TROY TECHNICAL

HYDROGEN ENERGY
WEEKLY REPORT

November 8 - November 14, 2026 | Issue 2026-W45

Delivered hydrogen economics, infrastructure readiness and bankable demand

13	10
ANALYZED ARTICLES	PRIORITY THEMES

Issued 2026-11-14 | English edition | fixed approved cover artwork



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

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

SIGNAL 01 | POWER & FEEDSTOCK

Nippon Steel: 100% Hydrogen Direct Reduction of Low-Grade Ore

Nippon Steel has successfully produced over 1,000t of direct reduced iron (DRI) using 100% hydrogen and low-grade iron ore.

SIGNAL 02 | PRODUCTION

Pt/Fe-NC Catalyst: Durable Ammonia Cracking for Hydrogen Production

Researchers at the National University of Singapore have developed a Pt/Fe-NC composite catalyst and regeneration protocol that enables over 2,000 hours of continuous hydrogen production from ammonia.

SIGNAL 03 | STORAGE & TRANSPORT

Green Rust Oxidation: Fe(II) Water-Driven H2 Production Mechanism

Researchers have identified a rapid hydrogen production pathway via the direct formation and oxidation of green rust (GR) from Fe(II) ions.

SIGNAL 04 | END USE

Green Hydrogen Production: 3D Model Reveals Bubble-Induced Energy Loss

Researchers from Cornell University and City University of Hong Kong developed a 3D computer model showing that bubbles in water electrolysis can increase voltage demand by over 50%.

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

100%
A13

SOURCE-BOUND CONDITION
Nippon Steel has successfully produced over 1,000t of direct reduced iron (DRI) using 100% hydrogen and low-grade iron ore.

000 hours
A10

SOURCE-BOUND CONDITION
Researchers at the National University of Singapore have developed a Pt/Fe-NC composite catalyst and regeneration protocol that enables over 2,000 hours of continuous hydrogen production from ammonia.

50%
A07

SOURCE-BOUND CONDITION
Researchers from Cornell University and City University of Hong Kong developed a 3D computer model showing that bubbles in water electrolysis can increase voltage demand by over 50%.

1 cm
A12

SOURCE-BOUND CONDITION
The process achieved a record-high yield rate of 40.67 μg h-1 cm-2 and a Faradaic efficiency of 24.9%.

11 million
A08

SOURCE-BOUND CONDITION
These milestones, achieved at the Global Technology Center in Greenville, S.C., build upon a global fleet record of over 11 million operating hours on hydrogen and hydrogen-blended fuels.

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

Nippon Steel has successfully produced over 1,000t of direct reduced iron (DRI) using 100% hydrogen and low-grade iron ore.

2

Production

P02/P07

Researchers at the National University of Singapore have developed a Pt/Fe-NC composite catalyst and regeneration protocol.

3

Storage & transport

P03/P08

Researchers have identified a rapid hydrogen production pathway via the direct formation and oxidation of green rust (GR).

4

End use

P04/P09

Researchers from Cornell University and City University of Hong Kong developed a 3D computer model showing that bubbles in.

5

Market & policy

P05/P10

RWE and Kawasaki Heavy Industries have commissioned a 34-megawatt hydrogen-compatible gas turbine at the Emsland power.

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	Nippon Steel: 100% Hydrogen Direct Reduction of Low-Grade Ore System / adoption | cue: trial
P02	Pt/Fe-NC Catalyst: Durable Ammonia Cracking for Hydrogen Production Tech / process | cue: no system/business cue
P03	Green Rust Oxidation: Fe(II) Water-Driven H2 Production Mechanism Tech / process | cue: no system/business cue
P04	Green Hydrogen Production: 3D Model Reveals Bubble-Induced Energy Loss Tech / process | cue: no system/business cue
P05	RWE and Kawasaki: 34-MW Hydrogen Turbine Trials in Lingen Tech / process | cue: no system/business cue
P06	Mitsui Mining & Metals: MOF Glass Membrane for Hydrogen Production Tech / process | cue: no system/business cue
P07	Cobalt Hydroxide Catalyst: HAHS Mechanism for Ammonia Synthesis Tech / process | cue: no system/business cue
P08	GE Vernova Hydrogen Turbines: LM2500XPRESS and LM6000 Specs Tech / process | cue: no system/business cue
P09	Hydrogen Spontaneous Ignition: Wall Roughness Effects on Tubes Business / rules | cue: infrastructure
P10	Ru-O-Cr Heterodiatomic Catalysts: Stability for PEM Water 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 Nippon Steel: 100% Hydrogen Direct Reduction of Low-Grade Ore

A13 | Power & feedstock | Joint evaluation

2026-11-10

FACT

Nippon Steel has successfully produced over 1,000t of direct reduced iron (DRI) using 100% hydrogen and low-grade iron ore. The trial achieved over 300 hours of continuous operation, overcoming technical hurdles related to endothermic reactions and ore powdering. This progress supports the company's roadmap toward carbon-neutral steelmaking by 2040.

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 21/25 | MATURITY 3/5 | DECISION LOCUS: SYSTEM / ADOPTION

P02 Pt/Fe-NC Catalyst: Durable Ammonia Cracking for Hydrogen Production

A10 | Production | Product adoption

2026-11-12

FACT

Researchers at the National University of Singapore have developed a Pt/Fe-NC composite catalyst and regeneration protocol that enables over 2,000 hours of continuous hydrogen production from ammonia. By suppressing platinum oxidation and nitrogen poisoning, this strategy addresses critical durability gaps in electrochemical ammonia cracking.

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 21/25 | MATURITY 4/5 | DECISION LOCUS: TECH / PROCESS

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

P03 Green Rust Oxidation: Fe(II) Water-Driven H2 Production Mechanism

A03 | Storage & transport | Product adoption

2026-11-12

FACT

Researchers have identified a rapid hydrogen production pathway via the direct formation and oxidation of green rust (GR) from Fe(II) ions. This mechanism, driven by water as the oxidant, outcompetes oxygen-based oxidation and differs from the slower Schikorr reaction. The findings suggest significant implications for early ocean chemistry and the structural integrity of industrial boilers and radioactive waste containers.

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 4/5 | DECISION LOCUS: TECH / PROCESS

P04 Green Hydrogen Production: 3D Model Reveals Bubble-Induced Energy Loss

A07 | End use | Product adoption

2026-11-11

FACT

Researchers from Cornell University and City University of Hong Kong developed a 3D computer model showing that bubbles in water electrolysis can increase voltage demand by over 50%. By identifying a critical bubble size threshold, the team provides a pathway to reduce energy waste and lower production costs for green hydrogen.

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 4/5 | DECISION LOCUS: TECH / PROCESS

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

P05 RWE and Kawasaki: 34-MW Hydrogen Turbine Trials in Lingen

A09 | Market & policy | Joint evaluation

2026-11-09

FACT

RWE and Kawasaki Heavy Industries have commissioned a 34-megawatt hydrogen-compatible gas turbine at the Emsland power station in Germany. The installation, described as Europe's largest fully hydrogen-compatible gas turbine, will undergo industrial-scale trials using up to 100 per cent hydrogen to support flexible power generation.

