FAA CENTER OF EXCELLENCE FOR ALTERNATIVE JET FUELS & ENVIRONMENT

Feedstock Availability

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Seattle, WA

Objectives

- Near and Long-term
  - The University of Tennessee will lead the Feedstock Production (Task 1) component of the project which targets the need to assess and inventory regional forest and agricultural biomass feedstock options (1.1); and delineates the sustainability impacts associated with various feedstock choices, including land use effects (1.2). Additionally, The University of Tennessee will support activities in Task 4 (Biorefinery Infrastructure and Siting) with information and insights on regional demand centers for aviation fuels and current supply chain infrastructure, as required.

Outcomes and Practical Applications

- Outcomes
  - Cellulosic feedstock county supply curves including
    - Perennial grasses (switchgrass (*Panicum virgatum*); miscanthus (*Miscanthus sinensis*); energy cane (*Saccharum complex*));
    - Short-rotation woody crops including poplar (*Populus species*); willow (*Salix species*); loblolly pine (*Pinus taeda*); sweetgum (*Liquidambar styraciflua*); and sycamore (*Plantanus occidentalis*));
    - Agricultural residue from wheat, oats, and barley straw, and corn stover; and
    - Forest residue
  - These county supply curves are database oriented
- Practical applications
  - Provide a baseline for others requiring spatial feedstock information

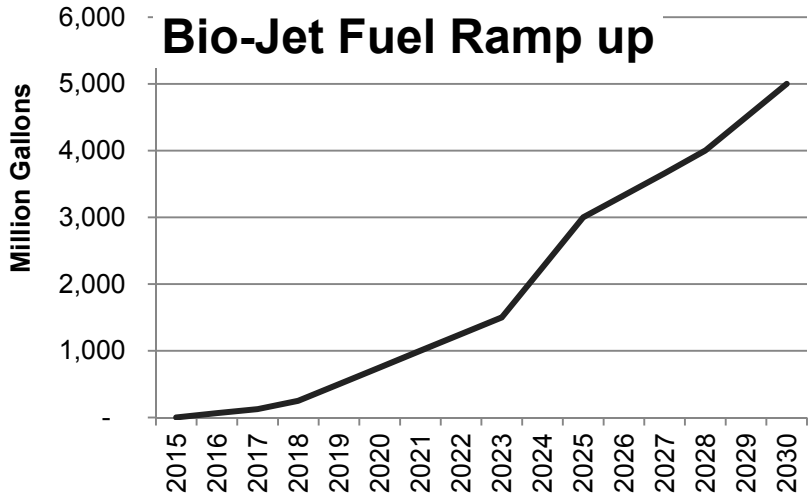
Approach

- Using an existing model, POLYSYS, annual demand targets were developed.
- Analysis conducted for alternative feedstocks – dedicated energy crops (DEC), short rotation woody crops (SRWC), forest residues (FR), and crop residues (CR).
- A combined solution and individual solutions were estimated for the bio-jet fuel ramp up of 5 billion gallons by 2030.
- The feedstock streams were placed in ASCENT 1's Database -- Box.
- Results were presented to the research team.
- Pass feedstock info to other team members.

