

Introduction to the Special Issue: Clean, Stable, And Sustainable Energy Future

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The global energy landscape is undergoing a profound transformation as nations strive to meet the dual challenges of climate change mitigation and sustainable economic development. As the urgency to transition toward a net-zero economy intensifies, questions surrounding the feasibility, equity, and resilience of energy transitions dominate policy and academic discussions.

The global energy sector stands at a crossroads, facing the challenge of balancing the imperatives of sustainability, stability, and security. Over the past decades, the accelerating impacts of climate change, resource depletion, and geopolitical upheavals have forced nations to rethink their energy strategies. Policymakers and researchers are in search of solutions about how to decarbonize while ensuring economic growth, how to scale up renewable energy technologies without compromising grid stability, and how to equitably distribute the benefits and burdens of energy transitions. These debates have gained even more urgency in the wake of the COVID-19 pandemic and recent energy crises, which have highlighted vulnerability in supply chains and underscored the need for resilient, adaptive energy systems.

Within this dynamic context, the 44th International IAEE Conference, held in Riyadh in 2023, provided a critical platform for advancing dialogue on these pressing issues. Organized by KAPSARC, the conference gathered outstanding leading experts, academics and policy makers to explore pathways toward a clean, stable, and sustainable energy future.

This special issue of *The Energy Journal*, a product of the Conference, addresses these critical debates through twelve articles that offer fresh insights into policy frameworks, empirical analyses, and sector-specific strategies. Collectively, these articles provide actionable insights into the multifaceted challenges and opportunities of energy transition, grouped in four major areas of research.

The first cluster of articles addresses overarching policy and global dynamics. The article “*Mitigating Climate Change While Producing More Oil: Economic Analysis of Government Support for CCS-EOR*” by Hossa Almutairi and Axel Pierru develops a novel analytical framework to quantify the CO₂ mitigation potential of Carbon Capture and Storage with Enhanced Oil Recovery (CCS-EOR), considering the lifecycle emissions of the additional oil produced and accounting for market equilibrium effects. Its findings are broadly consistent with the size of the subsidy in the revised Section 45Q of the 2022 US IRA.

Christina Kockel, Jakob Kulawik, Saskia Spiegelburg and Aaron Praktijnjo, in “*Long-term Energy Policy vs. Dynamic Public Preferences: A Review of German Energy Policy*,” delve into the interplay between shifting public preferences and long-term energy objectives in Germany. Using case studies of the nuclear phase-out post-Fukushima and coal phase-out, the authors illustrate the volatility of public opinion as a relevant factor in energy policymaking. The study calls for a dual focus on fostering resilient policy frameworks and enhancing public understanding of long-term

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energy trade-offs. This approach, the authors argue, will ensure that public sentiment strengthens rather than undermines energy transitions.

In “*Multivariate Convergence Toward SDGs 2, 6, and 7*,” Carlo Andrea Bollino and Marzio Galeotti introduce a novel multivariate approach to analyzing progress toward Sustainable Development Goals (SDGs) 2, 6, and 7, which address food security, water availability, and energy access, respectively. Their model reveals significant interlinkages among the three goals and is particularly relevant for policymakers in regions like the MENA, where challenges related to water, and food security are important. The authors highlight the role of targeted infrastructure investments in achieving balanced and sustainable development.

Fatih Karanfil and Axel Pierru’s “*Energy transition in Oil-Dependent Economies: Public Discount Rates for Investment Project Evaluation*” sheds light on a pivotal issue in energy transition economics: how to value future cash flows from energy investments in oil-exporting countries. Their study proposes a novel framework for deriving public discount rates that reflect the economic characteristics of these nations, including their exposure to global oil price volatility. The authors provide numerical estimates of the public discount rate for 26 oil-exporting countries. By emphasizing the importance of the opportunity cost in valuing the oil saved from domestic energy consumption, the study provides a vital tool to prioritize investments and policies.

