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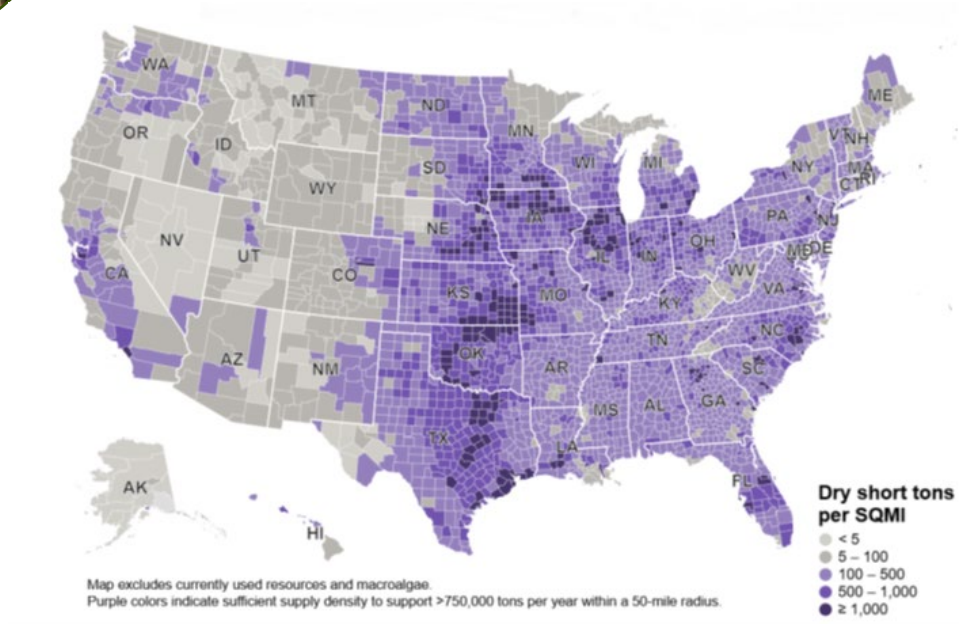
Opportunities to Incorporate Biomass and Waste as a Heat Source for Cement Production

Battelle Energy Alliance manages INL for the
U.S. Department of Energy's Office of Nuclear Energy

Idaho National Laboratory

What do we mean by Biomass?

>1 Billion Tons of biomass and wastes are available annually in the US



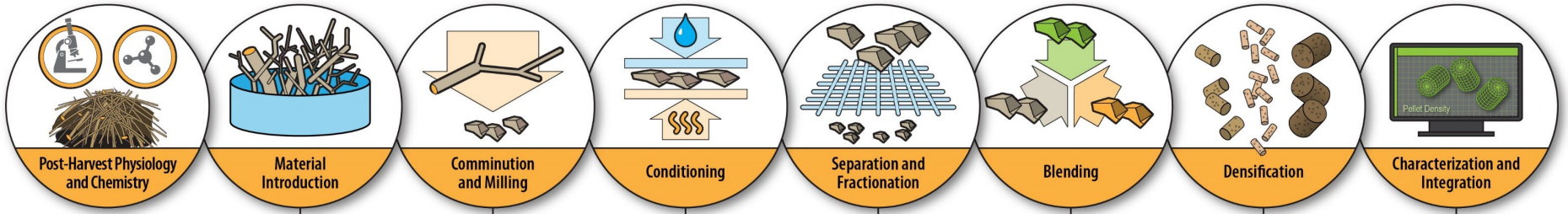
Overview: Biomass Feedstock National User Facility

