

GLOBAL ENERGY TRANSITION: REFLECTING ON COP 28 AND CASE STUDIES OF QATAR AND MOROCCO

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Abstract

This Article examines the contemporary framework for energy transition, focusing on the regulatory and legal obstacles inherent in the transition process. Part I provides an introduction and delves into the intricate interplay between trade dynamics and the establishment of smart grids, evaluating their impact on shaping the energy landscape. The concept of climate-resilient electricity grids is explored in Part I, particularly through the lens of digital solutions adopted in jurisdictions such as India, China, and the United States. Part II discusses the evolving framework set forth by Climate Change Conference of the Parties (COP 28) for the implementation of smart grids within the context of climate action. It also investigates the critical nexus between climate finance and the development of smart grids, emphasizing their pivotal role in advancing sustainable energy infrastructures. Parts III and IV analyze Qatar and Morocco respectively as case studies. This Article concludes by synthesizing key insights drawn from the analysis, underlining the significance of collaborative efforts and innovative strategies in fostering a resilient and environmentally sustainable energy future.

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INTRODUCTION

The advent of energy has shaped geopolitical conversations and is continuing to do so. On December 13, 2023, the 28th United Nations Climate Change Conference of the Parties (COP 28) signaled a new objective that included putting in efforts to end the fossil-fuel era by laying down the foundation for an equitable transition that would underlie deep emission cuts and enabling climate action through new funding and financial pledges.¹ The objective aims to shift away from reliance on oil, instead constructing an infrastructure that facilitates the utilization of new energy sources through new investments and new energy frameworks. These systems aim to be more sustainable and environmentally beneficial

1. Press Release, U.N. Climate Change, COP28 Agreement Signals “Beginning of the End” of the Fossil Fuel Era (Dec. 13, 2023), <https://unfccc.int/news/cop28-agreement-signals-beginning-of-the-end-of-the-fossil-fuel-era> [<https://perma.cc/RTG3-VC6X>].

on a global level. The transition in energy is based on the premise that a specific energy resource or group dominates the market for a period until this assumption is challenged and replaced by other resources. The challenges linked with this energy transition have sparked extensive debates across economic, technical, and social realms for an extended duration.²

Moreover, the economic feasibility of technical solutions for renewable energy is not consistently assured. The fundamental concept is for government environmental objectives to harmonize with the economic incentives of energy companies and consumers. The shift towards a more sustainable framework must mitigate environmental damage and avoid raising energy prices. The evolution of this transition depends on several factors necessary for establishing competitive advantages, including determining the knowledge needed to transition from fossil fuels to clean energy.

Nevertheless, while challenges persist in understanding which models may facilitate countries' transition, the absence of a comprehensive framework further impedes the adoption of a system that would drive progress. Additionally, the lack of consensus regarding the gradual phasing out of fossil fuels, coupled with the lack of political resolve and engagement of legislators, underscores the urgent need for unified action to address and implement the necessary changes. This emphasizes the importance of political and social commitment required to garner consensus in replacing fossil fuels with low-emission alternatives, while also implementing initiatives to enhance energy efficiency across various sectors. Power grids serve as the cornerstone for energy transition. Presently, the grid infrastructure is deficient, and according to the Energy Transitions Organization, an investment of \$3 trillion USD is required to establish a new infrastructure for a net-zero world,³ and this will be

2. See generally R. LEAL-ARCAS ET AL., *ELECTRICITY DECENTRALIZATION IN THE EUROPEAN UNION: TOWARDS ZERO CARBON AND ENERGY TRANSITION* (2d ed. 2023) [hereinafter LEAL-ARCAS ET AL., *ELECTRICITY DECENTRALIZATION IN THE EUROPEAN UNION*]; R. LEAL-ARCAS ET AL., *THE GREAT ENERGY TRANSITION IN THE EUROPEAN UNION: VOLUME 1* (2020); R. LEAL-ARCAS ET AL., *THE GREAT ENERGY TRANSITION IN THE EUROPEAN UNION: VOLUME 2* (2020); Tanya Leila Shaar & R. Leal-Arcas, *Fuel Subsidy Reform, Decentralized Electricity Markets and Renewable Energy Trade: Evidence for a Successful Energy Transition in the Middle East and North Africa Region*, 16 J. WORLD ENERGY L. & BUS. 112 (2023); R. Leal-Arcas, M. Karimabadi & S. Boskovic, *The Transition to Decentralized Energy: Challenges, Opportunities and Progress*, 11 U.P.R. BUS. L.J. 1 (2020); R. LEAL-ARCAS, *THE TRANSITION TOWARDS DECARBONIZATION: A LEGAL AND POLICY EXPLORATION OF THE EUROPEAN UNION* 1–31 (Feb. 29, 2016), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2739911 [<https://perma.cc/TU3G-3KDC>]; R. LEAL-ARCAS, *CIDADÃOS NO CENTRO DA TRANSIÇÃO ENERGÉTICA: UM NOVO MODELO DE GOVERNANÇA* (CITIZENS AT THE CENTER OF THE ENERGY TRANSITION: A NEW GOVERNANCE MODEL), 231–44 (2019) [hereinafter Leal-Arcas, *Citizens at the Center*], https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3399302 [<https://perma.cc/T6Y3-BY6B>].

3. Matthias Rebellius, *Energy transition: Getting our grids fighting fit for an electrified future*, WORLD ECON. F. (Aug. 3, 2023), <https://www.weforum.org/agenda/2023/08/energy-transition-electricity-grids-digital-net-zero/> [<https://perma.cc/T2NA-FHHK>].

apparent through new technologies and new ways of distributing electricity.

The focus of international institutions and public authorities has shifted towards addressing climate change, aiming to develop solutions that mitigate the negative externalities stemming from economic activities. However, the entire process of energy transition also introduces a host of new risks and challenges that concerns value chains that can allow the deployment of low-carbon technologies and system operations. Nevertheless, the transition goes beyond just utilizing new energy sources which can allow climate change mitigation. It includes new technologies and innovation, which will further require access to markets. This will further be dependent on adherence to new standards and frameworks. And, thus, the idea is not only to understand how energy transition will take place but also what is the interplay between policy design and market forces.

A Note on Trade and Energy⁴

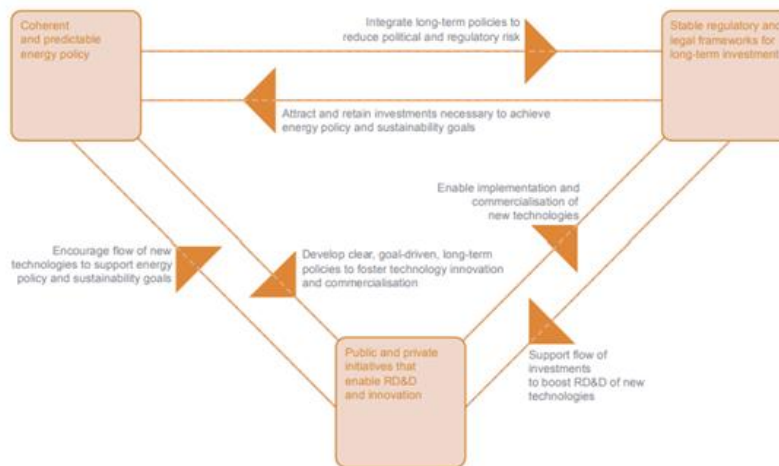
While the energy transition holds the promise of a shift towards sustainable practices, it also poses questions regarding global trade dynamics. It is plausible that countries may begin prioritizing self-sufficiency, potentially resulting in a decline in energy trade. This shift could provide an advantage to states with greater import capabilities, but it could also disrupt the global trade balance. Conversely, it can be argued that energy trade volumes may remain stable or even increase. This outcome hinges on countries' production capacities and their varying levels of acceptance of energy transformations, which could influence trade dynamics. Ultimately, the impact of trade between countries will be shaped by the infrastructures that emerge resulting from these shifts.

4. See generally RAFAEL LEAL-ARCAS, CLIMATE CLUBS FOR A SUSTAINABLE FUTURE: THE ROLE OF INTERNATIONAL TRADE AND INVESTMENT LAW (2021); RAFAEL LEAL-ARCAS, SOLUTIONS FOR SUSTAINABILITY: HOW THE INTERNATIONAL TRADE, ENERGY AND CLIMATE CHANGE REGIMES CAN HELP (2019); RAFAEL LEAL-ARCAS, CLIMATE CHANGE AND INTERNATIONAL TRADE, (2013); CLIMATE AND ENERGY GOVERNANCE FOR A SUSTAINABLE FUTURE (Rafael Leal-Arcas ed., 2023) [hereinafter Leal-Arcas, *Climate and Energy Governance for a Sustainable Future*]; UNIVERSITY INITIATIVES IN CLIMATE CHANGE MITIGATION AND ADAPTATION (Walter Leal-Filho & Rafael Leal-Arcas eds., 2018); R. Leal-Arcas, "Connections between climate change and international trade," House of Commons, International Trade Committee, UK Parliament (Aug. 2021), <https://committees.parliament.uk/writtenevidence/38010/pdf/> [<https://perma.cc/8SLV-3A4G>] [hereinafter Leal-Arcas, *Connections between climate change and international trade*] (written evidence from Rafael Leal-Arcas, who was Jean Monnet Chair Professor of EU International Economic Law at Queen Mary University of London (COP0001)); Rafael Leal-Arcas et al., *International Trade, Energy Transition and Climate Change Obligations: The perspective of small Pacific islands and the Caribbean Community*, 13 TRADE L & DEV. 198, 198–263 (2021), <https://www.researchgate.net/publication/355437728> [<https://perma.cc/R8SP-FAWM>] [hereinafter Leal-Arcas, *International Trade, Energy Transition and Climate Change Obligations*]; R. Leal-Arcas & Andrew Filis, *International Cooperation on Climate Change Mitigation: The Role of Climate Clubs*, 30 EUR. ENERGY & ENV'T L. REV. 195, 195–218 (2021), <https://kluwerlawonline.com/journalIssue/European+Energy+and+Environmental+Law+Review/30.5/19907> [<https://perma.cc/P2FS-2B87>].

Furthermore, the global energy transition will significantly impact the dynamics of regional integration in electricity trade. As the transition progresses towards sustainable energy sources, there is an expected surge in regional electricity trade. This surge is driven by the potential to generate revenue through the cross-border balancing of fluctuations in renewable energy supply, a phenomenon facilitated by the adoption of smart grid technologies. These smart grids are essential for optimizing energy distribution across regions, allowing for the efficient management of intermittent renewable sources.

Consequently, as depicted in Figure 1, the energy transition not only encourages greater regional cooperation, but also underscores the crucial role of smart-grid infrastructure in facilitating this evolving landscape. Moreover, this fuels the argument that control over grid infrastructure—including power lines and storage—will also be vital for national security and power influence. Countries using competitive advantages—countries that are oil and natural gas producers—can seek diversification strategies, such as supply chains and clean energy industries.

Figure 1: Aligning International Trade Law and Energy Transition⁵



Source: World Energy Council

Regarding the role of energy law in energy transition, the pace of law-making frequently lags behind the speed of energy transition, potentially

5. Three Key Interconnected Policy Areas Are Necessary to Support the Transition to Sustainable Energy, in World Energy Council, World Energy Trilemma: Time to Get Real—The Case for Sustainable Energy Policy 35 (2012), <https://www.worldenergy.org/assets/downloads/Time-to-get-real-the-case-for-sustainable-energy-policy-VOL-I1.pdf> [https://perma.cc/N47A-P5E6].

resulting in legal solutions that impose constraints due to their failure to keep up with the evolving technological and economic landscape in the real world.

This Article examines the contemporary framework for energy transition, focusing on the regulatory and legal obstacles inherent in the transition process. The concept of climate-resilient electricity grids is explored in Part I, particularly through the lens of digital solutions adopted in jurisdictions such as India, China, and the U.S. Part II discusses the evolving framework set forth by COP 28 for the implementation of smart grids within the context of climate action. It also investigates the critical nexus between climate finance and the development of smart grids, emphasizing their pivotal role in advancing sustainable energy infrastructures. Parts III and IV analyze Qatar and Morocco as case studies, respectively. This Article concludes by synthesizing key insights drawn from the analysis, underlining the significance of collaborative efforts and innovative strategies in fostering a resilient and environmentally sustainable energy future.

I. WHAT ARE CLIMATE-RESILIENT ELECTRICITY GRIDS?

Climate change has resulted in increased temperatures, irregular rainfall or precipitation, rising sea levels and catastrophic events.⁶ As per the Global Risk Report 2024, extreme weather events are a top risk which pose a severe impact over a 10-year period.⁷ Therefore, it is a pressing necessity to address how climate change impacts the electricity security and imposes further strict demand for the reliability and resilience of the energy power system.

Effects of climate change on generation, transmission and distribution can hinder energy security. Climate change contributes to problems in generation including reduced efficiency, altered availability, and overall production capability, including renewable and thermal facilities.⁸ Transmission lines can be easily damaged during severe weather too. For example, snow, ice, wildfire and strong wind can damage the visible powerlines and towers for transmission. Flooding can damage roads, railroads, storage grounds and pipelines, and has effects on underground transformers and powerlines. Heavy storms lead to the utility poles or

6. *Power Systems in Transition*, INT'L ENERGY AGENCY 1, 47 (Oct. 2020), https://iea.blob.core.windows.net/assets/cd69028a-da78-4b47-b1bf-7520cdb20d70/Power_sys_tems_in_transition.pdf [<https://perma.cc/SX9J-VKK5>] [hereinafter IEA].

7. *The Global Risks Report 2024*, WORLD ECON. F. 1, 7 (Jan. 2024), https://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2024.pdf [<https://perma.cc/N9TD-5E54>] [hereinafter WEF].

8. IEA, *supra* note 6.

trees colliding and collapsing on power lines.⁹ Near the coastal area, storms can ruin the petroleum storage tank. Heatwaves or increased temperature can alter the transmission lines' functions and carrying potential.¹⁰

Regarding the end-user distribution, climate change leads to increased and peak demand from consumers and catastrophic events can also knock down the equipment used for distribution. The energy power sector is the key pillar of the economy and a significant area of focus to adapt and combat climate change.¹¹ Efforts to increase the resilience of electricity grids have been underway for decades but have only gained popularity and momentum in the last decade.

A. *Climate-Resilient Electricity Grids*

Electricity has a vital role in shifting towards a low-carbon energy system. Insufficient resiliency in electricity systems creates an obstacle for transition towards clean energy due to the newly developed renewable energy technologies that cannot withstand unfavorable changing climate.¹² The important characteristics of a climate-resilient electricity grid are:

1. it must have the ability to withstand natural catastrophes;
2. it must quickly recover from impacts;
3. it must respond to demands immediately; and
4. it must not be a power plant powered by fossil fuels.

In simpler terms, the ultimate solution for energy decentralization and decarbonizing electricity is to transition towards clean energy, move away from fossil fuel resources, promote and invest in a grid that is climate resilient i.e., resistance against heavy storms, extreme rainfall or

9. *How to Increase Grid Resilience Through Targeted Investments*, MCKINSEY & CO. (Dec. 20, 2021), <https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/how-to-increase-grid-resilience-through-targeted-investments> [https://perma.cc/XMC3-UUYT]

10. *Climate Change Impacts on Energy*, EPA (Oct. 2, 2024), <https://19january2025snapshot.epa.gov/climateimpacts/climate-change-impacts-energy/index.html> [https://perma.cc/WPT8-EF59].

11. Yongping Sun, Ya Zou, Jingning Jiang, & Ying Yang, *Climate Change Risks and Financial Performance of the Electric Power Sector: Evidence from Listed Companies in China*, 39 CLIMATE RISK MGMT. 100474 (2023), <https://doi.org/10.1016/j.crm.2022.100474> [https://perma.cc/7D73-7NGT].

