New Supply Chains for the ‘Net-Zero Carbon’ Future

Strategies, risks and opportunities

A new IHS Markit Multiclient Study
September 2020
The Race to “Net-Zero” is On

“This is Europe’s man on the moon moment...\nWe are acting today to make the EU the world’s first climate neutral continent by 2050.”\nUrsula von der Leyen, European Commission President, March 2020

“At this moment of profound crisis, we have the opportunity to ...\nput the United States on an irreversible path to achieve net-zero emissions, economy-wide, by no later than 2050.”\nPresidential candidate Joe Biden, July 2020

“As we set out our plans to hit our ambitious 2050 net zero target across this year, so we shall urge others to join us in pledging net zero emissions.”\nUK Prime Minister Boris Johnson, announcing the goal to end sales of new gasoline, diesel and hybrid cars by 2035.

And it’s not just politicians making ambitious commitments. Energy, petrochemicals, mining and financial companies are increasingly adopting net zero carbon commitments, vehicle manufacturers are committing to electrification of the bulk of their automotive fleets, and investors are committing hundreds of billions of dollars to low carbon investments.

Achieving these ambitions means rebuilding the energy and infrastructure foundations across the world within the next decade to meet these goals by 2050. This timely multiclient study by IHS Markit will offer critical insight and quantification of the supply chains required for an endeavor of this scale, the investments it will take to build them, and the business risks and opportunities.
New Supply Chains for the ‘Net-Zero Carbon’ Future – Multiclient Study by IHS Markit

Objectives

Net Zero Carbon by 2050? More than half a billion electric cars? 14,000 GW of wind and solar?
To meet these ambitious targets existing and new technologies will need to be deployed at a pace and scale far beyond anything previously imagined or experienced. This creates enormous challenges for supply chains that do not currently exist at scale – or exist at all. The magnitude and pace of this industrial transformation raises considerable risks and uncertainty as well as very significant opportunities. Yet decision makers face a welter of contradictory information regarding low carbon energy technologies and the supply chains that will be needed to support them. This major new study will provide the objective, fact-based, comprehensive and independent analysis that is needed on the choices, strategies, investment risks and opportunities ahead in the race to build strong, robust, diversified, and at-scale supply chains required for a net-zero carbon future.

Context

Achieving net zero could require installed capacities of solar PV, wind turbines and grid-connected batteries to increase by factors of 14x, 9x and 160x respectively by 2050. The demand on vehicle batteries will increase even more rapidly, growing from an annual 144 GWh in 2019 to 1,400 GWh by 2030, a nearly ten-fold rise in a decade.

The supply chains to support this growth are nascent, and highly geographically concentrated. Currently, for solar and battery technologies, the top 3 countries account for over 80% of global manufacturing capacity, and for certain components in the supply chain the geographical concentration is even greater.

This makes it all the more urgent to assess the resilience of supply chains for low carbon technologies and the opportunities for growth and diversification.

At the same time there is the need to assure the sustainability and socio-environmental impact – from raw material extraction all the way through to end of life disposal or recycling. Stakeholders want to understand the full lifecycle carbon emissions from source to deployment to assess the true reductions in GHG emissions from adoption of alternative low carbon energy sources and the associated costs and investment implications.
“New Supply Chains for the Net Zero Carbon Future” will answer critical questions facing decision-makers:

- What are the characteristics of the existing ‘cleantech’ supply chains and the networks that support them?
- What is the scale and nature of the investments, supply sources, supply chains and costs needed to meet net zero ambitions by 2050?
- What new supply chains and business models will develop to deliver at the scale required?
- What are the strategies, investment risks and opportunities for energy companies, investors and supply chain participants?
- How will geopolitical factors and government policy drive supply chain localization? What is the potential for developing local suppliers and supply chains, and the implications?
- What are the life-cycle emissions and sustainability of these supply chains? What are the opportunities for recycling and re-use?
- How will innovation and technology be applied to meet supply chain challenges?

Deliverables from the study will provide answers to the above questions for key low carbon technologies. They will include in-depth data and analysis for existing supply chains, plus outlooks to 2050 for materials and manufacturing capacity and investment. They will also provide quantitative assessments of supply chain sustainability, the business opportunities and risks, and the strategies to be pursued.

