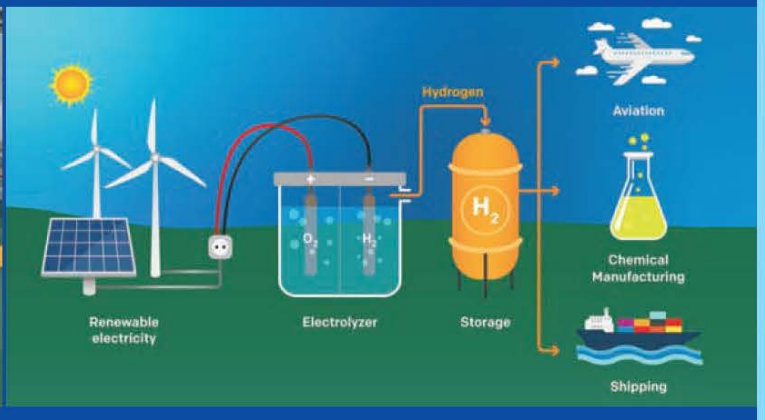
सत्यमेव जयते

पेट्रोलियम एवं प्राकृतिक गैस मंत्रालय

Ministry of Petroleum & Natural Gas

Government of India

# HydrogenTimes




## ELECTROLYSER

"If we were driving pure hydrogen automobiles, that automobile would actually help clean up the air because the air coming out of the exhaust would be cleaner than the air going into the engine intake.

***Dennis Weaver***

## हरित ऊर्जा से आत्मनिर्भर भारत की ओर

A Quarterly Newsletter of Ministry of Petroleum & Natural Gas (MoP&NG) on Green Hydrogen Initiatives

July, 2023, Vol.-II

# Initiatives by PSUs under MoP&NG

**Production plans for Green Hydrogen**

| Organization | Project Site | Green Hydrogen Capacity by 2030(KTA) |
|---|---|---|
| IOCL | IOCL Refineries | 350 |
| HPCL | Visakh Refinery & Barmer Refinery(Cumulative) | 29.1 |
| BPCL | Bina/Kochi/Mumbai | 28 |
| GAIL | H2 blending in City Gas Distribution Network | 45 |
| MRPL | MRPL, Mangalore | 5 |
| NRL | Numaligarh Assam | 9 |
| ONGC | Mangalore/Gujarat | 360 |
| CPCL | Manali, Chennai | 5 |
| Total | | ~831 |

Bharat Petroleum Corporation (BPCL) plans to establish a 1-megawatt electrolyser manufacturing facility in the country by 2025 using the Bhabha Atomic Research Centre's (BARC) technology for green hydrogen.

MRPL is working on Infrastructure to meet the needs of 18 MW production facility by 2025. Initially 3.5 MW production facility will be developed by 2025. Once commissioned, scalable to 18 MW production facility. EoI has been completed.

HPCL is the first OMC to place an order for large industrial electrolyser. Consortium of HPCL and ACME has submitted Bid in response to green hydrogen/ ammonia related tenders in Germany and Oman. HPCL is also setting up a 370 TPA Green Hydrogen infrastructure at Vizag Refinery.

GAIL (India) Limited has awarded a contract to set up one of the largest Proton Exchange Membrane (PEM) Electrolyser. The project would be installed at GAIL's Vijaipur Complex, in Guna District of Madhya Pradesh, and would be based on renewable power. The Project has been designed to produce around 4.3 Metric Tons of Hydrogen per day (approx. 10 MW capacity) with a purity of about 99.999 Volume %.

Numaligarh Refinery (NRL), located in Assam, plans to build a 5 KTPA facility in the state by 2030. NRL has floated a tender for the supply of 20 MW Electrolyser. The Electrolyser shall be based on Alkaline Water Electrolyser (AWE) or Proton Exchange membrane (PEM) technology.

