Performance of the liquid fuel production system via solar hybridised dual fluidised bed co-gasification of coal and biomass

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The concept offers a process that delivers a constant production rate of liquid fuel despite solar variability.

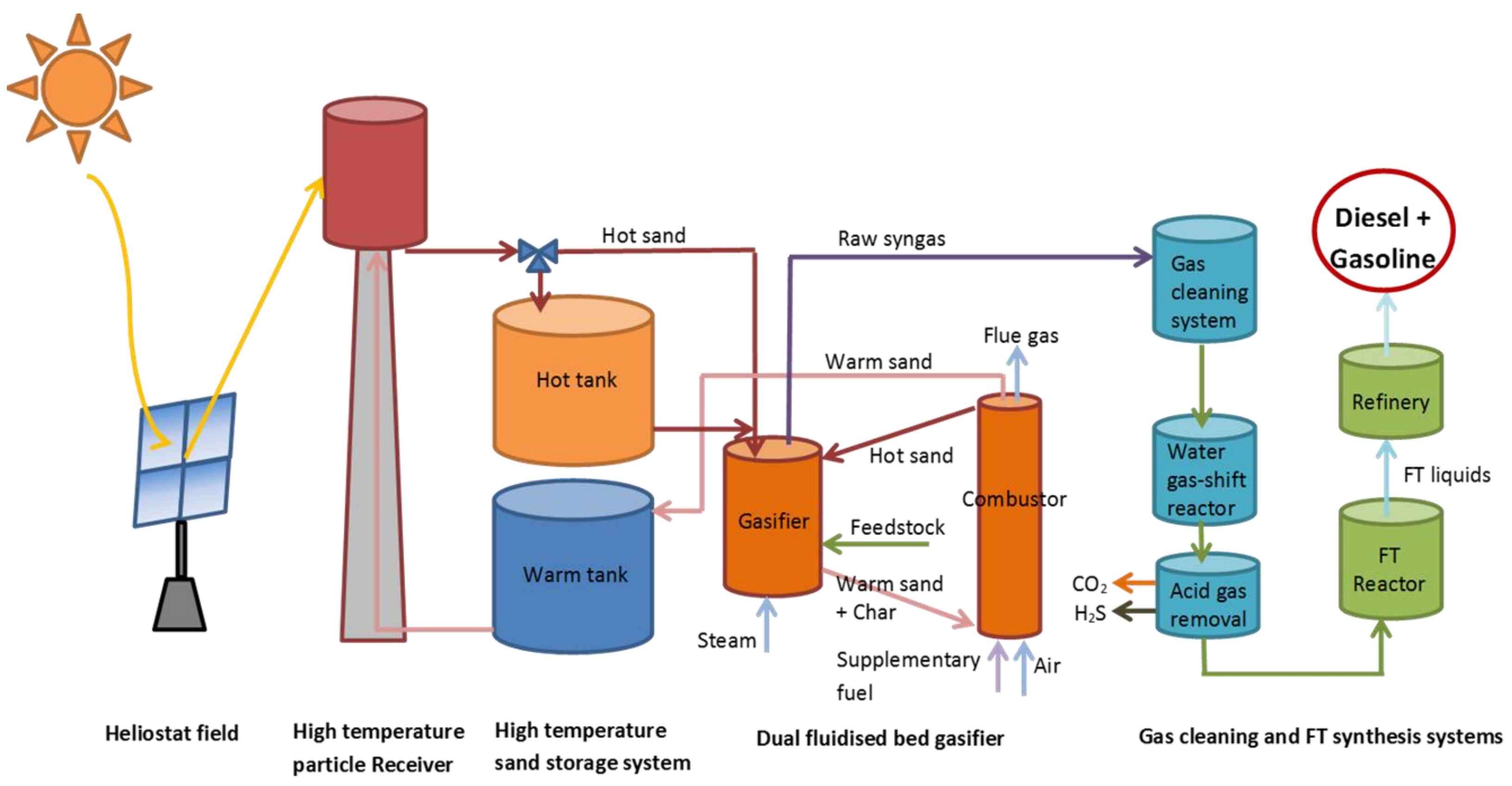

Figure 1: Schematic diagram of solar-to-liquids system via SDFB gasifier.

