2024-04

QATAR NATIONAL DIALOGUE ON CLIMATE CHANGE
حـــوار قطـــر الوطني حـــول تـــغيـــر الـــمـناخ
1-2 OCTOBER 2024 أكتـــوبر 2-1

OPTIMIZING OPPORTUNITIES FOR ENERGY TRANSITION

QNDCC 2024 White Paper

وزارة البيئـــة والتغيّـــر المناخـــي
Ministry of Environment and Climate Change
State of Qatar • دولـــة قطـــر

إرثنا earthna
عـضـو في مـؤسـسـة قـطـر
Member of Qatar Foundation

White Paper
QNDCC
December 17, 2024

OPTIMIZING OPPORTUNITIES FOR ENERGY TRANSITION

Prepared by Strategy Hub

About Earthna

Earthna Center for a Sustainable Future (Earthna) is a non-profit policy, research, and advocacy organization, established by Qatar Foundation to promote and enable a coordinated approach to environmental, social, and economic sustainability and prosperity.

Earthna is a facilitator of sustainability efforts and action in Qatar and other hot and arid countries, focusing on sustainability frameworks, circular economies, energy transition, climate change, biodiversity and ecosystems, cities and the built environment, and education, ethics, and faith. By bringing together technical experts, academia, government and non-government organizations, businesses and civil society, Earthna fosters collaboration, innovation, and positive change.

Using their home – Education City – as a testbed, Earthna develops and trials sustainable solutions and evidence-based policies for Qatar and hot and arid regions. The organization is committed to combining modern thinking with traditional knowledge, contributing to the well-being of society by creating a legacy of sustainability within a thriving natural environment.

For more information about Earthna and to stay updated on our latest initiatives, please visit www.earthna.qa

REPORT TEAM

Dr. Soud K. Al-Thani
Earthna, Qatar Foundation,
Doha, Qatar

Mohamed A. Mohamed
Earthna, Qatar Foundation,
Doha, Qatar

Francis Antony Jacob
Earthna, Qatar Foundation,
Doha, Qatar

Sheikha Amna Al Thani
Strategy Hub,
Doha, Qatar

Haajerah Khan
Strategy Hub,
Doha, Qatar

Abdul Rehmaan Qayyum
Strategy Hub,
Doha, Qatar

Mohammed Al Agha
Intern,
Doha, Qatar

EDITORIAL COMMITTEE

Dr. Gonzalo Castro de la Mata
Earthna, Qatar Foundation

Dr. Soud Khalifa Al Thani
Earthna, Qatar Foundation

Dr. Radhouane Ben Hamadou
Earthna, Qatar Foundation

Dr. Mona Matar Al-Kuwari
Earthna, Qatar Foundation

Dr. Muez Ali
Earthna, Qatar Foundation

Talha A. Mirza
Earthna, Qatar Foundation

Sebastien P. Turbot
Earthna, Qatar Foundation

P.O. Box: 5825, Doha, Qatar
Number: (+974) 4454 0242
Website: www.earthna.qa

PI: ETCC-2024-008

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The global energy landscape is undergoing a pivotal shift driven by the urgent need to combat climate change, secure reliable energy sources, and foster sustainable economic development. The transition from fossil fuels to renewable energy has become a socio-economic and environmental necessity, with countries around the world recognizing the need for significant policy, infrastructure, and technological advancements. Qatar, as one of the world's largest liquefied natural gas (LNG) exporters, is uniquely positioned to lead in this transition by leveraging LNG as a transitional fuel while actively investing in renewable energy initiatives.

Qatar's commitment to the Paris Agreement and its national climate targets underscores the importance of balancing economic growth with environmental responsibility. Strategic investments in solar power, Carbon Capture, Utilization, and Storage (CCUS), and smart grid technologies are central to Qatar's efforts to reduce emissions and diversify its energy mix. The Al Kharsaah Solar Power Plant, along with planned solar projects in Mesaieed and Ras Laffan, exemplify Qatar's ambitions in expanding renewable energy capacity. Similarly, CCUS initiatives, aimed at capturing millions of tons of CO_2 annually, showcase Qatar's dedication to sustainable energy solutions.

This white paper explores the critical role of technological innovation, policy reforms, and collaborative frameworks in achieving a balanced and resilient energy future.

SCOPE AND METHODOLOGY

The scope of this paper covers the topics discussed by the panelists in the Session "Optimizing Opportunities for Sustainable Transition" on the first day of the Qatar National Dialogue on Climate Change (QNDCC) 2024, including: H.E. Dr. Ibrahim Ibrahim, Vice-Chairman of the Al Attiyah Foundation, Former Economic Advisor at Emiri Diwan; Mr. Justin Mundy, Chairman of Earthna, Chairman of SLM Partners, Chairman of the Sustainability-linked Sovereign Debt Hub; and Mr. Aftab Ahmed, IFC's Regional Director for the Middle East, Pakistan, and Afghanistan.

In addition, supplementary research has been conducted to substantiate the session's key findings and produce optimally relevant recommendations. The findings can be utilized to enhance Qatar's national climate change goals and develop relevant local and regional climate change initiatives. The methodology followed for data collection includes preliminary academic research, on-site session note-taking, and post-session supplementary research and benchmarking. Based on these detailed insights, this White Paper provides a set of recommendations to support the energy transition to address climate change.

THE IMPERATIVE FOR ENERGY TRANSITION

The energy transition is a global necessity, driven by environmental, economic, and socio-cultural priorities. It seeks to address climate change, reduce economic vulnerabilities from fossil fuel dependence, and mitigate societal disruptions from environmental crises, presenting an opportunity to build a sustainable and equitable future.

The shift to renewable energy is driven by the urgent need to reduce greenhouse gas emissions, mitigate climate change, and preserve vital ecosystems. Fossil fuels are a major source of carbon dioxide (CO_2), accounting for 74% of U.S. greenhouse gas emissions in 2019, significantly driving global warming. [1] The International Renewable Energy Agency (IRENA) stresses that achieving the 1.5°C climate target requires a drastic reduction in CO_2 emissions, yet current trends point to a 3.5°C increase by 2100.[2]

Further, fossil fuel emissions endanger marine ecosystems, with rising sea temperatures causing coral bleaching and widespread coral death, as seen in the loss of 50% of the Great Barrier Reef's coral cover since the 1980s.[3] Oil spills and other extraction hazards also inflict severe damage on coastal and marine environments.[4]

On land, fossil fuel extraction destroys habitats and increases pollution, contributing to biodiversity loss. And the combustion of fossil fuels releases harmful air pollutants like sulfur dioxide and mercury, leading to health issues such as asthma and lung cancer. [5]

Economically, the continued reliance on fossil fuels poses risks, with global GDP projected to decline by up to 18% by 2050 due to climate-related impacts like reduced productivity, agricultural losses, and higher healthcare costs.[6] Shifting to renewables offers economic opportunities, with global renewable energy jobs growing to 13.7 million in 2022 and clean energy sectors outpacing broader job growth in countries like the U.S. [7, 8]

Moreover, renewables enhance energy security by reducing reliance on volatile fossil fuel imports, which accounted for 80% of global primary energy consumption in 2020.[9] Investments in domestic renewable infrastructure mitigate supply risks and foster stability. Decarbonization efforts, such as phasing out coal plants and internal combustion engine vehicles, are accelerating cleaner energy transitions worldwide, exemplified by Germany's plans to exit coal by 2038 and shift to zero-emission vehicles by 2050.[10, 11]

Technological advancements and falling renewable energy costs further drive the transition. Between 2010 and 2020, the levelized cost of solar PV fell by 85% and onshore wind by 56%, making renewables increasingly competitive. By 2022, 86% of newly commissioned renewable capacity was cheaper than fossil fuel options, making renewables a viable solution for both developed and developing countries.[12]

Lastly, the socio-cultural dimensions of the energy transition focus on equity and accessibility. Despite advancements, 733 million people worldwide lacked electricity in 2021, primarily in sub-Saharan Africa and South Asia, while 2.4 billion relied on biomass for cooking, leading to severe health issues. Achieving universal access to affordable and modern energy by 2030, as outlined in Sustainable Development Goal 7 (SDG 7), requires intensified efforts to expand green energy infrastructure in underserved regions.[13]

Consumer behavior is also shifting toward sustainability. A 2024 PwC report found that over 80% of consumers are willing to pay a premium for sustainable energy solutions, reflected in the growing adoption of renewables, energy-efficient appliances, and EVs. Global EV sales surpassed 10 million units in 2022, a 55% increase driven by demand for cleaner transportation.[14]

Therefore, the energy transition is a vital opportunity to address environmental, economic, and socio-cultural challenges while fostering sustainability and equity. By investing in renewables, advancing technologies, and ensuring accessibility, nations can reduce climate impacts, enhance energy security, and promote economic growth. This transition demands urgent, inclusive action and global collaboration to secure a resilient and just future for all.

[1] Environmental Protection Agency, Fast Facts: U.S. Transportation Sector Greenhouse Gas Emissions, 1990–2019, accessed November 26, 2024, https://www.epa.gov/sites/production/files/2021-04/documents/fastfacts-1990-2019.pdf.pdf.
[2] "IPCC Fifth Assessment Report," Wikipedia, accessed November 26, 2024, https://en.wikipedia.org/wiki/IPCC_Fifth_Assessment_Report.
[3] Gulf Times, "Marine Life Expert Talks About Coral Reefs in Qatar," accessed November 26, 2024, https://www.gulf-times.com/story/629019/marine-life-expert-talks-about-coral-reefs-in-qatar.
[4] National Oceanic and Atmospheric Administration (NOAA), "Deepwater Horizon," accessed November 26, 2024, https://darrp.noaa.gov/oil-spills/deepwater-horizon.
[5] Environmental and Energy Study Institute, "Fact Sheet: Climate, Environmental, and Health Impacts of Fossil Fuels," 2021, https://www.eesi.org/papers/view/fact-sheet-climate-environmental-and-health-impacts-of-fossil-fuels-2021.
[6] Swiss Re, "The Economics of Climate Change Risks," April 22, 2021, https://www.swissre.com/media/press-release/nr-20210422-economics-of-climate-change-risks.html.
[7] International Renewable Energy Agency, "Renewable Energy and Jobs: Annual Review 2023," 2023, https://www.irena.org/Digital-Report/Renewable-energy-and-jobs-Annual-review-2023.
[8] Reuters, "US Clean Energy Jobs Growth Rate Double That of Overall Jobs, Report Says," 2024, https://www.reuters.com/business/energy/us-clean-energy-jobs-growth-rate-double-that-overall-jobs-report-says-2024-08-28.
[9] Hannah Ritchie and Max Roser, "Emissions by Fuel," Our World in Data, accessed November 26, 2024, https://ourworldindata.org/emissions-by-fuel.
[10] Ibid.
[11] Ibid.
[12] International Renewable Energy Agency (IRENA), "Renewables Competitiveness Accelerates Despite Cost Inflation," August 2023, https://www.irena.org/News/pressreleases/2023/Aug/Renewables-Competitiveness-Accelerates-Despite-Cost-Inflation.
[13] PricewaterhouseCoopers (PwC), 2024 Voice of the Consumer Survey, accessed November 26, 2024, https://www.pwc.com/gx/en/news-room/press-releases/2024/pwc-2024-voice-of-consumer-survey.html.
[14] International Energy Agency (IEA), Global EV Outlook 2023: Executive Summary, accessed November 26, 2024, https://www.iea.org/reports/global-ev-outlook-2023/executive-summary.