12. IEA, *supra* note 6.

flood, and heatwave.¹³ However, there is not much value if resilience is factored in a certain area since it is effective only if it is in the overall system. Therefore, while investment in generation is necessary for a strong resilience strategy, it is also vital to invest in grid monitoring. Two key events in 2023, namely wildfires spread across Greece and the adverse heatwave in Texas that affected the grid functionality, have proven this resilience strategy effective, because relevant reports suggested that the power was flowing and uninterrupted because of the power's use of renewable sources.¹⁴

To make the power grid resilient to such natural catastrophes, it is very important to protect and conserve the assets, improve network distribution, and facilitate the input in a manner that is environmental friendly.¹⁵ Further development of grid and upcoming grid projects can only be cost-effective if utilities successfully evaluate and assess major factors such as climate change risks, asset health, and adoption of distributed-energy resources (DERs) by consumers.¹⁶ Microgrids, also called “mini-grids,” can incorporate a mix of DERs such as the wind

13. For an overview of energy decentralization and decarbonization in general, see Rafael Leal-Arcas, *Smart Grids as a Way to Democratize Energy*, YALE J. INT'L AFFS. (Sept. 24, 2020), <https://www.yalejournal.org/publications/smart-grids-as-a-way-to-democratize-energy> [https://perma.cc/WV58-69W8]; R. Leal-Arcas, A. Filis & V. Nalule, *Energy Decentralization and Decarbonization: The Case of Romania and Malta*, 60 NAT. RES. J. 117, 117–66 (2020); R. Leal-Arcas, A. Filis, M. Peykova & M. Greger, *Towards a Carbon-Free, Decentralized, and Democratized System of Energy Generation*, 35 CONN. J. INT'L L. 133–202 (2020); R. Leal-Arcas et al., *Electrifying the Energy Sector: The Case of Slovakia and the Czech Republic*, 13 KY. J. EQUINE, AGRIC., & NAT. RES. L. 1, 1–83 (2020); R. Leal-Arcas et al., *Energy, Electricity and Smart Grids in Latvia and Portugal — Developments and Concerns*, 12 KY. J. EQUINE, AGRIC., & NAT. RES. L. 1, 1–70 (2020) [hereinafter Leal-Arcas et al., *Energy, Electricity and Smart Grids in Latvia and Portugal*]; R. Leal-Arcas, S. Boskovic & M. Karimabadi, *The transition to decentralized energy: Challenges, opportunities and progress*, 11 U.P.R. BUS. L.J. 1, 1–70 (2020); R. Leal-Arcas, M. Kanakakis, G. Thanos & G. Fearnley, *Regulation and Innovative Finance for Sustainable Energy*, 34 EMORY INT'L L. REV. 435, 435–532 (2020); R. Leal-Arcas, G. Fearnley, & C. Gluck, *Regulation, Innovation, and Technology for the 21st Century Energy Goals*, 8 J.L. & CYBER WARFARE 30, 30–107 (2020).

14. See Ella Nilsen, *Wind and Solar are Propping up the Texas Power Grid Amid a Brutally Long Heat Wave*, CNN (July 28, 2023, 2:18 PM), <https://www.cnn.com/2023/07/28/business/texas-renewable-energy-heat-wave-climate/index.html> [https://perma.cc/H6KM-N3KP]; Kate Abnett & Susanna Twindale, *Solar Power to the Rescue as Europe's Energy System Weathers Extreme Heat*, REUTERS (Aug. 7, 2023, 7:47 AM), <https://www.reuters.com/sustainability/climate-energy/solar-power-rescue-europes-energy-system-weather-extreme-heat-2023-08-07/> [https://perma.cc/BNE4-DR3N].

15. See Lyster, R. & Verchick, R.R.M., *Protecting the Power Grid from Climate Disasters*, in RESEARCH HANDBOOK ON CLIMATE DISASTER LAW: BARRIERS AND OPPORTUNITIES 267, 267–84 (Lyster, R. & Verchick, R.R.M eds., Cheltenham: Edward Elgar Publ'g, 2018).

16. See Alfonso Encinas Fernandez, Blake Houghton, Adam Rubin & Aaron Schifrin, *Grid planning under uncertainty: Investing for the energy transition*, MCKINSEY & Co. (Dec. 5, 2023), <https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/grid-planning-under-uncertainty-investing-for-the-energy-transition> [https://perma.cc/GW9M-NN78].

turbines, batteries, etc. Microgrids can be defined as energy systems that are self-sufficient and operate independently from a centralized grid at a particular location to provide energy in that specific geographic area. Microgrids can therefore function independently in island mode, thereby increasing the resilience to outages against natural catastrophes by protecting the local region and community from power outages that are rooted in the centralized grid.¹⁷

There are several advantages of microgrids: (i) they promote the usage and consumption of renewable energy locally; (ii) they build a strong reliability of power supply and emergency resistance; and (iii) they save the loss of power transmission and boosts energy efficiency. It is pertinent to note that the cost of microgrid generation is subject to different regions or location, capacity, installation charge, among others, and, therefore, it is difficult to establish a certain or fixed price per kWh from a microgrid. Despite microgrids having several advantages, one of the drawbacks is that electricity is expensive. Microgrids require renewable sources to be combined with storage to provide the desirable outcome which makes them even costlier than the grid electricity.¹⁸ Therefore, deployment of microgrids on a large scale, at least in the near future, seems doubtful due to its high cost of installations and political decisions. If the cost of microgrids and their installation is reduced, there is a possibility that the microgrids will gain popularity and advancement, thereby enabling the climate-vulnerable communities as well as the local communities to install microgrids and establish an infrastructure that is climate-resilient.¹⁹

To meet Sustainable Development Goal 7 (SDG 7), the world will need to power 490 million people by constructing more than 217,000 microgrids.²⁰ Considering the progress so far, it seems only 44,800 new microgrids will be deployed by 2030 that can serve 80 million people.²¹ It is pertinent to note that the Climate Action Network Europe (CAN) has recommended and established design principles for European Grid Infrastructure. The five principles are as follows:

17. See Merle Weidt, *Microgrids: A Major Step Towards Climate Resilience*, NEW AM. (Nov. 21, 2023), <https://www.newamerica.org/the-thread/climate-change-microgrids/> [<https://perma.cc/2RXR-22NQ>].

18. See *Grid-Connected Renewable Energy Systems for Homes and Businesses*, PERCH ENERGY (Feb. 17, 2023), <https://www.perchenergy.com/blog/energy/grid-connected-renewable-energy-systems> (last visited Sept. 20, 2024).

19. Weidt, *supra* note 17.

20. ENERGY SECTOR MGMT. ASSISTANCE PROGRAM, MINI GRIDS FOR HALF A BILLION PEOPLE: MARKET OUTLOOK AND HANDBOOK FOR DECISION MAKERS 36 (World Bank Publications, 2022).

21. *Id.*

1. Enable and expedite a 100% renewable energy system:

To meet the goal of the Paris Agreement, renewable energy consumption must be at least 50% by 2030 and a complete shift to the Energy Renewable System by 2040.²² Therefore, the requirement is to double the usage of renewables by 2030 for EU electrification by setting up the key objective to encourage the usage of renewables for planning and executing the development of grids.²³ One of the main challenges currently to build a 100% infrastructure with renewable energy is the slow process to permit the grid development projects.²⁴

2. Plan for the phase-out of fossil-fuel infrastructure:

The upcoming energy infrastructure projects must comply with the targets set by the EU for phasing out fossil fuels; i.e., phase out of coal by 2030, fossil gas by 2035, oil by 2040, and phase out nuclear facilities.²⁵ Expansion of liquified natural gas (LNG) infrastructure must stop as well and there must be immediate plans for its decommissioning.²⁶ The EU's hydrogen production requires fossil fuels and, therefore, the EU is struggling to transition to 100% renewables for hydrogen production.²⁷ The non-renewable hydrogen, therefore, becomes a loophole for investment in fossil fuels which needs to be decommissioned at the earliest too.

3. Utilize the full potential of energy savings:

Energy savings can lower the consumption of fossil fuels. Further understanding the balance of supply and demand can stabilize the electricity grids, thereby promoting more savings that can be utilized during peak electricity demand and reduce the additional reliance on fossil fuels.²⁸ Further, while constructing new buildings, it is vital that they are equipped with renewable energy sources, have measures to save energy, improve performance and comfort for occupants, thereby reducing the costs of energy consumption and utilizing renewable heating and cooling solutions to meet the demands according to the weather.²⁹

22. *Powering Europe's Tomorrow – A blueprint for 100% renewable and resilient infrastructure*, CLIMATE ACTION NETWORK EUR. 1, 3 (2023), <https://caneurope.org/content/uploads/2023/11/24.11.23-Powering-Europes-Tomorrow-A-blueprint-for-100-renewable-and-resilient-infrastructure.docx.pdf> [<https://perma.cc/2NS2-76X7>].

23. *Id.*

24. *Id.* at 12.

25. *Id.* at 4.

26. *Id.*

27. *Id.* at 12.

28. CLIMATE ACTION NETWORK EUR., *supra* note 22, at 6.

29. *Id.*

4. Build a decentralized, flexible, and digitalized energy system:

The distribution grids to be built in the future will have the potential to interlink and connect households, workplaces, public spaces, buildings, structures and industries with decentralized photovoltaics, energy storage devices such as batteries and heat pumps, by enhancing and expanding the present grid system and upcoming innovative solutions.³⁰ To implement this, distribution system operators (DSO) and transmission system operators (TSO) will have a significant role to play by sharing and distributing real-time grid data, getting involved in planning and developing the energy system and sharing flexible areas or sources to combat traffic at the transmission level to make sure that the resources at the distribution level can combat traffic in the transmission level.³¹ It therefore helps in meeting energy demands with the supply. However, the challenge for European governments is (i) adaption of planning; (ii) Upgradation; (iii) Renovation; and (iv) Distribution Grid Management.³² As the CAN, Europe states: “Interconnections between countries are a means to stabilise grids, enhance security of supply, reduce the role of fossil gas peaking plants in the short term, and storage needs in the long-term.”³³

5. Develop people-centered and nature-inclusive infrastructure:

It is crucial to highlight that transitioning to 100% renewable energy will bring several benefits to people across the world. These advantages include reduced energy costs, the creation of local jobs, and increased involvement in energy production, ownership, and usage. Engaging the public at an initial stage can systematically streamline the planning and implementation of new infrastructure over time by proactively addressing concerns of the public from the outset.³⁴

B. Clean Energy Transition³⁵

Energy transition is changing the overall landscape and scenario of electricity generation. As decarbonization drives Renewable Energy

30. *Id.* at 7.

31. *Id.* at 8.

32. *Id.*

33. *Id.*

34. CLIMATE ACTION NETWORK EUR., *supra* note 22, at 10.

35. *See generally* R. LEAL-ARCAS ET AL., ELECTRICITY DECENTRALIZATION IN THE EUROPEAN UNION, *supra* note 2; R. LEAL-ARCAS ET AL., THE GREAT ENERGY TRANSITION IN THE EUROPEAN UNION: VOLUME 1 (2020); R. LEAL-ARCAS ET AL., THE GREAT ENERGY TRANSITION IN THE EUROPEAN UNION: VOLUME 2 (2020); Shaar & Leal-Arcas, *supra* note 2, at 112; Leal-Arcas, Karimabadi & Boskovic, *supra* note 2; LEAL-ARCAS, THE TRANSITION TOWARDS DECARBONIZATION: A LEGAL AND POLICY EXPLORATION OF THE EUROPEAN UNION, *supra* note 2; Leal-Arcas, *Citizens at the Center*, *supra* note 5, at 231–44.

Sources (RESs) demand, RESs are expected to account for 45% to 50% of the global power supply by 2030, and 60% to 70% by 2040.³⁶ Although renewable energy systems can independently power houses and small businesses without relying on the electricity grid, known as an off-grid or stand-alone system, many individuals opt for the benefits that are offered by the grid connection because they can be powered by renewable energy at any given time, including summer, winter or when it is windy or raining. The extra electricity that is produced is sent back to the grid and stored. In the absence of renewable sources during a particular unfavorable weather event, the same stored electricity is supplied from the grids thereby eliminating the need for storage devices (for example, batteries) and saves the cost for the same. In remote areas, stand-alone systems can often be more economical compared to the expense of extending a power line to the electricity grid, which can range from \$15,000 to \$50,000 per mile.³⁷

Examples of renewable energy systems connected to the grid include:

- (i) Community solar installations;
- (ii) Rooftop solar panels installed on residential homes;
- (iii) Wind turbines generating electricity for businesses; and
- (iv) Small hydropower turbines supplying power to family farms.

One of the benefits of renewable energy systems connected to the grid is that there are two ways a consumer could access the power that is fed in the grid:

(i) Net Purchase & Sale—contains two electric meters: one measures energy consumption, while the other tracks energy produced and sent to the grid. The utility compensates for this exported energy at a wholesale rate, and any surplus may appear as a credit on the bill.

(ii) Net metering—A single bidirectional electric meter operates in two directions: (1) moves forward when more power is drawn from the grid than produced, (2) backward when more power is generated than used. Eventually, the bill is based on net power use, which is the difference between production and consumption. If these balance out, there is no charge. If the generation is more than the usage, the bill can

36. Adam Barth et al., *How grid operators can integrate the coming wave of renewable energy*, MCKINSEY & CO. (Feb. 8, 2024), <https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/how-grid-operators-can-integrate-the-coming-wave-of-renewable-energy> [https://perma.cc/Y3QW-GFC3].

37. OFF. OF ENERGY SAVER, *Off-Grid or Stand-Alone Renewable Energy Systems* (Sept. 16, 2024), <https://www.energy.gov/energysaver/grid-or-stand-alone-renewable-energy-systems> [https://perma.cc/3AM6-7CHL].

be negative. In this case, the utility usually compensates for excess power at wholesale prices.³⁸

Consumption of electricity in the EU is projected to rise by approximately 60% by the year 2030.³⁹ The networks will have to adapt to a further digitalized, decentralized, and versatile system that incorporates hundreds of thousands of rooftop solar panels, heat pumps, and local energy community sharing resources. Additionally, there will be a rise in offshore renewables, more electric vehicles requiring charging infrastructure, and growing demands for hydrogen production. Approximately 40% of the European Union's distribution grids are over forty years old and inter-regional transmission capacity is estimated to increase by two folds by 2030, requiring investments totaling €584 billion, the equivalent of \$692.24 billion.⁴⁰

1. The European Union's Action Plan—Addressing the Missing Link of the Clean Energy Transition

The Action Plan focuses on the issues pertaining to expansion, digitalization, and optimization of the EU's electricity transmission and distribution grids. It outlines specific and customized actions to facilitate the necessary investments for modernizing and speeding up European electricity grids. The actions emphasize implementation and prompt execution to make a significant difference and outcome to achieve the 2030 goals:

- Escalate the execution of Projects of Common Interest and initiate other new projects by putting forth proposals, optimal monitoring and political will;
- Further advancing the long-term planning of grids to support increased renewable energy integration and electrified demands, including hydrogen, within the energy infrastructure by determining the efforts of system operators as well as national regulators;
 - Rolling out regulatory incentives that encourage investments for clean energy transition and inter-regional financial sharing for offshore projects;
 - Promote systematic and improved way of grid usage through transparency and better network tariffs for smarter grids, efficiency and innovative technologies and solutions by incentivizing it. This effort also involves fostering collaboration between system operators and

38. See PERCH ENERGY, *supra* note 18.

39. U.N. Press Release IP/23/6044, Commission sets out actions to accelerate the roll-out of electricity grids (Nov. 23, 2023), https://ec.europa.eu/commission/presscorner/detail/en/ip_23_6044 [<https://perma.cc/5EPF-FSD9>].