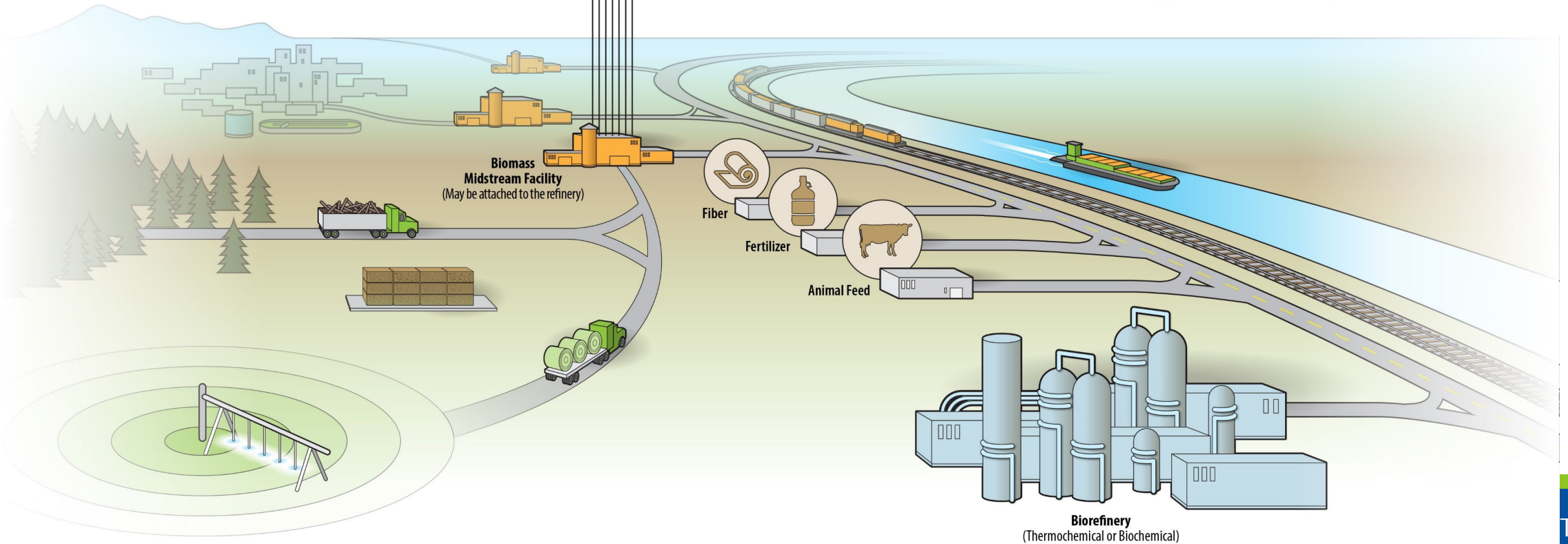
A national asset to de-risk the scale up of the bioeconomy, transforming diverse biogenic carbon sources and wastes into feedstocks for specific conversion processes.

Goal	Define the fundamentals of material preprocessing to mobilize feedstocks for clean fuels, chemicals and products

- Major Research Impacts and Challenges Addressed in BFNUF Upgrade
  - Solve challenges in **material variability and handling**
  - Material deconstruction and separations to **enable the circular carbon economy**
  - Mechanistic understanding to **enable new models and reduce scale up risk**
  - New characterization tools to **enable big data and AI development** into materials processing

