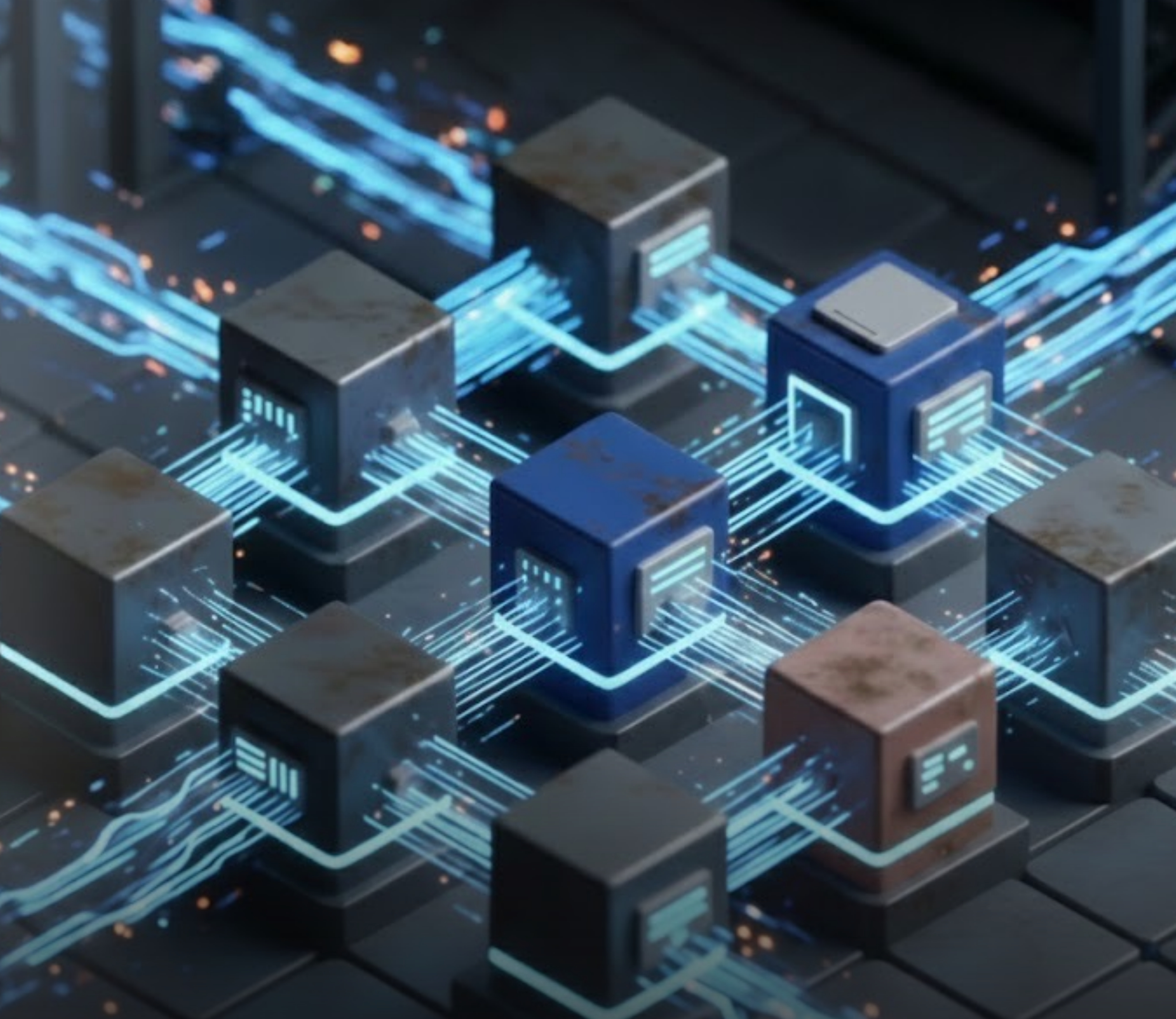
Jan. 2026



GREEN MOVING GRID

Hybridizing the Existing Grid with Orchestrated Hydrogen Nodes for a Sustainable, Resilient Energy Future in the AI Era

Dr. Kuan HUANG, Michael SHEREN, Dr. Bo BAI

EXECUTIVE SUMMARY

Electricity systems are entering a period of structural stress due to the rapid expansion of artificial intelligence (AI) and economy-wide electrification. Power demand is rising faster than grid infrastructure can be expanded, creating a widening gap between energy needs and deliverable capacity. This constraint is not only confined to AI. It increasingly affects electricity cost, reliability, and sustainability across manufacturing, transport, and essential services.