40. *Id.*

recommendations from the Agency for the Cooperation of Energy Regulators (ACER);

- Help in aiding funds towards grid projects by publicizing the projects and promote opportunities for EU funding programs for smart grids and for updating the existing distribution grids;
- Escalating the process of granting permission for deployment of grids by assisting in technical aspects and guide for better engagement with stakeholders and community; and
- Improve and secure the grid supply chain by harmonizing industry manufacturing criteria for generation and demand connections.⁴¹

In the U.S., the Southline project will be connecting wind power generated in New Mexico to cities in Arizona in response to rising demands for clean energy.⁴²

2. Green Hydrogen for Energy Transition

Green hydrogen is expected to significantly contribute to decarbonization across various sectors such as transportation, shipping, steel, etc. It is produced through electrolysis, a process that splits water into hydrogen and oxygen by utilizing electricity sourced from renewable energy such as solar, wind, or hydropower. This method produces a clean, emission-free fuel with significant potential to substitute fossil fuels and mitigate carbon emissions. Green hydrogen can also be produced by another method, i.e., from biomass gasification.

These two methods are sustainable, thereby making green hydrogen a preferred choice for transitioning to a clean and reduced carbon emissions future. Green hydrogen can also be an alternative for traditional fossil fuels in transportation to reduce emissions and can be utilized as a backup energy source for renewable energy plants. Green hydrogen can be a consistent and reliable energy source.⁴³ Green hydrogen has diverse and numerous applications. For example, it can be utilized in fuel cells to power vehicles, generating electricity, and microgrids, supplying power to remote locations and facilitating energy independence.

3. Digital Solution and Technology

It is estimated that digital technology could significantly contribute to the energy transition by cutting down greenhouse gas emissions by 15%.

41. *Id.*

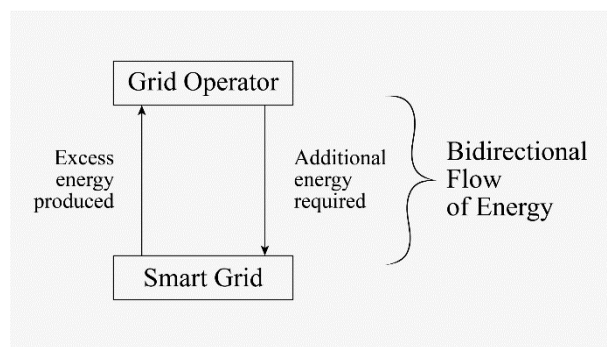
42. Joseph R. Biden, Jr., *FACT SHEET: Biden-Harris Administration Announces Historic Investment to Bolster Nation's Electric Grid Infrastructure, Cut Energy Costs for Families, and Create Good-paying Jobs*, THE AM. PRESIDENCY PROJECT (Oct. 30, 2023), <https://www.presidency.ucsb.edu/documents/fact-sheet-biden-harris-administration-announces-historic-investment-bolster-nations> [<https://perma.cc/E9FF-NRQP>].

43. *Hydrogen Overview: Brief of Green Hydrogen*, MINISTRY OF NEW AND RENEWABLE ENERGY, <https://mnre.gov.in/hydrogen-overview/> [<https://perma.cc/H9QG-7WA4>].

Integration of digital technologies with sustainable energy can be a potent tool for supporting climate action and community resilience. Digital technologies like automated grid management and smart meters play an important role in improving resilience. For instance, the installation of smart meters allows for remote monitoring of energy supply reliability during extreme weather events, real-time tracking of energy consumption, and the implementation of a pay-as-you-go system where users only pay for the electricity they have consumed.⁴⁴ The adoption of residential smart meters has seen notable progress in recent years and it is pertinent to note that China has a 100% share of households with smart meters.⁴⁵

The concept of smart grid is outlined in Figure 2.

Figure 2: Smart grid⁴⁶



Source: Authors

When the proportion of renewable energy sources like wind and solar grows, the fluctuation in their output can present challenges for grid stability.⁴⁷ Increased surges of demand arise as transportation and heating becomes electrified.⁴⁸ As heat pump and electric vehicle (EV) usage gains more popularity, there will be a rise in energy consumption thereby affecting the grid stability and flexibility, specifically if the infrastructure

44. *See id.*

45. Michael Drtil et al., *Smart Grids*, INT'L ENERGY AGENCY (July 11, 2021), <https://www.iea.org/energy-system/electricity/smart-grids> [<https://perma.cc/B3SP-369N>].

46. R. Leal-Arcas, Vishakha Joshi, & Dyuti Pandya, Illustration of a Smart Grid Concept (on file with author).

47. *See Stanford engineers develop a new method of keeping the lights on if the world turns to 100% clean, renewable energy*, STANFORDREPORT (Feb. 8, 2018), <https://news.stanford.edu/stories/2018/02/avoiding-blackouts-100-renewable-energy> [<https://perma.cc/H2NS-M5LH>].

48. *See Electrification*, Int'l Energy Agency (July 11, 2023), <https://www.iea.org/energy-system/electricity/electrification> [<https://perma.cc/4WHT-JB7C>].

is not ready to sustain the increased demand and load.⁴⁹ To improve resilience against these challenges, smart grid technology plays an important role by enabling real-time communication of power-usage patterns from homes and offices, and allows for dynamic distribution control during weather events.⁵⁰

Smart grid is a network that helps in monitoring power consumption by the usage of digital and other technologies and further plays a vital role in management of transportation of energy from generation sources to distribution sources as per the required demand.⁵¹ Smart grids manage the requirements and the potential capacity of generators, grid operators, consumers or end users, and stakeholders of the electricity market to optimize the entire system's efficiency.⁵² This approach minimizes the costs and environmental effects and at the same time boosts system reliability, resiliency, flexibility, and stability. In simpler terms, a smart grid is a powered grid having facilities that automates, communicates, and has IT development that enables monitoring of power flows from generating to consumption.⁵³ This technology allows for real-time or near-real-time control of power flow and reduces load to align with generation levels.⁵⁴ The smart grid has numerous benefits and characteristics that are beneficial to customers directly:

- Continuously enables real-time monitoring;
- Facilitates speedy restoration and automated outage management;
- Has a dynamic pricing mechanism;
- Provides incentives to consumers based on pricing signals throughout the day;
- Helps in energy management;
- Usage of in-house displays, web portals and mobile or tablet apps;
- Can monitor and manage the use of energy; and
- Provides an opportunity for electricity conservation.⁵⁵

The smart grid enables distributed generation, particularly rooftop solar, by facilitating bidirectional energy movement and measurement through control systems and net metering.⁵⁶ This allows “prosumers”

49. *See id.*

50. *See* Smart Grids, Int'l Energy Agency (July 11, 2023), <https://www.iea.org/energy-system/electricity/smart-grids> [<https://perma.cc/5RAM-PART>].

51. *Id.*

52. *Id.*

53. *Id.*

54. *Id.*

55. Gareth Shirley, *Smart Sensors in Smart Grid: Real-Time Energy Monitoring & Optimization*, FORESTROCK (Feb. 3, 2025), <https://www.forestrock.co.uk/smart-sensors-smart-grids/> [<https://perma.cc/MP5L-4P5V>].

56. *Id.*

(consumers who produce as well as use electricity) to safely connect to the grid.⁵⁷ To measure progress, it is vital to understand the traditional grid features and compare it with the smart grid features. Table 1 outlines the differences:

Table 1: Comparison of the Traditional Electric Grid and the Smart Grid⁵⁸

Traditional grid	Smart grid
Mechanization	Digitization
One-way communication	Bi-directional communication
Power generation is centralized	Distributed power generation
Radial network	Dispersed network
Fewer data involved	The large volume of data involved
Small numbers of sensors	Many sensors and monitors
Less or no automatic monitoring	Great automatic monitoring
Manual control and recovery	Automatic control and recovery
Less security and privacy concerns	Prone to security and privacy issues
Manual attention to system disruptions	Adaptive protection
Simultaneous production and consumption of energy/electricity	Use of storage system
Limited control	Extensive control system
Slow responses to emergencies	Fast responses to emergencies

Source: Y Yu, W Luan: Smart grid and its implementations

Smart grids can be used and linked to EVs too.⁵⁹ EVs operate with the help of an electric motor powered by an external energy source, occasionally also termed as electric vehicle supply equipment (EVSE).⁶⁰ The main challenge for electric utilities is managing the timing of EV charging on their system.⁶¹ For instance, when customers return home from work, many of them will automatically charge their EVs, and without control over this load, it could potentially destabilize the grid.⁶²

Utilities need to anticipate the scenario where multiple consumers charge their EVs simultaneously on the same transformer. Smart Grid

57. Drtil et al., *supra* note 45; see also R. Leal-Arcas et al., *Prosumers: New Actors in EU Energy Security*, 48 NETH. Y.B. INT'L L. 139, 139–72 (2017).

58. Y. Yu & W. Luan, *Smart grid and its implementations*, 29 Procs. CSEE 1, 1–8 (2009).

59. Archana et al., *Development of smart grid for the power sector in India*, in 2 CLEANER ENERGY SYSTEMS (July 2022), <https://doi.org/10.1016/j.cles.2022.100011> [<https://perma.cc/UY44-4HPG>].

60. *Id.*

61. *Id.*

62. *Id.*

technology plays an important role here by enabling intelligent scheduling of EV charging to address these concerns.⁶³ It also allows for the storage capacity of EV batteries to be used as a backup power source when there is an increased demand; some of the energy stored in these batteries can be returned to the grid during peak hours, with the batteries restored or charged again during off-peak periods.⁶⁴ It is pertinent to note that this concept of Vehicle-to-Grid Integration (VGI) is an essential component of emerging smart grid technology.⁶⁵

Deployment of smart grids is already one of the three priority areas under the EU's Trans-European Networks for Energy (TEN-E) policy, which emphasizes linking energy infrastructure throughout the area.⁶⁶ The European Commission introduced the European Union action plan "Digitalization of the energy system" in the year 2022. The European Commission estimates approximately €584 billion (\$633 billion) in investments in the European electricity grid by the year 2030, out of which €170 billion (\$184 billion) will be allocated for digitalization, i.e., on automated grid management, smart meters, digital technologies for metering and advancement on the field operations.⁶⁷ Investment in smart grids must increase more than two-fold by 2030 to align with the Net Zero Emissions (NZE) by 2050 Scenario, particularly in emerging and developing economic markets.⁶⁸

C. Regional Developments

The following section analyses climate-resilient electricity grids in three jurisdictions: the United States, India, and China.

1. United States

Throughout the United States, the electricity grid links 145 million houses and businesses.⁶⁹ However, several areas of the country's grid need to be upgraded urgently.⁷⁰ To facilitate more clean energy to curb residential energy cost and emissions, it further requires increased transmission. Presently, it is critical to act and allocate funds towards a cleaner, consistent and reliable electric grid to make sure that the local communities are not deprived of power during extreme weather events

63. *Id.*

64. *Id.*

65. Archana et al., *supra* note 59.

66. Charles Waine, *Powering up with Smart Grids*, INFRASTRUCTURE INV. (May 9, 2023), <https://www.infrastructureinvestor.com/powering-up-with-smart-grids/> [<https://perma.cc/5DPD-G4NN>].

67. Drtil et al., *supra* note 45.

68. *Id.*

69. Biden, *supra* note 42.

70. *See id.*

and also to reduce the energy costs for those communities. This will also accelerate the pace to achieve President of the USA, Biden's goal of energy transition to deliver 100% clean electricity by the year 2035.⁷¹

On March 13, 2024, 'Advancing Grid-Enhancing Technologies Act of 2024' or Advancing GETs Act was introduced to increase transmission capacity and support the United States in achieving its clean energy electricity goals by promoting the adoption of grid-enhancing technologies.⁷² There are several grid-enhancing technologies like dynamic line ratings, advanced power flow controls and topology optimization that can expedite the clean energy projects online swiftly.⁷³ Under this legislation, the Federal Energy Regulatory Commission would need to create an incentive program that enables savings to be shared for grid-enhancing technologies (GETs) to further enhance the capacity to existing transmission infrastructure.⁷⁴ It would enable a developer to be compensated for the cost of grid enhancing technologies project, along with the cost-savings generated by it and the remaining savings would benefit the ratepayers.⁷⁵

The U.S. Department of Energy has allocated \$3.46 billion for a total fifty-eight projects across forty-four states to enhance the resiliency and reliability of the country's electricity grid.⁷⁶ Supported by the Bipartisan Infrastructure Law, these initiatives will harmonize a total investment of more than \$8 billion from private as well as state sources.⁷⁷ Altogether, these projects will facilitate the integration of over 35GW of renewable energy capacity and will also enable the deployment of 400 microgrids.⁷⁸ Additionally, it will help in catalyzing development of new and upgraded transmission infrastructure leading to reduced electricity costs.

The Biden and Harris Administration is currently functioning to:

(i) "Expand capacity and unlock renewable energy resources." Transitioning houses, erected structures, and transportation to electric power would cut down greenhouse gas emissions and costs.⁷⁹ Additionally, the Twin States Clean Energy Link Project will integrate

71. *Id.*

72. Ethan Howland, *Bills aim to spur grid-enhancing technologies with shared-savings incentives from FERC*, UTIL. DRIVE (Mar. 14, 2024), <https://www.utilitydive.com/news/ferc-shared-savings-incentive-gets-grid-enhancing-bills/710287/> [<https://perma.cc/K94D-7PP7>].

73. *Id.*

74. *Id.*

75. *Id.*

76. Catherine Clifford, *Biden administration to invest \$3.5 billion to improve the resiliency of the electric grid*, CNBC (Oct. 18, 2023, 3:49 PM), <https://www.cnbc.com/2023/10/18/biden-administration-to-invest-3point5-billion-into-the-electric-grid.html> [<https://perma.cc/MC8V-ZZEU>].

77. *Id.*

78. *Id.*

79. Biden, *supra* note 42.

with the transmission lines which are currently existing to facilitate the exchange of clean energy between Canada and New England.⁸⁰

(ii) “Reduce the frequency and duration of power outages.” By investing in hardening of grid such as critical transmission lines strengthening, solidifying electric poles with even more stronger materials, and working on improvement of the flood mitigation, it will provide a guarantee that the communities are not deprived of power during extreme weather events and that a power outage does not last for long during that time.⁸¹ For example, in Pennsylvania, an energy company named PECO aims to boost grid’s resilience and reliability by substation flood mitigation, upgradation of tracking systems, deployment of devices such as batteries to store and backup power, replacement of infrastructure with modern technology, and installation of upgraded conductors to boost the capacity of the grid.⁸² And

(iii) “Mitigate risk of wildfire.” Through investment in projects aimed at relocating overhead power lines vulnerable to heavy winds or snow, eliminating hazardous trees and implementing technology-based upgrades, utilities can improve their ability to predict and identify high-risk wildfire conditions, detect wildfires at an early stage and minimize the necessity for proactive power shutdowns in wildfire-prone regions.⁸³ It is worth noting that Hawaiian Electric plans to allocate up to \$95 million for grid hardening efforts in Hawaii, which encompasses wildfire mitigation measures such as undergrounding power lines, tree elimination, and the installation of monitoring systems for outage alerts and detection of smoke.⁸⁴

It is pertinent to note that the Environmental Protection Agency (EPA) on April 25, 2024 issued a new rule for the United States coal fired power plants to either capture their own emissions or completely shut down by 2039. If, as priorly anticipated, the coal plants will not be shutting down, they will have to capture 90% of their CO₂ emissions by the year 2032.⁸⁵ However, the coal plants retiring by 2032 will not be subject to the new EPA rules.⁸⁶

80. *Id.*

81. *Id.*

82. *Id.*

83. *Id.*

84. *Id.*

85. *New rule compels US coal-fired power plants to capture emissions – or shut down*, THE GUARDIAN (Apr. 25, 2024), <https://www.theguardian.com/environment/2024/apr/25/new-rule-compels-us-coal-fired-power-plants-to-capture-emissions-or-shut-down> [<https://perma.cc/RU98-5BS7>].

