

energy

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Burgeoning hydrogen industry draws \$41 million in federal lobbying from fossil fuel companies
p.17

Renewable Energy

Renkubex AI-Driven
Solar Panel Innovation
Revolutionizing Renewable
Energy Solutions

p.07

Oil & Gas

Revolutionizing Oil
Refining AI-Driven Polymer
Membranes Set to Tra

p. 9

Nuclear

Safeguarding the Future
The Imperative of Nuclear
Waste Disposal

p. 11

POWER FOR RENT



PRAMAC produces, develops and distributes portable and industrial generators from 1 to 2600 KVA in standard and customized solutions, to follow the customers' needs from heavy duty activities to major power engineering projects.



Rental
Generators



Stationary
Generators



Lighting
Equipment



Portable
Generators



Material
Handling



Racing
Team

AI is Making Waves in the World of Energy



In the quest for a more sustainable future, the energy landscape is undergoing a profound transformation, with artificial intelligence (AI) emerging as a key catalyst for change. Across various fronts, AI is reshaping the industry, offering solutions for greater efficiency, sustainability, and reliability.

One of the primary areas where AI is making its mark is in enhancing the integration of renewable energy sources such as wind and solar power. The inherent variability of these sources poses challenges for energy providers seeking to balance supply and demand. However, AI algorithms are adept at analyzing vast amounts of data, including weather patterns and historical trends, to accurately forecast energy output. This capability allows for better management of renewable energy resources, enabling smoother integration into the grid.

Moreover, AI is proving invaluable in optimizing grid management. By leveraging data from sensors and smart meters, AI algorithms can monitor and control electricity flow across the network in real-time. This capability is particularly crucial at the distribution level, where maintaining grid stability and preventing outages are paramount. Through predictive analytics, AI enables proactive interventions, ensuring a reliable and resilient energy infrastructure.

Predictive maintenance is another area where AI is revolutionizing the energy sector. By analyzing sensor data and equipment performance, AI can identify potential issues before they escalate into costly failures. This proactive approach minimizes downtime, reduces maintenance costs, and enhances overall reliability, thus ensuring uninterrupted energy supply.

In addition to operational efficiencies, AI is also driving advancements in energy trading. By analyzing market dynamics and trends, AI algorithms can inform trading decisions, maximizing profitability and managing risks effectively. With its ability to process vast amounts of data and anticipate market fluctuations, AI brings a new level of agility and precision to energy trading activities.

In This Issue!

energyHQ's January-February 2024 issue covers the most recent developments and events pertaining to the energy industry, as well as including valuable insights, details and spec sheets / peer reviews related to latest technologies, innovations, products, services, and projects of relevance to the industry and its audience.

Article on page 11 talks about nuclear waste disposal

Article on page 17 focuses on the hydrogen industry

Article on page 21 sheds the light on the evolution and future of battery charging

Additional content is also available covering the latest activities of manufacturers, importers, and exporters – worldwide!

We hope you benefit from this issue's content and find it useful & actionable for your business. For any comments, suggestions, or feedback please don't hesitate to contact me.

Best wishes,
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Issue Contents

Introduction

- 01 Opening Letter
- 02 Issue Contents
- 04 World Energy Digest



Renewable Energy

Solar PV Technology Advancements

- 07 Renkuba's AI-Driven Solar Panel Innovation Revolutionizing Renewable Energy Solutions

Oil & Gas

Technological Advancements in Refining Oil & gas

- 09 Revolutionizing Oil Refining: AI-Driven Polymer Membranes Set to Transform the Industry



Nuclear

Nuclear Safety and Waste Management

- 11 Safeguarding the Future The Imperative of Nuclear Waste Disposal

Sustainability & Decarbonization

Industrial Decarbonization Solutions

- 13 Germany and UNIDO Forge Global Initiatives for Climate-Neutral Heavy Industries



Hydrogen

Green Hydrogen Production Technologies

- 15 Advancements in Green Hydrogen Production Innovations Driving Sustainability

Issue Contents

Cover Story

Green Hydrogen Industry

- 17 **Burgeoning hydrogen industry draws \$41 million in federal lobbying from fossil fuel companies**



Energy Storage & Grids

Battery Technologies and Advancements

- 21 **The Evolution and Future of Battery Charging Technology A Deep Dive into the Power of Electrification**
- 22 **Unveiling the Power of Lithium Batteries A Silent Revolution**

Country Reports

KSA, Australia, India

- 24 **Saudi Arabia launches 4 projects to generate 7,200 MW using carbon-capture tech**
- 25 **'Highly Attractive' Revenues Forecast In Australia's New Very Fast Ancillary Services Opportunity**
- 26 **India's Renewable Energy Sector is Booming**



Industry News

Corporate Happenings

- 28 **FTC Launches Investigation into ExxonMobil's Acquisition of Pioneer Amid Antitrust Concerns**
- 29 **CycleØ Group Expands Biomethane Reach with Acquisition of Biogasclean**
- 30 **Plenitude Expands U.S. Footprint with Acquisition of Solar Portfolio from EDP Renewables**

Services

- 32 **Buyer's Guide**
- 33 **Coming Events**

Info

- 34 **General Info**
- 36 **Closing Letter**

World Energy Digest



IRELAND

Leading Ireland's Renewable Energy Revolution with Statkraft

Statkraft has announced its ambitious commitment to deploy 3 GW of renewable energy projects in Ireland by 2030, with a significant focus on the 500 MW North Irish Sea Array (NISA) offshore wind project. This initiative is pivotal in Ireland's quest to generate 80% of its electricity from renewable sources by the end of the decade. Statkraft's plan involves a multifaceted approach, incorporating completed or under-construction projects, participation in government schemes like the Renewable Electricity Supply Scheme (RESS), and Corporate Power Purchase Agreements (CPPA). The company is also dedicated to advancing wind, solar, and grid services projects, with a strategic emphasis on sustainable growth.

Kevin O'Donovan, Managing Director of Statkraft Ireland, stresses the company's steadfast commitment to supporting the Irish government's renewable energy objectives. This announcement precedes O'Donovan's keynote address at the Wind Energy Ireland conference, where he will underscore Statkraft's integral role in Ireland's transition to clean energy.

Moreover, Statkraft's recent disclosure of plans to develop Ireland's first four-hour grid-scale battery energy storage system, alongside the Cushaling Wind Farm, exemplifies its proactive approach to innovation and sustainability in the energy sector.

EGYPT

Minister Shaker and NDB Discuss Future Ventures

Mohamed Shaker, Egypt's Minister of Electricity and Renewable Energy, met with Vladimir Kazbekov, Deputy Head of the New Development Bank of BRICS, to discuss enhancing cooperation between Egypt's electricity sector and the bank. Shaker commended the sector's reforms and emphasized a strategy to increase renewable energy's share in the energy mix to over 42% by 2030, aiming to reduce reliance on fossil fuels for economic efficiency and environmental protection.

Shaker highlighted measures to encourage private sector involvement in renewable energy projects, including negotiations for competitive solar and wind energy projects. He also noted Egypt's interest in green hydrogen, with agreements signed during COP27 for pilot projects and future exploration of export opportunities. Additionally, plans for electricity interconnection projects with neighboring countries and exporting to Europe were discussed, positioning Egypt as a regional energy hub.

Kazbekov praised Egypt's achievements and expressed the bank's desire to increase investment in the country, emphasizing its role as a gateway to Africa.

GERMANY

Bundesnetzagentur's Regulatory Reforms for Energy Transition Success

Germany's energy regulator, the Bundesnetzagentur, is spearheading transformative changes to the country's grid system to address the mounting challenges posed by the energy transition. Proposed adjustments, outlined in a key elements paper, target the electricity and gas network sectors' cost and incentive regulation.

A pivotal aspect of the plan is shortening the regulatory period from five to three years to accommodate the rapidly changing costs faced by network operators. To streamline the process further, the Bundesnetzagentur suggests replacing individual capital cost determinations for new projects with a weighted average cost of capital formula.

These reforms are crucial as Germany races towards its 2045 net-zero target. With renewable energy generation surging by 12% annually in 2023 and increased electrification straining the grid, bureaucratic hurdles threaten decarbonization goals.

Klaus Müller, President of the Bundesnetzagentur, emphasizes the need to support network operators amidst the energy transition. He highlights the necessity to simplify tariff regulation, likening its complexity to tax law. With the energy transition accelerating, Müller stresses the urgency of expanding and digitalizing electricity grids, alongside the conversion of parts of the gas network for hydrogen use. These measures aim to facilitate rapid adaptation to changing costs while ensuring cost efficiency.

