TROY TECHNICAL

HYDROGEN ENERGY
WEEKLY REPORT

November 14 - November 20, 2026 | Issue 2026-W46

Delivered hydrogen economics, infrastructure readiness and bankable demand

10	10
ANALYZED ARTICLES	PRIORITY THEMES

Issued 2026-11-20 | English edition | fixed approved cover artwork



Hydrogen Energy: the boundary moved from isolated claims to qualification evidence

10 English articles were reviewed independently from the Japanese edition. Ten themes are retained for management decisions.

SIGNAL 01 | POWER & FEEDSTOCK

Molten Industries: Natural Gas-to-Graphite Process and Specs

Molten Industries has commissioned a demonstration plant in Oakland, California, that produces battery-grade graphite and clean hydrogen from natural gas via methane pyrolysis.

SIGNAL 02 | PRODUCTION

SOEC Green Hydrogen: Techno-Economic Feasibility in Colombia

Industrial-scale photovoltaic-powered solid oxide electrolysis cells (SOEC) in Barrancabermeja, Colombia, demonstrate economic viability with a levelized cost of $9.65 USD/kg H2.

SIGNAL 03 | STORAGE & TRANSPORT

NYK "Izanami": Specs of World's First Ammonia-Fueled AFMGC

NYK has launched the "Izanami," the first Ammonia-Fueled Medium Gas Carrier (AFMGC) to utilize ammonia-fueled engines for both main and auxiliary power.

SIGNAL 04 | END USE

Donghwa Entec ARMS: Ammonia Recovery and Regeneration Specs

Donghwa Entec has successfully completed verification tests for its Ammonia Recovery and Regeneration System (ARMS), achieving a regeneration purity of over 99.5wt%.

DECISION

Focus this week's management attention on delivered hydrogen economics, infrastructure readiness and bankable demand. Move only when the linked evidence can be reproduced under your own operating conditions.

THREE MANAGEMENT MOVES

1. Buyers: compare projects by contracted demand, energy source, conversion loss, logistics and policy support.
2. Suppliers: tie materials and equipment performance to uptime, safety, maintenance and delivered cost.
3. Executives: track offtake, power price, efficiency, utilization, permitting, transport and subsidy.

EVIDENCE DISCIPLINE

FACT states what the collected English source reports. BUSINESS READ and ACTION are editorial interpretations. UNKNOWN lists information that the source file does not establish. A linked article is not treated as independent confirmation of every claim.

Numbers and evidence anchors that require conditions

95%
A07

SOURCE-BOUND CONDITION
The facility achieves natural gas-to-graphite yields above 95% with an annual capacity of 300 metric tons.

99.5w
A08

SOURCE-BOUND CONDITION
Donghwa Entec has successfully completed verification tests for its Ammonia Recovery and Regeneration System (ARMS), achieving a regeneration purity of over 99.5wt%.

30MW
A09

SOURCE-BOUND CONDITION
Kawasaki Heavy Industries has deployed the L30A 30MW-class gas turbine at the Emsland power plant in Germany to test flexible hydrogen-natural gas combustion.

33km
A10

SOURCE-BOUND CONDITION
The vessel reduced CO2 emissions by approximately 1.2 tons during a 33km trip in Osaka Bay, demonstrating a viable path for zero-emission shipping.

25%
A01

SOURCE-BOUND CONDITION
Researchers at KAIST have developed a ruthenium-based water electrolysis catalyst that matches the performance of commercial platinum catalysts while using only 25% of the precious metal.

HOW TO USE THESE NUMBERS
Each value is shown with the condition stated in the collected English article. Do not compare values across different test methods, device sizes, operating temperatures or commercial stages without normalizing those conditions.

Where the value chain moved

Each stage combines one leading theme and one supporting theme. The report treats handoffs as evidence transfers, not decorative arrows.

1

Power & feedstock

P01/P06

Molten Industries has commissioned a demonstration plant in Oakland, California, that produces battery-grade graphite and.

2

Production

P02/P07

Industrial-scale photovoltaic-powered solid oxide electrolysis cells (SOEC) in Barrancabermeja, Colombia, demonstrate.

3

Storage & transport

P03/P08

NYK has launched the " Izanami," the first Ammonia-Fueled Medium Gas Carrier (AFMGC) to utilize ammonia-fueled engines for.

4

End use

P04/P09

Donghwa Entec has successfully completed verification tests for its Ammonia Recovery and Regeneration System (ARMS).

5

Market & policy

P05/P10

Kawasaki Heavy Industries has deployed the L30A 30MW-class gas turbine at the Emsland power plant in Germany to test flexible.

EVIDENCE REQUIRED AT EACH HANDOFF

Power & feedstock to Production	Transfer test conditions, acceptance criteria, failure data, owner and decision date. Recheck offtake, power price, efficiency, utilization, permitting, transport and subsidy.
Production to Storage & transport	Transfer test conditions, acceptance criteria, failure data, owner and decision date. Recheck offtake, power price, efficiency, utilization, permitting, transport and subsidy.
Storage & transport to End use	Transfer test conditions, acceptance criteria, failure data, owner and decision date. Recheck offtake, power price, efficiency, utilization, permitting, transport and subsidy.
End use to Market & policy	Transfer test conditions, acceptance criteria, failure data, owner and decision date. Recheck offtake, power price, efficiency, utilization, permitting, transport and subsidy.

COMMON CONTROL POINT

No theme moves to a commercial commitment until a named owner has reproduced the relevant evidence and documented offtake, power price, efficiency, utilization, permitting, transport and subsidy.

