

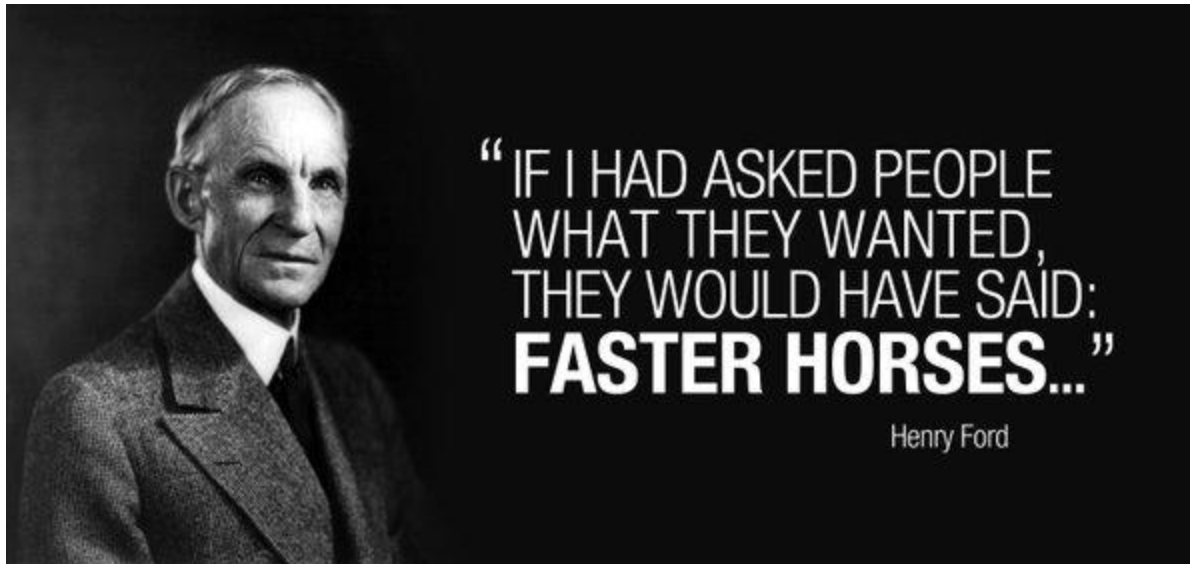


Challenges and Requirements in the Transition to New Fuels

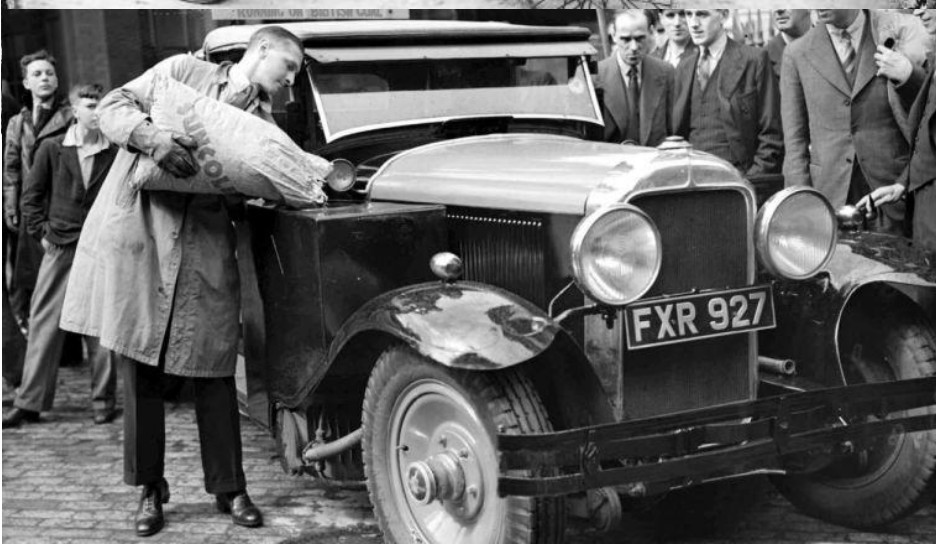
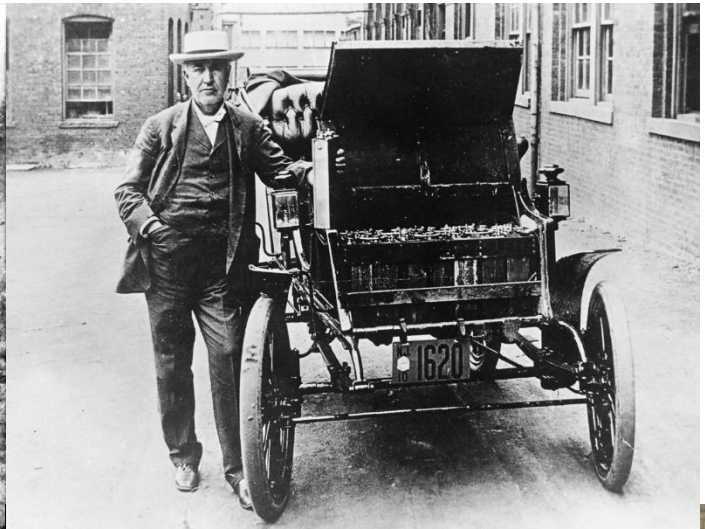
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Solutions We Didn't Know We Needed