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 3/5 | DECISION LOCUS: TECH / PROCESS

P06 Mitsui Mining & Metals: MOF Glass Membrane for Hydrogen Production

A06 | Power & feedstock | Product adoption

2026-11-10

FACT

Mitsui Mining & Metals and Kyoto University have developed a proton-conducting MOF glass membrane capable of operating in mid-temperature ranges. The technology successfully produced hydrogen via water electrolysis using steam at 170°C, filling a material gap for industrial waste heat recovery.

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 4/5 | DECISION LOCUS: TECH / PROCESS

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

P07 Cobalt Hydroxide Catalyst: HAHS Mechanism for Ammonia Synthesis

A12 | Production | Pilot

2026-11-11

FACT

Researchers have developed a cobalt hydroxide catalyst utilizing a "hydroxide-activated hydrogen spillover" (HAHS) mechanism to synthesize ammonia at ambient conditions. The process achieved a record-high yield rate of 40.67 µg h-1 cm-2 and a Faradaic efficiency of 24.9%. This advancement offers a sustainable, decarbonized alternative to the energy-intensive Haber-Bosch process.

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 20/25 | MATURITY 2/5 | DECISION LOCUS: TECH / PROCESS

P08 GE Vernova Hydrogen Turbines: LM2500XPRESS and LM6000 Specs

A08 | Storage & transport | Research

2026-11-10

FACT

GE Vernova has validated 50% hydrogen capability for the LM2500XPRESS and 100% hydrogen capability for the LM6000VELOX aeroderivative gas turbines. These milestones, achieved at the Global Technology Center in Greenville, S.C., build upon a global fleet record of over 11 million operating hours on hydrogen and hydrogen-blended fuels.

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 20/25 | MATURITY 1/5 | DECISION LOCUS: TECH / PROCESS

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

P09 Hydrogen Spontaneous Ignition: Wall Roughness Effects on Tubes

A04 | End use | Research

2026-11-09

FACT

Wall roughness increases the critical burst pressure threshold for spontaneous hydrogen ignition from 3.2 MPa to 3.5 MPa. The study demonstrates that surface roughness suppresses flame coalescence and shock wave velocities while intensifying boundary layer combustion. These findings provide a theoretical basis for quantitative risk assessment and future hydrogen infrastructure safety standards.

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 20/25 | MATURITY 1/5 | DECISION LOCUS: BUSINESS / RULES

P10 Ru-O-Cr Heterodiatomic Catalysts: Stability for PEM Water Electrolysis

A01 | Market & policy | Pilot

2026-11-12

FACT

Researchers have developed a RuCr heterodiatomic catalyst featuring proximal Ru-O-Cr motifs that significantly reduce ruthenium dissolution during acidic oxygen evolution. The design achieves a 55.7-fold increase in oxidation resistance compared to conventional single-atom catalysts, enabling high-rate PEM water electrolysis with durability comparable to bulk RuO2 and IrO2.

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 2/5 | 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 01-13

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	Ru-O-Cr Heterodiatomic Catalysts: Stability for PEM Water Electrolysis	https://doi.org/10.1038/s41563-026-02783-4
A02	Cobalt Phosphide (CoP): Surface Dynamics and pH-Universal Stability	https://www.tohoku.ac.jp/en/press/a_catalyst_that_protects_itself_while_producing_hydrogen.html
A03	Green Rust Oxidation: Fe(II) Water-Driven H2 Production Mechanism	https://doi.org/10.21203/rs.3.rs-11432397/v1
A04	Hydrogen Spontaneous Ignition: Wall Roughness Effects on Tubes	https://doi.org/10.21203/rs.3.rs-11370052/v1
A05	Battery vs Green Hydrogen Storage: LCOS Analysis for 2024-2046	https://doi.org/10.21203/rs.3.rs-11238794/v1
A06	Mitsui Mining & Metals: MOF Glass Membrane for Hydrogen Production	https://response.jp/article/2026/11/10/418829.html
A07	Green Hydrogen Production: 3D Model Reveals Bubble-Induced Energy Loss	https://interestingengineering.com/energy/tiny-bubbles-green-hydrogen-energy
A08	GE Vernova Hydrogen Turbines: LM2500XPRESS and LM6000 Specs	https://www.gevernova.com/news/press-releases/ge-vernova-advances-hydrogen-capabilities-aeroderivative-gas-turbines-new-milestones
A09	RWE and Kawasaki: 34-MW Hydrogen Turbine Trials in Lingen	https://news.europawire.eu/rwe-and-kawasaki-commission-34-mw-hydrogen-turbine-for-industrial-scale-trials-in-lingen/eu-press-release/2026/11/09/11/58/09/186750/
A10	Pt/Fe-NC Catalyst: Durable Ammonia Cracking for Hydrogen Production	https://bioengineer.org/novel-catalyst-regeneration-strategy-sustains-durable-hydrogen-production-from-ammonia-cracking/
A11	Palladium Hydrogen Sensors: Grain-Boundary Engineering for 2026	https://www.tohoku.ac.jp/en/press/crystal_boundaries_help_hydrogen_sensors_work_in_hot_humid_air.html
A12	Cobalt Hydroxide Catalyst: HAHS Mechanism for Ammonia Synthesis	https://www.miragenews.com/catalytic-shortcut-converts-nitrogen-to-ammonia-1774944/
A13	Nippon Steel: 100% Hydrogen Direct Reduction of Low-Grade Ore	https://news.yahoo.co.jp/articles/54de41e23cc74109e64e3bce1beb82f8a7d03de7

HydrogenEnergy — Selected Articles

Date: 2026-11-15

Articles: 13

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#04 Hydrogen Spontaneous Ignition: Wall Roughness Effects on Tubes

#05 Battery vs Green Hydrogen Storage: LCOS Analysis for 2024–2046

#06 Mitsui Mining & Metals: MOF Glass Membrane for Hydrogen Production

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#01 Ru-O-Cr Heterodiatomic Catalysts: Stability for PEM Water Electrolysis

Published November 12, 2026 Nature Materials



OVERVIEW

Researchers have developed a RuCr heterodiatomic catalyst featuring proximal Ru−O−Cr motifs that significantly reduce ruthenium dissolution during acidic oxygen evolution. The design achieves a 55.7-fold increase in oxidation resistance compared to conventional single-atom catalysts, enabling high-rate PEM water electrolysis with durability comparable to bulk RuO2 and IrO2.

IN DEPTH

Key Findings

The RuCr heterodiatomic catalyst (HDC) demonstrates a Ru dissolution rate of 0.03 μg cm^{-2} h^{-1}, which is 55.7-fold lower than the 1.67 μg cm^{-2} h^{-1} observed in Ru single-atom catalysts (SACs). In full-cell proton exchange membrane water electrolysis (PEMWE) at 1 A cm^{-2}, the RuCr HDC exhibited degradation rates 6.8-fold lower than Ru SACs and 14.4-fold lower than commercial RuO2, maintaining operation for over 285 h with a degradation rate of 0.28 mV h^{-1}.

