



Industrial Ecology and Alternative Aviation Fuel

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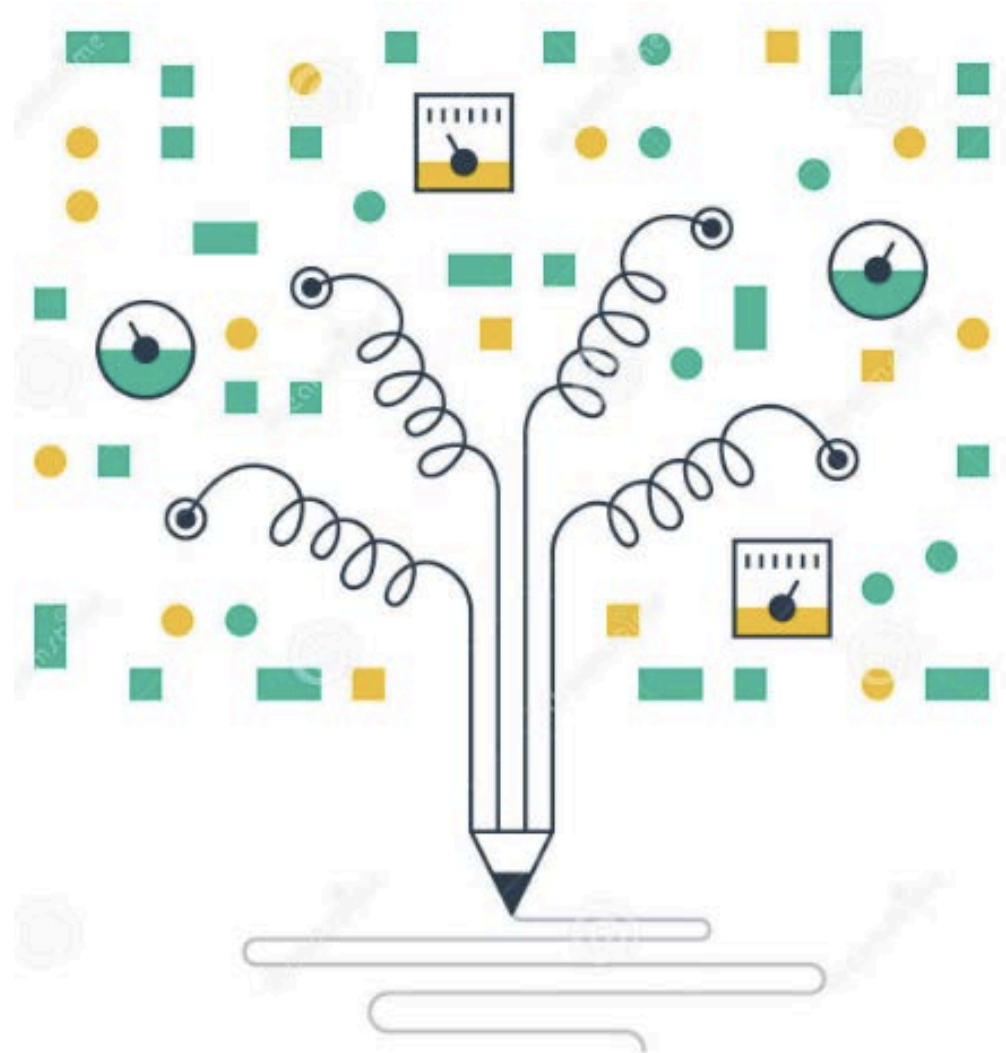
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June 16 2017