IOC had entered into an agreement with the renewable energy company, ReNew Power and the engineering major, L&T, for putting up green hydrogen plants. IOCL's own projections of Green Hydrogen Production increased from 70 KTPA to 350 KTPA by 2030, mainly due to the inclusion of Green Hydrogen production from the biomass pathway.

Chennai Petroleum Corporation (CPCL) plans to build a 1 KTPA unit in Tamil Nadu by FY27, while Mangalore Refinery and Petrochemicals (MRPL) plans to build a 0.5 KTPA green hydrogen generating unit in Karnataka by 2025.

# R&D Initiatives

The Ministry of Petroleum & Natural Gas has set up a Hydrogen Corpus Fund (HCF) to promote technologies related to production, storage and transportation of hydrogen. Centre for High Technology (CHT) is the Nodal Agency for executing HCF projects. Some of the major projects taken under HCF are:

1. Development & demonstration of BSVI compliant Hydrogen Fuelled Internal Combustion Engine in Commercial Vehicle
2. Development of cost effective 2.5 KW PEM Fuel cell stack based on less-Pt bimetallic electrocatalysts and mesoporous carbon support materials
3. Light weight Novel Multicomponent High Entropy Alloy for Hydrogen Storage Application.
4. Setting-up single step compact reformer unit of 4 TPD capacity to produce hydrogen blended CNG (H-CNG) and associated facilities in Delhi bus depot for demonstration in commercial CNG vehicles.
5. Development of cost-effective PEM fuel cell stack based on less-pt bimetallic electrocatalysts and mesoporous carbon support materials.
6. Cost effective hydrogen Production through membrane less electrolysers and storage.
7. Scale up studies and process development for hydrogen production by catalytic decomposition of Natural gas.
8. Development and scale-up of indigenous next generation Solid Oxide Fuel Cell (SOFC) Technology and demonstration of process line (10 Kw) for prototype production.

# Interesting Facts about "Electrolyser"

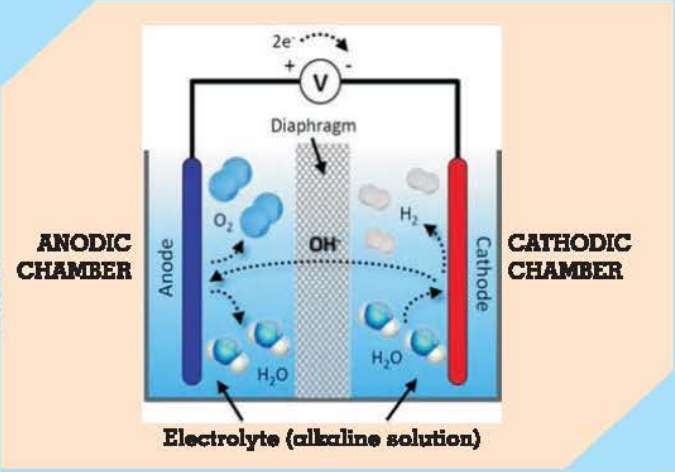
Electrolysers are a critical technology for the production of low-emission hydrogen from renewable electricity. Electrolysis capacity for dedicated hydrogen production has been growing at an accelerated pace since last few years. Total installed capacity has reached 1GW by the end of 2022. The National Green Hydrogen mission aims to achieve 5 MMT green hydrogen production targets by 2030 and to achieve this 60-100 GW Electrolyser capacity needs to be installed.