AGREEMENTS AND POLICIES DRIVING ENERGY TRANSITION

The transition to sustainable energy systems is one of the most critical challenges facing the modern world, driven by the dual imperatives of combating climate change and meeting rising global energy demands. International agreements, regional priorities, and national strategies are converging to accelerate this transformation. From the Paris Agreement's global framework to the ambitious, Nationally Determined Contributions (NDCs) and national visions, such as those outlined by Qatar, Saudi Arabia, and the United Arab Emirates, to diversify their economies, these efforts collectively aim to reduce emissions, advance renewable energy adoption, and foster economic sustainability.

INTERNATIONAL ACCORDS

As the world confronts the dual challenges of climate change and increasing energy demand, global agreements play a pivotal role in driving the global energy transition. The Paris Agreement, adopted in 2015 under the United Nations Framework Convention on Climate Change (UNFCCC), stands at the forefront of these efforts. With 196 signatories, it aims to limit global temperature rise to well below 2°C, with aspirations for a 1.5°C target, by requiring countries to submit Nationally Determined Contributions (NDCs). These NDCs outline strategies to reduce greenhouse gas emissions, promote renewable energy, and foster adaptation to climate impacts.[15] The Paris Agreement has sparked increased interest in developing sustainable energy solutions, addressing both the technological innovations required and the equitable distribution of energy access, ensuring a more inclusive approach to meeting global climate goals.[16] The Paris Agreement significantly impacts energy transition by encouraging countries to phase out fossil fuels and adopt low-carbon technologies, fostering innovation and international cooperation in clean energy solutions.

In line with these efforts, the Global Stocktake at COP28 served as a critical checkpoint in advancing climate action. The Global Stocktake is a key component of the Paris Agreement, held every five years, where countries assess their collective progress towards climate goals.[17] Nearly 200 parties collectively acknowledged the urgency of addressing climate change, with the Stocktake reflecting the scientific consensus that global greenhouse gas emissions must be cut by 43% by 2030, compared to 2019 levels, to keep the 1.5°C target within reach. [18]

This momentum is reflected in the broader international development agenda, particularly in the United Nations Sustainable Development Goals (SDGs). The SDGs consist of 17 global objectives aimed at addressing the world's most pressing challenges with the overarching aim of achieving a more sustainable and equitable world by 2030. These goals are universal, with specific targets designed to be measurable and applicable across all countries, promoting global collaboration. Goal 7, in particular, focuses on ensuring access to affordable, reliable, sustainable, and modern energy for all.[19] By promoting a just and inclusive energy transition, the SDGs motivate nations to accelerate renewable energy adoption, ensuring its benefits are equitably shared across all communities.

REGIONAL PACTS

Regional energy agreements are increasingly playing a role in addressing shared challenges, promoting economic integration, and driving the transition to sustainable energy sources. These agreements enable countries within specific regions to collaborate on energy production, distribution, and innovation while optimizing resources. For instance, the European Union (EU) has established a comprehensive framework for energy cooperation among its member states through initiatives such as the European Green Deal. This ambitious policy aims to achieve climate neutrality by 2050, emphasizing renewable energy adoption, energy efficiency, and emission reductions. [20]

The GCC has also made advances in regional energy integration through initiatives like the GCC Interconnection Authority. This power grid enhances electricity reliability and facilitates energy trading among member states.[21] Such initiatives underscore the growing energy collaboration between countries, such as within the GCC or the EU, reflecting their shared commitment to advancing renewable energy infrastructure and diversifying energy portfolios.

NATIONAL VISIONS/STRATEGIES

At the national level, countries have developed strategies to transition to sustainable energy. As an example, Qatar has crafted a roadmap through the National Vision 2030 (QNV 2030), focusing on sustainable economic development while managing its resources. It underscores the optimal exploitation of oil and gas to create a balance between reserves and production, supporting both economic diversification and the long-term maintenance of strategic reserves for national security.[22] The vision advocates for a vibrant oil and gas sector, driving technological innovations that enhance the energy sector and contributes to the development of human resources and infrastructure. Furthermore, it envisions Qatar becoming a global leader in clean energy, leveraging its fully developed gas industry as a major source of transitional energy.

The National Development Strategy 3 (NDS3) builds upon QNV 2030, outlining the country's roadmap for navigating the global energy transition and diversifying its economy. Qatar seeks to expand its role as a reliable energy exporter while simultaneously addressing the urgent need for low-carbon energy solutions. Through the completion of the North Field Expansion (NFE), Qatar aims to enhance its status as one of the world's leading gas producers, while investing in emerging low-emission technologies like blue ammonia and carbon capture to mitigate its environmental impact. The NDS3 sets ambitious goals to reduce emissions by at least 25%, with actions spanning across multiple sectors, including oil and gas, power and water, transportation, and industry.

This strategy includes advancing carbon capture technologies, promoting renewable energy, and introducing energy efficiency measures to accelerate Qatar's transition to a sustainable energy future.[23] Building on this, The Qatar National Renewable Energy Strategy (QNRES) – jointly developed by Kahramaa Qatar and QatarEnergy – supports NDS3 by targeting 18% renewable energy in the power mix by 2030, primarily through 4 GW of solar PV. It aims to reduce CO_2 emissions by 27%, enhance energy security, and boost economic competitiveness with $7.6 billion in investments.

By fostering private sector participation, advancing policies like net-billing, and addressing environmental challenges, QNRES positions Qatar as a leader in renewable energy, aligning with its climate goals and National Vision 2030 and NDS3.

Similarly in the Gulf region, UAE's Dubai Clean Energy Strategy 2050 envisions providing 75% of Dubai's energy needs through clean sources by 2050, positioning the emirate as a global hub for clean energy and green economy initiatives. This strategy underscores the UAE's commitment to achieving energy sustainability through innovation and investment in renewable technologies.[24]

In Saudi Arabia, the National Renewable Energy Program (NREP) reflects the goals of Vision 2030, targeting a renewable energy capacity of 58.7 GW by 2030. This program is instrumental in diversifying Saudi Arabia's energy mix, reducing its reliance on fossil fuels, and fostering a sustainable energy future. Both nations' strategies emphasize their leadership in advancing renewable energy technologies and promoting sustainable economic growth in the Middle East.[25]

[15] United Nations Framework Convention on Climate Change Secretariat, "The Paris Agreement," https://unfccc.int/process-and-meetings/the-paris-agreement.Accessed
[16] Mark M. Akrofi, Mahesti Okitasari, and Richa Kandpal, "Recent Trends on the Linkages between Energy, SDGs and the Paris Agreement: A Review of Policy-Based Studies," Discover Sustainability 3, no. 1 (October 10, 2022), https://doi.org/10.1007/s43621-022-00100-y.
[17] United Nations Framework Convention on Climate Change, "Why the Global Stocktake Is Important for Climate Action This Decade," Accessed November 17, 2024. https://unfccc.int/topics/global-stocktake/about-the-global-stocktake/why-the-global-stocktake-is-important-for-climate-action-this-decade.
[18] United Nations Framework Convention on Climate Change, "COP28 Agreement Signals 'Beginning of the End' of the Fossil Fuel Era," December 13, 2023, https://unfccc.int/news/cop28-agreement-signals-beginning-of-the-end-of-the-fossil-fuel-era.
[19] United Nations, "Sustainable Development Goals," Accessed November 19, 2024. https://sdgs.un.org/goals
[20] European Commission, "European Green Deal," accessed November 26, 2024, https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en.
[21] Gulf Cooperation Council Interconnection Authority (GCCIA) accessed November 26, 2024, https://gccia.com.sa/.
[22] Planning and Statistics Authority, "Qatar National Vision 2030," 2008, https://www.psa.gov.qa/en/qnv1/Documents/QNV2030_English_v2.pdf.
[23] Planning and Statistics Authority, "Third Qatar National Development Strategy," 2024. https://www.psa.gov.qa/en/nds1/nds3/Documents/QNDS3_EN.pdf.
[24] Emirates Nature-WWF, Enabling the UAE's Energy Transition, accessed November 26, 2024, https://www.emiratesnaturewwf.ae/sites/default/files/doc-2018-09/Enabling%20the%20UAE%E2%80%99s%20energy%20transition_%20F4_EWSWWF_WEB.pdf.
[25] Saudi Association for Energy Economics, Energy Transition in Saudi Arabia, accessed November 26, 2024, https://www.saudi-aee.sa/wp-content/uploads/2022/01/1-Energy-Transition-in-Saudi-Arabia.pdf.