The second cluster of articles moves into empirical analyses of oil-exporting countries. The article titled “*Strategic Commodities’ Price Risks and Financial Contagion in Oil and Gas Exporting Countries*” by Ilyes Abid, Christian Urom, Khaled Guesmi, and Syed Ali Raza explores the role of oil and gas price shocks in the transmission of financial market contagion among major oil and gas exporting nations. Their findings highlight that oil price fluctuations are a significant driver of contagion, while gas price shocks play a comparatively smaller role. Policymakers in resource-dependent economies can leverage these insights to mitigate systemic risks by diversifying their economies and employing advanced risk management strategies in their financial and commodity markets.

Canh Phuc Nguyen, Gabriel S. Lee, Muhammad Ali Nasir, and Binh Quang Nguyen, in their article “*Export Diversification and Energy Consumption Efficiency in the Light of Non-linear Evidence*,” examine the complex relationship between export diversification (ED) and energy consumption efficiency across 95 countries. They identify an inverted-U relationship where initial diversification increases inefficiency but later drives technological progress. The findings are particularly robust for low- and middle-income countries. Policymakers in these countries are advised to adopt comprehensive frameworks that integrate export diversification strategies with sustainability goals, ensuring that economic expansion does not come at the expense of environmental degradation.

The third article in this cluster, “*Net-Zero Policy vs Energy Security: The Impact on GCC Countries*” by Simona Bigerna, Maria Chiara D’Errico, Paolo Polinori, and Paul Simshauser, investigates, using portfolio theory, the risks faced by Gulf Cooperation Council (GCC) countries—Kuwait, Oman, Saudi Arabia, and the UAE—as the global push toward net-zero emissions accelerates. The study highlights the need for GCC countries to diversify their economies and adopt long-term fiscal strategies to delink public expenditures from oil revenues, strengthening non-oil sectors. This work provides a valuable framework for assessing and mitigating the risks associated with oil export dependency in a decarbonizing world.

Country-specific case studies feature prominently in the third cluster. The article “*Projecting Saudi Arabia’s CO₂ Dynamic Baselines to 2060: A Multivariate Approach*” by Abdulelah Darandary, Anwar A. Gasim, Lester C. Hunt, and Jeyhun I. Mikayilov explores Saudi Arabia’s carbon

dioxide emissions trajectory under various economic and policy scenarios. Employing econometric models, their projections reveal that CO₂ emissions could rise significantly under business-as-usual conditions, from 540 Mt in 2019 to as high as 985 Mt by 2060 in a high-growth scenario. Policymakers are urged to focus on strategies that channel oil revenues into non-oil sectors, implement energy price reforms, and invest in renewable energy to mitigate emissions growth while maintaining economic resilience. The work serves as a foundational guide for nations employing baseline targets in their climate action plans.

Fakhri J. Hasanov, Muhammad Javid, and Heyran Aliyeva, in “*The Role of the Petrochemical Sector’s Exports in the Diversification of the Saudi Economy: A Scenario Analysis of Foreign and Domestic Price Shocks*,” provide a rigorous analysis of how Saudi Arabia’s petrochemical exports can drive economic diversification, a central goal of Vision 2030, highlighting the sector’s potential in stabilizing non-oil growth, particularly when paired with targeted reinvestments and price reforms. Policymakers are advised to integrate investment localization measures and mitigation strategies to maximize the sector’s contribution to GDP growth and employment creation.

The article “*Which Way to Choose? A Generic Modular Life Cycle Assessment for Hydrogen Production and Import Pathways to Germany*” by Christina Kockel, Jakob Kulawik, David Wohlleben and Aaron Praktijnjo evaluates the environmental implications of various hydrogen production and import routes to Germany, with a modular life cycle assessment (LCA) approach. The study also assesses import scenarios from regions such as the Middle East, Africa, and Australia, providing a comprehensive guide for policymakers to prioritize pathways with the lowest emissions. These findings are pivotal for Germany as it seeks to establish a low-carbon hydrogen economy, emphasizing the need for strategic international partnerships and investments in renewable energy infrastructure.

