Beyond Electricity: Wind Power to Produce Carbon-neutral Synthetic Fuels

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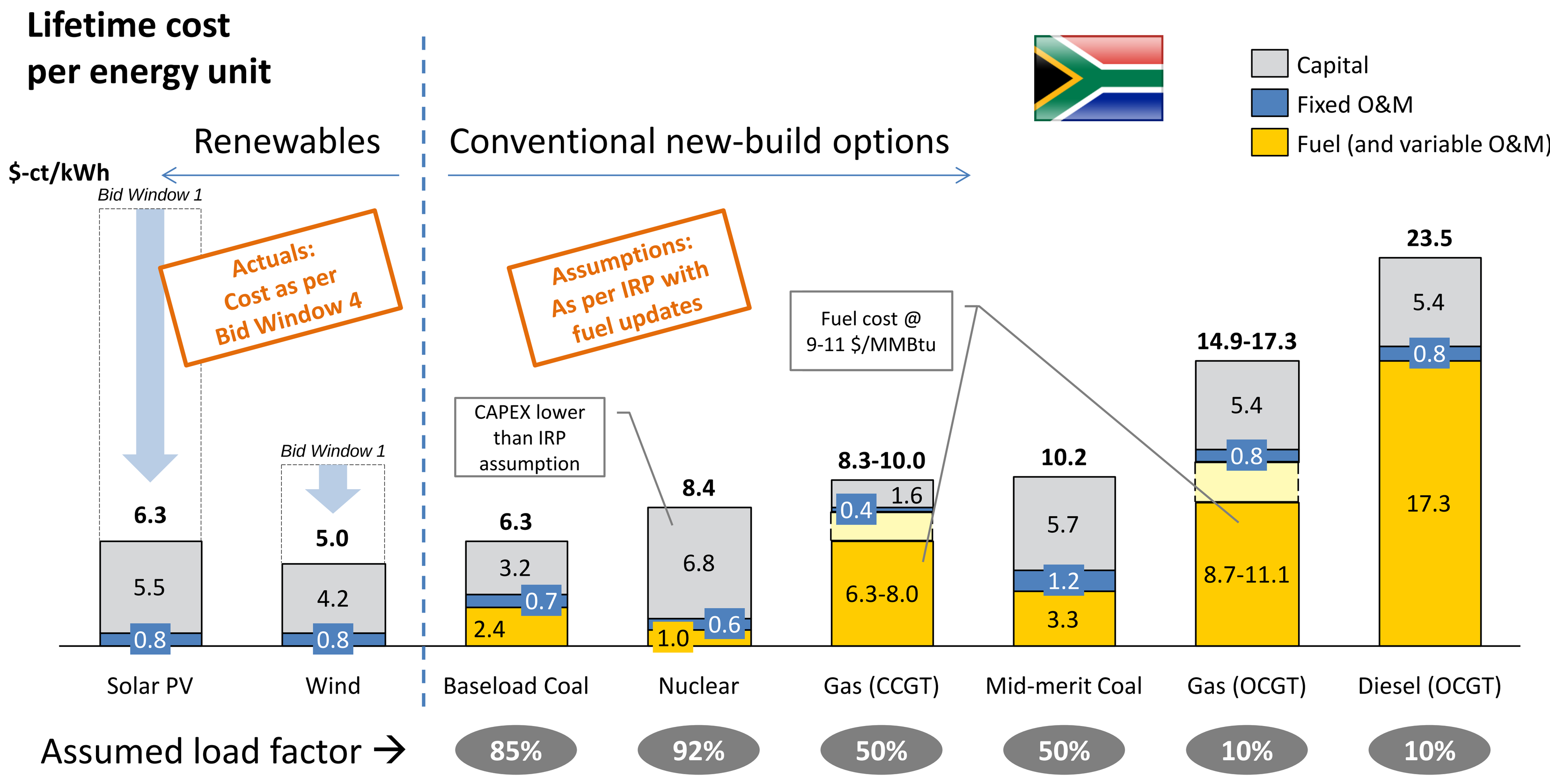
Background: Cost competitiveness of solar PV and wind

Solar PV and wind are the two cheapest new-build options in South Africa per energy unit today. Significant technology cost reductions in recent years combined with world class solar and wind (>35% load factor achievable in almost 70% of South Africa's land mass) resources in the country have led to this result.