Priority map: maturity and next decision locus



P01	Molten Industries: Natural Gas-to-Graphite Process and Specs Business / rules | cue: capacity
P02	SOEC Green Hydrogen: Techno-Economic Feasibility in Colombia Tech / process | cue: no system/business cue
P03	NYK "Izanami": Specs of World's First Ammonia-Fueled AFMGC System / adoption | cue: launched
P04	Donghwa Entec ARMS: Ammonia Recovery and Regeneration Specs System / adoption | cue: System
P05	Kawasaki Heavy Industries L30A: Hydrogen Gas Turbine Specs System / adoption | cue: deployed
P06	Kikou Maru: Hydrogen-Fueled Electric Propulsion Tanker Specs System / adoption | cue: pilot
P07	Ruthenium Catalyst: KAIST's atom-layer neighbor design vs Platinum System / adoption | cue: commercial
P08	Green Rust Oxidation: H2 Production Mechanism via Reaction R3 Tech / process | cue: no system/business cue
P09	Cobalt Phosphide: Surface Adaptation and Durability Mechanisms Tech / process | cue: no system/business cue
P10	Mn/NiSe2 Catalyst: Reversible Phase Cycling for Urea Electrolysis Tech / process | cue: no system/business cue

REPRODUCIBLE POSITIONING RULE

Horizontal position uses five discrete stages: Research, Prototype, Joint evaluation, Product adoption and Scale. The vertical bands classify the next decision locus: Tech / process, System / adoption, or Business / rules (including supply systems). Article-title cues take precedence; the overview is used only when the title is silent. These are categories, not impact ranks. Bubble diameter reflects the editorial score.

FACT is source-bound. BUSINESS READ, ACTION and UNKNOWN are explicit editorial layers.

P01 Molten Industries: Natural Gas-to-Graphite Process and Specs

A07 | Power & feedstock | Product adoption

2026-11-18

FACT

Molten Industries has commissioned a demonstration plant in Oakland, California, that produces battery-grade graphite and clean hydrogen from natural gas via methane pyrolysis. The facility achieves natural gas-to-graphite yields above 95% with an annual capacity of 300 metric tons. This process establishes a domestic U.S. supply chain for a critical battery material currently dominated by China.

WHY IT MATTERS

The decision relevance is delivered hydrogen economics, infrastructure readiness and bankable demand. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, tie materials and equipment performance to uptime, safety, maintenance and delivered cost.

ACTION

Within 30 days, compare projects by contracted demand, energy source, conversion loss, logistics and policy support; record the evidence and owner against P01.

UNKNOWN

Still unproven or incompletely stated: offtake, power price, efficiency, utilization, permitting, transport and subsidy.

EDITORIAL SCORE 22/25 | MATURITY 4/5 | DECISION LOCUS: BUSINESS / RULES

P02 SOEC Green Hydrogen: Techno-Economic Feasibility in Colombia

A04 | Production | Product adoption

2026-11-17

FACT

Industrial-scale photovoltaic-powered solid oxide electrolysis cells (SOEC) in Barrancabermeja, Colombia, demonstrate economic viability with a levelized cost of $9.65 USD/kg H2. The study emphasizes that scaling and the valorization of oxygen as a co-product are critical for achieving a positive NPV and high IRR.

WHY IT MATTERS

The decision relevance is delivered hydrogen economics, infrastructure readiness and bankable demand. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, tie materials and equipment performance to uptime, safety, maintenance and delivered cost.

ACTION

Within 30 days, compare projects by contracted demand, energy source, conversion loss, logistics and policy support; record the evidence and owner against P02.

UNKNOWN

Still unproven or incompletely stated: offtake, power price, efficiency, utilization, permitting, transport and subsidy.

EDITORIAL SCORE 20/25 | MATURITY 4/5 | DECISION LOCUS: TECH / PROCESS

FACT is source-bound. BUSINESS READ, ACTION and UNKNOWN are explicit editorial layers.

P03 NYK "Izanami": Specs of World's First Ammonia-Fueled AFMGC

A06 | Storage & transport | Research

2026-11-18

FACT

NYK has launched the "Izanami," the first Ammonia-Fueled Medium Gas Carrier (AFMGC) to utilize ammonia-fueled engines for both main and auxiliary power. The vessel will enter a time charter with Yara Clean Ammonia Switzerland SA to verify operational performance and GHG reduction effects under real-world conditions.

WHY IT MATTERS

The decision relevance is delivered hydrogen economics, infrastructure readiness and bankable demand. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, tie materials and equipment performance to uptime, safety, maintenance and delivered cost.

ACTION

Within 30 days, compare projects by contracted demand, energy source, conversion loss, logistics and policy support; record the evidence and owner against P03.

UNKNOWN

Still unproven or incompletely stated: offtake, power price, efficiency, utilization, permitting, transport and subsidy.

EDITORIAL SCORE 20/25 | MATURITY 1/5 | DECISION LOCUS: SYSTEM / ADOPTION

P04 Donghwa Entec ARMS: Ammonia Recovery and Regeneration Specs

A08 | End use | Research

2026-11-19

FACT

Donghwa Entec has successfully completed verification tests for its Ammonia Recovery and Regeneration System (ARMS), achieving a regeneration purity of over 99.5wt%. The system recovers residual ammonia from ship piping during engine stops or fuel switches to reduce waste and fuel loss.

WHY IT MATTERS

The decision relevance is delivered hydrogen economics, infrastructure readiness and bankable demand. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, tie materials and equipment performance to uptime, safety, maintenance and delivered cost.

ACTION

Within 30 days, compare projects by contracted demand, energy source, conversion loss, logistics and policy support; record the evidence and owner against P04.

UNKNOWN

Still unproven or incompletely stated: offtake, power price, efficiency, utilization, permitting, transport and subsidy.

EDITORIAL SCORE 20/25 | MATURITY 1/5 | DECISION LOCUS: SYSTEM / ADOPTION

FACT is source-bound. BUSINESS READ, ACTION and UNKNOWN are explicit editorial layers.