The final cluster examines energy consumption dynamics in business and residential contexts. Fateh Belaïd and Camille Massié’s article “*Beyond Cost: Financial Incentives and Residential Energy Renovation Behavior*” provides a detailed analysis of the barriers to energy-efficient renovations in French households. By using survey data to quantify the effectiveness of financial incentives, the authors identify a threshold for subsidies—approximately €2,400—necessary to trigger significant adoption. They also explore behavioral and structural barriers, offering targeted policy recommendations for designing subsidies that maximize impact.

Meanwhile, Thomas Chemmanur and Fatima Shuwaikh, in their study “*The Effect of Greenhouse Gas Emissions and Green Innovation on Corporate Investors’ Performance*,” investigate how sustainability practices influence financial outcomes in U.S. corporations. They find that reducing emissions and fostering green innovation lead to improved financial performance, particularly when integrated with corporate social responsibility (CSR) initiatives. This work demonstrates the dual benefits of aligning environmental sustainability with business strategies, offering a compelling case for integrating green innovation into corporate investment portfolios.

The articles in this special issue of *The Energy Journal* collectively underscore the profound complexity and interconnectedness of the energy transition, highlighting the challenges and opportunities at the nexus of sustainability, economic stability, and energy security. As policymakers and stakeholders navigate this critical juncture, several key takeaways emerge from the research presented here.

First, achieving a clean energy future requires nuanced policy frameworks that address both global and local dynamics. Articles on CCS-EOR, public discount rates, and multivariate SDG convergence reveal that the success of transition strategies depends heavily on tailored approaches

that reflect regional contexts and specific economic dependencies. For oil-exporting countries, for example, managing the trade-offs between diversification and decarbonization is vital.

Second, the transition must balance long-term strategic goals with the need for public engagement and acceptance. The German case studies demonstrate how shifts in public preferences can disrupt energy policies, even those designed with clear long-term objectives.

Third, the energy transition is inherently interdependent with broader development goals. The convergence analysis of SDGs related to food, water, and energy underscores the importance of integrated policies. Improvements in one sector can drive progress in others, creating multiplier effects that enhance sustainability outcomes. Policymakers must therefore adopt cross-sectoral strategies, leveraging synergies across water, energy, and food systems to maximize resource efficiency and resilience.

Fourth, economic diversification and structural transformation is crucial for emission reduction, as revealed by the analysis of Saudi Arabia's dynamic scenario to 2060, with clear policy implications for resource-rich economies globally. Similarly, the exploration of Saudi Arabia's petrochemical sector reveals how strategic investment and price reforms can transform sectoral performance into a driver of diversification and stability.

At a sectoral level, the studies on hydrogen pathways and energy efficiency in residential and commercial contexts illustrate the critical role of technological innovation and behavioral change. Similarly, the research on residential energy renovations highlights the importance of well-designed financial incentives in overcoming adoption barriers. These insights suggest that aligning policy mechanisms with technological advancements and end-user needs is crucial for accelerating the pace of transition.

Finally, the articles on corporate innovation and sustainability demonstrate that the private sector has a pivotal role to play. Companies that prioritize green innovation and corporate social responsibility (CSR) not only enhance their financial performance but also contribute to broader environmental goals. Policymakers can amplify these efforts by fostering an enabling environment that incentivizes sustainability-linked investments and supports public-private collaboration.

The overarching policy challenge derived from these contributions is the need to reconcile competing priorities: balancing the urgency of decarbonization with the imperatives of energy security and economic stability, addressing local realities while contributing to global goals, and ensuring inclusivity while driving technological innovation. The findings in this issue provide valuable guidance for navigating these tensions, offering a roadmap for policymakers, researchers, and industry leaders committed to shaping a clean, stable, and sustainable energy future.

This special issue seeks to inspire and equip stakeholders with the tools to meet this challenge, contributing to the collective effort to forge a resilient and equitable energy landscape for future generations.