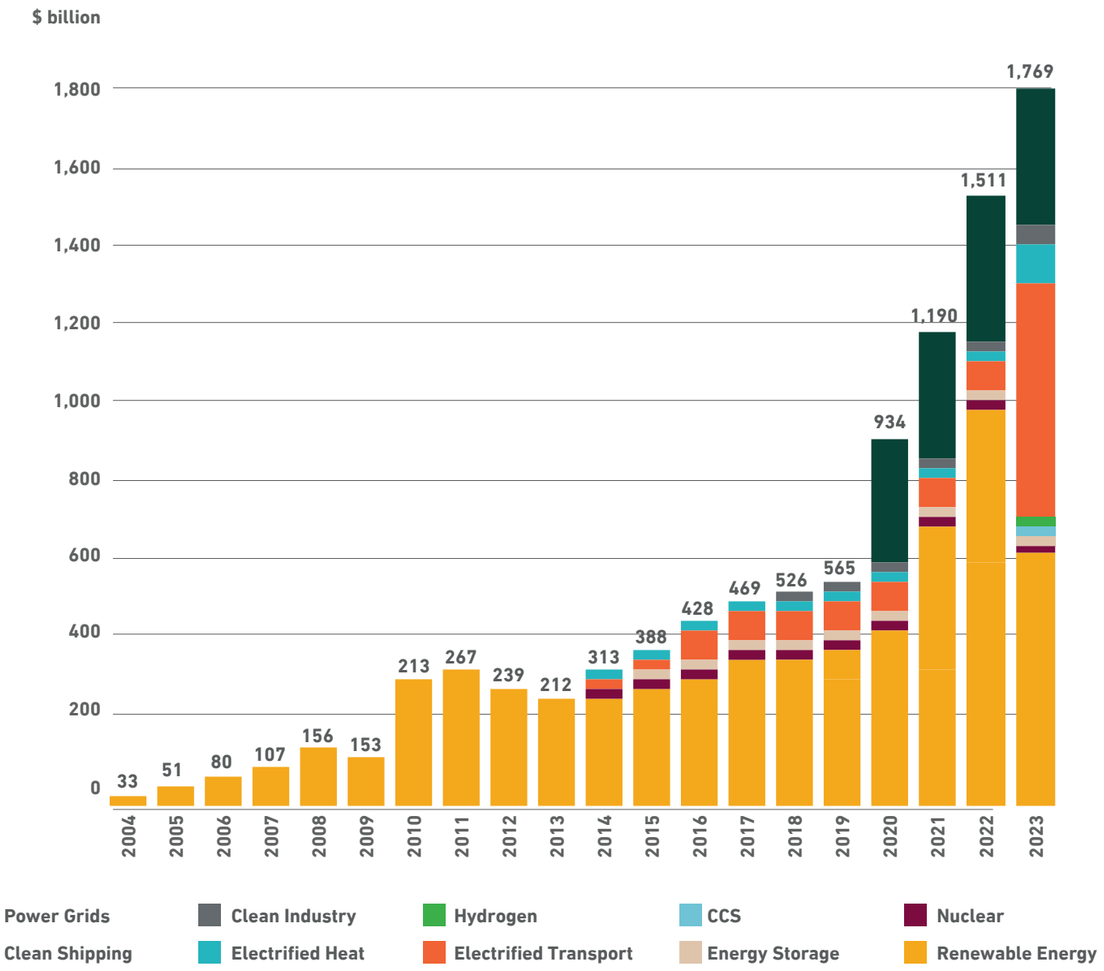
CURRENT STATUS OF ENERGY TRANSITION

GLOBAL RENEWABLE ENERGY TRENDS

The global energy landscape is undergoing a transformation, driven by the need to address climate change, advancements in renewable energy technologies, and shifting investment patterns. Renewable energy sources such as solar and wind are at the forefront of this transition, with global investments in clean energy reaching $1.8 trillion in 2023 (as seen in Figure 1).[26] This shift is reshaping energy markets as key energy importers, including Europe and China, prioritize decarbonization efforts and reduce reliance on traditional fossil fuels. However, natural gas remains a critical transitional fuel, bridging the gap between coal and renewables in many regions.

[26] Renewable Energy World, "Energy Transition Investments Hit Record $1.8 Trillion in 2023," accessed November 11, 2024, https://www.renewableenergyworld.com/news/energy-transition-investments-hit-record-1-8-trillion-in-2023/
[27] Reuters, "Renewables Provided Record 30% of Global Electricity in 2023, Ember Says," May 7, 2024, https://www.reuters.com/sustainability/climate-energy/renewables-provided-record-30-global-electricity-2023-ember-says-2024-05-07/.
[28] Edie, "Global Wind Industry Growth Hit Record High in 2023," Accessed November 26, 2024, https://www.edie.net/report-global-wind-industry-growth-hit-record-high-in-2023/.
[29] SolarBe Global, "IEA Forecasts Over 4,000GW of Global Solar Capacity by 2030," Accessed November 26, 2024. https://www.solarbeglobal.com/iea-forecasts-over-4000gw-of-global-solar-capacity-by-2030/.
[30] European Commission and the Ministry of Ecology and Environment of the People's Republic of China, "EU-China Cooperation on Green Recovery," European Commission, https://climate.ec.europa.eu/system/files/2021-06/eu_chn_paper_green_recovery_20201019_en.pdf.
[31] Sino-German Cooperation on Climate Change, "China's Installed Solar Capacity Rises 55.2% in 2023," January 26, 2024. https://climatecooperation.cn/climate/chinas-installed-solar-capacity-rises-55-2-in-2023/.
[32] Kara Anderson, "What Is Germany's Energiewende?" Greenly, March 20, 2024. https://greenly.earth/en-gb/blog/ecology-news/what-is-germanys-energiewende.
[33] Ibrahim Ibrahim Remarks on the panel "Optimizing Opportunities for Sustainable Transition." Qatar National Dialogue for Climate Change, Doha, Qatar, October 1, 2024.

Figure 1: Global investment in energy transition, by sector



Renewables currently account for over 30% of global electricity generation, with projections to grow to 50% by 2030.[27] In 2023, the global wind industry installed a record 117 GW of new capacity, representing a 50% increase from the previous year.[28] Similarly, solar energy continues to experience rapid growth, driven by cost reductions and advancements in photovoltaic technology. The International Energy Agency (IEA) highlights that solar PV alone will account for more than half of the global renewable capacity expansion by 2030. These trends underscore the pivotal role of renewables in meeting ambitious net-zero targets.[29]

Key energy importers, such as Europe and China, are prioritizing decarbonization efforts, which could potentially reduce demand for traditional fossil fuels over time.[30] China contributed over 120 GW of new renewable capacity in 2023, fueled by substantial investments in solar and wind energy.[31] In Europe, countries like Germany are accelerating their energy transition efforts, diversifying energy sources, and investing in renewable energy and smart grid technologies, owing to their push for sustainability, as well as geopolitical tensions.[32]

KEY REGIONAL DEVELOPMENTS

The Gulf Cooperation Council (GCC) countries are actively advancing their energy transitions through a combination of national initiatives and international collaborations. Qatar is committed to reducing its carbon footprint and aligning with global climate targets. As Dr. Ibrahim Ibrahim mentioned, Qatar's Al Kharsaah Solar Power Plant (as seen in Figure 2), a large-scale solar facility developed with TotalEnergies, QatarEnergy and Marubeni, is pivotal.[33] The plant, with a capacity of 800 MW, is designed to supply approximately 10% of Qatar's peak electricity demand, reducing the country's reliance on natural gas for power generation. It is also expected to offset 26 million tons of CO_2 emissions over its lifetime, positioning Qatar as a leader in renewable energy innovation. Further, Qatar is investing in other renewable projects, such as new solar plants in Mesaieed and Ras Laffan, which are expected to augment the country's renewable capacity.[34]

In Saudi Arabia, the Saudi Power Procurement Company finalized power purchase agreements in June 2024 for three new solar photovoltaic projects totaling 5.5 gigawatts. These agreements, involving entities like ACWA Power, Badeel (a subsidiary of the Public Investment Fund), and Aramco Power, are integral to Saudi Arabia's strategy to diversify its energy mix and increase renewable energy capacity. [36]

The United Arab Emirates (UAE) is making steady progress, with Masdar, the UAE's leading renewable energy company, announcing plans to expand its wind and solar capacity to 100 GW by the end of the decade. This ambitious target positions Masdar among the world's foremost renewable energy companies, surpassing competitors like Spain's Iberdrola and France's Engie. [37]

Figure 2: Qatar's Al-Kharsaah Power Plant [35]

[34] A TotalEnergies, "Al Kharsaah, A Pioneering Solar Power Plant in Qatar," accessed November 7, 2024, https://totalenergies.com/projects/solar/al-kharsaah-pioneering-solar-power-plant-qatar.
[35] Global Energy World, "Sungrow Delivered 800MW Al Kharsaah Solar Power Plant in Qatar," last modified October 25, 2022, https://www.globalenergyworld.com/news/sustainable-energy/2022/10/25/sungrow-delivered-800mw-al-kharsaah-solar-power-plant-qatar.
[36] "Saudi Power Procurement Company Signs Deals for Three Solar Projects," Reuters, June 27, 2024, https://www.reuters.com/business/energy/saudi-power-procurement-company-signs-deals-three-solar-projects-2024-06-27/.
[37] "UAE's Masdar outlines plan to become leading renewables group," Financial Times, accessed November 27, 2024, https://www.ft.com/content/1386a3e7-db11-43b6-ad07-900c401a66a3.
[38] Ahmed, Aftab Remarks on the panel "Optimizing Opportunities for Sustainable Transition," Qatar National Dialogue for Climate Change, Doha, Qatar, October 1, 2024.
[38] "World Bank Signs Project to Scale Up Innovative Renewable Energy Technologies in India," World Bank Press Release
[39] Ibid.

CURRENT FINANCIAL OUTLETS SUPPORTING ENERGY TRANSITION

As the global and regional shift toward renewable energy accelerates, certain financing outlets are being leveraged to bridge the funding gap for sustainable infrastructure. These outlets include multinational institutions, organized climate funds, and capital markets, which bridge the funding gap for sustainable infrastructure and drive the energy transition forward.

Multinational institutions, such as the World Bank, provide concessional loans, grants, and technical assistance for renewable energy projects, particularly in developing countries. As discussed by Mr. Aftab Ahmed, the World Bank provides concessional loans and grants for renewable energy projects, particularly in developing countries.[38] For instance, India's renewable energy expansion has benefited from climate finance tools through the World Bank, which have funded solar projects and grid upgrades.[39]

Climate funds also play a critical role by offering targeted financial support for climate adaptation and mitigation efforts. A key example of climate finance is the Glasgow Climate Pact, established during COP26 in 2021. This Pact underscores the commitment of developed nations to support developing countries in their climate transition. A pivotal aspect of the pact is the agreement to at least double adaptation finance from 2019 levels by 2025, aiming to reach approximately $40 billion annually. This financial boost is intended to assist developing nations in enhancing resilience and adapting to climate impacts. Additionally, the pact emphasizes the need for developed countries to fulfill the longstanding pledge of mobilizing $100 billion annually to support climate action in developing regions.[40]

Similarly, the Green Climate Fund collaborates with international organizations and governments to provide concessional loans and grants for renewable energy infrastructure, particularly in emerging markets.[41]

Capital markets contribute further to mobilizing private capital for sustainable energy projects, particularly through instruments like green bonds. These bonds are debt securities issued to raise capital specifically for environmentally sustainable projects, such as wind and solar energy installations. The global green bond market has grown rapidly, reaching nearly $1 trillion in 2021,[42] reflecting a rising demand for climate-aligned investments. Green bonds provide governments and corporations with access to a large pool of environmentally conscious investors and help mobilize capital for sustainable projects.

In May 2024, Qatar issued its inaugural green bonds, raising $2.5 billion to fund environmentally friendly projects (as seen in Figure 3). This landmark issuance was divided into two tranches: a $1 billion five-year bond and a $1.5 billion ten-year bond. The bonds attracted substantial investor interest, exceeding $14 billion, highlighting confidence in Qatar's commitment to sustainable development.[43] The net proceeds of green bonds issued are planned to be used to finance and refinance companies operating in the climate change and sustainability domain. [44] This will potentially support Qatar in mobilizing capital toward sustainable energy projects, facilitating the transition to a low-carbon economy, supporting efforts to combat climate change, and positioning itself as a leader in the region's green finance sector.

