The Outlook for Unconventional Liquids in AEO2006

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How’s Business?

Over 100 billion burgers sold since 1948.

- McDonalds

Over 63 billion CTL gallons produced since 1955.

- Sasol

Over 1.5 billion syncrude barrels produced since 1978.

- Syncrude Canada
Unconventional Often Evolves Into Conventional Production

• Technology allows yesterday’s “exotic” production to become today’s “ordinary” production. Recent examples include:
  • Coalbed Methane
  • Enhanced Oil Recovery (EOR)
  • Deepwater Gulf of Mexico

• Today, unconventional frequently includes:
  • Shale Oil
  • Heavy Oil
  • Oil Sands
  • Gas-to-liquids (GTL)
  • Coal-to-liquids (CTL)
  • Energy Crops
    • Biomass-to-liquids (BTL)
    • Ethanol
    • Biodiesel
Representative Unconventional Production in 2005

Legend
B- BTL
C- CTL
E- Ethanol
G- GTL
H- Extra-Heavy Oil
OS- Oil Sands
SO- Shale Oil

[0.00] - Million BPD
Unconventional Production in Reference Case, 2030

Legend
B- BTL
C- CTL
E- Ethanol
G- GTL
H- Extra-Heavy Oil
OS- Oil Sands
SO- Shale Oil

[0.0] - Million BPD
Unconventional Production in High Price Case, 2030

Legend
B- BTL
C- CTL
E- Ethanol
G- GTL
H- Extra-Heavy Oil
OS- Oil Sands
SO- Shale Oil

[0.0] - Million BPD

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### Unconventional Petroleum Production, 2030

(million barrels per day)

<table>
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<tr>
<th></th>
<th>Synthetic Crudes</th>
<th>Synthetic Fuels</th>
<th>Renewable Fuels</th>
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<td>Extra-Oil Sands</td>
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<td>Heavy Sands</td>
<td>GTL</td>
<td>Ethanol</td>
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<tr>
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<td>Shale Sands</td>
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<td>Total</td>
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</table>

**Notes**

- N/A - Not forecast
- a - Includes Biodiesel
Gas-to-Liquids, Coal-to-Liquids, and Oil Shale Production in the Price Cases, 1990-2030 (million barrels per day)
Simplified Synfuels Flow Diagram

- Biomass
- Natural Gas
- Coal

Front End Feedstock Handling & Syngas Production

Fischer-Tropsch Synthesis

By Products & Co-production Capability

Product Separation & Work-up Section

- Naphtha
- Diesel
- Kerosene
- Lubes/Waxes

Steam/Heat
Electricity
Water
CO₂/H₂
Coal-to-Liquids Production in the Price Cases, 1990-2030 (million barrels per day)
Gas-to-Liquids Production in the High Price Case, 1990-2030 (million barrels per day)
Simplified Oil Shale Process Diagram

Mining Process

Marlstone

Surface or Underground Mining → Kerogen

Surface Retorting → Bitumen

Cracking/Hydrotreating → Syncrude

In Situ Process

Marlstone

Drilling Wells → Heating

Production → Petroleum Products

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Oil Shale Production in the High Price Case, 1990-2030 (million barrels per day)
Unconventional Petroleum Liquids Capital Investment Costs
(Thousand 2004 dollars per daily barrel of capacity)

Source: Energy Information Administration
# Production Challenges

<table>
<thead>
<tr>
<th>Process</th>
<th>Challenges</th>
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<tbody>
<tr>
<td>Biomass-to-Liquids-</td>
<td>Material handling; large catchment areas required</td>
</tr>
<tr>
<td>Coal-to-Liquids-</td>
<td>Material handling; gasifier reliability</td>
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<tr>
<td>Gas-to-Liquids-</td>
<td>Efficiency; capital costs; stranded gas supplies</td>
</tr>
<tr>
<td>Extra-Heavy Oil-</td>
<td>Future investment for expansion</td>
</tr>
<tr>
<td>Oil Sands-</td>
<td>Fuel costs; diluents</td>
</tr>
<tr>
<td>Shale Oil-</td>
<td>Capital costs; open pit vs <em>in-situ</em> process</td>
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</tbody>
</table>
Summary

United States (2030)

• Unconventionals represent 5 to 13 percent of national supply across the price cases.
• CTL is the largest contributor at 7 percent of national supply in the high price case.

World (2030)

• Unconventionals represent 8 to 16 percent of total world supply across the price cases.
• Oil sands and extra-heavy oil are the largest global supply contributors at 5 and 3 percent, respectively, in the high price case.