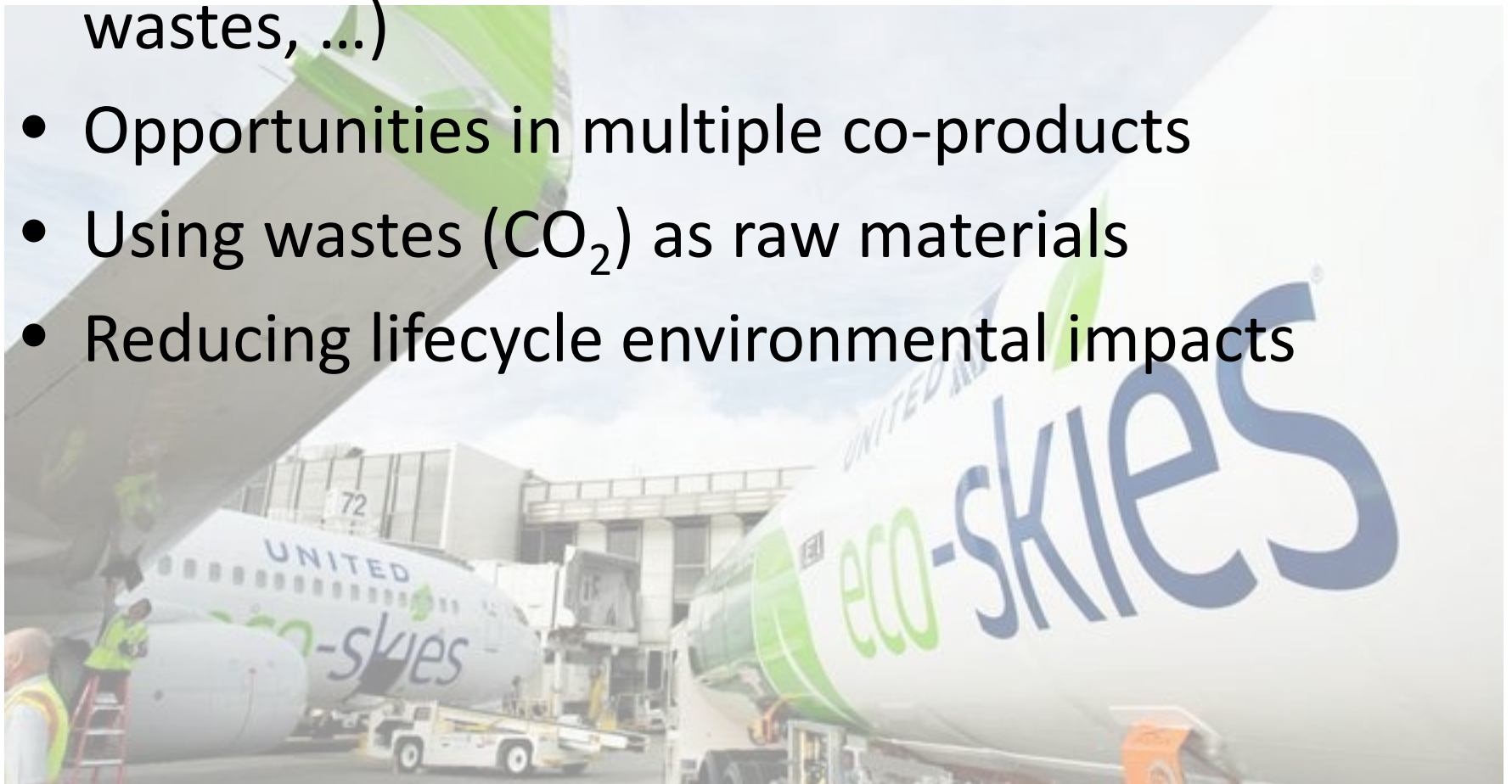
Industrial ecology: Testing ideas, designing and evaluating systems

- Why do some eco-industrial parks succeed?
- What are the system environmental impacts?
- What are the material and energy flows?
- What are optimal systems and how to find them?
- How do technology transitions happen?



Biofuel Efforts Exemplify Some Industrial Ecology themes

- Opportunities in low-value feedstocks (e.g. wastes, ...)
- Opportunities in multiple co-products
- Using wastes (CO_2) as raw materials
- Reducing lifecycle environmental impacts



