s (if not later)
- The NY Climate Leadership and Community Protection Act's targets will most likely be met only if the transportation sector is decarbonized via additional means

Carbon-negative renewable distillate fuels: A USDA AFRI project

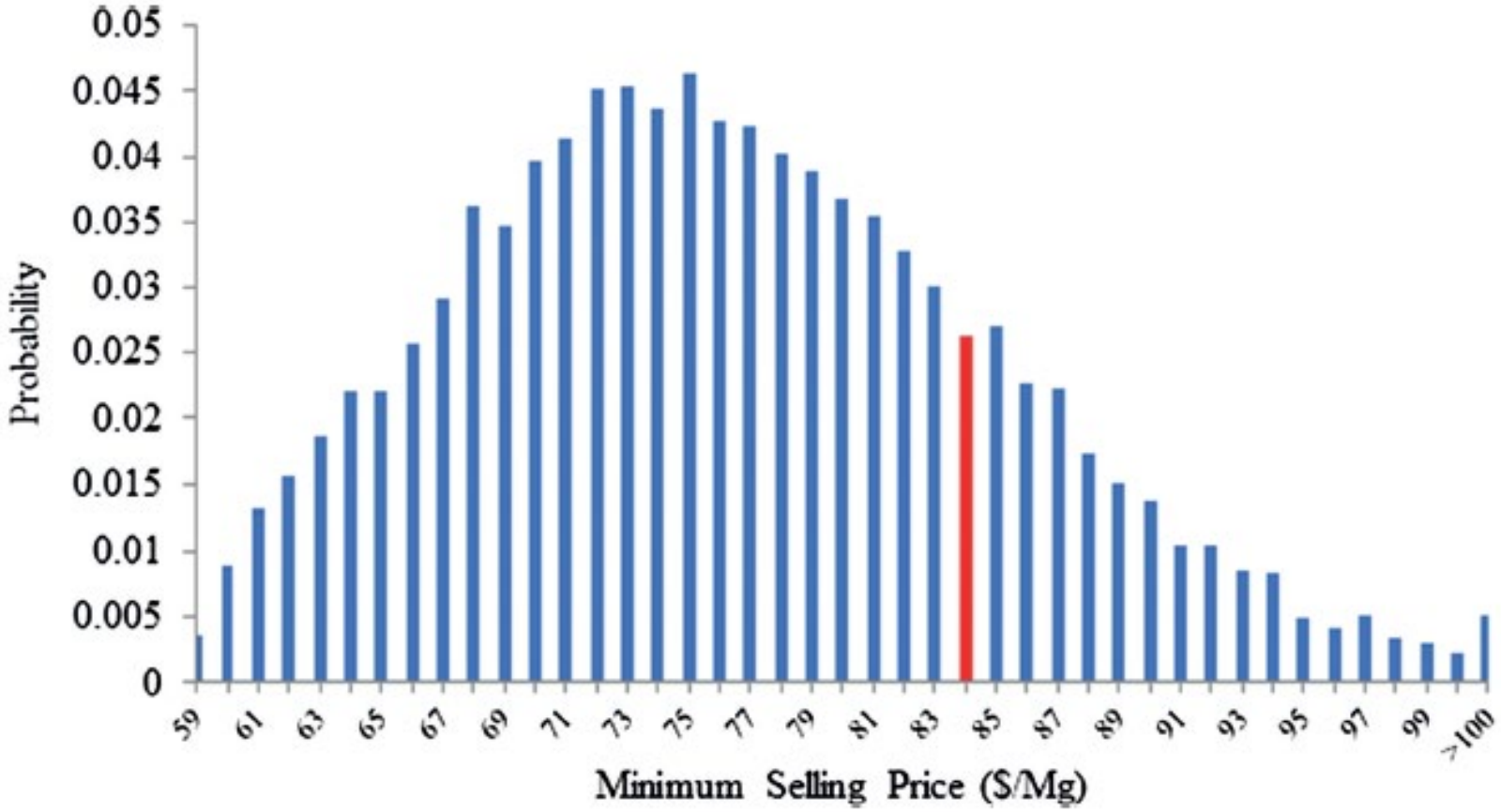
- SUNY-ESF grows shrub willow on marginal croplands that has been shown to achieve net-negative emissions via increased below-ground C
- SUNY-ESF operates a hot water extraction system that removes C5 sugars from willow chips, leaving behind cellulose and lignin in solid form ("HECs")
- Iowa State operates an autothermal pyrolysis system in which HECs are converted to phenolic oils, levoglucosan, biochar, and syngas
- Renewable Energy Group operates a pilot hydroprocessor in which phenolic oils will (in theory) be converted to renewable distillate fuels