This authoritative study will bring to bear insight from leading experts, as well as trusted and proprietary data from IHS Markit. The project is co-chaired by Dr. Daniel Yergin, IHS Markit Vice Chairman, Pulitzer Prize winner, and author of The Prize, The Quest and, most recently, The New Map: Energy, Climate, and the Clash of Nations; and Dr. Atul Arya, Chief Energy Strategist, IHS Markit.

“New Supply Chains for the Net Zero Carbon Future” will draw upon the broad integrated expertise unique to IHS Markit -- including foremost authorities ranging from energy to automotive, commodities, chemicals, maritime, agribusiness, financials and economics & country risk.

Project Directors Nick Lowes, Edurne Zoco, and Eduard Sala de Vedruna, along with Advisors Jamey Rosenfield, Carlos Pascual and Xizhou Zhou and project manager Ulviyya Abdullayeva, bring depth of experience and knowledge to the study.
Why this Study?

Recent studies examining global demand growth for low carbon technologies and the implications for critical raw materials are often narrowly focused and with a specific viewpoint.

What’s needed is an objective, integrated and holistic analysis examining the new supply chains and linkages. The IHS Markit study will assess the range of factors: investment, manufacturing, trade, security, environment, policy, in-country capacity-building and employment. In addition to providing original IHS Markit research, the study will foster a collaborative approach and bring together a diverse community of key stakeholders for shared learning and perspectives.

Who should Enroll?

Organizations

- Oil and gas companies and utilities - looking to deliver on their climate commitments, and meet regulatory, investor, and political requirements
- Financial investors - seeking opportunities in low carbon technologies and implementing their ESG objectives
- Manufacturers - looking for pathways to expand manufacturing capacity, develop new products, or restructure their supply chains
- Technology companies - looking for new opportunities to help accelerate low carbon supply chains
- Raw materials providers – seeking insights on end use markets, the impact of new technologies on raw material demand, and the potential for entirely new customer bases to emerge
- Policy makers – looking to understand the practical implications of regulatory commitments and the supply chains needed to deliver them
- All companies committing to lower carbon or net-zero carbon – seeking strategies and for help navigating new low carbon investments and technologies

Critical insights for:

- Strategy and planning
- Lenders and portfolio managers
- Sustainability leaders
- New ventures
- Business development
- Procurement
- Supply chain
- Low carbon businesses
- Market and competitive intelligence
- Technology and innovation officers
- Project development managers
Why IHS Markit?

IHS Markit has unique expertise on global industrial and energy supply chains, markets and strategies. We also have the proven ability to convene diverse thought leadership communities to test ideas, foster dialogue and create mutual learning on complex global business challenges.

IHS Markit has the most comprehensive and trusted cross-cutting data, expertise and research capabilities needed to understand the industrial transformation ahead. We will draw on deep subject matter expertise from across IHS Markit:

- **Macroeconomics** on global economic outlooks
- **Energy sector** on energy markets and global and national energy scenarios
- **Renewables and batteries** on supply chains, costs and technology trends
- **Financial sector** on investor appetite and expectations for low carbon investment
- **Automotive sector** to assess the impact of vehicle technology trends on the market for alternative battery technologies
- **Mining sector** on the scale and sustainability of raw material extraction required
- **Maritime and trade** on future trade patterns, and the implications of significant growth and reconfiguration of low carbon technology supply chains
- **Geopolitics and security** on implications and risks of national and supra-national energy and trade policy on the low carbon sector
- **Country level analysis** on drivers and capabilities for supply chain localization
- **Emissions estimation** on analysis of lifecycle carbon intensity
- **Corporate ESG** on future trends, commitments and expectations around supply chain sustainability, and the implications
- **Chemicals and agribusiness** for analysis of CCUS, hydrogen and biofuels supply chains
Our Approach

“New Supply Chains for the Net-Zero Carbon Future” will develop original and independent analysis. The project will also bring together a diverse group of key stakeholders: from policy makers and investors to project developers, technology providers, manufacturers and other supply chain participants. Participants will benefit from the insights and detailed analysis, and the dialogue as part of an exclusive community focused on sharing experiences and perspectives. The project also will draw upon existing and on-going IHS Markit research, such as the ground-breaking *Reinventing the Wheel* and the *Hydrogen Forum*.

Geographic coverage

“New Supply Chains for the Net-Zero Carbon Future” will consider all major global energy demand and technology end-use markets to forecast aggregate global demand and supply scale-up requirements.