Biofuel Efforts Missing Some Industrial Ecology themes

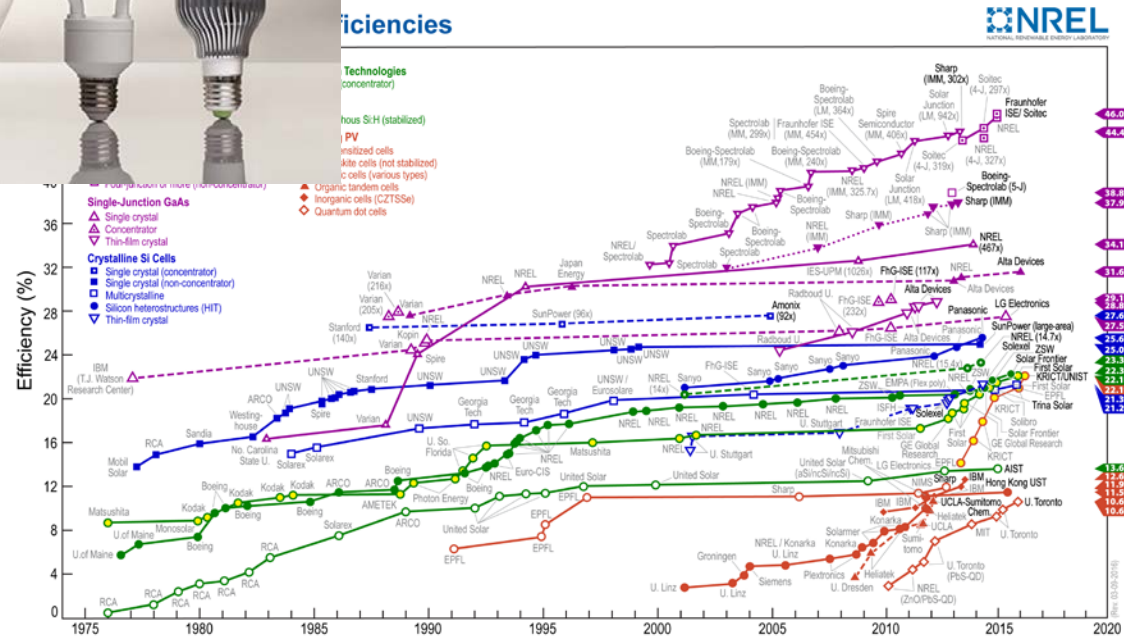


- Full system perspective?
- Technology transition perspective?
- Co-evolution of vehicle and fuel and market?
- Scale issue?