Technical Details

The catalyst consists of proximal Ru−O−Cr motifs anchored on delta-phase manganese oxide (δ-MnO2), with a configuration fraction estimated at 26.5 ± 2.3%. Unlike traditional doping, this design utilizes a proximity-dependent redox coupling mechanism. In situ X-ray absorption near-edge structure (XANES) analysis reveals that Ru oxidation is synchronized with anticorrelated and partially reversible Cr redox evolution. In this motif, Cr acts as a proximal redox partner that buffers the oxidation state of Ru, preventing its progression into soluble high-valent species. The optimized RuCr HDC delivers 1.53 A cm^{-2} at 1.8 V with a Ru loading of 0.05 mg cm^{-2}, resulting in a mass activity of 30,666 A g^{-1}.

Background & Context

Single-atom catalysts offer high intrinsic activity and minimize noble-metal usage but typically suffer from oxidative instability in acidic oxygen evolution reactions (OER). Ruthenium SACs, while efficient, are prone to irreversible oxidation and dissolution, particularly at industrial current densities of ≥1 A cm^{-2}. Conventional bulk-tuning strategies, such as doping, are ineffective for SACs because isolated atoms lack the extended coordination and collective electronic buffering found in bulk lattices.

Significance & Outlook

By shifting from compositional modification to valence-state design, this proximal oxidation damping approach provides a route to stabilize atomically precise catalysts. The RuCr HDC achieves mass durability comparable to commercial IrO2 and bulk RuO2 benchmarks. This heteroatomic design principle is reported to be transferable across RuX and IrCr systems, offering a potential solution for the multi-gigawatt-scale deployment of hydrogen technologies by reducing reliance on scarce iridium.

Source: https://doi.org/10.1038/s41563-026-02783-4

Collected: November 15, 2026 | Automated Research System (AI)

#02 Cobalt Phosphide (CoP): Surface Dynamics and pH-Universal Stability

Published November 10, 2026 Tohoku University Japan



OVERVIEW

Researchers have discovered that cobalt phosphide (CoP) maintains high activity and durability across acidic, neutral, and alkaline environments by dynamically altering its surface during water electrolysis. This self-protecting mechanism prevents material degradation and offers a more affordable alternative to platinum for green hydrogen production.

IN DEPTH

Key Findings

Cobalt phosphide (CoP) exhibits pH-universal activity and stability by undergoing surface transformations in response to applied electrical voltage. Rather than remaining chemically static, the catalyst forms a protective layer of adsorbed species that prevents cobalt and phosphorus from dissolving into the surrounding solution, thereby limiting oxidation and maintaining performance.

Technical Details

The catalyst's surface dynamics vary based on the voltage applied during operation:

- **Lower Voltages:** Hydroxyl groups (P-OH) form on phosphorus sites, which enable neighboring cobalt atoms to activate water and bind hydrogen more efficiently.
- **Higher Voltages:** The surface transitions to be covered with hydrogen-containing species (Co-H and P-H), balancing the binding and release of hydrogen.

To validate these findings, researchers utilized AI-assisted analysis of 2,282 observations from approximately 886 CoP-based catalysts across 700 publications. These data, combined with computer simulations and experiments using CoP nanosheets and deuterium, confirmed the predicted surface changes. Spectroscopic techniques verified the chemical species involved. The catalyst remained stable for 24 hours at current densities exceeding 1 A cm^{-2}.

Background and Context

While CoP has been viewed as a promising platinum alternative, computer models previously suggested it should be unstable under hydrogen production conditions. However, experimental data consistently showed the material remained active across various pH levels. This study, published in the Journal of the American Chemical Society on October 29, 2026, resolves this discrepancy by identifying the operando surface dynamics that protect the material.

Significance and Outlook

These results provide a pathway toward developing more affordable and versatile catalysts for green hydrogen production. The study suggests a shift in catalyst design philosophy: researchers should prioritize how a material's surface evolves under actual operating conditions rather than focusing solely on the initial state of the material.

Source:
https://www.tohoku.ac.jp/en/press/a_catalyst_that_protects_itself_while_producing_hydrogen.html

Collected: November 15, 2026 | Automated Research System (AI)

#03 Green Rust Oxidation: Fe(II) Water-Driven H_2 Production Mechanism

Published November 12, 2026　Research Square（プレプリント）



OVERVIEW

Researchers have identified a rapid hydrogen production pathway via the direct formation and oxidation of green rust (GR) from Fe(II) ions. This mechanism, driven by water as the oxidant, outcompetes oxygen-based oxidation and differs from the slower Schikorr reaction. The findings suggest significant implications for early ocean chemistry and the structural integrity of industrial boilers and radioactive waste containers.

IN DEPTH

Key Findings

The study demonstrates that hydrogen (H_2) is produced through the water-driven oxidation of Fe(II) specifically when green rust (GR) precipitates. A critical discovery is that the presence of silica enables the compartmentalization necessary to maintain a pH between 6 and 7 and high concentrations of Fe^{2+} and Cl^-, which are essential for GR stability. In contrast, experiments without silica resulted in the formation of amorphous $Fe(OH)_2$ without H_2 production.

Technical Details

The proposed reaction pathway identifies R3 as the key chemical equation: $4Fe^{2+} + 8H_2O + Cl^- = Fe(iii)Fe(ii)_3(OH)<0xE2><0x82><0x88>Cl + 7H^+ + 0.5H_2$. The process occurs in two primary segments:

- **Segment A:** Proton transfers across a membrane raise the internal pH from 4.5 to 6. While goethite is the stable phase, green rust precipitates first due to a lower critical supersaturation for nucleation (CSN), following Ostwald's rule.
- **Segment B:** Once GR forms, H_2 activity increases by 14 orders of magnitude for every one-unit increase in pH within the tubular structure, driving massive H_2 production.

The researchers noted that H_2 production remained significant even when air was used as the headspace gas, indicating that water-driven oxidation to form GR can outcompete oxidation by O_2.

Background & Context

This mechanism provides an alternative to the Schikorr reaction, where Fe^{2+} forms $Fe(OH)_2$ before reacting with water to form magnetite (Fe_3O_4) and H_2. The oxidation of pure $Fe(OH)_2$ is extremely slow, even near 100°C. The study suggests that previous observations of H_2 production involving salts like NaCl or Na_2CO_3 may actually be attributed to the precipitation of green rust, as these salts act as counterions in GR structures.