GREECE

Greece breaks records in renewables, energy efficiency in 2023

In 2023, Greece witnessed a remarkable surge in renewable electricity production, reaching a historic high of 57%, including large hydropower plants, marking a pivotal moment in the nation's energy landscape. This achievement, facilitated by investments in green energy and grid infrastructure development, underscores a decisive shift towards sustainability. Wind power capacity, exceeding 5 GW, played a significant role in this milestone, with 153 new turbines installed throughout the year.

Notably, natural gas consumption declined by 10.1%, reflecting a decreasing reliance on fossil fuels. A striking indication of this transition was the absence of coal power for nearly a month, signaling substantial progress in reducing carbon emissions and fostering a cleaner energy mix. The Hellenic Wind Energy Association reported the total wind power capacity in Greece surpassing 5 GW for the first time, with ongoing projects poised to further bolster this figure. Leading energy companies such as Terna Energy, Motor Oil's subsidiary MORE, and Iberdrola Rokas contributed significantly to this growth, highlighting the private sector's commitment to renewable energy expansion. With renewables surpassing fossil fuels in electricity production and emissions plummeting by 23%, Greece is at the forefront of the global energy transition, setting an inspiring example for sustainable development.

BRAZIL

Challenges and Opportunities in Brazil's Energy Sector Amid Policy Shifts

In 2024, Brazil anticipates continued growth in oil and natural gas production, driven by ongoing offshore field development. However, the energy sector faces renewed uncertainties under President Luiz Inacio Lula da Silva's government, which is shifting towards a state-led model. The installation of four new floating production units, coupled with Petrobras' plans to launch the FPSO Sepetiba in December, underscores the nation's production momentum.

Nonetheless, Petrobras's investment plan indicates a softer growth trajectory for 2024. Regulatory and market uncertainties loom large, exacerbated by policy shifts in fuel pricing and refinery ownership. The government's emphasis on Petrobras's dominant role in the energy sector raises questions about market competition and stability.

Moreover, challenges persist in formulating regulatory frameworks for emerging sectors like offshore wind and green hydrogen. Despite efforts to bolster local content requirements, concerns remain about investment attractiveness, potentially hampering future exploration ventures. These uncertainties cast a shadow over Brazil's energy landscape, prompting stakeholders to navigate a complex terrain characterized by evolving policies and market dynamics.

ANGOLA

Renewable Energy Could Usher a Revolution in Angola

Angola stands on the cusp of a transformative energy revolution, harnessing its abundant renewable resources to propel its development forward. Bolstered by the Ministry of Energy and Water's findings showcasing the nation's vast potential in solar, wind, and hydropower generation, Angola's government has crafted the ambitious Angola 2025 Plan. This strategic blueprint charts a course towards a future where renewable energy plays a pivotal role, with electrification rates soaring to 60%, 70% of which will be sourced from renewables. Central to this plan are three monumental solar projects, including a landmark collaboration between the United Arab Emirates and Angola, poised to erect a 150 MW solar farm. The implications of this paradigm shift are profound and multifaceted. Firstly, it promises to bridge the gaping chasm of energy access, with projects such as the Masdar solar plant poised to illuminate the lives of 90,000 previously underserved homes. Secondly, this transition heralds a burgeoning job market, fueled by the demand for skilled labor in the burgeoning renewable energy sector. The infusion of capital and expertise from foreign investors further catalyzes this growth, fostering a climate ripe with opportunity for employment and economic advancement. Notably, the ripple effects of this economic resurgence are felt most keenly in rural enclaves like the Masdar solar plant, where poverty rates are highest. Here, the influx of jobs not only uplifts individual households but also injects vitality into local communities, precipitating a virtuous cycle of prosperity. In embracing renewable energy, Angola not only charts a sustainable path towards energy security but also ignites a beacon of hope for a brighter, more equitable future for all its citizens.

Renewable Energy

07 Solar PV Technology Advancements



Renkube's AI-Driven Solar Panel Innovation Revolutionizing Renewable Energy Solutions

In the realm of renewable energy solutions, Renkube emerges as a beacon of innovation with its groundbreaking AI-powered software tailored for solar panel optimization. Renkube's strategic focus on enhancing solar panel efficiency through geometrically patterned glass marks a significant leap forward in the renewable energy sector, promising an impressive boost in energy production.

Founded in 2017 by visionary Indian engineers Balaji Lakshmikanth Bangolae, Lakshmi Santhanam, and Deepika Gopal, formerly of Cisco, Renkube has spearheaded a movement towards more sustainable energy practices. Their pioneering technology utilizes a patented prismatic glass design with intricate geometric patterns, a feat that magnifies panel efficiency by a remarkable 20 to 40%. This remarkable achievement is particularly noteworthy against the backdrop of Spain's recent strides in renewable energy, with solar energy accounting for 14% of the national energy mix, a testament to the growing significance of solar power globally.

Renkube's innovation comes at a pivotal moment, addressing the challenge of efficiency loss in solar panels due to the sun's daily movement. Unlike conventional solar farms reliant on mechanical trackers, Renkube's solution offers a streamlined alternative ideal for residential and commercial installations. The company's movement-free optical tracking system (MFOT) ensures maximum light absorption, enhancing energy output without the need for costly mechanical adjustments.

One of Renkube's most compelling advantages lies in its maintenance-free design, with the exception of routine cleaning. Leveraging their AI software, Renkube customizes panel designs to suit specific environmental conditions, ensuring optimal performance while safeguarding solar cells from potential damage.

Collaborating closely with solar panel manufacturers, Renkube is poised to commercialize its high-efficiency panels. Although priced slightly higher than conventional options, the rapid return on investment stemming from enhanced energy output makes Renkube's panels an economically viable choice for businesses seeking sustainable energy solutions.

Beyond commercial applications, Renkube's innovation extends to agrovoltaic projects, where solar panels are integrated with agricultural practices to minimize crop shading. Collaborating with esteemed partners such as PJTSAU and AgHub Foundation, Renkube's panels hold the promise of not only bolstering energy generation but also potentially enhancing agricultural yields, aligning seamlessly with sustainable development goals.

Renkube's advancements in solar panel technology herald a new era of renewable energy solutions, bridging the gap between technology and nature while championing sustainability in every aspect of energy production. As businesses increasingly prioritize environmentally responsible practices, Renkube's transformative innovation stands poised to shape the future of renewable energy.

<https://contxto.com/>

Oil & Gas

09 Technological Advancements in Refining Oil & gas



Revolutionizing Oil Refining: AI-Driven Polymer Membranes Set to Transform the Industry

In a groundbreaking leap forward, researchers at Georgia Tech have unveiled a transformative digital system designed to revolutionize membrane separation in oil refining processes. This high-performance digital system is poised to redefine how polymers are tailored for membrane applications, promising unparalleled efficiency and sustainability in the refining industry.

At the heart of this innovation lies a sophisticated computational platform meticulously crafted to expedite the design and optimization of polymer structures tailored explicitly for oil refining membrane applications. The system operates through a meticulously orchestrated process, beginning with comprehensive inputs encompassing desired separation properties and the chemical composition of the polymer.

Utilizing advanced algorithms, the platform conducts intricate simulations at the molecular level, offering profound insights into polymer behavior and interaction dynamics. These simulations not only facilitate a comprehensive analysis of membrane performance but also pave the way for the generation of optimized polymer structures meticulously tailored to meet specific separation requirements.

The benefits of this groundbreaking technology are manifold. By streamlining the design process and minimizing the need for extensive experimentation, researchers can significantly accelerate the development of novel membrane materials. Moreover, the targeted design capabilities of the system empower researchers to craft polymers precisely attuned to the unique demands of oil refining, thereby maximizing efficiency while minimizing resource consumption.

However, the journey toward practical implementation is still ongoing, with further research necessary to ensure seamless integration into real-world refinery settings. Excitingly, the potential for integration with machine learning algorithms holds promise for even greater automation and expedited material discovery.

Central to this transformative endeavor is the development of a new class of polymer membranes dubbed “DUCKY polymers.” These innovative membranes, crafted using spirocyclic monomers, boast a unique structural composition characterized by numerous 90-degree turns. This distinctive



architecture imbues the membranes with unparalleled selectivity and permeability, enabling precise molecule filtration with remarkable efficiency.

The significance of this breakthrough extends far beyond mere efficiency gains. With oil distillation accounting for a substantial portion of global energy consumption, the advent of membrane separation technology heralds a paradigm shift in refining methodologies. By circumventing traditional distillation processes, these membranes offer a sustainable alternative that minimizes energy, water, and carbon footprints.