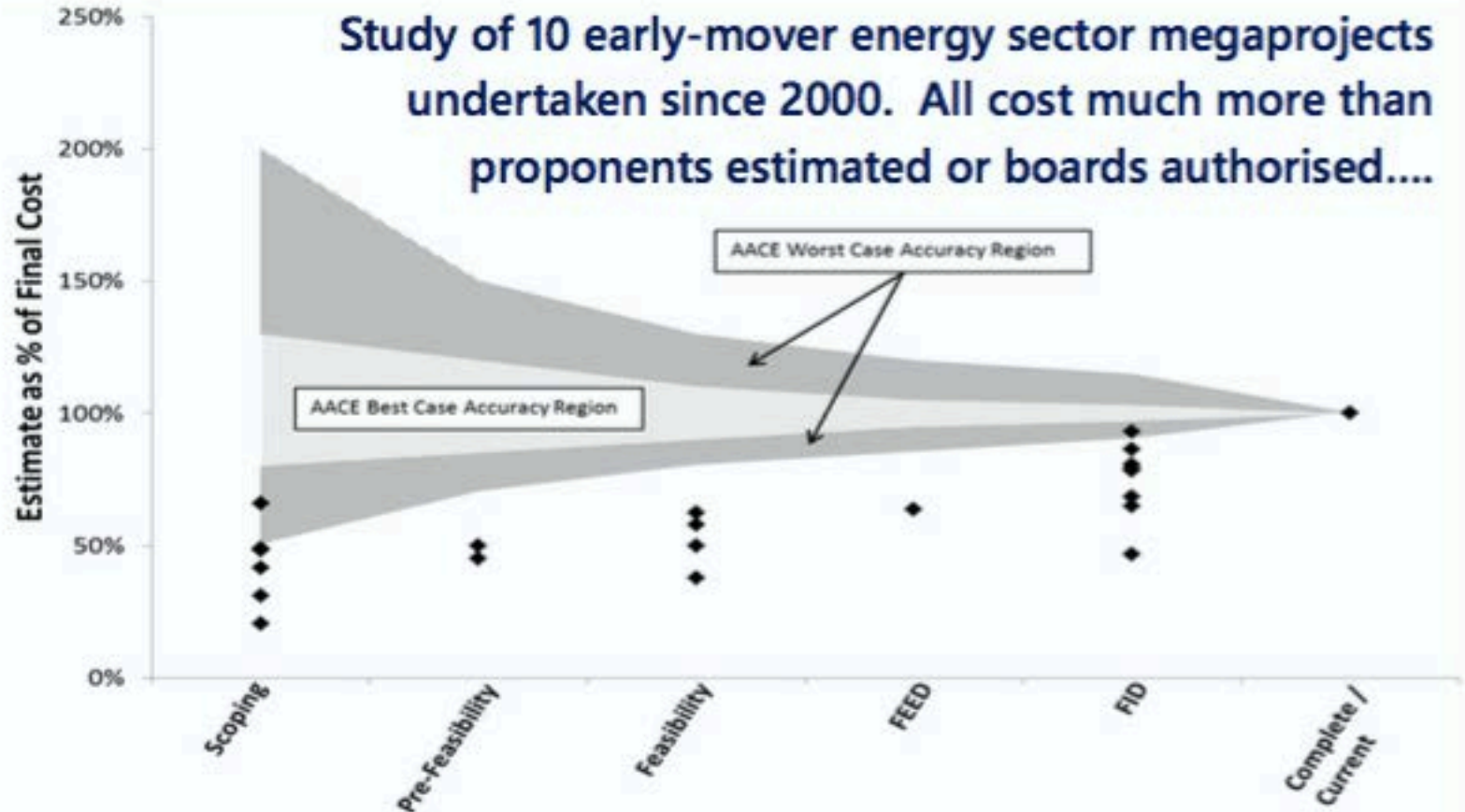
Comparison to Other industries



- Lighting
- Telephones
- Photovoltaics
- Ethanol
- Nuclear Power
- Carbon Capture and Storage
- Fusion