P05 Kawasaki Heavy Industries L30A: Hydrogen Gas Turbine Specs

A09 | Market & policy | Scale-up

2026-11-18

FACT

Kawasaki Heavy Industries has deployed the L30A 30MW-class gas turbine at the Emsland power plant in Germany to test flexible hydrogen-natural gas combustion. The system allows for seamless switching between 0% and 100% hydrogen fuel to mitigate the instability of hydrogen supply and pricing. This deployment serves as a critical test for integrating renewable energy storage via hydrogen conversion.

WHY IT MATTERS

The decision relevance is delivered hydrogen economics, infrastructure readiness and bankable demand. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, tie materials and equipment performance to uptime, safety, maintenance and delivered cost.

ACTION

Within 30 days, compare projects by contracted demand, energy source, conversion loss, logistics and policy support; record the evidence and owner against P05.

UNKNOWN

Still unproven or incompletely stated: offtake, power price, efficiency, utilization, permitting, transport and subsidy.

EDITORIAL SCORE 20/25 | MATURITY 5/5 | DECISION LOCUS: SYSTEM / ADOPTION

P06 Kikou Maru: Hydrogen-Fueled Electric Propulsion Tanker Specs

A10 | Power & feedstock | Joint evaluation

2026-11-17

FACT

The oil tanker Kikou Maru successfully completed a world-first demonstration voyage using a pilot-ignition hydrogen-dedicated engine. The vessel reduced CO2 emissions by approximately 1.2 tons during a 33km trip in Osaka Bay, demonstrating a viable path for zero-emission shipping.

WHY IT MATTERS

The decision relevance is delivered hydrogen economics, infrastructure readiness and bankable demand. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, tie materials and equipment performance to uptime, safety, maintenance and delivered cost.

ACTION

Within 30 days, compare projects by contracted demand, energy source, conversion loss, logistics and policy support; record the evidence and owner against P06.

UNKNOWN

Still unproven or incompletely stated: offtake, power price, efficiency, utilization, permitting, transport and subsidy.

EDITORIAL SCORE 20/25 | MATURITY 3/5 | DECISION LOCUS: SYSTEM / ADOPTION

FACT is source-bound. BUSINESS READ, ACTION and UNKNOWN are explicit editorial layers.

P07 Ruthenium Catalyst: KAIST's atom-layer neighbor design vs Platinum

A01 | Production | Product adoption

2026-11-14

FACT

Researchers at KAIST have developed a ruthenium-based water electrolysis catalyst that matches the performance of commercial platinum catalysts while using only 25% of the precious metal. By utilizing a novel "atom-layer neighbor" structure, the team significantly increased mass activity and durability for green hydrogen production.

WHY IT MATTERS

The decision relevance is delivered hydrogen economics, infrastructure readiness and bankable demand. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, tie materials and equipment performance to uptime, safety, maintenance and delivered cost.

ACTION

Within 30 days, compare projects by contracted demand, energy source, conversion loss, logistics and policy support; record the evidence and owner against P07.

UNKNOWN

Still unproven or incompletely stated: offtake, power price, efficiency, utilization, permitting, transport and subsidy.

EDITORIAL SCORE 19/25 | MATURITY 4/5 | DECISION LOCUS: SYSTEM / ADOPTION

P08 Green Rust Oxidation: H2 Production Mechanism via Reaction R3

A05 | Storage & transport | Product adoption

Prior release 2026-11-12

FACT

Research indicates that hydrogen production from the water-driven oxidation of Fe(II) is driven by the direct formation of green rust (GR) rather than iron hydroxide intermediates. This process is facilitated by silica-induced compartmentalization and specific counterions, offering a faster alternative to the Schikorr reaction.

WHY IT MATTERS

The decision relevance is delivered hydrogen economics, infrastructure readiness and bankable demand. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, tie materials and equipment performance to uptime, safety, maintenance and delivered cost.

ACTION

Within 30 days, compare projects by contracted demand, energy source, conversion loss, logistics and policy support; record the evidence and owner against P08.

UNKNOWN

Still unproven or incompletely stated: offtake, power price, efficiency, utilization, permitting, transport and subsidy.

EDITORIAL SCORE 19/25 | MATURITY 4/5 | DECISION LOCUS: TECH / PROCESS

FACT is source-bound. BUSINESS READ, ACTION and UNKNOWN are explicit editorial layers.

P09 Cobalt Phosphide: Surface Adaptation and Durability Mechanisms

A02 | End use | Product adoption

2026-11-16

FACT

Researchers at Tohoku University have discovered that cobalt phosphide catalysts maintain stability during water splitting by dynamically altering their outer surface. This self-protecting mechanism enables the material to function across acidic, neutral, and alkaline solutions, potentially reducing the cost of clean hydrogen production.

WHY IT MATTERS

The decision relevance is delivered hydrogen economics, infrastructure readiness and bankable demand. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, tie materials and equipment performance to uptime, safety, maintenance and delivered cost.

ACTION

Within 30 days, compare projects by contracted demand, energy source, conversion loss, logistics and policy support; record the evidence and owner against P09.

UNKNOWN

Still unproven or incompletely stated: offtake, power price, efficiency, utilization, permitting, transport and subsidy.

EDITORIAL SCORE 19/25 | MATURITY 4/5 | DECISION LOCUS: TECH / PROCESS

P10 Mn/NiSe2 Catalyst: Reversible Phase Cycling for Urea Electrolysis

A03 | Market & policy | Product adoption

2026-11-14

FACT

Researchers from Fuzhou University have developed a manganese-doped nickel selenide catalyst that utilizes a dynamic phase-transition trigger to enhance urea electrolysis for hydrogen production. The Mn/NiSe2 catalyst achieves an onset potential of 1.26 V versus the reversible hydrogen electrode, enabling a sustainable method to generate hydrogen while treating urea-rich wastewater.

WHY IT MATTERS

The decision relevance is delivered hydrogen economics, infrastructure readiness and bankable demand. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, tie materials and equipment performance to uptime, safety, maintenance and delivered cost.