Evolution of Go...Steam, Electricity and Coal



TODAY'S TECHNOLOGIES ARE NOT ENOUGH NEW FEEDSTOCKS, NEW APPROACHES ARE NEEDED



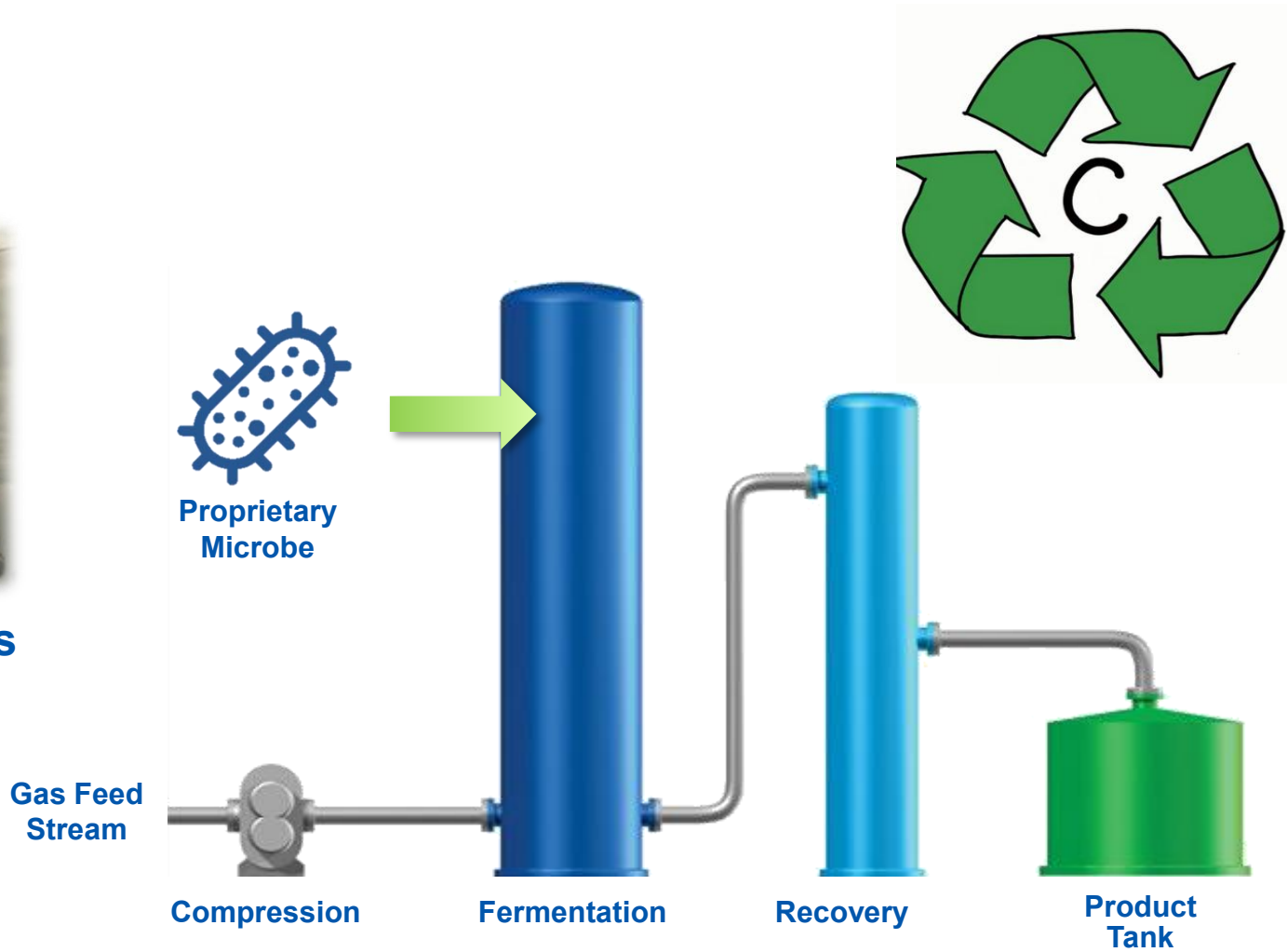
INNOVATION = OPPORTUNITY



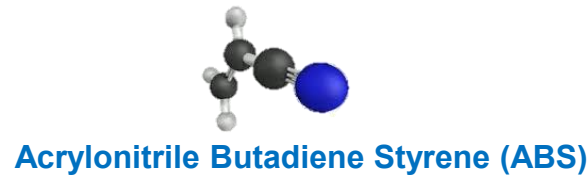
