A BIO-PHYSICAL AND NET-ENERGY COMPARISON OF CCS AND RE BASELOAD SYSTEMS

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Key Words: Renewable energy, Carbon-capture and storage, net energy analysis.

While CCS is considered a key component for climate change mitigation, actual installed capacity to date creates concerns about its ability to scale sufficiently fast. In the face of this lag, a considered complementary trajectory is for CCUS to play a role in later phases as a way to actively reduce CO2 emissions in combination with biomass. This paper discusses an alternative option: under which circumstances would simply eschewing fossil-based CCS and readily switching the energy system to abundant renewable energy (RE) resources be preferable? We discuss the relative merits of CCS vs RE investments using net-energy as the primary metric but also provide ancillary considerations on the utilization pathway, geological, and infrastructural requirements.

We derive a simple equation that relates the energy return on invested of the CCS system (EROI\textsubscript{CCS}) to the EROI of the original process. This equation critically depends on the operational energy penalty ($f\textsubscript{op}$) of the CCS process under the assumption that capital energy investment is a small fraction of the operational energy:

\[
ER0I_{CCS} \approx \frac{(1 - f\textsubscript{op}) EROI}{1 + f\textsubscript{op} \cdot EROI}
\]

As shown in Fig. 1, for an energy penalty of 15%, if the EROI of the coal-fired process is 60, the equivalent EROI\textsubscript{CCS} undergoes a very significant to 5.

![Figure 1 – EROI\textsubscript{CCS} curves against the equivalent EROI for a plant different $f\textsubscript{op}$ and $f\textsubscript{cap}$ parameters](image)

We showcase these results for different realistic cases of CCS options (see Table) and then discuss how they compare with equivalent energy systems using RE with storage in order to be fully comparable. We do so through a matrix-based, bottom-up analysis of each option. We find that outside a few niche cases, the energy system evolution should preferentially be directed towards RE deployment that displaces fossil fuel use. Exceptions would be cases where the system is not developed for energy purposes but for other uses (industrial development and perhaps active carbon storage).

Wednesday, May 24, 2017 Technical Session 4