ACTION

Within 30 days, compare projects by contracted demand, energy source, conversion loss, logistics and policy support; record the evidence and owner against P10.

UNKNOWN

Still unproven or incompletely stated: offtake, power price, efficiency, utilization, permitting, transport and subsidy.

EDITORIAL SCORE 19/25 | MATURITY 4/5 | DECISION LOCUS: TECH / PROCESS

Playbook and 0-5 year roadmap

STAKEHOLDER	NOW | 0-30 DAYS	NEXT | 1-12 MONTHS	LATER | 1-5 YEARS
Operating companies	compare projects by contracted demand, energy source, conversion loss, logistics and policy support	Run production-like qualification with explicit acceptance and stop criteria.	Build a portfolio and architecture that can absorb technology and supplier changes.
Materials, equipment and technology suppliers	tie materials and equipment performance to uptime, safety, maintenance and delivered cost	Create shared reliability, process-window and failure-analysis data with customers.	Standardize interfaces, traceability, lifecycle support and recovery services.
Trading, investment and legal teams	Map offtake, power price, efficiency, utilization, permitting, transport and subsidy.	Contract for capacity, quality, change notice, liability, alternatives and exit.	Diversify regional, technical and customer concentration risk.

ROADMAP

NOW | 0-30 DAYS
Evidence ledger
Owner: Strategy + quality
Deliverable: claim, source, condition, owner

NOW | 0-30 DAYS
Risk screen
Owner: Procurement + legal
Deliverable: unknowns, alternatives, stop

NEXT | 1-12 MONTHS
Joint qualification
Owner: R&D + supplier
Deliverable: process window and failure data

NEXT | 1-12 MONTHS
Commercial gate
Owner: Business + finance
Deliverable: unit economics and capacity

LATER | 1-5 YEARS
Platform strategy
Owner: Executive team
Deliverable: portfolio and interface roadmap

LATER | 1-5 YEARS
Service layer
Owner: Operations + channel
Deliverable: monitoring, maintenance and recovery

GO / NO-GO GATES

GATE	OWNER	REQUIRED EVIDENCE	NO-GO CONDITION
G1 Evidence	**Quality**	Source, test conditions and reproducibility	No traceable evidence
G2 Integration	**R&D**	Interface, process window and failure analysis	Cannot meet system conditions
G3 Commercial	**Business**	Capacity, total cost, contract and alternatives	Economics or supply cannot be supported
G4 Lifecycle	**Operations**	Monitoring, maintenance, change notice and exit	No accountable operating plan

ANALYZED ARTICLES | ITEMS 01-10

Every title and URL is displayed in full. URLs wrap without shortening and remain clickable. A verified-reference label means the translated HTML did not retain its original source URL.

ID	FULL ARTICLE TITLE	FULL SOURCE / VERIFIED REFERENCE URL - CLICKABLE
A01	Ruthenium Catalyst: KAIST's atom-layer neighbor design vs Platinum	https://bioengineer.org/ruthenium-catalyst-matches-platinum-performance-with-quarter-metal/
A02	Cobalt Phosphide: Surface Adaptation and Durability Mechanisms	https://knowridge.com/2026/11/self-protecting-material-could-make-clean-hydrogen-production-cheaper/
A03	Mn/NiSe2 Catalyst: Reversible Phase Cycling for Urea Electrolysis	https://bioengineer.org/manganese-trigger-drives-reversible-phase-cycling-in-nickel-selenide-urea-catalysts/
A04	SOEC Green Hydrogen: Techno-Economic Feasibility in Colombia	https://doi.org/10.21203/rs.3.rs-10659000/v1
A05	Green Rust Oxidation: H2 Production Mechanism via Reaction R3	https://doi.org/10.21203/rs.3.rs-11432397/v1
A06	NYK "Izanami": Specs of World's First Ammonia-Fueled AFMGC	https://www.nyk.com/news/2026/20261118_01.html
A07	Molten Industries: Natural Gas-to-Graphite Process and Specs	https://www.mining.com/molten-industries-launches-first-us-graphite-plant-using-natural-gas/
A08	Donghwa Entec ARMS: Ammonia Recovery and Regeneration Specs	https://www.energy-news.co.kr/news/articleView.html?idxno=229909
A09	Kawasaki Heavy Industries L30A: Hydrogen Gas Turbine Specs	https://www.gizmodo.jp/article/kawasaki-hydrogen-gas-turbine-germany/
A10	Kikou Maru: Hydrogen-Fueled Electric Propulsion Tanker Specs	https://monoist.itmedia.co.jp/mn/articles/2611/17/news010.html

HydrogenEnergy — Selected Articles

Date: 2026-11-21

Articles: 10

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#05 Green Rust Oxidation: H_2 Production Mechanism via Reaction R3

#06 NYK "Izanami": Specs of World's First Ammonia-Fueled AFMGC

#07 Molten Industries: Natural Gas-to-Graphite Process and Specs

#08 Donghwa Entec ARMS: Ammonia Recovery and Regeneration Specs

#09 Kawasaki Heavy Industries L30A: Hydrogen Gas Turbine Specs

#10 Kikou Maru: Hydrogen-Fueled Electric Propulsion Tanker Specs

#01 Ruthenium Catalyst: KAIST's atom-layer neighbor design vs Platinum

Published November 14, 2026 BIOENGINEER（KAIST） South Korea



OVERVIEW

Researchers at KAIST have developed a ruthenium-based water electrolysis catalyst that matches the performance of commercial platinum catalysts while using only 25% of the precious metal. By utilizing a novel "atom-layer neighbor" structure, the team significantly increased mass activity and durability for green hydrogen production.

