Piloting Bioenergy Technology at NREL, Lesson Learned and a New Philosophy

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Mission Need

Motivation:

Dozens of technologies at TRL 1-3

Unique equipment needs (unit operations) and hazards (e.g., flammable gases).

NREL PDU configurations are hard-piped and are not easily reconfigurable. Designed to handle the hazards of 2-3 decades ago.

Appropriate capabilities that can support the variety of technologies do not exist in the U.S.

Lack of facilities will result in lack of scale-up diligence, building individual conversion path specific greenfield pre-pilot capabilities are time and cost prohibitive.

Community Engagement

Why has bioenergy struggled over the past decade(s) with commercialization?

What is needed to support successful deployment in the future?

How does a national lab piloting program fit within that solution?

Industry
Big and small
successful and those less so
Domestic and foreign

Academics
Experience going from inception to deployment

~150 interviews

Govt

National Labs

Why has bioenergy struggled?

Feedback	Approach
Funding	
Skipping steps and not understanding fundamentals	
Not using commercially relevant conditions or changing design between scale up steps	EFR Catalyst manufacturing capability Synergy with INL

What is needed for future success?

Feedback	Approach
Stop skipping steps/focus on fundamentals	
Timely access to pilot capabilities	
pilot what is needed, not what is there	Plug and play
End to end operations – need to make final products	Avoid stopping at the intermediate (bio-oil)

What is the role of a national lab pilot plant?

Feedback	Approach
10 ton/day, 5000 hours vs small/flexible	Focus on small/flexible; it's better aligned with our core capabilities

Additional feedback

1. Clear demand for flexible, modular piloting at the national labs
2. Retain leadership in analytical capabilities
3. Selective piloting coupled with computational modeling is the strongest approach to connecting to the *next* scale.
4. Look beyond biomass and prepare for future technologies
5. Machine learning, process data science, automation = strategic piloting

Where do we fit?

	Bench Work	NREL Piloting	Industrial Piloting	Demonstration
Purpose	Innovation and discovery	Technology and integration challenges	Engineering challenges	Operational challenges
Risks/barriers to be addressed	New chemistry, materials, or processes	Interface/interaction between unit ops, use of real form factors, optimization to hit major technology benchmarks, initial aging and durability tests	Maintenance cycles, process upsets, energy balances, corrosiveness, extended durability testing	Prove financial viability
Time (hours)	10s	100s	1,000s	10,000s
Product evaluation	Yield and selectivity Property estimation Scale: milliliters	Mass and elemental closures Compliance testing and fuel/blend property measurement (Tier 1 and 2) Scale: liters	Application testing Scale: barrels	Salable product Finalization of market testing Scale: tanker car
Feed and materials	Pristine (model compounds, powders) in idealized reactors	Relevant feedstocks and materials (form factors) in scalable unit operations	Commercial-spec feedstocks and materials starting to use actual unit ops	Commercial-spec feedstocks and materials starting to use actual unit operations and equipment
Number of operations	Might contain multiple unit operations, but R&D focused on a single unit operation	Integrated end-to-end processing	Inclusive with most ancillary operations	Everything
TRL	1–3	3–6	6–7	8

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