The research will draw upon deep IHS Markit regional on the ground expertise. Particular focus is on EU, US, China, India and other emerging Asian economies, where the majority of demand growth will occur. Demand estimates will take into consideration the myriad of “green stimulus” programs that are being announced by policy makers around the world in light of Covid-19.
All significant sources of raw material supply, processing and manufacturing will be considered for each emerging energy technology, recognizing that low-carbon supply chains are currently concentrated in Asia, especially in China. Our researchers based in China, SE Asia and India will be key contributors to understanding regional supply chain drivers. Sources of raw materials for batteries include developing countries in Africa and Latin America. We will examine challenges of rapid scale up of raw material extraction in these economies, their social and environmental sustainability considerations, and investment opportunities, and risks.

The study will have two parts.

All participants will join Part I; they will also have the opportunity to select from the list of three technology “deep-dives” in Part II.

- **Part I** maps existing supply chains for the selected technologies; and defines the investment and capacity build-out required for a credible pathway to a ‘net-zero carbon’ future.
- **Part II** uses this framework to examine the supply chain challenges, risks and opportunities specific to select low carbon technologies. We are offering three modules: (1) battery storage, (2) solar PV and (3) wind - both onshore & offshore. Study participants may choose one or more modules, with discounted rates for multiple modules.

Subsequent phases of research, if requested, will offer deep dives on other low carbon technology supply chains including hydrogen, CCUS and biofuels.

Members choose one or more low carbon technologies for Part II deep dive

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**Part I: Mapping Supply Chains and their Scale-up Requirements**

**Part II: Strategies, Risks and Opportunities in Low Carbon Technology Supply Chains**

- Batteries
- Solar PV
- Wind Onshore/offshore
Part I: Mapping Supply Chains and their Scale-up Requirements

Mapping Current Supply Chains
In Part I we will develop an initial high-level mapping of the supply chains for each of the low carbon technologies: batteries, PV solar and wind. We will identify the major components and activities within the supply chain and illustrate their geographical distribution.

This exercise will provide all participants with a baseline understanding of how current supply chains are configured: key raw materials, processing/manufacturing activities, geographical spread, typical unit scale, end use markets and application.

Setting a Baseline ‘Net-Zero Carbon’ Scenario
Part I will set the framework scenario for the ‘net-zero carbon’ future; including estimates on future energy mix out to 2050, and contributions of different fuel types and low carbon technologies. The purpose is not to make a precise forecast or prediction, but to offer a baseline pathway to ‘net-zero carbon’. This study will build upon IHS Markit’s “Autonomy” scenario that articulates a pathway to meet the Paris target of no more than 2 degrees rise in global temperature. The scenario includes a consistent set of macroeconomic, energy market and technology assumptions and quantification. It also offers granular data for energy supply by technology out to 2050.

Investment and Resource Requirements
The ‘net-zero carbon’ scenario will provide a view of how low carbon technologies will need to be scaled up to meet the policy commitments and societal expectations over the next 30 years. We will analyze the implications, in terms of the investments and additional capacity needed, and raw material requirements, for the three low carbon technologies. This will offer a comprehensive overview of the low carbon investment landscape.

Although the study will assess the supply chain scale-up challenges implied by this scenario over the 30-year period, special attention will be paid to the next 10 years, which are most critical for investors and policy makers.
Part II: Technology-Specific Deep Dives: Supply Chain Strategies, Risks and Opportunities

Study participants will have the option to select one or more technology-specific supply chain “deep dives” in Part II of the study

• Batteries
• PV solar
• Wind

(Note: hydrogen, carbon capture, biofuels and other technologies maybe addressed thereafter in subsequent phases if requested)

For each technology, we will identify and assess critical supply chain questions facing companies, investors, operators and policy makers, as well as creating a reference knowledge base and data set.

Critical Part II Questions

For each technology we will analyse specific characteristics of the respective supply chain, building on the initial high-level analysis in Part I, and offering insight into the following:

• **What are the characteristics of the current supply chain on a granular basis?**
  Processes, activities, materials and components; geographical concentration; transportation and trade patterns; market structure and characteristics; business models; key/ dominant players; proprietary technologies.

• **What are the current challenges to the supply chain?**
  How robust are current supply chains, where are potential bottlenecks? What is the risk of ‘decoupling’ given current economic and geopolitical pressures?