IN DEPTH

Key Findings

A research team led by Professor Jinwoo Lee at the Korea Advanced Institute of Science and Technology (KAIST) has developed a ruthenium catalyst that achieves hydrogen production performance comparable to commercial platinum catalysts. Despite using 75% less precious metal, the catalyst demonstrated approximately four times higher efficiency in terms of catalytic activity per unit mass. In an anion-exchange membrane water electrolyzer (AEMWE) cell at 80°C and 2.0 volts (V), the catalyst achieved a current density of 9.82 amperes per square centimeter (A/cm²).

Technical Details

The team introduced an "atom-layer neighbor" structure, which groups three or four ruthenium atoms in a single atomic layer. This design avoids the inefficiencies of conventional nanoparticle catalysts, where internal atoms cannot participate in reactions, and overcomes the limitations of single-atom catalysts, which lack the cooperative interaction required for certain reactions. To stabilize this structure, the researchers used molecular interactions during synthesis and a tungsten carbide (WC_x) support to anchor the atoms via strong metal-support interactions during heat treatment.

Additionally, the team optimized the local environment by leveraging hydroxyl species (OH) on the support surface. This strengthened the hydrogen-bond network among water molecules, facilitating faster proton transfer during the reaction.

Background & Context

Green hydrogen production via water electrolysis is currently hindered by the high cost and scarcity of precious metal catalysts. Conventional catalysts rely on large particles that waste material, while single-atom dispersions often fail to maximize efficiency due to the isolation of active sites. The KAIST study, published in Nature Communications, sought to bridge this gap by maximizing atom utilization through cooperative small-group arrangements.

Significance & Outlook

The catalyst demonstrated superior stability in a 500-hour continuous operation test, with performance loss approximately half that of the platinum catalyst. By reducing reliance on expensive precious metals without sacrificing performance or durability, this technology provides a pathway to lower the economic barriers to scaling green hydrogen production.

Source: https://bioengineer.org/ruthenium-catalyst-matches-platinum-performance-with-quarter-metal/

Collected: November 21, 2026 | Automated Research System (AI)

#02 Cobalt Phosphide: Surface Adaptation and Durability Mechanisms

Published November 16, 2026　Knowridge Science Report（東北大学）　Japan



OVERVIEW

Researchers at Tohoku University have discovered that cobalt phosphide catalysts maintain stability during water splitting by dynamically altering their outer surface. This self-protecting mechanism enables the material to function across acidic, neutral, and alkaline solutions, potentially reducing the cost of clean hydrogen production.

IN DEPTH

Key Findings

Tohoku University researchers have identified the mechanism that allows cobalt phosphide to remain stable during hydrogen production, despite computer models suggesting the material should be unstable under operating conditions. The study reveals that the catalyst undergoes surface changes during operation that simultaneously enhance hydrogen-producing reactions and improve the material's overall durability.

Technical Details

The research team utilized a combination of computer modeling, laboratory measurements, and an AI-assisted review of over 2,200 observations from hundreds of previously reported cobalt phosphide catalysts. The findings indicate that the material's surface adapts based on electrical conditions:

- At specific operating voltages, chemical groups containing oxygen and hydrogen form on phosphorus sites, assisting nearby cobalt atoms in releasing hydrogen.
- Different hydrogen-containing groups appear as electrical conditions shift, allowing the catalyst to adjust how it holds and releases hydrogen across various pH levels (acidic, neutral, and alkaline).
- These surface modifications act as a shield, reducing unwanted oxidation and limiting the loss of phosphorus and cobalt into the surrounding liquid.

The team validated these predictions using specially prepared thin sheets of cobalt phosphide, which remained stable during a 24-hour test under demanding conditions.

Background & Context

Hydrogen production via water electrolysis is a low-carbon process if powered by renewable energy. While platinum is a highly effective catalyst for this process, its high cost drives the search for affordable alternatives. Cobalt phosphide emerged as a candidate due to its strong experimental performance, though the reason for its stability remained a puzzle until this study.

Significance & Outlook

The results, published in the Journal of the American Chemical Society, suggest that catalyst design should focus on how materials behave during operation rather than their initial state. While further long-term testing, large-scale manufacturing studies, and comparisons with other materials are required before commercial application in hydrogen plants, the discovery establishes a design principle: adaptive ability can be key to catalyst survival.

Source: https://knowridge.com/2026/11/self-protecting-material-could-make-clean-hydrogen-production-cheaper/

Collected: November 21, 2026 | Automated Research System (AI)

#03 Mn/NiSe2 Catalyst: Reversible Phase Cycling for Urea Electrolysis

Published November 14, 2026 BIOENGINEER（福州大学） China



OVERVIEW

Researchers from Fuzhou University have developed a manganese-doped nickel selenide catalyst that utilizes a dynamic phase-transition trigger to enhance urea electrolysis for hydrogen production. The Mn/NiSe2 catalyst achieves an onset potential of 1.26 V versus the reversible hydrogen electrode, enabling a sustainable method to generate hydrogen while treating urea-rich wastewater.

IN DEPTH

Key Findings

A research team led by Prof. Yuekun Lai and Prof. Jianying Huang from Fuzhou University has demonstrated that introducing manganese into nickel selenide (NiSe2) significantly enhances catalytic activity for the urea oxidation reaction. The resulting Mn/NiSe2 catalyst exhibits an onset potential of 1.26 V versus the reversible hydrogen electrode and maintains stable electrochemical operation over extended periods. When coupled with cathodic hydrogen evolution, the system enables efficient urea-assisted electrolysis for clean hydrogen production.

Technical Details

The researchers utilized a doping engineering strategy to move beyond static electronic modulation. In-situ characterizations and theoretical calculations revealed two primary mechanisms driven by manganese:

- **Electronic Tuning:** Manganese doping modifies the local electronic environment around nickel sites, which strengthens urea adsorption and lowers the activation energy barriers for critical bond-cleavage steps.
- **Dynamic Phase Cycling:** Manganese acts as a trigger that drives continuous and reversible crystal-phase cycling between active gamma-NiOOH and beta-NiOOH structures during operation.

