DOE Bioenergy Technologies Office (BETO) 2019 Project Peer Review

2.1.0.502 Bioeconomy Carbon Flux Assessment – Bioenergy with Carbon Capture and Sequestration

March 4th-8th, 2019

Analysis and Sustainability Area Review

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Oak Ridge National Laboratory

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Goal Statement

- *Goal: Assess the potential quantity and economic feasibility of CO_2 management of the U.S. bioeconomy through BECCS.*
- *Outcome: An understanding of the potential scale and economic accessibility of BECCS.*
  - *Comparable with other CO_2 management strategies.*
  - *Cost (\$/tonne CO_2)*
  - *Supply, by feedstock type and logistical strategy*
  - *Tonnes CO_2 per hectare per year*
  - *Identify strategies that optimize BECCS (increase Quantity or reduce Price).*
  - *Position BETO to respond to future bioeconomy applications.*

Quad Chart Overview

Timeline

- October 1st 2018
- September 30th 2021
- 10% complete

	FY 19 Costs	Total Planned Funding (FY 19-Project End Date)
DOE Funded	$500k	$1.5 million
Project Cost Share*	$0	$0

- **Partners: N/A**

Barriers addressed

At-A. Analysis to Inform Strategic Direction

At-D. Identifying New Market Opportunities for Bioenergy and Bioproducts

Objective

Assess the quantity and feasibility of CO_2 management potential of the U.S. bioeconomy through BECCS.

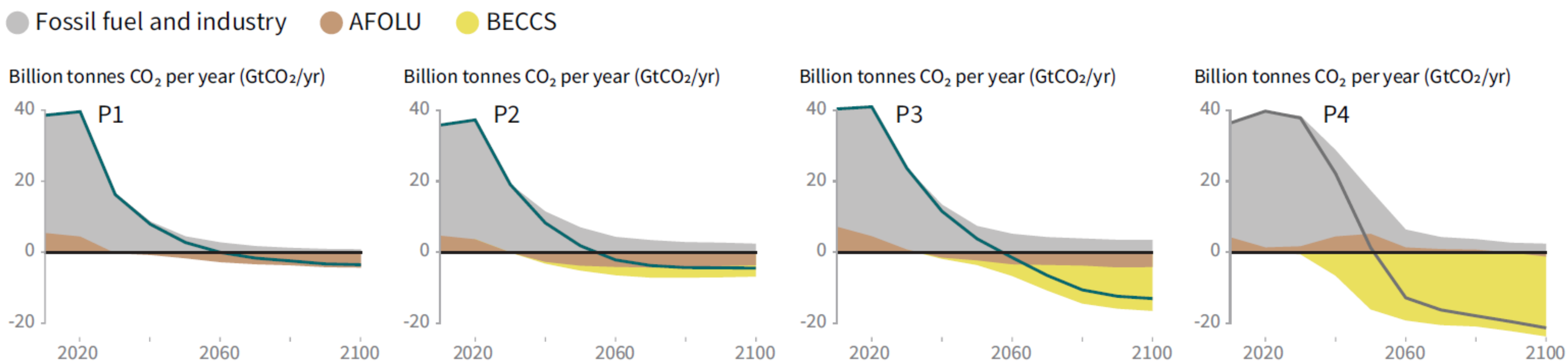
End of Project Goal

Comprehensive vision of potential to leverage the bioeconomy for BECCS.

1 - Project Overview

- *Three of four IPCC illustrative pathways to limit global warming to 1.5°C use BECCS (IPCC 2018).*

Breakdown of contributions to global net CO_2 emissions in four illustrative model pathways



- *Goal: Quantify the supply and cost of CO_2 management potential of the U.S. bioeconomy through BECCS.*
- *To inform potential future CO_2 management strategies, both BECCS compared to other strategies and optimal BECCS strategies.*

2 – Approach (Management)

- *Weekly team meetings and regular meetings with BETO Technology Manager and C project at LLNL.*
- *Multidisciplinary project building on ORNL resources*
  - *Biomass Analytics developed from the 2016 Billion-ton Report*
  - *Logistics/transportation modeling*
  - *NTRC Center for Transportation Analysis www.ornl.gov/ntrc*
- *Team members:*
  - *Maggie Davis: Feedstocks resources*
  - *Olufemi Omitaomu: Siting model, Oak Ridge Siting Analysis for power Generation Expansion (ORNL-SAGE)*
  - *Melissa Allen: Energy demand*
  - *Ingrid Bush: Logistics model (BILT)*
  - *McFarlane: Geological BECCS*
  - *Costas Tsouris: CO_2 engineering*
  - *Mike Hilliard: Interactive visualization*
  - *Matt Langholtz: PI*

2 – Approach (Technical)