Furthermore, the integration of artificial intelligence tools adds an additional layer of innovation, facilitating predictive modeling of membrane performance and expediting materials design. Through a data-driven approach, researchers can navigate vast chemical spaces with unparalleled efficiency, ushering in an era of unprecedented precision in membrane engineering.

In essence, the confluence of advanced computational methodologies, innovative polymer design, and artificial intelligence heralds a new frontier in oil refining. As researchers continue to push the boundaries of innovation, the promise of sustainable, efficient, and cost-effective membrane separation technologies looms ever closer, poised to reshape the landscape of the refining industry for generations to come.

By **Joshua Stewart**
[Phys.org](https://www.phys.org)

Nuclear

11 Nuclear Safety and Waste Management



Safeguarding the Future The Imperative of Nuclear Waste Disposal

In the realm of nuclear energy, one of the most pressing challenges lies in the responsible management and disposal of nuclear waste. This article delves into the complexities surrounding nuclear waste disposal, examining the challenges, current solutions, advanced technologies, additional considerations, future developments, ethical considerations, and overall importance of this critical issue.

Challenges: Nuclear waste comes in various forms, each presenting unique challenges for disposal. From spent fuel to high, intermediate, and low-level waste, the differing radioactivity levels and decay times necessitate tailored disposal strategies. Moreover, the longevity of some radioactive isotopes, with half-lives spanning thousands of years, underscores the need for long-term isolation from the environment.

Current Solutions: Deep geological repositories (DGRs) stand out as the safest method for high-level waste and spent fuel disposal. These engineered facilities, located deep underground in stable geological formations, offer secure containment over extended periods. Near-surface facilities, on the other hand, cater to low-level waste and select intermediate-level waste with shorter half-lives, providing effective disposal at shallower depths.

Advanced Technologies: Transmutation and recycling emerge as promising technologies for mitigating nuclear waste's long-term impact. Transmutation involves converting long-lived radioactive isotopes into shorter-lived or stable ones, while recycling entails reprocessing spent nuclear fuel to extract reusable materials, reducing overall waste volume.

Additional Considerations: Addressing public perception and fostering trust in authorities remain paramount. Long-term management necessitates continuous monitoring and robust governance structures to ensure the safety and integrity of disposal sites. Regulatory frameworks must be established to uphold safety standards over extended timeframes, while international collaboration facilitates the sharing of knowledge, technology, and best practices.

Future Developments: Engineered barrier systems (EBS), comprising natural geological formations and human-made barriers, hold



promise in preventing radioactive material release. Research into new waste forms, such as glass and ceramic materials, aims to enhance radionuclide immobilization. Borehole disposal in stable geological formations presents a potential alternative to traditional DGRs.

Ethical Considerations: Ensuring that the burden of managing long-lived waste does not unfairly burden future generations is imperative. Public engagement and transparent decision-making are essential for garnering societal acceptance and fostering a sense of responsibility among stakeholders.

Overall Importance: Safe nuclear waste disposal is indispensable for a responsible nuclear fuel cycle. An integrated approach, combining advanced technology, scientific understanding, stringent regulations, and public engagement, is crucial for developing sustainable and safe disposal methods. Collaboration on globally harmonized standards and the sharing of best practices are essential for effective and safe waste disposal.

Sustainability & Decarbonization

13 Industrial Decarbonization Solutions



Germany and UNIDO Forge Global Initiatives for Climate-Neutral Heavy Industries



In a groundbreaking move announced at the United Nations Climate Change Conference (COP28), the Government of the Federal Republic of Germany, represented by the Federal Ministry for Economic Affairs and Climate Action (BMWK), and the United Nations Industrial Development Organization (UNIDO) have unveiled two pioneering initiatives. These initiatives, backed by an initial funding of EUR 23 million from Germany's International Climate Initiative (IKI), signify a significant step towards enabling developing countries to transition their heavy industries to climate neutrality by 2050.

Under the banner of the newly inaugurated Climate Club, championed by German Chancellor Olaf Scholz, these initiatives target the vital decarbonization of heavy-emitting industries such as steel, cement, and concrete. The urgency is clear, as global emissions from these sectors must be reduced by 90% by 2050 to align with climate objectives.

At the heart of this endeavor is the Global Matchmaking Platform, poised to become the Climate Club's pivotal hub for collaboration

with developing nations. Facilitated by UNIDO, this platform will streamline the alignment, coordination, and matchmaking of international technical and financial assistance, alongside private finance instruments, tailored to the unique needs of emerging markets and developing economies.

Complementing this platform is the Partnership for Net Zero Industry, designed to extend technical assistance to developing countries in their journey towards decarbonizing heavy-emitting sectors like steel and cement. Initially focusing on five countries, the partnership aims to expand its support network by engaging additional donors and philanthropies.

Gerd Müller, UNIDO Director General, underscored the imperative for industrialized nations to aid in the decarbonization of heavy industries worldwide. He emphasized the disproportionate impact of climate change on developing nations and commended Germany for spearheading these initiatives. Müller called for a collective effort from both public and private donors to support the transition to climate-friendly industrial development.

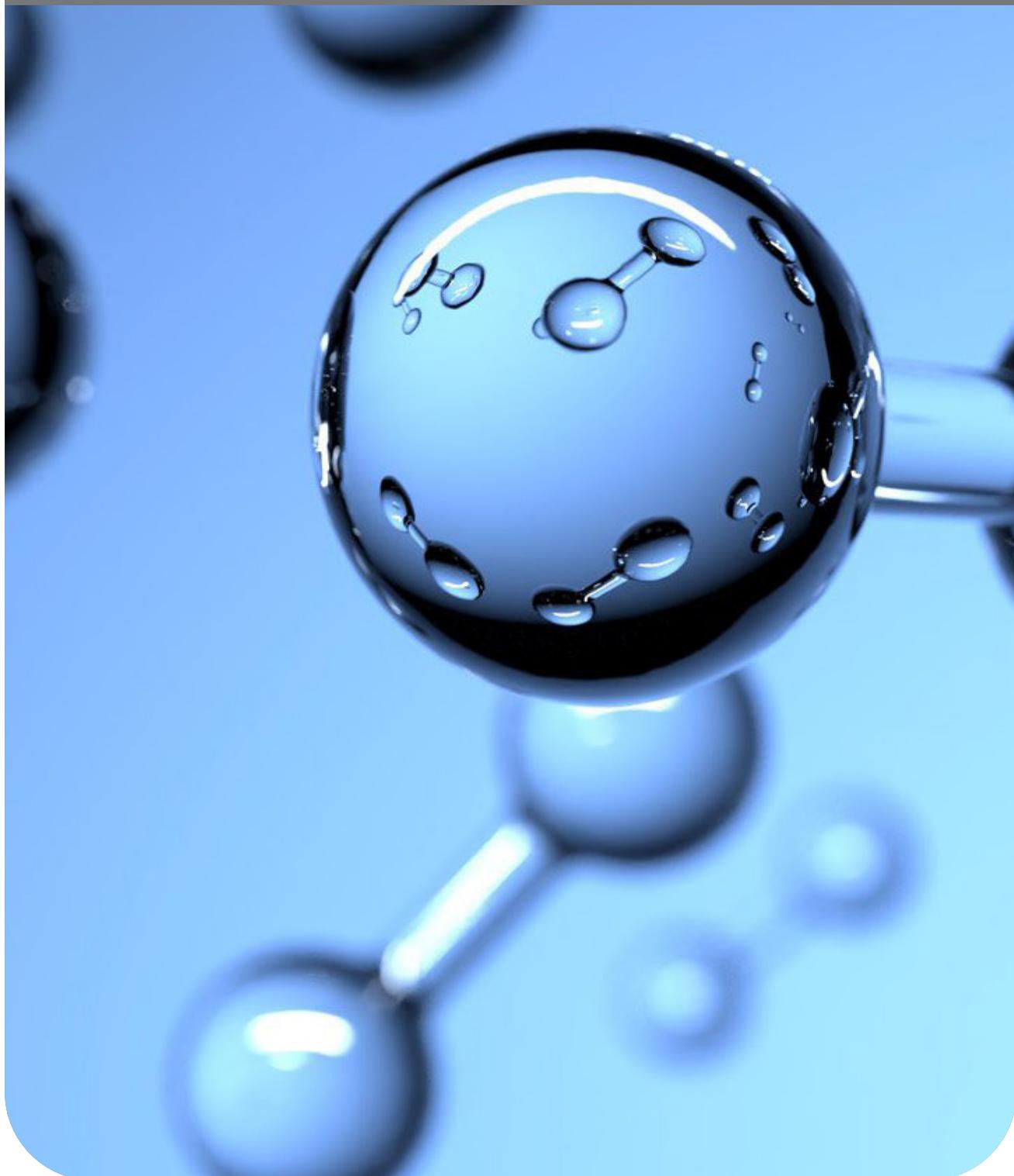
Robert Habeck, Vice Chancellor and Federal Minister for Economic Affairs and Climate Action, emphasized the necessity of developing competitive solutions for net-zero industrial processes. He highlighted the commitment of German companies to decarbonize production processes and affirmed Germany's readiness to collaborate with UNIDO, particularly in supporting developing and emerging countries. Habeck expressed gratitude for UNIDO's partnership, recognizing their expertise and global network as invaluable assets in this transformative journey.