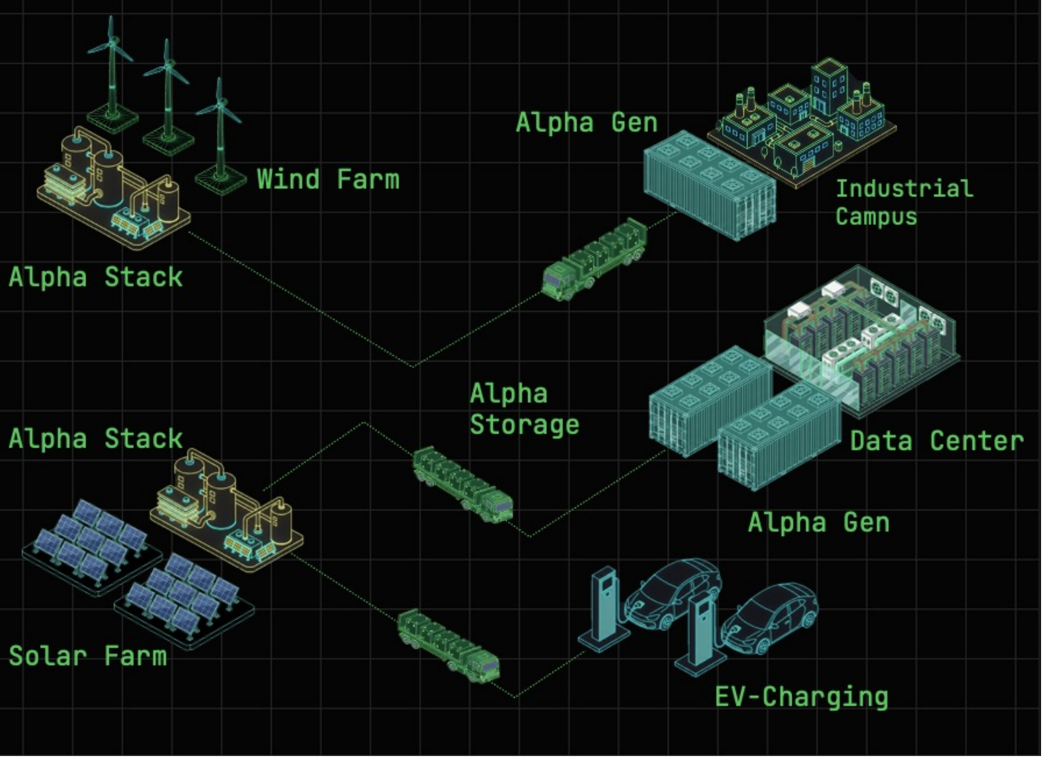
The power grid provides an indispensable solution, but its expansion is outpaced by the power demand. Transmission upgrades and permitting require years, while new digital and industrial capacity is deployed in months. Renewable energy coupled with battery storage is critical for decarbonization, yet constrained in duration, location, and deployment speed. As competition for marginal electricity supply intensifies and fossil fuel availability becomes more volatile, power systems face an impossible triangle of security, stability, and sustainability.

The Green Moving Grid (GMG) is an augmentative power architecture that hybridizes the conventional grid with a distributed grid, enhancing operational efficiency, scalability, and deployability. It consists of an orchestrated, mobile ensemble of standardized power nodes delivering **resilient, agile, and affordable power capacity**. Unlike fixed infrastructure, these nodes use **green hydrogen as the energy carrier**. They store, transport, and redeploy clean electricity across locations and time, functioning as a **“moving grid”.**

This GMG enables **rapid deployment** where grid capacity is unavailable or delayed. It allows **power to be reallocated from regions of abundant renewable energy to demand-constrained nodes** and **energy to be shifted from surplus periods to extended scarcity events.** It strengthens the **security and resilience of supply**, and delivers **firm, low-carbon power** where conventional grid expansion, batteries, or fossil backup cannot respond with sufficient speed, duration, or sustainability.