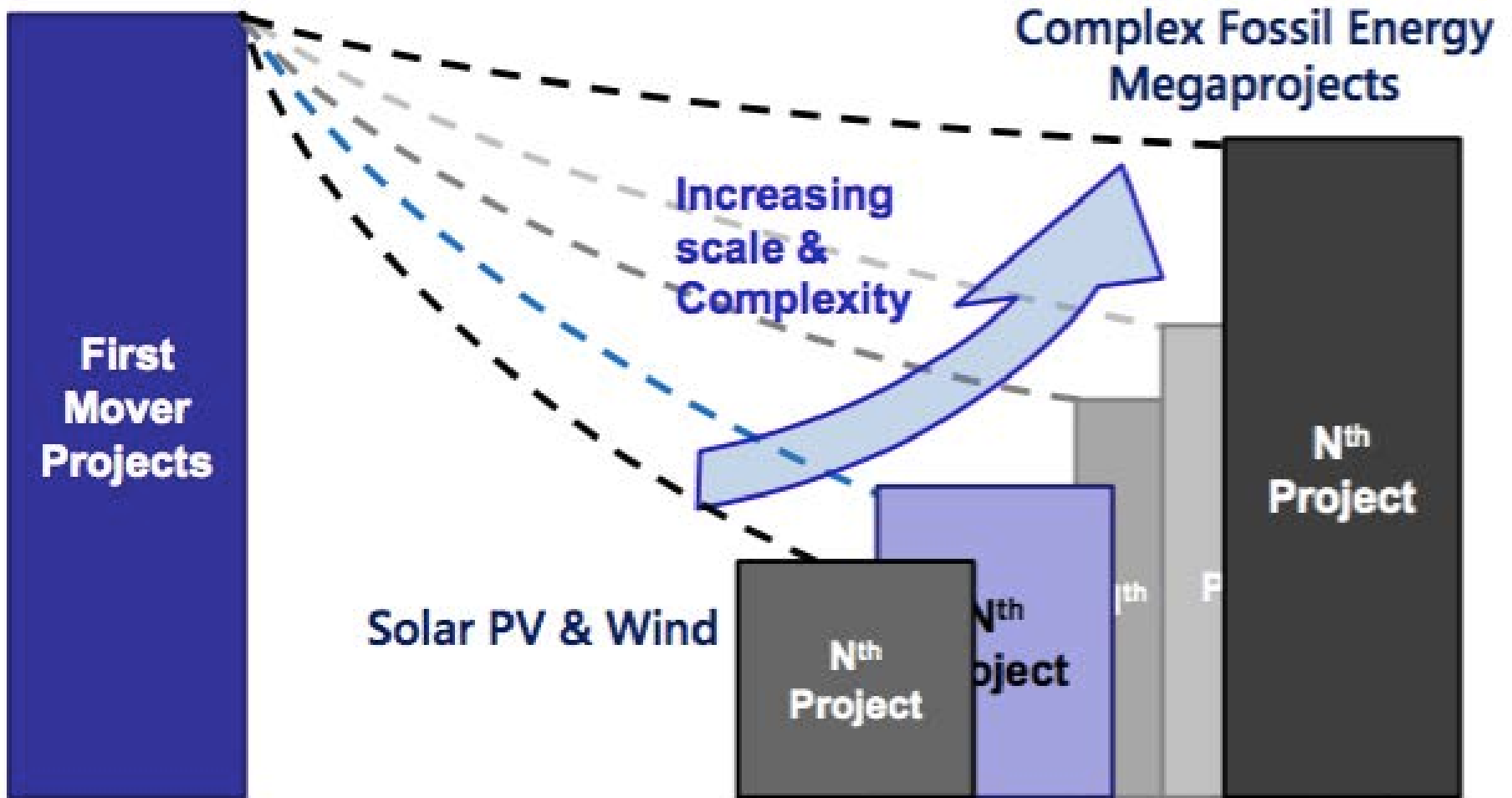


First of a kind projects are challenging

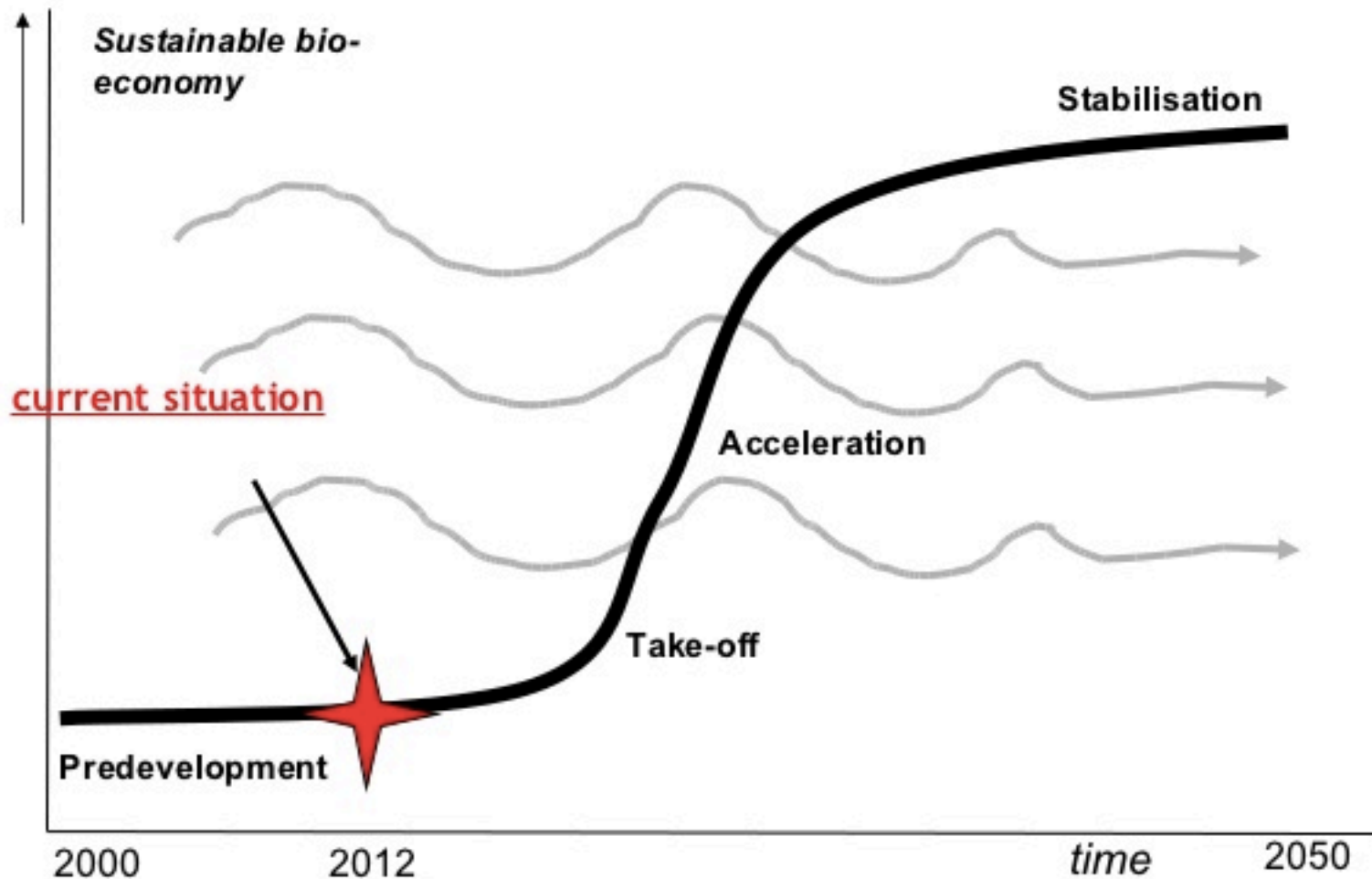


Greig, Garnett, Oesch, & Smart, (2014) *Guidelines for Scoping and Estimating Early Mover CCS Projects*, ANLEC R&D Final Report.

Learning Curves Uncertain as Scale and Complexity Increase



