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Determinants of carbon dioxide emissions from oil shale-derived fuels

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Without mitigation or technology improvements, full-fuel-cycle carbon dioxide (CO_2) emissions from oil shale derived liquid fuels are likely to be 25 to 75% higher than those from conventional petroleum-based fuels, depending on the details of the production processes used. In this talk we describe the key determinants of CO_2 emissions in order to better understand: 1) areas requiring research for improved understanding, 2) methods for effective emissions mitigation. For six studied estimates of CO_2 emissions, full fuel cycle emissions ranged from 110-160 grams of CO_2 per megajoule (MJ) of reformulated gasoline produced, compared to 86 grams of CO_2 per MJ of reformulated gasoline produced from conventional oil. These CO_2 emissions occur in three general stages: 1) production of raw shale oil by retorting of shale, 2) upgrading and refining of raw shale oil, and 3) combustion of resulting refined fuels. The average distribution of emissions from these three stages is ≈ 40, 10, and 50%, respectively, with in situ processes typically resulting in lower upstream emissions. Emissions from the retorting stage are highly variable. Key sources of variation include carbonate decomposition rates, shale quality, and retorting fuel source. We recommend further fundamental study of carbonate decomposition, since published models give widely varying results. Also of importance is the choice of retorting fuel source (e.g., natural gas vs. shale char), and energy delivery method (e.g., electricity vs. direct combustion). The carbon intensity of primary energy from these sources (gCO_2/MJ of primary energy) varies by 1.5 - 2 times, and the generation of electricity can result in higher emissions through generation losses. Options for mitigating CO_2 include: using non-fossil energy sources, higher thermal efficiency, minimizing carbonate decomposition, and CO_2 sequestration by deep geologic injection, enhanced oil recovery, or mineralization in spent retorts.