# The economics of water supply for electrolysis

## Looking into the green hydrogen production cost stack

By Stephen B. Harrison, sbh4 consulting

Pure water supply to an electrolyser is essential. Electrolysis splits water molecules to oxygen and hydrogen. The cost of water supply for a typical green hydrogen scheme will be insignificant compared to the cost of the renewable power and will generally be only 1% or 2% of the total operating cost.

However, the consequences of water supply issues are unacceptable. Impurities such as calcium ions in the water will rapidly damage a PEM electrolyser membrane due to the interaction with the catalyst coating. Alkaline electrolysers also have sensitivities to poisons in the water.

Failure to supply water means the electrolyser scheme must shut down. For a PEM system that will probably not be a major issue. For an alkaline system, an unplanned shutdown may result in corrosion of the electrodes and a reduction in the electrolysis efficiency during future operation.

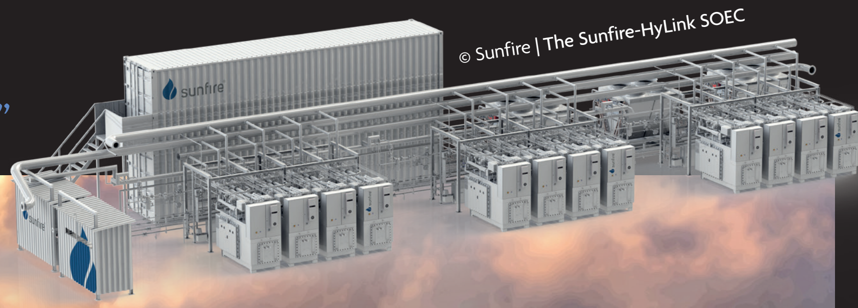
Supply of pure water to the electrolyser must be guaranteed. The capital and operating costs are low, but the consequences of failure can be very high: reliability is key. >>

"Impurities such as calcium ions in the water will rapidly damage a PEM electrolyser membrane due to the interaction with the catalyst coating..."

Cooling towers with air fans.

"Electrolyser manufacturers will provide a more detailed specification for the feed water, and most will provide the required de-ionisation equipment as part of a complete package, if required by the customer"

Tanker lorries for water deliveries to remote locations.




Nelson Mandela Bay.

## How pure is pure?

The main quality parameter associated with the pure water supply to an electrolyser is the conductivity. As a rule of thumb, less than 2µS/cm (0.2 mS/m) should be the target. Ions, such as calcium or sodium that are dissolved in the water will increase its conductivity. So, measurement of this parameter will confirm that damaging dissolved salts are not present. Electrolyser manufacturers will provide a more detailed specification for the feed water, and most will provide the required de-ionisation equipment as part of a complete package, if required by the customer.

There are two internationally recognised standards that refer to demineralised water purity. The US based ASTM D1193-06(2018) Standard Specification for Reagent Water identifies three grades of purity. Many electrolyser producers will request supply of Type 2 water as a minimum purity. It has a maximum permissible conductivity of 1µS/cm (0.1 mS/m).

The ISO Standard is ISO 3696:1987 is an alternative to the ASTM document. It is titled 'Specifications for Water for Analytical Laboratory Use'. This standard includes three grades of purity. The typical feed for an electrolyser would be Grade 2 with a maximum conductivity of 0.1 mS/m – identical to the ASTM Type 2 water. In addition to the conductivity, the total organic content and total silica are important parameters that are also specified in the above standards.

Gerald Hammerschmid, Product Manager SOEC at Sunfire in Dresden, says that, "For alkaline electrolysis, Grade 2 or Type II demineralised water specifying < 1,0µS/cm is a commonly used standard. However, we see benefits in using 0.5µS/cm or less. Our observation from years of operational experience of our Sunfire-HyLink Alkaline electrolysis is that the better purity results in an increased stack lifetime and less electrolyte maintenance." These cost savings transfer to the bottom line and outweigh the marginal additional costs of better purification. Other contaminants include carbonate and sulphate ions as well as silicon and aluminium oxides.

"For use on our Sunfire-HyLink SOEC", adds Hammerschmid, "the permissible conductivity is slightly higher, however specific contaminants such as silicon and sulfur compounds have a high potential to poison catalysts in the electrolysis cell. These impurities may only be present at very low levels to avoid accelerated degradation."

Moreover, for co-electrolysis both the steam and carbon dioxide ($CO_2$) feed to the solid oxide electrolyser (SOEC) must meet the requirements regarding low levels of these contaminants. Therefore, when considering $CO_2$ utilisation, the requirement for $CO_2$ purification can vary significantly depending on its source. Some $CO_2$ captured from combustion of fossil-fuels or biogas derived $CO_2$ can contain sulfur compounds that must be removed. On the other hand, $CO_2$ derived from direct air capture (DAC) is generally free of these compounds.

EDI plant for pure water polishing.

Pump and reverse osmosis plant.

"The water treatment plant can represent around 5% of the capital cost of an electrolyser scheme"

## Pure water comes at only a small cost

The default technology for seawater desalination and brackish water purification is reverse osmosis. For general use, the reverse osmosis plant will operate at around 15 bar. For seawater desalination a higher operating pressure of around 80 bar is used.

Pumping water to these pressures requires strong pumps with large motors. However, in the case of freshwater purification the power required to operate the RO plant will be only 1 or 2% of the electrolyser scheme total. For seawater treatment, this may rise to be around 5%. If a solar powered thermal desalination process is used upstream of the reverse osmosis plant, the water purification power requirement can be reduced.