The initiatives unveiled by Germany and UNIDO mark a significant milestone in the global pursuit of climate neutrality. By fostering collaboration, facilitating access to resources, and providing technical assistance, these initiatives promise to accelerate the transition towards sustainable, climate-resilient industries worldwide.

<https://www.bmwk.de/>

Hydrogen

15 Green Hydrogen Production Technologies



Advancements in Green Hydrogen Production Innovations Driving Sustainability

The global energy landscape is rapidly evolving, spurred by the urgent need to combat climate change and reduce reliance on fossil fuels. Hydrogen emerges as a promising alternative fuel in this transition due to its ability to produce water upon combustion, making it environmentally friendly. However, conventional hydrogen production methods, often reliant on fossil fuels like natural gas or coal, negate its environmental benefits by emitting substantial carbon dioxide.

Fortunately, a clean alternative exists green hydrogen, produced through electrolysis powered by renewable energy sources such as wind and solar. Its potential across various sectors—transportation, industry, and heating—offers significant prospects for decarbonization.

One major challenge facing green hydrogen is achieving cost-effective scalability. Recognizing its long-term benefits, various initiatives are underway to address the financial hurdles associated with production.

A partnership between the Ulsan National Institute of Science and Technology (UNIST) and the Korea Advanced Institute of Science and Technology (KAIST) has yielded a breakthrough in green hydrogen generation. They've developed a bifunctional water electrolysis catalyst, replacing expensive precious metal catalysts with a more economical combination of ruthenium, silicon, and tungsten. This innovation ensures high efficiency and stability, enabling the production of high-purity green hydrogen at a remarkable level while substantially reducing greenhouse gas emissions.

Before this discovery, electrolysis was achieved through the use of catalysts like noble metals like platinum and iridium. While effective, these metals are expensive, which makes them inefficient in large-scale processes. On the other hand, catalysts like metal oxides offer a more balanced approach, as they are much cheaper than these noble metals.

Another innovation comes from the Technion



Israel Institute of Technology, where researchers have refined the electrolysis process with an approach called decoupled water electrolysis. By utilizing sodium bromide aqueous electrolyte, they've overcome operational challenges associated with solid electrodes, achieving simultaneous production of hydrogen and oxygen in separate cells. This continuous process boosts efficiency and scalability, showcasing promising feasibility for high-rate hydrogen production.

In parallel, a team from UNIST has tackled challenges in solar-powered hydrogen production by addressing limitations of perovskite solar cells (PSCs). Their breakthrough involves enlarging photoelectrodes by 10,000 times, significantly enhancing efficiency, durability, and scalability. Using formamide instead of methylammonium as the cation in perovskite, coupled with a nickel foil securing the contact surface, ensures stability even when wet. This innovation has achieved a solar hydrogen conversion efficiency of over 10 percent, marking a significant milestone for large area photoelectrodes and commercial viability.

These advancements underscore the growing momentum toward sustainable hydrogen production, driven by innovative technologies that promise to revolutionize the global energy landscape. As research and development efforts continue, green hydrogen emerges as a key player in realizing a cleaner, more sustainable future.

Cover Story

17 Green Hydrogen Industry



Burgeoning Hydrogen Industry Draws \$41 Million In Federal Lobbying From Fossil Fuel Companies



In the race to combat climate change, hydrogen has emerged as a promising clean energy solution. However, behind the scenes of this technological advancement lies a contentious battle between the fossil fuel industry and climate advocates over the direction of hydrogen development.

Under the Biden administration, there has been a notable surge in lobbying efforts surrounding hydrogen technology. While this may initially appear as a positive sign of interest and investment, a closer examination reveals a tug-of-war between competing interests.

At the forefront of this struggle is the fossil fuel industry, which has heavily invested in promoting what's known as «blue hydrogen.» Blue hydrogen is produced from natural gas, with the promise of carbon capture technology mitigating emissions. Fossil fuel companies argue that blue hydrogen offers a quicker and cheaper solution for near-term emission reduction, thus warranting its prioritization.

However, climate advocates raise significant concerns about this approach. They emphasize the importance of prioritizing «green hydrogen,» which is produced from water using renewable energy sources such as wind or solar power. Advocates argue that while blue hydrogen may seem like a cleaner alternative, its reliance on fossil fuels prolongs our dependence on non-renewable resources and perpetuates carbon emissions.

One of the key points of contention revolves around the reliability and environmental impact of current carbon capture technology used in blue hydrogen production. Critics

argue that these methods may not be as effective or as clean as advertised, potentially undermining the climate benefits of hydrogen technology.

Furthermore, there are fears that prioritizing blue hydrogen could divert attention and resources away from developing green hydrogen and accelerating the transition to renewable energy sources. Climate advocates stress the importance of building sufficient renewable energy infrastructure to support widespread green hydrogen production, rather than doubling down on fossil fuel-based solutions.

The current situation reflects this clash of interests. The Biden administration's allocation of billions towards hydrogen development has sparked the planning of several regional hydrogen hubs, some of which rely on natural gas. Debate surrounds the regulations for clean hydrogen tax credits, with stakeholders pushing for policies that align with their respective interests.

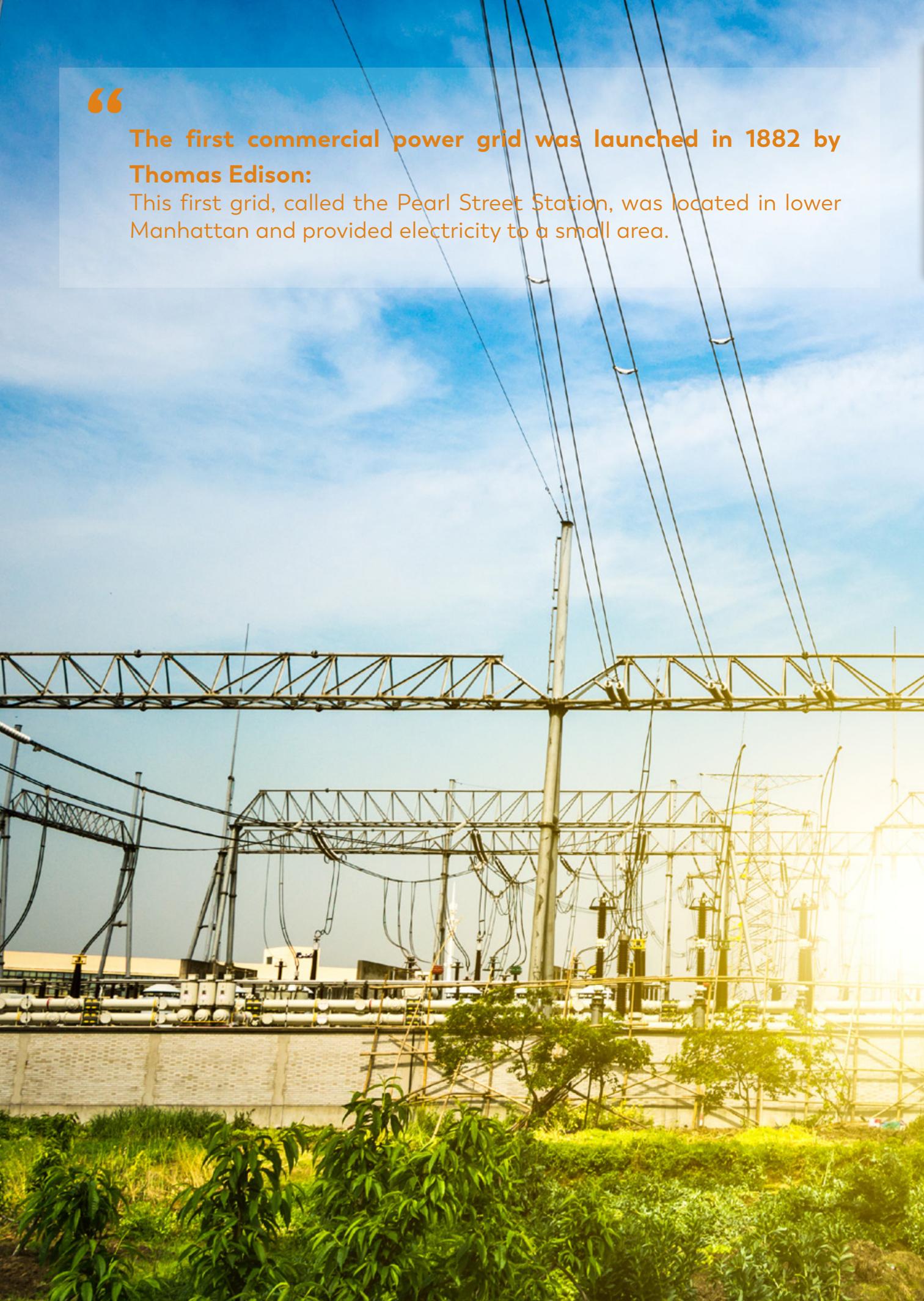
In essence, there is a race to develop clean hydrogen technology to achieve climate goals. However, the influence of the fossil fuel industry threatens to steer this progress in a direction that may not align with the urgent need for decarbonization. As stakeholders continue to vie for dominance in shaping hydrogen policy, the outcome will determine whether hydrogen emerges as a true catalyst for climate action or becomes another battleground in the fight against entrenched fossil fuel interests.