**Principle of Water Electrolysis**

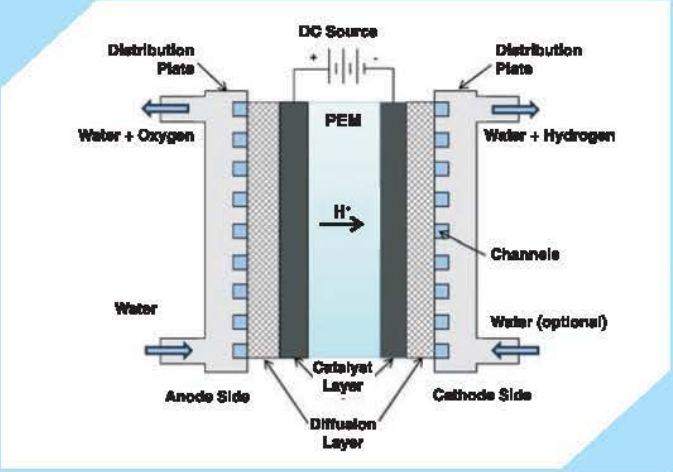
Two electrodes or plates that are made from an inert metal such as platinum or iridium are placed in the water. A DC electrical power source is connected to these plates. At the cathode (where electrons enter the water), hydrogen will appear. On the anode side, oxygen will appear. If we consider the ideal Faradaic efficiency, hydrogen molecule will be produced twice the molecule of oxygen.

**Electrolysis was first discovered in England by two men named William Nicholson and Anthony Carlisle. They used electrolysis to break down water into hydrogen and oxygen in the year 1800.**

There are four main types of water electrolysis technology: Alkaline Water Electrolysis (AWE), Proton Exchange Membrane (PEM), Anion Exchange Membrane (AEM) and solid oxide (SOEC). Each electrolyser functions slightly different depending on the electrolyte material involved. Alkaline and PEM Electrolysers are already commercially available and for production of hydrogen, both technologies are at the same technology readiness level (TRL9). Considering the number and scale of projects under development, it seems that alkaline designs will have a larger market share than PEM Electrolysers in the short term. AEM and SOEC are still in developing stage (TRL-5-7)

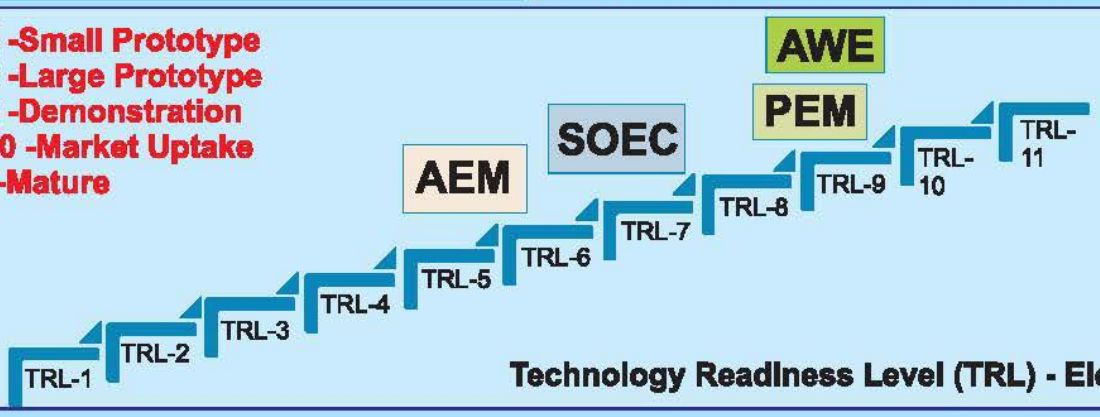



**Alkaline electrolyzers contain water and a liquid electrolyte solution such as potassium hydroxide (KOH). When current is applied to an alkaline cell tack, the hydroxide ions ($OH^-$) move through the electrolyte solutions from the cathode to the anode of each cell. The hydrogen gas bubbles are generated at the cathode, and the oxygen gas is generated at the anode.**