With advancements in underlying materials technologies and the establishment of the AI-enabled orchestration layer, Greenlyzer, a Singapore-headquartered, deep-tech company and a subsidiary of the Alpha Ladder Group, is leading the operational realization of this paradigm through its **Alpha Energy System**. The system integrates modular **Alpha Nodes, the physical nodes for** green hydrogen production, storage, and on-demand power generation, with the **Alpha Orchestrator**, a network layer that optimizes dispatch, logistics, and system performance across the distributed deployments. Together, they form a scalable, deployable implementation of the GMG, translating a system-level necessity into real infrastructure for sustainable and resilient energy in the Era of AI.

The Green Moving Grid (GMG) exemplified by Greenlyzer’s Alpha Energy System



GMG is an augmentative power layer that uses a molecular carrier (green hydrogen) to move clean energy as kinetic infrastructure, hybridizing into conventional grid operations to address rapid power-demand growth in the Era of AI

1. POWER DEMANDS AND LIMITATIONS IN THE AI ERA

Electricity systems are entering a period of structural stress as rapid growth in data centers and economy-wide electrification outpaces the capacity of traditional grid infrastructure. Large digital and industrial loads are emerging quickly and concentrating geographically, while transmission reinforcement, substation upgrades, and permitting processes typically require 7–15 years to complete[1]. As a result, grid expansion is increasingly misaligned with both the pace and the location of demand growth across advanced economies.

Fuel Dependence and Energy Security Risk

The delivery constraints of the grid are further reinforced by energy-security risks arising from dependence on centralized fuel supply chains. In the UK and much of Europe, gas-fired generation remains a key source of balancing and peak power, exposing electricity systems to fuel price volatility and geopolitical disruption. Singapore represents a more concentrated case, with approximately 90–95% of electricity generation reliant on imported natural gas, combined with tight land and grid constraints.[2] Together, these systems illustrate how centralized fuel dependence amplifies systemic vulnerability under conditions of rising demand.

Marginal Energy Costs Pressure the Entire Economy

As demand growth exceeds deliverable grid capacity, electricity markets increasingly clear under scarcity conditions. During such periods, marginal prices are set by high-value digital and industrial loads, driving wholesale prices sharply higher—reaching €500/MWhin recent European stress events[3]. Because wholesale markets clear at a uniform price, these spikes propagate system-wide, transmitting cost pressure to manufacturing, logistics, and households, even though incremental demand originates from a narrow set of users.

Sustainability Gap Limited by the Flexibility Challenge

Current pathways toward net-zero rely predominantly on large-scale deployment of wind and solar. While these sources are essential, their inherent variability and location dependence impose growing demands on grid flexibility. In systems where transmission capacity, stability margins, or balancing resources are insufficient, renewable output is increasingly curtailed. The UK illustrates this constraint: in FY2024/25, wind curtailment reached approximately 13% of potential output (National Energy System Operator, 2025). Avoiding such losses requires large scale battery storage whose duration is designed to multiple hours, and the cost increases exponentially when longer-duration storage is needed. As a result, despite rapid renewable build-out, the volume of affordable, firm green power deliverable under real grid conditions remains limited, revealing a widening gap between net-zero targets and practical system capability.

Taken together, these dynamics elevate electricity infrastructure from a planning challenge to a strategic systems constraint. In the AI era, power systems must simultaneously deliver security of supply, system stability, and environmental sustainability under conditions of rapid demand growth, slow infrastructure delivery, and fuel-supply risk. Grid-centric architectures alone are increasingly strained in meeting all three objectives, defining the structural problem addressed in the sections that follow.

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[1] European Parliamentary Research Service (EPRS), *Electricity grids: planning, investment and challenges to 2040*, Brussels, 2023.

[2] Energy Market Authority (EMA), *Singapore Energy Statistics 2024*, Singapore, 2024.

[3] International Monetary Fund (IMF*), Shocked: Electricity Price Volatility Spillovers in Europe*, Jan 10, 2025

2. THE GREEN MOVING GRID (GMG)

The Green Moving Grid (GMG) is an augmentative power architecture designed to address the structural limits of grid-centric electricity systems under conditions of rapid demand growth and slow infrastructure expansion. It introduces a mobile, dispatchable, low-carbon power layer that operates alongside the traditional grid, extending system capability where fixed infrastructure is constrained, delayed, or economically prohibitive. The GMG is not a replacement for the existing grid, but hybridizes with it to reinforce system adequacy, resilience, and responsiveness under emerging load and deployment pressures.