This reversible transition prevents the irreversible over-oxidation of active components and allows for the continuous self-regeneration of functional catalytic sites, preventing the performance degradation typically seen in nickel-based catalysts.

Background & Context

Conventional water electrolysis is energy-intensive due to the sluggish kinetics of the anodic oxygen evolution reaction. Urea oxidation is an appealing alternative because it requires a lower thermodynamic potential for hydrogen generation. Additionally, this process provides environmental remediation by treating urea-laden wastewater from industrial and agricultural discharge. However, low-cost nickel-based catalysts often suffer from uncontrolled structural reconstruction under working conditions, which destabilizes catalytic centers and compromises long-term durability.

Significance & Outlook

By establishing a design framework for adaptive electrocatalysts, this research addresses the bottleneck of catalyst degradation in urea electrolysis. The ability to regulate phase transitions dynamically ensures higher hydrogen output and operational stability, contributing to international efforts toward carbon neutrality through more efficient clean energy carriers.

Source: https://bioengineer.org/manganese-trigger-drives-reversible-phase-cycling-in-nickel-selenide-urea-catalysts/

Collected: November 21, 2026 | Automated Research System (AI)

#04 SOEC Green Hydrogen: Techno-Economic Feasibility in Colombia

Published November 17, 2026 Research Square コロンビア



OVERVIEW

Industrial-scale photovoltaic-powered solid oxide electrolysis cells (SOEC) in Barrancabermeja, Colombia, demonstrate economic viability with a levelized cost of $9.65 USD/kg H_2. The study emphasizes that scaling and the valorization of oxygen as a co-product are critical for achieving a positive NPV and high IRR.

IN DEPTH

Key Findings

Industrial-scale deployment of photovoltaic-powered SOEC systems is economically viable, whereas pilot-scale operations are not. The industrial-scale system, producing 46.6 t/day H_2, achieved a positive NPV and high IRR, with levelized costs calculated at \$9.65 USD/kg H_2 and \$2.40 USD/kg O_2.

Technical Details

The study utilized an integrated framework combining Aspen HYSYS simulation, photovoltaic system sizing, and financial analysis to evaluate two scales of production in Barrancabermeja: a pilot scale (0.02 t/day H_2) and an industrial scale (46.6 t/day H_2). Technical specifications for the SOEC systems include:

- **Operating Temperature:** 800°C
- **Operating Pressure:** Up to 30 bar
- **Product Purity:** 99.8 vol% for H_2 and 99.6 vol% for O_2
- **Energy Consumption:** Specific electrical energy consumption of ~32 kWh/kg H_2

Background & Context

Integrating photovoltaic energy with SOEC provides a pathway for large-scale green hydrogen production in regions characterized by high solar potential. This research represents the first techno-economic assessment in Colombia to explicitly incorporate the valorization of oxygen co-products into the financial modeling of photovoltaic-driven hydrogen production.

Significance & Outlook

The results indicate that the economic feasibility of green hydrogen production via SOEC is heavily dependent on the scale of the installation and the ability to monetize oxygen. Integrated system design and the transition from pilot to industrial scales are essential for reducing levelized costs and ensuring financial sustainability in high-solar-potential regions.

Source: https://doi.org/10.21203/rs.3.rs-10659000/v1

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#05 Green Rust Oxidation: H_2 Production Mechanism via Reaction R3

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OVERVIEW

Research indicates that hydrogen production from the water-driven oxidation of Fe(II) is driven by the direct formation of green rust (GR) rather than iron hydroxide intermediates. This process is facilitated by silica-induced compartmentalization and specific counterions, offering a faster alternative to the Schikorr reaction.

IN DEPTH

Key Findings

The study identifies the direct formation of green rust (GR) as the primary driver for rapid and efficient H_2 production during the water-driven oxidation of Fe(II). Specifically, the researchers claim that reaction R3 ($4Fe^{2+} + 8H_2O + Cl^- = Fe(iii)Fe(ii)_3(OH)$<0xE2><0x82><0x88>$Cl + 7H^+ + 0.5H_2$) is the key reaction in their system. Notably, experiments showed that when amorphous $Fe(OH)_2$ formed in silica-free environments, no H_2 was produced, contradicting previous theories that iron hydroxide acts as a necessary intermediate.

Technical Details

The proposed reaction pathway relies on silica to create compartmentalization, which maintains a pH between 6 and 7 and high concentrations of Fe^{2+} and Cl^-. The process follows these stages:

- **Initial Phase:** Proton transfers raise the pH from 4.5 to 6, creating a supersaturated solution.
- **Precipitation:** Following Ostwald's rule, the metastable green rust precipitates on tubular walls before the more stable goethite because it has a lower critical supersaturation for nucleation (CSN).
- **H_2 Generation:** Because roughly 1/4th of the iron in GR is ferric, its formation oxidizes Fe(II) using water as the oxidant. A pH increase of one unit within the tubular structure can increase H_2 activity by 14 orders of magnitude.

The study also found that H_2 production occurred even when air was the headspace gas, indicating that water-driven oxidation to GR can outcompete oxidation by O_2.

Background & Context

This mechanism is presented as a realistic alternative to the Schikorr reaction, where Fe^{2+} forms $Fe(OH)_2$ which then reacts with water to form magnetite (Fe_3O_4) and H_2. However, the oxidation of pure $Fe(OH)_2$ is extremely slow, even near 100°C. The researchers suggest that previous observations of catalysts (Na_2CO_3, NaCl, or Na_2SO_4) in the Schikorr reaction may actually have been the precipitation of green rust, as these salts are common counterions in GR structures.

Significance & Outlook

Understanding this oxidation route is critical for predicting H_2 production in industrial and safety-critical systems, such as central boilers and radioactive waste containers, where H_2 can cause severe structural damage. Additionally, these findings suggest that green rust and H_2 production may have played a significant role in the early ocean.

