Observatorio Tecnológico del Hidrógeno

TECHNICAL WORKSHOP

Technological developments in electrolysis systems

Conclusions

April 28th, 2025

Major advances in both technologies at the commercial stage: ALK & PEM Electrolysers

Main conclusions

- **Alkaline (ALK) and Proton Exchange Membrane (PEM) electrolyser** technologies are the most mature technologies on the market, and both **have clear complementarities in real projects**
- **Significant efficiency improvements have been achieved in PEM and alkaline technologies, with ongoing efforts to enhance them further**
- **Developments to extend the lifetime of electrolysers are being pursued through improved design, material selection and operational experience**
- **Real electrolysis facilities**, such as the one started by Repsol at the Petronor Industrial Centre, **are fundamental for gaining experience in the successful deployment of this technology**
- **Collaboration among stakeholders is essential**, as demonstrated by the 53 partners of the Hydrogen Technology Observatory

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During the presentation of the 3rd Technical Workshop of the Hydrogen Technology Observatory, Arturo Gonzalo, CEO of Enagás, pointed out that the **electrolysis system is a key element of the hydrogen value chain, which really strengthens and accelerates the development of the hydrogen ecosystem**. He mentioned that collaboration among partners is essential: the **Hydrogen Technology Observatory already has 53 partners**, showing the value of an alliance to successfully make the hydrogen ecosystem happen.

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Vanesa Gil, ARAID Senior Research and Head of R&D at the Aragon Hydrogen Foundation, underlined the **importance of electrolysers in low-emission hydrogen production for the future energy market**. "Electrolysers make it possible to connect sectors that were not connected until now", she said.

She highlighted the **challenges of the technology in terms of equipment lifetime, cost reduction, improving efficiency** and, for some technologies, the use of critical materials such as precious metals. **Tracking the evolution of electrolysis efficiency is complicated** because each technology is unique, as are its applications and conditions, so efficiency is measured with different parameters.

During the workshop, two electrolyser manufacturers, Accelera by Cummins and Nordex Electrolyzers, explained the benefits and challenges of PEM and ALK technologies.

Anne Murray, Customer Solutions Engineering Director at Accelera by Cummins, described Accelera's experience in hydrogen technology on PEM electrolysis. In fact, Accelera has the world's largest industrially proven PEM stack and has been working with this PEM stack for about a decade. She highlighted the **flexibility and efficiency of PEM technology, which is readily available**.

Javier Fernández de Manzanos, CTO at Nordex Electrolyzers, explained Nordex Electrolyzers is focusing on **ALK technology because of its flexibility for large-scale projects**. He underlined the 500 kW prototype electrolyser built and commissioned last year and explained the company's plans to develop larger electrolyser models in the near future.

Murray agreed that one advantage of ALK is that the cost per stack is lower, although "the total installed cost level that you see for PEM because of the scaling, the size and the highly integrated nature of the equipment has a lot of advantages from their point of view", she emphasized. **PEM technology has very low turndown and very high efficiency**. Flexibility - in terms of fast response time - is becoming an increasingly important aspect of overall project feasibility.

Both agree that **PEM is more flexible in terms of integration with other technologies**. However, Fernández de Manzanos pointed out some **advantages of ALK technology: it has lower costs and fewer materials restrictions**. "Durability could make a huge difference to OPEX, especially for large projects", he said. He assured that **experts are analysing the combination of both technologies in a large plant:** ALK could form the basis for consumption and production but PEM technology in the same project allows it to react more quickly to power fluctuations.

Improvements in electrolysis efficiency were discussed by both experts. Nordex Electrolyzer's expert affirmed: "efficiency is important but it depends on the project, stack lifetime may be more important". They're working on **improving efficiency in some projects and in lifetime in others**. On the other hand, Accelera is looking to maintain its "very compact highly efficient product and to be able to drive it harder effectively and get more hydrogen out of it without compromising on durability or efficiency". Accelera's expert said "it's not just about efficiency; it's about increasing capacity without compromising efficiency. **Efficiency, capacity and durability all need to be kept in as the roadmap develops".**

In terms of what contributes more to the **degradation of electrolysers**, both agree that **pressure and temperature are less of a concern as they are controlled variables** and can be considered in the design phase. Fernández de Manzanos pointed out that in tests carried out by them for **ALK technology, it was shown that what can degrade the electrodes more is switch-off and startup frequency.** On the other hand, Murray explained that **for PEM technology, water quality has the greatest impact on durability**.

Many tests are being carried out to improve both technologies, and experts have explained their plans for the future of both companies. For Accelera: the scale is still to be determined and they're working on this with partners. For larger applications, it's all about the stack and they're looking at increasing the capacity of the stacks, which means **reducing the number of stacks needed per installation**. Moreover, Nordex Electrolyzers is also focusing on improving the efficiency and reducing degradation rates. They are also looking at different technologies for the future, such as anionic exchange membranes (AEM), which has advantages of both technologies. They're working on **cost reduction on the capex side, so industrialising the economies of scale and making better manufacturing processes for components, while also looking at the OPEX, developing autonomous and remote operation modes**.

A pioneering green hydrogen facility in operation

The webinar also presented the **practical case of the Petronor Industrial Centre in the Basque Country, where Repsol commissioned the first electrolyser manufactured in Spain**. The **2.5 MW electrolyser** project was the first to produce renewable hydrogen on a demonstration scale in an industrial complex. María Molina, Repsol Senior Hydrogen Projects Manager, explained that the **ALK technology was chosen for this project** because it had more production benchmarks and lower capital costs in 2021**, although she agreed that right now both ALK and PEM technologies have similarities in efficiency and operating range**. The **electrolyser can produce around 375 tons of hydrogen per year**, **with an efficiency at beginning of life of 52 MWh per ton**. Repsol's expert explained the main features of this plant, including the layout of the electrolyser plant *(see presentation here)*.

Some of the objectives of the project included integrating different uses of hydrogen (refinery, mobility logistics, residential sector and hydrogen distribution by pipeline). Some of the lessons learned from the commissioning of this plant were explained, such as the balance between compact design and practical operability and maintainability; or adaptation to new services.

Molina also listed Repsol's future projects, such as the 10 MW electrolyser in the north of Spain that's due to be in operation by the end 2025; or the 100 MW also at Petronor refinery and 100 MW at the Cartagena Hub that they're working on.

Finally, Igor Pagazaurtundua, Coordinator of the Hydrogen Technology Observatory, summarised the **main conclusions of this workshop**, such as the **complementarity of both PEM and ALK technologies, the importance of the new plants being built in Spain and their potential for scaling up the technology**. He also highlighted the **lifetime enhancement and efficiency improvements made by manufacturers**, such as Accelera by Cummins or Nordex Electrolyzers, being aware of the **importance of reducing the levelised cost of hydrogen (LCOH)** by improving their electrolysis systems to reduce the CAPEX/Investment requirements as well as reducing the quantity needs of renewable electricity.

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