Figure 3: Qatar's green bond and sustainability efforts

[40] United Nations Framework Convention on Climate Change, "The Glasgow Climate Pact – Key Outcomes from COP26," accessed November 7, 2024, https://unfccc.int/process-and-meetings/the-paris-agreement/the-glasgow-climate-pact-key-outcomes-from-cop26.
[41] Green Climate Fund, "Home Page," n.d., https://www.greenclimate.fund/.
[42] International Finance Corporation, Emerging Market Green Bonds Report 2021, https://www.ifc.org/content/dam/ifc/doc/mgrt/202206-emerging-market-green-bonds-report-2021-vf-2.pdf.
[43] QNB, "Green Bond Framework," accessed November 11, 2024, https://www.qnb.com/sites/qnb/qnbqatar/document/en/enGreen2021#:~:text=The%20net%20proceeds%20of%20green,eligibility%20criteria%20in%20this%20Framework.
[43] The Peninsula Newspaper, "The Peninsula Qatar," August 23, 2022, https://thepeninsulaqatar.com/article/23/08/2022/mega-solar-power-plants-in-qatar-to-start-production-by-end-of-2024.
[44] Vision 2030, "Dumat Al Jandal Wind Farm." Accessed November 18, 2024, https://www.vision2030.gov.sa/en/explore/explore-more/dumat-aljandal.

TECHNOLOGICAL SOLUTIONS ENABLING THE ENERGY TRANSITION

Technological innovation is central to the global shift towards sustainable energy solutions, enabling cleaner, more efficient energy systems. Key advancements, including solar and wind energy, carbon capture and storage (CCS), smart grid technologies, and green hydrogen are pivotal for reducing carbon emissions and ensuring reliable energy supplies.

SOLAR AND WIND ENERGY

Solar energy technologies are foundational to the global energy transition. Solar photovoltaic (PV) systems, which convert sunlight into electricity, are particularly effective in regions with high solar irradiance, such as the Middle East. Solar energy plants are expected to generate a combined capacity of 875 megawatts by the end of 2024. As an example, The IC Solar project in Qatar will contribute to reducing the country's carbon emissions by approximately 28 million tons over its lifetime.[45]

[50] Kyle Hodge, "Carbon Capture and Storage (CCS) in the Middle East – a Future Powerhouse of the Hydrogen Industry?" S&P Global, October 9, 2022, https://www.spglobal.com/commodityinsights/en/ci/research-analysis/carbon-capture-and-storage-ccs-in-the-middle-east.html.
[51] S&P Global Commodity Insights, "Location of Operational CCS Projects in the Middle East," accessed November 26, 2024, https://cdn.ihsmarkit.com/www/images/1022/Location-of-operational-CCS-projects-in-the-Middle-East.png.
[52] Equinor, "Sleipner CO_2 Storage Data," June 12, 2019, https://www.equinor.com/news/archive/2019-06-12-sleipner-co2-storage-data.

Additionally, wind energy holds major potential as a renewable power source, like solar energy. In the Middle East, Saudi Arabia is making progress in developing wind energy. An example is through the development of the Dumat Al Jandal Wind Farm, located in the Al Jouf region. Inaugurated in 2019 as part of the Kingdom's National Renewable Energy Program, the wind farm became operational in 2022 with 99 turbines and a total capacity of 400 MW. This project, the first and largest of its kind in Saudi Arabia, is capable of supplying electricity to around 70,000 homes. The project sets a benchmark with its record-breaking low electricity generation rate of $0.0199/KWh, earning it the 2019 Renewable Deal of the Year award. This wind farm is crucial to Saudi Arabia's Vision 2030 goal of achieving 50% renewable energy in its energy mix by 2030.[46]

Meanwhile, other regions around the world are also making substantial investments in wind power, recognizing its capability to generate clean, sustainable electricity. For instance, Germany, a global leader in wind energy, has one of the largest onshore wind power capacities in the world. As of 2023, nearly 29,000 turbines with a cumulative capacity of 61 gigawatts (GW) were operational across the country.[47]

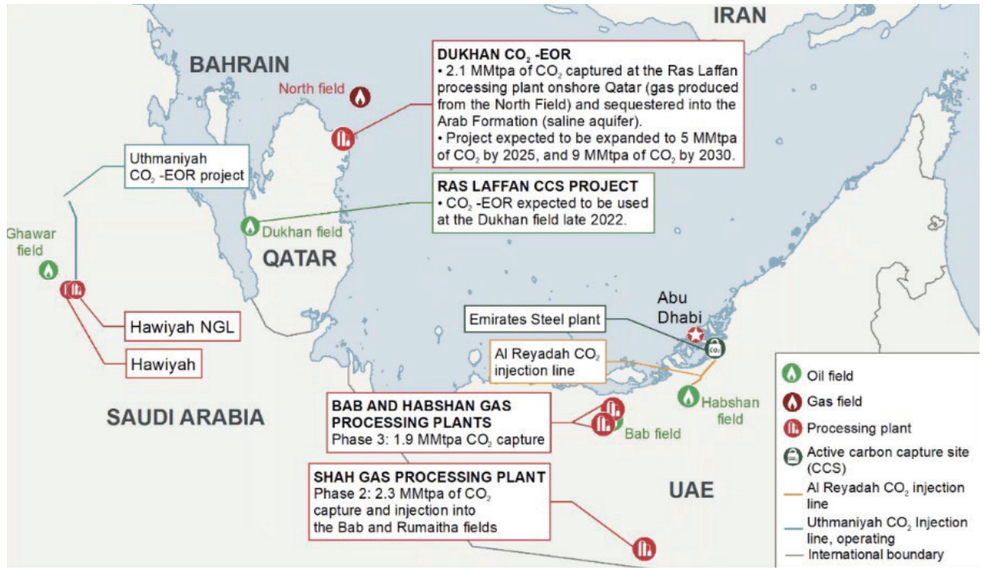
CARBON CAPTURE AND STORAGE (CCS)

Carbon capture and storage (CCS) technology is critical for reducing emissions from fossil fuel-dependent industries and power plants by capturing CO_2 emissions at their source and storing them underground, thus lowering the carbon footprint of heavy industries. According to the Center for Climate and Energy Solutions, CCS could mitigate up to 14% of global CO_2 emissions by 2050,[48] making it a key technology in the fight against climate change.

CCS initiatives are gaining momentum in the Middle East, a region that currently accounts for approximately 10% of the global CO_2 capture capacity. The region's unique drivers for adopting CCS include high per capita CO_2 emissions, rapid economic and industrial growth contributing to increased emissions, and opportunities to integrate CCS in power generation and blue hydrogen production. Additionally, the region's reliance on fossil fuels for energy, desalination, and industrial activities, alongside abundant natural gas reserves, makes CCS a vital tool for balancing emission reductions with energy demands.[49]

This growing interest in CCS is underscored by the development of three major commercial facilities: Saudi Arabia's Uthmaniyah CO_2-enhanced oil recovery (EOR) Demonstration Project, Abu Dhabi's Al Reyadah CO_2-EOR Project, and Qatar's Ras Laffan CCS Project. [50] A more detailed snapshot of CCS projects in the region is given below in Figure 4.

Figure 4: CCS projects in the GCC [51]



www.energysage.com/electric-vehicles/evs-vs-ices-full-lifecycle-environmental-impact-analysis/.
[54] Deepak John, "Qatar Advancing o
n Transition to Electric Vehicles," The Peninsula Qatar, July 21, 2024, https://thepeninsulaqatar.com/article/21/07/2024/qatar-advancing-on-transition-to-electric-vehicles.
[55] Sanaullah Ataullah, "Kahramaa Sets u
trification of Public Bus Fleet: Transport Minister," Qatar Tribune, September 25, 2024, https://www.qatar-tribune.com/article/142005/nation/qatar-has-achieved-73-electrification-of-public-bus-fleet -transport-minister.

[47] Clean Energy Wire, "German Onshore Wind Power – Output, Business and Perspectives," last modified February 13, 2024, https://www.cleanenergywire.org/factsheets/german-onshore-wind-power-output-business-and-perspectives.
[48] Center for Climate and Energy Solutions, "Carbon Capture," accessed November 11, 2024, https://www.c2es.org/content/carbon-capture/.
[49] Abu Zahra, Mohammad and Global CCS Institute, "Current Status of CCUS in the Middle East and North Africa (MENA) Region," The 3rd CCUS & Hydrogen International Symposium, August 25, 2022. https://www.env.go.jp/earth/ccs/3rd_speech5.pdf.

[53] Federal Ministry for Economic Affairs and Climate Action (BMWK), "Cabinet Clears Path for CCS in Germany," May 20, 2024, https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2024/05/20240529-cabinet-clears-path-for-ccs-in-germany.html.
[54] Oluwayemi-Oniya Aderibigbe and Trynos Gumbo, "The Role of Electric Vehicles in Greening the Environment: Prospects and Challenges." REAL CORP 2023 Proceedings, September 18–20, 2023. https://corp.at/archive/CORP2023_51.pdf.
[54] Jacob Marsh, "Electric vs. Gas Cars: Which Is Better for the Environment?" EnergySage, December 6, 2023, https://

Globally, CCS projects like Norway's Sleipner Project, operational since 1996 and capturing approximately 1 million tons of CO_2 annually, highlight the long-term viability of carbon storage technologies. [52] Additionally, Germany has recently taken steps to integrate CCS into its climate strategy. The German government adopted key principles for a Carbon Management Strategy in 2024, focusing on using CCS for hard-to-abate emissions and permitting offshore CO_2 storage, aligning with European counterparts like Norway.

This strategy aims to establish clear rules for CO_2 pipeline infrastructure, support industrial decarbonization, and foster long-term industrial competitiveness while excluding coal-based emissions from CCS initiatives.[53] The policy underscores the importance of CCS for achieving Germany's goal of climate neutrality by 2045 and maintaining industrial viability in a low-carbon economy.

ELECTRIC MOBILITY

Electric mobility has emerged as an enabler of energy, offering a pathway to reduce greenhouse gas emissions, improve urban air quality, and enhance energy efficiency.[54] The shift from traditional combustion-engine vehicles to electric alternatives aligns with global efforts to mitigate climate change while supporting sustainable development. Electric Vehicles (EVs), metros, and trams represent cornerstone technologies in this shift, creating ripple effects across environmental, economic, and social dimensions.

