The Future of SAF Panel: feedstocks, conversion, and innovation beyond 2030

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Air bp’s global aviation sustainability director
## bp’s ambitions in the energy transition

### Sustainability – we are accelerating our net zero ambition in line with the progression of our strategy

<table>
<thead>
<tr>
<th>Aim</th>
<th>Scope</th>
<th>2025</th>
<th>2030 aims</th>
<th>2050 or sooner aims</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aim 1</td>
<td><strong>Net zero operations</strong>&lt;sup&gt;*&lt;/sup&gt;</td>
<td>Scope 1+2</td>
<td>20%</td>
<td>50%</td>
</tr>
<tr>
<td>Aim 2</td>
<td><strong>Net zero production</strong>&lt;sup&gt;*&lt;/sup&gt;</td>
<td>Scope 3</td>
<td>20%</td>
<td>35-40%</td>
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<tr>
<td>Aim 3</td>
<td><strong>Net zero sales</strong>&lt;sup&gt;*&lt;/sup&gt;</td>
<td>Lifecycle intensity (including end-use emissions)</td>
<td>5%</td>
<td>15-20%</td>
</tr>
<tr>
<td>Aim 4</td>
<td><strong>Reducing methane</strong></td>
<td>Methane intensity</td>
<td>0.20% (measurement approach)</td>
<td></td>
</tr>
</tbody>
</table>

*Source: bp financial results update for 2021*
Total final energy consumption decarbonizes as fossil fuels are replaced by electricity and hydrogen

Source: bp Energy Outlook 2022
A net zero refinery*

Natural gas
Water
Ethanol
Methanol
Renewable power
Oils fats
Solid waste
Pyrolysis oils
Carbon dioxide

SMR
Electrolyzers
Gasifier
rWGS

H₂
O₂
CO₂

Hydrocracker
Fischer-Tropsch
Methanol synthesis

Alcohol dehydration
Oligomerization
Hydro-treater

Gasoline
Jet
Diesel
Lubricants

CCS

*Possible scenario
Integrated Energy Hub Example – many projects that require capital, multiple possible sources of value

- Offsets
- Solar PPA
- Biogas
- Wind PPA
- Clean asphalt
- Airport solutions
- EV hubs
- Hydrogen fueling
- CCUS & H2
- Carbon transport and storage
- Carbon capture
- Ammonia
- Power generation
- Refinery
- Offsets
- Solar PPA
- Biofuels
- Circular economy
- Port solutions
- Railway solutions
- Power plant carbon capture
- Retrofit for H2 furnaces
- Blue H2
- Green H2

Source: bp project ideation
Sustainable and available feedstock in 2050 defines the maximum supply of SAF (global view)

Sources: ATK, S2Biome, FAO

2050 Rapid demand (conversion): 350Mtpa~8Mbd~15 Exojoules~115B gallons
There are several SAF technology pathways. HEFA and ATJ require lower CAPEX because they use/convert existing assets. All pathways produce SAF that is more expensive than conventional jet.

### Key take away
- **HEFA** is a near term option that uses fungible feedstock and back-integrates to refineries.
- First generation ATJ is capital lite and produces SAF from existing ethanol markets.
- Second generation biomass technologies have long term, low cost potential.
- FT MSW provides near-mid term potential in urban areas with tipping fees for waste.
- eFuels potential is increasing due to the pace of renewables and green H₂.

### Time to market & current scale

<table>
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<tr>
<th>HEFA (waste oil)*</th>
<th>1G Ethanol to jet</th>
<th>2nd Generation Biomass***</th>
<th>FT (MSW)</th>
<th>eFuels****</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time to market &amp; current scale</strong></td>
<td><strong>2020s</strong> Currently commercial.</td>
<td><strong>2025-2035</strong> 1G ethanol is mature. Dehydration to ethylene commercial. Ethylene to jet not yet commercial.</td>
<td><strong>2021-2030</strong> Commercial demo.</td>
<td><strong>2030-2040</strong> rWGS not yet commercial. FT demonstrated. Electrolysis is commercial.</td>
</tr>
<tr>
<td><strong>Key opportunities</strong></td>
<td>Fungible feedstock, scalable technology Back-integration to refineries. Capital Lite.</td>
<td>Lower capital intensity Attractive in areas with existing ethanol capacity (US/Brazil)</td>
<td>Significant feedstock availability long-term low-cost potential</td>
<td>Negative cost feedstock FT technology integrates to eFuels</td>
</tr>
<tr>
<td><strong>Near term constraints</strong></td>
<td>Competition with renewable diesel (HVO) for a highly limited feedstock</td>
<td>Opportunity cost to sell ethanol for road transport is high</td>
<td>Costs and technology readiness Investment risk</td>
<td>Progress at pace of renewables societal preference Highest sustainability credentials</td>
</tr>
<tr>
<td><strong>Long term constraints</strong></td>
<td>Feedstock supply is limited to &lt;1-5% jet demand unless oilseed energy crops emerge post 2035.</td>
<td>Opportunity cost to sell as chemicals may be high sustainability concerns</td>
<td>Build rates biomass aggregation</td>
<td>Investment risk Costs and technology readiness Improvements required in multiple areas of technology</td>
</tr>
<tr>
<td><strong>Estimated GHG reduction vs. fossil jet</strong></td>
<td>65-79%</td>
<td>60-70% sugarcane; 20-30% corn</td>
<td>76-94%</td>
<td>70-100%**</td>
</tr>
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### **Key**
- **HEFA** is a near term option that uses fungible feedstock and back-integrates to refineries.
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### Notes:
- *1G food crop vegetable oils could also be used as a feedstock for HEFA
- **assumes avoided landfill emissions are counted as part of analysis; landfill practice changes pose a risk to this accounting
- ***multiple other technology routes from 2nd generation biomass to SAF should also be considered including alternate catalytic/fermentative conversions, LC ethanol to jet, etc.
- ****alternate routes to eFuels also exist including a route through methanol and others at R&D stage
What do we need to scale SAF investment in US?

Federal (and state) programs are needed to create a wide and sustainable base for demand:

- Mandates provide regulatory certainty which is needed for significant investments
- Incentives – to close the gap to conventional (at least in transition)
- Recognize and address the gap with ground fuels economics

Multiple feedstocks and SAF technologies to achieve the industry goals

- All feedstocks and pathways are needed if they meet sustainability criteria
- Co-processing could help deliver SAF economically at refineries that can use this process and have access to feedstocks
- Mass balancing, book and claim, with robust assurance programs

Risk sharing with other industry stakeholders:

- Capex (especially for high capex pathways; ex: grants, co-investment, CFD)
- Feedstock
- Regulatory

Integrated projects can bring optionality, multiple sources of value and risk mitigation
Thank you!

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