CARBON RECYCLING FOR A CIRCULAR ECONOMY

World Steel Association
December 5, 2023

LanzaTech
Nasdaq: LNZA
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POWER CAN BE CARBON FREE
FUELS
NEED CARBON
CHEMICALS FOR EVERYDAY PRODUCTS NEED CARBON
A NOVEL CIRCULAR SOLUTION, RECYCLING WASTE CARBON INTO VALUABLE PRODUCTS

THE LANZATECH PROCESS

FERMENTATION

STORAGE

CO₂

FUELS

PROTEIN

MATERIALS

ELECTROLYSIS & DIRECT AIR CAPTURE

INDUSTRIAL OFF-GAS

AGRICULTURAL & MUNICIPAL WASTE

GASIFICATION

COMPRESSION

CLEAN UP

SEPARATION
2018
Production Volume: 46,000 Tons per Year Ethanol
Carbon Source: Steel Mill Emissions

2021
Production Volume: 46,000 Tons per Year Ethanol
Carbon Source: Ferroalloy Emissions

2022
Production Volume: 60,000 Tons per Year Ethanol
Carbon Source: Ferroalloy Emissions

2023
Production Volume: 60,000 Tons per Year Ethanol
Carbon Source: Ferroalloy Emissions
### 2023 GAS FERMENTATION PLANT START UPS

**IndianOil**

<table>
<thead>
<tr>
<th>Project/Partner</th>
<th>Carbon Source</th>
<th>Actual or Anticipated Start Date</th>
<th>Ethanol Production Volume (tons/year)</th>
<th>CO₂ Abated (tons/year)</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>IndianOil</td>
<td>Refinery Off Gas</td>
<td>3Q 2023</td>
<td>33,500</td>
<td>~60,000</td>
<td>India</td>
</tr>
<tr>
<td>ArcelorMittal</td>
<td>Steel Off Gas</td>
<td>4Q 2023</td>
<td>64,000</td>
<td>~125,000</td>
<td>Belgium</td>
</tr>
</tbody>
</table>

**Total of 6 commercial-scale gas fermentation facilities online at end of 2023 with cumulative nameplate capacity of +300,000 tonnes per year**
Steelanol: January 2019
We have worked with LanzaTech for several years, know their leadership team well and understand the potential of their technology and the role it can play in not only helping us to decarbonise, but also in producing valuable products from our carbon bearing gases which can help the decarbonisation of other sectors.
COMMERCIAL PRODUCING

DRESSES | YOGA PANTS | FLEECE JACKETS | SHOE SOLES | PACKAGING

ATHLETIC SHORTS | FRAGRANCES | CLEANING PRODUCTS | SHIRTS | SAF

TENNIS SHOES | ATHLETIC DRESSES | DETERGENTS | CONTAINERS | SURFACTANTS

**CLEANING PRODUCTS**
- DETERGENTS
- CONTAINERS
- SURFACANTS
LANZATECH ENABLES CARBON NEGATIVE PRODUCTS TODAY WITH FORESEEABLE IMPROVEMENT OVER TIME

### Renewable Energy
Further reduces carbon intensity of LanzaTech process and products

### Carbon Negative Feedstocks
Enable increasingly negative product carbon intensity

### Net Zero Economy
Supported by LanzaTech products

### Certifications
RSB & ISCC certifications for value chain integrity

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**Sustainable Aviation Fuel with LanzaJet Process**

<table>
<thead>
<tr>
<th></th>
<th>g CO₂e/MJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil Equivalent</td>
<td>89</td>
</tr>
<tr>
<td>LanzaTech with biogas feedstock</td>
<td>14</td>
</tr>
<tr>
<td>LanzaTech with renewable energy</td>
<td>-10</td>
</tr>
</tbody>
</table>

**Monoethylene glycol (MEG) as a chemical intermediate**

<table>
<thead>
<tr>
<th></th>
<th>kg CO₂e/kg product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil Equivalent</td>
<td>2.1</td>
</tr>
<tr>
<td>LanzaTech from offgas</td>
<td>-0.2</td>
</tr>
<tr>
<td>LanzaTech with renewable energy</td>
<td>-0.8</td>
</tr>
</tbody>
</table>

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1 ICAO Sustainable Aviation Fuels Guide, Version 2, December 2018, Page 6; 2 The ecoinvent database, version 3
WHERE WE’RE HEADED: DIRECT PRODUCTION OF BULK COMMODITY CHEMICALS ON A DISTRIBUTED SCALE

“Hardware”
Existing Commercial Plants

“Software”
New Strains To Expand Product Portfolio & Efficiency

✓ Same reactor ✓ Same feedstock ✓ Same process

100+ Potential Chemicals Identified

New product development and direct production of high value chemicals if achieved, can expand TAM and increases demand for Biorefining CCT licensing
Iron & Steel Decarbonization - Technologies

Direct Reduced Iron & EAF
+ Quick fix (NG / Ore)
+ Potential to deep cut with H2-DRI?
- Capex and Opex intensive
- Significant disruption
- Resources challenge

Carbon capture utilization
+ Value Creation
+ Feedstock to produce fuels and chemicals
+ Retrofit
+ Definitive Payback
- Policy recognition
- Scale-up