86. *Id.*

2. India⁸⁷

India announced its goal to achieve energy independence by the year 2047 and has set a net zero emissions target of 2070. India's energy usage has doubled over the past twenty years and it is predicted that it will increase by at least 25% by 2030 and currently imports over 40% of its primary energy requirements, totaling over \$90 billion annually.⁸⁸ During the Glasgow Climate Summit in the year 2021, India announced plans to transition 40% of its power generation to renewable energy sources by 2030, with 60% of this renewable energy generating from solar power.⁸⁹

During the G20, India considered mini grids as a potential solution to combat energy poverty. Until now, India has installed solar microgrids, which have supplied approximately 2 MW of electricity, and it is currently leading the countries with planned microgrids. India aims to deploy 18,900 microgrids, then followed by Nigeria with 2,700 mini-grids, Tanzania with 1,500, Senegal with 1,200, and Ethiopia with 600.⁹⁰ Large private investments are also contributing to accelerating the microgrid installations and it is worthy to note that the giant company, Tata Power, has partnered with Rockefeller Foundation to set up 10,000 microgrids by the year 2026.⁹¹

To achieve energy independence, India has also launched its "National Green Hydrogen Mission." Given the renewable energy potential and the supportive framework outlined in the Mission, it is expected that India's green hydrogen production costs would be the lowest in the world.⁹² Furthermore, the National Smart Grid Mission (NSGM), is an institutional mechanism that has been set up to strategize, monitor, and supervise the development and execution of policies and

87. See generally Noriko Fujiwara, *The Political Economy of India's Climate Agenda* (Ctr. Eur. Pol'y Stud., Working Document No. 325, 2010), http://aei.pitt.edu/14585/1/WD_on_India%27s_Climate_Agenda_by_Fujiwara_e-version.pdf [<https://perma.cc/8CSJ-AA2A>]. Fujiwara N, "The Political Economy of India's Climate Agenda," CEPS Working Document No. 325, March 2010 (discussing the issues facing India's climate policies).

88. Ministry of New and Renewable Energy, 3-Day International Conference on Green Hydrogen begins in New Delhi, PRESS INFO. BUREAU DELHI (July 5, 2023, 6:33 PM) (India), <https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1937584> [<https://perma.cc/ZJK6-GDMA>].

89. Suniti Kaur & Sragvi Chaturvedi, *India's Commitment to Clean Energy: Laws & Regulations*, MONDAQ (Mar. 23, 2023), <https://www.mondaq.com/india/renewables/1297088/indias-commitment-to-clean-energy-laws-regulations> [<https://perma.cc/FR77-3JGL>].

90. Kundan Pandey, *The potential of mini-grids as a sustainable and economical alternative for global electrification*, MONGABAY (Aug. 23, 2023), <https://india.mongabay.com/2023/08/are-mini-grids-the-sustainable-and-economical-solution-to-achieving-global-electrification/> [<https://perma.cc/8BXG-LZH6>].

91. Priya Aggarwal, *The role of microgrids in India*, RENEWABLE ENERGY WORLD (Sept. 1, 2020), <https://www.factorthis.com/power-grid/microgrid/the-role-of-microgrids-in-india/> [<https://perma.cc/E5VK-MXDP>].

92. Hydrogen Overview: Brief of Green Hydrogen, *supra* note 43.

programs that are related to Indian smart grid activities.⁹³ NSGM operates within India's Ministry of Power and other concerned ministries such as the Ministry of New & Renewable Energy, the Ministry of Urban Development, and the Ministry of Heavy Industry.⁹⁴ A comprehensive twenty-year plan has been formulated to integrate transmission networks that are connected inter-state and inter-region across India.⁹⁵ This network will serve as a vital foundation for achieving the vision of twenty-four seven electricity for all households and for ensuring uninterrupted power supply to every household in India.⁹⁶

The Ministry of Power also launched one of the significant initiatives, Resource Adequacy Planning Framework (RA Framework), which was established in June 2023. Resource adequacy (RA) and its association with the capacity market have been crucial within the U.S. and Europe's grid operators for maintaining the reliability of systems and to secure sufficient resource availability. However, comprehending the planning of RA and its execution are currently in the initial phase.

India's Ministry of Power had approved and completed eleven smart grid pilot projects. As of March 2024, there were two ongoing National Smart Grid Mission projects: (i) in Chandigarh (which currently has smart meters and supervisory control and data acquisition (SCADA) system installed on site) and (ii) another in six areas of Rajasthan State (which has an NSGM grant of Rs.1.927 crores and 1,45,343 smart meters deployment started in November 2023).⁹⁷

3. China

The microgrid industry in China is growing rapid due to the increased adoption of renewable energy and supportive government regulations promoting sustainable energy. The Chinese government is committed to promoting distributed energy generation from renewable sources to improve electricity access in interior and rural areas of the country. This has resulted in a significant increase in microgrid installations. One of the largest Chinese technology companies, Tencent, has installed a new microgrid at its High-Tech Cloud Data Center in Tianjin. Currently, there is a total installed capacity of 10.54 MW, and it is anticipated that the

93. *Id.*

94. *Id.*

95. *See id.*

96. National Smart Grid Mission, INDIA SMART GRID F., <https://indiasmartgrid.org/nsgm> [<https://perma.cc/PZD3-H85R>].

97. Ministry of Power, Status of Ongoing NSGM Smart Grid Projects (issued March 2024) (India), <https://www.nsgm.gov.in/sites/default/files/SG-Projects-Status-March-2024.pdf> [<https://perma.cc/GA3B-GH6C>]; *see also* National Smart Grid Mission, Ministry Power, Gov't India, <https://www.nsgm.gov.in/> [<https://perma.cc/8CPG-NDL6>].

microgrid will generate 12 million kW of electricity annually which is equivalent to the energy usage of 6,000 households.⁹⁸

In the deserts of the north-western part of China such as the Gobi Desert, a large and leading electricity production and transmission network is being built. The region now has the installed capacity of renewable energy of 230GW, with 50% of this electricity transmitting over ultra high-voltage direct current transmission lines to coastal provinces in the east having high density of population.⁹⁹ Spanning over thousands of kilometers, the power lines are placed across almost the entire region spanning China, thereby making the north west power grid the regional power grid with the strongest outbound capacity and the largest scale in the world.¹⁰⁰

To address the growing demands, China has also increased its smart grid development recently. The Chinese smart grid market is projected to grow by \$13.96 billion USD from 2022 to 2027, gradually increasing at a compound annual growth rate—i.e., a CAGR, of 14.34%.¹⁰¹ This growth is backed by the fact that the Chinese power utility industry is enduring a notable transformation from a rigid and firm structure to an adaptable and flexible system, driven by policies on climate change, urbanization, and technological advancements. The power sector is therefore transitioning and is facilitated by the establishment of advanced metering infrastructure (AMI) and SCADA systems. This leads to the incorporation of smart technologies into the grid that enables utilities to have more control over the grid operations and functions. Therefore, because of the beneficial smart grid features, it is reckoned that the Chinese Smart Grid Market will have a predictable and rapid growth.¹⁰²

98. Kathy Hitchens, *Tencent Commissions New 10.54-MW Data Center Microgrid in China*, MICROGRID KNOWLEDGE (Feb. 2, 2024), <https://www.microgridknowledge.com/data-center-microgrids/article/33035504/tencent-commissions-new-1054-mw-data-center-microgrid-in-china> [https://perma.cc/HRT5-KATG].

99. See Stephen Chen, *China builds up electric power in Gobi and western deserts equal to half US capacity*, SOUTH CHINA MORNING POST (Feb. 20, 2024), <https://www.scmp.com/news/china/science/article/3252564/china-builds-electric-power-gobi-and-western-deserts-equal-half-us-capacity> [https://perma.cc/2DK4-W7DT].

100. Stephen Chen, *Deserts marvel sends clean power to heart of industry; Scientists hail 'world-leading' electricity production network taking shape in country's northwest.*, SOUTH CHINA MORNING POST (HONG KONG), Feb. 21, 2024, Gale General OneFile, Gale Doc. No. GALE|A783585916.

101. Smart Grid Market Size in China to Grow by USD 13.96 Billion from 2022 to 2027|ABB Ltd., Cisco Systems Inc., General Electric Co., Huawei Technologies Co. Ltd. and More Among the Key Companies in the Market – Technavio, PRNEWswire (Nov. 21, 2023, 11:35 PM), <https://www.prnewswire.com/news-releases/smart-grid-market-size-in-china-to-grow-by-usd-13-96-billion-from-2022-to-2027-abb-ltd-cisco-systems-inc-general-electric-co-huawei-technologies-co-ltd-and-more-among-the-key-companies-in-the-market---technavio-301995052.html> [https://perma.cc/7YW2-353N].

102. *Id.*

II. COP 28 FRAMEWORK ON ENERGY TRANSITION

A. *The Framework*

The Paris Agreement on Climate Change is a legally binding international treaty on climate change, adopted by 196 Parties at the UN Climate Change Conference of the Parties (COP21) in Paris, France, on December 12, 2015.¹⁰³ With the Paris Agreement, these nations also developed an enhanced transparency framework (ETF).¹⁰⁴ As per the ETF, all the countries will have to make transparent disclosures on actions by the respective countries and their progress and growth in mitigating climate change, their adapted measures, and the support given or received.¹⁰⁵ The consolidated data and information collected through the ETF will contribute to the global stocktake and the global stocktake will eventually do the assessment of the collective progress for achieving the long-term climate goals.¹⁰⁶

The first global stocktake report during the COP 28 on Energy Transition acknowledged the need for swift and consistent reduction of greenhouse gas emissions to be aligned with the 1.5 °C pathways.¹⁰⁷ It urged the signatories to the United Nations Framework Convention on Climate Change (UNFCCC) to contribute to the following global efforts, in a nationally determined manner, considering the Paris Agreement and the parties' respective national circumstances, pathways, and approaches.¹⁰⁸

- (a) Tripling the capacity of renewable energy globally and doubling the global average yearly rate of improving energy efficiency by the year 2030;
- (b) Implementing the phase-down of unabated coal power plants;
- (c) Escalating efforts for developing energy systems that are low-carbon or have zero emissions;
- (d) Cutting down the usage of fossil fuels in existing energy systems, in a just and equitable manner to meet net-zero target of 2050;
- (e) Escalating carbon free and low-carbon technology, including renewables, nuclear, *et cetera*;

103. U.N., The Paris Agreement (Sept. 21, 2024), <https://unfccc.int/process-and-meetings/the-paris-agreement>[<https://perma.cc/54JJ-GX6L>].

104. *Id.*

105. *Id.*

106. *Id.*

107. U.N. Framework Convention on Climate Change, *Conference of the Parties serving as the meeting of the Parties to the Paris Agreement*, U.N. Doc. FCCC/PA/CMA/2023/L.17 (Dec. 13, 2023), https://unfccc.int/sites/default/files/resource/cma2023_L17E.pdf [<https://perma.cc/ES22-MNNE>]

108. *Id.*

(f) Escalating the reduction of non-CO₂ emissions such as methane emissions by the year 2030;

(g) Escalating efforts to reduce emissions from transportation by improving and building required infrastructure and promoting the usage of zero- and low-emission vehicles by deploying them at a significant pace; and

(h) Phasing out inefficient fossil fuel subsidies at the earliest, which are irrelevant in addressing energy poverty or just transitions.

During COP 28, to align with an equitable energy transition path, the Global Renewables and Energy Efficiency Pledge was signed by 133 nations.¹⁰⁹ Collectively, the pledge signatories have committed to increase the installed renewable energy generation capacity of the world by three times, i.e., at least 11,000 GW, by 2030.¹¹⁰ It also recognized a need to further strengthen inter-regional partnerships and associations on renewable energy and energy efficiency. To carry this out, the actions highlighted below are vital:¹¹¹

- Fostering collaboration to strengthen the overall value chain, making them resilient and developing new innovative technologies;
- Increasing financial support to expand and promote the usage of renewable energy and energy systems including investments for wider initiatives from private sector, development banks, *et cetera*;
- Making financing mechanisms easily available to lower the capital cost in developing markets and economies;
- Improving technological assistance and potential for renewable energy generation, especially in developing nations; and
- Expediting the development of grid connections across different regions.

To achieve these targets, it is important to act on the following:

- Speeding up the permitting process for projects on renewable energy and developing resilient infrastructure;
- Integrating energy systems and improve grid interconnections;

109. See Global Renewables and Energy Efficiency Pledge, COP28 UAE, <https://www.cop28.com/en/global-renewables-and-energy-efficiency-pledge> [<https://perma.cc/W8AF-DUMR>]

110. Priyanka Kwatra, *COP28 Takeaways: Global Stocktake outlines strategies to close implementation gaps by 2030*, POWERLINE (Jan. 4, 2024), <https://powerline.net.in/2024/01/04/cop28-takeaways-global-stocktake-outlines-strategies-to-close-implementation-gaps-by-2030/> [<https://perma.cc/8Z25-XCZS>].

111. Global Renewables and Energy Efficiency Pledge, *supra* note 109.

- Clarifying and strengthening market conditions and structure, incentive schemes, and incorporating frameworks on investment to accelerate the growth of renewable energy and efficiency;
- Promoting the usage of clean electricity and planning to address energy demand across various relevant sectors;
- Increasing public knowledge and community awareness;
- Putting effort into on diversified private and public investments, more importantly for developing economies; and
- Scaling-up adoption of new technological solutions by innovation, research and development.

Additionally, for promoting electrification, the development of renewable-ready grids, and the deployment of clean-energy aligned with the 2030 Breakthrough goals, the Utilities for Net-Zero Alliance was established consisting of thirty-one partners, that includes twenty-five global utilities and energy companies.¹¹²

At COP 28, Zambia also announced its plan to deploy mini-grids across the country. The Zambian government has collaborated with other partners such as the Rockefeller Foundation, the Global Energy Alliance For People and Planet, and Sustainable Energy For All to revolutionize the nation's overall energy transition scenario.¹¹³ It is significant to note that the United Arab Emirates Just Transition Work Programme in 2024 is expected to focus on "Just Transition pathways to achieving the goals of the Paris Agreement through NDCs, NAPs and LT-LEDs."¹¹⁴ It is our hope that other countries in the region and across the globe will replicate these initiatives.

Following the energy transition outcomes at COP 28, a notable progress has been made at the G7 Ministerial meeting on April 30, 2024 regarding the end of the unabated coal power plants by 2035.¹¹⁵ The G7

112. Kwatra, *supra* note 110.

113. *Zambia Launches Mini-Grid Initiative in Collaboration with Rockefeller Foundation at COP28*, LUSAKA TIMES (Dec. 3. 2023), <https://www.lusakatimes.com/2023/12/03/zambia-launches-mini-grid-initiative-in-collaboration-with-rockefeller-foundation-at-cop28/> [https://perma.cc/MJ69-365U].

114. U.N. Climate Change Secretariat, First dialogue under the United Arab Emirates Just Transition Work Programme in 2024, Message from the Chairs of the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI), 1, U.N. MTP/OBS./Topic/UAE JTWP (Mar. 27, 2024), https://unfccc.int/sites/default/files/resource/Message_to_Parties_and_observers_JTWP_First_Dialogue_Topic_Announcement.pdf [https://perma.cc/BTQ3-XW92].