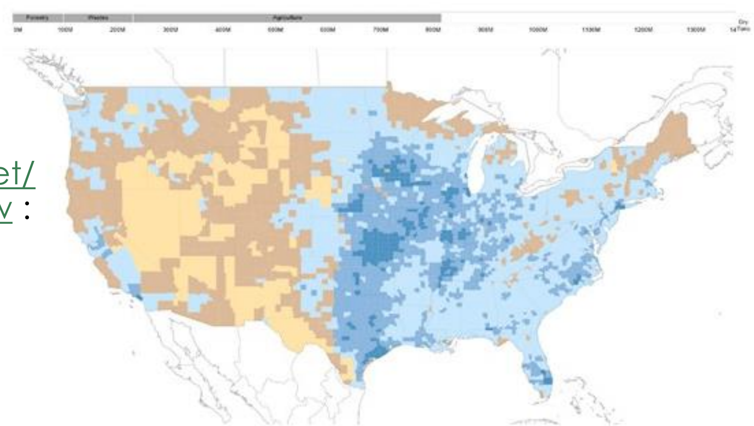
Scenarios: FY19 2nd quarter, FY19 3rd quarter, and Future work:

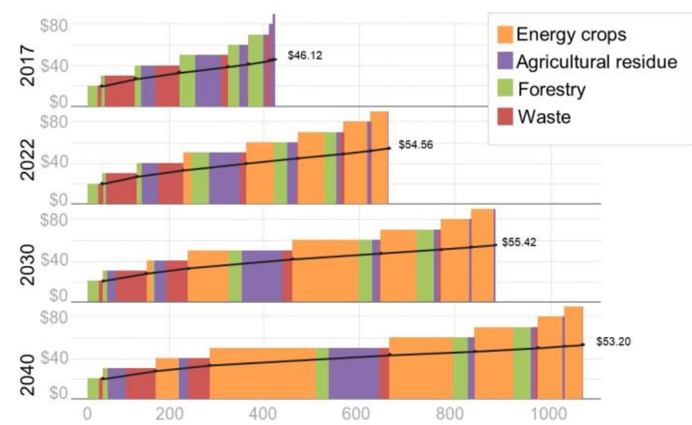
	Biomass resources		FY20
	Conventional logistics/existing feedstocks	Advanced logistics/energy crops	CO_2 transport
Existing power generation, feedstocks within sequestration basins	Conventional biomass logistics with existing power	Advanced biomass logistics with existing power	CO_2 transport from existing power
New power generation, feedstocks outside sequestration basins	Conventional biomass logistics with new power	Advanced biomass logistics with new power	CO_2 transport from new power

2 – Approach (Technical)

- *Modeling approach:*
  1. *Facility siting: Oak Ridge Siting Analysis for power Generation Expansion (OR-SAGE)*
  2. *Biomass feedstocks: 2016 Billion-ton Report for existing feedstocks, and custom regional demand simulations for energy crops*
  3. *Biomass logistics: Biofuel Infrastructure, Logistics and Transportation Model (BILT)*
  4. *CCS engineering costs: Establish cost assumptions*
  5. *CO_2 Lifecycle assessment: BT16 volume 2 and logistics energy use assumptions*
- *Output: Interactive visualization of scenario results*

Examples from https://bioenergykdf.net/billionton2016/overview :





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2 – Approach (Technical)

Facility siting constraints:

Existing OR-SAGE Screening Criteria	Clean Coal Value (750 MWe on 300-acre site)	Large Nuclear Value (1.6 GWe on 500-acre site)	Small Nuclear Value (350 MWe on 50-acre site)	CAES Value (110 MWe on 10-acre site)	Biopower Value (500 MWe on ??-acre site)
Population density (people/sq. mi)	>500 within 20 miles	>500 within 20 miles	>500 within 10 miles	>500	>500 within 1 mile
Wetlands / Open Water	- -	- -	- -	- -	- -
Protected lands	- -	- -	- -	- -	- -
Slope	>12% grade	>12% grade	>18% grade	>12% grade	>12% grade
Landslide Hazard (moderate or high)	- -	- -	- -	- -	- -
100 – year floodplain	- -	- -	- -	- -	- -
Streamflow / cooling water make-up (k gpm) within 20 miles – assumes closed-cycle cooling - limits plant to no more than 10% of resource	125	200	65	N/A	100[1]
EPA non-attainment data (ozone and particulates)	--	N/A	N/A	N/A	- -
Distance to saline formation	> 150 miles	N/A	N/A	N/A	>150 miles
Access to rail, barge, or road (for proximity to biomass feedstock)	> 20 miles, > 1 mile	N/A	N/A	N/A	> 20 miles, > 1 mile, >100 miles
Carbon pipeline	Availability	N/A	N/A	N/A	Availability

