U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2023 BETO Peer Review

Thoughts from BETO's Chief Engineer

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April 3, 2023

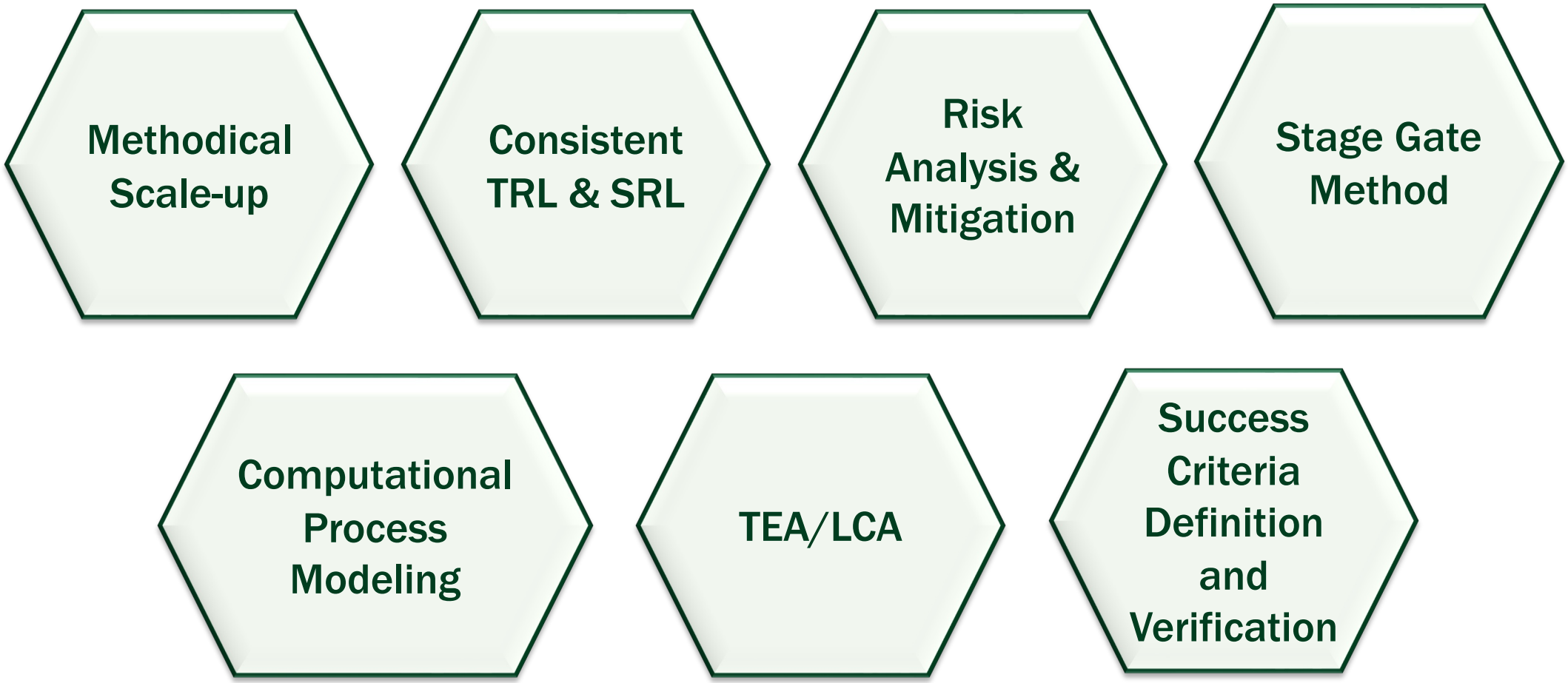
Agenda

- **Chief Engineer role in BETO**
  - Technology scale-up
  - Portfolio Analysis
- **An example of addressing barriers**
  - Cellulosic sugar production/depot model
- **Key take away messages**