Source: https://doi.org/10.21203/rs.3.rs-11432397/v1

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#06 NYK "Izanami": Specs of World's First Ammonia-Fueled AFMGC

Published November 18, 2026　日本郵船株式会社　Japan



OVERVIEW

NYK has launched the "Izanami," the first Ammonia-Fueled Medium Gas Carrier (AFMGC) to utilize ammonia-fueled engines for both main and auxiliary power. The vessel will enter a time charter with Yara Clean Ammonia Switzerland SA to verify operational performance and GHG reduction effects under real-world conditions.

IN DEPTH

Key Findings

NYK has transitioned its ammonia-fueled vessel project from the development phase to operational deployment with the naming and unveiling of the "Izanami." This vessel is the first in the world to employ ammonia-fueled engines for both its main and auxiliary machinery, aiming to eliminate CO_2 emissions during combustion to advance the decarbonization of international shipping.

Technical Details

The "Izanami" is a Japanese-flagged vessel with the following specifications:

- **Cargo Capacity:** Approximately 40,000 ㎥
- **Dimensions:** Length 180 m, Width 32 m, Depth (molded) 18.45 m
- **Main Engine:** Ammonia-fueled Dual Fuel (DF) 2-stroke engine manufactured by Japan Engine Corporation
- **Auxiliary Engine:** Ammonia-fueled Dual Fuel (DF) 4-stroke engine manufactured by IHI Corporation

Background and Context

The development of the vessel was conducted under the Green Innovation Fund project by the New Energy and Industrial Technology Development Organization (NEDO), starting in October 2021. The project involved a collaboration between NYK, Japan Engine Corporation, IHI Corporation, and Japan Shipyard, with cooperation from the ClassNK. The vessel was built at the Japan Marine United Ariake Works in Kumamoto Prefecture, where the naming ceremony took place on November 6 and the unveiling ceremony occurred on November 17, 2026.

Significance and Outlook

The vessel will be chartered to Yara Clean Ammonia Switzerland SA, a group company of YARA International ASA. During the charter period, NYK will conduct demonstration voyages to collect data on safety, operational performance, and greenhouse gas (GHG) reduction effects. This follows NYK's previous development of the "Sakigake," a commercial ammonia-fueled tugboat that has been in operation since August 2024. The data gathered from the "Izanami" is intended to facilitate the broader adoption of ammonia-fueled ships to achieve net-zero emissions in international shipping.

Source: https://www.nyk.com/news/2026/20261118_01.html

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#07 Molten Industries: Natural Gas-to-Graphite Process and Specs

Published November 18, 2026 MINING.COM USA



OVERVIEW

Molten Industries has commissioned a demonstration plant in Oakland, California, that produces battery-grade graphite and clean hydrogen from natural gas via methane pyrolysis. The facility achieves natural gas-to-graphite yields above 95% with an annual capacity of 300 metric tons. This process establishes a domestic U.S. supply chain for a critical battery material currently dominated by China.

IN DEPTH

Key Findings

Molten Industries has commenced operations at its Oakland, California, demonstration plant, marking the first facility globally to produce battery-grade graphite from natural gas at a commercial scale. The plant utilizes a single full-scale modular reactor to convert methane into carbon and hydrogen without the use of oxygen, combustion, or the emission of CO_2.

Technical Details

The production process employs methane pyrolysis to split natural gas into its elemental components. According to the company, this method offers several technical and economic advantages over conventional synthetic graphite production:

- **Efficiency:** The process uses 3× less electricity and 4× cheaper feedstock.
- **Infrastructure:** It eliminates the need for a graphitization furnace.
- **Environmental Impact:** The process produces zero process emissions.
- **Yield and Capacity:** The Oakland plant has a capacity of 300 metric tons of graphite anode production per year, with yields exceeding 95%.

In addition to battery-grade graphite, the process generates clean hydrogen as a by-product, which is used in the production of steel, semiconductors, methanol, refined petroleum products, and ammonia fertilizer.

Background & Context

Graphite is essential for lithium-ion batteries used in electric vehicles, robotics, drones, grid storage, and data centers, as well as for jet engines, nuclear reactors, and semiconductor processing. While the U.S. has domestic sources for nuclear and steelmaking graphite, it remains heavily dependent on foreign sources for battery-grade material; currently, China controls 96% of global battery graphite processing.

Significance & Outlook

The operational status of the Oakland plant demonstrates a 100%-U.S.-made pathway for critical battery materials using widely available domestic natural gas. CEO Kevin Bush noted that while splitting natural gas was patented in 1889, the company has developed the technology necessary to produce high-quality graphite. The modular reactor serves as the fundamental building block for future larger-scale production facilities.

Source: https://www.mining.com/molten-industries-launches-first-us-graphite-plant-using-natural-gas/

Collected: November 21, 2026 | Automated Research System (AI)

#08 Donghwa Entec ARMS: Ammonia Recovery and Regeneration Specs

Published November 19, 2026 에너지신문 South Korea



OVERVIEW

Donghwa Entec has successfully completed verification tests for its Ammonia Recovery and Regeneration System (ARMS), achieving a regeneration purity of over 99.5wt%. The system recovers residual ammonia from ship piping during engine stops or fuel switches to reduce waste and fuel loss.

IN DEPTH

Key Findings

Donghwa Entec has verified the performance of its Ammonia Recovery and Regeneration System (ARMS), meeting all target specifications during demonstration tests. The system achieved a final discharge ammonia concentration of 25ppm or less, a regenerated ammonia purity of 99.5wt% or higher, and a moisture content of 0.5wt% or less.

Technical Details

The ARMS is designed to recover ammonia remaining in the piping of ammonia-fueled vessels during engine shutdowns, fuel transitions, or emergency stops. The system operates during the purge process (removing residual gas) and the drain process (removing remaining liquid). Specifically, the system captures ammonia during these phases and separates it so it can be recycled back into the vessel's fuel supply system or fuel tanks.