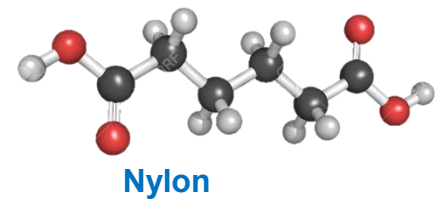
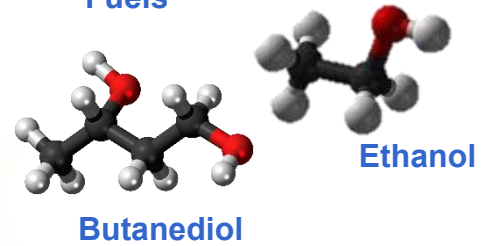
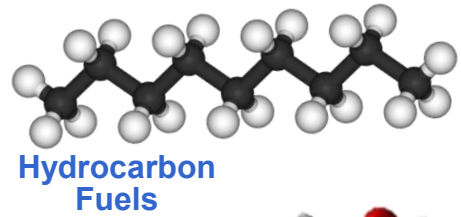
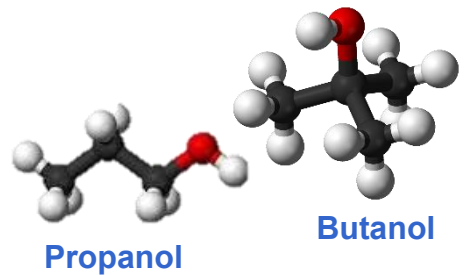
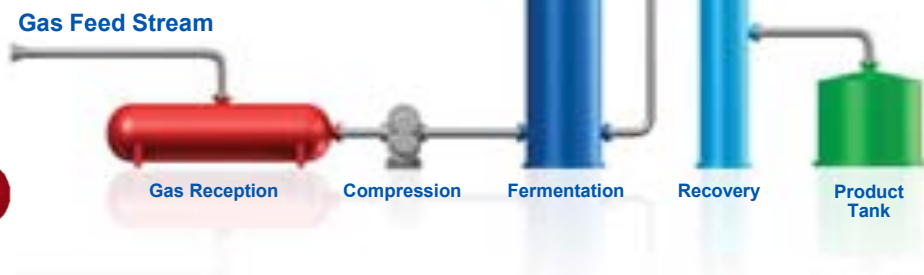
Recycling Carbon



