Q4 2019 | Pulse
Power To Gas

FutureBridge

WHAT'S INSIDE!

- Electrolysis technology making inroads in industrial sector
- Danish Energy Agency funding power to gas projects with aim to achieve country's clean hydrogen programme
- Researchers continue their expedition for suitable electrolysis catalyst
- Germany and United States of America are the startup hubs for P2G technology

01 Emerging trends

The deployment of electrolysis technology for green hydrogen production in industries is gaining traction, with steel industry and refineries leading from the front. The commencement of the mentioned projects will be a basis for electrolysis usage in future green hydrogen projects on an industrial scale

The carbon intensive industrial sector is next to clean their hands with P2G technology

22st Nov 2019

Shell and Everfuel enters in to strategic partnership to build green hydrogen plant at the Shell refinery

20th Nov 2019

Greenfield Global Inc. and Hy2gen Canada establishes JV for industrial-scale production of green hydrogen in Canada

18th Nov 2019

Siemens to build a 2.2 MW PEM electrolysis plant with a capacity of 400 Nm3 of hydrogen for Salzgitter Flachstahl's steel making facility in Germany

11th Nov 2019

Part of the EU-funded H2FUTURE project, a 6 MW electrolyser has commenced production of green hydrogen at the voestalpine Linz steel plant in Austria

DEVELOPMENTS Emerging Trends

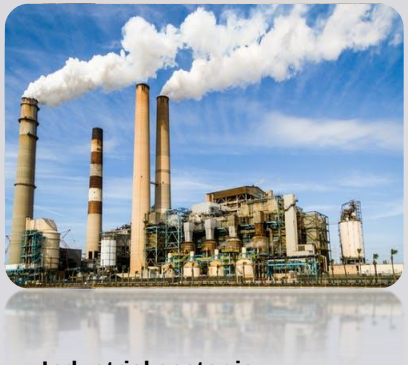
Last quarter witnessed several projects announcement for decarbonizing the industries by usage of green hydrogen produced through electrolysis.

At present most of the hydrogen consumed in industries is produced through steam methane reforming which also emits carbon dioxide during the hydrocarbon decomposition process.

Electrolysis is looked up as a preferred technology to replace SMR for hydrogen production and growing interest among industry and governments to produce green hydrogen for industry as well as for other sectors will aid this power to gas technology to infiltrate the market.

FutureBridge Insight & What should you investigate ?

The carbon intensive industrial sector is next to clean their hands with P2G technology



Industrial sector is responsible for over 22% of the carbon emissions globally.

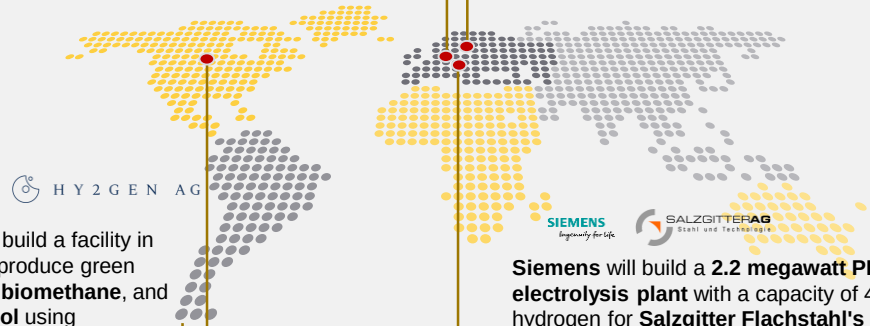
Steel manufacturing facilities and oil and gas refineries are the leading environmental polluters which need to take proactive steps in curbing the emissions in order to avoid major losses from rising carbon prices and climate regulations.

voestalpine ONE STEP AHEAD. SIEMENS Ingenuity for life

Siemen's Silyzer 300 PEM electrolyser has commenced production of green hydrogen at the **voestalpine Linz steel plant** in Austria
The 6 MW electrolysis plant will generate 1200 Nm3/hr hydrogen for use in the voestalpine steel manufacturing plant and will also provide network services

