The Wedge from Capturing CO_2 at Coal-to-Synfuels Plants

A wedge can be achieved through Capturing CO_2 at coal-to-synfuels Plants

- Coal-to-synfuels production: 30 million barrels per day
- Sasol's production is 0.165 mbd that emits 7 MtC per year

Comments

Looming over the 2054 energy scene is the possibility that liquid fuels from petroleum will have become substantially more costly than today, not because of imperfect markets but because of geophysical factors: the cheaper oil may have been largely extracted. For each 100 GtC of carbon emissions from oil, 860 billion barrels of oil are extracted from the ground. By 2000, the world had extracted almost exactly this amount. Estimates of ultimately recoverable conventional oil currently still in the ground are in the range of 2000 ± 1000 billion barrels[1].

It is therefore likely that by 2054 a significant fraction of the fuels used at small unit scale in vehicles and buildings will not come from conventional oil, but from unconventional oil and coal. We specifically identify synthetic fuels (synfuels) from coal here. A synfuel, chemically, can be any of the current fuels produced from crude oil and natural gas, or a new "tailored" fuel. If large-scale synfuels production from coal occurs, the challenge of global carbon management will become more difficult, because obtaining fuels from coal is significantly more carbon intensive than obtaining fuels from crude oil. However, CCS provides a way to cancel much of the extra carbon intensity of coal-based-fuels, relative to oil-based-fuels (S48). The reason is that in the conversion of coal to synfuels, abundant CO_2 will be produced.

In a modern plant, we estimate that, for each two carbon atoms in coal, one will appear as CO_2 and one in the synfuels. Given that assumption, how much synfuels production is associated with a wedge, when one considers the alternatives of CCS and its absence? A flow of 23.56 mbd of reference crude oil carries a carbon flow of 1 GtC/y[2]. If we assume that synfuels and reference crude oil have approximately the same carbon content and specific gravity, then 1 GtC/y is also 23.56 mbd (rounding off, say, to 25 mbd) for synfuels. We make the rough assumption that, at a 2054 synfuels plant, carbon will leave in equal amounts as vented CO_2 and as product. In that case, a carbon flow of 1 GtC/y in synfuels leaves behind at the coal-to-synfuels plant an equal 1 GtC/y flow of capturable and storable carbon. It follows that applying CCS rather than venting the CO_2 emitted at 25 mbd of synfuels plants is a wedge, if the CCS captures all the carbon, and a wedge is more like CCS deployed at 30 mbd of synfuels plants with less than perfect capture.

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[1] A good discussion of oil reserve estimates can be found in reference S47, chapter 3. Cumulative consumption by 2000 is estimated as "close to 900" billion barrels (S47, p. 43).

[2] The equality of these two carbon flows, 1 GtC/y and 23.56 million barrels of reference crude oil per day (mbd) links the unit of our carbon discussion with perhaps the world's most widely used unit of bulk energy flow. This equality requires only two assumptions about reference crude oil: Its specific gravity is assumed to be 0.860 ($API^{\circ} = 33.0^{\circ}$), and it is assumed to be 85.0% carbon by weight. Also, 1 barrel = 42 gallons = 159 liters. Multiplying by 365.24 days per year, an alternate form of this equality is that 1 GtC is the carbon in 8.605 billion barrels of reference crude oil.

Currently, Sasol produces 165,000 barrels per day of synfuels and chemicals from coal in Secunda, South Africa, east of Johannesburg (S49). This is the world's largest synfuels facility, and it is similar in scale to a typical large refinery. Assuming the average specific gravity and carbon content of these synfuels is the same as reference crude oil, there is a carbon flow of 7 MtC/y in the synfuels leaving the Sasol plant. The Sasol plant is the largest point source of atmospheric CO_2 emissions in the world.

Comparing 165,000 barrels per day synfuels production from Sasol's plants with our estimate that 1 GtC/y will be available for capture in 2054 from 30 mbd of coal-to-synfuels production, a wedge is an activity that, over 50 years, achieves the ability to capture the CO_2 emissions from 180 Sasol-scale coal-to-synfuels plants.

A synfuels plant can be designed to "polygenerate" both electricity and synfuels from coal, and, as well, to capture and store as CO_2 the carbon not in the synfuels product. Over time, polygeneration could evolve to include a greater proportion of hydrogen production (S48).

References

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