Willow-to-distillate fuels

USDA AFRI project scope



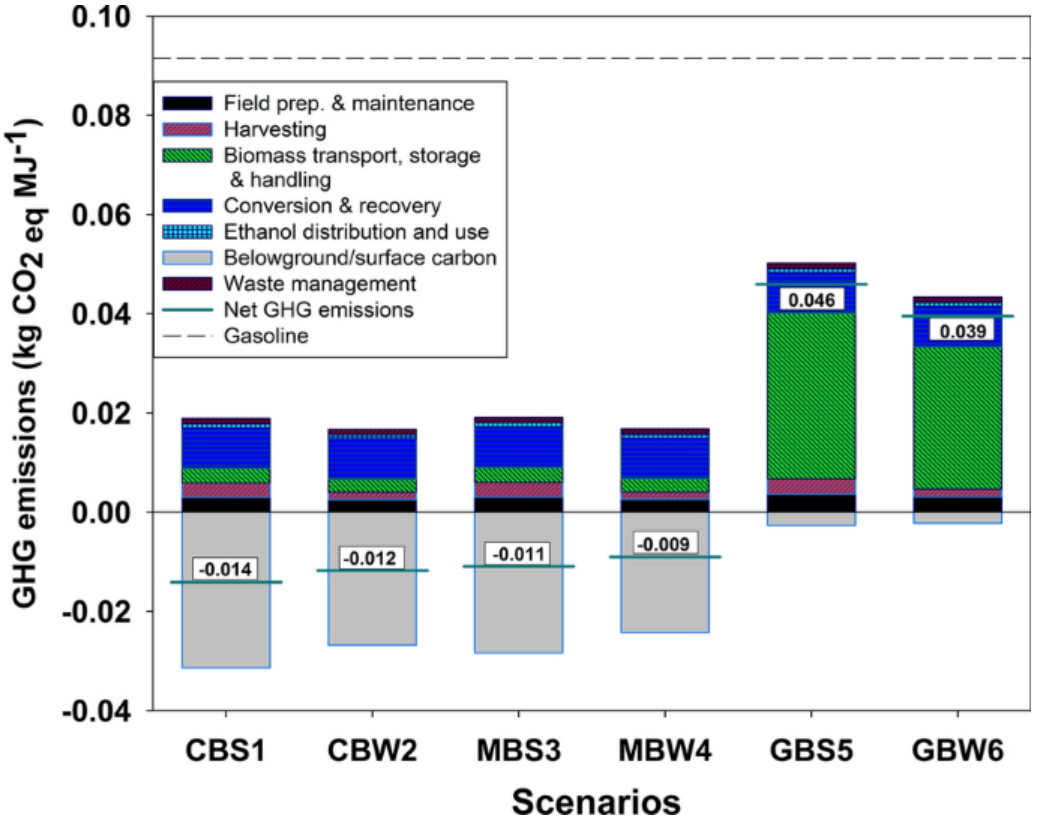
Minimum selling price of NYS willow



Frequency distribution for the minimum selling price for willow biomass grown in the northeastern U.S. and delivered to an end user. Red column denotes U.S. DOE lignocellulosic feedstock price target.