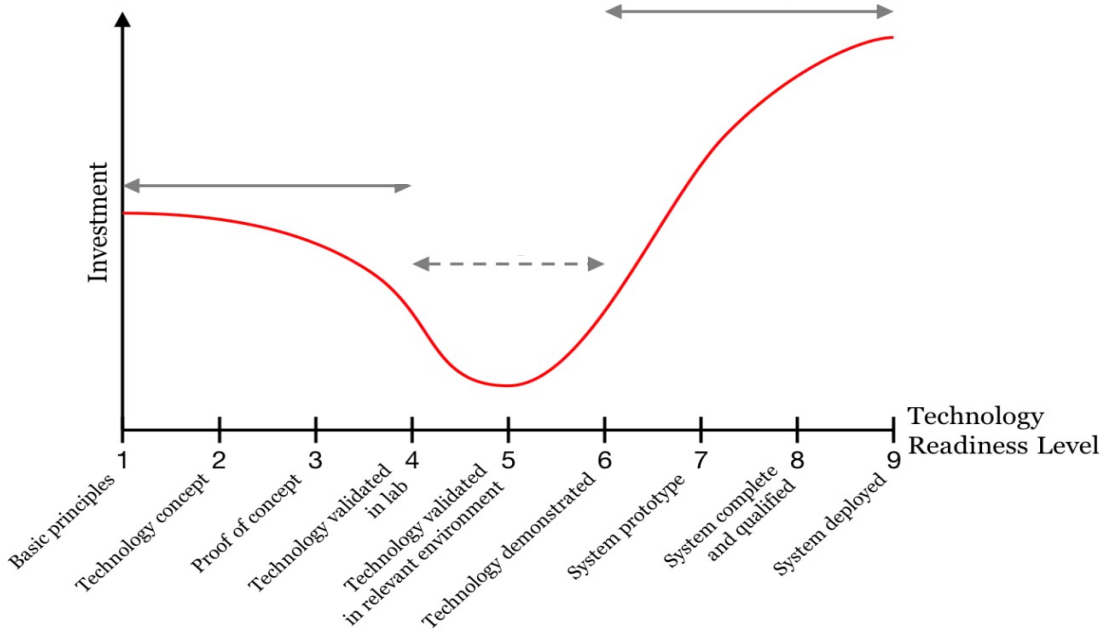
Chief Engineer Role

- Responsible for:
  - addressing key challenges to the integration and scale-up of bioenergy technologies
  - Identifying and addressing research gaps to reduce barriers to technology integration and scale-up
  - Managing bench-scale and sub-pilot research to accelerate scale-up and reducing the uncertainty that hinders private sector investment
  - Performing RDD&D portfolio analysis to map BETO's projects to its goals and identifying research gaps, with the aim to expedite the decarbonization of the transportation and the industry sectors

Successfully Scaling Up Chemicals and Fuels Technologies



- Understand the “disaster risk” factors like compressed schedule, rushed commissioning, or changing the feedstock/technology midstream
- Avoid after-thought approach to safety, regulatory, utilities
- Do not intentionally leave lessons to be learned at demo scale, full integration should start at pilot scale (scale down vs scale up)
- Adequate financing the pilot and demonstration scale is critical
  - Commissioning may take longer than anticipated (1-2 years)
  - Demonstrating successful operation is another 1 to 2 years



Industrial Involvement is crucial

- Any scaleup to engineering scale (pilot) or higher must include all stakeholders across the entire supply chain without competition in any area
- Partners should have commitments in form of
  - Joint development if still in research scale, and
  - Joint venture if in demonstration scale
- Use of industry ‘advisors’ is not sufficient at TRL>4, industry partners should be stakeholders with their own deliverables, commitments, and financial inverstment
  - This is how to ensure there is market pull

Key Activities and Collaborators for Technology Scale-up

Key activities

- Compelling business model preparation (which requires favorable stable policies and product positioning)
- Technology and manufacturing concept development
- Partnership development
- Product separation and finishing
- Quality assurance/quality control/product certification
- Long term feedstock and take off agreements
- Permits (environmental, water, production…)
- Waste disposal