Midstream Supply Chains to Manage Variability



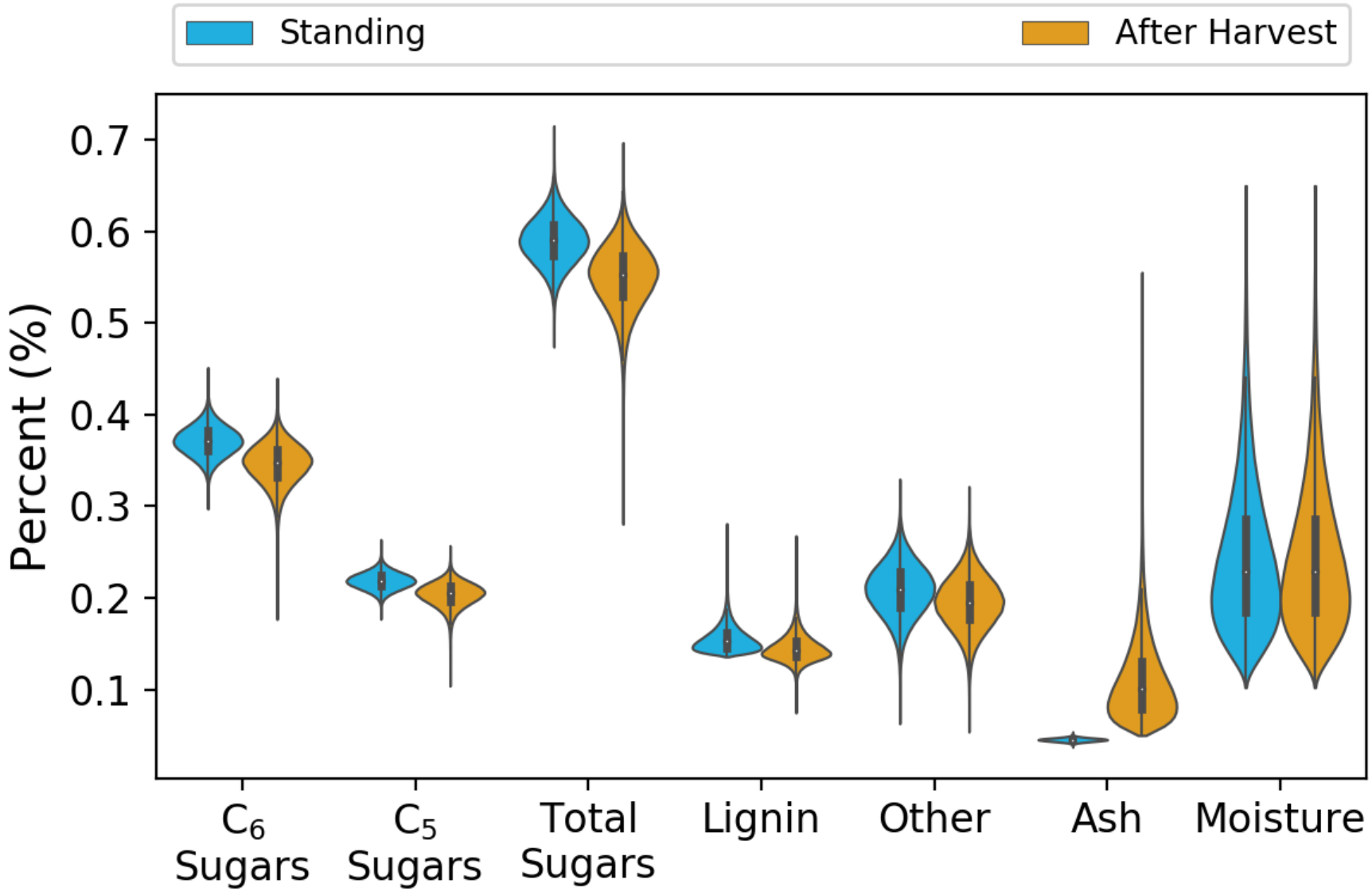


TORY

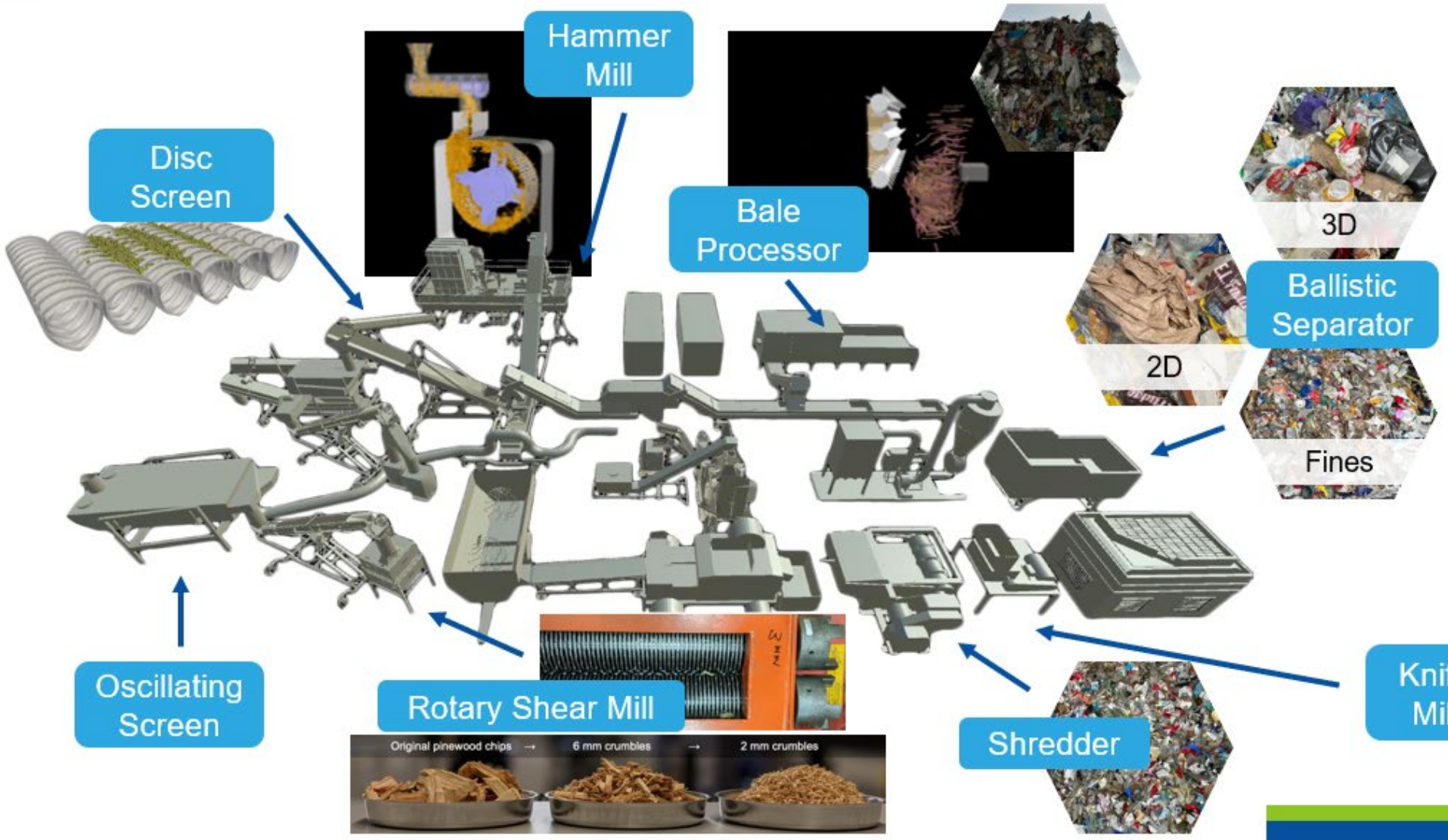
Challenges and concerns with utilizing biomass in cement production

- Biomass Supply and Availability:
  - Ensuring a consistent and reliable supply of biomass can be challenging, especially in regions with fluctuating agricultural output or limited forestry resources.
  - Seasonal variations and competition with other industries for biomass can lead to supply shortages or price volatility.
- Logistics and Transportation:
  - Transporting biomass from its source to cement plants can be costly and logistically complex, particularly for bulky and low-energy-density materials.
  - Efficient supply chain management and infrastructure are needed to minimize transportation costs and environmental impacts.
- Quality and Consistency:
  - Biomass feedstock can vary widely in terms of moisture content, calorific value, and chemical composition, which can affect combustion efficiency and emissions.