115. Meg Jones, *G7 agrees to phase out use of unabated coal power plants, and other nature and climate stories you need to read this week*, WORLD ECON. F. (Sept. 10, 2024), <https://www.weforum.org/agenda/2024/05/g7-coal-power-plant-phase-out-nature-climate-news-06052024/#:~:text=1.-,G7%20agrees%20to%20phase%20out%20use%20of%20unabated%20coal%20power,strong%20signal%20from%20industrialized%20countries> [https://perma.cc/L6LY-4A9R].

has committed to phase out the unabated coal power generation during the early months of the year 2030.¹¹⁶ The efforts have already commenced to progress towards energy transition and countries such as the U.S. are likely to follow the pace and make similar commitments to phase out of coal power during the COP 29.¹¹⁷

B. *Climate Finance*¹¹⁸

As per the United Nations: “Climate Finance refers to all financial flows addressing the causes and consequences of climate change.”¹¹⁹ It

116. Department of Energy, *G7 Energy Ministers Achieve Breakthroughs on Unabated Coal Phaseout, Global Energy Storage, and Phasing Out Harmful Non-CO2 Pollutants* (May 9, 2024), <https://www.energy.gov/articles/g7-energy-ministers-achieve-breakthroughs-unabated-coal-phaseout-global-energy-storage-and> [<https://perma.cc/Z2N5-V7Q6>].

117. *Id.*

118. For an overview on climate finance, *see generally* Arunabha Ghosh, *Negotiating Around Tradeoffs: Alternative Institutional Designs for Climate Finance*, ECP Rep. No. 10, CTR. EUR. POL’Y STUD. (Dec. 9, 2010), <https://www.ceps.eu/ceps-publications/negotiating-around-tradeoffs-alternative-institutional-designs-climate-finance/> [<https://perma.cc/AUT5-YNU7>]; Neil Bird, Jessica Brown & Liane Schalatek, *Design Challenges for the Green Climate Fund*, Climate Fin. Pol’y Brief No. 4, HEINRICH BÖLL STIFTUNG FOUND., OVERSEES DEV. INST. GLOB. (Jan. 2011), <https://odi.org/en/publications/design-challenges-for-the-green-climate-fund/> [<https://perma.cc/8WEC-WNLH>]; Jessica Brown, Neil Bird & Liane Schalatek, Direct Access to the Adaptation Fund: realising the potential of National Implementing Entities, Climate Fin. Pol’y Brief No. 3, HEINRICH BÖLL STIFTUNG FOUND., OVERSEES DEV. INST. GLOB. (Nov. 2010), <https://odi.org/en/publications/direct-access-to-the-adaptation-fund-realising-the-potential-of-national-implementing-entities/> [<https://perma.cc/2AMB-DKHC>]; Richard B. Stewart, Benedict Kingbury & Bryce Rudyk, *Climate Finance: Key Concepts and Ways Forward*, HARV. PROJECT ON INT’L CLIMATE AGREEMENTS (Dec. 2009), <https://guaranicenter.org/wp-content/uploads/2009/12/Stewart-Final.pdf> [<https://perma.cc/QTb4-9F4Y>]; Athena Ballesteros, Smita Nakhoda, Jacob Werksman & Kaija Hurlburt, *Power, Responsibility and Accountability: Re-Thinking the Legitimacy of Institutions for Climate Finance*, WORLD RES. INST. (2010), http://pdf.wri.org/power_responsibility_accountability.pdf [<https://perma.cc/9PZM-MRQW>]; U.N. Convention on Climate Change, Conf. of the Parties Dec. 1/CP.16, *The Cancun Agreements: Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention*, U.N. Doc. FCCC/CP/2010/7/Add.1, at ¶¶ 95–112 (Mar. 15, 2011), <http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf> [<https://perma.cc/X8HS-U4BA>]; U.N. Secretary-General, *Report of the Secretary General’s High-level Advisory Group on Climate Change Financing*, U.N. Doc. SG/SM/13232-ENV/DEV/1168 (Nov. 5, 2010), <https://www.cbd.int/financial/interdevinno/un-climate-report.pdf> [<https://perma.cc/CWA3-RYJL>]; *From Climate Finance to Financing Green Growth*, PROJECT CATALYST (Dec. 2010), https://seors.unfccc.int/applications/seors/attachments/get_attachment?code=CU32L302QVZ4KS71HJ3WZBHUVF2973Q7 [<https://perma.cc/C8YY-4ESW>]; Charlotte Streck, *The Global Environment Facility – a Role Model for International Governance?*, 1 GLOBAL ENV’T POLITICS 71, 71 (May 2001), <https://doi.org/10.1162/152638001750336604> [<https://perma.cc/8JWJ-6GWV>].

119. Climate Finance: Unlocking real economy investments for climate action, mitigation and adaptation included, is critical, U.N. ENV’T PROGRAMME, <https://www.unep.org/topics/climate-action/climate-finance#:~:text=Climate%20finance%20refers%20to%20all,and%20con%20sequences%20of%20climate%20change> [<https://perma.cc/ABK7-XF4C>].

includes grants financed by multilateral funds, funds borrowed from financial institutions, bonds and the amount of reserves raised by carbon credits, trading and taxes. Currently, there is inadequate financial flow required to mitigate climate change and the financial flow needs to grow at least three-fold to achieve the Paris Agreement on Climate Change goals.¹²⁰ However, there has been significant effort in combating climate change and investment towards energy transition has risen in the last decade. Moreover, according to the International Renewable Energy Agency's analysis in "World Energy Transitions Outlook 2023," a record was set with high global investments of \$1.3 trillion USD into technologies in 2022 that are required for energy transition.¹²¹ Overall investment in the world towards energy transition reached \$1.8 trillion in the year 2023, which grew by 17% compared to the previous year and set a new record.¹²²

Further, the World Bank's Climate Change Action Plan for 2021-2025 expects to incorporate climate and other emerging developments to optimally achieve positive climate impact of its actions and undertaken projects.¹²³ The Sustainable Renewables Risk Mitigation Initiative (SRMI) by the Energy Sector Management Assistance Program utilizes climate finance for mitigating actions that cut down emissions and boosts climate resiliency.¹²⁴ SRMI helps the nations to encourage and speed up the deployment of renewables as well as decarbonization the power sector with (i) technological assistance and (ii) private funding and climate finance mobilization. SRMI has also supported over sixty nations, resulting in facilitating 4.4 gigawatts of new renewable energy projects across fourteen nations and two regional projects, catalyzing more than \$5.5 billion in private investment, acquiring \$4 billion in public infrastructure capital, and mobilizing \$1.2 billion in climate finance.¹²⁵

120. *What is climate finance and why do we need more of it?*, UN. DEV. PROGRAMME (Oct. 2, 2023), <https://climatepromise.undp.org/news-and-stories/what-climate-finance-and-why-do-we-need-more-it> [https://perma.cc/Y8VM-SDFK].

121. Lena Dente, *Financing a Just Energy Transition*, WORLD FUTURE COUNCIL, <https://www.worldfuturecouncil.org/financing-a-just-energy-transition/> [https://perma.cc/EF77-D2TW].

122. *Global Clean Energy Investment Jumps 17% Hits \$1.8 Trillion in 2023, According to BloombergNEF Report*, BLOOMBERGNEF (Jan. 30, 2024), <https://about.bnef.com/blog/global-clean-energy-investment-jumps-17-hits-1-8-trillion-in-2023-according-to-bloombergnef-report/> [https://perma.cc/JN74-2NYC].

123. *Climate Change Action Plan 2021-2025: Supporting Green, Resilient, and Inclusive Development*, WORLD BANK GRP., at 16 (2021), <https://www.miga.org/sites/default/files/2021-08/CCAP-2021-25-2.pdf> [https://perma.cc/4XPA-QNJY].

124. *See Sustainable Renewables Risk Mitigation Initiative (SRMI) | Program Profile*, ENERGY SECTOR MGMT. ASSISTANCE PROGRAM, https://www.esmap.org/Sustainable_Renewables_Risk_Mitigation_Initiative_SRMI_Program_Profile [https://perma.cc/8EH9-SFRZ].

125. *Catalyzing Private Investments and Climate Finance to Turn Energy Transition*

In the U.S., the Inflation Reduction Act was welcomed as a major step up in federal clean energy spending. The Biden Administration committed \$391 billion to energy transition efforts, while the Inflation Reduction Act also included the first ever tax credit for microgrid components in the U.S., aimed at cutting costs and driving greater growth. Since the start of the pandemic, the International Energy Agency (IEA) estimates that at least \$20 billion has been granted in transmission and distribution system spending directly by the U.S. government.¹²⁶ It is pertinent to note that the Asian Infrastructure Investment Bank has financed \$304 million towards the Assam Intra-State Transmission System Enhancement Project that is estimated to be completed by 2025 to further strengthen and improve the region's transmission system by constructing new transmission sub-stations and laying new transmission lines; refining existing substations, transmission lines and existing ground wire; and providing technical support for the execution of the project.¹²⁷

During COP 28, more than \$85 billion was earmarked to climate action by governments, corporations and charitable and non-profit organizations, out of which \$792 million was allocated to the Loss and Damage Fund and a further \$3.5 billion was allocated towards the Green Climate Fund.¹²⁸ COP 28 witnessed the inauguration of a vision for climate finance—the “COP28 UAE Declaration of Leaders on a Global Climate Finance Framework,” which was endorsed by thirteen nations.¹²⁹ It explains the requisite for consolidated action and opportunities and delivering at scale, at the same time acknowledging the requirement of financing \$5–\$7 trillion yearly in an effort for bringing down the emissions level and greening economy by 2030.¹³⁰ A finance forum was also announced by the United Arab Emirates (UAE) which is scheduled

Ambitions to Reality, THE WORLD BANK GROUP (Aug. 4, 2023), <https://www.worldbank.org/en/results/2023/08/04/catalyzing-private-investments-and-climate-finance-to-turn-energy-transition-ambitions-to-reality> [https://perma.cc/L2G3-ETAB].

126. *Government Energy Spending Tracker*, INT'L ENERGY AGENCY (June 2023), <https://www.iea.org/reports/government-energy-spending-tracker-2> [https://perma.cc/89RA-YC MW]; Charles Waine, *Powering up with smart grids* (May 9, 2023), <https://www.infrastructureinvestor.com/powering-up-with-smart-grids/> [https://perma.cc/G2BV-E569].

127. ASIAN INFRASTRUCTURE INV. BANK, CLIMATE FINANCING FOR GREEN GRIDS, 1, 6 (2022), https://www.unescap.org/sites/default/d8files/event-documents/6.%20Seung%20Myun%20Lee_AIIB.pdf [https://perma.cc/J4LL-XTWA].

128. Maurizio Di Paolo Emilio, *The Green Future: COP28 Key Decisions for a Sustainable Planet* (Dec. 18, 2023), <https://www.eetimes.eu/the-green-future-cop28-key-decisions-for-a-sustainable-planet/> [https://perma.cc/9N9H-V8YR].

129. See *COP28 UAE Leaders' Declaration on a Global Climate Finance Framework*, COP28 UAE, https://www.cop28.com/en/climate_finance_framework [https://perma.cc/98GE-C4MF].

130. *Id.*

to be implemented in the year 2024, to monitor progress of its commitments undertaken during COP 28.¹³¹

1. A Note on Private Finance

Private sector financing is crucial for expanding investment in renewable energy. However, there are various obstacles that influence the investment of the private sector. For instance, when the renewable energy projects have high initial costs which are linked with lengthy project timelines, private sector stakeholders may not invest easily as they might be seeking shorter payback periods. While governments globally are framing policies to support the targets to cut down greenhouse gas emissions and boost renewable energy usage, there still remains uncertainty regarding how these goals will be met and what will be the role of the private sector. Due to this uncertainty, many investors may refrain from making long-term commitments to clean energy projects.¹³²

Experts anticipated that there will be a constrained growth in public investment, and major contributions will have to be made by the private sector towards the climate funding requirement for emerging markets and economies.¹³³ The non-governmental or private industries will be required to supply around 80% of the requisite funding, and this portion increases to 90% if China is not considered, as shown in the analytical chapter of the IMF's Global Financial Stability Report.¹³⁴ Figure 3 outlines the current and estimated share of private climate finance needed from the total climate investments to reach net zero by 2050.¹³⁵

131. Kwatra, *supra* note 110.

132. Lena Dente, *Financing a Just Energy Transition*, WORLD FUTURE COUNCIL, <https://www.worldfuturecouncil.org/financing-a-just-energy-transition/> [<https://perma.cc/SF22-DWFD>].

133. See Prasad Ananthakrishnan et al., *Emerging Economies Need Much More Private Financing for Climate Transition*, IMF BLOG (Oct. 2, 2023), <https://www.imf.org/en/Blogs/Articles/2023/10/02/emerging-economies-need-much-more-private-financing-for-climate-transition> [<https://perma.cc/U28S-N6E5>].

134. IMF, *Chapter 3: Financial Sector Policies to Unlock Private Climate Finance in Emerging Market and Developing Economies*, in GLOB. FIN. STABILITY REP., 1, 2–3 (Oct. 2023), <https://www.imf.org/-/media/Files/Publications/GFSR/2023/October/English/ch3.ashx> [<https://perma.cc/S5UW-7JPH>]; see also *Global Financial Stability Report*, IMF, <https://www.imf.org/en/Publications/GFSR/Issues/2023/10/10/global-financial-stability-report-october-2023?cid=bl-com-AM2023-GFSREA2023002#> [<https://perma.cc/EQL4-SME7>].

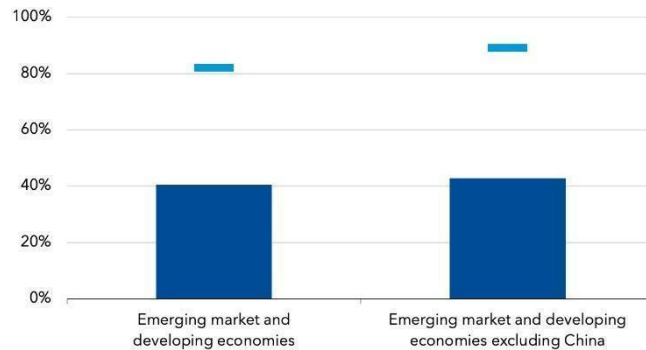
135. *Id.* at 3–4.

Figure 3: Private Climate Finance¹³⁶**Private capital for climate**

A major share of climate mitigation investment in emerging market economies must come from the private sector.

Current and estimated share of private climate finance in total climate investments needed to reach net zero emissions by 2050

■ Current share of private climate finance ■ Required share of private sector by 2030



Sources: Climate Policy Initiative, International Energy Agency, and IMF staff calculations.
Note: The point estimate is based on a public climate financing share in total public investment that increases by a factor of 1.5 until 2030.

IMF

Source: International Monetary Fund¹³⁷

It is worthwhile to note that China is at the top in acquiring and captivating climate finance, advancing in adaptation of renewable energy and collaborating with the European Union to establish significant policies for financing sustainability, such as the “Common Ground Taxonomy” and “China Green Bond Principles.”¹³⁸

To summarize, there is a dire need for improved climate finance and further scope for increased funding. Mobilizing increased climate finance is essential for mitigating carbon emissions as well as for building adaptable capacity by investing in climate-resilient infrastructure.¹³⁹

136. Ananthakrishnan et al., *supra* note 133.

137. *Id.*

138. Rita Basu & Cheng Hoon Lim, *Explainer: How Asia Can Unlock \$800 Billion of Climate Financing*, IMF BLOG (Jan. 29, 2024), <https://www.imf.org/en/Blogs/Articles/2024/01/29/explainer-how-asia-can-unlock-800-billion-of-climate-financing> [https://perma.cc/9WYD-AUMB].

139. *Id.*

III. QATAR AS A CASE STUDY¹⁴⁰

A. General Overview

Qatar is aiming to reduce its current levels of greenhouse gas emissions by 25% by 2030.¹⁴¹ The nation also hopes to increase its renewable energy capacity to 2-4 gigawatts (GW) by that time. In addition, Qatar aims to cut its methane emissions intensity to 0.2 weight percent by 2025.¹⁴² Furthermore, by 2030, the country intends to achieve zero percent regular flaring.