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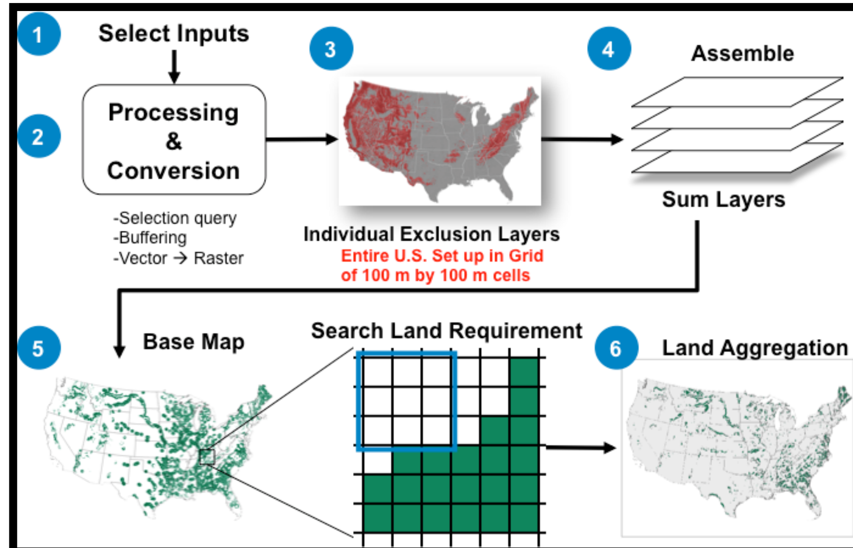
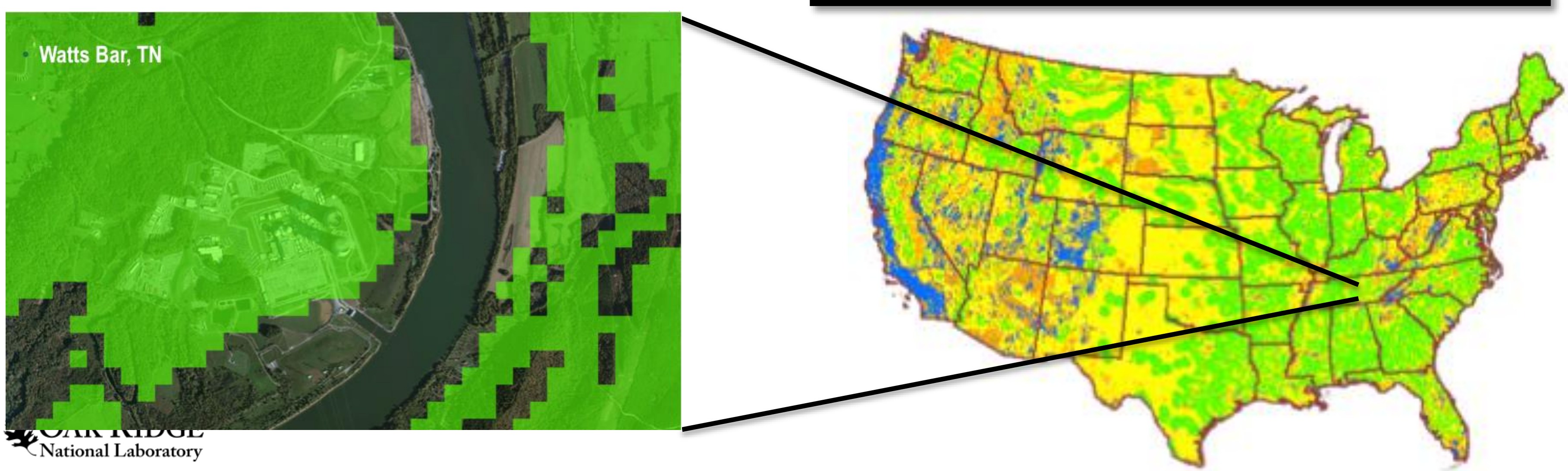
2 – Approach (Technical)

Facility Siting: Oak Ridge Siting Analysis for Power Generation Expansion (OR-SAGE)