Industrial Off Gas
✓ Steel
✓ Refining
✓ Ferroalloy



Building a Technology Platform



New Technology is Not for the Faint of Heart



Multiple Demo plants at various scales; >60,000 hours operation

LanzaTech

CELEBRATING 10 YEARS



Commercial Scale-up Factor Less Than What Has Been Proven at Demo Site



Commercial Scale Facilities



首钢朗泽

Shougang LanzaTech

Caofeidian, China
16M gallons/year
2017



ArcelorMittal



Gent, Belgium
21M gallons/year
2018



Commercial Scale Beyond Steel



IndianOil



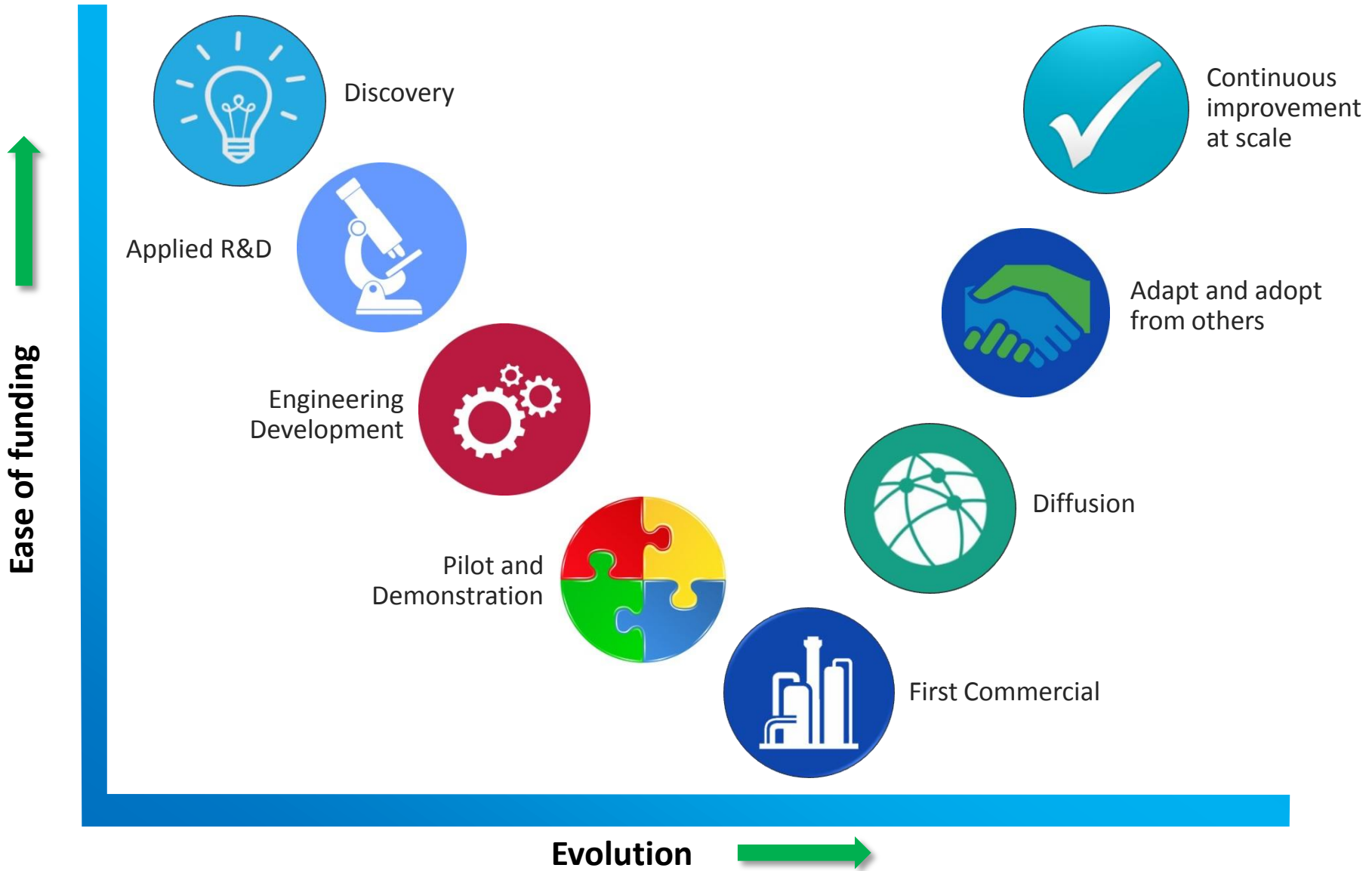
Hayrana, India
13M gallons/year
Refinery offgas
2019