Significance & Outlook

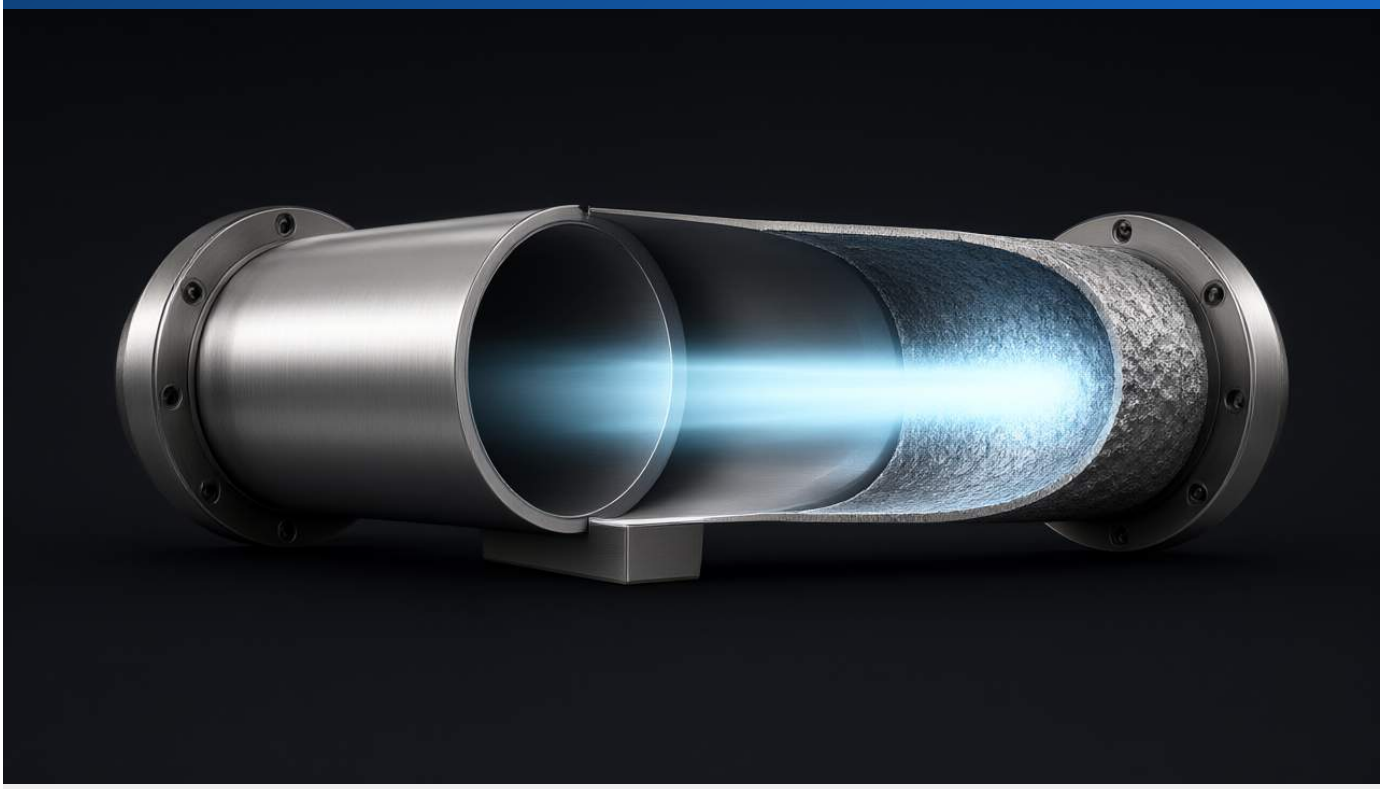
Understanding this oxidation route is critical for predicting H_2 production in high-risk environments, such as central boilers and radioactive waste containers, where gas accumulation can cause severe structural damage. Additionally, the results support the theory that green rust and H_2 production played a significant role in the chemistry of the early ocean.

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

Collected: November 15, 2026 | Automated Research System (AI)

#04 Hydrogen Spontaneous Ignition: Wall Roughness Effects on Tubes

Published November 09, 2026　Research Square（プレプリント）



OVERVIEW

Wall roughness increases the critical burst pressure threshold for spontaneous hydrogen ignition from 3.2 MPa to 3.5 MPa. The study demonstrates that surface roughness suppresses flame coalescence and shock wave velocities while intensifying boundary layer combustion. These findings provide a theoretical basis for quantitative risk assessment and future hydrogen infrastructure safety standards.

IN DEPTH

Key Findings

Wall roughness significantly alters the ignition dynamics of pressurized hydrogen released into a tube, most notably by elevating the critical burst pressure threshold required for spontaneous ignition from 3.2 MPa to 3.5 MPa. The research indicates that higher roughness scales lead to the dissipation of the central reaction zone by suppressing the radial expansion and central coalescence of the flame front.

Technical Details

The investigation utilized Large Eddy Simulation (LES) combined with a mixture averaged transport model and an Improved Partially Stirred Reactor (PaSR) combustion model. The study compared an absolutely smooth boundary condition (Ra = 0 mm) against varying equivalent sand-grain wall roughness (Ra) levels of 0.1, 0.5, and 1.0 mm. Technical observations include:

- **Flame Evolution:** Roughness-induced localized vortices drastically intensify combustion within the boundary layer.
- **Shock Wave Dynamics:** Wall roughness introduces a non-linear suppression of leading shock wave velocities.
- **Energy Dissipation:** The increase in the ignition threshold is driven by intense thermal and near-wall momentum dissipation.

Background & Context

While the general understanding of spontaneous ignition during accidental pressurized hydrogen releases has advanced, the specific aerodynamic effects of tube surface conditions have remained critically underexplored. This numerical study addresses this gap by evaluating how different surface textures influence non-premixed flame evolution and shock wave propagation.

Significance & Outlook

These results offer critical theoretical foundations for the quantitative risk assessment of hydrogen infrastructure. By quantifying the relationship between wall roughness and ignition thresholds, the data serves to inform future iterations of tube safety standards to better prevent accidental ignitions in industrial environments.

Source: https://doi.org/10.21203/rs.3.rs-11370052/v1

Collected: November 15, 2026 | Automated Research System (AI)

#05 Battery vs Green Hydrogen Storage: LCOS Analysis for 2024–2046

Published November 12, 2026　Research Square（プレプリント）



OVERVIEW

Economic rankings of battery and green hydrogen storage in Nusantara Capital City depend on cost provenance rather than universal technology superiority. While batteries showed a lower LCOS under mixed-vintage scenarios, hydrogen became more economical under provenance-locked assumptions. These findings provide critical decision evidence for sustainable infrastructure and clean-energy systems.

IN DEPTH

Key Findings

The economic viability of energy storage depends heavily on the documented economic inputs and the specific storage service required. In 2024, battery storage delivered 206.08 kWh/day with a curtailment of 437.82 kWh/day, while green hydrogen delivered 174.08 kWh/day with a curtailment of 151.45 kWh/day. Under mixed-vintage LCOS scenarios, batteries were more favorable at IDR 4,581.41/kWh compared to IDR 8,105.05/kWh for hydrogen. However, under provenance-locked assumptions, the ranking reversed, with hydrogen costing IDR 8,947.97/kWh and batteries costing IDR 10,498.69/kWh.

Technical Details

The study utilized a year-specific representative-day dispatch model covering the period from 2024 to 2046, based on a 24-h photovoltaic generation and demand profile in Nusantara Capital City, Indonesia. The model incorporated several technical variables:

- Photovoltaic degradation
- Battery state of charge and replacement
- Electrolysis, hydrogen compression, and storage
- Fuel-cell reconversion and lifecycle costs

Break-even analysis indicated that battery-capital-cost parity occurs near USD 292.97/kWh at the baseline electrolyser CAPEX.