At a system level, the GMG is organized as a coordinated network of renewable electricity capture through electrochemical conversion, long-duration energy storage and physical redeployment, and on-demand power reconversion at the point of use. This structure enables firm power to be delivered with-out additional loading on congested transmission and distribution networks while remaining compatible with existing market and regulatory frameworks.

Hydrogen serves as the enabling energy carrier in the GMG. As a high energy density carrier, it functions to decouple energy production from the location and timing of electricity consumption. When produced from renewable electricity, hydrogen uniquely combines long-duration storage, transportability, and near-zero carbon intensity, allowing clean energy to be shifted beyond the spatial and temporal limits of the grid.

With this essential energy carrier in place, the GMG provides a deployable source of firm, low-carbon power under grid-constrained conditions. It converts surplus renewable electricity into reliable capacity that can be delivered where grid expansion is unavailable or delayed, reducing reliance on fossil-based firm generation and mitigating exposure to scarcity-driven price volatility.

In practical terms, the GMG delivers flexibility and value across three dimensions.

- **Spatially**, energy is produced in regions with abundant renewable resources and lower network congestion, then delivered to demand-constrained nodes.
- **Temporally**, energy is stored during surplus or low-price periods and reconverted into electricity during scarcity events that increasingly span many hours or days.
- **Operationally**, power capacity can be deployed, relocated, and reconfigured on timescales of weeks rather than years, aligning infrastructure response with real demand dynamics rather than long planning cycles.

In system terms, the GMG functions as a flexible capacity buffer for the AI era, reinforcing energy security, stabilizing system costs during scarcity, and advancing decarbonization without waiting for long-cycle grid expansion.

3. GREENLYZER'S IMPLEMENTATION

Recent technological advances have enabled the GMG from a conceptual architecture to a deployable system. Improvements in electrochemical materials, electrolyzer efficiency and durability, safe hydrogen storage, and fuel-cell power systems have reduced capital intensity and improved operational performance. In parallel, advances in AI-based forecasting, optimization, and orchestration enable distributed assets to operate as coordinated systems rather than isolated equipment.

Greenlyzer, an Alpha Ladder Group company, is spearheading the operational realization of the GMG through its Alpha Energy System, translating system-level architecture into deployable infrastructure.

Critically, Alpha Nodes embed breakthrough material innovations that raise efficiency, durability, and safety. Built on over two decades of electrochemical advances and a strengthened patent portfolio of more than 40 patents for electrolysis, energy storage and carbon abatement, the platform integrates STARION® AEM membranes and catalyst systems. It delivers >80% peak energy efficiency (HHV) and has achieved a record-breaking >15,000 hours of real-operation durability testing, among the longest reported in published literature[4].

Advances in metal hydride solid-state hydrogen storage enable hydrogen storage and delivery at near-ambient pressure and temperature, materially reducing the risks associated with high-pressure gaseous hydrogen systems. Further improvements in gravimetric hydrogen density are expected to lower transportation costs and reduce on-site space requirements. Overall, material-level innovation enables higher utilization, longer service intervals, and improved safety margins relative to conventional hydrogen and fuel-cell systems.

System-level coordination is provided by the Alpha Energy Orchestrator, an AI-enabled control plane that manages distributed Alpha Nodes as a coherent operational system. The Orchestrator integrates electricity price signals, grid congestion indicators, renewable availability, asset condition data, and logistical constraints to determine production, dispatch, and redeployment decisions in near real time. This transforms the system from static backup infrastructure into an actively managed capacity resource.

The Alpha Energy System emphasizes asset reuse, reliability, and regulatory alignment. Modular design improves utilization by allowing assets to be redeployed as conditions evolve, while zero-emission operation supports compliance with tightening environmental and permitting requirements. The system is designed to integrate with existing grid and market structures rather than bypass them, positioning it as a complementary capacity layer rather than an alternative to the grid.