Key collaborators

- Investors
- Developers
- Farmers/forest owners…
- Biomass harvester and supplier
- Biomass preprocessor
- Process/technology supplier and guarnator
- Catalyst/enzyme/microorganisms supplier
- Operators
- Distributors
- Customers

Cross cutting activities

Computational modeling | TEA/LCA | Risk analysis and mitigation

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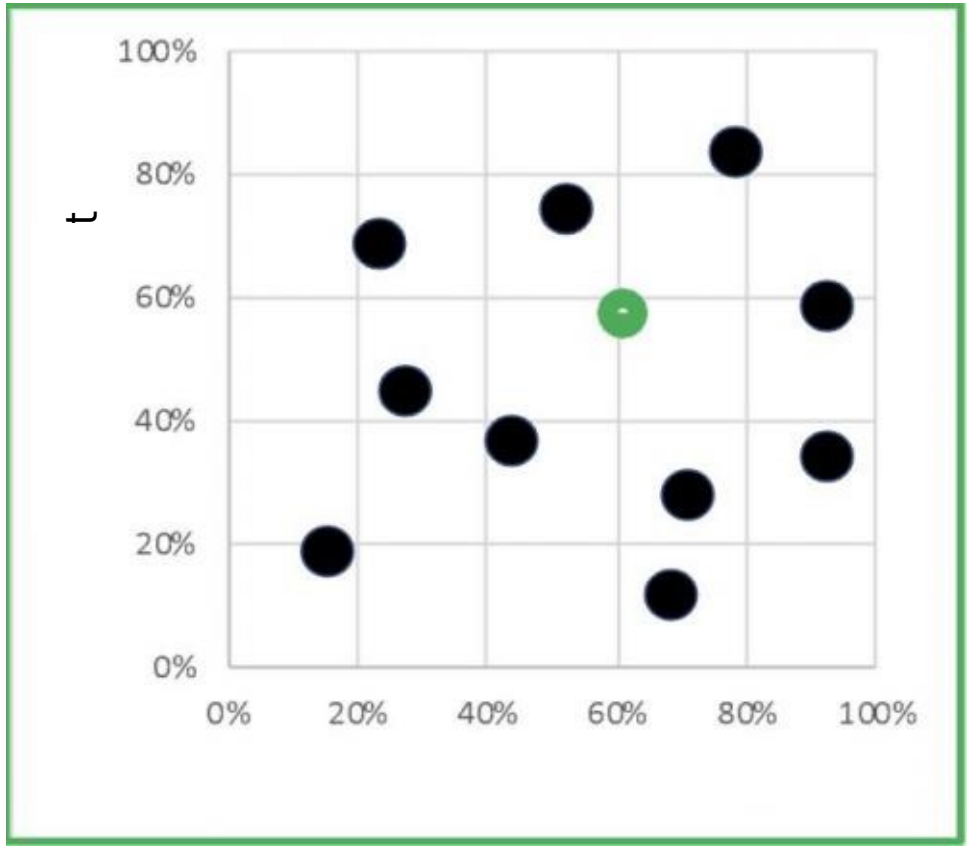
- RDD&D portfolio is a compilation of information about an organization’s investments in its technology research, development, demonstration and deployment

- The information is organized to show how these investments support the organization's goals and to demonstrate the relationships among current and planned investments

- Portfolio analysis is the process of reviewing or assessing the elements of the entire portfolio of projects



Portfolio Analysis Goals

- **Map each BETO project to:**
  - BETO Strategic Goals
  - BETO Performance Goals
  - BETO Priority R&D Strategies

- Identify and address overemphasized or underemphasized areas

- Identify and address portfolio gaps

- PEER review and Portfolio analysis will help identify priorities and manage BETO's portfolio with limited budget

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Addressing the Barriers to BETO's Goals