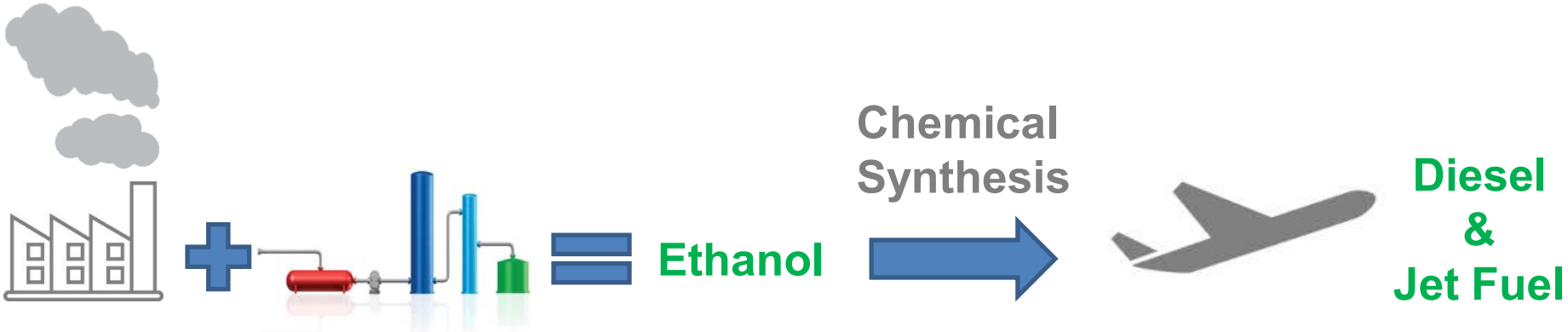
Modesto, California
8M gallons/year
Biomass Syngas
2018



Getting a New Process to Scale



Getting a New Fuel to Market



HSBC 

virgin atlantic 

 **BOEING**




Pacific Northwest
NATIONAL
LABORATORY

U.S. DEPARTMENT OF
ENERGY | Energy Efficiency &
Renewable Energy



LanzaTech 
capturing carbon. fueling growth.

LanzaTech Jet Fuel Production



✓ 4000 gallons Jet
✓ 600 gallons Diesel

- **Demonstrated feedstock flexibility**
 - 1,500 gal from Lanzaol
 - 2,500 gal from Grain Ethanol
- **Lanzaol produced in an RSB-certified facility**
 - Shougang-LanzaTech 100,000 gal/yr China demonstration plant