Background & Context

Comparing battery and green hydrogen storage requires a consistent energy boundary and component-cost provenance. The researchers evaluated delivered electricity, curtailment, and levelized cost of storage (LCOS) across three economic scenarios: mixed-vintage, monetary-normalised, and provenance-locked.

Significance & Outlook

The results demonstrate that technology rankings are conditional and not universal. These thresholds offer evidence relevant to Sustainable Development Goal 7 (clean-energy systems) and Goal 9 (sustainable infrastructure). The study specifically focuses on these economic drivers without measuring seasonal storage performance or overall progress toward the mentioned Sustainable Development Goals.

Source: https://doi.org/10.21203/rs.3.rs-11238794/v1

Collected: November 15, 2026 | Automated Research System (AI)

#06 Mitsui Mining & Metals: MOF Glass Membrane for Hydrogen Production

Published November 10, 2026　レスポンス（Response.jp）　Japan



OVERVIEW

Mitsui Mining & Metals and Kyoto University have developed a proton-conducting MOF glass membrane capable of operating in mid-temperature ranges. The technology successfully produced hydrogen via water electrolysis using steam at 170°C, filling a material gap for industrial waste heat recovery.

IN DEPTH

Key Findings

Mitsui Mining & Metals and a research group led by Professor Satoshi Horige of the Graduate School of Science at Kyoto University have successfully generated hydrogen through water electrolysis using 170°C steam. This was achieved through the development of a new proton-conducting Metal-Organic Framework (MOF) glass membrane designed specifically for mid-temperature operations.

Technical Details

The research focuses on MOF glass, a material derived from Metal-Organic Frameworks. MOFs are porous materials composed of metal ions and organic molecules. The group utilized MOF glass due to its specific characteristics, which include:

- The ability to incorporate molecules with various functions.
- Suitability for molding and processing.

Background & Context

Water electrolysis is a critical technology for achieving a decarbonized society. However, a technical gap existed regarding electrolyte materials suitable for the 150–250°C temperature range. This specific temperature window is highly valuable because it aligns with the temperature of waste heat and steam typically generated in industrial factory settings.

Significance & Outlook

By developing a membrane that functions within this previously unsupported mid-temperature range, the research enables the utilization of industrial steam and waste heat for hydrogen production. This development provides a material solution for water electrolysis in environments where traditional electrolytes were not viable.

Source: https://response.jp/article/2026/11/10/418829.html

#07 Green Hydrogen Production: 3D Model Reveals Bubble-Induced Energy Loss

Published November 11, 2026 Interesting Engineering USA



OVERVIEW

Researchers from Cornell University and City University of Hong Kong developed a 3D computer model showing that bubbles in water electrolysis can increase voltage demand by over 50%. By identifying a critical bubble size threshold, the team provides a pathway to reduce energy waste and lower production costs for green hydrogen.

IN DEPTH

Key Findings

A new 3D mathematical model has revealed that tiny bubbles formed during water electrolysis can significantly disrupt hydrogen production and increase electricity consumption. The study identified a critical bubble radius beyond which the additional voltage required for electrolysis rises exponentially. Under specific simulated conditions, this extra voltage demand can exceed 50 percent of the voltage required in a bubble-free environment. Conversely, keeping bubbles below this critical threshold could limit additional voltage requirements to within three percent.

Technical Details

The computational tool acts as a digital twin of an electrolyzer, simulating processes across eight orders of magnitude in length. It allows researchers to reproduce real electrode shapes, materials, and operating conditions to observe microscopic processes that are difficult to isolate experimentally. Key technical achievements include:

- Identification of the critical bubble size, which depends on electrode geometry and the ease of liquid spread across the surface.
- Determination that the greatest energy losses occur when bubbles block active electrode surfaces.
- Implementation of a computational method that reduces the effort needed to run simulations by approximately 1,000 times without compromising numerical accuracy.

Background & Context

Green hydrogen is produced by splitting water (H2) into hydrogen and oxygen using electrolysis powered by renewable sources like wind or solar energy. While it emits zero carbon dioxide (CO2), the process is hindered by hydrogen and oxygen bubbles that develop on the electrodes. These bubbles block active reaction sites, prevent water from reaching electrode surfaces, and interfere with the movement of charged particles, forcing the electrolyzer to consume more electricity.

Significance & Outlook

The findings, published in *EES Catalysis*, suggest that efficiency can be improved by designing electrodes that release bubbles before they reach the critical size. The research team plans to expand the model to analyze how multiple bubbles grow, merge, and interact. Future goals include integrating this technology with 3D printing and computational optimization to develop more efficient electrode designs, ultimately making green hydrogen cheaper to produce for industries such as chemical manufacturing and steelmaking.

Source: https://interestingengineering.com/energy/tiny-bubbles-green-hydrogen-energy

Collected: November 15, 2026 | Automated Research System (AI)

#08 GE Vernova Hydrogen Turbines: LM2500XPRESS and LM6000 Specs

Published November 10, 2026 GE Vernova USA



OVERVIEW

GE Vernova has validated 50% hydrogen capability for the LM2500XPRESS and 100% hydrogen capability for the LM6000VELOX aeroderivative gas turbines. These milestones, achieved at the Global Technology Center in Greenville, S.C., build upon a global fleet record of over 11 million operating hours on hydrogen and hydrogen-blended fuels.

IN DEPTH

Key Findings

GE Vernova has achieved two primary technical milestones in hydrogen-ready aeroderivative gas turbine development. The company validated the LM2500XPRESS aeroderivative gas turbine package for operation using fuel blends containing up to 50% hydrogen in a Dry Low Emission (DLE) configuration. Additionally, the LM6000VELOX aeroderivative gas turbine package successfully completed testing for 100% hydrogen capability using a Singular Annular Combustion (SAC) configuration.

Technical Details

- **LM2500XPRESS:** This modular package, derived from aviation technology, maintains the ability to reach full power in five minutes or less while utilizing up to 50% hydrogen blending in DLE configuration. The LM2500 series has over 1,150 units sold and more than 200 million operating hours.
- **LM6000VELOX:** Testing utilized advanced SAC systems to mitigate the specific challenges of hydrogen combustion to ensure stable operation at 100% hydrogen. The LM6000 platform has an installed and shipped base of nearly 1,350 units across approximately 60 countries.
- **Operational Scale:** Across its global gas turbine fleet, GE Vernova has surpassed 11 million operating hours on hydrogen and hydrogen-blended fuels, with more than 120 turbines having operated on these fuels.

Background and Context

These developments were unveiled during the Energy & Transport Day at COP31 in Antalya. The testing was conducted at a new dedicated hydrogen testing facility within the Global Technology Center in Greenville, South Carolina. This facility is part of a broader investment in the Greenville site announced in 2025, intended to increase the company's capacity to validate hydrogen-ready power solutions and support US manufacturing.