Variability in biomass quality



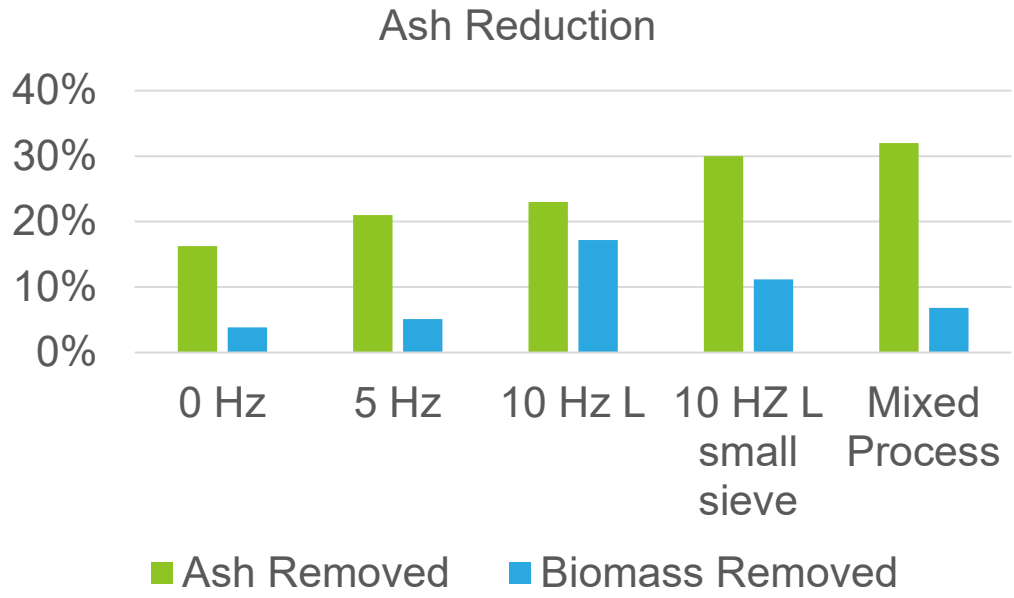
BFNUF Capabilities in SMART Piloting



Additional items not shown:

- Eddy Current Separator
- Air Classification
- Gravity Separator, Brush Screen
- Robotic Sorters
- Chemical Preprocessing
- Torrefaction
- Densification (Pellet, Cube, Briquette)

Separation of Organics and Inorganics – Air Classification



Black Bag Garbage Separation

Black Bag Garbage

Ballistic Screen

Paper and plastic rich fines

Paper

Glass

Light Plastic

Rigid Plastic

2D: Paper, OCC, Flexible Plastics

3D: Cartons, Bottles, Cans

Robotic, Automated Sorting

Examples of Preprocessed Feedstocks for Power Production

- Densification is a useful tool to manage variability:
  - Enables formulation to optimize quality
  - Enhances material flowability in handling and conveyance
  - Reduces transportation costs, enables rail and barge

50% biomass-MSW pellets

Corn stover pellets that resemble the heating value and particle size qualities of coal