Figure 1 shows the cost of solar PV and wind in South Africa, based on actual tariff results of South Africa's competitive tender process. To the right it shows the current planning assumptions for alternative new-build options from the country's Integrated Resource Plan (IRP).



Note: Changing full-load hours for conventionals drastically changes the fixed cost components per kWh (lower full-load hours → higher capital costs and fixed O&M costs per MWh); Assumptions: average efficiency for CCGT = 50%, OCGT = 35%; coal = 37%; nuclear = 33%; IRP cost from Jan 2012 escalated with CPI to Jan 2016; assumed EPC CAPEX inflated by 10% to convert EPC/LCOE into tariff; ZAR/USD = 12.8 (2015 average); Sources: IRP Update; REIPPPP outcomes; StatsSA for CPI; Eskom financial reports on coal/diesel fuel cost; CSIR analysis

Figure 1: Levelised Cost of Energy for different new-build options in South Africa

Energy Storage and Sector Coupling

Although solar PV and wind power are the cheapest form of electricity production today in South Africa and in many other parts of the world, they have a disadvantage: Solar PV and wind are the only two power-generating technologies that are dispatched by the weather and not by the owner of the asset or by the system operator. With widespread spatial distribution the short0-term variability of solar PV and wind power on portfolio level can be largely reduced. But residual fluctuations (intra-day, intra-week, intra-month) still exist and must be managed through additional interventions.

One such intervention is the introduction of energy storage. Energy storage however is much broader than the typically referenced "power-to-power" use case. Figure 2 shows the comprehensive spectrum of energy storage use cases relevant today.

1 Power-to-Power

Storing electricity for later use in the electricity sector
- Shifting large energy amounts: the "pumped storage" use case
- Providing power quickly: frequency control (reserves)
- Grid infrastructure deferral
- End-customer use cases

2 Power-to-Gas/Liquids

Utilising electricity to produce natural gas and/or liquid fuels
- Electrolysis of water to produce hydrogen (H2)
- Subsequent methanisation (CH4), methanol synthesis (CH3OH) or Fischer-Tropsch (-CH-)
- Utilising CO2 (and electricity) as chemical feedstock
- Additional input required: CO2

3 Power-to-Heat

Utilising electricity to produce heat
- Shifting existing power-to-heat demand to later times
- Creating additional power-to-heat demand trough fuel switching

4 Power-to-eTransport

Utilising electricity in the electrically-driven transport sector
- Electric vehicles (batteries, hydrogen storage)
- Electric train transportation

Sources: CSIR analysis

Figure 2: Different use cases of energy storage

Power-to-Liquids and the Export Potential for South Africa

Of the energy storage use cases, only the first one is a use case within the electricity sector. The other three use cases couple the electricity sector with other energy end-use sectors (transport and heat). The sector coupling has two advantages: First, it is a "pressure valve" for excess energy in the electricity sector. Second, through the sector coupling to the production of hydrogen and subsequent processes it is possible to convert electricity into an exportable product beyond directly neighbouring and interconnected countries.

For South Africa, the production of synthetic liquid fuels from renewable electricity, water and carbon dioxide (such as long-chained hydrocarbons as depicted in Figure 3, or methanol through synthesis of syngas) is of particular interest. The reason being that the cost of producing these liquid fuels is mainly driven by the cost of renewable electricity that feeds the process.

South Africa as one of the countries with the lowest solar PV and wind electricity production costs in the world, in combination with the vast experience of the country in producing synthetic liquid fuels from coal, is in a advantageous position to produce some of the cheapest carbon-neutral liquid fuels globally. The production costs are estimated to be approx. $0.9 per litre for the electricity component and another $0.3 per litre for the capital component ($1.2 per litre in total). That is at today's cost of wind power and without any efficiency improvements and cost reductions on the side of the production process.

The European Union (EU) has recently created a market for these type of carbon-neutral fuels through its directive that allows renewable-electricity-based fuels to count towards the mandatory blending requirement of biofuels into the EU's liquid fuel mix.

For South Africa, the deployment of renewables-based liquid fuels could stem from:
1) Production of drop-in fuels (petrol, diesel) for export into the EU
2) Production of methanol for chemical processes and for future liquid fuel demands
3) Production of kerosene to de-carobonise the aviation industry

1% of the EU's annual liquid fuel demand stands for an addressable market of ~$5 billion per year.

