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Application of Particle Technology to Solar Reforming for Fuel Production

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Generation of electricity using renewable inputs has increased significantly in recent years with some technologies approaching or matching the costs of traditional fossil fuel technologies. However, production of liquid fuels using entirely renewable inputs has proven to be a greater challenge and current renewable products tend to have high cost or incompatibility with existing products and utilisation technology. Solar thermal technologies have been demonstrated to produce synthesis gas that is suitable for conversion to high quality conventional liquid fuels, but there have been challenges to achieving commercial uptake of the technology. Firstly, the solar reformer requires high temperatures (>800C) that have previously required direct solar irradiance, with the resultant problems of only operating during daylight hours and the equipment being subjected to repeated thermal cycling that is likely to reduce plant life. Secondly, the feed to the reformer in past demonstrations has been natural gas and this results in the technology being only partially (~25%) renewable on an energy input basis. The first of these challenges appears likely to be addressed by promising progress being made in Australia and the USA in the development of high temperature particle receiver and storage technologies. This offers a method of extending operation of a reformer at appropriate temperature by using the particle storage, providing better use of the capital investment in the reformer, reduced thermal cycling and more reliable synthesis gas provision to a downstream liquid fuels production process. The second challenge requires the replacement of the fossil fuel feed with a renewable input such as biogas. While it is theoretically possible to extract the carbon needed for production of conventional liquid fuels from waste carbon dioxide streams, in practice it is an energy intensive and expensive process so biological sources of carbon are preferred. However, this requires a significant resource of appropriate biological material for conversion to biogas to be co-located with a suitable solar resource for economical supply of solar irradiance to the particle receiver.

In this assessment, a particle receiver with tower of appropriate size for the technology is defined and costed, then the solar field optimised to match this design at a range of potential Australian sites and annual performance predicted for each site with indicative costing. Subsequently, a simultaneous optimisation of storage, reformer size and cost was conducted with the aim of minimising the cost of reforming biogas feeds to produce a synthesis gas suitable for typical fuel production processes. This is used to produce estimates of the levelized cost of fuel (LCOF) from the solar reforming of biogas, using the methodology developed in the ARENA-funded Solar Fuels Roadmap for comparing process options. Fuel products considered include Fischer-Tropsch liquids, methanol, ammonia and hydrogen. Finally, estimation of the size of biogas resource required to supply a plant operating at significant scale is presented. Definitive identification of sites where suitable solar and biogas resources are co-located has not been conducted, but tentative guidelines for further progress in development of the technology are proposed.