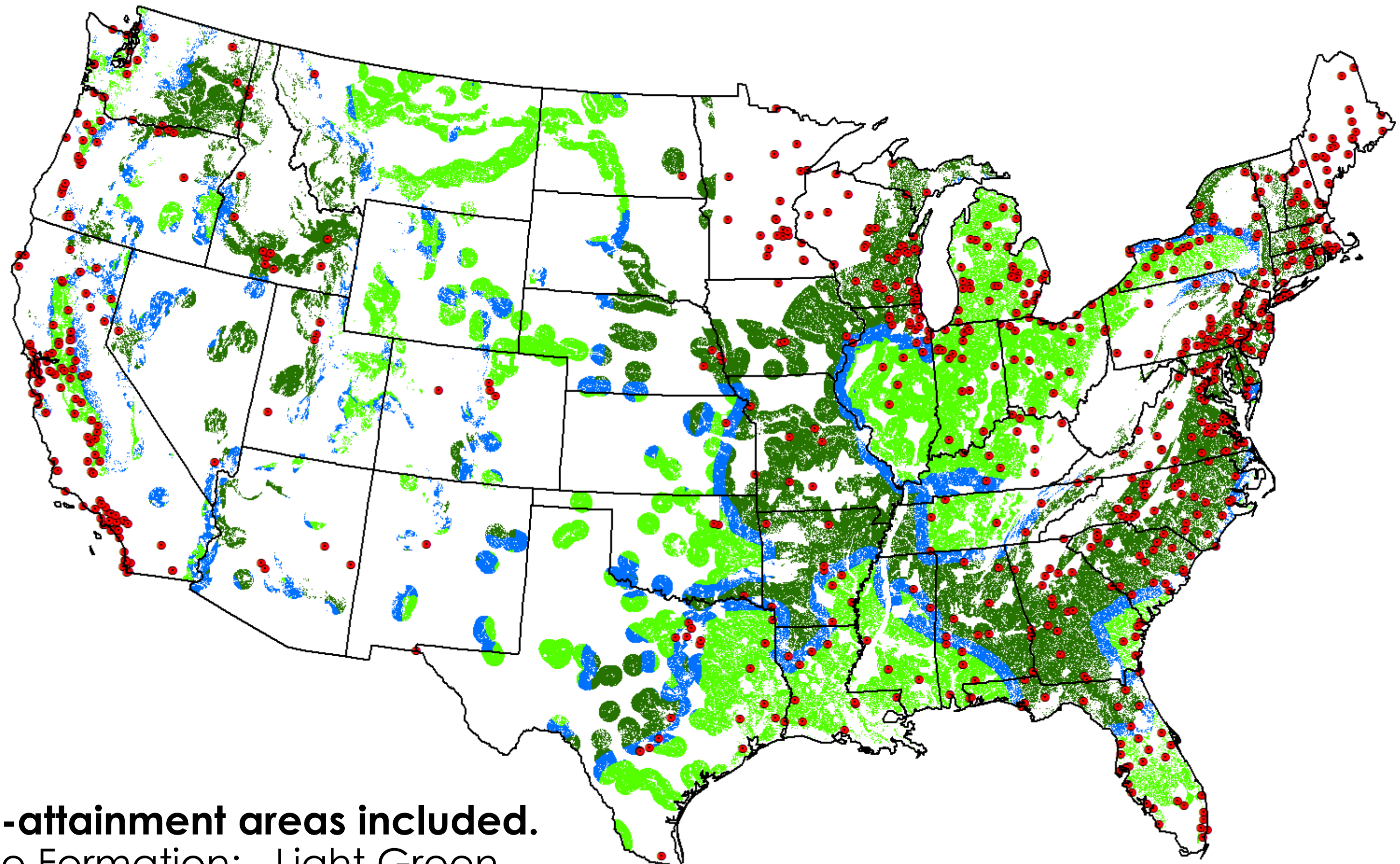
- A spatially explicit framework, > 40 spatial datasets to identify potential sites.
- For coal, nuclear, solar, wind, and energy storage options.
- Sponsored by EPRI and DOE NE





2 – Approach (Technical)