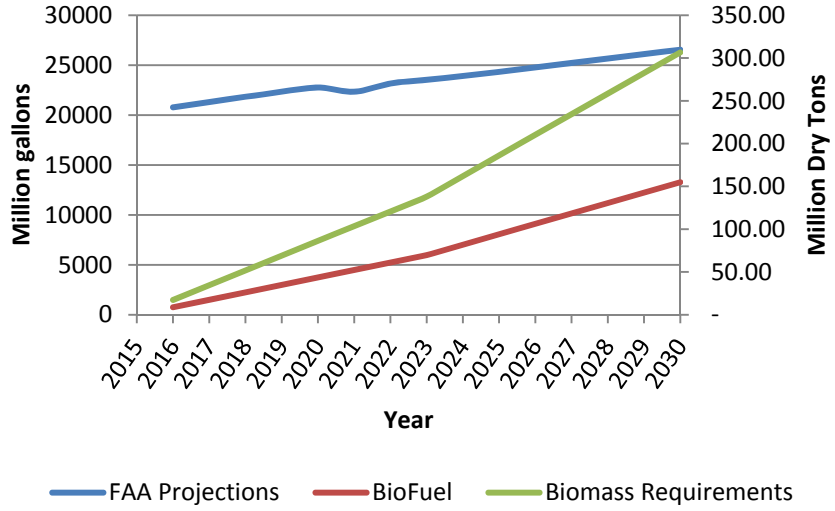
Schedule and Status

Schedule activity	Status

- Supply curves delivered April, 2015 for a 5 billion gallon bio fuel supply



- New ramp up developed for cellulose-derived jet fuel



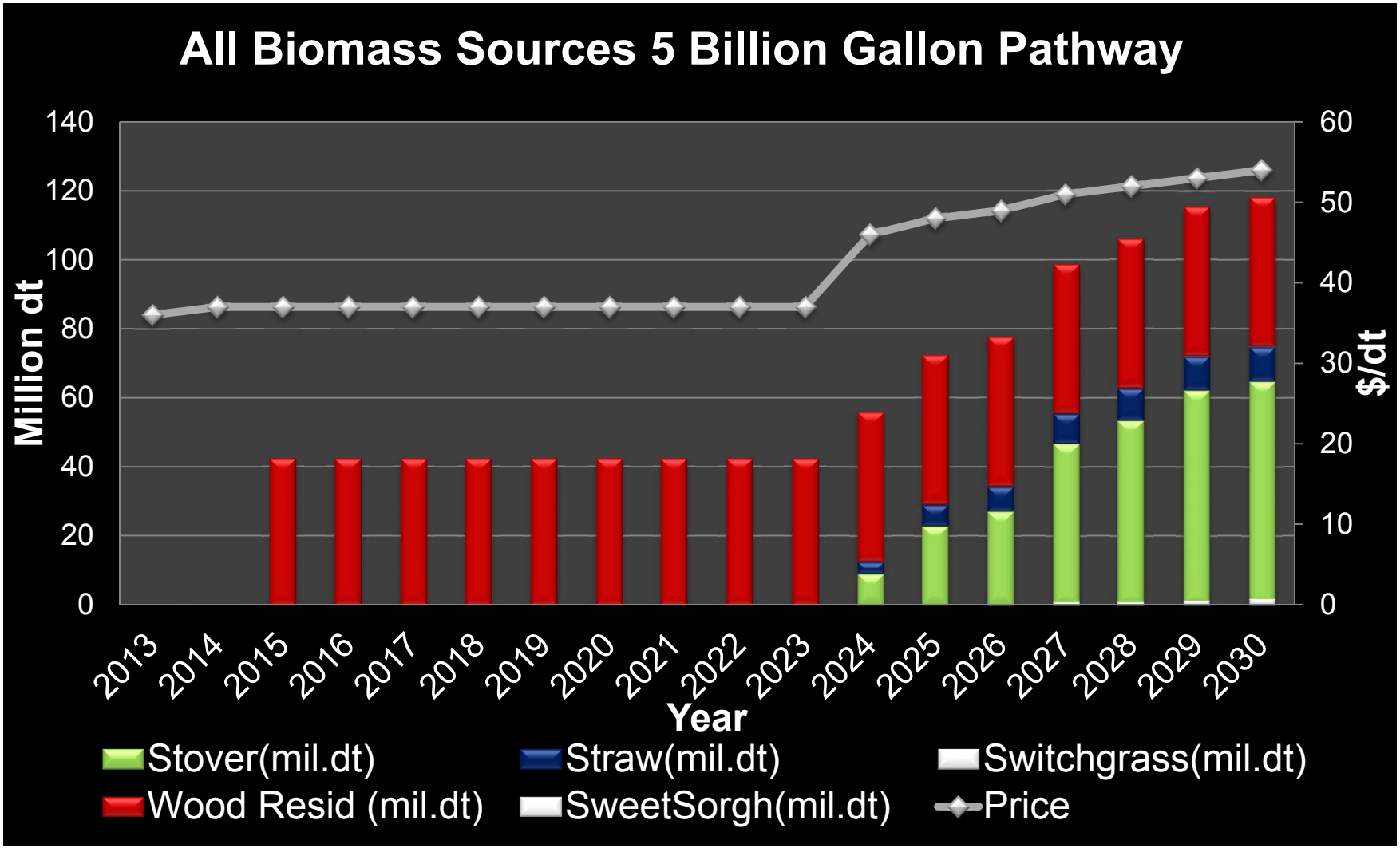
Schedule and Status

Schedule activity	Status
• Develop spatial pennycress rotations and budgets	• Info collected, fact sheet developed, spatial characteristics under development
• Develop sustainability criteria for biofuel pathways including – Carbon emissions info – Soil erosion indicator – Sediment delivery indicator – Fertilizer use indicator – Ag. Chemical use indicator	• Coefficients developed and ACCESS database in development
• Develop new Forest Residue Sector (Billion Ton update)	• Nearly completed