Qatar also plans to raise its production of LNG to 126 million tons per annum (MTPA) by 2026 to replace energy sources like coal and oil, which create more emissions.¹⁴³ Additionally, the goal is to use technology for the capture and storage of 7 to 9 MTPA of carbon to make up for leftover emissions by 2030.¹⁴⁴ Qatar wants over 90% of its energy to originate from natural gas sources. These initiatives should result in a 15% decrease in net carbon intensity from upstream activities and around a 25% reduction from LNG plants, including direct and indirect emissions.¹⁴⁵ Tackling the issue of greenhouse gas emissions in Qatar represents a pressing need to safeguard the planet and secure the well-being of both current and future generations, both within Qatar and globally.

Despite Qatar's commitment to environmental protection, it faces complex challenges stemming from vested interests and economic dependencies. Powerful stakeholders in Qatar, who hold significant influence over policy decisions, often have vested interests tied to industries reliant on polluting substances. Consequently, achieving a significant reduction in greenhouse gas emissions appears daunting and, at times, insurmountable.

140. This section was researched and written by Flwa Alfraiji, Nofe Alkhudair, Setah Alsanie, Jude Algosaibi, and Fahdah Albawardi.

141. Hazrate Bilal et al., *A pathway to 25% reduction in greenhouse gas emission by 2030 using GIS-Based multi-criteria decision making for renewables, date palm (phoenix dactylifera), and carbon credits: a case for Qatar*, 12 FRONTIERS ENERGY RSCH. (Jan. 31, 2024), <https://www.frontiersin.org/articles/10.3389/fenrg.2024.1272993/full> [https://perma.cc/T2CQ-EYBL].

142. *Climate Change Mitigation*, QATAR ENERGY, <https://www.qatarenergy.qa/en/Sustainability/Pages/Retired/ClimateChangeMitigation.aspx> [https://perma.cc/UGA4-6CLW] [hereinafter *Climate Change Mitigation*].

143. Melisa Čavčić, *New gas expansion project to magnify Qatar's LNG production by nearly 85%*, OFFSHORE ENERGY (Feb. 26, 2024), <https://www.offshore-energy.biz/new-gas-expansion-project-to-magnify-qatars-lng-production-by-nearly-85/> [https://perma.cc/QL87-D86D].

144. *Climate Change Mitigation*, *supra* note 142.

145. *Qatar Energy' Sustainability Strategy*, INT'L ENERGY AGENCY (May 3, 2022), <https://www.iea.org/policies/14924-qatar-energys-sustainability-strategy> [https://perma.cc/L2F4-995C].

To address this challenge effectively, a multi-faceted approach is necessary. First, there must be a concerted effort to raise awareness and foster a collective sense of responsibility among decision-makers, industry leaders, and the general population regarding the urgency of reducing greenhouse gas emissions. Education and advocacy initiatives can play a pivotal role in this regard. Furthermore, it is imperative to implement robust regulatory frameworks and incentivize sustainable practices to gradually transition away from reliance on environmentally harmful substances. This may involve offering subsidies or tax incentives for clean energy alternatives, investing in research and development of green technologies, and fostering partnerships with international organizations and other nations to share knowledge and resources.

Qatar has modernized its energy industry with notable progress, utilizing smart grid technology and incorporating renewable energy sources. Kahramaa, the energy and water company of Qatar, has created a smart grid roadmap aimed at implementing smart grid technology by 2026 and revolutionizing the nation's electrical infrastructure,¹⁴⁶ in collaboration with Texas A&M University at Qatar.¹⁴⁷ It plans to upgrade all of its meters to smart ones, opening doors for American companies that provide smart grid solutions. Additionally, Qatar and the Belgian consultant Elia Grid have inked a contract to work together on smart grid projects with an emphasis on transmission development, network design, and asset management.¹⁴⁸

According to Qatar's National Vision 2030 objectives, 20% of energy will come from renewable sources by 2030.¹⁴⁹ With more than 340 bright days annually, the nation has a wealth of solar resources that might help reduce carbon intensity.¹⁵⁰ The 800 MW PV tender in Qatar in 2020 saw a world record final price of \$0.01567/kWh.¹⁵¹ By 2025, 10% of Qatar's

146. *The Second International Conference on Smart Grids and Renewable Energy*, KAHRAMAA (Nov. 19, 2019), www.km.qa/MediaCenter/pages/NewsDetails.aspx?ItemID=320 [<https://perma.cc/4PF3-27E7>].

147. *Qatar Energy Transmission and Distribution*, INT'L TRADE ADMIN. (Sept. 29, 2020), <https://www.trade.gov/market-intelligence/qatar-energy-transmission-and-distribution> [<https://perma.cc/8VGQ-SPPF>].

148. *Elia Grid will help Qatar to develop its smart grid projects*, VELATIA, <https://www.velatia.com/en/blog/elia-grid-will-help-qatar-to-develop-its-smart-grid-projects/> [<https://perma.cc/Q3GJ-NP7S>].

149. *Qatar's plans for renewable energy*, DENTONS (May 10, 2023), <https://www.dentons.com/en/insights/alerts/2023/may/10/qatars-plans-for-renewable-energy> [<https://perma.cc/CRV8-3PVC>].

150. Bayram Safak, *Smart Grid Status in Hot Arid Climates – Drivers, Challenges, and Lessons Learned from Qatar*, IEEE SMART GRID (July 2020), <https://smartgrid.ieee.org/bulletins/july-2020/smart-grid-status-in-hot-arid-climates-drivers-challenges-and-lessons-learned-from-qatar> [<https://perma.cc/END6-83JL>].

151. *Id.* (citing Emiliano Bellini, *Qatar's 800 MW tender draws world record solar power price of \$0.01567/kWh*, PV MAG. (Jan. 23, 2020), <https://www.pv-magazine.com/2020/01/23/>

fleet of cars will be electric vehicles (EVs).¹⁵² Since 2019, a number of 50 kW CHAdeMo fast chargers have been installed, and there are intentions to grow the network of charging stations to 500 fast chargers.¹⁵³ Nevertheless, there are still issues to be resolved, such the high price when compared to cars with internal combustion engines, the performance of batteries in arid climates, and low customer acceptability because of the migratory character of the expat community.

B. Energy Profile

Qatar Energy (QE), the national oil and gas firm in charge of upstream to downstream operations, dominates the country's energy market. The water and electricity utility, Kahramaa, controls the flow of power. Of Qatar's total 2021 energy supply, 93% came from natural gas, making it a crucial part of the country's energy mix.¹⁵⁴ Just under 1% came from renewables, while 7% came from oil.¹⁵⁵ Oil output hit 72 Mt in 2022.¹⁵⁶

In 2014, the nation ranked as the fourth-largest producer of natural gas worldwide. Seventy-nine percent of its natural gas output and 82% of its oil production were exported in 2020.¹⁵⁷ The Kahramaa-managed power grid in Qatar is well developed. By 2026, the nation wants to have modernized its system with smart grid technology.¹⁵⁸ Qatar's production facilities are connected to both local users and export terminals by a vast network of pipelines for oil and gas. The nation is also linked to the GCC Interconnection Grid for power. The industrial sector accounted for the majority of Qatar's power use, with 55% of the overall consumption in 2021. The business and government sectors consumed 18%, while the residential sector accounted for 27%.¹⁵⁹

Qatar is gradually changing its energy mix, with an emphasis on boosting the share of renewable energy sources and decreasing the use of fossil fuels. In 2020, natural gas comprised 92% of the country's total

qatars-800-mw-pv-tender-saw-world-record-final-price-0-01567-kwh/ [https://perma.cc/6U3J-PHLH]).

152. *Id.*

153. *Id.*

154. *Energy Profile: Qatar*, INT'L RENEWABLE ENERGY AGENCY, (2024), https://www.irena.org/-/media/Files/IRENA/Agency/Statistics/Statistical_Profiles/Middle%20East/Qatar_Middle%20East_RE_SP.pdf [https://perma.cc/257Y-TKMC] [hereinafter IRENA].

155. *Id.*

156. *QatarEnergy awards US \$6bn in contracts for a major oil field expansion (Qatar)*, ENERDATA, <https://www.enerdata.net/publications/daily-energy-news/qatarenergy-awards-us6bn-contracts-major-oil-field-expansion-qatar.html> [https://perma.cc/DN8E-ZH4K].

157. IRENA, *supra* note 154.

158. *Smart Meters: For a Modern, Smart Electricity Grid*, KAHRAMAA, <https://www.km.qa/AboutUs/Pages/SmartMeters.aspx> [https://perma.cc/ZMT7-983K].

159. *Qatar Energy Profile*, ENERDATA, <https://www.enerdata.net/estore/country-profiles/qatar.html> [https://perma.cc/P79V-4Q2Q].

energy consumption, with oil following at 8%.¹⁶⁰ By 2030, the nation wants to lower its greenhouse gas emissions by 25% from levels associated with business as usual.¹⁶¹ To achieve this, the nation is aiming for 20% of its energy to stem from renewable sources. By 2030, it expects to increase its capacity for producing renewable energy to around 4 GW, with distributed solar being the main focus.

Qatar wants to cut emissions from the transportation sector by 10%, replacing its current fleet of cars with electric ones. Between 2000 and 2013, Qatar's overall energy usage increased at a pace of 11% annually. The nation aspires to raise its output of LNG to 126 MTPA by 2027 to replace energy sources like coal and oil that create more emissions.¹⁶² By 2030, natural gas will comprise over 90% of Qatar's energy mix, with the rest being generated by sources that are sustainable.¹⁶³

As the energy industry in Qatar moves toward a more diverse and sustainable future, it faces a number of significant obstacles. The oil and gas industry, which has continuously provided at least 80% of the government's overall revenue since 2014, is a major contributor to the nation's economy. Although the nation wants to diversify its economy and lessen its dependency on hydrocarbons, the country's continued investments in the North Field LNG development initiative suggest that gas and oil will still be the main sources of income.¹⁶⁴ There is a likelihood that hydrocarbon resources will degrade, when billions of dollars' worth of assets become unnecessary and lose value, as Qatar's clients choose renewable energy and environmental protection.

The country must be flexible and resilient, using sound policymaking and innovation to respond to shifting requirements for energy and alterations in environmental legislation. Even though Qatar is making investments in knowledge-driven industries such as information and communication technologies (ICT), medical care, and education to promote economic diversification, it is doubtful that non-revenue-generating expenditures on infrastructure for the 2022 FIFA World Cup would considerably lessen the nation's dependency on hydrocarbons.¹⁶⁵ Therefore, revenue diversification needs to be incorporated into all future

160. *Qatar Analysis*, U.S. ENERGY INFO. ADMIN., <https://www.eia.gov/international/analysis/country/QAT> [<https://perma.cc/922S-RRYT>].

161. Hannah Ritchie & Pablo Rosado, *Qatar: Energy Country Profile*, OUR WORLD IN DATA (2020), <https://ourworldindata.org/energy/country/qatar> [<https://perma.cc/HJ7J-KLNE>].

162. IRENA, *supra* note 154.

163. *QatarEnergy 2022 Sustainability Report*, QATARENERGY (2020), <https://www.qatarenergy.qa/en/MediaCenter/Publications/QatarEnergy%202022%20Sustainability%20Report.pdf> [<https://perma.cc/BVY9-HCRQ>].

164. *Qatar Country Commercial Guide*, INT'L TRADE ADMIN. (2022), <https://www.trade.gov/country-commercial-guides/qatar-market-challenges> [<https://perma.cc/GKB6-UULP>].

165. *Id.*

energy and climate policies to guarantee longevity. Qatar can benefit from investing in research that looks at how global supply chains are affected by disruptions like shifts in international markets or regulations related to climate change.¹⁶⁶ To design policies that allow stakeholders to evaluate numerous scenarios for diverse economic, ecological, or political stability goals, the nation should employ technical and engineering integrative approaches.

Qatar's energy plan and governance structure are cohesive and in line with the country's aspirations, global obligations, and sustainability objectives. The United Nations Sustainable Development Goals, the Paris Agreement on Climate Change, and Qatar National Vision 2030 provide key reference points for the country's energy policy.¹⁶⁷ The national oil and gas committee's duties were moved to Qatar Energy by a princely decree in 2017,¹⁶⁸ thus consolidating the industry's control. Qatar Energy is in charge of creating and carrying out the nation's sustainability plan, which calls for cutting emissions and maintaining its position as the industry leader in LNG. The three primary pillars of Qatar Energy's sustainability policy are lowering emissions, making up for leftover emissions, and creating a low-carbon energy department.¹⁶⁹ Qatar is investing in the creation of regional knowledge and working with foreign partners to aid in its attempts to diversify its energy supply.

In navigating its transition to clean energy, Qatar's commitment to international frameworks, like the United Nations Sustainable Development Goals and the Paris Agreement, is evident. These agreements provide a roadmap for Qatar's energy policies, ensuring alignment with global sustainability objectives. Ultimately, Qatar finds itself at an important crossroads, poised to lead the region towards a more diverse and sustainable energy future.¹⁷⁰ Success will depend on the

166. See generally RAFAEL LEAL-ARCAS, *CLIMATE CLUBS FOR A SUSTAINABLE FUTURE: THE ROLE OF INTERNATIONAL TRADE AND INVESTMENT LAW* (2021); RAFAEL LEAL-ARCAS, *SOLUTIONS FOR SUSTAINABILITY: HOW THE INTERNATIONAL TRADE, ENERGY AND CLIMATE CHANGE REGIMES CAN HELP* (2019); RAFAEL LEAL-ARCAS, *CLIMATE CHANGE AND INTERNATIONAL TRADE* (2013); Rafael Leal-Arcas, *Climate and Energy Governance for a Sustainable Future*, *supra* note 4; WALTER LEAL & RAFAEL LEAL-ARCAS, *UNIVERSITY INITIATIVES IN CLIMATE CHANGE MITIGATION AND ADAPTION* (2018); Leal-Arcas, *Connections between climate change and international trade*, *supra* note 4, Leal-Arcas, *International Trade, Energy Transition and Climate Change Obligations*, *supra* note 4, Rafael Leal-Arcas & Andrew Filis, *International Cooperation on Climate Change Mitigation: The Role of Climate Clubs*, 30 EUR. ENERGY & ENV'T L. REV. 195–218 (2021).

167. *Qatar Energy's Sustainability Strategy*, INT'L ENERGY AGENCY (May 3, 2022), <https://www.iea.org/policies/14924-qatar-energys-sustainability-strategy> [<https://perma.cc/YT38-9SFJ>].

168. *Id.*

169. *Id.*

170. See generally Yuehong Lu, et al., *A critical review of sustainable energy policies for the promotion of renewable energy sources*, 12 SUSTAINABILITY 5078 (2020).

country's ability to balance economic imperatives with environmental responsibilities, making a more resilient and sustainable energy landscape possible.

C. Governance System¹⁷¹

Qatar Energy (QE) is the country's state energy company, which has the authority to conduct or approve petroleum-related work. QE is in charge of creating and carrying out the nation's sustainability plan, which calls for cutting emissions, making up for leftover emissions, and maintaining its position as the industry leader in LNG. On the other hand, the water and electricity utility Kahramaa is in charge of controlling Qatar's electrical supply. Kahramaa and Texas A&M University at Qatar have created a smart grid roadmap to implement smart grid technology into the nation's electrical infrastructure by 2026.¹⁷² Kahramaa has released standards, guidelines, and specifications for the production, transmission, and distribution of electricity, including solar energy.¹⁷³ Environmental protection and climate change policy in Qatar are under the jurisdiction of the Ministry of Environment and Climate Change, which ensures that environmental factors are incorporated into energy and development strategies in close collaboration with other government departments.¹⁷⁴

The transportation industry is governed by the Ministry of Transport, which also develops regulations and infrastructure for electric vehicles.¹⁷⁵ It works along with other organizations to advance environmentally friendly transportation options.¹⁷⁶ In addition, urban planning, which

171. See generally RAFAEL LEAL-ARCAS, ANDREW FILIS & EHAB ABU GOSH, *INTERNATIONAL ENERGY GOVERNANCE: SELECTED LEGAL ISSUES* (2014); Leal-Arcas, *Climate and Energy Governance for a Sustainable Future*, *supra* note 4; Rafael Leal-Arcas & Stephen Minas, Mapping the international and European governance of renewable energy, 35 *OXFORD YEARBOOK EUR. L.*, 621, 621–66 (2016) 10.1093/yel/yew022; Rafael Leal-Arcas and Andrew Filis, *The Fragmented Governance of the Global Energy Economy: A Legal-Institutional Analysis*, 6 *J. WORLD ENERGY L. & BUS.*, 348, 348–405 (2013); Leal-Arcas, *Citizens at the center*, *supra* note 5.