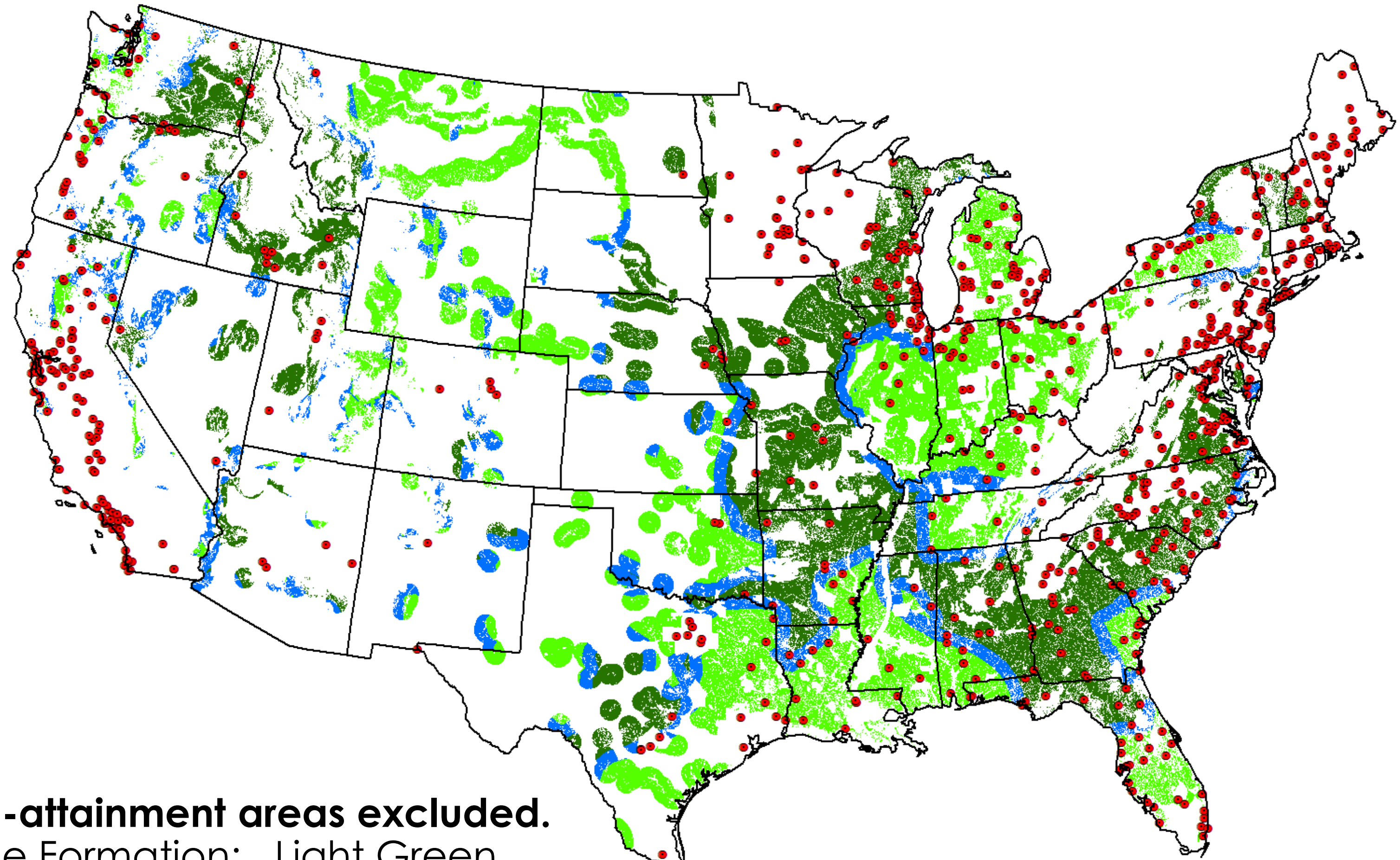
Facility Siting: Oak Ridge Siting Analysis for Power Generation Expansion (OR-SAGE)



EPA non-attainment areas included.
On Saline Formation: Light Green
Saline Formation within 25 miles: Light Green + Blue
Saline Formation within 150 miles: Light Green + Blue + Dark Green
Red dot: current biopower facility

2 – Approach (Technical)

Facility Siting: Oak Ridge Siting Analysis for Power Generation Expansion (OR-SAGE)



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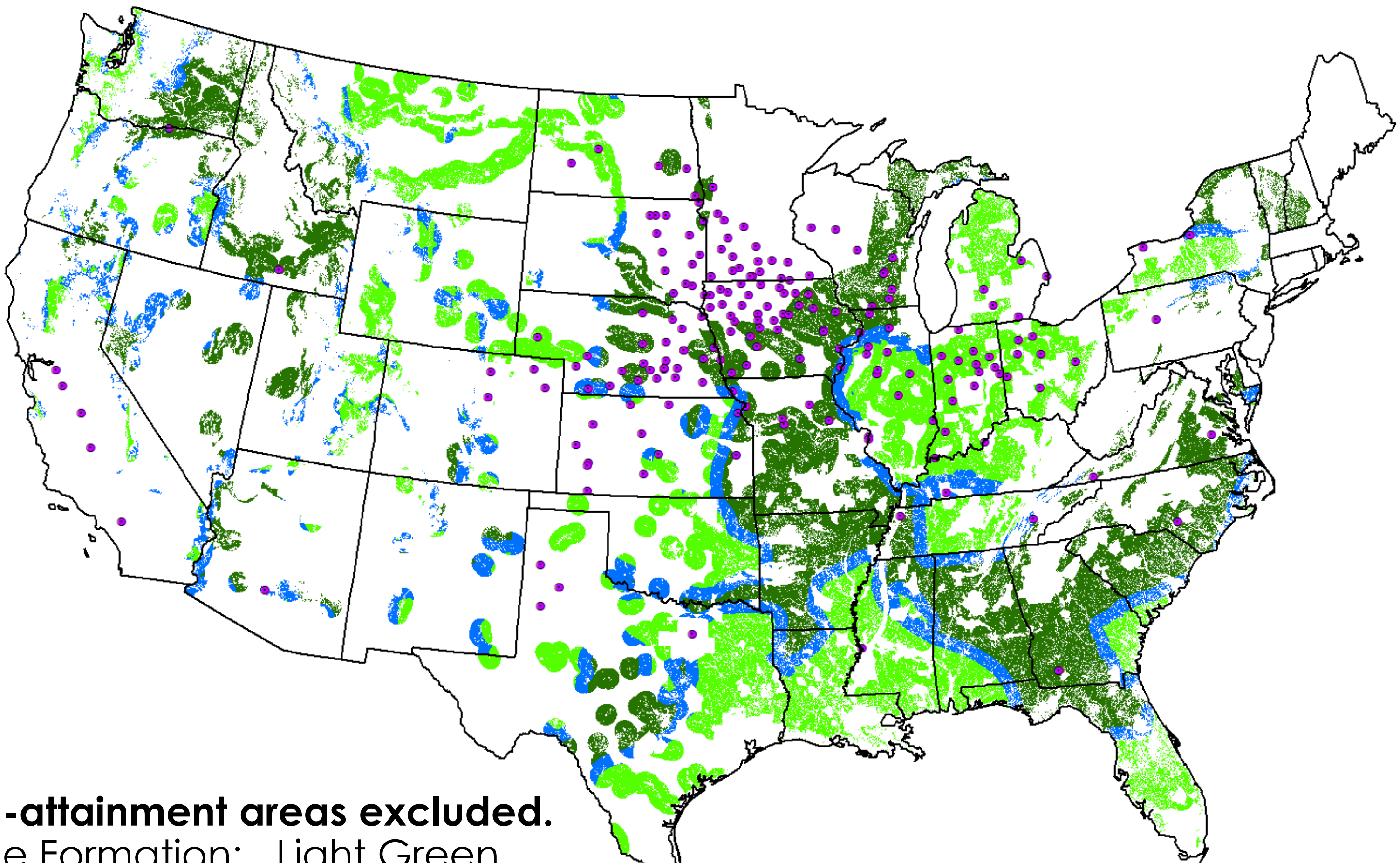