Increased Run Time and Production Rate

Improved Product Yield

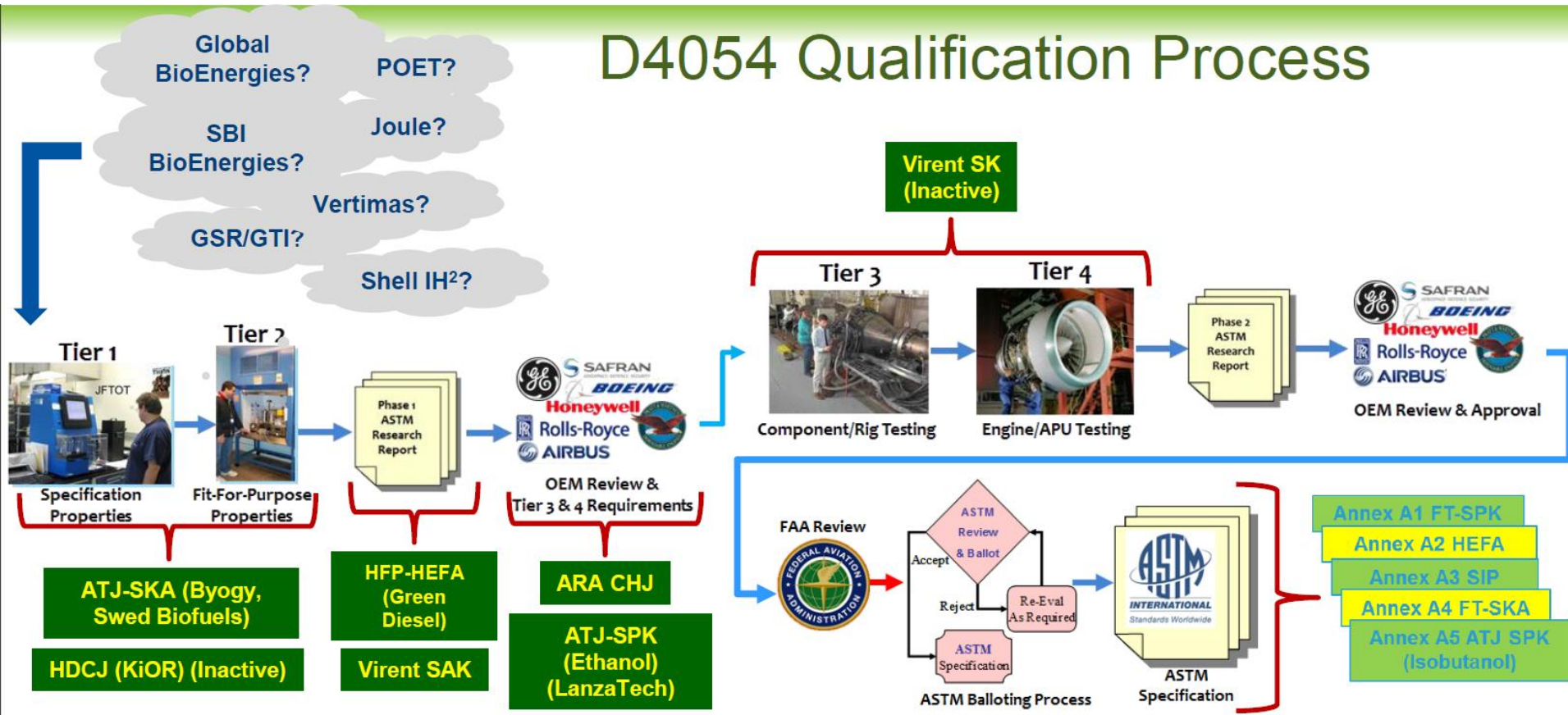
Reduced Operating Cost

Lower Cost Commercial Product



Qualification of Alternative Jet Fuels

D4054 Qualification Process



Mark Rumizen, FAA. "Alternative Jet Fuel (AFJ) Certification"
 ICAO Seminar on Alternative Fuels (Montreal), February 8-9, 2017

Alternative Jet Fuels qualified through a rigorous process of testing and review by engine and aircraft OEMs.