By Jimmy Cloutier
energynews.us

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The first commercial power grid was launched in 1882 by Thomas Edison:

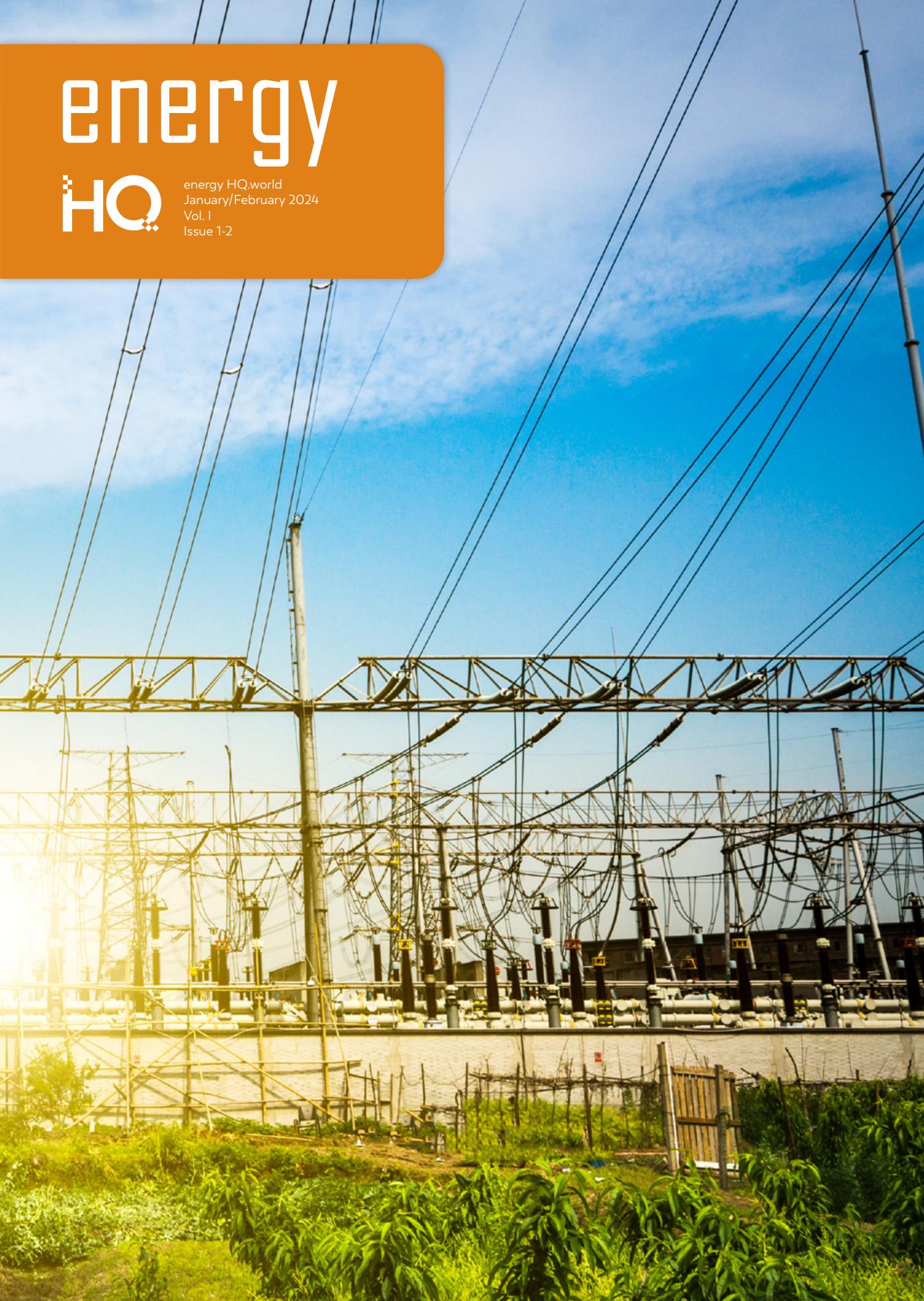
This first grid, called the Pearl Street Station, was located in lower Manhattan and provided electricity to a small area.



energy

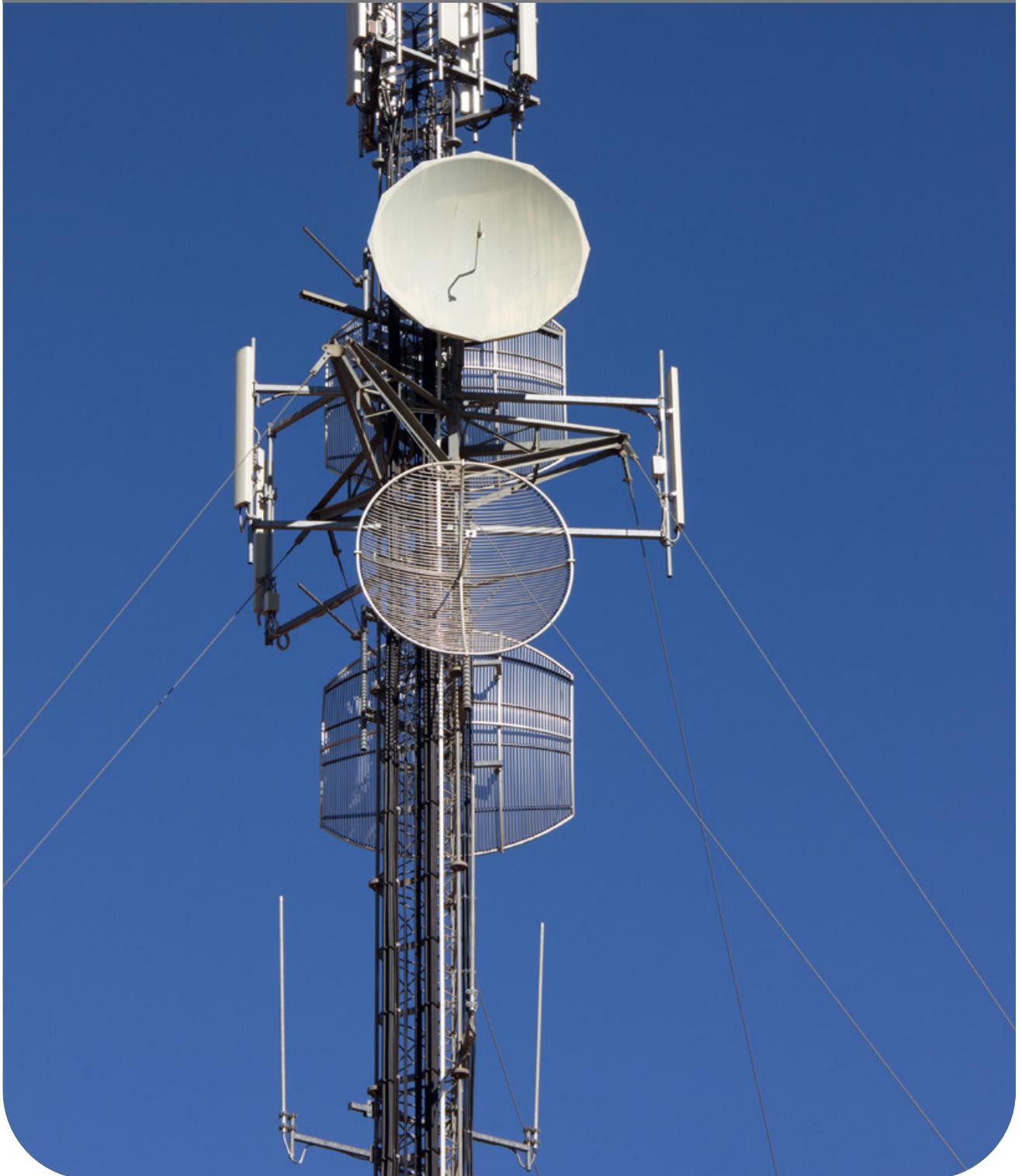
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Energy Storage & Grids

21 Battery Technologies and Advancements



The Evolution and Future of Battery Charging Technology A Deep Dive into the Power of Electrification

In the journey towards an all-electric future, few technologies hold as much transformative potential as battery charging systems. Today, these systems are evolving from basic designs to cutting-edge marvels, with advancements driving significant shifts across industries.