The verification tests were conducted on November 11 at the Korea Institute of Industrial Technology's Marine Plant Equipment R&D Center, with the Korean Register (KR) in attendance. In addition to purity and concentration metrics, the tests confirmed that safety functions operated normally via integration with the Emergency Shutdown (ESD) system when simulated ammonia concentrations exceeded set limits.

Background and Context

Ammonia-fueled ships require a method to evacuate gas and liquid from the fuel supply system during operational changes or emergencies. Conventional processes may result in fuel loss and the generation of ammonia aqueous waste. By recovering and regenerating this ammonia, the ARMS reduces the volume of wastewater that must be transferred to shore-based facilities after docking.

Significance and Outlook

The successful demonstration of the ARMS is expected to lower operational burdens and waste treatment costs for ship operators by minimizing fuel loss and wastewater production. CEO Kim Dong-gun stated that the company will use the acquired verification data to refine the integrated design with ship fuel supply systems and pursue the supply of a commercial model that balances safety and economic efficiency.

Source: https://www.energy-news.co.kr/news/articleView.html?idxno=229909

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#09 Kawasaki Heavy Industries L30A: Hydrogen Gas Turbine Specs

Published November 18, 2026　ギズモード・ジャパン　Japan



OVERVIEW

Kawasaki Heavy Industries has deployed the L30A 30MW-class gas turbine at the Emsland power plant in Germany to test flexible hydrogen-natural gas combustion. The system allows for seamless switching between 0% and 100% hydrogen fuel to mitigate the instability of hydrogen supply and pricing. This deployment serves as a critical test for integrating renewable energy storage via hydrogen conversion.

IN DEPTH

Key Findings

Kawasaki Heavy Industries has installed the L30A gas turbine at the Emsland power plant in Lingen, Germany, operated by RWE. The turbine, which has an output of 34MW according to RWE, is the first 30MW-class turbine in Europe capable of both hydrogen co-firing and mono-firing as of November 2026.

Technical Details

The primary technical feature of the L30A is its ability to adjust the fuel mix between hydrogen and natural gas anywhere from 0% to 100%. To verify operational stability, tests are being conducted across five specific volume ratios: 0%, 25%, 50%, 75%, and 100% hydrogen. The objective is to ensure that power output remains consistent regardless of the fuel blend.

Background and Context

The project addresses the volatility of hydrogen availability and cost. By allowing the fuel ratio to fluctuate based on current inventory, the plant can rely more heavily on natural gas when hydrogen is scarce and shift to hydrogen when it is abundant. This infrastructure is situated next to a water electrolysis plant that produces hydrogen using renewable electricity. The site is also adjacent to a nuclear power plant that ceased operations in April 2023, one of the last three to operate in Germany.

Significance and Outlook

This deployment is a strategic response to "Dunkelflaute" (dark doldrums)—periods of low wind and solar output—as Germany targets 80% renewable energy consumption by 2030. The system enables the storage of excess renewable energy as hydrogen, which can later be converted back into electricity via the turbine. While currently in the testing phase, the project will evaluate emissions compliance, flame stability, component durability, and operational ease over several months. There is an expectation that this technology could eventually produce up to 10 times more electricity than previous hydrogen turbines.

Source: https://www.gizmodo.jp/article/kawasaki-hydrogen-gas-turbine-germany/

Collected: November 21, 2026 | Automated Research System (AI)

#10 Kikou Maru: Hydrogen-Fueled Electric Propulsion Tanker Specs

Published November 17, 2026 MONOist Japan



OVERVIEW

The oil tanker Kikou Maru successfully completed a world-first demonstration voyage using a pilot-ignition hydrogen-dedicated engine. The vessel reduced CO2 emissions by approximately 1.2 tons during a 33km trip in Osaka Bay, demonstrating a viable path for zero-emission shipping.

IN DEPTH

Key Findings

On September 25, 2026, the oil tanker Kikou Maru completed a demonstration voyage in Osaka Bay, traveling approximately 33km (about 18 nautical miles) over two hours. According to the Nippon Foundation, this marks the world's first demonstration voyage of a vessel equipped with a pilot-ignition hydrogen-dedicated engine. The voyage resulted in a CO2 emission reduction of approximately 1.2 tons compared to conventional fuels.

Technical Details

The vessel utilizes a configuration where the hydrogen engine serves as a generator to supply power to an existing electric propulsion system. The technical architecture includes:

- **Power Generation:** Four diesel generators with a total rated output of 5200kW (1300kW each).
- **Propulsion:** Two propulsion motors with a total rated output of 3300kW (1650kW each), which drive two propeller shafts via inverters for speed control.
- **Energy Storage:** Lithium-ion batteries are integrated into the power system to absorb load fluctuations from the propulsion motors, smoothing the load on the generators. Batteries also provide power during mooring to reduce generator operation.
- **Power Distribution:** A common distribution system supplies electricity to both the propulsion motors and cargo pumps, a specific advantage of electric propulsion for tankers.

Background and Context

Owned and operated by Ueno Transtech and built by Fukuoka Shipbuilding's Nagasaki plant in 2025, the Kikou Maru is a 104.93m vessel with approximately 4500 gross tonnage and a cargo capacity of approximately 5000 kiloliters. The project was part of the "Zero Emission Ship Project" started by the Nippon Foundation in 2022. Yanmar Power Solution developed the hydrogen-dedicated engine and related equipment, while Ueno Transtech handled vessel modification and crew training.

Significance and Outlook

The vessel was designed as "hydrogen fuel ready," allowing for a retrofit approach. It was first completed as a diesel-powered electric propulsion tanker, with hydrogen engine power equipment and tanks added later. This method allows vessels to maintain normal operations using conventional fuels while integrating zero-emission technology.

Source: https://monoist.itmedia.co.jp/mn/articles/2611/17/news010.html

Collected: November 21, 2026 | Automated Research System (AI)