Significance and Outlook

Aeroderivative gas turbines provide fast-starting, flexible power generation necessary for stabilizing electric grids and meeting peak demand for utilities, data centers, and industrial sectors such as steel, refining, and petrochemicals. By integrating hydrogen-ready capabilities, GE Vernova provides a transition path for customers to utilize current fuels while preparing infrastructure for lower-carbon options as the energy transition progresses.

Source: https://www.gevernova.com/news/press-releases/ge-vernova-advances-hydrogen-capabilities-aeroderivative-gas-turbines-new-milestones

Collected: November 15, 2026 | Automated Research System (AI)

#09 RWE and Kawasaki: 34-MW Hydrogen Turbine Trials in Lingen

Published November 09, 2026 EuropaWire Germany



OVERVIEW

RWE and Kawasaki Heavy Industries have commissioned a 34-megawatt hydrogen-compatible gas turbine at the Emsland power station in Germany. The installation, described as Europe’s largest fully hydrogen-compatible gas turbine, will undergo industrial-scale trials using up to 100 per cent hydrogen to support flexible power generation.

IN DEPTH

Key Findings

RWE and Kawasaki Heavy Industries (KHI) have commissioned a 34-megawatt (MW) hydrogen-compatible gas turbine at the Emsland gas-fired power station in Lingen, Germany. The project, which marked the start of trial operations on 6 November 2026, represents the largest fully hydrogen-compatible gas turbine in Europe. The installation is designed to demonstrate industrial-scale electricity generation using hydrogen to ensure a reliable power supply as grids transition toward wind and solar energy.

Technical Details

The turbine is engineered for high fuel flexibility, capable of operating on natural gas, pure hydrogen, or any blend of the two (0 to 100 per cent hydrogen). Over several months, the partners will conduct trials to test various operating modes and load conditions. The hydrogen required for these trials is supplied by the adjacent GET H2 Nukleus electrolysers, which utilize renewable electricity to split water into hydrogen and oxygen.

Background & Context

The project is supported by Japan’s funding organisation NEDO. The commissioning ceremony was attended by representatives from RWE, Kawasaki Heavy Industries, and NEDO, as well as Olaf Lies, Minister-President of Lower Saxony, and Mitsuko Shino, Japan’s Ambassador to Germany. This initiative follows RWE's recent success in a Federal Network Agency tender for flexible power stations.

Significance & Outlook

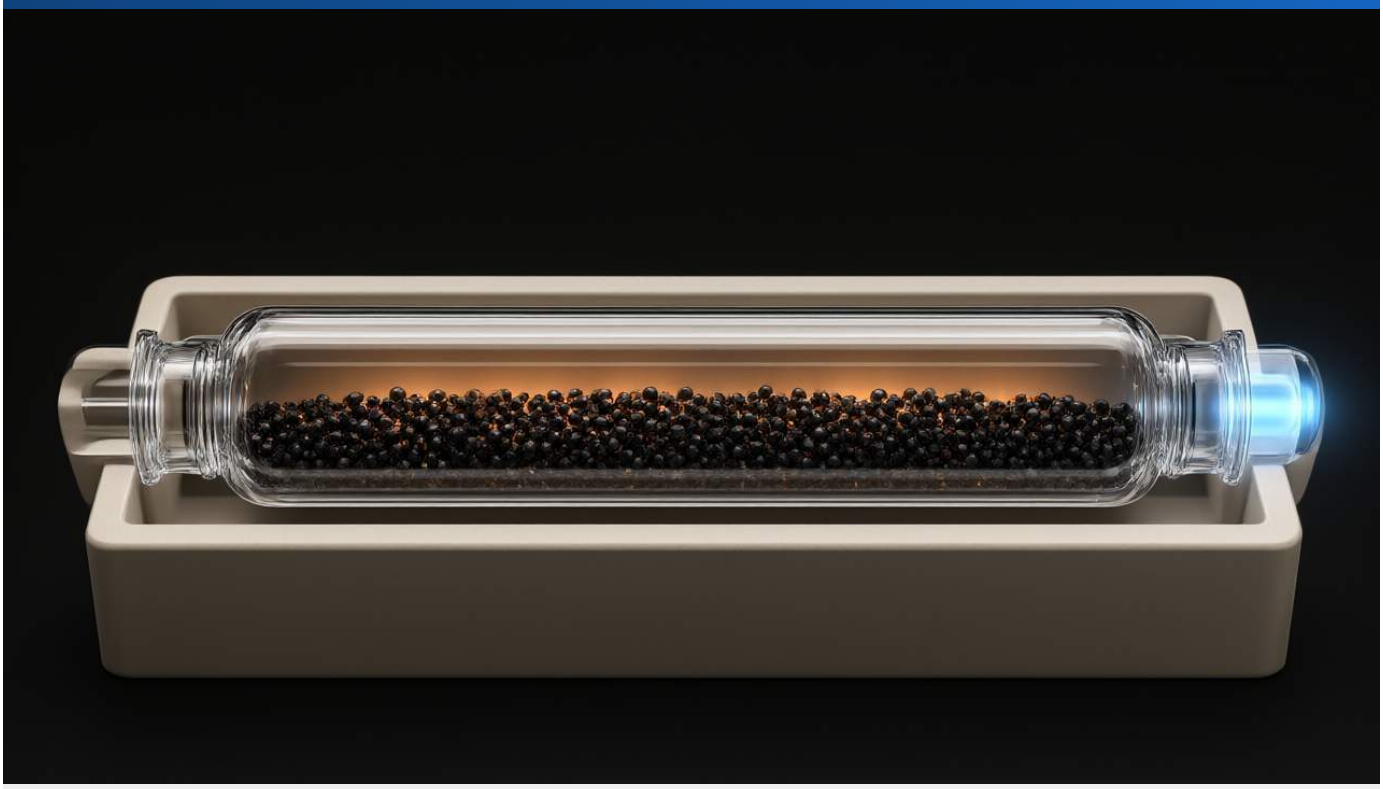
The 34-MW turbine generates up to ten times the power of previous hydrogen turbines. According to Nikolaus Valerius, CEO of RWE Generation, the operational experience gained from this project is critical for the future deployment of even larger turbines capable of supplying electricity to hundreds of thousands of households. Motohiko Nishimura of Kawasaki Heavy Industries noted that the ability to adjust the hydrogen-natural gas co-firing ratio based on availability and cost is a key step toward realizing a hydrogen-based society. The trials aim to provide the necessary data to support flexible generating capacity when renewable energy production is insufficient.

Source: https://news.europawire.eu/rwe-and-kawasaki-commission-34-mw-hydrogen-turbine-for-industrial-scale-trials-in-lingen/eu-press-release/2026/11/09/11/58/09/186750/

Collected: November 15, 2026 | Automated Research System (AI)

#10 Pt/Fe-NC Catalyst: Durable Ammonia Cracking for Hydrogen Production

Published November 12, 2026 BIOENGINEER Singapore



OVERVIEW

Researchers at the National University of Singapore have developed a Pt/Fe-NC composite catalyst and regeneration protocol that enables over 2,000 hours of continuous hydrogen production from ammonia. By suppressing platinum oxidation and nitrogen poisoning, this strategy addresses critical durability gaps in electrochemical ammonia cracking.