• **What will be the magnitude of the scale-up required to deliver a ‘zero carbon’ future?**
  What resource extraction, processing and manufacturing capacity will need to be added along the supply chain, and what will be the capital required?

• **What are the critical drivers and risks in such a scale up?**
  How quickly can additional supply chain capacity be added, and where? What incentives may be required? How might the market structure evolve? What are the implications for costs and competitiveness?

• **What are the opportunities for companies and investors to develop meaningful positions in the new supply chains?**

• **What major innovation and technology developments could impact the supply chain?**
  What is the likely technology pathway over the next 10 years? Over the next 30 years? What new technologies could create entirely new supply chains? How will technology and innovation improve supply chain efficiency and help resolve some of the challenges?
• What is the potential for localization of processing/manufacturing along the supply chain?
  What specialist capabilities are required in the various processes and activities? What opportunities do they provide for job creation? Which supply chain activities will governments prioritize for domestic capacity-building?

• What are the implications of rapid scale-up for global trade and supply chain security and what are the geopolitical risks?

• How to assess the sustainability of the full supply chains?
  What is the current full lifecycle emissions footprint for the technology, from raw material extraction through to recycling/disposal? How does this vary by location/technology, and how might it change in the future? What other sustainability issues might be raised by a massive scale up? What is the risk of new sustainability challenges that could bring investor activism and government intervention?

• What role could recycling and re-use play in reducing resource inputs and waste?
  How much waste will be generated when equipment reaches end-of-life? What recycling/reuse options and technologies are available to reduce waste and material use? What investment opportunities might this create? What policy support might be required to make recycling or re-use financially viable?
Within the context of these common issues, the study will include the following specific areas of focus.

**Battery Supply Chains**
- Technology trends, and potential for new breakthrough battery technologies.
- Availability, cost and sustainability of raw materials based on alternative technology pathways, and implications for supply chains.
- Recycling of batteries at end of life; ‘second life’ use of vehicle batteries for grid storage.

**Solar PV Supply Chains**
- Technology trends within specific system components and impact on raw material sourcing and equipment.
- Feasibility and cost to diversify from the current concentration in China.
- Extent to which policy (e.g. Green Deal) will bring manufacturing closer to the end markets; especially Europe, US, India.
- Recycling of modules & inverters. How critical in 5-10 years as the installed based becomes very large and older installations reach end of life or are superseded by new technologies?

**Wind Turbine Supply Chains**
- Access to rare earths, including competition from other industries such as electronics and defence.
- Recycling or disposal of components as ageing capacity is decommissioned.
- Logistics around transport and installation of wind turbines, as wind turbines get bigger in size, towers get higher and the length of the blades increases.
- Market for vessels and cranes - for installation, maintenance and service of offshore wind farms.
Deliverables: Content and Community

Participants will benefit from in depth analysis, presentations, workshops and detailed accompanying data. Reports will be in PowerPoint format for Parts I and II; supported by Excel datasets.

Part I deliverables will include forecasts of:

- Annual generation capacity growth to 2050 for solar PV by region/country required to meet a ‘net zero carbon’ scenario
- Annual generation capacity growth to 2050 for onshore wind and offshore wind by region/country
- Annual demand growth to 2050 for electric vehicles (LDV, HDV) by region/country and associated battery capacity demand growth
- Annual demand growth to 2050 for utility battery storage systems by region/country
- Annual investment/expenditure profiles for each technology by region/country to 2035; indicative to 2050
- Mapping of the major components and activities within each technology supply chain, including geographical distribution
- Investment/expenditure profiles for supply chain components and activities to 2035; indicative to 2050
- Demand growth to 2035 for key raw materials for each technology; indicative to 2050

Part II deliverables will include for each technology:

- Detailed mapping of current supply chains, including manufacturing locations and capacities, transportation and trade routes
- Analysis of supply chain market structures, major players and business models; costs, competition from other end-use markets
- Analysis of geopolitical risks to current and future supply chains; key signposts to monitor
- Technology roadmap to 2030, indicative out to 2050; implications for supply chains
- Evaluation of alternative scale-up pathways, including the key drivers, constraints, opportunities and risks
- Investment/expenditure profiles to 2035 for main supply chain components and activities broken down by geography; key drivers and uncertainties
- Estimates of decommissioning requirements and waste volumes; analysis of recycling technologies and their potential impact
- Analysis of localization potential for supply chain elements; assessment of the impact of localization policies by major governments on global supply chains
- Estimation of current full lifecycle emissions footprint; variation with specific technology components
- Summary of sustainability issues (current and potential future)

Participants will gain much value from the exchange of ideas in workshops and community gatherings including two virtual workshops delivered during Part I; and three workshops for each technology deep dive in Part II (either in-person or virtual depending on pandemic status.)
Timeline for the Study
(subject to change)

Part I

• **29th September 2020:** Part I kick-off workshop (virtual). Definition of ‘net-zero carbon’ scenario, analysis framework and Part I work plan.