To achieve the low levels of permissible conductivity of 0.1 mS/m it may be required to use a polishing stage after the reverse osmosis plant. The most suitable technology for this is referred to as Electro De-ionisation or EDI.

The water treatment plant can represent around 5% of the capital cost of an electrolyser scheme. To put this into context the power management system involving the transformer and rectifier to convert grid, wind, or hydro power to be suitable DC electricity for the electrolyser would be around 20%. So, water treatment is an essential element of the scheme, but it will not eat too far into the project budget. A focus on reliability is therefore recommended.

## Cooling water is also required

Electrolysers are approximately 70% efficient when they convert electrical power to hydrogen. The 30% of wasted power generates heat. Since most electrolysers operate at around 80°C there is very little potential to utilise this heat for industrial applications, so it is generally dissipated on a cooling tower which is an essential balance of plant item for the electrolyser.

Cooling water flows continuously through heat exchangers that cool the electrolyser and then to the cooling tower. Cooling towers rely on the principle of evaporative cooling. Water is pumped to the top of the cooling tower where it falls down the cooling tower as fine water droplets. These pass against a strong upward moving current of air that is generated using a large fan. As water evaporates from the surface of the water droplets, they cool. A typical cooling tower will need about 2% of the daily recirculated cooling water volume to be topped up due to the evaporation losses. >>

>> The pumps that recirculate the cooling water, drive the cooling tower fans and recirculate the electrolyte around alkaline electrolysers all consume power. However, the power demand for these so-called balance of plant items is small compared to the power-hungry electrolyser. Only around 10% of the total electricity consumption for an electrolyser will be required for these balance of plant items, the majority flows to the stack.

Compact cooling towers.

## Diversification, added value and economies of scale

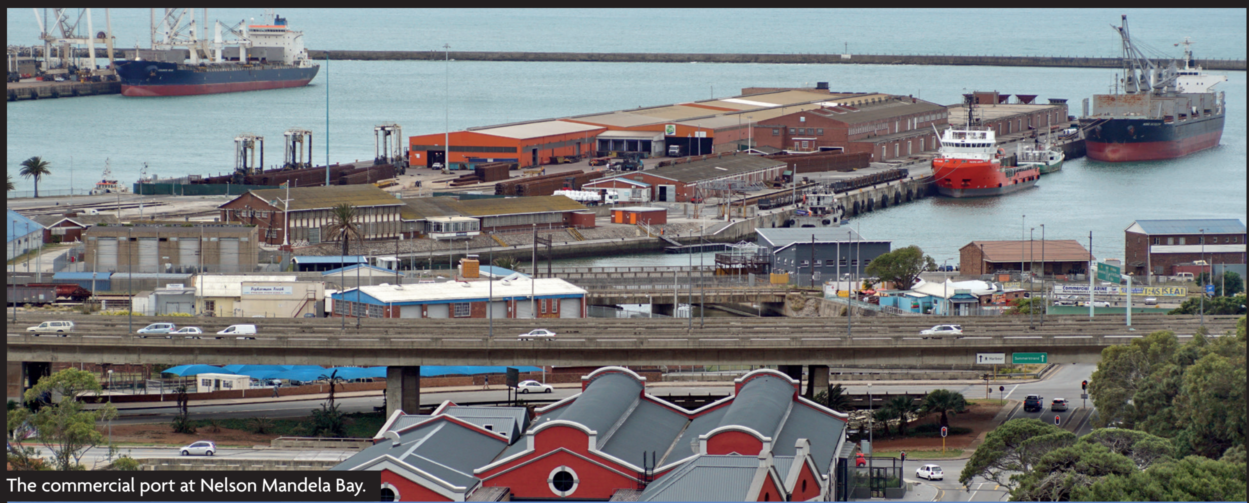
A major green ammonia project announced will be developed in Nelson Mandela Bay, South Africa. The bay has a commercial port and lies on the southern coast between Cape Town and Durban. Renewable power generation, green hydrogen production and ammonia synthesis will be led by Hive Energy and AFROX, a member of The Linde Group.

Electrolysers to provide hydrogen, an air separation unit to generate nitrogen and a synthesis loop to convert the hydrogen and nitrogen to ammonia will be implemented. The scheme will be capable of 800,000 tonnes per year of green ammonia production. The project is expected to cost more than €4bn with a phased go-live between 2024 and 2025. The green ammonia will be shipped internationally as a clean energy vector through the deep-water Port of Ngqura.

Drought and water shortages have blighted the Eastern Cape province of South Africa for years. The large scale of the Hive Hydrogen scheme would stress local natural fresh water supply beyond breaking point, so salt water from the ocean will be desalinated to ensure the electrolysers have a steady feedstock of fresh water to generate green hydrogen.

The well-known South African table salt producer Cerebos will take charge of the water desalination challenge in partnership with Coega Development Corporation. They will commission a reverse osmosis facility at nearby Port Arthur in 2021. The abundant local sunlight will support the desalination process to minimise the power demand and energy consumption.

The plant will be able to produce 15,000 tonnes of fresh water per day to feed the electrolysers, the local town of Port Elizabeth and bottling operations for freshwater and other beverages. Cerebos also markets industrial and consumer salt products. Expansion of the water usage to multiple applications increases the economies of scale to all water off-takers. Further, diversification to produce salt in addition to fresh water can secure additional revenue and profit to fund the investment. H2V



The commercial port at Nelson Mandela Bay.

"A major green ammonia project announced will be developed in Nelson Mandela Bay, South Africa. The bay has a commercial port and lies on the southern coast between Cape Town and Durban..."