Small Dry Process Facility – 500,000 tonne/yr production

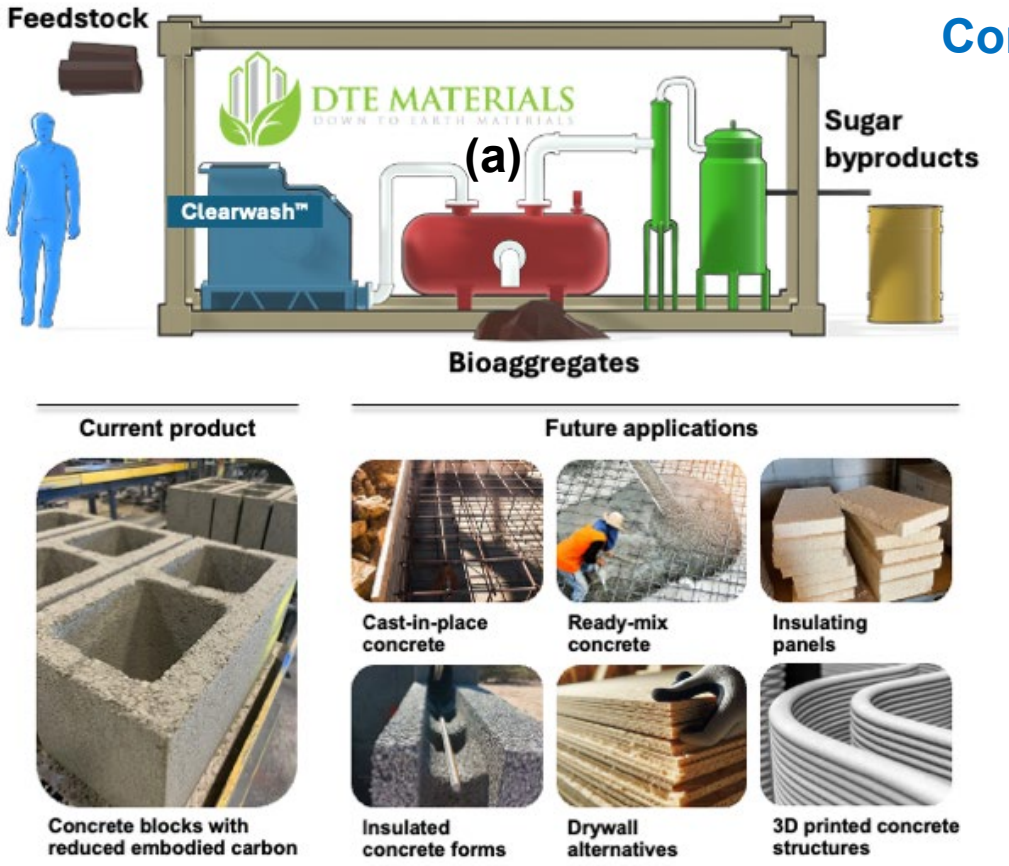
- Annual Feedstock Requirements
  - Wood: 138,695 tons/yr (533 tons/day)
  - Herbaceous: 148,601 tons/yr (571 tons/day)
  - Pellets: 130,026 dry tons/yr (500 tons/day)
- Transportation
  - Trucks
    - Wood: 25 trucks/day (1.5 trucks/hr)
    - Herbaceous: 30 trucks/day (1.9 trucks/hr)
    - Infrastructure needed: 1 offload points
  - Rail:
    - Pellets: 5 rail cars/day (2 100 car unit train every month)

Large Dry Process Facility – 2,000,000 tonne/yr production

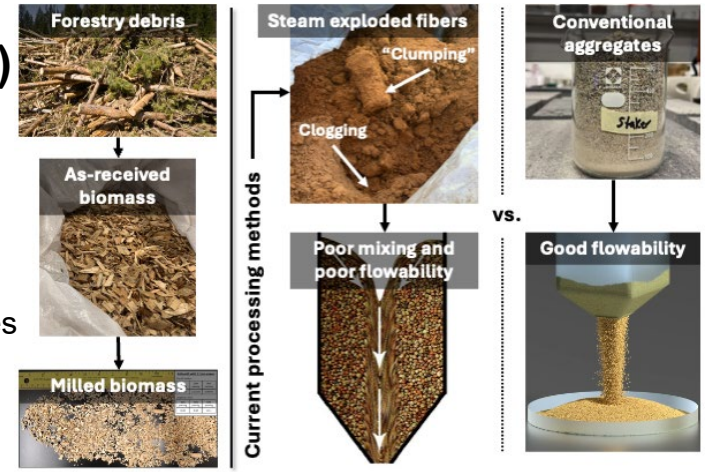
- Annual Feedstock Requirements
  - Wood: 554,779 tons/yr (2134 tons/day)
  - Herbaceous: 594,406 tons/yr (2,286 tons/day)
  - Pellets: 520,105 dry tons/yr (2,000 tons/day)
- Transportation
  - Trucks
    - Wood: 97 trucks/day (6.1 trucks/hr)
    - Herbaceous: 120 trucks/day (7.5 trucks/hr)
    - Infrastructure needed: 4 offload points
  - Rail:
    - Pellets: 20 rail cars/day (1 100 car unit train every five days)