• **19th November 2020:** Present and discuss Part I deliverables and Part II work plan (virtual workshop).

Part II

• **17th December 2020:** First intermediate workshop (Part II) to discuss results from deep dive analysis of supply chains. One workshop per technology stream (virtual and/or in person).

• **Mid January 2021:** Second intermediate workshop to discuss results from deep dive analysis of supply chains. One workshop per technology stream (virtual and/or in person).

• **Mid February 2021:** Final workshop to present Part II study results to participating members.

• **March 2021:** CERAWeek Future Visions, a private workshop for senior executives from participating companies, to be convened in conjunction with IHS CERAWeek in Houston (in person or virtual). Key insights from the study will be presented by Dr. Daniel Yergin and the IHS Markit Project team followed by interactive Chatham House Rules discussion.
Project Team

This team will draw on leading experts from across IHS Markit

Daniel Yergin

Project Co-Chairman

Daniel Yergin is a highly respected authority on energy, international politics, and economics. He is Vice Chairman of IHS Markit and chairs CERAWeek. Time magazine said, “If there is one man whose opinion matters more than any other on global energy markets, it’s Daniel Yergin.” Fortune said that he is “one of the planet’s foremost thinkers about energy and its implications.”

A Pulitzer Prize winner, Dr. Yergin is the author of the new book, The New Map: Energy, Climate, and the Clash of Nations. He authored the bestseller The Quest: Energy, Security, and the Remaking of the Modern World. The Quest has been called “a masterly piece of work” by The Economist and was described by the Financial Times as “a triumph.”

Dr. Yergin is known around the world for his book The Prize: The Epic Quest for Oil, Money, and Power, which was awarded the Pulitzer Prize. It became a number one New York Times best seller and has been translated into 17 languages.

Of Dr. Yergin’s book The Commanding Heights: The Battle for the World Economy, which has been translated into 13 languages, The Wall Street Journal said, “No one could ask for a better account of the world’s political and economic destiny since World War II.”

Both The Prize and Commanding Heights were made into award-winning television documentaries for PBS and BBC.

Dr. Yergin was awarded the United States Energy Award for “lifelong achievements in energy and the promotion of international understanding.” India’s prime minister presented him with a Lifetime Achievement Award, and the US Department of Energy presented him with the first James Schlesinger Medal for Energy Security.

Dr. Yergin is a member of the National Petroleum Council, a trustee of the Brookings Institution, and a director of Council on Foreign Relations. He is a member of the Dallas Federal Reserve Energy Advisory Board, the advisory boards of the Massachusetts Institute of Technology Energy Initiative and Columbia University’s Center on Global Energy Policy, Singapore’s International Energy Advisory Panel, and the India Petroleum Minister’s Think Tank. He holds a BA from Yale University and a PhD from Cambridge University, where he was a Marshall Scholar.
**Atul Arya**  
**Project Co-Chairman**  
Atul Arya is Senior Vice President and Chief Energy Strategist at IHS Markit. Dr. Arya has over 30 years of leadership experience in the energy industry. He is responsible for integrating energy content, analysis and insights across the entire energy value chain and for c-suite client engagements. His areas of expertise include business strategy, commercial analysis, oil markets, energy technologies, climate change and renewables. Prior to this, he led Energy Insight, Research and Analysis and Energy Research teams at IHS Markit.

Dr. Arya previously worked for BP for over 20 years in a number of operational, business, technical and strategic positions around the world. His career includes international leadership experience in a diverse array of energy fields spanning strategy development, business planning, field operations and technology commercialization. His experience includes leadership in solar energy development as well as oil and gas. Dr. Arya is member of the World Economic Forum’s Global Future Council on Advanced Energy Technologies. He has previously served on boards of several companies and institutions and including national Council for Atmospheric Research, Green Mountain Energy and US Solar Energy Industry Association. He is 30+ year member of the Society of Petroleum Engineers. Dr. Arya is a sought-after speaker and moderator at public conferences, company boards and industry events and a member of the CERAWeek leadership team. He holds B.S., M.S. and Ph. D. Degrees in engineering.