Shell Everfuel

Shell and Everfuel to build a **20 MW electrolysis plant** in Fredericia, with a aim to expand the capacity up to 1 GW
The plant will produce green hydrogen utilizing the excess wind power to fulfil requirements of the refinery and transport sector



HY2GEN AG

The **JV** will build a facility in Canada to produce green **hydrogen**, **biomethane**, and **biomethanol** using electrolysis technology. The JV facility will be built at **29 MW** and expanded to meet demand with a possible scale-up to **80 MW in 2024**.

SIEMENS Ingenuity for life SALZGITTER AG Stahl und Technologie

Siemens will build a **2.2 megawatt PEM electrolysis plant** with a capacity of 400 Nm3 of hydrogen for **Salzgitter Flachstahl's steel making facility** in Germany.
The 30 MW seven wind turbines will provide the necessary power. The cost of the project as a whole – including the construction of the wind turbines and the hydrogen plant and connecting these to the existing supply networks – amounts to around 50 million euro.

Denmark fuels large-scale hydrogen production projects

Danish Energy Agency has provided more than $19 million of funding to build large-scale renewables energy storage projects.

The government is looking to fuel transport, particularly buses, aircrafts and ships, with hydrogen as the country shift towards sustainable goals.

GreenLab

20th Dec 2019

Danish Energy Agency provides funding to GreenLab Slice PtX project.

Ørsted Everfuel DSV ENERGINET Brintbranchen Hydrogen Denmark GRØNHYDROGEN.DK

20th Dec 2019

Ørsted with its partners, Everfuel, NEL Hydrogen, GreenHydrogen, DSV Panalpina, Hydrogen Denmark and Energinet Elsystemansvar have been awarded funding of DKK 34.6 million by Danish Energy Agency for the H2RES project.

Everfuel

18th Dec 2019

Everfuel secures EUR 6 million from the Danish Energy Agency for large-scale hydrogen production facility in Denmark.

DEVELOPMENTS Emerging Trends

The recent funding by Danish Energy Agency to hydrogen generation projects clearly indicates the government commitment in reducing 70% GHG emissions in the country by 2030. The country political target of 100% fossil fuel independence by 2050 in all energy sectors will only be possible if hydrogen is being integrated with renewable energy sources to support power and heat production, fuel cell electric vehicles and gas and fuel production.

FutureBridge Insight & What should you investigate ?

The funding by Danish Energy Agency will aid country in implementing its Hydrogen Energy Programme which aims to utilize the full potential of renewables especially wind energy by converting it to hydrogen when production exceed demand.

Hydrogen will provide backup for both planned and unplanned fluctuations in wind power production. It will also allow the country to make use of import/export opportunities by engaging in both

bulk sales across the boundaries and short-term trade on the Nordic power pool.

Denmark fuels large-scale hydrogen production projects

GreenLab

Electrolyzer Capacity
12 MW

GreenLab Slice PtX

GreenLab Slice PtX project will be one of the the world's first large-scale facility for production of green hydrogen and methanol. The project, GreenLab Slice PtX, will consist of 10 MW methanol plant and a 12 MW electrolysis plant, and will be using renewable power from a local 80MW hybrid wind and PV plant.