4. APPLICATIONS AND SYSTEM-LEVEL IMPACT

AI Data Centers: Safeguarding the Intelligence with Fast-deployable and Low Carbon Power
AI data **centers** require not only continuous power supply, but firm backup with fast response, capable of sustaining operations for multiple days during grid outages, maintenance events, or extreme system stress. The GMG provides MW-scale, instantaneous power back-up with the duration from hours to days. It supplies economic, low-carbon power during demand surges, when marginal electricity prices peak and grid supply tightens. By displacing diesel generators in both emergency and scarcity-driven operation, the GMG enhances operational resilience while reducing exposure to price volatility and carbon constraints.

EV Charging : Supporting the EV growth without the grid or space constraints
The rapid growth of EV penetration has outpaced the ability of local distribution networks to support high-power charging, with many charging stalls constrained by feeder capacity limits and substation upgrade requirements. The GMG enables grid-independent EV charging hubs to be deployed in days rather than years, bypassing slow and costly distribution network reinforcements in congested urban and industrial areas. Powered by the Alpha Energy System, fast charging at multiple-hundred-kilowatt levels can be delivered without overloading local feeders or substations. Its modular architecture allows charging capacity to scale incrementally as EV adoption grows, supporting private, HDB, and public charging deployments with equal flexibility.

Industrial and Construction: Powering the projects with affordability and zero-emission energy
Industrial sites and construction projects require reliable, dispatchable power beyond the reach of the grid. Traditional solutions rely on diesel generators that are costly, noisy, and emissions-intensive. The GMG delivers affordable, zero-emission power that can be deployed rapidly without infrastructure build-out delays. By replacing diesel with hydrogen-based power, operators achieve zero on-site emissions and significantly reduced noise, improving air quality and site compatibility in dense or regulated environments. Its mobile, modular assets can be rotated across multiple sites as project

[4] Stanic et al. (2026) *A Highly Conductive and Robust Anion-Exchange Membrane for Water Electrolysis under Industrially Relevant Conditions*, ChemRxiv

locations and power needs evolve, maximizing utilization, ensuring compliance with tightening emissions standards and corporate ESG commitments.

System-Level Impact: Flexibility Through Reuse

Across these use cases, the GMG delivers system value through flexibility and redeployment rather than permanence. Capacity is deployed where constraints are binding and redeployed as conditions evolve, improving capital efficiency, reducing stranded-asset risk, and supporting decarbonization during the transition period. In this role, the GMG complements long-term grid expansion by absorbing near-term stress and stabilizing system operation under real-world constraints.

5. CONCLUSION

The GMG represents a fundamentally new way to deliver firm, clean, and intelligent power in an era where AI-driven electricity demand is rising faster than conventional grids can expand. By combining high-performance green hydrogen production, solid-state transportable storage, modular on-site power generation, and an AI-native orchestration layer, the system addresses the three structural challenges facing modern power systems: where energy is produced, when it is needed, and how it can be delivered reliably without overloading the grid.

For data centers, the Moving Grid provides instantaneous backup, peak-shaving capacity during short high-price or high-load intervals, and a scalable pathway for sustainable growth. For construction sites, industrial campuses, remote communities, and EV charging, it offers a flexible, mobile alternative to traditional grid reinforcement, facilitating both decarbonization and resilience.

As global energy systems contend with rising volatility, tightening grids, and fast-accelerating digital demand, the GMG is not merely a technical solution but a new paradigm: a distributed, intelligent, hydrogen-enabled power layer that complements national grids and unlocks the next wave of sustainable digital and economic growth.

ALPHA LADDER
www.alphaladder.com

Alpha Ladder Group, headquartered in Singapore with first member subsidiary founded in 2016, focuses on driving digital green transformation with technologies. Its key subsidiaries include:

- ***MetaComp*** and affiliates, Asia's leading licensed fiat & stablecoin hybrid platform providing compliant payment & wealth services, with more than US$10 billion payment volume and US$600 million wealth AUM in 2025;
- ***Asia Green Fund,*** an award-winning impact investment firm with around to US$2.5 billion AUM focusing on investing in deep tech companies for decarbonization;
- ***MVGX,*** a leading AI ESG platform providing end-to-end carbon SaaS solutions: AI emission factor search engine, Scope 1, 2, & 3 measurement, decarbonization rating, AI ESG reporting, green asset tokenization & trading; and
- ***Greenlyzer,*** a deep tech company building a hydrogen-based Green Moving Grid, a distributed power grid to augment traditional grid, to deliver a robust, intelligent and sustainable power infrastructure for next-generation AI.