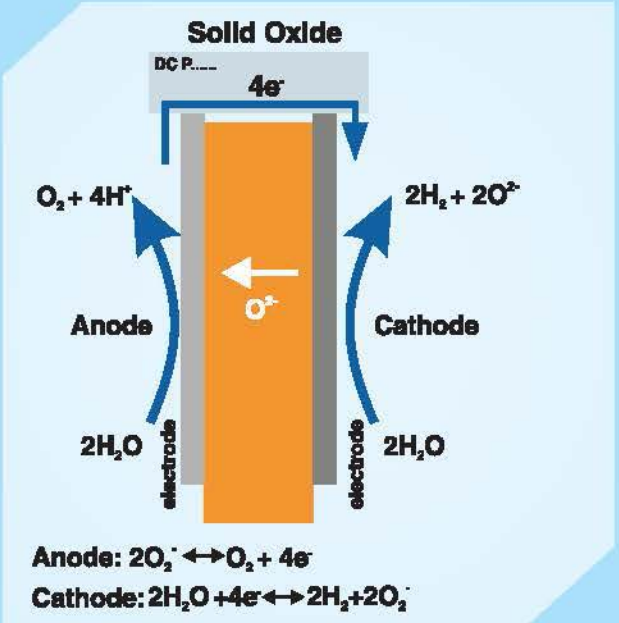

**PEM electrolyzers contain a proton exchange membrane that uses a solid polymer electrolyte. When an electrical current is applied to its cell stack during water electrolysis, the water splits into hydrogen and oxygen. The hydrogen protons pass through the membrane to form $H_2$ on the cathode side.**

**TRL-1-4 -Small Prototype**
**TRL-5-6 -Large Prototype**
**TRL-7-8 -Demonstration**
**TRL-9-10 -Market Uptake**
**TRL-11 -Mature**

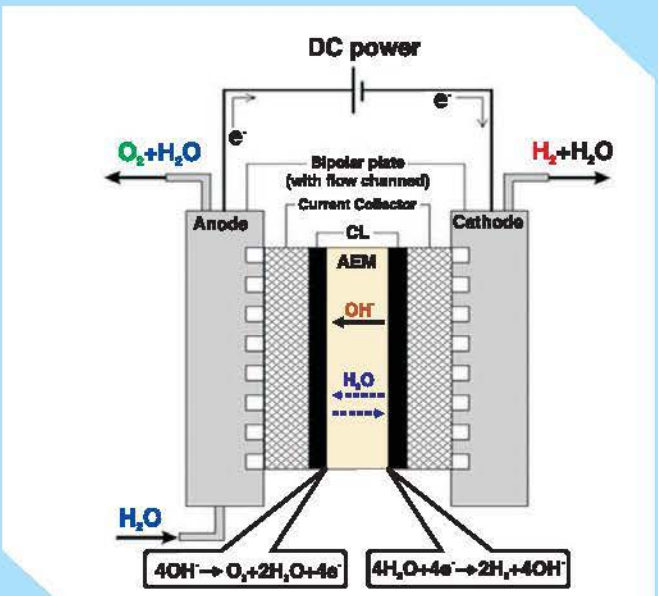



**Technology Readiness Level (TRL) - Electrolyser**

# Interesting Facts about "Electrolyser"




A solid oxide electrolysis cell (SOEC) uses a solid oxide, or ceramic, electrolyte. When current is applied, and water is fed into its cathode, the water converts into hydrogen gas and oxide ions. While the hydrogen gas is captured for purification, the oxide ions move to the anode and release electrons to an external circuit to become oxygen gas.




AEM Electrolyser use a semipermeable membrane that conducts hydroxide ions ($OH^-$) called an anion exchange membrane. Advantage of AEM Electrolyser is that a high-cost noble metal catalyst is not required. AEM electrolysis is similar to alkaline water electrolysis, which uses a non-ion-selective separator instead of an anion-exchange membrane.