IN DEPTH

Key Findings

The research team, led by Professor CHEN Wei, has demonstrated an electrochemical catalyst-regeneration strategy that sustains hydrogen production for more than 2,000 hours of continuous operation at a lower electrical current density. In laboratory trials conducted at 80 degrees Celsius, the system also maintained stable operation for 500 hours under a substantially higher current density. Bench tests revealed that the synthesized Pt/Fe-NC catalyst exhibits more than ten times the ammonia oxidation activity of standard commercial platinum-on-carbon catalysts under identical parameters.

Technical Details

The Pt/Fe-NC catalyst integrates metallic platinum nanoparticles onto a nitrogen-doped carbon support featuring atomically dispersed iron coordination sites. The material employs a synergistic two-part mechanism to prevent degradation:

- **Oxidation Suppression:** Direct electron transfer from the iron-nitrogen-doped carbon support into the platinum nanoparticles suppresses platinum oxidation and accelerates the rate-determining dehydrogenation step.
- **Poisoning Mitigation:** Atomically dispersed Fe-N4 coordination centers promote the dissociation of ambient water molecules. This facilitates the hydrogenation of nitrogen residues bound to the platinum surface, converting them into reactive intermediates and clearing active catalytic sites.

To further extend operational life, the researchers implemented a dedicated cyclic regeneration protocol executed during operation.

Background & Context

Ammonia serves as a carbon-free medium for storing and transporting hydrogen. While electrochemical ammonia cracking offers an energy-efficient method to produce hydrogen locally, standard platinum catalysts typically suffer from two degradation pathways: progressive electrochemical oxidation of the metallic platinum surfaces and nitrogen poisoning, where intermediate nitrogen species obstruct active sites.

Significance & Outlook

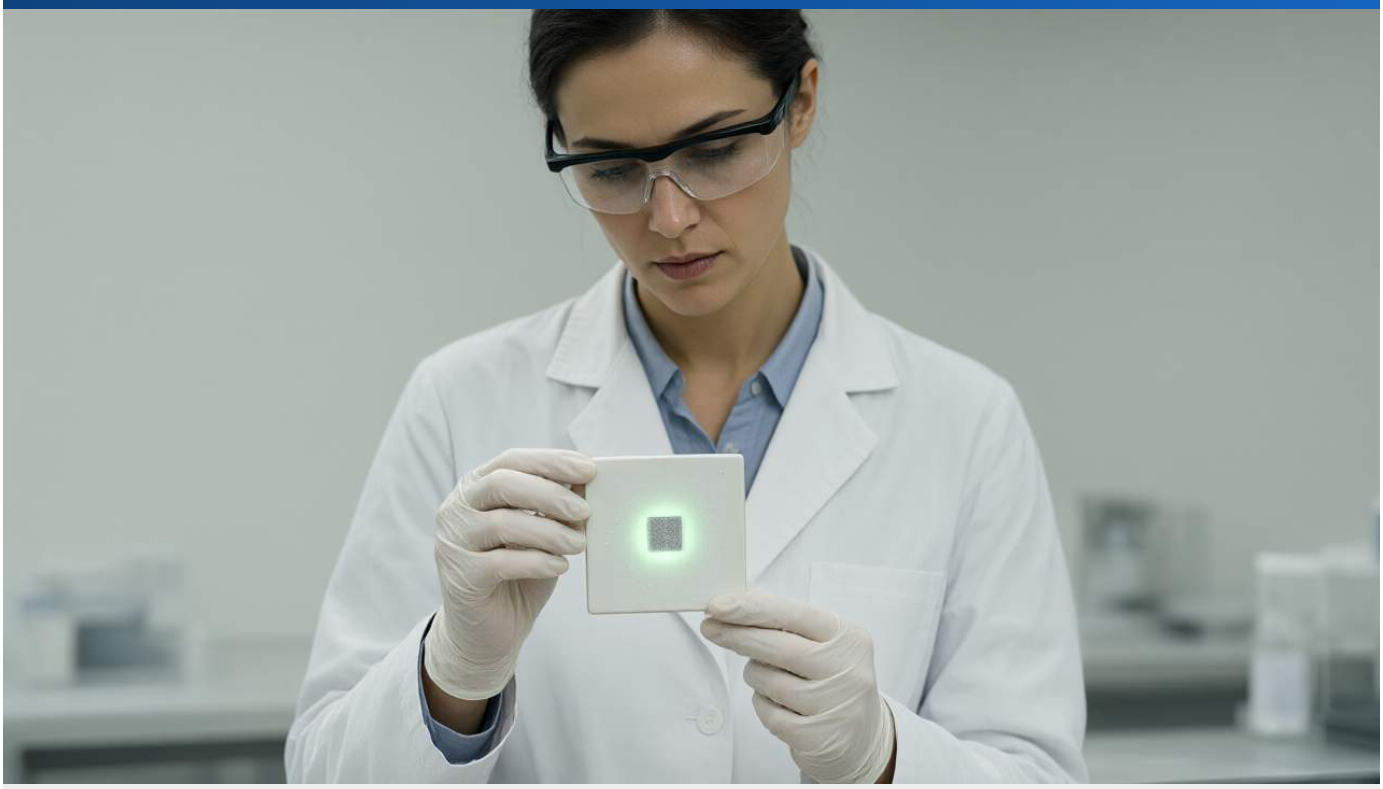
This study, published in *Nature Synthesis*, establishes a viable framework for durable hydrogen production. Professor CHEN noted that these design principles may be applicable to other applications, such as direct ammonia fuel cells. While the researchers emphasized that further study is required to evaluate the technology at industrial scales, the Pt/Fe-NC catalyst significantly improves both oxidation rates and the complementary hydrogen-evolution reaction.

Source: https://bioengineer.org/novel-catalyst-regeneration-strategy-sustains-durable-hydrogen-production-from-ammonia-cracking/

Collected: November 15, 2026 | Automated Research System (AI)

#11 Palladium Hydrogen Sensors: Grain-Boundary Engineering for 2026

Published November 10, 2026 Tohoku University Japan



OVERVIEW

An international research team has developed a catalytic hydrogen sensor using palladium nanoparticles with abundant grain boundaries to maintain reliability in hot, humid environments. The device detects concentrations as low as 100 ppm at 80 °C and 90% relative humidity without requiring an external heater. This advancement addresses a critical safety gap in hydrogen infrastructure by overcoming moisture interference.

IN DEPTH

Key Findings

The developed catalytic hydrogen sensor demonstrates stable performance across ambient temperatures from 22 to 80 °C and relative humidity levels from 0% to 90%. Notably, the sensor can detect hydrogen concentrations as low as 100 parts per million even under extreme conditions of 80 °C and 90% relative humidity. The device meets ISO 26142 humidity-response requirements, shows strong selectivity against 21 potentially interfering gases, and maintained stable operation over 125 days and 100 consecutive sensing cycles.