Ørsted
Everfuel
Brintbranchen Hydrogen Denmark
DSV ENERGINET
GREENHYDROGEN.DK

Electrolyzer Capacity
2 MW

H2RES

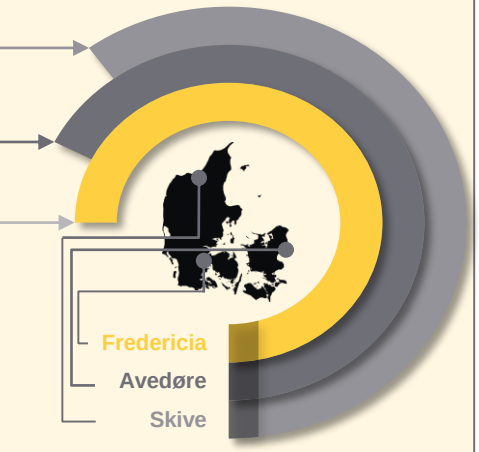
The project will consist of 2 MW electrolysis plant with appurtenant hydrogen storage, for buses, lorries and potentially taxis. The daily hydrogen production is expected to total around 600kg from 2MW electrolyser, which will using power directly from Ørsted's two 3.6MW offshore wind turbines at the Avedøre Power Station.

Everfuel

Electrolyzer Capacity
20 MW

HySynergy

Everfuel is developing hydrogen production project facility at the Shell refinery in Fredericia, with an initial capacity of the electrolyser of 20 MW, and be prepared to accommodate for a capacity increase of up to 1GW. The project will supplying hydrogen for the refinery itself, and also for light- and heavy-duty fuel cell electric vehicles operating in the area.



FutureBridge Insight on Power to Gas

Power to gas technologies, electrolysis in particular is gaining traction with the industry players showing interest in integrating it with their facilities for hydrogen production. The commencement of H2FUTURE project along with announcements of few others will be an example among other industry players to follow the carbon neutral path. In addition, stringent government policies w.r.t carbon emissions will also propel similar projects in the near future.

What should you investigate ?

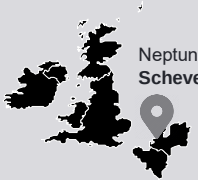
What are the upcoming power to gas projects in the industrial sector?

Which industry is likely to take a lead in adopting the power to gas technology and why?

Which are the other countries which are following the similar path as Denmark in deploying the power to gas projects?

POSHYDON - The world's first green offshore hydrogen

The first offshore green hydrogen pilot in the world, to integrate three energy systems in the North Sea, Offshore wind, offshore gas and hydrogen. It will be consisting of megawatt-scale electrolyzer, to be placed within a sea container and installed near cost of The Hague. The platform will convert seawater to demineralized water and use offshore wind power to produce hydrogen.



Neptune's Q13a-A Platform, **Scheveningen, The Hague**

Pilot Initiative from

nexstep

TNO innovation for life

PEM Electrolyzer

- **Input Power – 1 MW**
- **H_2 Flow - 200 Nm3/h**
- **H_2O Consumption – 300 l/h**
- **H_2 Purity – 1 MW**

RHETICUS II

Artificial photosynthesis using CO_2 electrolyzer and bacteria to produce H_2

The project will comprises electrolyzers and 8-metre high, 2,000L stainless steel bioreactor for combined operation to convert carbon dioxide and water into hydrogen and carbon monoxide, and subsequently convert the CO into chemicals via special micro-organisms. In the test facility, bacteria will produce butanol and hexanol for research purposes.

BMBF Funding: €3.5 Million

EVONIK POWER TO CREATE

SIEMENS

World's First CO2 Electrolyzer

Comprises 10 cells

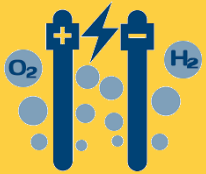
Total surface area of electrodes is 3,000cm2.