**Table 1. Comparison of characteristics of alkaline electrolyser and PEM electrolyser.**

| Name | Alkaline Electrolyser | PEM Electrolyser |
|---|---|---|
| Electrolyte | 30% wt KOH solution or 25% wt NaOH solution | Solid polymer |
| Current density(A/m2) | 2000~4000 | 10000~20000 |
| Work pressure(MPa) | ⩽3.2 MPa | ⩽5MPa |
| Operating temperature(°C) | 80-90 | 50-80 |
| Hydrogen purity(%) | ⩾99.8 | ⩾99.99 |
| Raw material | Deionized water and alkali | Deionized water |
| Corrosion | Alkaline corrosion | No |
| Operating characteristics | Isobaric operation | Differential pressure operation |
| Volume and weight | Big | Small, about 1/3 of the alkaline electrolyzer |
| Manufacturing cost | Low | High |
| Lifetime | 10 years | 3~4 years |

~7.5MW Electrolyser Capacity on an average needed to produce 1KTPA $GH_2$

~7.5GW Electrolyser Capacity on an average needed to produce 1MMTPA $GH_2$ (1 MW = 200 $NM^3/h$ $GH_2$)

~37.5GW Electrolyser Capacity is required to meet the 5MMTPA Green Hydrogen

*"We have decided that Electrolysers can be made in India. So, we have worked out the PLI (production linked incentive) scheme for their domestic manufacturing that will cover manufacture of 15 giga watts (GW) capacity. But we expect the capacity to be established to almost in the region of 60 GW (by 2030)."*

-Union Minister RK Singh, MNRE

# Latest Developments

# INDIA

**Indian Railways initiates "Hydrogen for Heritage" project**

The Indian Railways has announced its plans to operate 35 Hydrogen Trains under the 'Hydrogen for Heritage' initiative, with the goal of reducing carbon emissions and embracing a greener approach. The Hydrogen for Heritage project aims to revolutionise the railway industry by incorporating hydrogen fuel cells as an alternative to diesel engines. The project also promotes clean energy sources with the aim of minimising harmful pollutants. Initially estimated at an expenditure of Rs 80 crores per train and Rs 70 crores per route for ground infrastructure, the project marks a significant investment in sustainable transportation.

**India will be epicenter for green H2 development: Hardeep Singh Puri**

Union Minister Hardeep Singh Puri said that India will be the place for green hydrogen development because there is a demand here. The private sector has shown great interest in the green hydrogen segment in India and acquired large manufacturing facilities and contracted to supply green ammonia, Puri said, speaking at a conference on India's Role in the Future of Energy. Many electrolyser manufacturers in the world today have got a tie up or production here, he said. IEA chief Fatih Birol, who also addressed the session, said India has the opportunity to become a "superpower" in green hydrogen space with its cheap and abundant renewable energy sources.

**No interstate transmission fee for offshore wind, green H2 projects**

The government has waived off interstate transmission charges on offshore wind power units commissioned by calendar 2032 for 25 years from the date of commissioning. It has also extended the commissioning date for applicability of such charges on green hydrogen and ammonia projects to 2030 from 2025. Offshore wind projects should be established through power purchase agreements or on a merchant basis. For offshore wind projects commissioned after 2032, the charges will be 25% of existing interstate transmission system (ISTS) charges and increase biennially by 25 percentage points till 2038 when it becomes 100% of applicable charges. For green hydrogen and ammonia projects, exemption is being given for 25 years starting the date of commissioning of the project. The projects should be using renewable energy from solar, wind, or large hydro projects commissioned after March 8, 2019, or energy storage systems, the ministry said. For green hydrogen and ammonia plants commissioned after 2030, the ISTS charges will be levied at 25% of the applicable charges and thereafter increase biennially by 25 percentage points till 2036.

**Green Port policy launched to catalyse carbon reduction**

India's Major Ports will need to have clean fuel storage and ship refueling facilities according to the freshly launched 'Harit Sagar' the Green Port guidelines. These norms were issued by the Ministry of Ports, Shipping and Waterways (MoPSW). Speaking at the event, Minister for Ports, Shipping and Waterways said that these guidelines provide a comprehensive framework for India's Major Ports to achieve quantifiable reductions in carbon emissions over defined timelines. These guidelines cover all areas of the port ecosystem that contribute to the carbon intensity of our ports. An official statement said the Harit Sagar guidelines are designed to promote sustainability and minimize the environmental impact of port operations.