Source: Frank et al. (2018)

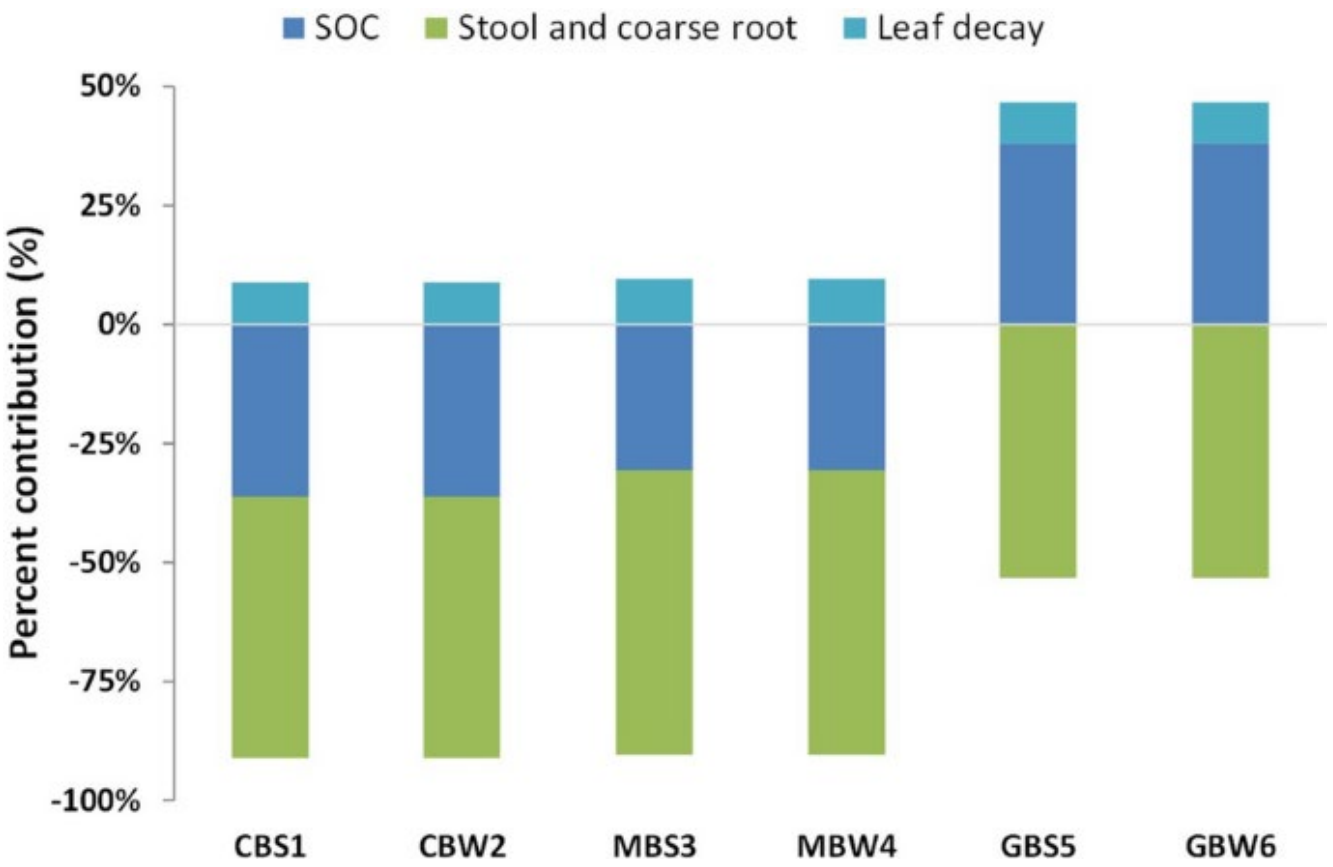
Life cycle GHG emissions from NYS willow-to-ethanol



- CBS1 = Cropland, summer harvest
- CBW2 = Cropland, winter harvest
- MBS3 = 11.3% grassland, 88.7% cropland, summer harvest
- MBW4 = 11.3% grassland, 88.7% cropland, winter harvest
- GBS5 = Grassland, summer harvest
- GBW6 = Grassland, winter harvest