Chris Botting, Manager of Research Engineering at Delta-Q Technologies, offers an insightful exploration of electric evolution in his webinar titled «The Evolution and Future of Battery Charging Technology.» He delves into the seismic shifts, challenges, and innovative solutions that are reshaping industries, highlighting Delta-Q's pivotal role in shaping the future of electrification.

Historical Trends: The Golf Cart Case Study

From the 1960s to the 1990s, battery charging technology saw incremental improvements, with chargers featuring heavy steel and copper constructions. While functional, these chargers suffered from efficiency issues and were unsuitable for onboard and mobility applications.

Delta-Q Technologies Early Charging Solutions

Delta-Q Technologies emerged as a leader in high-frequency, switch-mode power supplies. In the early 2000s, they introduced their QuiQ Series chargers, boasting significant improvements in efficiency. These chargers featured a 1000x frequency boost, 30x smaller and lighter transformers, and a 50% reduction in efficiency losses.

In 2013, Delta-Q Technologies set a new industry standard with the IC650 charger, designed for high-reliability industrial applications. This charger featured a die-cast aluminum enclosure, ensuring durability in harsh environments.

The Lithium-Ion Revolution

The 2020s marked a pivotal transition with the adoption of lithium-ion batteries in electric vehicles (EVs). Lithium-ion batteries offered superior energy density, cost dynamics, and charging capabilities compared to lead-acid batteries. The energy density of lithium-ion batteries surged by 500% compared to lead-acid batteries, while charging times decreased significantly.



Modern Charging Challenges

As battery technology advances, new challenges emerge, including limitations in AC supply, DC current, and onboard charger dimensions. These challenges require innovative solutions to maximize efficiency and performance.

Future Charging Trends

Delta-Q Technologies is leveraging various strategies to address these challenges and pave the way for the next wave of charging solutions:

- Soft switching to reduce energy losses
- Active AC-DC rectification to minimize rectification losses
- Integration of GaN and SiC for faster switching and lower losses
- Advanced cooling mechanisms to maintain component temperatures
- Denser construction principles to optimize space
- System integration to simplify design and reduce complexity

Charging Forward: Key Insights

Battery charging technology has evolved significantly, with a focus on enhancing charger capabilities to meet the demands of lithium-ion batteries. Addressing current challenges requires a multifaceted approach, rooted in innovation and system integration.

As technology continues to advance, these strategies will shape the future of battery charging, ensuring chargers are potent, efficient, and aligned with the needs of electrification.

Unveiling the Power of Lithium Batteries: A Silent Revolution



In the realm of modern technological progress, there exists a silent yet profound revolution reshaping energy consumption and innovation: the lithium battery revolution. These unassuming powerhouses have become indispensable in powering some of today's most ambitious projects, from marine navigation to robotics and off-grid power systems, quietly ushering in a new era of energy storage and efficiency.

While lithium batteries aren't a recent innovation, their widespread integration into various facets of technology and daily life is nothing short of remarkable. With their exceptional energy density, lightweight construction, and impressive longevity, lithium batteries have become the driving force behind the energy transition. They have transcended their role as mere components to become the beating heart of modern devices, offering stable and enduring power supplies that push the boundaries of portable energy storage.

The transition to lithium batteries was propelled by their unique characteristics that set them apart from conventional battery technologies. These batteries offer unparalleled advantages, including high voltage capacity, minimal self-discharge rates, and remarkable efficiency. Their ability to retain charge for extended periods, coupled with their compact size and lightweight design, makes them ideal for applications where space and weight are critical factors, such as in drones and smartphones.

Lithium batteries boast significantly higher energy density compared to their predecessors, packing more power into a smaller and

lighter package. This efficiency makes them indispensable for users who require mobility without compromise, whether in drones covering vast distances or smartphones delivering long-lasting performance without sacrificing portability.

Robust and reliable, lithium batteries offer a longer lifespan and can undergo numerous charge cycles while maintaining peak performance. This durability reduces the need for frequent replacements, resulting in cost savings and less environmental waste. Moreover, lithium batteries operate efficiently across a wide range of temperatures, making them suitable for use in diverse climates and conditions.

As technology advances, lithium batteries will continue to shape the future, enabling innovations and lifestyles previously deemed unattainable. With every advancement, the horizons of possibility expand, driving us towards a more sustainable and efficient world.

The lithium battery revolution isn't just a technological trend—it's a transformative force shaping how we power our lives. By enabling greater efficiency, reliability, and sustainability, lithium batteries are paving the way for a future that values innovation and environmental stewardship. As we embrace the possibilities of this remarkable technology, one thing is clear: the future is bright, and it is powered by lithium batteries.

Bioennopower.com

Country Reports

24 KSA

25 Australia

26 India



Saudi Arabia Launches 4 Projects To Generate 7,200 Mw Using Carbon-Capture Tech



The Saudi Power Procurement Co. has invited bids for four independent power plant projects with a combined capacity of 7,200 megawatts.

The company has specified that two of the projects, namely Rumah1 and Rumah2, are slated for the central region, while the remaining two, Nairyah1 and Nairyah2, will be situated in the eastern region of the Kingdom, the Saudi Press Agency reported.

All these projects will have a capacity of 1,800 MW each and use natural gas combined-cycle technology, along with carbon capture.

SPPC emphasized that these projects are in alignment with the objectives of the Saudi Green Initiative. The aim is to achieve net-zero greenhouse gas emissions by 2060, adopting a circular carbon economy approach, with the timeline subject to the maturity and availability of technology.

The project also aligns with the Kingdom's efforts to realize the goals of Vision 2030, focusing on enhancing energy generation efficiency and reducing costs by diversifying power production.

Saudi Arabia aims for a balanced 50-50 split in electricity production, seeking to leverage both renewable sources and gas while concurrently reducing reliance on liquid fuel in the power sector.

Through initiatives like the SGI and the broader Middle East Green Initiative, the Kingdom is at the forefront of spearheading the energy transition journey in the region.

In an October 2023 interview with Arab News, Muneef Al-Muneef, general director of renewable energy policies at the Saudi Ministry of Energy, stated that the Kingdom is actively advancing with 22.8 gigawatts of renewable energy projects.

He noted that Saudi Arabia is open to advanced technologies like hydro-storage and geothermal in the energy sector as the world sails toward a sustainable future.

“We don't really tie ourselves to one. We're consistently monitoring the potential of these technologies and their level of applicability in the Kingdom and whether these technologies can help us achieve our targets,” said Al-Muneef at that time.

In October, Saudi utility firm ACWA Power received a commercial operation certificate for the second phase of the 1,500 MW Sudair solar power project. This accomplishment reflects the Kingdom's ongoing commitment to its renewable journey.

In December 2023, addressing the National Industrial Development and Logistics Program's annual ceremony, Saudi Arabia's Minister of Industry and Mineral Resources Bandar Alkhorayef affirmed that the Kingdom is on course to access green energy at competitive prices.

‘Highly Attractive’ Revenues Forecast In Australia’s New Very Fast Ancillary Services Opportunity



Australia’s National Electricity Market (NEM) is witnessing a surge in interest in battery energy storage systems (BESS) due to the lucrative opportunities in the Very Fast Frequency Control Ancillary Services (VF FCAS) markets. Recent analysis by Cornwall Insight Australia reveals that BESS assets can expect significantly higher revenues compared to other storage options.

VF FCAS, introduced by the Australian Energy Market Operator (AEMO) on October 9, 2023, offers two new markets: Raise-1 (R1) and Lower-1 (L1), requiring response times within one second. This initiative aims to ensure grid stability in the face of potential contingencies.

