

Mill to Wing: *New Low Carbon Route to Aviation Fuel*



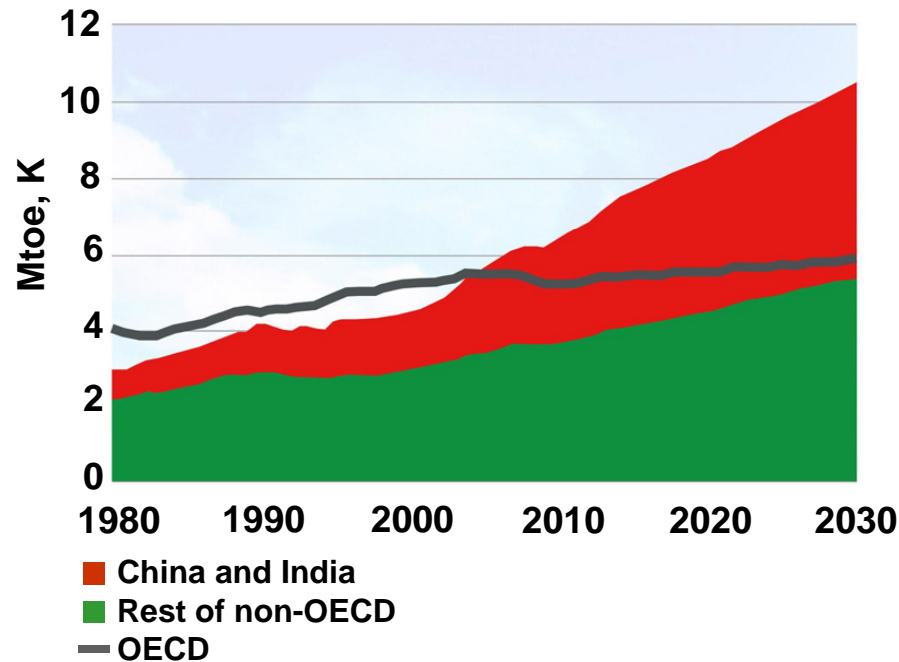
Dr. Jennifer Holmgren
CEO, LanzaTech Inc.

ICAO Workshop on Aviation & Sustainable Alternative
October 18-22, 2011
Montreal, Canada

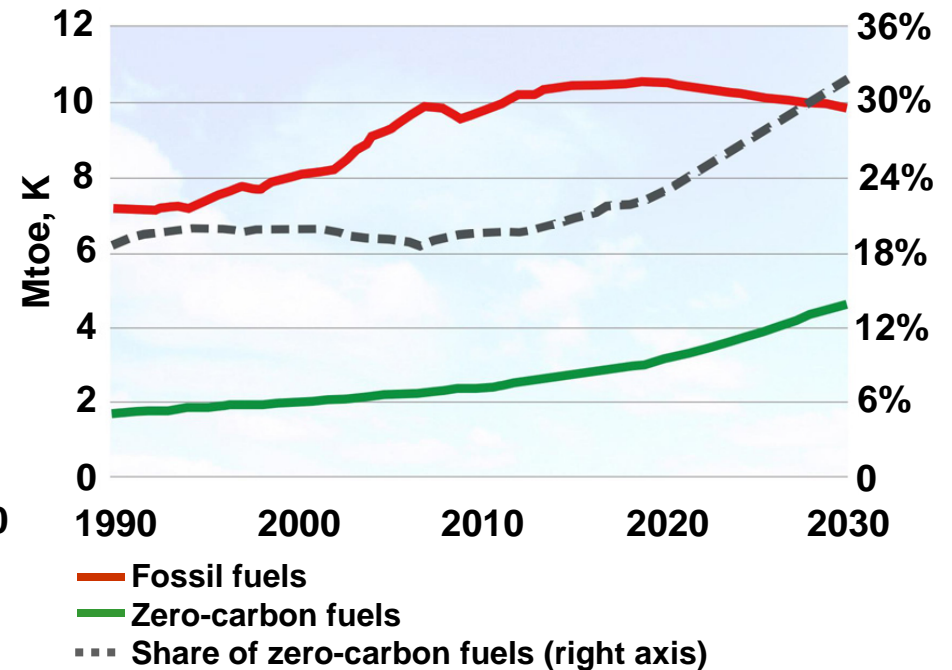


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Carbon Capture, Beneficial Re-Use & the Need for Renewable Fuel