172. *A Cooperation Agreement to Develop a Roadmap for Smart Grids in KAHRAMAA*, KAHRAMAA (May 9, 2018), <https://www.km.qa/MediaCenter/pages/NewsDetails.aspx?ItemID=265> [https://perma.cc/4PY7-92KY].

173. See *Renewable Energy*, KAHRAMAA, <https://www.km.qa/RenewableEnergy/Pages/BeSolar.aspx> [https://perma.cc/B6J3-FV8W].

174. See *Qatar... A Comprehensive Approach to Conserve Environment, Achieve Sustainable Development*, QATAR NEWS AGENCY (Nov. 26, 2024, 3:49 PM), <https://qna.org.qa/en/news/news-details?id=0046-qatar-a-comprehensive-approach-to-conserve-environment,-achieve-sustainable-development&date=26/11/2024> [https://perma.cc/HCK2-NLAY].

175. See *id.*

176. See *About the Ministry*, MINISTRY OF TRANSP., <https://www.mot.gov.qa/en/about/ministry> [https://perma.cc/GC5T-C49F].

includes incorporating energy-efficient features into infrastructure and buildings, is within the mandate of the Ministry of Municipality and Environment.¹⁷⁷ One of the key organizations for organizing and assisting with research projects is the Qatar Foundation, which oversees the Qatar National Research Fund (QNRF).¹⁷⁸ Through initiatives like the National Priorities Research Program (NPRP) and the National Research Priorities (QNRP), QNRF provides funding opportunities.¹⁷⁹ Dissemination of smart grid research findings occurs through conferences, publications in academic journals, and professional networks.¹⁸⁰ Researchers publish their work in respected journals and present their findings at conferences and workshops.¹⁸¹ To promote innovation and technological development, platforms such as the Qatar Science and Technology Park (QSTP) encourage knowledge exchange and teamwork between academic institutions, business, and entrepreneurs.¹⁸²

Significant smart grid projects in Qatar includes the creation of the Lusail Smart Grid. The Lusail Smart Grid project's main goal is to implement smart grid technologies in Lusail, fostering the development of an environmentally conscious and energy-efficient neighborhood.¹⁸³ To implement smart grid solutions and evaluate their efficacy in practical settings, government agencies, utility companies, and technology providers collaborate on these projects.¹⁸⁴

The current Qatari government's strategy places a strong emphasis on utilizing smart meter and smart grid technology in conjunction with sustainable energy production.¹⁸⁵ By adopting advanced digital technologies and intelligent grid solutions, Qatar aims to improve energy efficiency, cut carbon emissions, and boost the reliability and resilience

177. See *Ministry of Municipality & Environment*, US-QATAR BUS. COUNCIL, <https://portal.usqbc.org/organization/ministry-of-municipality-environment/> [https://perma.cc/FCG5-FCSQ].

178. See generally NIDHI KALRA ET AL., RECOMMENDED RESEARCH PRIORITIES FOR THE QATAR FOUNDATION'S ENVIRONMENT AND ENERGY RESEARCH INSTITUTE (2011), https://www.rand.org/content/dam/rand/pubs/monographs/2011/RAND_MG1106.pdf [https://perma.cc/7NS8-PX57].

179. See *id.* at 204–05.

180. See *id.*

181. See *id.*

182. See *id.* at 206–07.

183. See *GE powers up Qatar's Lusail City with locally designed substation automation and protection*, ZAWYA (Nov 8, 2016), <https://www.zawya.com/en/press-release/ge-powers-up-qatars-lusail-city-with-locally-designed-substation-automation-and-protection-b0bwz100> [https://perma.cc/9A6T-D3RB].

184. See *id.*

185. See *Smart Meters Kahramaa's Strategic Project for Digital Transformation*, KAHRAMAA, <https://www.km.qa/CustomerService/Pages/SmartMeters.aspx> [https://perma.cc/KR6W-XY2E] [hereinafter *Smart Meters*].

of its energy infrastructure.¹⁸⁶ The government plays a crucial role in energy governance by setting policies and regulations, promoting sustainable energy practices, encouraging innovation, and supporting research and development initiatives. It offers the essential structure for energy investment, planning, and project execution targeted at fulfilling the nation's energy needs while maintaining environmental sustainability.

D. Electricity Market and Smart Grid Deployment¹⁸⁷

The electricity market in Qatar is going through a marked transformation process, based on an increasing population, a corresponding increase in energy demand, and a global emphasis on sustainability. In this context, the country is working on developing its grid infrastructure and smart grid strategy. It will be crucial to establish clear regulations for these efforts to be successful.¹⁸⁸ This section will provide an in-depth overview and examination of the Qatar electricity market regulatory landscape, and how it impacts smart grid strategy development. The section will also reveal some avenues for improvement.

1. Regulatory Framework and Smart Grid Implementation

Qatar's prime legal base for the electric sector is Law Number 30 of the year 2002, on the Regulation of the Electric and Water Sector (the Electricity Act).¹⁸⁹ This Act manifests itself in the creation of the General Electricity and Water Corporation (Kahramaa) as the entity of single ownership which is the only authority responsible for electricity generation, transmission, and circulation.¹⁹⁰ Additional national plans

186. *See id.*

187. *See generally* LEAL-ARCAS ET AL., ELECTRICITY DECENTRALIZATION IN THE EUROPEAN UNION, *supra* note 2 (regarding a comprehensive examination of the electricity market in the European Union (EU) and specific EU member states); Leal-Arcas et al., *Energy, Electricity and Smart Grids in Latvia and Portugal*, *supra* note 13. *See* Tanya Shaar & Rafael Leal-Arcas, *Fuel Subsidy Reform, Decentralized Electricity Markets and Renewable Energy Trade: Evidence for a Successful Energy Transition in the Middle East and North Africa Region*, 1 J. WORLD ENERGY L. & BUS. 112, 112–26 (2023) (regarding an examination of the electricity market in the Middle East and North Africa (MENA) region); Rafael Leal-Arcas, Nelson Akondo, & Juan Alemany Rios, *Energy trade in the MENA Region: Looking beyond the Pan-Arab electricity market*, 10 J. WORLD ENERGY L. & BUS., 520, 520–49 (2017).

188. Zeineb Abdmouleh, Adel Gastli, & Lazhar Ben-Brahim, *Survey About Public Perception Regarding Smart Grid, Energy Efficiency & Renewable Energies Applications in Qatar*, 82 RENEWABLE & SUSTAINABLE ENERGY REVS. 168, 168–75 (2018).

189. *See Law No. 30 of 2002 – Environmental Protection Law*, INT'L ENERGY AGENCY (Mar. 8, 2024), <https://www.iea.org/policies/12010-law-no-30-of-2002-environmental-protection-law> [<https://perma.cc/5ERR-5Y3W>].

190. *See id.*

and efforts also have some bearing on the evolution of grid strategy and technology, including:

- **Qatar National Vision 2030.** In the framework of the national development plan, environmental friendliness, and energy versatility are set as the key targets in Qatar National Vision 2030, paving the way for smart grid projects.¹⁹¹
- **Renewable Energy Strategy.** This strategy centers around boosting the renewable energy share in Qatar's energy mix, which encompasses the need to modernize the grid in order to smoothly integrate these sources.¹⁹²
- **Smart Grid Center-Qatar (SGC-Q).** The project is housed in a research center, which aims to integrate innovation with existing techniques in smart grids development.¹⁹³

However, the electric act and current efforts alone are insufficient to usher in the smart grid strategy. Other governmental initiatives are needed to achieve this goal. While Qatar has started the first phase of its smart grid implementation, the existing regulatory institutions demonstrate some barriers to the smooth operation of efficient smart grids.¹⁹⁴ These barriers include:

- **Limited Market Competition.** At present, Kahramaa (Energy) is the one and only authority supplying electricity across the whole country, leading to potential issues such as lack of competition and innovation in the sector.¹⁹⁵
- **Tariff Structure.** At the moment, the rate of electricity is heavily subsidized.¹⁹⁶ This curbs energy efficiency and proves to be a

191. *Qatar unveils energy strategy, aims for 4 GW of new renewable capacity by 2030*, ENERDATA (May 7, 2024), <https://www.enerdata.net/publications/daily-energy-news/qatar-unveils-energy-strategy-aims-4-gw-new-renewable-capacity-2030.html#:~:text=The%20new%20energy%20strategy%20targets,train%20on%20centralized%20grid%20infrastructure> [https://perma.cc/LQT7-T9JQ].

192. *Qatar National Renewable Energy Strategy (QNRES)*, INT'L TRADE ADMIN. (July 17, 2024), <https://www.trade.gov/market-intelligence/qatar-national-renewable-energy-strategy-qnres> [https://perma.cc/EJV5-6LVQ].

193. See Lesley Kriewald, *Smart Grid Center signs collaborative agreement with Qatar General Electricity and Water Corporation*, TEXAS A&M ENGINEERING EXPERIMENT STATION (May 18, 2018), <https://tees.tamu.edu/news/2018/05/smart-grid-center-signs-collaborative-agreement-with-qatar-general-electricity-and-water-corporation.html> [https://perma.cc/YG54-L7PL].

194. *Id.*

195. Corporate Statement, KAHRAMAA, <https://www.km.qa/AboutUs/Pages/CorporateStatement.aspx> [https://perma.cc/9GP2-GCBU] [hereinafter Corporate Statement].

196. Alecia W. Cassidy et al., *The Power to Conserve: A Field Experiment on Electricity Use in Qatar 7* (Nat'l Bureau of Econ. Rsch., Working Paper No. 31931, 2023), https://www.nber.org/system/files/working_papers/w31931/w31931.pdf [https://perma.cc/MF

counterproductive factor for wise grid investments that try to achieve an economically feasible rate of optimum consumption.¹⁹⁷

- **Data Privacy Concerns.** Smart grids are characterized by a two-way data session between utilities and consumers as information sharing is a key for such systems.¹⁹⁸ A strict privacy protective law that will help foster trust and consumer involvement in smart grid programs is crucial.¹⁹⁹

2. The Impacts of Existing Regulation and Market Structure

The current regulatory regime presents both opportunities and roadblocks for Qatar's smart grid strategy. Economies of scale, zero competition, and subsidies for primary resources result in under-investment in smart grid technologies. To some extent, the government's backing of renewable energy sources and research facilities represents fundamental requisites to a newer grid approach. Here is how the existing framework impacts different aspects of smart grid development:

- **Grid Modernization.** Insufficient capital prevents the upgrade of aged infrastructures. Upgrading existing infrastructure is necessary for including renewable energy sources and for building a dynamic grid.²⁰⁰
- **Demand-Side Management (DSM).** Subsidized tariffs make it less cost-advantageous for consumers to purchase energy-efficient house appliances or register in the DSM programs.²⁰¹
- **Distributed Generation.** Market dominance and an inadequate regulatory framework concerning distributed generation, like rooftop solar panels, hinders investment in crucial aspects of smart grids.²⁰²

A8-52P5].

197. *Id.*

198. See *From One-Way to Two-Way: The Future of Electricity with Smart Grids*, ALTENERGYMAG.COM (June 26, 2024, 6:37 AM), <https://www.altenergymag.com/news/2024/06/26/from-one-way-to-two-way-the-future-of-electricity-with-smart-grids/42377/> [https://perma.cc/Y47Q-RNBB].

199. See *Smart Grid Deployment in Qatar: Enhancing Energy Efficiency and Stability*, EUROGROUP CONSULTING, <https://eurogroupconsultingmea.com/case-studies/smart-grid-deployment-in-qatar-enhancing-energy-efficiency-and-stability/> [https://perma.cc/Q44S-DDWU].

200. Fadi Al-Noaimi, Tareq Al-Ansari, & Yusuf Bicer, *Decarbonization pathways for Qatar: A sectoral approach for energy transition*, 13 ENERGY REPS. 1178, 1196 (2025), <https://www.sciencedirect.com/science/article/pii/S2352484724008692> [https://perma.cc/LLF9-HMUY].

201. Ebubekir S. Sahin, I. Safak Bayram, & Muammer Koc, *Demand side management opportunities, framework, and implications for sustainable development in resource-rich countries: Case study Qatar*, 241 J. CLEANER PROD., Sept. 7, 2019, at 118332, <https://doi.org/10.1016/j.jclepro.2019.118332> [https://perma.cc/J4DB-M98X].

202. Hazem Al Samman & Syed Ahsan Jamil, *The Impact of Foreign Direct Investment (FDI) on Stock Market Development in GCC Countries*, 26 PERTANIK J. OF SOC. SCI. & HUMANITIES, 2085, 2085–100 (2018).

3. Balancing Incentives for Investment

The present regulatory regime does not have a systematic approach for promoting smart grid investments. Though the government facilitates research work with SGC-Q funding, private-sector enterprises shy away from investing, not knowing where the returns are. Potential solutions include:

- Feed-in tariffs. This puts into force marginal pricing for electricity generated from alternative energy technologies, driving investment into solar and wind projects.
- Performance-based regulation. The principle herein is that success is guaranteed so long as utilities meet specific standards concerning grid efficiency, performance, and adoption of renewable energy infrastructure.
- Grants and subsidies. Public Authority Investments in smart grid technologies are designed to kick-start private developments that suffer from early-stage investment costs.

4. Regulated vs. Non-Regulated Activities

Today, the Director of Electricity Network Affairs of Kahramaa is responsible for the Grid Code, while its implementation, enforcement, and control are handled by bodies appointed by the Ministry of Energy.²⁰³ However, opportunities exist for introducing non-regulated activities, including the following:

- Demand-Side Management (DSM). DSM programs encourage end-users to shift their electricity usage during high energy times of the day.²⁰⁴ Companies independent from the utility could also be DSM service providers.²⁰⁵
- Energy Service Companies (ESCOs). ESCOs can develop specific energy-saving offers for office and industrial buildings. Using the ESCO industry more broadly can achieve the purpose of a smart grid—in this case, energy efficiency—without active market participation.²⁰⁶ Smart grids are an emerging innovation, which are expected to have a huge impact on the future of electricity grids.

203. *ES-M4 Qatar Transmission Grid Code*, KAHRAMAA Mar. 25, 2020, at 12, <https://www.km.qa/CustomerService/ServiceRegulations/Grid%20Code%202020.pdf> [https://perma.cc/HT2B-6KF8].

204. Abdmouleh, Gastli, & Ben-Brahim, *supra* note 188.

205. *Id.*

206. *Id.*

To support smart grid development, Qatar may consider introducing new regulations in several areas:

- **Cybersecurity.** Smart grids are data-centric and use advanced communication technologies, which make them vulnerable to cyber-attacks. Strong regulation in cyber-security is crucial for safeguarding critical infrastructures and personal data.
- **Data Standards.** Interoperable standards both in data formats and protocols are fundamental for non-stop and fluent smart grid communication.²⁰⁷ Rules that give way to the standardization of data may make the data comparable across different sources and providers without being dependent on a single vendor.²⁰⁸
- **Consumer Protection.** Clear regulations on consumer rights concerning data privacy and smart grid data access are key for active citizen participation in the smart grid.²⁰⁹

5. Unbundling and Market Openness

Kahramaa oversees and manages the electricity transmission and distribution networks continuously, operating through four dedicated control centers.²¹⁰ The ultimate goal might be market unbundling by fixed-income producers, whereas having competition in only one segment (like retail electricity) could still serve as a tool to motivate innovations and smart grids. The automatic subsidies policy for all consumer classes instead deprives citizens of an energy-efficient way of life, a core aspiration of smart grids. A more focused strategy is required. This could entail:

- **Phasing-out subsidies.:** Slowly taper down subsidies for people who are above a certain income level, while maintaining subsidies for low-income earners.
- **Offering efficiency rebates.** Achieve this by providing rebates or tax breaks to people installing energy-saving appliances and smart home devices.
- **Establishing smart grid investment grants.** Provide financial support to firms that implement and execute smart grid technologies.