At Alpha Ladder, our name isn't just symbolism from physics — it's how we move the world forward to pursue infinite alpha, one particle at a time.

GREENLYZER
www.greenlyzer.com

Greenlyzer is a Singapore-based deep tech company operating at the intersection of AI and energy. Incubated by Alpha Ladder Group, Greenlyzer focuses on building a hydrogen-based Green Moving Grid, a distributed power grid to augment traditional grid, to deliver a robust, intelligent and sustainable power infrastructure for next-generation AI.

Powered a suite of material and carbon abatement technologies (more than 40 patents) and, in particular, an Anion Exchange Membrane technology that has demonstrate >80% peak energy efficiency and one of the world's longest durability records for water electrolysis, Greenlyzer's Alpha Energy System aims to supply mission-critical equipment with AI orchestration systems to build a centralized & distributed hybrid power grid system to provide secure, sustainable systems to power AI and increasing electrification of transportation and industrial and commercial applications.

Dr. Bo BAI
Executive Chairman
Greenlyzer &
Alpha Ladder Group

Dr. Bo Bai is the Executive Chairman and Co-Founder of Alpha Ladder Group, a Singapore-based group focusing on digital green transformation with technologies, with subsidiaries including: MetaComp & affiliates as a leading licensed fiat & stablecoin hybrid platform for compliant payment & wealth services with US$10 billion payment volume and US$600 million wealth AUM in 2025, Asia Green Fund as an award-winning impact investment firm with around to US$2.5 billion AUM focusing on investing in deep tech companies for decarbonization, MVGX as a leading AI ESG platform providing and end-to-end carbon SaaS solutions, and Greenlyzer as a deep tech company building a hydrogen-based Green Moving Grid to deliver a robust, intelligent and sustainable power infrastructure for next-generation AI.

Previously, Dr. Bai was a Partner and Managing Director for Warburg Pincus from 2009-2016 where he led its investments in the energy, industrials, and business services sectors in Asia. He also served as Vice President at First Reserve Corporation and Associate at Goldman Sachs. Dr. Bai is also a founding member of the China Impact Investment Network (CIIN), and a member of ASPEN global leadership network. Dr. Bai holds a BSc and an MSc in Modern Physics from the University of Science and Technology of China, a degree certificate in the Financial Technology Option from MIT's Sloan School of Management, and a Ph. D. in Physics from MIT.

Dr. Kuan HUANG
Chief Executive Officer
Greenlyzer

Dr. Huang Kuan is a driving force in sustainable innovation, forging a distinctive path in an era defined by rapid environmental and technological change. He is the Chief Executive Officer of Greenlyzer and draws on his deep expertise to lead forward-looking initiatives that advance the adoption and commercialization of green technologies and sustainable practices.

Previously, he was an Investment Partner at Asia Green Fund, helping mobilize large-scale private placements to accelerate the commercialization of clean technologies across renewable energy, smart mobility, sustainable fuels, and bio-manufacturing. He also led application R&D and product marketing at Picarro, a Silicon Valley company specializing in laser-based and IoT solutions.

Dr. Huang served as a NOAA/UCAR Climate and Global Change Fellow. He holds a B.S. from Peking University, an M.Phil. from the University of Hong Kong, and a Ph.D. from Princeton University.

Michael SHEREN
Managing Director,
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Michael Sheren is a global leader in Sustainable Finance, Technology, Policy, and Investments. He is a former Bank of England Senior Advisor and G20 Co-Chairman of the Sustainable Finance Study Group. While at the Bank of England, Michael co-founded of the Bank's Fintech Accelerator. He is a Fellow at the Cambridge University Institute for Sustainability Leadership and a Senior Advisor to the UNDP Sustainable Finance Hub.

Michael is active in greentech projects in Asia and Europe and holds the position of Managing Director, Europe & UK, at Greenlyzer. He is a Non-Executive Director on a variety of greentech corporate boards and a Senior Advisor to governments and corporations on how to drive a sustainable economic transition through green industrial technology. Michael has over 25 years of experience in investment banking based in New York and London and holds master's degrees from Harvard University, the London School of Economics and New York University.