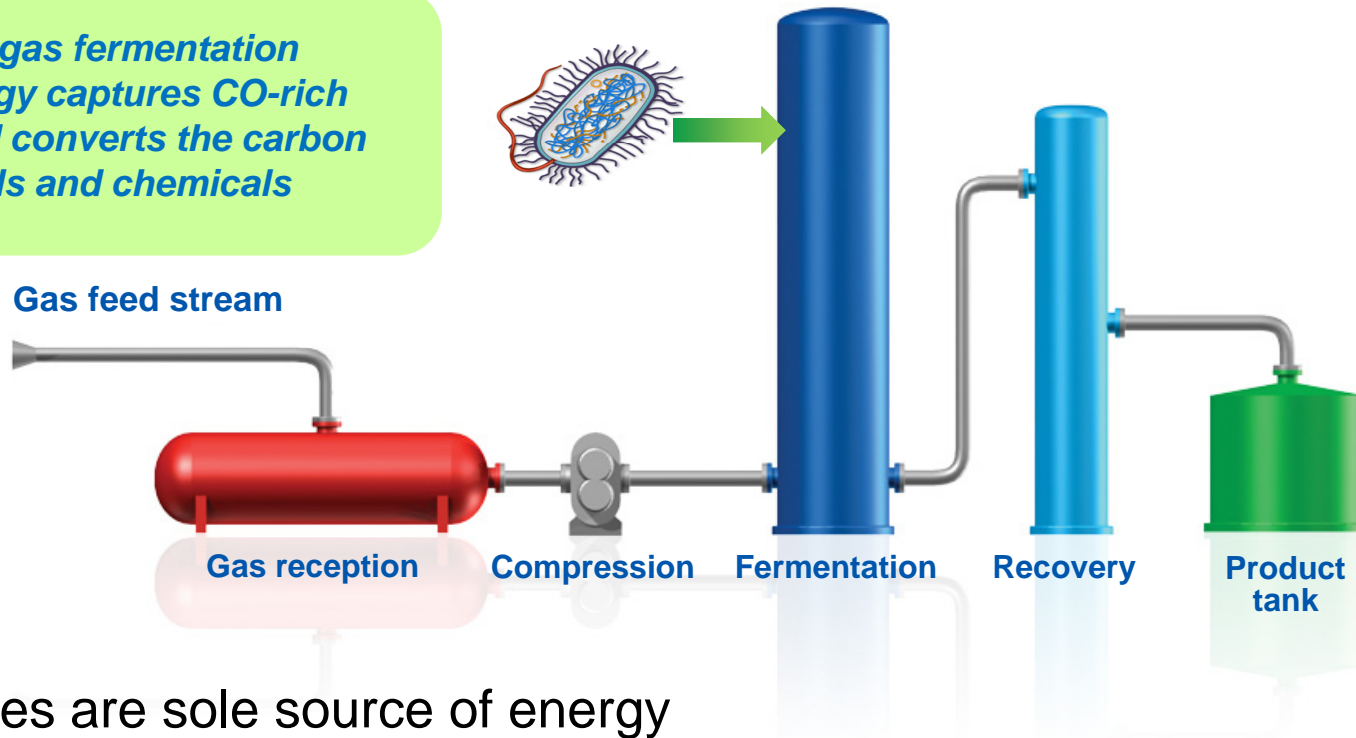
Source: IEA World Energy Outlook 2009



- **Global energy demand will double over the next 40 years.**
- **Containing CO₂ growth to safe atmospheric levels requires that zero carbon renewable fuels make up more than 30% of the fuel pool.**
- **Industrial growth must be offset by increased energy efficiency, minimized waste and a reduced GHG footprint.**

The LanzaTech Process

Novel gas fermentation technology captures CO-rich gases and converts the carbon to fuels and chemicals