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Saline Formation within 150 miles: Light Green + Blue + Dark Green
Purple dot: corn ethanol facility

2 – Approach (Technical)

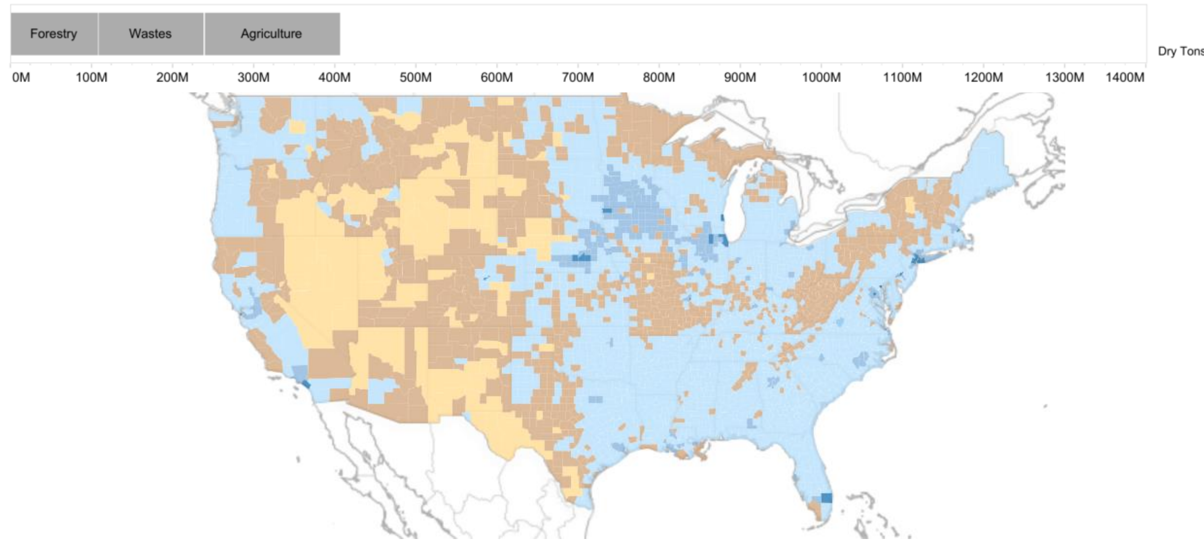
Biomass feedstocks

Near-term, conventional biomass logistics: Agricultural residues and forestland resources from the 2016-Billion-ton Report.