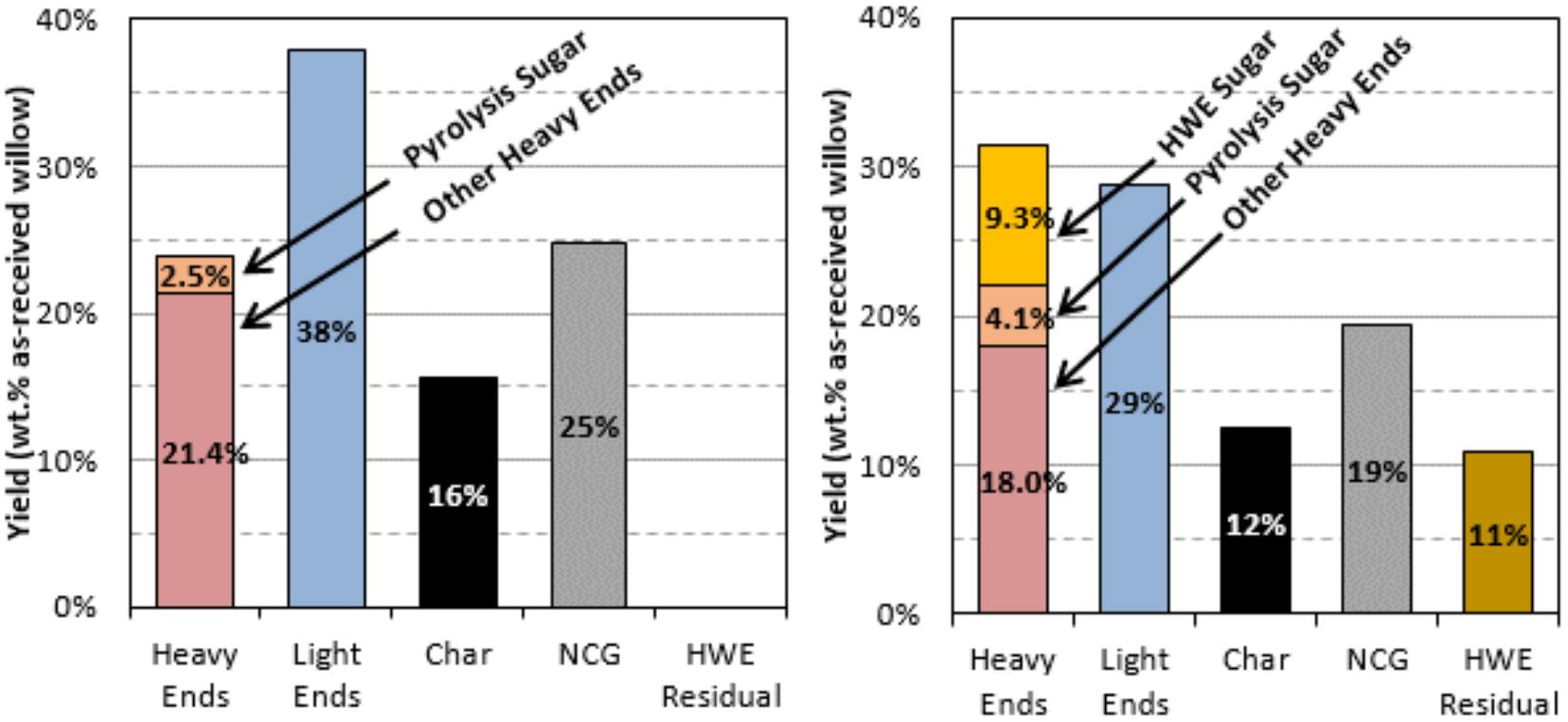
Source: Therasme et al. (2021)

Willow feedstock contributions to belowground/aboveground carbon



Source: Therasme et al. (2021)

Initial results from pyrolysis of HEC



Yields from autothermal (air-blown) pyrolysis at 500 °C of (left) as-received willow; (right) HEC willow. Product yields of HEC willow are normalized to as-received willow and include sugar and residual yields from extraction process. Total yield is greater than 100% due the reaction of oxygen with products.

Next steps

- Begin tests to determine if ferrous sulfate pretreatment step serves as a lignin depolymerization catalyst
- Develop integrated life cycle assessment and techno-economic models of pathway for optimization of climate and financial outcomes
- Work with behavioral scientists to identify hurdles to carbon-negative distillate fuel commercialization in NYS

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Questions?

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