Background

Why using concentrated solar thermal (CST)?

- To develop an alternative market for CST plants, such as high value liquid fuels (~$26/GJ) vs electricity (~$12/GJ).

Why adding CST to a dual fluidised bed (DFB) gasifier?

- To increase the output production rate per unit feedstock by reducing the partial combustion of the feedstock to drive the endothermic gasification reactions.

Aim

- To assess the energetic and environmental performance of the SCBTL system as a function of biomass fraction and char conversion in the gasification reactor and to compare with the non-solar coal and biomass to liquid (CBTL) system.
- To assess the CO_2 emission of the SCBTL and CBTL systems with carbon capture and storage (CCS) and compare with the systems without CCS.

Methodology

- The dynamic operation of the system was calculated in EXCEL and the process operation was assumed to be steady state at each time step of a one-year, hourly averaged solar insolation time-series [1].
- The steady operated system was simulated by ASPEN Plus v 7.1 [1].
- Wood was considered to be 85% carbon neutral [2,3].

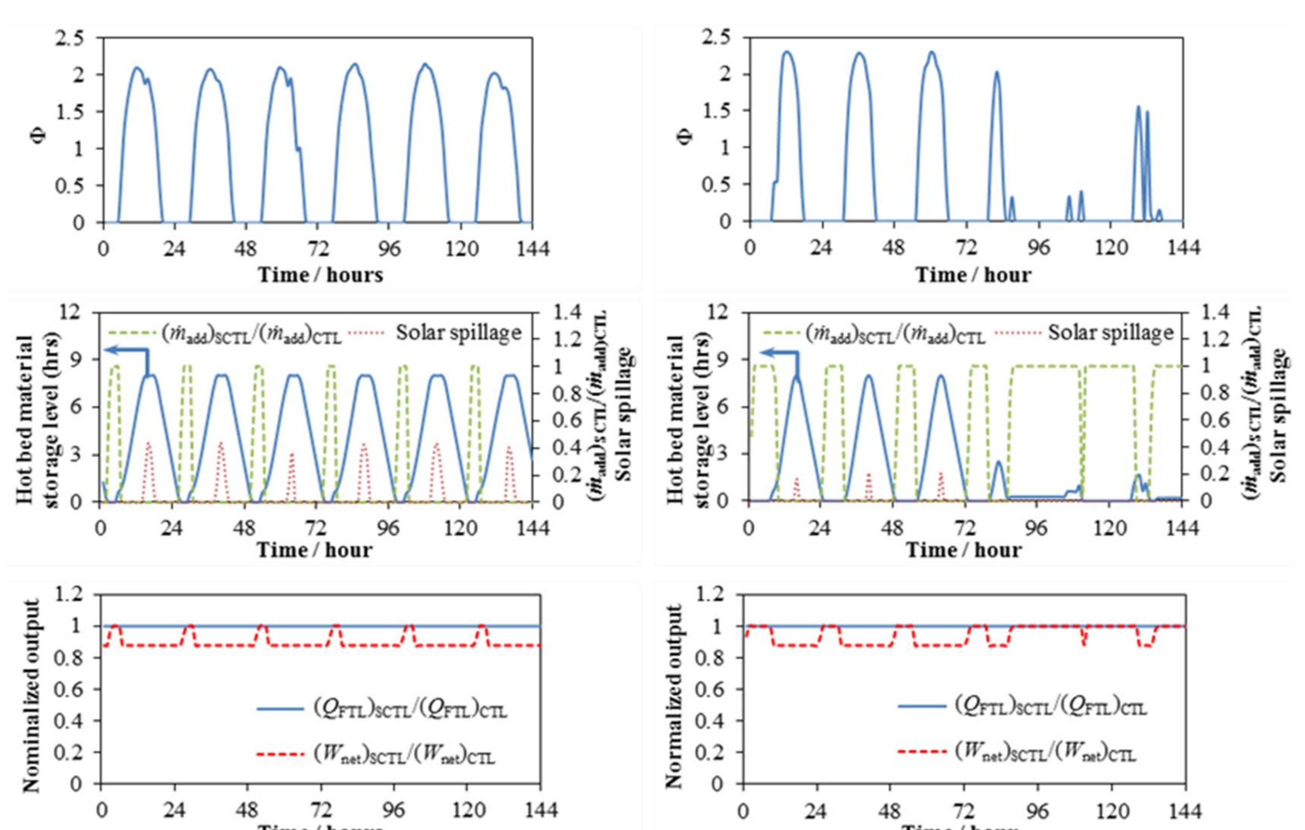

Figure 2: Pseudodynamic response of the SCTL system for two six-day (144-hour) hourly averaged solar insolation time series, which are representative of winter and summer conditions in Farmington for the case solar multiple = 2.4, storage capacity = 8 hours and X_{char} = 85%. [1]