Operational Year

2020-21

02 Quarterly review of early-stage research

RESEARCH & DEVELOPMENT



Catalysts will play a major role in making electrolysis reach technology maturity for large scale energy storage. Last quarter witnessed more than 120 patents filling and similar number of research papers being published which clearly shows the intensity with which research is being carried out to make electrolysis the technology of the future

Research activity continue to strive for best suited catalyst for electrolysis

UNIVERSITY of HOUSTON

11th Nov 2019

Researchers from the University of Houston develops catalyst to efficiently produces hydrogen from seawater

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

15th Nov 2019

Eindhoven University of Technology improves hydrogen storage by 20 times using platinum-nickel catalyst

MONASH University

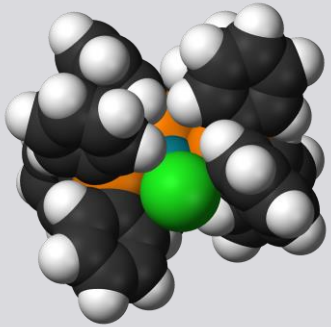
24th Sep 2019

Monash University researchers make electrolysis more economically viable

DEVELOPMENTS Emerging Trends

Electrolysis process is one of the oldest method to generate hydrogen but its commercialization to generate hydrogen for energy storage still suffers due to high cost, low efficiency and limitations to the quality of water used. Continuous research efforts are being put in to solve above challenges..

Cheap and efficient catalysts are being researched on to replace expensive platinum-based catalysts. Catalysts are being developed which can achieve industry suited current densities and start sea water electrolysis at low voltages



Catalyst's multi functional behavior and properties to be a one stop solution to several challenges faced by electrolysis technology is continuously driving the research community to unearth several unexplored chemistries and compound to replace currently used expensive, rare and inefficient materials. Efforts are being made to find cheap, abundantly available catalyst which can deliver high productivity even in extreme environment without getting deteriorated.

A continuous quest for economical and efficient hydrogen production technology - Photocatalysis

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Researchers have developed a catalyst with hollow nanocages of an alloy of nickel and platinum with 20 times higher activity than presently used platinum catalyst.

The developed hollow nanocages offers greater surface area allowing more material to react with water molecules, thereby leading to higher activity.

UNIVERSITY of HOUSTON

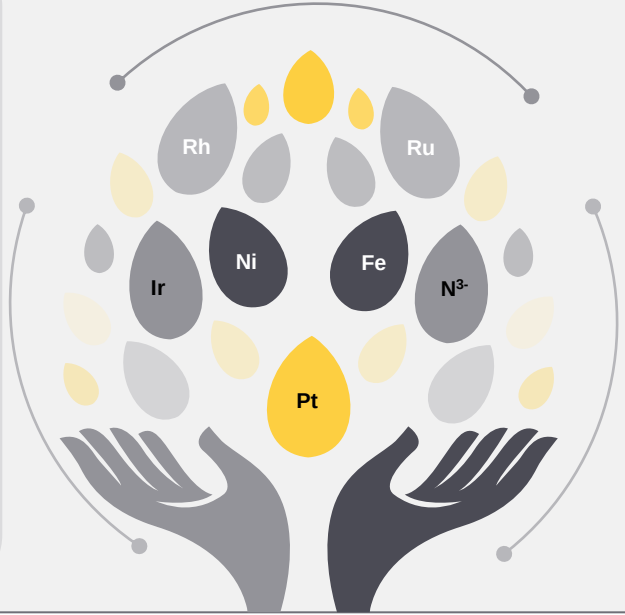
Researchers reported a significant breakthrough in developing an inexpensive non-noble metal nitride-based for seawater electrolysis. The researchers designed and synthesized a three-dimensional core-shell oxygen evolution reaction catalyst using transition metal-nitride, with nanoparticles made of a nickle-iron-nitride compound and nickle-molybdenum-nitride nanorods on porous nickle foam.

Non-noble metal nitride-based catalyst achieving industry suited current densities (500 and 1000 mA cm-2) while requiring relatively low voltage (1.608 and 1.709 V) to start seawater electrolysis..

MONASH University

Researchers have managed an ingenious solution to the requisite rare and expensive metal catalysts, such as platinum and iridium. They are replacing iridium with elements that are abundant, cheap, and operate in a more stable manner and demonstrated their stability in very strongly acidic conditions and up to 80 degrees Celsius, which is an industrially relevant temperature.