Industrial Ecology: Framework for Industrial System Transition





LanzaTech
CELEBRATING
10 YEARS

Industrial Ecology: Carbon Recycling



LanzaTech
capturing carbon. fueling growth.



Energy can be Carbon free



Aviation Fuel needs Carbon



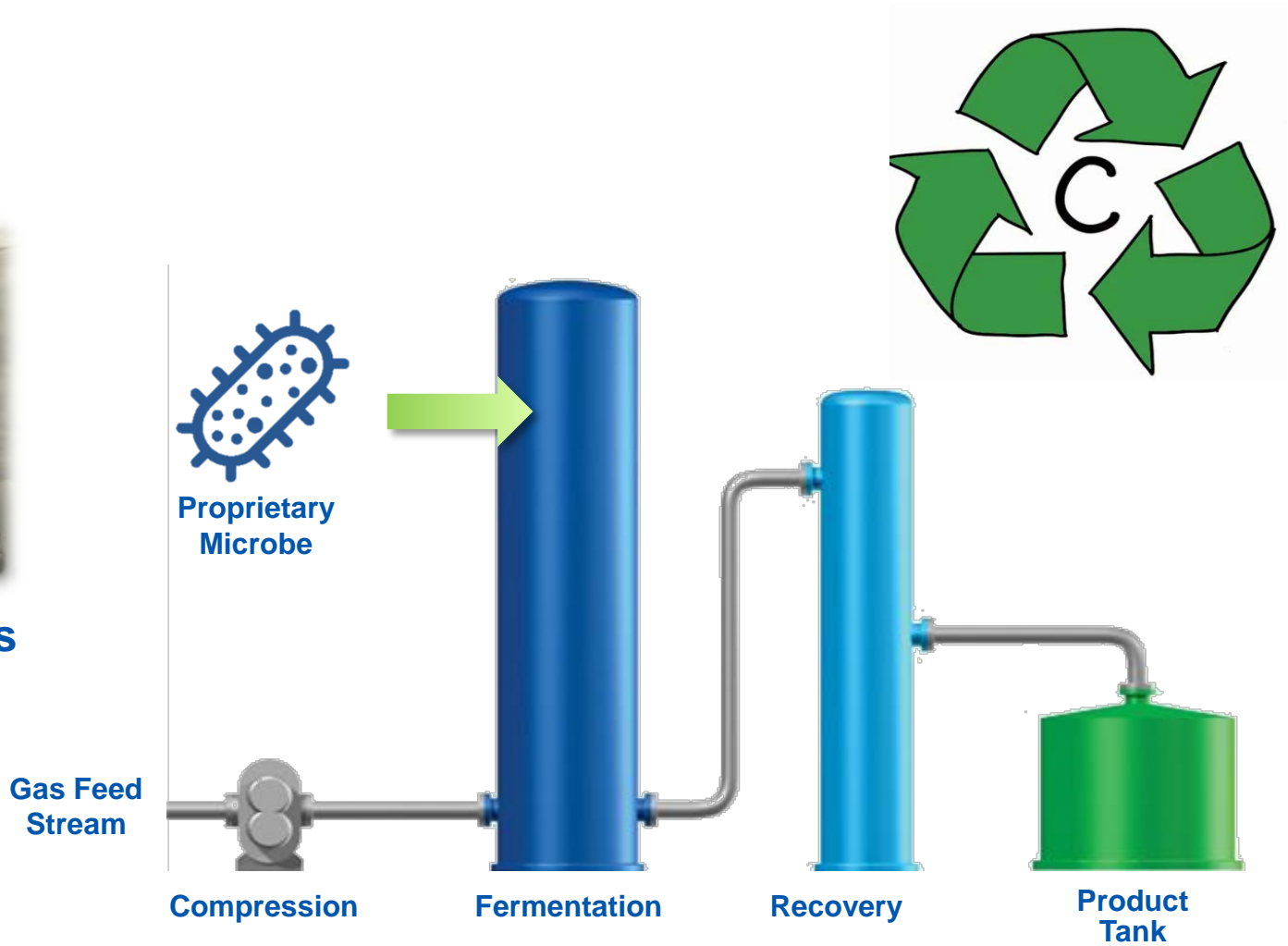
Chemicals for Everyday Products need Carbon