Recent Accomplishments and Contributions (1 of 2) for 5 billion gallon analysis

- Potential feedstocks include: corn stover; straw from wheat, barley, and oats; dedicated energy crops including: switchgrass, miscanthus, poplars, willows, sweet sorghum, energy cane, and algae; and wood residue.
- Biomass price for forest residues (tops and limbs) enter in at $37/dry ton. In 2019, crop residues enter into the solution with biomass at $46/dry ton. Dedicated energy crops do not enter the solution until biomass price is at $49/dry ton for sweet sorghum and $53/ton for dedicated energy crops.
- Harvesting stover or straw on 25.1 million acres producing 76 million dt of biomass (31% of the 2014 corn + wheat acreage). Only have 110 thousand acres of dedicated energy crops. 43.3 million tons of wood residues enter the solution first at about $37.0/dt.
- After taking an average of commodity prices over 19 years, they changed very little. A decrease in commodity prices for grain oats, barley, and wheat of $0.07/bu, $0.14/bu, and $0.05/bu, respectively. Soybeans decrease by $0.13/bu.

Recent Accomplishments and Contributions (1 of 2)



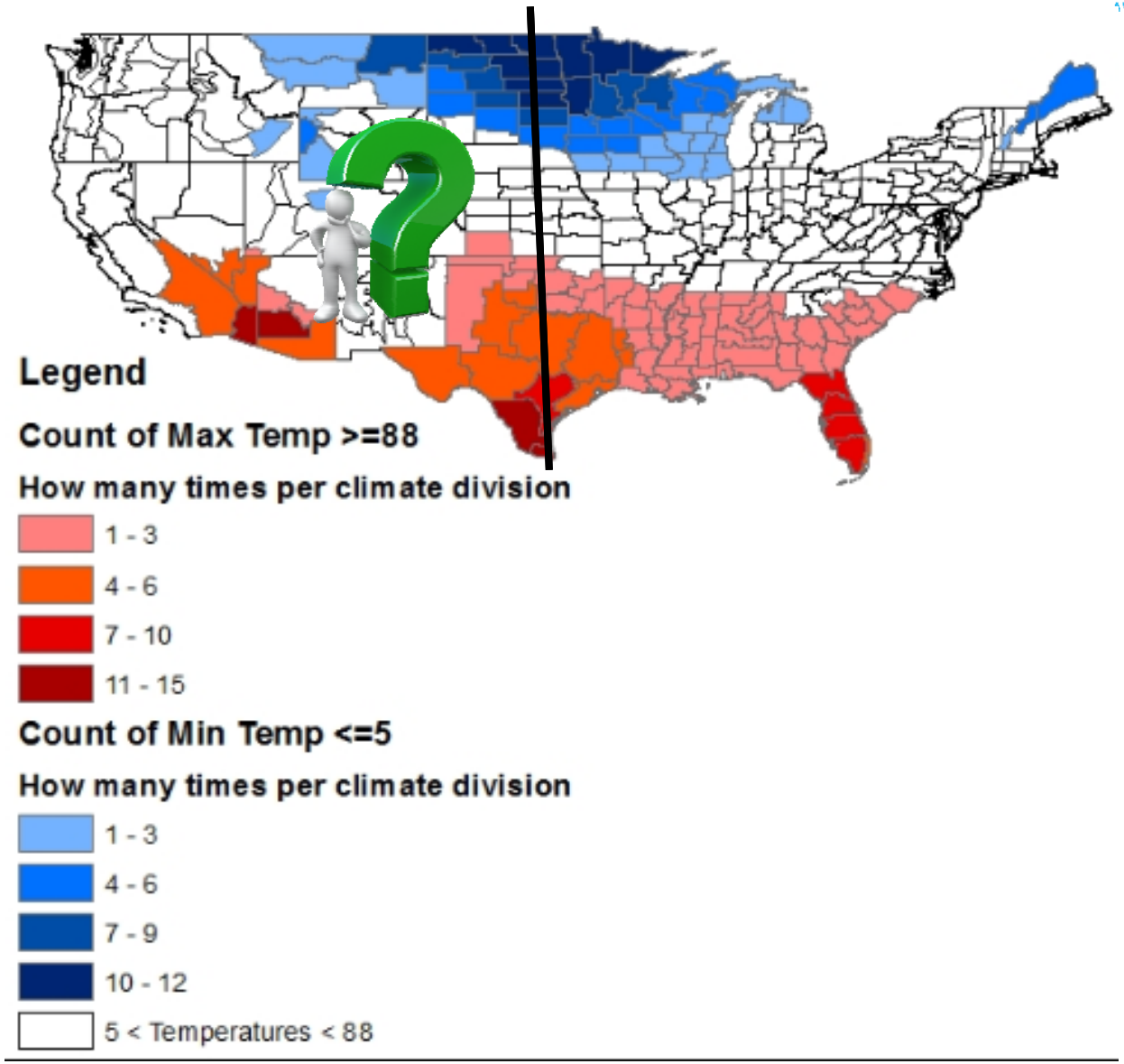
Recent Accomplishments and Contributions (2 of 2) for Pennycress