The researchers are working to for the development of a self-healing system which might just solve the dissolvability problem, as dissolved metallic during electrolysis could be redeposit on the electrode during operation.



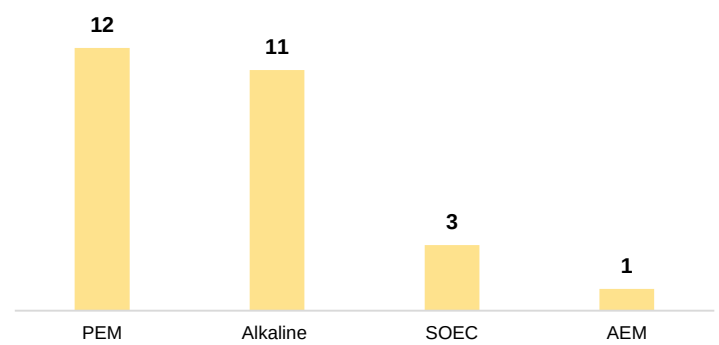
03 Startup Tracker highlights

Startup Tracker summary Q4 2019

22
Total Startups

Hidrogena · HOELLER (The Stack Company) · sunfire · HydrogenPro · Sylfen · Enapter · AREVA H2Gen (We make it happen)

Distribution by technology segmentation



Note: Total numbers for technology distribution will be more than total number of startups as a single startup may offer multiple technologies.

Funding distribution & activities

Enapter
$8.7 Million

Enapter develops hydrogen generators with patented Anion Exchange Membrane (AEM) technology.

Toscana, Italy

Enapter raised $8.7 million funding in two rounds. The latest funding of **$4.7 million** was raised from a **Series A** round on Sep 2019

ERGOSUP
€11 Million

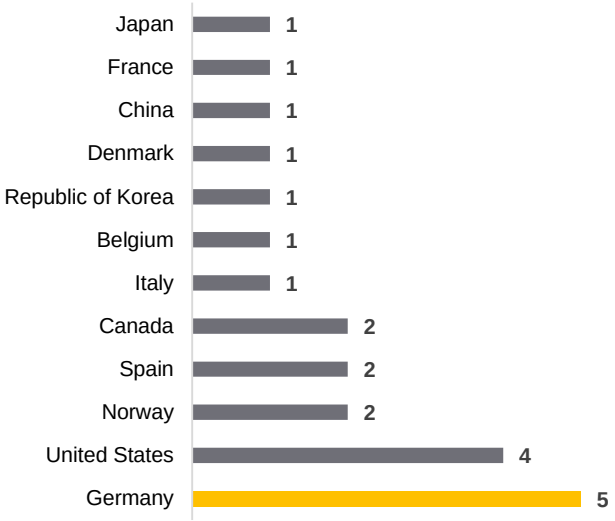
Ergosup develops hydrogen infrastructure based on its patented technology of direct electrolysis of water under high pressure.

Malataverne, France

bpifrance (Servir l'avenir) · KOUROS · APVentures (Advance & Pioneer) · GO CAPITAL · Air Liquide (creative oxygen) · ARKEA CAPITAL · DEMETER

What are the hubs of startup innovation for Electrolyzer Technology

Distribution of Start-ups by Country



- Europe is the hot bed for startups with over 60% of the company originating from the region
- More than 50% of the startup covered focus on PEM technology
- Germany and United States are the major startup hubs with five and four startups, respectively

Key startups from major hubs

North America
55 Madison Ave, Suite 400
Morristown, NJ 07960
USA
T: +1 212 835 1590

Europe
328-334 Graadt van Roggenweg
4th Floor, Utrecht, 3531 AH
Netherlands
T: +31 30 298 2108

United Kingdom
5 Chancery Lane
London EC4A 1BL
United Kingdom
T: +44 207 406 7548

Asia Pacific
Millennium Business Park
Sector 3, Building # 4, Mahape
Navi Mumbai 400 710
India
T: +91 22 6772 5700