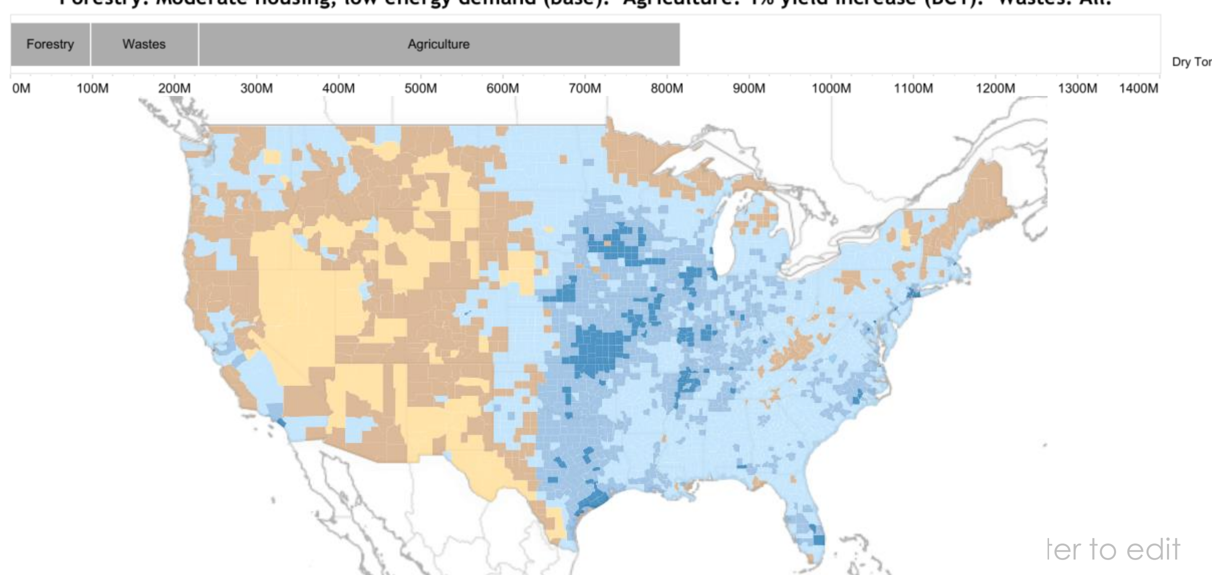
Long-term, conventional biomass logistics: Regional demand for energy crops.

Long-term, advanced biomass logistics: National demand for energy crops.

2022 Combined potential supplies at $60/dt or less, roadside.
Forestry: Moderate housing, low energy demand (base). Agriculture: 1% yield increase (BC1). Wastes: All.



2040 Combined potential supplies at $60/dt or less, roadside.
Forestry: Moderate housing, low energy demand (base). Agriculture: 1% yield increase (BC1). Wastes: All.



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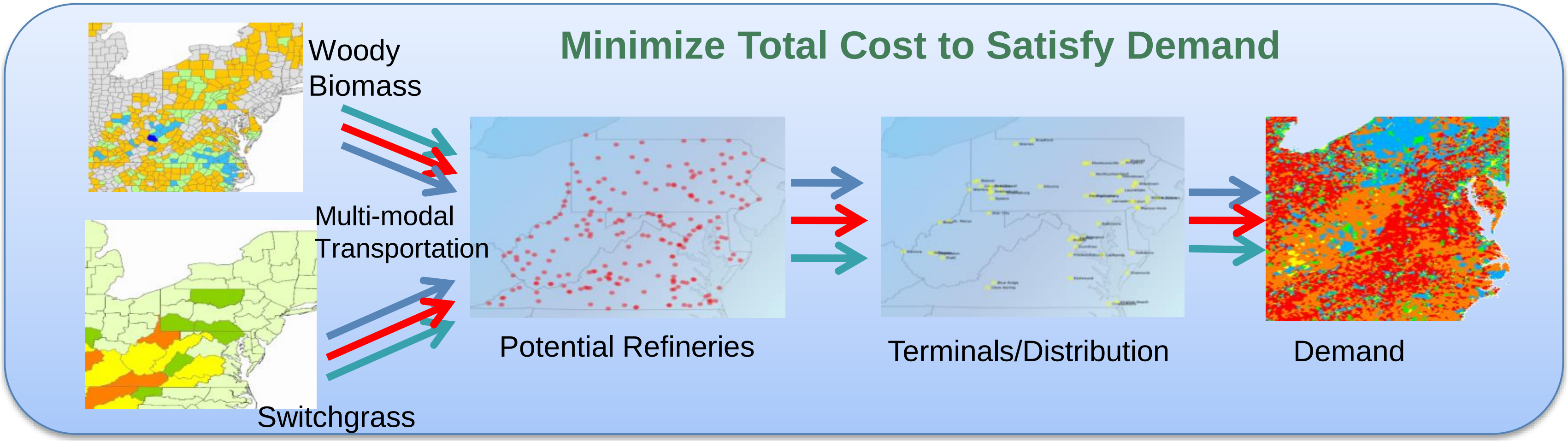
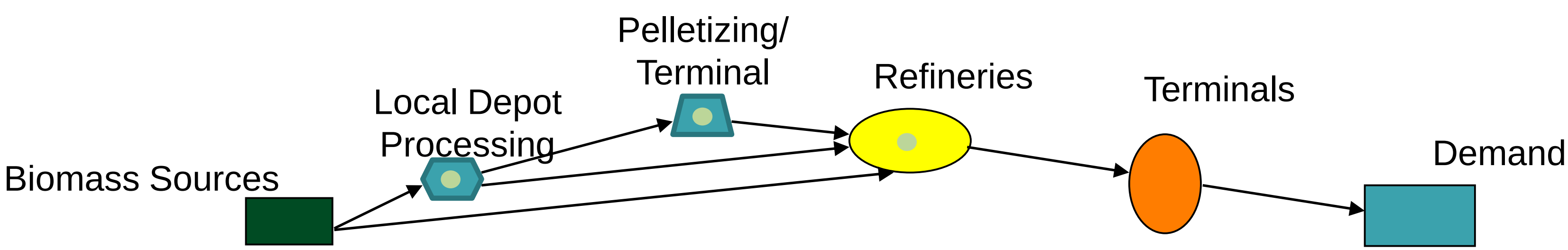
2 – Approach (Technical)