- **BETO Strategic goal:** *Decarbonize the transportation sector through research, development, and demonstration to produce cost-effective, sustainable aviation fuel and other strategic fuels*.
- **BETO performance goal:**
  - By 2030, enable delivery, preprocessing, and deconstruction of biomass and waste feedstocks to targeted biofuel intermediates that can meet industry-relevant cost and performance requirements, with a focus on sustainable aviation fuels capable of >70% reduction in GHG emissions relative to petroleum.
  - Along with industrial and federal partners, support 3 billion gallons of domestic SAF production and use, consistent with a trajectory to ultimately producing 35 billion gallons by 2050.

A major barrier: preprocessing and pretreatment of agricultural residues and energy crops

Barrier to SAF Production from Agricultural Biomass

1. Of the 1 billion tons potentially available biomass in 2030:
   - Agricultural residues' share: 150 million dry tons/year
   - Energy crops' share: 240 million dry tons/year
   - These two challenging to process agricultural feedstocks: 40% of total 1 billion tons/year

2. Harvesting and converting 30% of the total corn stover, could potentially produce 2.6 Billion gallons of biofuel (SAF)/year (assuming 52 GGE ethanol/dry ton CS)

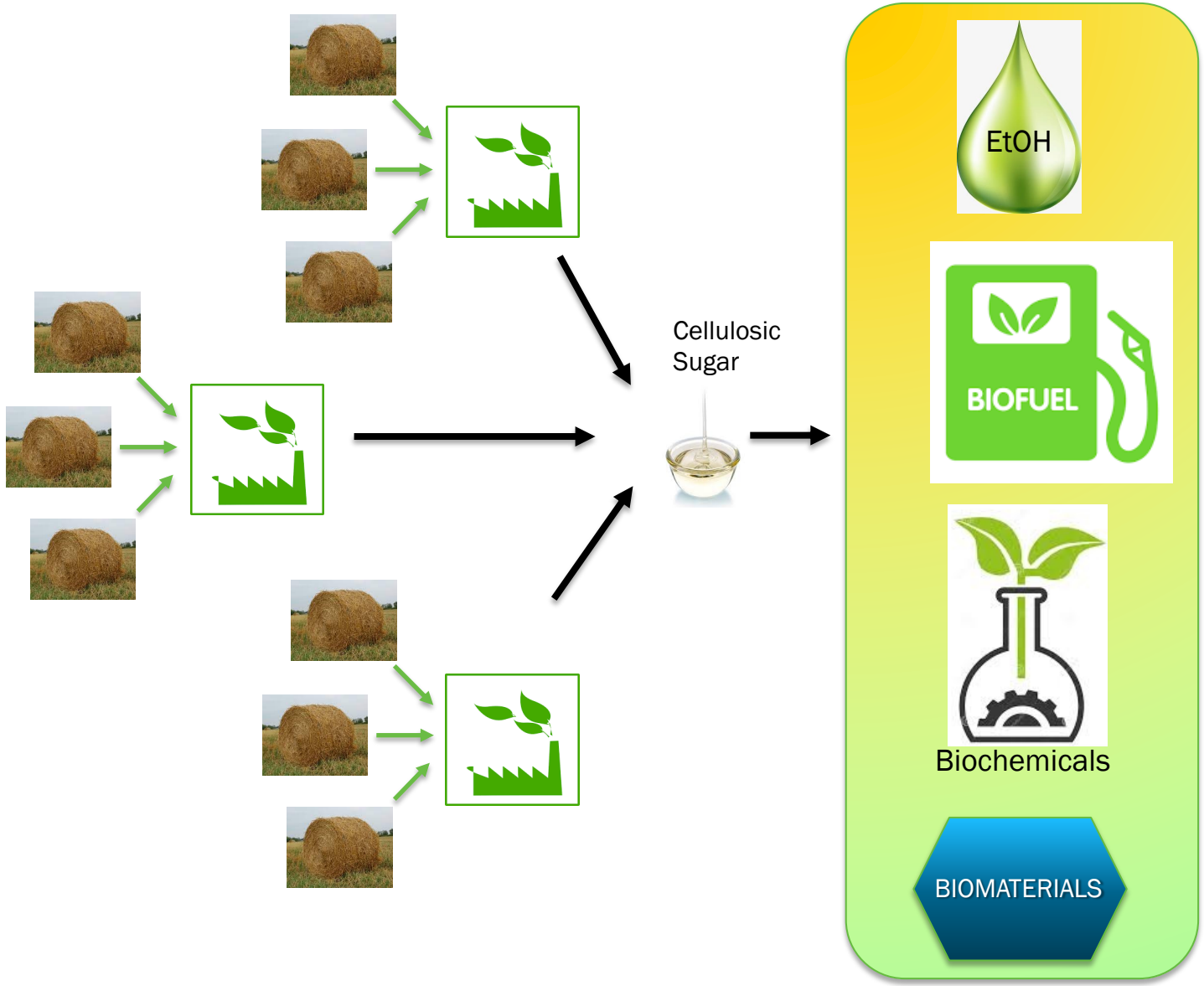
3. One of the major challenges to IBRs was in handling, feeding, pretreatment and liquefaction of the corn stover feedstocks