Emerging technologies (mostly at low TRL)
Boston Metals (MOE)
Volteron™ (ArcelorMittal)
Electra
Hydrogen production
Syngas
Use of Biomass

Steel production and technology pathways

<table>
<thead>
<tr>
<th>Milestones</th>
<th>2022</th>
<th>2030</th>
<th>2035</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share of near-zero emission iron production</td>
<td>0%</td>
<td>8%</td>
<td>27%</td>
<td>95%</td>
</tr>
<tr>
<td>CCUS equipped</td>
<td>0%</td>
<td>3%</td>
<td>10%</td>
<td>37%</td>
</tr>
<tr>
<td>Electrolytic hydrogen based</td>
<td>0%</td>
<td>5%</td>
<td>15%</td>
<td>44%</td>
</tr>
<tr>
<td>Iron ore electrolysis</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
<td>14%</td>
</tr>
<tr>
<td>CO2 captured (Mt CO2)</td>
<td>1</td>
<td>27</td>
<td>131</td>
<td>399</td>
</tr>
<tr>
<td>Low emission hydrogen demand (Mt)</td>
<td>0</td>
<td>6</td>
<td>17</td>
<td>41</td>
</tr>
</tbody>
</table>

Carbon Capture storage
+ Potentially a quick-fix too?
+ Retrofit
+ Cost avoidance
- infrastructure;
- recurring cost year on year.

Source: LanzaTech /IEA steel and Aluminium
TOWARDS CARBON NEUTRAL WITH LANZATECH

Towards – 55% target by 2030  
Towards – carbon neutral by 2050

Proven and promising Technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Description</th>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>BF+LT</td>
<td>LanzaTech integration in BF</td>
<td>Commercialized</td>
</tr>
<tr>
<td>BF+GI</td>
<td>Gas injection technologies in BF</td>
<td>Under development</td>
</tr>
<tr>
<td>DRI (H₂)</td>
<td>Hydrogen</td>
<td>Under development</td>
</tr>
<tr>
<td>HBI in BF</td>
<td>HBI as feedstock in BF</td>
<td>Proven</td>
</tr>
</tbody>
</table>

Source: LanzaTech
TOWARDS CARBON NEUTRAL WITH LANZATECH:
Transition from BF to CO2 rich gases & increase in carbon capture rate with H2

**Case study**: 100 kt Ethanol production tons per year

- BF gas
- BF gas +H₂
- BF gas +H₂
- CO₂+H₂

Carbon Capture In ethanol
- X%
- 2X%
- 4X%
- 90%+

Source: LanzaTech
### ADDED HYDROGEN INCREASES CARBON CAPTURE

<table>
<thead>
<tr>
<th>Reaction</th>
<th>$\text{H}_2:\text{CO}$ Ratio</th>
<th>Carbon Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>$6 \text{CO} + 3 \text{H}_2\text{O} \rightarrow \text{C}_2\text{H}_5\text{OH} + 4 \text{CO}_2$</td>
<td>0:1</td>
<td>33.3%</td>
</tr>
<tr>
<td>$3 \text{H}_2 + 3 \text{CO} \rightarrow \text{C}_2\text{H}_5\text{OH} + \text{CO}_2$</td>
<td>1:1</td>
<td>66.7%</td>
</tr>
<tr>
<td>$4 \text{H}_2 + 2 \text{CO} \rightarrow \text{C}_2\text{H}_5\text{OH} + \text{H}_2\text{O}$</td>
<td>2:1</td>
<td>100%</td>
</tr>
<tr>
<td>$5 \text{H}_2 + 1 \text{CO} + 1 \text{CO}_2 \rightarrow \text{C}_2\text{H}_5\text{OH} + 2 \text{H}_2\text{O}$</td>
<td>5:1</td>
<td>100%</td>
</tr>
<tr>
<td>$6 \text{H}_2 + 2 \text{CO}_2 \rightarrow \text{C}_2\text{H}_5\text{OH} + 3 \text{H}_2\text{O}$</td>
<td>1:0</td>
<td>100%</td>
</tr>
</tbody>
</table>

Multiple avenues to reach 100% carbon capture.

Gas fermentation can flexibly add green H2 to tailor carbon capture.

Source: LanzaTech
TYPICAL USE OF WASTE GASES

Value of the steel mill off-gas decreases over time as the ETS free allocations decrease in the 2026+ time frame.

Source: LanzaTech
VALUE CREATION POTENTIAL

Off-gas

Energy Value of off-gas + Sharing of LanzaTech carbon capture value

ETS CO₂ burden transferred

Free allocations transferred, as available

Part tail gas used by LanzaTech for heat

ethanol produced from captured CO + CO₂

Source: LanzaTech
THE NEW CARBON ECONOMY IS DISTRIBUTED AND CIRCULAR

Source: LanzaTech
THE WORLD HAS ENOUGH CARBON ABOVE GROUND TO MAKE EVERYTHING WE NEED

WE CREATE VALUE WHERE OTHERS SEE WASTE

JOIN US ON THIS JOURNEY
Recycling Carbon with Biology