The global impact of electric mobility is considerable. EVs emit fewer greenhouse gases over their lifecycle compared to internal combustion engine vehicles, even when powered by electricity from fossil-based grids.[55] Qatar has rapidly expanded its EV infrastructure establishing over 200 charging stations nationwide with plans to triple this number by 2025.[56] Additionally, 73% of Qatar's public bus fleet is already electric, with plans to achieve full electrification by 2030.[57]

Globally, countries are driving the adoption of electric mobility through infrastructure investments and policy measures. For instance, Norway continues to lead the way, as seen in the 2023 Global Electric Mobility Readiness Index (GEMRIX), with EVs accounting for over 80% of new car sales in 2022, supported by robust incentives such as tax exemptions, toll waivers, and free parking.[58]

Electrification is also transforming public transportation systems globally. Qatar has built state-of-the-art metro and tram systems; operational since 2019, the Doha Metro and Trams across various areas in Qatar, including Qatar Foundation, Msheireb, and Lusail, are integral to Qatar's sustainable urban mobility framework.[59] Globally, Singapore's Mass Rapid Transit (MRT) system delivers eco-friendly and efficient transport options, reducing vehicular congestion and emissions across the city-state.[60]

SMART GRID TECHNOLOGIES

Smart grids play a central role in integrating renewable energy sources by optimizing power distribution and balancing supply and demand in real time. They enable two-way communication between energy producers and consumers, enhancing grid stability and reducing waste. For instance, the U.S. Department of Energy reports that smart grids can improve energy efficiency by 9% and reduce peak demand by 15%.[61]

Qatar is advancing its smart grid capabilities through strategic partnerships and research initiatives. Iberdrola, in collaboration with Kahramaa, has established its innovation center, focusing on smart grid design and renewable energy integration.[62] Additionally, the Qatar Environment and Energy Research Institute (QEERI) at Hamad Bin Khalifa University leads the Smart Grid Portfolio, developing advanced power systems to sustainably meet Qatar's electricity needs by integrating solar energy and enhancing grid management.[63]

Italy's Telegestore project, pioneered by Enel SpA starting in 2001, is one of the world's first large-scale implementations of smart grid technology, deploying over 32 million smart meters nationwide. The project leveraged advanced metering infrastructure, real-time monitoring systems, and automated meter reading to transform Italy's energy management landscape. It aimed to reduce electricity theft, enhance billing accuracy, and enable remote meter management. For consumers, the ability to monitor real-time energy usage and respond to price signals encouraged more efficient energy consumption behaviors.[64]

The Telegestore project generated noteworthy results, including annual savings of approximately €500 million for Enel and a 5% reduction in nationwide energy usage. The introduction of smart metering minimized operational costs by eliminating the need for manual meter readings and reducing energy theft, while improved billing accuracy enhanced customer satisfaction.

Additionally, the project bolstered grid stability by managing demand and reducing peak loads, laying a strong foundation for renewable energy integration. As a result, the Telegestore project not only advanced Italy's energy efficiency and security but also established a global benchmark in the deployment of smart grid technologies.[65]

[57] Alingal, Shafeeq. "Transport Ministry Mulls over Comprehensive Plans to Ensure EV Standards." Gulf Times, April 30, 2024. https://www.gulf-times.com/article/681583/qatar/transport-ministry-mulls-over-comprehensive-plans-to-ensure-ev-standard
[58] Norwegian Electric Vehicle Association, "Norway Celebrates Another Record-Breaking Year for Electric Vehicles," 2023, https://elbil.no/norway-celebrates-another-record-breaking-year-for-electric-vehicles.
[59] Qatar News Agency. "18.2 million Passengers Used Doha Metro & Lusail Tram Networks during World Cup," December 22, 2022. https://www.qna.org.qa/en/News-Area/Special-News/2022-12/21/0056-qatar-2022-182-million-passengers-used-doha-metro-,-a-,-lusail-tram-networks-during-world-cup.
[60] MRT, "Home Page," n.d., https://mrt.sg/.
[61] U.S. Department of Energy, "Data Access and Privacy Issues Related to Smart Grid Technologies," accessed November 11, 2024, https://www.energy.gov/gc/articles/department-energy-data-access-and-privacy-issues-related-smart-grid-technologies.
[62] Iberdrola, "Innovation Middle East in Qatar: innovation for the digital utility," accessed December 25, 2024, https://www.iberdrola.com/innovation/innovation-middle-east-qatar.
[63] Hamad Bin Khalifa University, "Smart Grid," accessed December 25, 2024, https://www.hbku.edu.qa/en/qeeri/research-portfolios/sg.
[64] Enel Group, "Telegestore Project," https://www.enel.com

CHALLENGES IN ENERGY TRANSITION

Transitioning to sustainable energy poses complex implementation challenges worldwide, particularly for developing economies. Key obstacles include infrastructural and financing needs, social and economic impacts, and regulatory barriers.

INFRASTRUCTURE

Infrastructural hurdles pose several challenges to achieving a successful energy transition, particularly in regions where existing systems are outdated or heavily reliant on fossil fuels. Traditional energy infrastructure, such as coal-powered plants, aging transmission lines, and limited renewable energy facilities, can create bottlenecks that hinder the integration of cleaner energy sources like wind, solar, and hydrogen. As shared by Dr. Ibrahim Ibrahim, infrastructure in many developing economies is suboptimal in terms of capacity, reliability, and technological advancement, requiring extensive upgrades to accommodate renewables like solar and wind power.[66] Another notable infrastructural challenge that exists with technology like Carbon, Capture and Storage (CCS) is the requirement for a robust network of pipelines, storage facilities, and transportation infrastructure to capture and sequester carbon dioxide emissions from power plants and industrial facilities. However, building and maintaining these facilities is both costly and complex, as they often need to be located near large emission sources and geologically suitable storage sites.

These infrastructural limitations, combined with the need for advanced grid support for electric mobility, highlight the necessity for substantial investment, innovation, and regulatory support to modernize infrastructure and advance a sustainable, low-carbon future.

[65] Ibid.
[66] Ibrahim Ibrahim, Remarks on the panel "Optimizing Opportunities for Sustainable Transition," Qatar National Dialogue for Climate Change, Doha, Qatar, October 1, 2024.

TECHNOLOGY

The transition to a sustainable energy system relies heavily on advancements in various technologies, yet each faces unique challenges that must be addressed to ensure their effective deployment and integration. Solar and wind energy, while crucial to renewable power generation, are inherently intermittent due to weather and seasonal variations, requiring additional infrastructure like energy storage systems to maintain reliability. Moreover, the production and disposal of solar panels involve resource-intensive processes, raising concerns about waste management at the end of their lifecycle. Wind energy, though promising, faces regulatory barriers and infrastructure constraints, particularly in regions still exploring its feasibility and scalability.[67]

Carbon capture and storage (CCS) and electric mobility are equally pivotal but come with their own hurdles. CCS, critical for reducing emissions in fossil fuel-dependent industries, demands significant upfront costs and infrastructure, such as CO_2 pipelines and geological storage sites, which may not be universally available. Additionally, concerns over potential CO_2 leakage challenge its long-term reliability. Meanwhile, the adoption of electric mobility is constrained by the excessive costs of vehicle manufacturing and charging infrastructure, particularly for heavy-duty vehicles. Innovations like battery-as-a-service and electric road systems are essential to overcome range and load limitations, but achieving cost parity with traditional combustion engines remains a key barrier.[68]

Smart grid technologies, essential for integrating renewables into the energy system, also face challenges. Developing and upgrading smart grid infrastructure requires considerable financial investment, with global costs projected to reach $2.1 trillion by 2050. The integration of digital technologies introduces cybersecurity risks, while privacy concerns arise from the collection of consumer energy usage data.[69]

Addressing these challenges is essential for realizing the full potential of these technologies in driving the energy transition. Strategic investments, innovative solutions, and supportive policies will be critical to overcoming these barriers and accelerating the shift to a sustainable, low-carbon future.

FUNDING

Financial constraints represent another obstacle to the energy transition, as shifting to a sustainable energy model requires substantial upfront investment in modern technologies, infrastructure, and research. Developing renewable energy sources like wind, solar, and green hydrogen, as well as advancing grid modernization and energy storage, demands billions of dollars in funding.

Mr. Aftab Ahmed outlined that the global transition to alow-carbon economy will require an estimated $10 trillion by 2030[70] , with renewable projects typically involving higher upfront costs compared to traditional fossil fuel ventures.[71] Securing these funds, especially in developing countries, is challenging. Access to finance is another issue as outlined by Mr. Aftab. Developing countries and emerging economies often face difficulties in securing affordable financing due to perceived risks, lack of creditworthiness, limited access to affordable financing, and underdeveloped financial markets. The World Bank highlights that higher interest rates and shorter loan tenors in these regions can deter investment in renewable energy projects.[72] Moreover, currency fluctuations can affect the profitability of renewable energy projects, especially when equipment is imported, or financing is sourced in foreign currencies. This volatility can lead to increased costs and financial instability for projects in developing countries.[73] While tools like green bonds, climate finance, and public-private partnerships (PPPs) are increasingly being utilized to bridge the funding gap, substantial efforts are still required to mobilize capital at the scale needed. Overcoming financial constraints in the energy transition will therefore require innovative financing models, international cooperation, and supportive policy frameworks to attract the investments necessary for a low-carbon future.

SOCIAL AND ECONOMIC EQUITY

Economically, the transition requires substantial investments in new infrastructure, technologies, and workforce development. These costs can strain both public budgets and private sector resources, particularly in countries where fossil fuel revenues play a significant role in national income. A just transition that includes retraining and reskilling programs is crucial to prevent social disruption and to support the growth of a workforce prepared for roles in renewable energy sectors. A well-managed transition can help mitigate job losses and create new employment opportunities, allowing economies to evolve from primary resource sectors to more diverse and sustainable industries.

On a social level, there are also equity issues in the accessibility and affordability of clean energy technologies. For many communities, the initial costs of adopting renewable energy systems, energy-efficient appliances, or electric vehicles can be prohibitive, creating a divide between those who can afford to participate in the green transition and those who cannot. Additionally, renewable energy projects can lead to local opposition if they disrupt landscapes, cultural sites, or ecosystems, highlighting the need for community engagement in planning processes. Addressing these social and economic hurdles is essential to achieving an inclusive and resilient energy transition that benefits all segments of society.

POLICY AND REGULATORY BARRIERS

Policy frameworks play a vital role in either facilitating or hindering the energy transition. In some countries, fossil fuel subsidies and existing regulations may limit the competitiveness of renewable energy.

[67] Arunachala S. Gopinathan, "Implications of Diurnal and Seasonal Variations in Renewable Energy Sources," Journal of Renewable and Sustainable Energy 6, no. 3 (2014): 033105, https://pubs.aip.org/aip/jrse/article/6/3/033105/285954/Implications-of-diurnal-and-seasonal-variations-in.
[68] Carbon Herald, "New Report Finds Carbon Capture and Storage Far Too Expensive," accessed November 11, 2024, https://carbonherald.com/new-report-finds-carbon-capture-and-storage-far-too-expensive/.
[69] Ibid.
[70] Aftab Ahmed, remarks on the panel "Optimizing Opportunities for Sustainable Transition," Qatar National Dialogue for Climate Change, Doha, Qatar, October 1, 2024.

Another key barrier is the lack of harmonized standards and regulations that enable renewable energy technologies to integrate smoothly into national grids and markets. For example, renewable energy sources like solar and wind, which produce variable output, require flexible grid management, advanced storage solutions, and modernized transmission infrastructure. However, regulatory frameworks are often not designed to accommodate decentralized energy production and can create hurdles for new projects. The absence of consistent and supportive policies for emerging technologies, such as energy storage, green hydrogen, and carbon capture, limits investment and innovation, stalling the deployment of these solutions on a large scale.

Additionally, regulatory challenges extend to international collaboration, which is essential for tackling global climate issues. Cross-border cooperation in clean energy often encounters barriers due to varying policy approaches, energy market structures, and priorities among countries. Trade policies, import tariffs, and inconsistent carbon pricing mechanisms can inhibit the flow of clean energy technology and resources. Harmonizing policies across borders is crucial to scaling the energy transition, but achieving alignment requires coordinated political commitment and diplomatic effort.[74] Each of these challenges highlights the need for coordinated efforts among governments, industry leaders, and financial institutions to create an enabling environment for the global energy transition.