4. Scaleup of solids handling and processing presents a unique challenge

Cellulosic sugar as an intermediate commodity for further upgrading

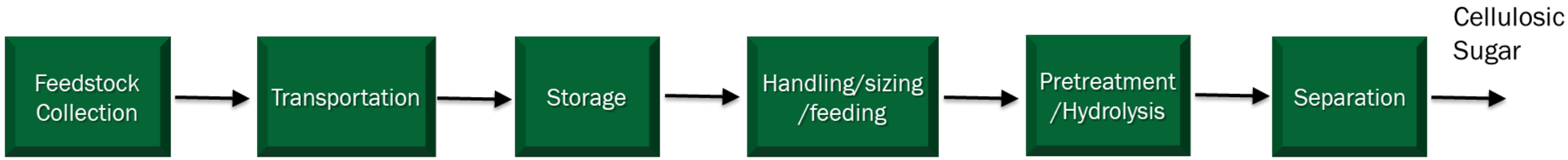
- Efficient and broad utilization of these residues/energy crops requires local transformation from a difficult-to-process solid feedstock to a higher density, stabilized, and valorized liquid or solid sugar commodity product.

- The stable, transferable, processable sugar can be further upgraded to SAF in refineries or biorefineries or be sold as a commodity for production of biochemicals and biomaterials.



Cellulosic Sugar Depot Study - Objectives

- Collect information on the state of the technology within industry.
- Assess the technology readiness for the sugar depot model
- Draw comparison between hot water hydrolysis/steam explosion, acid hydrolysis, DMR hydrolysis, and Ethanol/SO_2 hydrolysis including a TRL/SRL assessment of each, and identification of knowledge and research gaps.
- Update/tailor existing models for TEA and LCA of cellulosic sugar production from corn stover.
  - Verify whether this model is viable form technical, economical and sustainability point of views.
- Identify the CMA of the feedstock for the process (based on excellent FCIC's work)
- Identify the CMA of the cellulosic sugar for various applications



Key Take Away Messages

- The stakes are high, the scale is enormous, and the time is limited
- The feedstock is distributed and at times difficult to process and convert
- To succeed in decarbonizing the transportation and chemical industries, it is critical to:
  - Focus on the whole supply chain
  - Work with industrial partners and stakeholders
  - Learn from lessons learned and scale up methodically
  - Use existing industries and build around existing processes and their knowhows
  - Focus on scale up to achieve our goals for 2030
  - Fill the research and development pipeline to achieve our net zero goal by 2050 with new feedstocks and new technologies

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Together, we can do it!

Thank You!

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Questions for the BETO team?

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Learn more about BETO: energy.gov/bioenergy