- Gases are sole source of energy
- Potential to make material impact on the future energy pool (>100s of billions of gallons per year)
- Completely outside of the food value chain
- Biofuel, carbon capture and energy efficiency technology solution



1.4 billion
tons steel/yr Globally

Ethanol Potential From LanzaTech Process

30 billion gal/yr

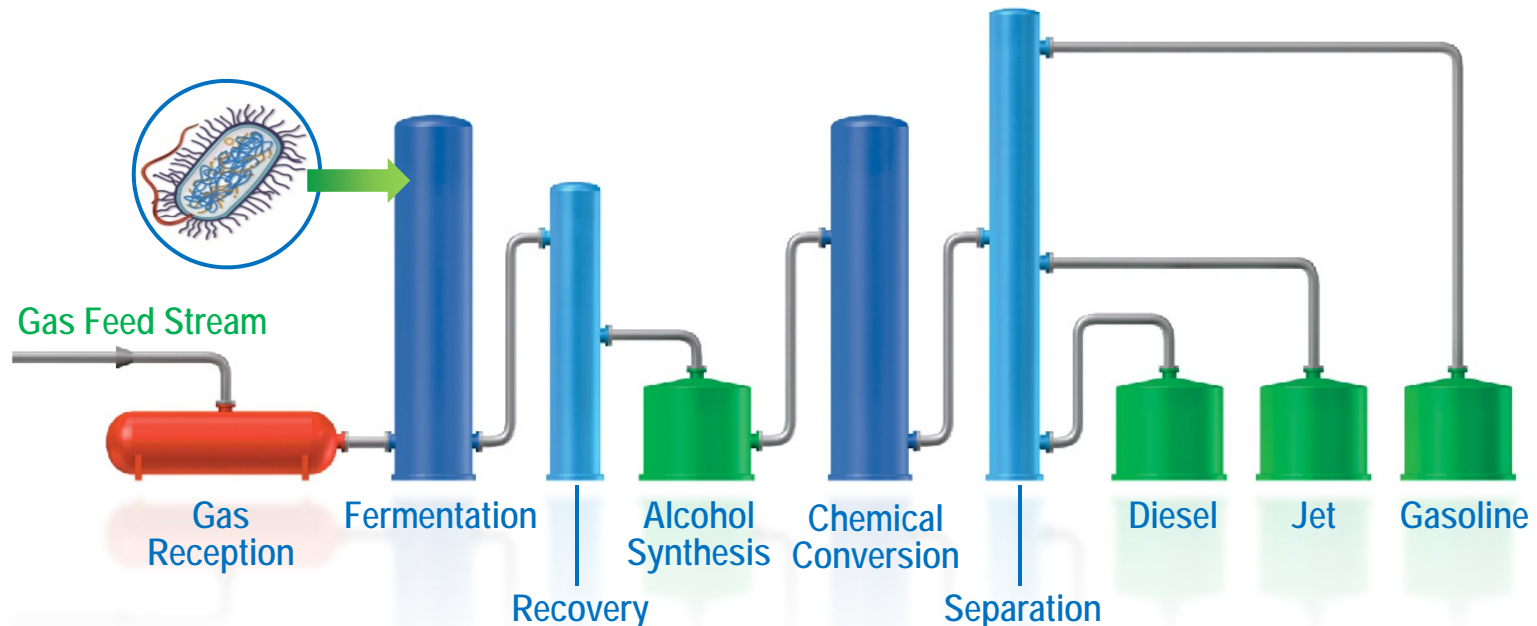


1.3 billion
tons/yr potential in US

190 billion gal/yr

- Access to opportunity and on purpose derived gas streams
- Potential to make significant impact on the fuel pool
- No impact on food production





Gas Feed Stream

- CO from Industrial Waste Gases
- Syngas from Biomass, MSW, Reformed Natural Gas or Other Sources