**Nick Lowes**  
**Project Director**

Nick Lowes, Vice President, leads IHS Markit’s Energy Transition consulting activities and has over 30 years’ experience across the energy sector. He currently focuses on providing advisory services to governments, investors and energy companies related to climate change and energy transition issues. He has worked as an advisor to many national and international energy companies and governments on issues ranging from energy policy and strategy development to investment analysis and due diligence. He has led reorganization and process re-engineering exercises and has designed & implemented management systems.

Over the course of his career Mr Lowes has worked with client organizations in every region of the world. He was formerly a Principal with Strategic Decision Group’s oil and gas practice prior to its acquisition by IHS, and a Senior Manager with the consulting firm Arthur D Little Ltd. Previously, he spent 15 years in engineering and project management for major oil and gas projects in UK, Australia, Malaysia and Oman.

Mr Lowes holds a BA in Engineering Sciences from Cambridge University; an MSc from Imperial College, London University; and an MBA from the UK Open University Business School. He is a Member of the UK Energy Institute.
Edurne Zoco
Project Director

Edurne Zoco, Executive Director, manages the Clean Technology & Renewables research team at IHS Markit, leading the team’s research activities across renewables, energy storage, and batteries. Dr. Zoco has been involved in the solar industry for more than a decade. Prior to joining IHS Markit in 2015, she was employed by solar photovoltaic (PV) manufacturer Trina Solar, where she held global positions within corporate and strategic marketing.

Dr. Zoco contributes to a wide range of deliverables across the research team, including both subscription products and custom research and consulting projects. In particular, she provides insight, experience, and research capability focused on the solar PV module supply chain and the development of global demand for solar PV and its role in the wider energy transition. She has presented at leading industry events and conferences since 2007.

Dr. Zoco holds a PhD from the University of Notre Dame, United States. She speaks English, French, Spanish, and Italian.

Eduard Sala de Vedruna
Project Director

Mr. Sala de Vedruna is Executive Director, Global Power and Renewables. His team delivers competitive strategy and market analysis to developers, utilities, and renewables equipment manufacturers on key trends and market opportunities, with particular focus on the wind and solar sectors. He is the author of numerous IHS Markit reports, including analyses of business models and competitive strategies employed by equipment manufacturers, utilities, and developers in the global renewables sector.

Mr. Sala de Vedruna has more than 17 years of consulting and research experience in the energy sector with a focus on market analysis and competitive strategy, particularly with the global renewables market. He has worked on numerous consulting assignments providing strategic advice and recommendations. Prior to joining IHS Markit, he was responsible for market research and management consulting at International Venture Consultants, where he contributed to a variety of projects for major oil and gas companies.

Mr. Sala de Vedruna holds a degree in economics from the University of Barcelona, Spain. He is based in Paris and is fluent in English, Spanish and French.
Carlos Pascual
Project Advisor
Carlos Pascual is Senior Vice President at IHS Markit, focusing on global energy issues and international affairs. He was U.S. Envoy for Affairs in the U.S. State Department, where he established the Energy Resources Bureau. He served as the Senior Advisor on Energy to the U.S. Secretary of State. In that role, he led the negotiations on Iranian oil sanctions with China, India and other countries. Mr. Pascual was previously US Ambassador to both Mexico and Ukraine and was special assistant to the US president for Russia, Ukraine, and Eurasia on the National Security Council.

Mr. Pascual created the position of coordinator for reconstruction and stabilization in the State Department, establishing the first civilian response capacity to conflicts. Mr. Pascual has held board positions in energy companies as well as energy- and power-focused private investment firms. He is also part of the GE Ecomagination Advisory Board and is a board member of the Atlantic Council. Mr. Pascual holds a Bachelor of Arts from Stanford University and a Master of Public Policy from the Kennedy School of Government at Harvard University, both in the United States.