**L&T to build energy infra for world's largest green hydrogen plant at NEOM**

L&T Construction will create renewable energy infrastructure for the world's largest green hydrogen plant at NEOM, the company said in a BSE filing. L&T will engineer, procure, and construct a 2.2 GW PV solar plant, 1.65 GW wind generation balance of plant and a 400 MWh battery energy storage system at Oxagon in Saudi Arabia's region of NEOM. NEOM Green Hydrogen Company (NGHC) is an equal joint-venture by ACWA Power, Air Products and NEOM. The scope also includes the Energy Power Monitoring System (EPMS) for the complete network. The value of the packages awarded to L&T aggregate to $2.779 billion. NGHC is setting up a mega plant to produce green hydrogen at-scale for global export in the form of green ammonia with a total investment of $8.4 billion.

**BPCL partners BARC to scale up green hydrogen production.**

Bharat Petroleum Corporation (BPCL) plans to help establish a 1-megawatt electrolyser manufacturing facility in the country by 2025 using the Bhabha Atomic Research Centre's (BARC) technology for green hydrogen. BPCL's R&D is working with BARC to scale up alkaline electrolyzer technology for green hydrogen production. The cost of an alkaline electrolyser can be halved with some technological and economic innovations, according to BPCL. Alkaline electrolysers produced from the proposed facility will likely cost 20-30% less than the current rate of about $800 per kilowatt. About 55 kilowatt-hours of renewable electricity is needed to produce a kilogram of green hydrogen.

# Latest Developments

**MNRE announce PLI schemes under the Green Hydrogen ecosystem**

MNRE has announced PLI schemes under the Green Hydrogen ecosystem. PLI guidelines cover two such critical areas of the Green Hydrogen ecosystem, namely, production of Green Hydrogen and manufacturing of electrolysers in India. A total budgetary outlay of Rs 13,050 crore is earmarked for the production of Green Hydrogen while the Electrolysers gets an allocation of Rs 4,440 crore. Incentives under the Green Hydrogen PLI scheme would be provided for duration of three years starting from the date of commencement of Green Hydrogen production. Beneficiaries would be selected through a competitive selection process wherein applicants quoting minimum fiscal incentive would be given preference.

**Central aid for R&D to set up pilot using green hydrogen to make steel**

The Centre will aid R&D projects to set up pilot plants for production and utilization of green hydrogen in the iron and steel making processes. ₹455 crore has been earmarked under the National Green Hydrogen Mission to support the domestic steel industry's endeavours to find scalable uses of hydrogen produced using environmentally sustainable practises. This low-environment-footprint hydrogen is called green hydrogen to signify its superior acceptability. Tightening regulatory regimes around the world threaten to make steel produced in India uncompetitive due to the levy of higher duties (CBAM- Carbon Border Adjustment Mechanism) by the European countries. Most steel around the world, including in India, is made using direct reduction of iron (DRI) using coal. To reduce emissions from this exercise, efforts are being made globally to use green hydrogen instead of coal.

# GLOBAL

**Aircraft will fly on 35% hydrogen-based fuels by 2050 under new EU blending rules**

Aircraft departing European airports will need to refuel with sustainable aviation fuels (SAFs) and hydrogen-based synthetic fuels as soon as 2025, under new blending rules agreed by the European Commission (EC). The proposal, agreed by the EC, envisages planes refuelling with blends containing at least 2% of SAFs in 2025. Hydrocarbons such as e-kerosene made by combining carbon molecules with green hydrogen made with renewable energy. Blend mandates will be ratcheted up every five years until they reach 70% of SAFs by 2050, of which 35% should be made from synthetic aviation fuels, sometimes called e-fuels.

**Kawasaki unveils cargo containment system (CCS)-** Kawasaki Heavy Industries, Ltd. announced its completion of technological development for a cargo containment system (CCS) to be used in large liquefied hydrogen carriers. This project was carried out under the NEDO subsidy program "Technology Development Project for Building a Hydrogen Society, Technology Development for Using Hydrogen Energy on a Large Scale, Development of Large-Scale Transport and Storage Equipment and Export and Import Terminal Equipment for Liquefied Hydrogen." In this project, Kawasaki designed and built a test tank to be used to verify the performance of a CCS for large liquefied hydrogen carriers.