Opportunities to Incorporate Biomass into Cement

Project: Enable Scale-up of Forestry Debris Carbon Entombment in Concrete Masonry Units via Optimized Feedstock Preprocessing

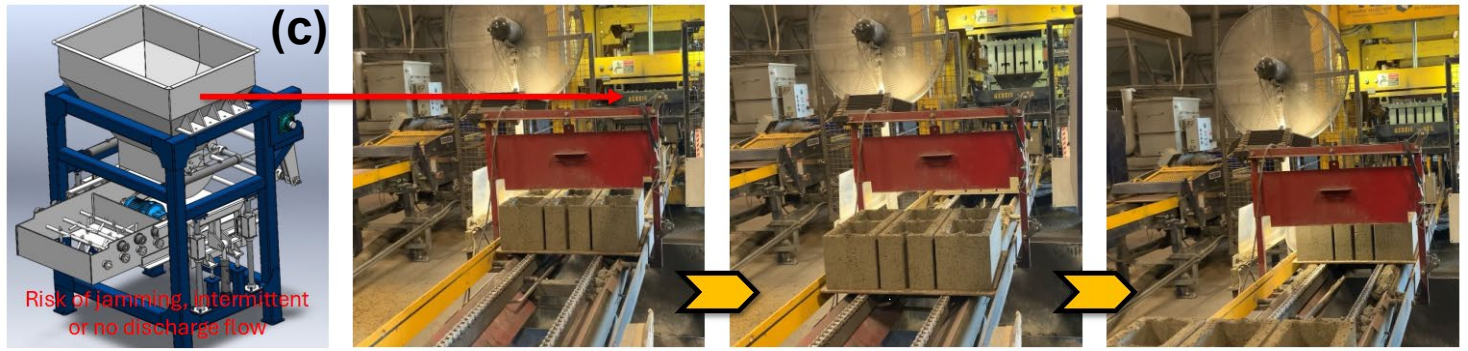


(a) A diagram of DET Materials' Clearwash™ technology and main output (bioaggregates) and by-products. The bioaggregates are currently used in CMU blocks with reduced embodied carbon.



(b) Illustration of processing pathway from forest debris to bioaggregates and the poor mixing and flowability problem as a bottleneck for production scale-up in contrast to conventional aggregates.

(c) Illustration of the silo-hopper flow of bioaggregates into the mold on the production line. INL's feedstock preprocessing capabilities will help industry optimize flowability of bioaggregates for scale-up production.



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Conclusions

- Cement production is a highly energy intensive industry that currently relies primarily on fossil-based fuel sources for the generation of heat.
- The high proportion of fossil energy use results in high carbon emissions, which may be a focus of regulation and/or a barrier to participation in some markets.
- Biomass may be a solution to reduce the use of fossil-based fuels and reduce the carbon emissions, while diversifying the energy portfolio and providing local economic development opportunities.
- There are a few technical challenges that exist with the use of biomass
  - Supply can be temporally and spatially variable
  - Logistics can be somewhat complicated
  - The quality of the material can be inconsistent
- Biomass can make sense as a fuel for thermal applications in the right locations, but opportunities should be evaluated carefully.

Acknowledgments

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Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy. INL is the nation's center for nuclear energy research and development, and also performs research in each of DOE's strategic goal areas: energy, national security, science and the environment.