Jamey Rosenfield
Project Advisor
Jamey Rosenfield is cofounder with Daniel Yergin of IHS Markit Cambridge Energy Research Associates. Mr. Rosenfield led its growth for over three decades, responsible for major projects, strategy, operations, and business development. He created and cochairs CERAWeek, the world’s leading senior global energy gathering, whose evolution he has overseen from its inception. He focuses on energy innovation, including establishing the Innovation Agora, a global gathering of energy thought and technology leaders.

Mr. Rosenfield spearheaded or contributed to numerous high-impact strategic initiatives, including Fuelling North America’s Energy Future: The Unconventional Gas Revolution and the Carbon Agenda; America’s New Energy Future; A More Competitive Energiewende: Securing Germany’s Global Competitiveness in a New Energy World; and Advancing the Landscape of Clean Energy Investment.

Mr. Rosenfield was a Senior Fellow at the Center for Business and Government at Harvard, and he serves as a Trustee of the Woods Hole Oceanographic Institution. He received his undergraduate education at Harvard College and holds an MBA from Boston University.
Xizhou Zhou
Project Advisor

Xizhou Zhou is a Vice President at IHS Markit in Beijing and leads the company’s power and renewables practice globally. Mr. Zhou has expertise in power and renewable market fundamentals analysis and forecasting, power market design and policy analysis, renewable energy business models, and company strategies, among other areas. He previously headed the firm’s Power, Gas, Coal, and Renewables practice in Asia Pacific, managing energy research and consulting activities across regional teams based in Beijing, Delhi, Seoul, Singapore, and Tokyo.

Mr. Zhou began his career at IHS Markit through one of its predecessor companies, Cambridge Energy Research Associates (CERA), as part of its Emerging Markets and Global Power groups in Cambridge, Massachusetts. Before that, he worked as a consultant on regulatory economics for Industrial Economics, Inc. in Boston and as a research analyst at the World Resources Institute in Washington, DC. Fluent in Mandarin Chinese and proficient in Spanish.

Mr. Zhou holds a Bachelor of Arts and a Master of Environmental Management, both from Yale University in the United States. He is currently an editorial board member of China Petroleum Society’s journal, Guoji Shiyou Jingji (International Petroleum Economics). He also serves on the Board of Trustees of the Yale-China Association.

Ulya Abdullayeva
Project Management Lead

Ulya Abdullayeva is a Director in the IHS Markit Oil & Gas Consulting team based in the UK. In her role, she advises public and private oil and gas clients across the world and project manages large scale consulting engagements. Project scope spans strategy, due diligence, country entry, fiscal benchmarking, market assessment and sizing, investment evaluation, and opportunity identification and screening.

Ms Abdullayeva brings over 16 years of experience in the energy industry, including over 6 years of commercial and business development roles with BP and 10 years in management consulting.

Ms Abdullayeva holds a BA in International Relations from Baku State University and an MBA in International Management from Thunderbird School of Global Management in Arizona, USA.
Sam Wilkinson
Solar & Battery Storage Lead

Sam Wilkinson is an associate director within the Energy Technology research team at IHS Markit based in the UK. Upon joining the team in 2008, Mr. Wilkinson was responsible for researching the photovoltaic (PV) inverter market and the PV module and polysilicon supply chain, working closely with leading global suppliers to develop detailed analysis on these markets. He has also been responsible for establishing primary research reports focusing on solar demand and policy, complementing IHS Markit extensive research of the complete PV supply chain.

Building on his experience in the solar research team, Mr. Wilkinson established the Energy Technology team’s coverage of energy storage in 2012, covering a wide range of topics within this fast-developing sector, including development of battery technology. In addition to a continued contribution to the team’s syndicated research products, he also coordinates and contributes to a wide range of custom research, consulting, and advisory projects. Mr. Wilkinson’s analysis and commentary is regularly published by leading PV and energy industry media and the global press. He has also presented at many leading industry events and conferences.

Mr. Wilkinson holds a bachelor’s degree in math and engineering from the University of Nottingham, United Kingdom.

Vinod Raghothamarao
Supply Chain Lead

Vinod Raghothamarao is an Associate Director in the Energy Transition consulting team at IHS Markit, based in Dubai. He delivers advisory services around supply chains, energy scenarios, integrated modeling, carbon and climate analysis, and other analysis that extends globally across energy sectors.

