

The share of renewable electricity in global energy consumption will rise, replacing the share of chemical energy (coal, crude oil, natural gas). Wherever possible, electricity must be used directly. Renewable electricity supply deviates from demand, requiring grid stabilization mechanisms. Reversible electrolyzers and fuel cells that produce and use low carbon fuels can contribute to grid stability by operating according to renewable energy availability. The chemical, fuel and heat sector cannot be electrified in full. Chemical energy carriers will keep a major role in future energy systems. Those applications that cannot be electrified and are left over must be fed by low carbon chemicals and fuels. One major pathway is to derive them from renewable electricity via sector coupling. This will expand the energy transition from the electricity sector to the chemical and fuel sector. High temperature electrolyzers are a key PtX coupling technology for best efficiency. They allow existing chemical and refinery industry to use their assets while becoming renewable by producing low carbon fuels. In order to allow energy transition in all sectors, renewable business models must be equal or better than fossil ones. This is a prerequisite for low carbon fuels but applies to renewable energy valorization business in all sectors: electricity, chemistry & fuels, heat. Even if we had PtX at 100% efficiency and zero capex, the cost for renewable energy would still make low carbon chemistry & fuels more expensive than their fossil counterparts. In addition to technology development, renewable energy business, especially low carbon fuels, requires economic circumstances via legal regulations that force fossil business to cover their full cost. Externalization of CO<sub>2</sub>-cost whilst internalization of profits must stop.

Efficiency potentials from electricity to hydrogen or syngas are already well leveraged. Sunfire's rSOC can turn electric into chemical energy at 85% efficiency. But Technology Readiness Level (TRL) must rise (actual: 3-5; required for commercial plants: 7-8). CAPEX must be reduced. OPEX can only be significantly reduced by lowering the price for renewable electric energy. In order to increase TRL and lower CAPEX, it requires further R&D for increasing the robustness of PtX technology (lifetime) as well as industrial projects whose risk due to low TRL is backed by government funding. Chemical and refinery industry plants must allow the feed of H<sub>2</sub> and Syngas (CO + H<sub>2</sub>) from electrolyzers as well as renewable Fischer-Tropsch and Methanol instead of crude oil. This allows the use of existing industrial assets while making them renewable. It prevents stranded assets.

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