Biomass Infrastructure Logistics and Transportation (BILT) (Lautala et al 2015):





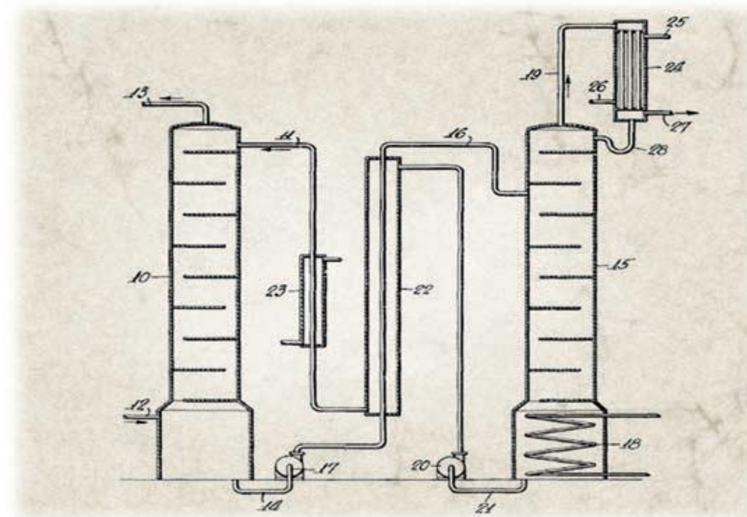
Biomass Sources for Selected Refineries

Biomass Sources for Selected Refineries

2 – Approach (Technical)

CO_2 engineering:

- **~80% of the cost of CCS is capture at the power plant**. Compression and transportation, injection and storage in geologic formation.
- **Existing CO_2 capture technologies and cost models from fossil-energy CCS**; mature and emerging technologies applicable to BECCS.
- **Apply bioenergy variables**: biomass properties, flue gas properties, power output.



The amine scrubbing process invented by Bottoms in 1930 (Rochelle, 2009, Science). Besides **absorption by liquid amine-based solvents,** competing emerging technologies include **membrane separation** and **cyclic adsorption**. Current research is driven by the high cost of FE CCS.

3 – Technical Progress, FY19

- Selected scenarios, data inputs, and supply chain assumptions. (Completed)
- 1st Scenario: **existing biomass and conventional logistics within sequestration basins**. (In progress)
- Next scenario: **Energy crops** and **advanced biomass logistics systems** within sequestration basins.
- **Interactive visualization** of net carbon flux for specified feedstocks and supply chain scenarios in terms of $/ton CO_2 and tons CO_2/acre.

4 – Relevance

- *BECCS is one potential revenue stream for the bioeconomy.*
- *MYPP: "…determine the impact of competing uses, policy and market demands (e.g., biopower, pellet exports) on feedstock supply and price projections."*
- *Will need an understanding of cost competitiveness of BECCS vis-à-vis alternative carbon-negative strategies and biomass uses.*
- *CO_2 quantity and cost potential is expected to vary by:*
  - *Existing or new power plants*
  - *Existing biomass resources or new energy crops*
  - *Conventional or advanced biomass logistics*
  - *Transporting biomass vs. transporting CO_2*

5 – Future Work

- *Advanced biomass logistics and energy crops within sequestration basins*
- *Additional BECCS scenarios*
  - *0, <25, and <150 miles from sequestration basins*
  - *Existing biomass feedstocks vs energy crops*
  - *Conventional vs advanced feedstock logistics*
  - *With and without EPA non-attainment areas*
- *FY20: Transport CO_2 to BECCS from distributed power*
- *Future: Report and companion landing page with interactive visualization*

Summary

- Overview: New project, assessing potential for novel application of the bioeconomy.
- Approach: Leveraging ORNL capabilities in power, engineering, feedstocks, and carbon management.
- Technical progress: Site suitability and feedstocks established for first scenario; subsequent scenarios pending.
- Relevance: BECCS is a potential growth area for the bioeconomy.
- Future work: Add scenarios of energy crops, advanced logistics, and CO_2 pipelines; reporting and visualizations.

Additional Slides