Technical Details

The sensor utilizes a network of palladium nanoparticles characterized by abundant grain boundaries—the interfaces where neighboring crystals meet. According to research combining molecular dynamics, first-principles calculations, and structural tracking, these grain boundaries facilitate the entry of hydrogen into palladium to rapidly form palladium hydride, even when the surface is wet. Because this hydride binds water weakly, catalytic sites remain accessible for the hydrogen-oxygen reaction that generates the sensing signal.

To enhance practical application, the team integrated a machine-learning model into a portable prototype. This system accounts for fluctuations in temperature and humidity, allowing the sensor to estimate hydrogen concentrations with deviations within 5% during randomized prototype tests.

Background & Context

Hydrogen is a key component for cleaner energy systems, but its volatility necessitates reliable leak detection. A primary technical hurdle has been humidity; in hot, moisture-rich environments, water molecules typically cover the active surfaces of detectors, preventing accurate responses. This research was a collaboration between Tohoku University's Advanced Institute for Materials Research (WPI-AIMR), the University of Utah, and Pacific Northwest National Laboratory.

Significance & Outlook

By eliminating the need for an external heater to remove moisture, this grain-boundary engineering strategy provides a more robust method for hydrogen monitoring. The findings, published in *Advanced Materials* on October 23, 2026, suggest a promising path for improving safety in industrial facilities and future hydrogen-energy infrastructure.

Source:
https://www.tohoku.ac.jp/en/press/crystal_boundaries_help_hydrogen_sensors_work_in_hot_humid_air.html

Collected: November 15, 2026 | Automated Research System (AI)

#12 Cobalt Hydroxide Catalyst: HAHS Mechanism for Ammonia Synthesis

Published November 11, 2026 Mirage News USA



OVERVIEW

Researchers have developed a cobalt hydroxide catalyst utilizing a "hydroxide-activated hydrogen spillover" (HAHS) mechanism to synthesize ammonia at ambient conditions. The process achieved a record-high yield rate of 40.67 μg h^{-1} cm^{-2} and a Faradaic efficiency of 24.9%. This advancement offers a sustainable, decarbonized alternative to the energy-intensive Haber-Bosch process.

IN DEPTH

Key Findings

A collaborative team from Qingdao Agricultural University, Politecnico di Milano, and Trinity College Dublin has achieved a record-high ammonia yield rate of 40.67 μg h^{-1} cm^{-2} with a Faradaic efficiency of 24.9%. Published in September 2026 in *eScience* (DOI: 10.1016/j.esci.2025.100513), the study introduces a cobalt hydroxide catalyst that enables efficient nitrogen reduction under ambient conditions.

Technical Details

The core innovation is the "hydroxide-activated hydrogen spillover" (HAHS) mechanism. By controlling synthesis temperature, the researchers induced targeted lattice distortion in the $Co(OH)_2$ catalyst, which elongated Co–O bonds and weakened adjacent O–H bonds. This structural tuning allows hydrogen atoms from surface hydroxyl groups to detach and participate directly in the nitrogen reduction reaction, creating surface hydrogen vacancies that are continuously replenished by the electrolyte.

- **Energy Barrier:** Density functional theory calculations show the initial N_2 activation on $Co(OH)_2$ is nearly barrierless (ΔG = 0.01 eV).
- **Stability:** The catalyst maintained structural integrity over 180 hours of continuous operation.
- **Validation:** The mechanism was verified using in situ electron spin resonance and isotope-labeled differential electrochemical mass spectrometry.

The HAHS mechanism bypasses one elementary step compared to conventional associative pathways, accelerating intermediate turnover and suppressing the competing hydrogen evolution reaction.

Background & Context

Global ammonia production currently relies on the Haber-Bosch process, which requires extreme heat and pressure, consuming 1–2% of global energy and emitting approximately 1.6 tons of CO_2 per ton of ammonia. While electrocatalytic nitrogen reduction is a greener alternative, the strong N≡N triple bond (941 kJ/mol) typically creates high activation barriers and poor selectivity.

Significance & Outlook

This lattice engineering approach enables a scalable, cost-effective strategy for distributed, on-site ammonia production. By aligning with renewable energy sources, the process allows for green ammonia synthesis from air, water, and electricity. Beyond fertilizer production, this technology supports the use of ammonia as a carbon-free hydrogen carrier for energy storage and transportation.

Source: https://www.miragenews.com/catalytic-shortcut-converts-nitrogen-to-ammonia-1774944/

Collected: November 15, 2026 | Automated Research System (AI)

#13 Nippon Steel: 100% Hydrogen Direct Reduction of Low-Grade Ore

Published November 10, 2026　MONOist（Yahoo!ニュース）　Japan



OVERVIEW

Nippon Steel has successfully produced over 1,000t of direct reduced iron (DRI) using 100% hydrogen and low-grade iron ore. The trial achieved over 300 hours of continuous operation, overcoming technical hurdles related to endothermic reactions and ore powdering. This progress supports the company's roadmap toward carbon-neutral steelmaking by 2040.

IN DEPTH

Key Findings

Nippon Steel has demonstrated the feasibility of producing direct reduced iron (DRI) using 100% hydrogen as the reducing agent and low-grade iron ore (blast furnace grade pellets) as the raw material. In trials conducted at the Hasaki Research and Development Center in Kamisu, Ibaraki Prefecture, the company achieved over 300 hours of continuous operation and a cumulative production volume exceeding 1,000t of reduced iron.

Technical Details

The trials utilized a shaft furnace that began operation in March 2026, featuring a height of approximately 60m and a production capacity of 1t/h. The company addressed two primary technical challenges:

- **Thermal Management:** Because reduction using only hydrogen is an endothermic reaction that lowers furnace temperature, Nippon Steel implemented advanced heat compensation technology to maintain stable operating temperatures.
- **Material Stability:** Low-grade iron ore is prone to powdering during reduction, which typically impairs gas permeability and reaction control. The company developed specific operating techniques to suppress this powdering.

Background and Context

Currently, global DRI production relies on commercial furnaces using natural gas, totaling approximately 100 million t annually. However, natural gas emissions necessitate a shift toward hydrogen. While hydrogen reduction is a viable alternative, it traditionally requires high-grade iron ore (direct reduction grade pellets) due to purity and stability requirements. Since high-grade ore supplies are limited, establishing technology that utilizes the more abundant low-grade ore is critical for long-term resource security.

Significance and Outlook

This achievement is part of the "Nippon Steel Carbon Neutral Vision 2050," supported by the Green Innovation Fund project from the New Energy and Industrial Technology Development Organization (NEDO). The company is simultaneously pursuing three pillars: hydrogen-based DRI production, hydrogen reduction in blast furnaces, and high-grade steel production via large electric furnaces. Following continued optimization of operating conditions, Nippon Steel will pursue scale-up development starting in fiscal 2027, targeting the establishment of commercial-scale technology by approximately 2040.

Source: https://news.yahoo.co.jp/articles/54de41e23cc74109e64e3bce1beb82f8a7d03de7

Collected: November 15, 2026 | Automated Research System (AI)