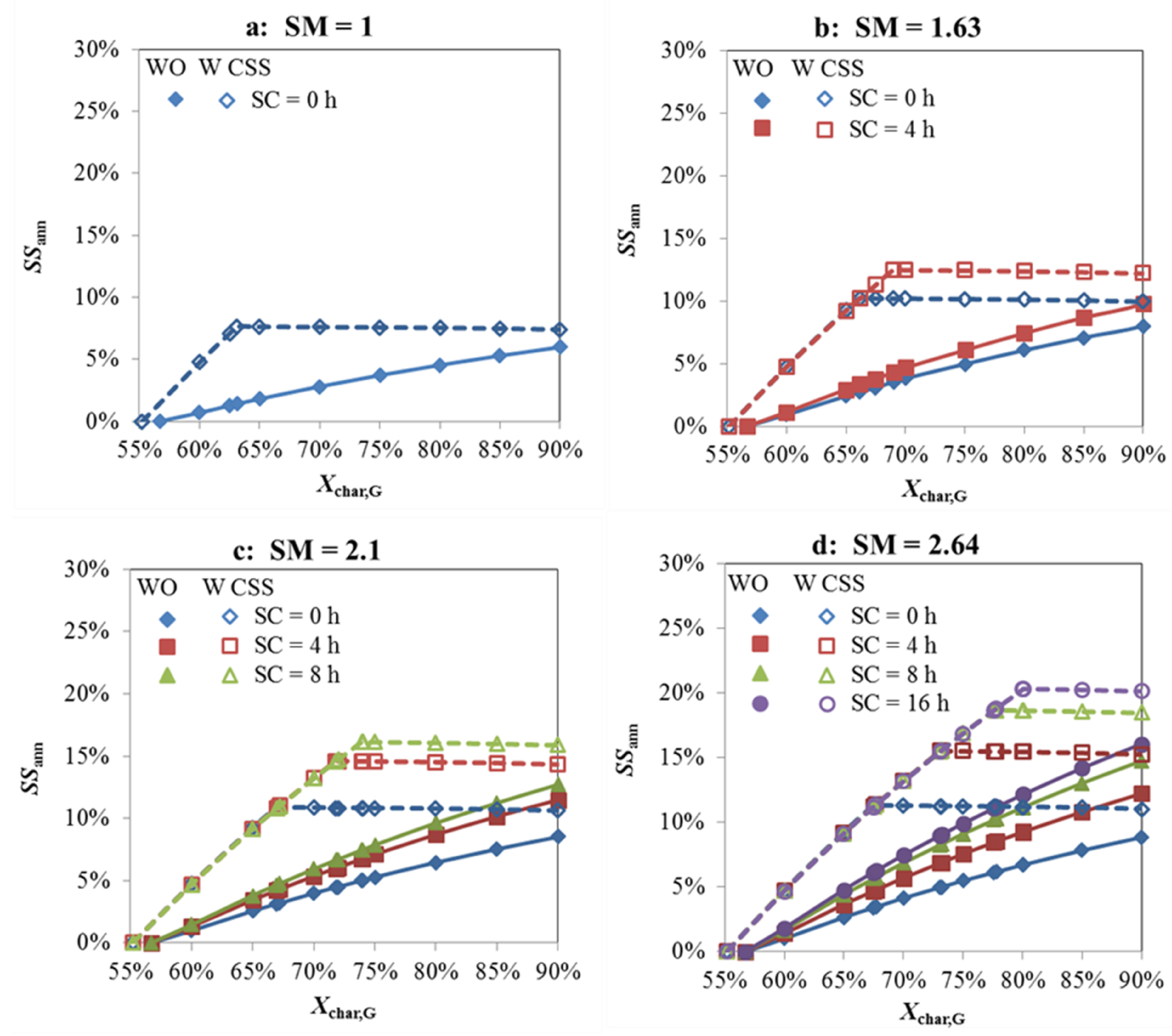

Figure 3: Annual solar share (SS_{ann}) of the SCTL system with and without char separation and storage (CSS) as a function of char gasification conversion ($X_{char,G}$) for various solar multiple (SM) and bed material storage capacity (SC). Note: The char separation ratios are set as threshold values for CSS.