Great Progress on AJF Qualification

“Less than a decade ago, the prospect of flying commercial aircraft on sustainable aviation fuels (SAF) seemed unrealistic due to the associated technical and safety challenges, the developments have been impressive!” IATA Roadmap

Type	ASTM approval	When
Fischer Tropsch (FT) (or BtL)	Max 50% blend	2009
Hydrotreated Esters and Fatty Acids (HEFA)	Max 50% blend	2011
Renewable Synthesized Iso-Paraffinic (SIP)	Max 10% blend	2014
FT-SPK/A	Max 50% blend	2015
Butanol to Jet Fuel (ATJ)	Max 30% blend	2016

...but qualification requires large volumes of fuel plus time, cost and effort by all parties



A Model to Expedite Qualification

D4054 Clearinghouse Concept

Structured as a Cost Share Arrangement

FAA Seed Money Under ASCENT Center of Excellence

Accepts In-Kind Contributions (testing partners)

Also Accepts Direct Contributions

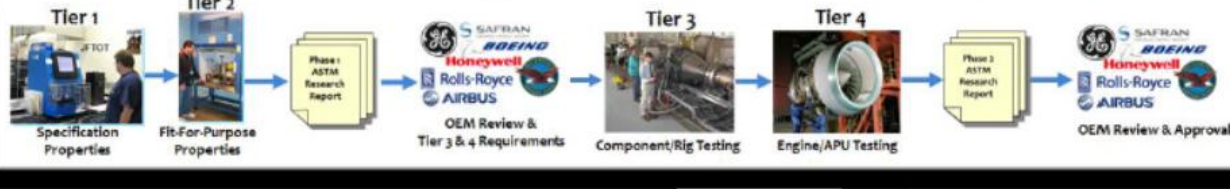
Stakeholder Engagement /Support Needed!

Final Research Report Out

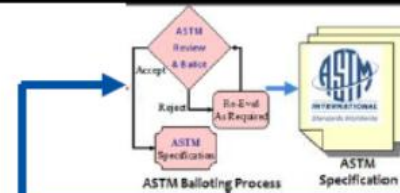
University of Dayton Research Institute (UDRI)



Candidate AFJ In



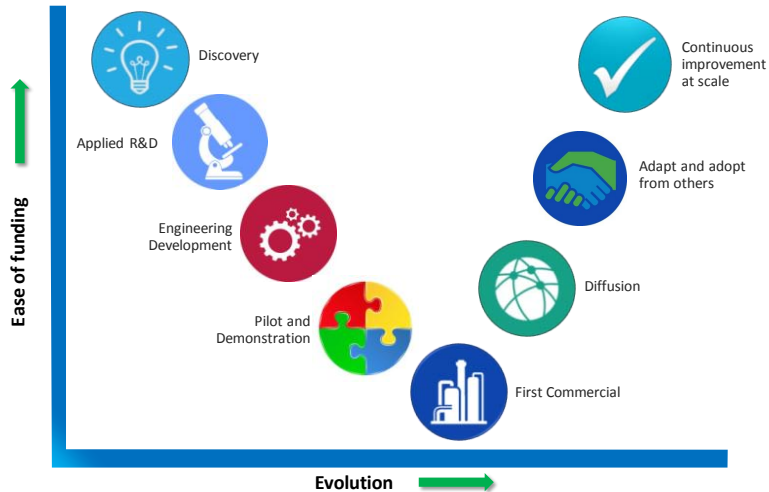
UDRI Contact
 Dr. Steven Zabarnick
Steven.Zabarnick@udri.udayton.edu
 (937) 255-3549



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What is Required for Success from a Producer's Perspective?