While traditionally provided by fossil fuel generators, battery storage is now recognized as the optimal low-emission technology for such services, thanks to its millisecond response times. With coal generation set to phase out by 2038, batteries are poised to play a crucial role in maintaining grid stability.

According to Cornwall Insight Australia’s projections, participants in R1 could earn around AU\$9.64/MW/hr on average, while L1 participants could earn AU\$10.95/MW/hr by 2026. This represents a significant increase compared to other

markets, where revenues are currently under a dollar per megawatt.

Despite the initial high value, Cornwall Insight Australia predicts that VF FCAS revenues will stabilize at around AU\$5.5/MW/hr over a 20-year period. While energy arbitrage is becoming more prevalent, FCAS remains the primary revenue source for large-scale battery storage, with VF FCAS expected to be the most lucrative.

The consultancy anticipates over a gigawatt of batteries participating in the VF FCAS market by 2026, driven by the attractive revenue potential. This surge in involvement is expected to attract both new players and existing battery assets to actively contribute to the evolving energy markets.

In conclusion, the VF FCAS markets offer substantial revenue opportunities for battery storage assets in Australia’s NEM. As coal generation phases out, batteries are stepping in to provide vital grid stability services, further solidifying their role in the country’s energy landscape.

By **Andy Colthrope**
energy-storage.com

India's Green Energy Sector: Turning Over a New Leaf

India's green energy sector has seen a remarkable surge in investment, marking a significant departure from its historical reliance on coal. This shift comes amidst a warming political climate and mounting pressure to tackle climate change. With enormous renewable energy potential and ambitious decarbonization goals, India's role in global climate efforts has become increasingly pivotal.

Despite its status as the third-largest emitter of carbon dioxide globally, India's progress on climate goals has been uneven. The country missed its 2022 target for renewable energy installation, with only a handful of states meeting their objectives. However, recent policy measures and incentives have injected newfound optimism into the sector.

One such initiative is the Production-Linked Incentive (PLI) scheme, aimed at boosting investment and instilling confidence in investors. Vibhuti Garg, an energy economist, notes that the favorable investment climate has led to a significant uptick in market activity. If these policies pay off, India's clean energy sector could experience exponential growth, positioning the country as a global leader in renewable energy.

India's potential for green energy production is staggering, ranking among the top seven countries in the world according to a report by the Global Energy Monitor. Plans for large-scale solar and wind farms signal a promising shift away from fossil fuels. If India achieves its goal of 76 gigawatts of solar and wind power by 2025, the nation could save billions annually while reducing coal consumption significantly.

However, the transition away from coal won't be easy. Fossil fuels currently dominate India's energy mix, with coal accounting for a substantial 70%. Despite the scale of the challenge, there's a silver lining: massive investments are pouring into the country's energy sector.

At recent summits such as the Vibrant Gujarat Global Summit and the Tamil Nadu Global Investors Summit, pledges



for green energy projects reached unprecedented levels. Asia's wealthiest man, Gautam Adani, pledged \$24 billion for green energy projects in Gujarat alone, signaling a strong private sector commitment to sustainability. Additionally, the Indian government announced a substantial investment of \$116 billion in the sector over the next few years.

While the road ahead is fraught with challenges, India's burgeoning green energy sector offers hope for a sustainable future. With continued investment, supportive policies, and a growing appetite for renewable energy, India has the potential to not only meet but exceed its climate commitments. As the world looks to curb carbon emissions and combat climate change, India's role in the green energy revolution has never been more critical.

While the transition away from coal presents formidable obstacles, India's newfound momentum in the green energy sector signals a turning point in the country's commitment to sustainability. By harnessing its vast renewable energy potential and capitalizing on substantial investments, India stands poised to emerge as a global leader in the fight against climate change.

By [Haley Zaremba](#)
oilprice.com

Industry News

28 Corporate Happenings



FTC Launches Investigation into Exxon Mobil's Acquisition of Pioneer Amid Antitrust Concerns

ExxonMobil

The Federal Trade Commission (FTC) has launched an investigation into ExxonMobil Corp's acquisition of Pioneer Natural Resources Co., raising concerns over potential antitrust violations in the oil and gas industry. Despite Pioneer expressing confidence that the \$64.5 billion deal will proceed as planned, regulatory scrutiny looms large.

The investigation comes on the heels of a letter from a group of senators to the FTC, urging a probe into the mergers between ExxonMobil and Pioneer, as well as Chevron Corp. and Hess Corp. These senators cautioned that such consolidations could harm competition, elevate oil and gas prices, and diminish domestic output. The FTC's request for additional information underscores the gravity of these concerns.

In response, Pioneer, based in Irving, Texas, confirmed the start of the investigation, emphasizing its commitment to cooperate with regulatory authorities. Although the investigation could prolong the process, Pioneer remains optimistic about completing the transaction by mid-2024, pending regulatory and shareholder approvals.

ExxonMobil's proposed acquisition of Pioneer aims to bolster its reserves in the US Permian basin, consolidating Pioneer's extensive acreage with ExxonMobil's holdings. This merger would create a dominant player in the industry with a substantial undeveloped inventory position. However, the FTC's intervention

reflects broader apprehensions about the concentration of power within the oil and gas sector.

The concerns raised by lawmakers echo historical precedents of consolidation in the petroleum industry. They point to past mergers, such as Exxon's acquisition of Mobil and Chevron's merger with Texaco, which led to decreased competition and potential anticompetitive behavior. Citing studies and reports, the senators argue that such consolidation can result in higher consumer prices and reduced production.

ExxonMobil's CEO, Darren Woods, remains bullish on the acquisition, emphasizing its potential benefits in terms of resource recovery, efficiency, and environmental performance. However, Democratic Senator Amy Klobuchar of Minnesota underscores the importance of thorough antitrust scrutiny, particularly when such a significant acquisition could potentially lead to market dominance.

Klobuchar's sentiments reflect broader concerns about protecting competition and consumers' interests. As the largest oil and gas company in the United States seeks to expand its footprint in a crucial oil-producing region, ensuring fair competition and preventing monopolistic practices become paramount.

By Jov Onsat
[Rigzone.com](https://www.rigzone.com)

CycleØ Group Expands Biomethane Reach with Acquisition of Biogasclean



In a move set to redefine the landscape of renewable natural gas (RNG) production, CycleØ Group Limited (CycleØ) has announced its acquisition of Biogasclean, a pioneering Danish firm specializing in biological methanation and desulphurisation systems. Backed by Ara Partners, a leading private equity and infrastructure investment firm focused on industrial decarbonisation, this strategic maneuver marks a significant milestone for CycleØ and the biomethane sector at large.

The 150 million DKK (£17 m) transaction solidifies CycleØ's position as a prominent, pan-European biomethane platform. With a core focus on developing, building, owning, and operating RNG projects across Europe and Latin America, CycleØ now stands poised to usher in a new era of efficiency and sustainability within the green gas industry.

At the heart of this acquisition lies the promise of more efficient and fully circular green gas solutions. By harnessing Biogasclean's expertise in capturing biogenic CO₂ and converting it into e-methane—a sustainable, synthetic gas derived from green hydrogen—CycleØ aims to revolutionize the biomethane landscape. This innovative approach not only enhances the efficiency of biomethane sites but also facilitates a significant reduction in greenhouse gas emissions, while simultaneously boosting green gas production by approximately 70%.

Laurence Molke, CEO of CycleØ, expressed enthusiasm regarding the acquisition, stating, "We are delighted to welcome Biogasclean's talented and experienced team to our Group. We look forward to deploying

their patented biocatalyst technologies to produce more carbon-negative fuels for the hard-to-electrify energy, heat, transport, and industrial sectors."

Biogasclean's global footprint and trailblazing technologies position it as a key player in the biological desulphurisation field. With offices spanning five continents and over 350 systems operational or underway in 40 countries, the company's impact on the global biomethane sector is undeniable. Notably, Biogasclean's biological methanation technology has been validated at scale as an integral component of the world's largest plant for commercial e-methane production via electrolysis and biological methanation. Located in Sønderborg on Als in Denmark, these facilities inject 33 GWh of sustainable e-methane into the gas grid annually.

Niels Holst Jensen, CEO of Biogasclean, emphasized the critical role of this partnership in addressing climate change, stating, "The combination of CycleØ and Biogasclean is uniquely positioned to reduce methane emissions and capture CO₂ from the atmosphere, at scale."

Chris Picotte, Partner at Ara Partners, highlighted the significance of the deal in advancing Europe's decarbonisation agenda, stating, "CycleØ's acquisition of Biogasclean completes the group's biomethane carbon loop, and helps Europe to meet its aggressive 2030 decarbonisation targets."