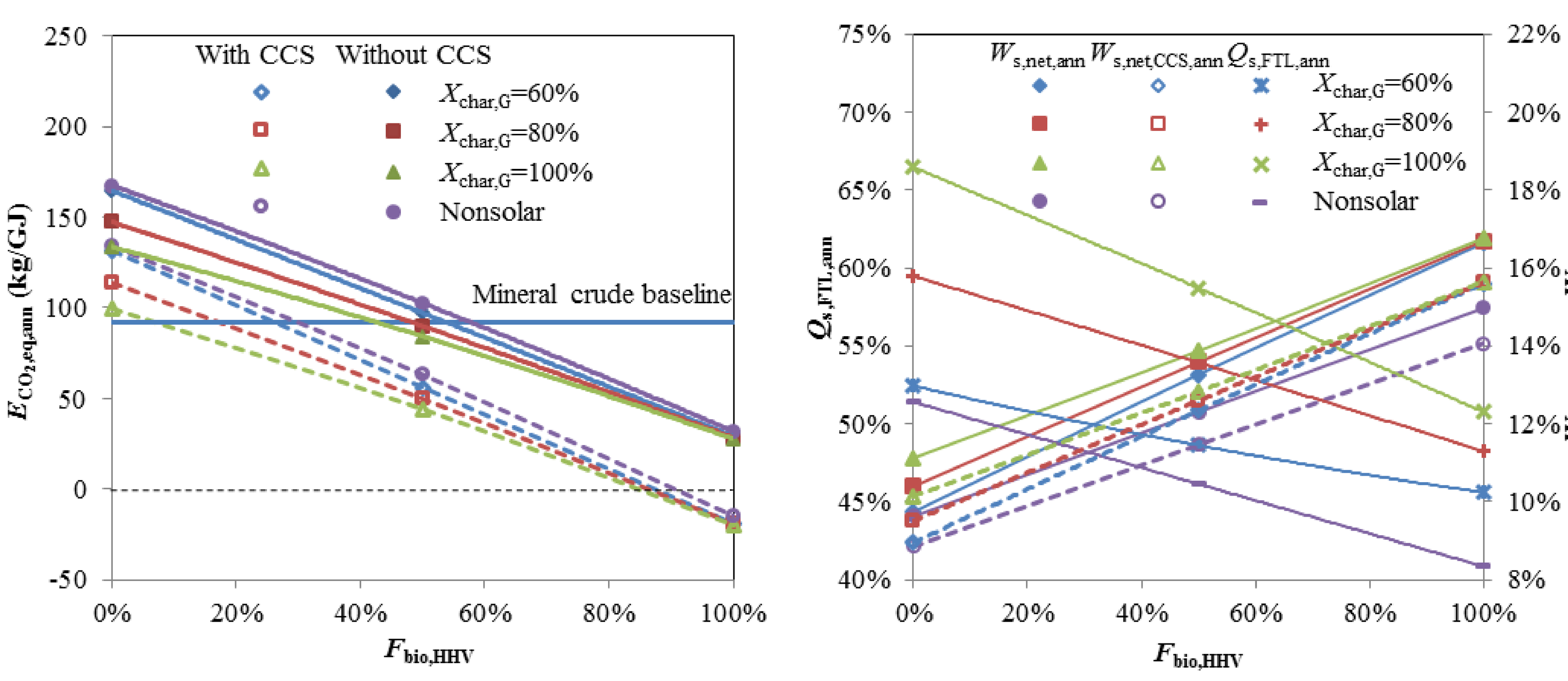

Figure 4: CO_2 emissions ($E_{CO2,eq,ann}$) and Specific energetic output per unit feedstock of the liquid fuels produced by the CBTL and SCBTL systems with and without carbon capture and storage (CCS) as a function of biomass fraction ($F_{bio,HHV}$) for different char gasification conversion ($X_{char,G}$). Note: solar multiple = 2.64 and storage capacity = 16 hours.

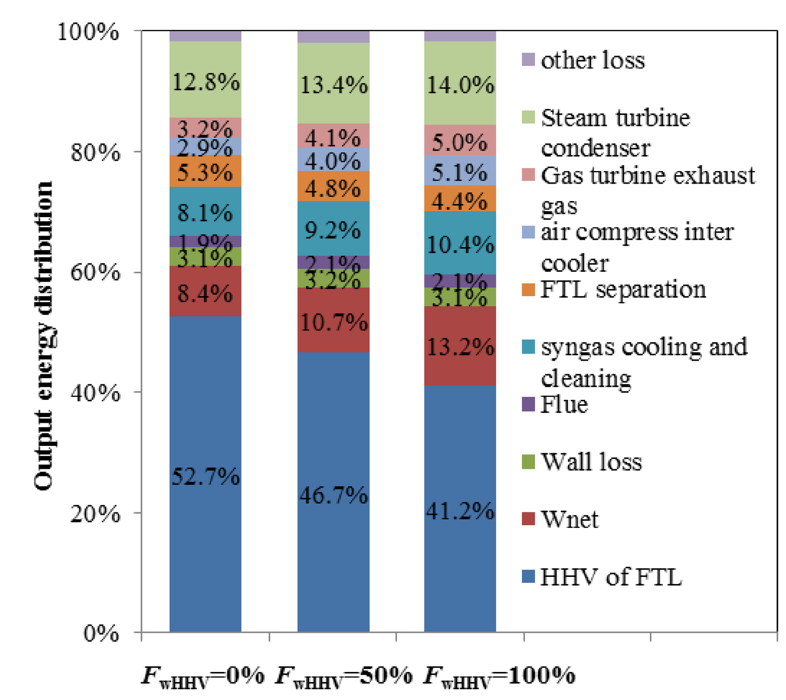

Figure 5: The annual energy distribution of the SCBTL system per unit feedstock as a function of wood fraction (F_{wHHV}) for a char conversion in the gasification reactor is 85%. Note: solar multiple = 2.64 and storage capacity =16 hours.

Conclusion

- Co-gasification of coal with biomass can reduce the effect of char conversion in the gasification reactor on the performance of the solar hybridized FTL production system with a SDFB gasifier.
- Co-gasification of coal with biomass combine with CCS can reduce the CO_2 emission of the FTL production from SCBTL and CBTL system significantly. However, to match life cycle CO_2 emissions of the mineral crude oil baseline, the SCBTL system requires less wood than the CBTL system. This reduction is important due to the high price of biomass, especially in Australia.

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