Mr. Raghothamarao brings 18+ years of consulting expertise in energy sector supply chain and procurement, local content development, technology strategy and general investment strategy. His expertise includes helping clients in the energy industry with issues related to supply chain optimization, supply chain market intelligence, sourcing and procurement, catalog management and technology. He has advised clients on strategy, process improvement, operations, cost improvement, HSE and risk management within the energy and mining sectors across USA, Latin America, Europe, Middle East, Africa and Asia Pacific.

Mr. Raghothamarao holds a Bachelor’s in Computer Engineering from NIT Surathkal India and an MBA from ESADE Business School Barcelona Spain.
Youmin Rong
Batteries Expert
Youmin Rong, a senior analyst within the Gas, Power, and Energy Futures team in Beijing, covers global battery technology and industries along the battery value chain. Dr. Rong's responsibilities include analyzing the global battery supply chain and energy storage markets in Asia Pacific and providing input to customers on battery technology, e-mobility transition, battery cost, and pricing trends.

Prior to joining IHS Markit, Dr. Rong served as the project lead and investment advisor for advanced batteries at NIO, the first Chinese electric vehicle company publicly listed on the New York Stock Exchange. He also worked for State Grid Corporation of China as an energy storage research fellow. In addition to his industrial experience, Dr. Rong was a postdoctoral fellow at Stanford Energy Corporate Affiliates of Stanford University, where he developed scientific research in advanced battery technology. Based on his research findings, he has published more than 15 papers in leading international peer-reviewed journals. During his prior career, he also worked closely with the Department of Energy (United States) and National Energy Administration (China) on technology research.

Dr. Rong holds a Bachelor of Engineering and a Master of Engineering from Imperial College London, United Kingdom, and a PhD from the University of Oxford, United Kingdom.

Steven Knell
Scenarios Lead
Steven Knell, director with the Gas, Power, and Energy Futures team at IHS Markit, is a specialist in low-carbon energy transitions. Dr. Knell’s expertise includes analysis of environmental regulatory frameworks and their impacts on company strategy and the energy market landscape. He is a lead for the Energy and Climate Scenarios capability and is a main contributor to global climate policy and greenhouse gas emission research across IHS Markit.

Dr. Knell’s current research and consulting work focus is on company responses to the recommendations of the Task Force on Climate-related Financial Disclosures; the implications of the Paris Agreement and national climate policy on conventional energy production and consumption; the features of low-emission cases and 2-degree Celsius–consistent global energy scenarios; carbon capture, use, and storage; and the role of carbon pricing, emission markets, and low-carbon technology strategies for the oil and gas and power sectors. Dr. Knell has previously served in the Canadian Federal Ministry of Environment and with the United Nations Development Programme.

Educated in the United Kingdom, he holds a Bachelor of Arts from the University of Kent at Canterbury, a Master of Science from the London School of Economics, and a PhD from the University of Sussex.
Rashika Gupta
Power Markets Expert

Rashika Gupta is a director on the Gas, Power, and Energy Futures team at IHS Markit, responsible for research and analysis for the India, Sri Lanka, Pakistan, and Bangladesh markets. Dr. Gupta has more than a decade of experience in energy markets. Her expertise includes economic and policy assessment, power and fuel market analysis, power market modeling, power trading, energy management, regulatory and commercial analysis, and environmental policy analysis for Indian and Asia Pacific power markets.

Prior to joining IHS Markit, Dr. Gupta was with Statkraft Markets and with ICF International. She has worked on numerous consulting assignments and commercial projects and with independent power producers, investors, private equity funds, power utilities, energy majors, industrial consumers, and government planning bodies to support their business and commercial strategies.

Dr. Gupta holds a bachelor’s degree from Kirori Mal College, India; a master’s degree from Hansraj College, India; and a doctorate from Delhi University, India.

Alex Connell
Commercial Lead

Alex Connell is a Director with IHS Markit’s CERAWeek group. He has expertise in providing clients with strategic consulting, and advisory services on global energy trends & decarbonization scenarios.

Mr. Connell has spent his entire career in the energy industry with a focus on energy transition trends and technologies. Since joining IHS Markit, Alex has driven business development efforts for IHS Markit’s CERAWeek & Gas, Power, and Energy Futures groups. Previously, he held various roles providing enterprise energy risk management & decarbonization solutions to commercial and industrial end users.

Mr. Connell holds a Bachelor of Arts degree in Economics from Union College.
To join New Supply Chains for the Net-Zero Carbon Future or for more information:

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