Novel Route to Drop in Hydrocarbon Fuels



<i>Property</i>	<i>ASTM Test Method</i>	<i>ASTM D7566</i>	<i>LT-SB Sample</i>
Total Aromatics, volume %	D1319	≤ 25	0.6
Freeze point, ° C	D5972	≤ -40	< -77
Flash point, ° C	D93	≥ 38	54
Density at 15° C, kg/L	D4052	0.751 - 0.770	0.762
Heat of combustion, MJ/kg	D4809	≥ 42.8	43.5
Hydrocarbon Type Analysis			
Aromatics, volume %	D6379	≤ 0.5	< 0.2
Aromatics, mass %	D2425	≤ 0.5	< 0.3
Cycloparaffins, mass %	D2425	≤ 15	8
Paraffins	D2425	report	91
API Gravity at 60°F	D1298	52 - 57	54.2
Olefins, % volume	D1319	report	1.0

Key Properties Confirmed

A Fast Path to Commercialization

Pilot



2008

- 15,000 gallons ethanol per year
- BlueScope steel mill, NZ
- Operating since 2008

Demonstration



4Q2011

- 100,000 gallons ethanol per year
- Baosteel
- March 27: Ground breaking

Commercial



2013

- > 30 million gallons per year
- Baosteel

Commercial Production by 2013

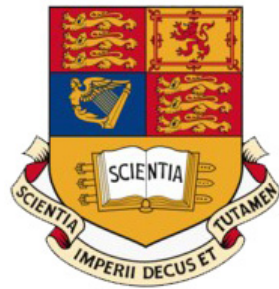
- **Founded in January 2005**
- **Funding**
 - New Zealand and US Governments
 - Privately held: Khosla Ventures, K1W1, Qiming Ventures, SBCVC
- **Team**
 - **CSO/Founder: Dr. Sean Simpson**
 - 75 staff
 - Auckland (New Zealand), Chicago (USA) and Shanghai (China)
- **IP Portfolio**
 - >60 patents filed
 - 2 proprietary microbe families



Getting there from here....



Swedish BioFuels

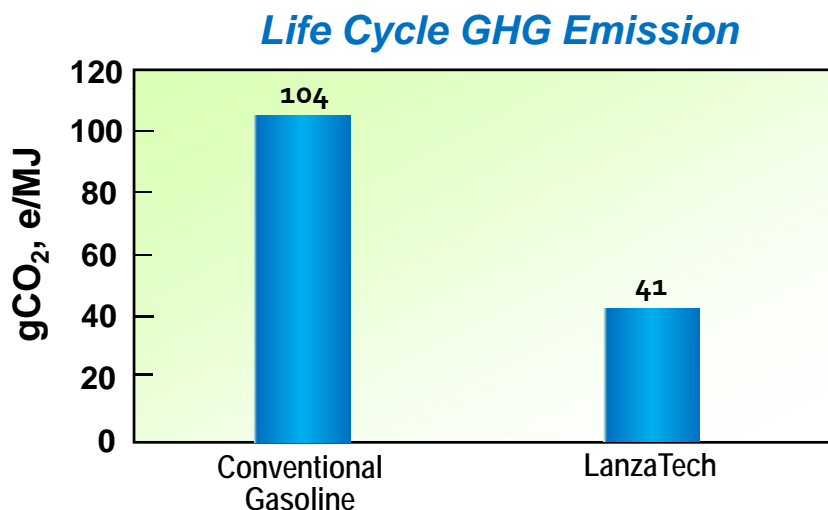


Imperial College of London



Team Work is Key to Success

- **LanzaTech Basic Oxygen Furnace (BOF) Gas Process ~ 60% reduction**
 - Based on LCA analyses performed by Michigan Technological University and Tsinghua University relative to petroleum gasoline



GHG footprint is <50% of the footprint of producing petroleum fuels

A Sensible Path...

Waste for Energy

Aligns:



Allows:



- To meet growing energy demand and stabilize atmospheric CO₂ levels, we need to quickly diversify the fuel pool and introduce >30% drop-in zero carbon fuels
- Innovation is creating viable options which will enable a clean energy future, energy security and energy equality
- Success requires that we accelerate scale up and commercialization activities
- Global partnerships between industry, academia and government are required to create success

*Innovation and Team Work
are the Key to Success*

