Monosilane Estimated Consumption for 4 GW and 10 GW ecosystemSilane is the primary source gas for both amorphous and microcrystalline Si:H-based PV manufacturing. When silane is deposited, only approximately 15% of the gas gets used, while the remaining 85% goes unused and is treated as waste (Briend, 2011). The typical method of disposing of unused silane, which is a pyrophoric gas that undergoes spontaneous combustion in air, is to utilize combustion.

The scope of this life cycle analysis will be limited to differences in inputs for processing (“cut-off method”) of silane for recycling versus not-recycling. The functional unit is 1 kg of silane used in PV production. However, the inventory data associated with these inputs will embody a “cradle-to-gate” system boundary. These results will be compared with previous LCA results from the literature to quantify the variance in embodied energy and greenhouse gas emissions.

After designing an input for the recycled silane component, the LCA can be conducted for the actual deposition using recycled silane by considering Equation 1, which will be referred to as the recycled silane mixture. Using equation 1, it is found that 32% raw silane will be needed for the deposition process in conjunction with 68% recycled silane, due to the 32% loss during the initial deposition process and the recycling process.

For comparison, 1 kg of silane can produce approximately 129 m2 of a-Si:H PV material with 15 percent deposition efficiency.

A 1 GW single-junction a-Si:H manufacturer running continuously will use 111,000 kg of silane per year of which 94,300 kg of silane will go through the deposition chamber and be wasted. By recycling, there is a potential to save 55,400 kg for reuse in the deposition chamber, with an end result of only 18,900 kg being disposed. When the difference in the amount of energy and CO2 associated with 1 kg of silane is considered and multiplied by the amount of silane used per year, the end result of recycling silane is approximately 81,700 GJ of energy savings and 4.4 million kg of CO2 eq per year.

Raw silane has a cost associated with its purchase approximated by Sematech at US$0.30/g for bulk production (Visokey, et al., 1995), although it should be noted that costs are highly variable. Thus, the process outlined here for recycling reduces this cost by 68 percent, or approximately $22.6 million/year for a 1 GW a-Si:H-based PV production facility. These cost savings thus help provide a cushion for thin film PV manufacturers from volatile silane cost fluctuations.

The impacts of recycling silane in a 1 GW tandem a-Si:H/μc-Si:H manufacturing plant under the same recycling assumptions is even more substantial. The tandem fab will use 388,000 kg of silane per year and could save 264,000 kg of silane by recycling. This is equivalent to 290,000 GJ of energy savings and 15.6 million kg of CO2 eq per year. This represents a larger potential embodied energy savings than integrating recycled glass in the back glass encapsulation layer (Nosrat, et al., 2009). Most strikingly, silane recycling results in a reduction of raw silane purchase costs of approximately $79.2 million/year for a 1GW-scaled tandem a-Si:H/μc-Si:H manufacturing plant. At a thin film PV module cost of $0.70/Wp a 1GW-scaled plant generates $700 million in revenue/year, so the potential cost savings from silane recycling are approximately 11% of revenue. The percentage of potential savings from recycling would increase, as cost declines are made possible by improved efficiency and increased market competition reduces margins.

The analysis finds that approximately 45.1-50.7 tonnes of silane would be required to manufacture 712-800 MW of a-Si modules. In 2012, an estimated 50 tonnes of silane was consumed by the a-Si thin film industry. <https://shaktifoundation.in/wp-content/uploads/2017/06/RE-Mfrg-Final-Report-2015.pdf>

Figure 4.8: Technology Wise Estimate of the Range of Installed c-Si and a-Si (in GW) During 2017-32 Table 4.14 shows the material requirement of the different critical components. As glass, encapsulant and backsheet are common for both c-Si and a-Si technologies, the Table represent the material requirements of these components together. The table also comprises of an estimate of the global consumption of these components in 2012. The comparison shows that for all the components, the material requirement by 2032 will be approximately equal to global consumption in 2012. Finally, in the long-term; all the components should be manufactured in India.

Table 4.14: Long-Term Material Requirement for the Different Critical Components

Critical Components Material Requirement for c-Si and a-Si PV (2017-32) Estimated Global Consumption in 2012 Polysilicon (kt) 65 - 174 179 Silane (tonnes) 125 - 303 76 Glass (kt) 914 – 2,520 1,538 Encapsulant(million m2) 288 - 566 192 Backsheet (million m2) 120 - 330 98

**SWOT Analysis – Silane gas – India**

[**https://shaktifoundation.in/wp-content/uploads/2017/06/RE-Mfrg-Final-Report-2015.pdf**](https://shaktifoundation.in/wp-content/uploads/2017/06/RE-Mfrg-Final-Report-2015.pdf)

**Important document in terms of consumption-** [**https://shaktifoundation.in/wp-content/uploads/2017/06/RE-Mfrg-Final-Report-2015.pdf**](https://shaktifoundation.in/wp-content/uploads/2017/06/RE-Mfrg-Final-Report-2015.pdf)

Shaanxi Non-Ferrous Tian Hong REC Silicon Materials (Yulin JV), a joint venture established by REC Silicon (Norway) and Shaanxi Non-Ferrous Tian Hong New Energy (SNF) (China), started development of granular silicon with the FBR process in the first quarter of 2018. The company has the production capacities of 18 000 tons/year for FBR-based granular polysilicon, 1 000 tons/year for Siemens-based polysilicon, and 500 tons/year for silane gas. In 2018, the company manufactured 5 400 tons of FBR-based polysilicon, 100 tons of Siemens-base (semiconductor grade) polysilicon. Asia Silicon (China) announced that it successfully developed granular polysilicon in June 2018 by the process of direct decomposition of chlorosilane. According to Asia Silicon, it is possible to manufacture granular polysilicon with 10 kWh/kg or lower electricity consumption, compared to about 40 kWh/kg for manufacturing Siemens-based polysilicon. In 2017, GCL-Poly Energy (China) acquired the FBR technology from SunEdison (USA) for manufacturing polysilicon.[**https://iea-pvps.org/wp-content/uploads/2020/02/5319-iea-pvps-report-2019-08-lr.pdf**](https://iea-pvps.org/wp-content/uploads/2020/02/5319-iea-pvps-report-2019-08-lr.pdf)

**Table given with per MW consumption of silane** [**http://www.clca.columbia.edu/papers/8CO.1.2\_Dresden\_Risk\_06.pdf**](http://www.clca.columbia.edu/papers/8CO.1.2_Dresden_Risk_06.pdf)