[71] AGIC Energy, "How Much Does Renewable Energy Cost? (Know The Cost)," May 25, 2024, https://agicenergy.com/how-much-does-renewable-energy-cost-know-the-cost/.
[72] Aftab Ahmed, remarks on the panel "Optimizing Opportunities for Sustainable Transition," Qatar National Dialogue for Climate Change, Doha, Qatar, October 1, 2024.
[73] McKinsey & Company, "Solving the Climate Finance Equation for Developing Countries," accessed November 11, 2024, https://www.mckinsey.com/capabilities/sustainability/our-insights/solving-the-climate-finance-equation-for-developing-countries.

OPPORTUNITIES AND RECOMMENDATIONS

To drive the global energy transition and build a sustainable, diversified energy mix, countries worldwide can implement key strategies that address infrastructural, financial, policy, and collaborative needs. These combined recommendations and opportunities support national efforts to adopt renewable energy, enhance energy security, and position as leaders in sustainability.

LEVERAGE LNG AS A TRANSITIONAL FUEL

LNG offers a bridge between high-emission fuels like coal and renewable energy sources, helping to meet immediate emissions reduction goals while providing stable energy as renewable infrastructure scales up. LNG combustion produces lower levels of emissions, compared to traditional fuel, making it a cleaner alternative to traditional fossil fuels.[75]

Moreover, LNG is widely available and benefits from established infrastructure, enabling countries to meet growing energy demands efficiently. Its infrastructure also offers long-term adaptability, such as integrating green hydrogen systems, aligning with global sustainability objectives, and paving the way for a smoother transition to a low-carbon energy future. While critics argue that it might delay adoption of renewable energy sources, it serves as a fuel to bridge the gap between countries that have transitioned and those who do not yet have the capacity to adopt renewable energy.

For Qatar, LNG is a cornerstone of its energy strategy and a significant driver of its economy. As the world's leading LNG exporter, Qatar is uniquely positioned to leverage its expertise and infrastructure to support the global energy transition. By implementing stringent methane emission controls and exploring pathways to integrate LNG facilities with emerging renewable technologies, Qatar can maintain its leadership while ensuring its LNG operations align with its sustainability goals. These measures will enhance Qatar's role in balancing immediate energy needs with long-term commitments to a low-carbon future.

INVEST IN GRID MODERNIZATION AND ENERGY STORAGE

Investing in grid modernization and expanding energy storage capacities are important steps toward integrating renewable energy sources into global power systems. Traditional electrical grids, designed for centralized power generation, often struggle to accommodate the variable nature of renewable sources like solar and wind. Modernizing these grids involves implementing smart technologies that enhance real-time monitoring, control, and communication across the energy network. Smart grids facilitate two-way communication between energy producers and consumers, improving grid stability and reducing waste.[76]

Enhancing grid capacity is also essential to manage the increased load from renewable energy sources. Upgrading transmission and distribution infrastructure allows for the efficient transfer of electricity from renewable generation sites to consumption areas, minimizing losses and bottlenecks.[77] Additionally, developing energy storage solutions is crucial for balancing supply and demand, given the intermittent nature of renewable energy. Battery energy storage systems (BESS) and pumped hydro storage are among the technologies that store excess energy generated during periods of low demand and release it when demand is high.

For Qatar, investing in smart grid technologies and energy storage is vital to achieving its renewable energy ambitions, particularly with its focus on solar power expansion. Enhancing grid infrastructure will enable Qatar to integrate renewable sources seamlessly while improving energy distribution efficiency. The deployment of energy storage systems can address the variability of renewable generation, ensuring a reliable power supply. By prioritizing these investments, Qatar can enhance its energy security, reduce waste, and strengthen its position as a leader in the region's energy transition.

STRENGTHEN REGULATORY FRAMEWORKS

Policy reforms that enhance the competitiveness of renewable energy are essential for accelerating the global energy transition. Phasing out fossil fuel subsidies could level the playing field for renewables and better direct valuable resources towards cleaner technologies. Introducing carbon pricing further incentivizes low-carbon investments by assigning a cost to emissions, encouraging companies to reduce their carbon footprint. Establishing renewable energy quotas or procurement targets mandates a minimum share of renewables in the energy mix, creating long-term market stability and encouraging investment in green infrastructure.[78]

In addition, aligning national regulations with international climate goals, such as those outlined in the Paris Agreement, signals a strong commitment to sustainability. This alignment can attract international funding and partnerships, as investors increasingly seek out markets that demonstrate clear and consistent climate policies. Such reforms would incentivize market participation to foster a supportive environment for innovation, enabling countries to build robust, low-carbon economies while addressing global climate challenges.

[74] United Nations Conference on Trade and Development (UNCTAD), "Investing in Energy Transition: Countries Need More Balanced Policies," accessed November 11, 2024, https://unctad.org/news/investing-energy-transition-countries-need-more-balanced-policies.
[75] Lloyd's Register, "Fuel for Thought: LNG," accessed November 11, 2024, https://www.lr.org/en/knowledge/research/fuel-for-thought/lng/.
[76] National Renewable Energy Laboratory (NREL), "Renewable Energy Integration," accessed November 11, 2024, https://www.nrel.gov/grid/renewable-energy-integration.html.
[77] U.S. Department of Energy, "DOE Announces Intent to Issue $13M for New Grid Modernization Funding," accessed November 11, 2024, https://www.energy.gov/oe/articles/us-department-energy-announces-intent-issue-13m-two-new-grid-modernization-funding.
[78] United Nations Conference on Trade and Development (UNCTAD), "Investing in Energy Transition: Countries Need More Balanced Policies," accessed November 11, 2024, https://unctad.org/news/investing-energy-transition-countries-need-more-balanced-policies.
[75] Aftab Ahmed, remarks on the panel "Optimizing Opportunities for Sustainable Transition," Qatar National Dialogue for Climate Change, Doha, Qatar, October 1, 2024
.

For Qatar, strengthening its regulatory framework in line with global sustainability goals can further support its transition to renewable energy. This could include enhancing incentives for private sector involvement in clean energy technologies, including solar and green hydrogen. In addition, setting clear renewable energy targets and integrating carbon pricing mechanisms would encourage investment and innovation. By aligning with international frameworks and ensuring a supportive policy environment, Qatar can attract more global investments and foster a competitive, low-carbon energy market.

FOSTER PUBLIC-PRIVATE PARTNERSHIPS (PPPS)

Public-private partnerships (PPPs) are a powerful tool for driving the transition to renewable energy. By combining the financial and technical resources of both sectors, PPPs enable governments to accelerate large-scale renewable projects. These partnerships allow governments to share the financial risks of projects while benefiting from private sector expertise in renewable energy development. Offering financial incentives, such as subsidies or tax exemptions, can attract private investment in renewable infrastructure, reducing the financial burden on the public sector and making high-cost projects more attractive to investors. Mr. Justin Mundy mentioned that ideally the ratio of public-to-private financing should be 1:10 – equating to 1 unit of public funding for every 10 units of private funding. However, this ratio often starts at 1:1 to initiate investments, as governments provide the initial capital and guarantees to reduce project risks and build investor confidence [80].

Successful examples of PPPs demonstrate the potential to accelerate renewable energy adoption. For instance, in Germany, a collaboration between the government and VPI, a private power firm, plans to invest up to €450 million in battery storage projects by 2030, aiming to develop up to 500 MW of capacity. This initiative aligns with Germany's target of generating 80% of its electricity from renewables by 2030 and underscores the role of PPPs in scaling energy storage infrastructure.[81]

For Qatar, fostering PPPs in the energy sector could be a key strategy for accelerating the adoption of clean energy solutions. Qatar's ambitious plans to expand its renewable energy capacity, especially solar and green hydrogen, could benefit from collaborations with international and local private sector players. Notably, Qatar has developed the Al Kharsaah Solar Power Plant, Mesaieed and Ras Laffan Solar Power Plants, and Blue Ammonia Plant in Mesaieed Industrial City. These projects demonstrate how PPPs can mobilize funding and technical expertise for large-scale renewable infrastructure, such as solar farms and energy storage systems, while driving innovation in energy technologies. Additionally, PPPs could help reduce the financial risks associated with transitioning to a low-carbon economy and ensure that Qatar meets its long-term sustainability targets. By leveraging the strengths of both the public and private sectors, Qatar can enhance its renewable energy capabilities and drive sustainable development.

ENCOURAGE RESEARCH AND INNOVATION IN ENERGY TRANSITION

Encouraging research and innovation is a critical driver of the energy transition, enabling the development of advanced technologies, enhancing efficiency, and overcoming existing barriers to decarbonization. Investment in research fosters breakthroughs in renewable energy technologies such as solar, wind, and hydrogen, while innovation in energy storage and grid integration ensures reliability and scalability. By prioritizing research, governments and industries can identify cost-effective solutions to optimize the deployment of clean energy systems and improve their accessibility across diverse regions.

Policymakers should establish funding mechanisms, incentives, and public-private partnerships to support research initiatives. For instance, grants for clean energy startups, tax incentives for R&D investments, and funding for academic research can catalyze technological progress. Platforms for knowledge sharing and collaboration, such as international energy forums, further strengthen global efforts to scale innovative solutions. These measures are instrumental in addressing the challenges of the energy transition and unlocking its full potential for economic, social, and environmental benefits.

For Qatar, encouraging research and innovation is critical to meeting the nation's ambitious energy transition goals. Towards that end, Qatar has demonstrated a strong commitment to research and development (R&D), particularly in the fields of sustainability and energy transition. In 2021, the country's R&D expenditure was reported at 0.68% of GDP, reflecting a strong increase from 0.53% in 2018. A sizable portion of this budget is directed toward sustainability and energy transition, through institutions like Qatar Environment and Energy Research Institute (QEERI) and Qatar Research Development and Innovation (QRDI) Council. These institutions advance research focusing on Qatar's challenges related to energy and the environment and help position Qatar among the leading nations in the region.[82]

[81] "Vitol-Backed VPI to Invest up to 450 Mln Euros in German Battery Projects," Reuters, September 12, 2024, https://www.reuters.com/business/energy/vitol-backed-vpi-invest-up-450-mln-euros-german-battery-projects-2024-09-12/.
[83] Trading Economics, "Qatar - Research and Development Expenditure (% of GDP)," n.d., https://tradingeconomics.com/qatar/research-and-development-expenditure-percent-of-gdp-wb-data.html.
Aftab Ahmed, remarks on the panel "Optimizing Opportunities for Sustainable Transition," Qatar National Dialogue for Climate Change, Doha, Qatar, October 1, 2024.
[84] Ibid.