- Pennycress (*Thlaspi Arvense*) is commonly referred to as “stinkweed” or “French-weed” and found throughout the United States but is predominately found in the northern states, especially in the northwest, and sparsely established in the southeast.
- Pennycress is being evaluated as a potential feedstock for biodiesel and biojet fuels. The crop has the potential to supply both oil and meal to the biofuels market and livestock feed market.
- Pennycress provides the benefits of a winter cover crop and also provides producers economic benefits.
  - As a winter cover crop for corn-soybean rotations, pennycress is established in the fall and harvested in mid-to-late-spring.
  - Pennycress can reduce weeds and enhance nutrient uptake.
  - Pennycress is grown on fallow winter land and does not impact the yields of spring crops, a cash crop which avoids the pitfalls of the food-versus-fuel debate.

Recent Accomplishments and Contributions (2 of 2) for Pennycress

- The U.S. EPA has invited comments on its assessment of greenhouse gas emissions attributable to the production and transportation of pennycress feedstock bio-diesel and bio-jet fuels.
  - The U.S. EPA indicates that based on its analysis, pennycress could qualify as biomass-based diesel or advanced biofuel if typical fuel production process technologies are used (USEPA 2015).
  - USEPA anticipates approval for the generation of renewable identification numbers, following existing rule making related to camelina feedstock production
- Large scale cultivation has not yet been undertaken for pennycress, thus management practices and stand establishment practices are still in research and development.
  - Variety trials have been undertaken throughout the Midwest, particularly in Western Illinois, Minnesota, and Nebraska.
  - Aerial seeding over standing corn canopy or a broadcast with light incorporation after corn harvest have been successful at seeding rates of 5 lbs/acre have generated yields ranging from approximately 1400lbs/acre to 2200lbs/acre with an average yield of1800 lbs/acre. To establish a stand of pennycress ready for harvest in May-June so as to not interfere with soybean planting, aerial seeding over corn canopy may generate the best results.
  - Planting earlier than September 1st should be avoided, because if the plant flowers too early in winter months, survival rates are low.
- Pennycress is cold tolerant and can grow in wide range of conditions. However the plant is sensitive to high heat conditions. Temperatures above 85 degrees pose a risk to pennycress and temperatures of 92 degrees and above will terminate the plant

Recent Accomplishments and Contributions (2 of 2) for Pennycress



Summary

- Summary statements
  - US can grow sufficient biomass.
  - The price for the celluosic materials can be less than $80/ton.
  - Win for Rural America through additional income and jobs.

- Key challenges/barriers
  - Answering the following questions
    - What locations does Pennycress do well and how do yields change based on location
    - Development of environmental indicators needs to progress to answer the sustainability question.
      - Erosion/Sediment
      - Carbon emissions
      - Fertilizer expenditures
        - » N, P, K
      - Chemical Expenditures
        - » Herbicide, Insecticide, Other
  - What would you like the Advisory Board to help you with or provide comment on?
    - The assumed pathways – 5 billion or 13 billion gallons by 2030 or ????.

Contributors

- Chad Hellwinckel, Tim Rials, Edward Yu, Jamey Menard, Kim Jensen, Lixia He, and Dayton Lambert