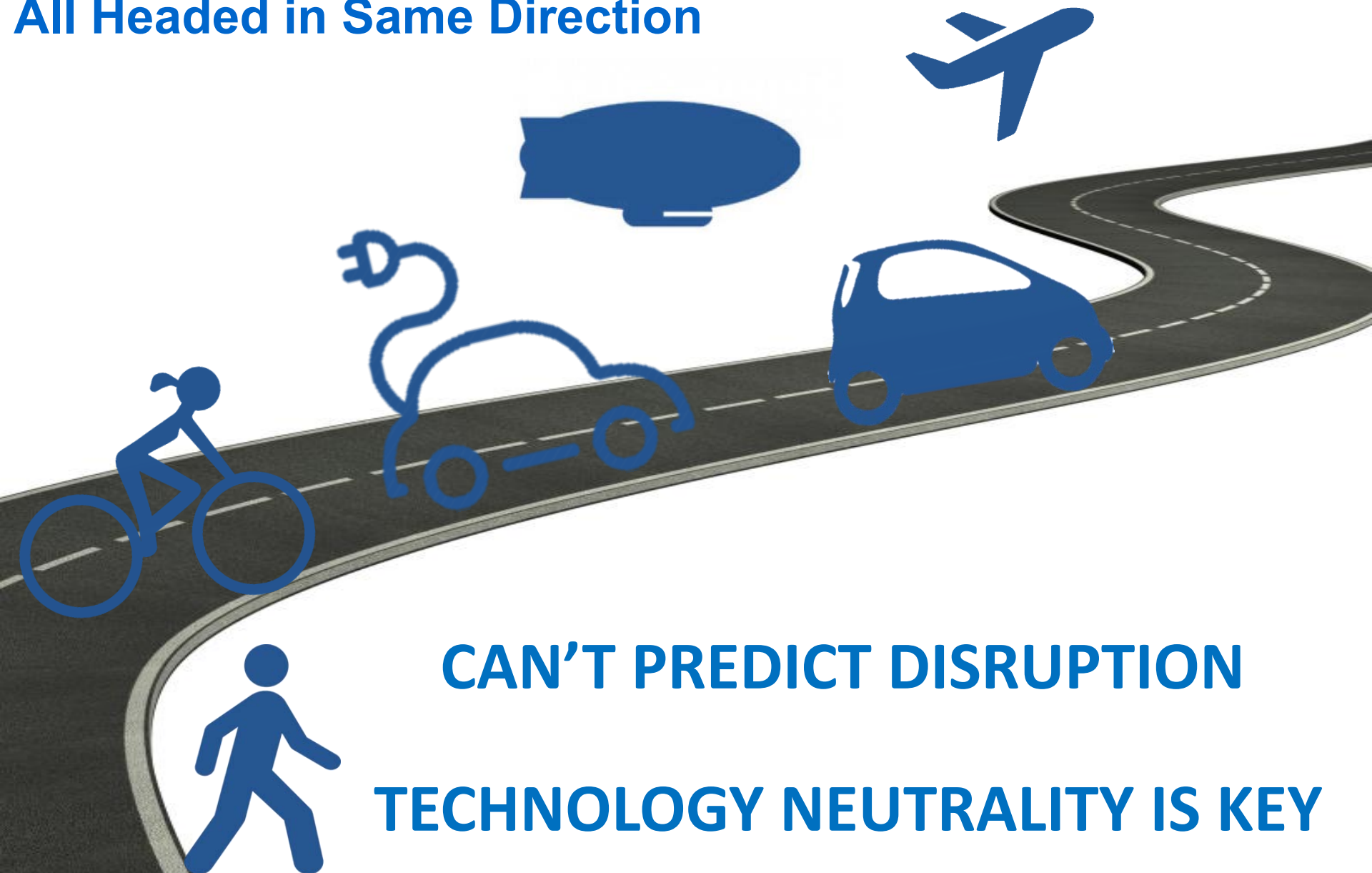


- **Technology-neutral, performance-based standards for new fuels and fuel components**
- **Clear process and data requirements for qualifying new fuels and additives in the context of current and future engines**
- **Structure and resources for stakeholder engagement (fuel producers, engine and vehicle OEMs, government agencies)**
- **Technology-neutral regulatory framework(s) that can encompass new fuels and additives without legislative change**

All elements must be in place with sufficient lead time to provide certainty for investment in scale-up and commercial deployment



All Headed in Same Direction



CAN'T PREDICT DISRUPTION

TECHNOLOGY NEUTRALITY IS KEY