PROMOTE CLIMATE FINANCE AND INTERNATIONAL COLLABORATION

Promoting climate finance and fostering international collaboration are vital to scaling renewable energy solutions globally. Partnerships that facilitate technology transfer and knowledge sharing allow countries to adopt best practices from leaders in renewable energy, such as Denmark's expertise in wind power and Germany's advancements in solar energy. These collaborations will certainly enhance project efficiency, drive innovation, and enable countries to overcome barriers to renewable adoption that are specific to their environmental and economic contexts.[83]

As highlighted by Mr. Aftab Ahmed, climate finance, backed by international institutions like the World Bank and the Green Climate Fund, plays a crucial role in funding renewable energy projects, particularly in developing countries.[84] Climate finance initiatives provide concessional loans and grants, making large-scale projects more feasible and accessible.

Promoting climate finance can significantly enhance Qatar's energy transition by attracting both international investments and cutting-edge technologies. The Qatar Fund for Development (QFFD) actively participates in global climate initiatives, exemplified by its unearmarked contribution to the Adaptation Fund, which finances climate change adaptation projects in the most vulnerable countries.[85] Additionally, the Qatar Investment Authority (QIA), Qatar's sovereign wealth fund, integrates climate considerations into its investment strategies. As a founding member of the One Planet Sovereign Wealth Fund Working Group, QIA helped develop a framework to incorporate climate change analysis into investment decisions. Demonstrating this commitment, QIA invested €2.43 billion in RWE AG, Germany's largest power producer, to support RWE's 'Growing Green' strategy. This investment facilitated RWE's acquisition of Con Edison Clean Energy Businesses in the U.S., positioning RWE as a leading renewable energy company in both Germany and the U.S.[86]

[85] Qatar Fund for Development, "Qatar Fund for Development Signs a Contribution Agreement with the Adaptation Fund," 2023, https://www.qatarfund.org.qa/project/qatar-fund-for-development-signs-a-contribution-agreement-with-the-adaptation-fund.
[86] RWE AG, "QIA Invests EUR 2.43 billion to Accelerate RWE's Growing Green Strategy," October 1, 2022, https://www.rwe.com/en/press/rwe-ag/2022-10-01-qia-invests-to-accelerate-rwe-grow-green-strategy/.

CONCLUSION

The global energy transition presents both a challenge and a transformative opportunity. As nations work to reduce carbon emissions and enhance energy security, coordinated policies, investment in renewables, and technological innovation are critical. Transitional fuels like LNG, coupled with advancements in solar, wind, and carbon capture, offer a pathway to balance climate goals with energy needs.

This transition demands adaptability to local contexts but is unified by a shared vision of a low-carbon future. Through strategic investments, robust policies, and international collaboration, the world can build a resilient and sustainable energy system essential for a secure, climate-responsible future.

ACKNOWLEDGMENT

The Ministry of Environment and Climate Change and Earthna extend their heartfelt gratitude to the German Embassy in Doha and the German Industry & Commerce Office Qatar (AHK Qatar) for their invaluable collaboration in making the 2024 QNDCC a success.

We are especially grateful to Qatar National Bank (QNB) Group as our Strategic Partner, DHL Express as our Logistics Partner, and the Al-Attiyah Foundation as our Knowledge Partner. Their support was integral to the success of this year's Dialogue.

Our deepest appreciation goes to the QNDCC event speakers, panelists, moderators, organizers, volunteers, and interns, whose efforts were pivotal in shaping this impactful event.

Finally, we thank the Strategy Hub team for their significant contributions to the development of this report and to Earthna and their leadership for their support.

OPTIMIZING OPPORTUNITIES FOR ENERGY TRANSITION

REFERENCES

Aderibigbe, Oluwayemi-Oniya, and Trynos Gumbo. "The Role of Electric Vehicles in

Greening the Environment: Prospects and Challenges." REAL CORP 2023 Proceedings, September 18–20, 2023. https://corp.at/archive/CORP2023_51.pdf.

AGIC Energy. "How Much Does Renewable Energy Cost? (Know the Cost)." May 25, 2024.

https://agicenergy.com/how-much-does-renewable-energy-cost-know-the-cost/.

Ahmed, Aftab. Remarks on the panel "Optimizing Opportunities for Sustainable Transition."

Qatar National Dialogue for Climate Change, Doha, Qatar, October 1, 2024.

Ahmed, Aftab. Remarks on the panel "Optimizing Opportunities for Sustainable Transition."

Qatar National Dialogue for Climate Change, Doha, Qatar, October 1, 2024.

Akrofi, Mark M., Mahesti Okitasari, and Richa Kandpal. "Recent Trends on the Linkages

between Energy, SDGs and the Paris Agreement: A Review of Policy-Based Studies." Discover Sustainability 3, no. 1 (October 10, 2022). https://doi.org/10.1007/s43621-022-00100-y.

Anderson, Kara. "What Is Germany's Energiewende?" Greenly, March 20, 2024.

https://greenly.earth/en-gb/blog/ecology-news/what-is-germanys-energiewende.

Ataullah, Sanaullah. "Kahramaa Sets up 200 EV Charging Stations." The Peninsula Qatar, January

14, 2024. https://thepeninsulaqatar.com/article/14/01/2024/kahramaa-sets-up-200-ev-charging-stations.

Carbon Herald. "New Report Finds Carbon Capture and Storage Far Too Expensive." Accessed

November 11, 2024. https://carbonherald.com/new-report-finds-carbon-capture-and-storage-far-too-expensive/.

Center for Climate and Energy Solutions. "Carbon Capture." Accessed November 11, 2024.

https://www.c2es.org/content/carbon-capture/.

Clean Energy Wire. "German Onshore Wind Power – Output, Business and Perspectives." Last

modified February 13, 2024. https://www.cleanenergywire.org/factsheets/german-onshore-wind-power-output-business-and-perspectives.

Climate Action Tracker. "Global Temperatures." Accessed November 26, 2024.

https://climateactiontracker.org/global/temperatures/.

Dentons. "Qatar's Plans for Renewable Energy." March 10, 2023.

https://www.dentons.com/en/insights/alerts/2023/may/10/qatars-plans-for-renewable-energy.

Edie. "Global Wind Industry Growth Hit Record High in 2023." Accessed November 26, 2024.

https://www.edie.net/report-global-wind-industry-growth-hit-record-high-in-2023/.

Emirates Nature-WWF. Enabling the UAE's Energy Transition. Accessed November 26, 2024.

https://www.emiratesnaturewwf.ae/sites/default/files/doc-2018-09/Enabling%20the%20UAE%E2%80%99s%20energy%20transition_%20F4_EWSWWF_WEB.pdf.

Enel Group. "Telegestore Project." Accessed November 26, 2024. https://www.enel.com/.

Equinor. "Sleipner CO_2 Storage Data." June 12, 2019. https://www.equinor.com/news/archive/2019-06-12-sleipner-co2-storage-data.

Environmental and Energy Study Institute. "Fact Sheet: Climate, Environmental, and Health

Impacts of Fossil Fuels." 2021. https://www.eesi.org/papers/view/fact-sheet-climate-environmental-and-health-impacts-of-fossil-fuels-2021.

Environmental Protection Agency. Fast Facts: U.S. Transportation Sector Greenhouse Gas

Emissions, 1990–2019. Accessed November 26, 2024. https://www.epa.gov/sites/production/files/2021-04/documents/fastfacts-1990-2019.pdf.pdf.

European Commission and the Ministry of Ecology and Environment of the People's Republic of

China. "EU-China Cooperation on Green Recovery." Accessed November 26, 2024. https://climate.ec.europa.eu/system/files/2021-06/eu_chn_paper_green_recovery_20201019_en.pdf.

European Commission. "European Green Deal." Accessed November 26, 2024.

https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en.

Federal Ministry for Economic Affairs and Climate Action (BMWK). "Cabinet Clears Path for CCS

in Germany." May 20, 2024. https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2024/05/20240529-cabinet-clears-path-for-ccs-in-germany.html.

Financial Times. ""UAE's Masdar Outlines Plan to Become Leading Renewables Group."

Accessed November 27, 2024. https://www.ft.com/content/1386a3e7-db11-43b6-ad07-900c401a66a3.

Global Energy World. "Sungrow Delivered 800MW Al Kharsaah Solar Power Plant in Qatar." Last

modified October 25, 2022. https://www.globalenergyworld.com/news/sustainable-energy/2022/10/25/sungrow-delivered-800mw-al-kharsaah-solar-power-plant-qatar.

Gopinathan, Arunachala S. "Implications of Diurnal and Seasonal Variations in Renewable

Energy Sources." Journal of Renewable and Sustainable Energy 6, no. 3 (2014): 033105. https://pubs.aip.org/aip/jrse/article/6/3/033105/285954/Implications-of-diurnal-and-seasonal-variations-in.

Green Climate Fund. "Home Page." n.d. https://www.greenclimate.fund/.

Gulf Cooperation Council Interconnection Authority (GCCIA). Accessed November 26,

2024. https://gccia.com.sa/.

Gulf Times. "Marine Life Expert Talks About Coral Reefs in Qatar." Accessed November 26,

2024. https://www.gulf-times.com/story/629019/marine-life-expert-talks-about-coral-reefs-in-qatar.

Hamad Bin Khalifa University. "Smart Grid." Accessed December 25, 2024.

https://www.hbku.edu.qa/en/qeeri/research-portfolios/sg.

Hannah Ritchie and Max Roser. "Emissions by Fuel." Our World in Data. Accessed

November 26, 2024. https://ourworldindata.org/emissions-by-fuel.

Hodge, Kyle. "Carbon Capture and Storage (CCS) in the Middle East – a Future Powerhouse of

the Hydrogen Industry?" S&P Global, October 9, 2022. https://www.spglobal.com/commodityinsights/en/ci/research-analysis/carbon-capture-and-storage-ccs-in-the-middle-east.html.

Iberdrola. "Innovation Middle East in Qatar: innovation for the digital utility." Accessed December

25, 2024. https://www.iberdrola.com/innovation/innovation-middle-east-qatar.

Ibrahim, Ibrahim. Remarks on the panel "Optimizing Opportunities for Sustainable Transition."

Qatar National Dialogue for Climate Change, Doha, Qatar, October 1, 2024.

International Energy Agency (IEA). Global EV Outlook 2023: Executive Summary. Accessed

November 26, 2024. https://www.iea.org/reports/global-ev-outlook-2023/executive-summary.

International Energy Agency (IEA). SDG7: Data and Projections – Access to Clean Cooking.

Accessed November 26, 2024. https://www.iea.org/reports/sdg7-data-and-projections/access-to-clean-cooking.

International Renewable Energy Agency (IRENA). "Renewables Competitiveness

Accelerates Despite Cost Inflation." August 2023. https://www.irena.org/News/pressreleases/2023/Aug/Renewables-Competitiveness-Accelerates-Despite-Cost-Inflation.

International Renewable Energy Agency (IRENA). "Renewable Energy and Jobs: Annual Review

2023."https://www.irena.org/Digital-Report/Renewable-energy-and-jobs-Annual-review-2023.

International Finance Corporation. Emerging Market Green Bonds Report 2021. Accessed

November 26, 2024. https://www.ifc.org/content/dam/ifc/doc/mgrt/202206-emerging-market-green-bonds-report-2021-vf-2.pdf.