**USA National Clean Hydrogen Strategy and Roadmap-** USA administration releases first-ever national clean hydrogen strategy and roadmap to build a clean energy future, accelerate American manufacturing boom. new government-wide strategy advances clean hydrogen and supports President Biden's investing in America agenda for building clean energy economy, creating good-paying jobs, and boosting American competitiveness.

**Plug to supply 8MW $H_2$ Fuel Cell-** Plug Power Inc. a leading provider of turnkey hydrogen solutions for the global green hydrogen economy announced that it will supply 8 MW (megawatts) of Hydrogen Fuel Cells to Energy Vault to Displace Diesel Generators in California Wine Country. This will be the largest planned hydrogen powered fuel cell installation in the United States.

**Endua's flagship power bank-Breakthrough Australian-** built technology will enable reliable renewable energy for communities, remote industries and off-grid infrastructure. Australian clean energy company Endua unveiled the first of its purpose-built standalone hydrogen power banks. Endua's flagship power bank is designed to close the gap in microgrid applications, where the need for reliable power means reliance on emissions-heavy energy production such as diesel generators.

# GLOBAL

**Japan commitment towards Green Hydrogen-** Japan plans to invest 15 trillion yen ($107.5 billion) over the next 15 years to supply the country with hydrogen, as it accelerates efforts to use the gas to shift to a low carbon economy.

**Hydrogen Flight Alliance-** Key players in the Australian aviation and green hydrogen industries have officially launched the Hydrogen Flight Alliance (HFA) at Brisbane Airport. The aim of the alliance is to ensure Australia plays a leading role in the aviation industry's transition towards net-zero by 2050.

**Water-taxi Rotterdam-** Rotterdam has expanded its fleet with a hydrogen water- taxi. It is the first ship in Europe's largest port to run on this sustainable energy. The 12-person MSTX 22 was developed by SWIM, a partnership between Water-taxi Rotterdam, maritime innovator Flying Fish and hydrogen/fuel cell manufacturer zepp.

**China pumped $72 billion tax break scheme.** China is accelerating its commitment to support green vehicles by rolling out a massive $72 billion tax break scheme over the next four years. The government's new policy extends a purchase tax exemption for new energy vehicles (NEVs) until the end of 2027, a move that is expected to bolster slower auto sales growth while supporting the transition to cleaner energy sources.

**US incentives for 'green' hydrogen - Inflation Reduction Act-**

The Inflation Reduction Act will over the next decade unleash hundreds of billions of dollars in subsidies designed to make clean technologies so cheap that they will be rapidly deployed, helping the nation cut emissions by some 40 percent by 2030. It could accelerate a critical climate solution that could drive down greenhouse gas emissions in many sectors of the economy. Or it could underwrite a process that actually increases emissions. The outcome depends largely on accounting rules that the Treasury Department has yet to write. A tax credit tucked into the Inflation Reduction Act gives the maximum tax credit, $3 per kilogram, to hydrogen produced with renewable energy and nuclear energy.

**H175 Program H2FLY,** the world's leading developer of hydrogen-electric powertrain systems for aircraft, announces the next generation of its proprietary fuel cell system H175. The H175 program will provide a series of fuel cell systems that can be combined and upscale to power hydrogen-electric aircraft in the megawatt-class range, which complies with aircraft that comprise of 20 to 80 seats. H2FLY is responsible for the development, integration and testing of the overall fuel cell systems hardware and software.

***"We will ensure uptake of green hydrogen in refineries and city gas distribution (CGD) through both public sector entities and private sector and try to design new projects with maximum chances of hydrogen deployment to strategically phase out fossil fuels and aid decarbonisation goals."***

**-Union Minister Hardeep S. Puri, MoP&NG.**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