[Azocleantech.com](https://www.azocleantech.com)

Plenitude Expands U.S. Footprint with Acquisition of Solar Portfolio from EDP Renewables



Plenitude, the sustainable energy giant, has taken another significant stride towards its ambitious renewable energy goals with the acquisition of an 80% equity stake in a trio of operational photovoltaic plants in the United States. In a strategic move, Plenitude, operating through its U.S. subsidiary Eni New Energy US Inc., has partnered with global energy leader EDP Renováveis, S.A. (EDPR) to secure this substantial investment.

The solar parks—Cattlemen in Texas, Timber Road, and Blue Harvest in Ohio—represent a combined installed capacity of 340 MWac (478 MWdc). With Plenitude's share amounting to 272 MWac (382 MWdc), the agreement solidifies its foothold in key U.S. energy markets. Spanning over 1,500 hectares of land, these facilities are poised to generate more than 800 GWh of renewable energy annually, contributing significantly to the green energy landscape.

Stefano Goberti, CEO of Plenitude, expressed his enthusiasm, highlighting the strategic implications of the acquisition. «This transaction represents Plenitude's entry into the PJM energy market in Ohio with already operational, medium to large size projects and consolidates the company's presence in Texas,» he stated. Goberti underscored the importance of the agreement in propelling Plenitude towards its global goal of reaching 7 GW of installed capacity by 2026.

Miguel Stilwell d'Andrade, CEO of EDP Renewables, echoed similar sentiments, emphasizing the value of the partnership. «We are pleased to reach this agreement, which is a clear sign of the quality of our assets and the added value that EDP's expertise

brings,» said d'Andrade. With this transaction, EDP Renewables has executed more than 25% of its target announced for its asset rotation program for 2023-26, reaffirming its commitment to sustainable growth and renewable energy investment.

Plenitude, a Benefit Corp controlled by Eni, has positioned itself as a pioneer in sustainable energy solutions. Integrating 100% renewable energy production, energy sales and services, and an extensive network of electric vehicle charging points, the company is dedicated to surpassing 15 GW of installed capacity by 2030. Moreover, it aims to achieve zero net Scope 1, 2, and 3 CO₂ emissions by 2040, aligning its operations with global environmental objectives.

EDP Renewables, a global leader in renewable energy development, operates in 28 regions worldwide, focusing on onshore wind, solar, offshore wind, storage, and green hydrogen technologies. The partnership between Plenitude and EDP Renewables signifies a collaborative effort towards accelerating the transition to a sustainable energy future.

With the acquisition of these solar assets, Plenitude continues to bolster its presence in the U.S. renewable energy market while advancing its overarching mission of driving environmental sustainability and reducing carbon emissions. As the world increasingly turns towards renewable energy sources, collaborations like this are pivotal in shaping a greener and more sustainable future for generations to come.

[Solarquarter.com](https://www.solarquarter.com)

Services

32 *Buyer's Guide*

33 *Coming Events*





Coming Events

E-World

Essen, Germany
20 - 22 Feb 2024

<https://www.e-world-essen.com/en/>

E-world energy & water is the place where the European energy industry comes together. Serving as an information platform for the energy sector, E-world is gathering international decision makers in Essen each year.

Energy Tech Summit 2024

Bilboa, Spain
10 - 11 April 2024

<https://energytechsummit.com/>

This 2-day event will focus squarely on decarbonisation. It will feature industry experts, investors, innovators, and government leaders who will rub minds to proffer new and sustainable ways to achieve global decarbonisation.

Neckar-ALB Regenerative 2024

volksbankmesse Balingen, Balingen, Germany
09 - 10 Mar 2024

<https://www.neckar-alb-regenerativ.de/>

On the expert stage, experts from the energy, construction and mobility sectors will answer questions from the moderators and energy consultants from the Zollernalb Energy Agency. The experts will talk about current topics...

POWER TOOLEX 2024

Milan Mela, Kolkata, India
15 - 17 Mar 2024

<https://powertoolex.com/>

POWERTOOLEX is a pure B2B exhibition focusing on the fast-growing hand tools and power tools sector in India. The goal of the POWERTOOLEX is to bring buyers and sellers together in an interactive environment to conduct business...

Richmond Energy Business Forum Spring 2024

Rimini, Italy
06 - 08 March 2024

<https://www.richmonditalia.it/eventi/energy-business-forum/>

The Richmond Energy Business Forum is a three-day, two-faceted cocktail of rich energy-related activities. The first section is a day and a half packed with energy conferences, workshops, and business meetings aimed at discussing and understanding direct-impact global energy trends.

International Conference on Application of Renewable Energy and Environmental Sustainability (ICAREES-24)

Rome, Italy
09 Jan 2024

<https://researchsociety.co/event/>

ICAREES-24 catalyzes progress in renewable energy and environmental sustainability. Uniting global researchers, the event addresses challenges, fosters collaboration, and shapes policies for steadfast growth.

Future of Utilities: Energy Transition Summit 2024

Amsterdam, The Netherlands
20 - 21 March 2024

<https://futureofutilities.com/events/energy-transition-summit/>

The two-day summit will provide enough substrate for innovators, policymakers, and investors to address key factors that will help accelerate the global energy sector's transition to clean energy.

CERAWeek 2024

Barcelona, Spain
18 - 22 March 2024

<https://ceraweek.com/index.html>

The Executive Conference will focus on the quadrilemma of the energy sector concerning transitioning to clean energy. It will address the four wings of this quadrilemma namely markets, climates, technology, and geopolitics and how to satisfy all four.

General Queries & Contact Info

Launched in 2023, **energyHQ** has rapidly transformed from a B2B publication into a dynamic energy industry platform. Our comprehensive multimedia outlets—magazine, website, services, events, reports, newsletters, and online presence—cater to a global audience. Actively participating in key energy events worldwide, we offer partners unmatched exposure at exhibitions, tradeshow, and conferences. Join energyHQ as we illuminate the path forward in the evolving energy landscape!

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https://www.energyhq.world/energyHQ_Media%20Kit_2023.pdf

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What's Next for Offshore Wind



In the realm of renewable energy, offshore wind power stands as a beacon of hope for a cleaner, more sustainable future. However, recent months have brought forth challenges that have cast a shadow over its trajectory. Despite setbacks, the industry is resilient, with both obstacles and opportunities shaping its course in 2024.

The cancellation of Ørsted's Ocean Wind 1 and Ocean Wind 2 projects in New Jersey serves as a stark reminder of the turbulent waters offshore wind developers must navigate. Rising interest rates, inflation, and supply chain disruptions have inflated costs, rendering previously negotiated contracts untenable. This phenomenon isn't isolated to the US; global markets, including the UK and Taiwan, grapple with similar challenges.

While setbacks abound, they are not indicative of a failing industry but rather the pains of growth. The US, a relative newcomer to offshore wind, faces unique hurdles. Supply chain limitations, exemplified by the scarcity of specialized installation vessels, hamper progress. However, initiatives like Dominion Energy's investment in a US-built installation ship signal a commitment to overcoming such barriers.

Legislative support, such as tax credits, incentivizes domestic supply chain development, albeit with hurdles. Compliance with sourcing regulations necessitates a delicate balance between cost efficiency and regulatory adherence. Despite these challenges, progress is palpable; the commissioning of the nation's second large-scale offshore wind farm underscores the industry's momentum.

Technological innovation offers a beacon of hope amidst economic uncertainty. Wind turbine design evolves rapidly, with larger, more efficient models becoming the norm. Vestas' 15 MW turbine epitomizes this trend, promising increased energy capture at reduced costs. Similarly, floating offshore wind turbines hold promise, particularly in deep-water regions where traditional installations are impractical.

However, technological advancement must align with economic viability. While standardization may streamline floating turbine deployment, economic feasibility remains paramount. Floating projects are projected to constitute a minority share of installations, highlighting the importance of striking a balance between innovation and pragmatism.

As the winds of change sweep through the renewable energy landscape, offshore wind power emerges as a cornerstone of the transition to a sustainable future. While challenges persist, the industry's resilience and adaptability offer cause for optimism. 2024 heralds both tribulations and triumphs, with offshore wind power poised to weather the storm and emerge stronger on the horizon.

While offshore wind power faces significant challenges in 2024, including supply chain disruptions, economic uncertainty, and technological complexities, its potential for growth and contribution to a cleaner energy future remain undeniable. With continued innovation, investment, and strategic navigation of obstacles, offshore wind power stands poised to overcome current challenges and thrive in the years to come.

By Casey Crownhart
[technologyreview.com](https://www.technologyreview.com)



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