International Trade Administration. "QatarEnergy Greenhouse Gas (GHG) Emissions Reductions and Sustainability." Last modified August 23, 2023.

"IPCC Fifth Assessment Report." Wikipedia. Accessed November 26, 2024. https://en.wikipedia.org/wiki/IPCC_Fifth_Assessment_Report.

John, Deepak. "Qatar Advancing on Transition to Electric Vehicles." The Peninsula Qatar, July 21, 2024. https://thepeninsulaqatar.com/article/21/07/2024/qatar-advancing-on-transition-to-electric-vehicles.

Lloyd's Register. "Fuel for Thought: LNG." Accessed November 11, 2024. https://www.lr.org/en/knowledge/research/fuel-for-thought/lng/.

Marsh, Jacob. "Electric vs. Gas Cars: Which Is Better for the Environment?" EnergySage, December 6, 2023. https://www.energysage.com/electric-vehicles/evs-vs-ices-full-lifecycle-environmental-impact-analysis/.

McKinsey & Company. "Solving the Climate Finance Equation for Developing Countries." Accessed November 11, 2024. https://www.mckinsey.com/capabilities/sustainability/our-insights/solving-the-climate-finance-equation-for-developing-countries.

Mills, Andrew. "Qatar Targets 25% Cut in Greenhouse Gas Emissions by 2030 under Climate Change Plan." Reuters, October 28, 2021. https://www.reuters.com/business/cop/qatar-targets-25-cut-greenhouse-gas-emissions-by-2030-climate-change-plan-2021-10-28/.

Mohammad Abu Zahra and Global CCS Institute. "Current Status of CCUS in the Middle East and North Africa (MENA) Region." The 3rd CCUS & Hydrogen International Symposium, August 25, 2022. https://www.env.go.jp/earth/ccs/3rd_speech5.pdf.

MRT. "Overview." n.d. https://mrt.sg/.

Mundy, Justin. Remarks on the panel "Optimizing Opportunities for Sustainable Transition." Qatar National Dialogue for Climate Change, Doha, Qatar, October 1, 2024.

OPTIMIZING OPPORTUNITIES FOR ENERGY TRANSITION

National Oceanic and Atmospheric Administration (NOAA). "Deepwater Horizon." Accessed November 26, 2024. https://darrp.noaa.gov/oil-spills/deepwater-horizon.

National Renewable Energy Laboratory (NREL). "Renewable Energy Integration." Accessed November 11, 2024. https://www.nrel.gov/grid/renewable-energy-integration.html.

Norwegian Electric Vehicle Association. "Norway Celebrates Another Record-Breaking Year for Electric Vehicles." 2023. https://elbil.no/norway-celebrates-another-record-breaking-year-for-electric-vehicles.

Planning and Statistics Authority. Qatar National Vision 2030. 2008. https://www.psa.gov.qa/en/qnv1/Documents/QNV2030_English_v2.pdf.

Planning and Statistics Authority. Third Qatar National Development Strategy. 2024. https://www.psa.gov.qa/en/nds1/nds3/Documents/QNDS3_EN.pdf.

PricewaterhouseCoopers (PwC). 2024 Voice of the Consumer Survey. Accessed November 26, 2024. https://www.pwc.com/gx/en/news-room/press-releases/2024/pwc-2024-voice-of-consumer-survey.html.

Qatar News Agency. "18.2 million Passengers Used Doha Metro & Lusail Tram Networks during World Cup." December 22, 2022. https://www.qna.org.qa/en/News-Area/Special-News/2022-12/21/0056-qatar-2022-182-million-passengers-used-doha-metro-,-a-,-lusail-tram-networks-during-world-cup.

Qatar News Agency. "Qatar Issues USD 2.5 Billion Green Bonds." May 22, 2024. https://www.qna.org.qa/en/News-Area/News/2024-05/22/0068-qatar-issues-usd-25-billion-green-bonds.

QatarEnergy. "What Is LNG?" Accessed November 26, 2024. https://www.qatarenergy.qa/en/whoweare/Pages/WhatIsLNG.aspx.

QatarsTalk. "Renewable Energy Projects in Qatar." Qatar News, Business, Tech & Community

Insights, July 20, 2024. https://www.qatarstalk.com/2024/07/20/renewable-energy-projects-in-qatar/.

Qatar Fund for Development. "Qatar Fund for Development Signs a Contribution Agreement with

the Adaptation Fund." 2023. https://www.qatarfund.org.qa/project/qatar-fund-for-development-signs-a-contribution-agreement-with-the-adaptation-fund.

QNB. "Green Bond Framework." Accessed November 11, 2024.

https://www.qnb.com/sites/qnb/qnbqatar/document/en/enGreen2021#:~:text=The%20net%20proceeds%20of%20green,eligibility%20criteria%20in%20this%20Framework.

Renewable Energy World. "Energy Transition Investments Hit Record $1.8 Trillion in 2023."

Accessed November 11, 2024. https://www.renewableenergyworld.com/news/energy-transition-investments-hit-record-1-8-trillion-in-2023/.

Reuters. "Renewables Provided Record 30% of Global Electricity in 2023, Ember Says." May 7,

2024. https://www.reuters.com/sustainability/climate-energy/renewables-provided-record-30-global-electricity-2023-ember-says-2024-05-07/.

Reuters. "Saudi Power Procurement Company Signs Deals for Three Solar Projects." June 27,

2024. https://www.reuters.com/business/energy/saudi-power-procurement-company-signs-deals-three-solar-projects-2024-06-27/.

Reuters. "US Clean Energy Jobs Growth Rate Double That of Overall Jobs, Report Says." 2024.

https://www.reuters.com/business/energy/us-clean-energy-jobs-growth-rate-double-that-overall-jobs-report-says-2024-08-28.

Reuters. "Vitol-Backed VPI to Invest up to 450 Mln Euros in German Battery Projects."

September 12, 2024. https://www.reuters.com/business/energy/vitol-backed-vpi-invest-up-450-mln-euros-german-battery-projects-2024-09-12/.

RWE AG. "QIA Invests EUR 2.43 billion to Accelerate RWE's Growing Green Strategy." October 1,

2022. https://www.rwe.com/en/press/rwe-ag/2022-10-01-qia-invests-to-accelerate-rwe-grow-green-strategy/.

S&P Global Commodity Insights. "Location of Operational CCS Projects in the Middle East."

Accessed November 26, 2024. https://cdn.ihsmarkit.com/www/images/1022/Location-of-operational-CCS-projects-in-the-Middle-East.png.

OPTIMIZING OPPORTUNITIES FOR ENERGY TRANSITION

Saudi Association for Energy Economics. Energy Transition in Saudi Arabia. Accessed November

26, 2024. https://www.saudi-aee.sa/wp-content/uploads/2022/01/1-Energy-Transition-in-Saudi-Arabia.pdf.

Shell Global. "Electric Truck Revolution." Accessed November 26, 2024.

https://www.shell.com/business-customers/shell-commercial-road-transport/heavy-duty-fleet-insights/electric-truck-revolution.html.

Sino-German Cooperation on Climate Change. "China's Installed Solar Capacity Rises 55.2% in

2023." January 26, 2024. https://climatecooperation.cn/climate/chinas-installed-solar-capacity-rises-55-2-in-2023/.

SolarBe Global. "IEA Forecasts Over 4,000GW of Global Solar Capacity by 2030." Accessed

November 26, 2024. https://www.solarbeglobal.com/iea-forecasts-over-4000gw-of-global-solar-capacity-by-2030/.

Statista. "Global Temperature Increase by Scenario." Accessed November 26, 2024.

https://www.statista.com/statistics/1278800/global-temperature-increase-by-scenario/.

Swiss Re. "The Economics of Climate Change Risks." April 22, 2021.

https://www.swissre.com/media/press-release/nr-20210422-economics-of-climate-change-risks.html.

The Peninsula Newspaper. "The Peninsula Qatar." August 23, 2022.

https://thepeninsulaqatar.com/article/23/08/2022/mega-solar-power-plants-in-qatar-to-start-production-by-end-of-2024.

TotalEnergies. "Al Kharsaah, A Pioneering Solar Power Plant in Qatar." Accessed November 7,

2024. https://totalenergies.com/projects/solar/al-kharsaah-pioneering-solar-power-plant-qatar.

Trading Economics. "Qatar - Research and Development Expenditure (% of GDP)." n.d.

https://tradingeconomics.com/qatar/research-and-development-expenditure-percent-of-gdp-wb-data.html.

U.S. Department of Energy. "DOE Announces Intent to Issue $13M for New Grid Modernization

Funding." Accessed November 11, 2024. https://www.energy.gov/oe/articles/us-department-energy-announces-intent-issue-13m-two-new-grid-modernization-funding.

UCAR Center for Science Education. "Predictions for Future Global Climate." Accessed

November 26, 2024. https://scied.ucar.edu/learning-zone/climate-change-impacts/predictions-future-global-climate.

United Nations Conference on Trade and Development (UNCTAD). "Investing in Energy

Transition: Countries Need More Balanced Policies." Accessed November 11, 2024. https://unctad.org/news/investing-energy-transition-countries-need-more-balanced-policies.

United Nations Framework Convention on Climate Change Secretariat. "The Paris Agreement."

Accessed November 26, 2024. https://unfccc.int/process-and-meetings/the-paris-agreement.

United Nations Framework Convention on Climate Change. "COP28 Agreement Signals

'Beginning of the End' of the Fossil Fuel Era." December 13, 2023. https://unfccc.int/news/cop28-agreement-signals-beginning-of-the-end-of-the-fossil-fuel-era.

United Nations Framework Convention on Climate Change. "The Glasgow Climate Pact – Key

Outcomes from COP26." Accessed November 7, 2024. https://unfccc.int/process-and-meetings/the-paris-agreement/the-glasgow-climate-pact-key-outcomes-from-cop26.

United Nations Framework Convention on Climate Change. "Why the Global Stocktake Is

Important for Climate Action This Decade." Accessed November 17, 2024. https://unfccc.int/topics/global-stocktake/about-the-global-stocktake/why-the-global-stocktake-is-important-for-climate-action-this-decade.

United Nations. "Sustainable Development Goals." Accessed November 19, 2024.

https://sdgs.un.org/goals.

Vision 2030. "Dumat Al Jandal Wind Farm." Accessed November 18, 2024.

https://www.vision2030.gov.sa/en/explore/explore-more/dumat-aljandal.

OPTIMIZING OPPORTUNITIES FOR ENERGY TRANSITION

World Bank. "World Bank Signs Project to Scale Up Innovative Renewable Energy Technologies

in India." World Bank Press Release. Accessed November 26, 2024.

Worley. "Supporting QatarEnergy LNG's Decarbonization Ambitions through Carbon

Sequestration." News release, September 25, 2023. https://www.worley.com/en/insights/our-news/conventional-energy/2023/supporting-qatarenergy-lng-carbon-sequestration.