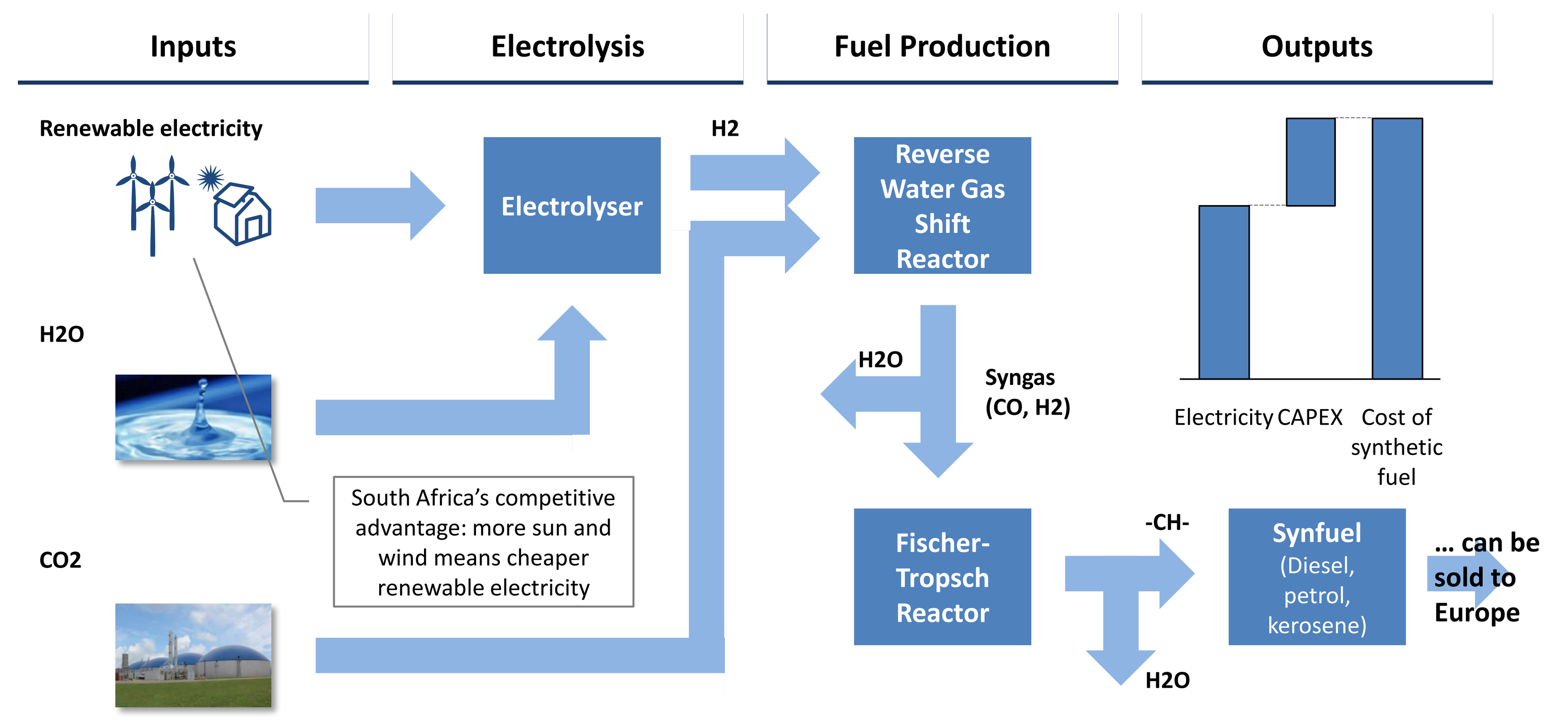


Figure 3: In-principle process of production of carbon-neutral synthetic liquid fuels from renewable electricity, water and carbon dioxide

Conclusions

South African renewable electricity will always be cheaper than in most other parts of the world, thanks to the excellent solar and wind resource. Cheapest renewable electricity is a competitive advantage that will never go away.

In addition, South Africa has vast experience in the creation of synthetic liquid fuels. The country gets roughly 1/3 of its liquid fuel demand from Coal-to-Liquid processes. Sasol is one of the largest Coal-to-Liquid producers globally.

This combination provides an opportunity for South Africa to commercialise renewable-electricity-based, carbon-neutral synthetic fuels and chemicals from Power-to-Liquid processes and turn them into export articles for the country. The EU has started to create the market for such fuels via its mandatory biofuels blending requirements.

The CSIR intents to pilot a Power-to-Liquid plant on its campus in Pretoria to commercialise the technology together with partners from private industry.