Recycling Carbon



Industrial Off Gas
✓ Steel
✓ Refining
✓ Ferroalloy





LanzaTech

SAFETY FIRST

Recycling Carbon Around the World



首钢朗泽
Shougang LanzaTech

Caofeidian, China
16M gallons/year
2017



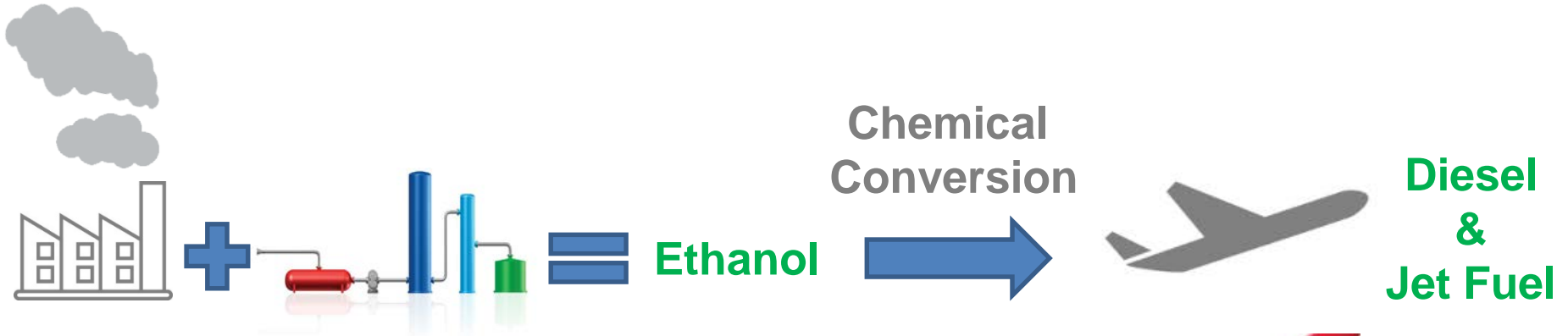
ArcelorMittal



Gent, Belgium
21M gallons/year
2018



From Mill to Wing



HSBC



virgin atlantic



首钢朗泽
Shougang LanzaTech



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



Recycling waste from manufacturing
into hydrocarbon fuels



LanzaTech
capturing carbon. fueling growth.

LanzaTech Jet Fuel Production at Freedom Pines



✓ 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





Liquid Fuels



Polyethylene

+\$ /MT CO₂



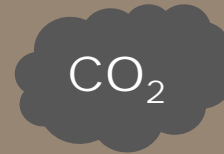
PET



Nylon



Carbon
- \$ /MT CO₂



Capturing Carbon. Generating Revenue. Reducing Emissions.
NOW