207. See Sustainability Directory, *Why is Interoperability Vital for Smart Grids' Success?*, ENERGY SUSTAINABILITY DIRECTORY (Apr. 14, 2025), <https://energy.sustainability-directory.com/question/why-is-interoperability-vital-for-smart-grids-success/> [https://perma.cc/6ECZ-5WPS].

208. *Id.*

209. *Smart Grid Deployment in Qatar: Enhancing Energy Efficiency and Stability*, *supra* note 199.

210. See *Electricity Sector*, KAHRAMAA, <https://www.km.qa/AboutUs/pages/electricity-sector.aspx> [https://perma.cc/CY2E-4WVL].

6. Challenges and Areas for Improvement

The current power sector of Qatar is based mainly on fossil fuels, especially natural gas. Although the Qatar National Vision 2030 and the Renewable Energy Strategy emphasize the importance of diversification, the use of renewable energy sources is scarce.²¹¹

Some of the challenges for integration are:

- **Low Penetration.** The renewable energy contribution to Qatar's electricity currently is negligible.²¹² The commissioning of Al Kharsaah solar power station is a positive step,²¹³ but its large-scale integration is hindered by various challenges.
- **Technical Hurdles.** Incorporating variable renewable sources together, including solar and wind, necessitates advanced grid management techniques and infrastructure upgrades. The current grid might not be ready to control their volatility.²¹⁴
- **Policy Uncertainties.** The lack of regulatory clarity and long-term contracts for renewable energy producers makes investors less likely to invest and retards integration.²¹⁵

Some of the areas for improvement are:

- **Research and Development.** SGC-Q is currently working on projects to integrate renewables into the grid.
- **Storage Solutions.** Investing in battery storage options will raise the reliability of renewable power sources.
- **Pilot Projects.** Pilot projects can offer useful information for larger-scale rollout.

As for a smart grid roadmap for the future, Qatar's electricity market is at the point of bifurcation. Although some initial moves have been made towards smart grid planning, a profound regulatory restructuring

211. Eric C. Okonkwo et al., *Grid integration of renewable energy in Qatar: Potentials and limitations*, 235 ENERGY (July 1, 2021), <https://www.sciencedirect.com/science/article/pii/S0360544221015589> [<https://perma.cc/W8RG-JT57>].

212. See *Electricity in Qatar in 2023/2024*, LOWCARBONPOWER, <https://lowcarbonpower.org/region/Qatar> [<https://perma.cc/965M-7X92>].

213. See *Al Kharsaah Solar Power Project*, POWER TECH. (Nov. 17, 2023), <https://www.power-technology.com/projects/al-kharsaah-solar-power-project/?cf-view> [<https://perma.cc/5F5J-3D6N>].

214. See Al-Noaimi, Al-Ansari, & Bicer, *supra* note 200, at 1196.

215. See NAT'L ASS'N OF REGUL. UTIL. COMM'RS, ENCOURAGING RENEWABLE ENERGY DEVELOPMENT: A HANDBOOK FOR INTERNATIONAL ENERGY REGULATORS 63 (Jan. 2011), https://regulationbodyofknowledge.org/wp-content/uploads/2013/04/NARUC_Encouraging_Renewable_Energy.pdf [<https://perma.cc/WTW8-8PLX>].

should be accomplished for maximum impact. Moving forward, Qatar should prioritize the following:

- Market reforms. Investigate the possibilities that incorporate competitive tendering, for instance in the electricity retailing sector.
- Tariff reform. Offer time-of-use tariffs based on real-time energy prices with adjustments for energy efficiency.
- Regulatory clarity. Set rules for data privacy, cybersecurity, and smart grid technology standards so that they are transparent and clear.
- Investment incentives. Use a mix of feed-in tariffs, performance-based regulation, and specific financial incentives to attract investments in the fields of smart grid infrastructure and technology.²¹⁶

By adopting these changes, Qatar can develop regulations needed for innovation, investment, and improvements in electricity sector efficiency, reliability and sustainability. With smart energy, Qatar can not only support its growing power needs, but can also contribute to its national sustainability plan and prepare a future-ready energy provision for the country.

7. Interconnections

The interconnectedness of Qatar with its neighboring states is currently low. The GCC Interconnection Project was conceived to contribute to energy security in the region and enable the integration of renewable energy.²¹⁷ Nevertheless, the process faces several technical and regulatory constraints:

- Technical Challenges. Coordinating grids from countries with diverse technical settings and energy management approaches is complicated. Collaboration among national grid operators will be crucial to overcome the technical issues.

Regulatory Hurdles. It is important to develop a uniform regulatory structure that facilitates cross-border electricity trade for the success of the GCC interconnection project.

216. Hazem Al Samman, & Syed Ahsan Jamil, *The Impact of Foreign Direct Investment (FDI) on Stock Market Development in GCC Countries*, 26 PERTANIKA J. SOC. SCI. & HUMANITIES (2018), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3671037 [<https://perma.cc/JX4X-SPQY>].

217. See *GCC Summit: Gulf Electricity Interconnection Project come to fruition*, GULF TIMES (Dec. 4, 2023, 11:37 AM), <https://www.gulf-times.com/article/672936/qatar/gcc-summit-gulf-electricity-interconnection-project-comes-to-fruition> [<https://perma.cc/T5AW-WLMX>].

Despite these challenges, GCC member states have reiterated their dedication to the interconnection project.²¹⁸ Although potential closing dates are yet to be discussed, the renewed commitment is a positive sign. Several cross-border projects are currently underway to improve regional energy cooperation, including:

- GCC Interconnection Project. This project will establish an electricity grid linking countries throughout the GCC region.²¹⁹
- Qatar-Saudi Arabia Interconnector. This project integrates the Saudi Arabia - Qatar power line, which will facilitate electricity trading in the future.²²⁰

Several vulnerabilities exist in the interconnection project, including:

- Cybersecurity. A regional power grid would be subject to cyberattacks, thereby posing a big threat to the uninterrupted electricity supply within multiple countries. An integrated, rigid approach to cybersecurity is key to making critical infrastructure secure.
- Dependency on Neighbors. Interdependence on regional electricity imports could make countries vulnerable to the policy changes and potential instability of neighboring states' electricity networks.

E. *Smart Metering Systems*

Smart meters are sophisticated meters that measure energy consumption in real time, which helps analyze energy usage patterns, both from the utility service and users' points of view.²²¹ Setting up smart meters is the next step towards building a safer and more intelligent power network. In Qatar, Kahramaa is the entity responsible for smart meters being bought, installed, and maintained.²²² Kahramaa is introducing a plan for pilot projects, but large-scale deployment does not exist yet.²²³

One major step in modernizing the country's electrical networks is the implementation of smart metering systems across Qatar. A smart

218. *Id.*

219. *Id.*

220. ECONOMIC CONSULTING ASSOCIATES, THE POTENTIAL OF REGIONAL POWER SECTOR INTEGRATION 1 (Feb. 2010), https://www.esmap.org/sites/esmap.org/files/BN004-10_REISP-CD_Gulf%20Countries-Transmission%20&%20Trading.pdf [<https://perma.cc/P7ZY-J8F7>].

221. *What are smart meters*, IBM, <https://www.ibm.com/think/topics/smart-meter> [<https://perma.cc/96JB-2WVN>].

222. *Smart Meters Kahramaa's Strategic Project for Digital Transformation*, KAHRAMAA, <https://www.km.qa/CustomerService/Pages/SmartMeters.aspx> [<https://perma.cc/TG45-V8PQ>] [hereinafter *Smart Meters*].

223. *Id.*

metering system is an advanced metering infrastructure (AMI) that allows for two-way communication between utility companies and consumers.²²⁴ It enables remote monitoring and control of energy consumption, power demand rates, and power quality, among other features.²²⁵

The electricity networks in Qatar have undergone remarkable modernization in recent years, with the incorporation of smart metering systems playing a pivotal role.²²⁶ These cutting-edge technologies allow for the effective management of energy resources and the promotion of sustainable practices by enabling real-time monitoring and analysis of energy use.²²⁷ Modern technology, such as data analytics and Internet of Things (IoT) devices, has made Qatar's electrical networks more responsive, adaptable, and ecologically friendly.²²⁸ Smart metering systems also enable users to make educated choices regarding their energy consumption by properly capturing and transmitting consumption data, thereby promoting a culture of sustainability and conservation.²²⁹

The smart meter technology and communication network for Qatar energy meters has been completed by Kahramaa, in collaboration with Vodafone and Siemens.²³⁰ The project intends to deploy 600,000 IoT-enabled smart meters to create an infrastructure that comprises the newest gadgets, devices, and software for integration and connection.²³¹ In addition to allowing grid operators to balance the networks and incorporate renewable energy into the grid, smart meters are essential for decarbonizing the energy system—a goal that aligns with the Qatar National Vision 2030 and the country's overall digital transformation.²³²

Qatar's smart meters initiative, comprising more than 12 small projects, aims to replace all customers' outdated digital meters with more

224. *What is advanced metering infrastructure (AMI)?*, IBM, [https://www.ibm.com/think/topics/advanced-metering-infrastructure#:~:text=Advanced%20metering%20infrastructure%20\(AMI\)%20is,water%20usage%20in%20real%20time](https://www.ibm.com/think/topics/advanced-metering-infrastructure#:~:text=Advanced%20metering%20infrastructure%20(AMI)%20is,water%20usage%20in%20real%20time) [https://perma.cc/2WW3-682N].

225. *See Smart Metering*, SCIENCE DIRECT, <https://www.sciencedirect.com/topics/engineering/smart-metering> [https://perma.cc/9GVS-N8BU]; *see also* Javier Leiva et al., *Smart metering trends, implications and necessities: A policy review*, 55 RENEWABLE & SUSTAINABLE ENERGY REVS. 227 (2016), <https://www.sciencedirect.com/science/article/abs/pii/S1364032115012526> [https://perma.cc/549E-7YD4].

226. *Kahramaa, Vodafone launch Internet of Things-powered smart meters*, THE PENINSULA, Nov. 3, 2020, at P3, https://thepeninsulaqatar.com/pdf/20201103_1604357063-14962.pdf [https://perma.cc/NHA7-2V2J].

227. *Id.*

228. *Id.*

229. *Id.*

230. *Id.*

231. *KAHRAMAA completes construction of smart meters system*, THE PENINSULA (Nov. 1, 2021), <https://thepeninsulaqatar.com/article/24/10/2021/KAHRAMAA-completes-construction-of-smart-meters-system> [https://perma.cc/5VVK-YAEK].

232. *Id.*

advanced ones. The total cost of the Siemens metering system is 30 million Qatari riyals.²³³ During the first phase, 200,000 smart meters, accounting for 44% of the total, will be installed along with their respective system connections.²³⁴ Additionally, the total cost of the smart meters connecting infrastructure project is 19 million Qatari riyals.²³⁵ The strategic plan targets the installation of about 450 thousand meters by the first quarter of 2023. The project is scheduled to be completed by the end of 2024 for water meters and by the end of 2023 for electricity meters.²³⁶

While energy suppliers and the national infrastructure are responsible for smart metering systems, the Data Communications Company (DCC) oversees the national infrastructure that facilitates seamless communication between smart meters and all energy providers.²³⁷ Its role is to guarantee the smooth operation of the entire smart metering system and make sure its advantages are realized.²³⁸ In Qatar, energy suppliers are deploying the latest generation of smart meters, which are linked to a national smart metering communications network from the start.²³⁹ This setup ensures compatibility among suppliers and prevents disruptions in energy readings or bill payments when switching suppliers.²⁴⁰ Furthermore, the DCC is responsible for remotely upgrading first-generation meters to the national infrastructure through a remote upgrade, restoring their smart functionality.²⁴¹ Overall, energy suppliers and the DCC are collaborating to ensure the successful implementation and functioning of smart metering systems in Qatar.

In Qatar, utility companies are usually the ones responsible for handling payment matters related to smart metering systems.²⁴² These companies are responsible for overseeing and maintaining smart meters, as well as ensuring precise billing and collecting payments from consumers.²⁴³ The introduction of smart metering systems in Qatar has transformed the method of measuring and billing energy usage, leading

233. *Smart Meters*, *supra* note 222.

234. *Id.*

235. *Id.*

236. *Id.*

237. *Get a smart meter*, OFF. GAS & ELECTRICITY MARKETS, <https://www.ofgem.gov.uk/get-smart-meter> [<https://perma.cc/6GTF-85PT>].

238. *Id.*

239. *KAHRAMAA and Vodafone launch smart meters powered by the Internet of Things*, VODAFONE (Nov. 2, 2020), <https://www.vodafone.qa/en/about-us/media/press-release/kahramaa-and-vodafone-launch-smart-meters-powered-by-the-internet-of-things> [<https://perma.cc/X5F4-RNQQ>].

240. DEPT. ENERGY SEC. NET ZERO & DEPT. BUS., ENERGY INDUS. STRATEGY, *Smart meters: how they work*, GOV.UK (Oct. 14, 2021), <https://www.gov.uk/guidance/smart-meters-how-they-work> [<https://perma.cc/ZX7H-U2RZ>].

241. *Id.*

242. *See Smart Meters*, *supra* note 222.

243. *Id.*

to enhanced transparency and efficiency in the payment process.²⁴⁴ By assigning payment management to utility companies, consumers can benefit from automated billing and payments, while also supporting a more sustainable and eco-friendly energy infrastructure.²⁴⁵

In summary, Qatar is making significant progress towards modernizing its electricity networks by implementing smart metering systems. The nation's commitment to embracing advanced technology and promoting sustainable energy practices is evident through ongoing trials, legislative advancements, and regulatory changes. A comprehensive cost-benefit analysis also identifies the financial benefits of smart metering systems, showing that adherence to minimal functionality requirements ensures data accessibility and consumer savings.²⁴⁶ With a target to install smart meters by 2030, and with the active involvement of multiple stakeholders, Qatar is set to revolutionize its power industry and build a more sustainable and energy-efficient future.

F. Data Protection²⁴⁷

Data protection is a crucial aspect of ensuring privacy and security in the digital age. Data protection refers to the practices, regulations, and procedures that aim to prevent unauthorized access, use, sharing, changing, or destruction of data.²⁴⁸ In essence, data protection measures help safeguard the confidentiality, integrity, and availability of data, and ensure compliance with relevant laws and regulations to protect individuals' personal information.²⁴⁹ In Qatar, several regulations are currently in place to protect personal data and regulate its use.²⁵⁰ The Personal Data Protection Law of 2016 (PDPL) serves as the cornerstone of data protection in the country,²⁵¹ while the National Information

244. *Id.*

245. *See id.*

246. *See generally* THE WORLD BANK, IMPACT ASSESSMENT ON SMART METERING: DATA AND METHODOLOGIES FOR A COST-BENEFIT ANALYSIS OF SMART METERING IMPLEMENTATION IN ROMANIA (2018) (analyzing the costs and benefits of smart meter implementation in Europe).

247. *See generally* Rafael Leal-Arcas et al., *The Digitalization of Trade and Artificial Intelligence: a Pandora's Box*, 12 PENN ST. J. L. & INT'L AFFS. 1, 1–75 (2024) (regarding a legal analysis of data protection issues).

248. *What is Data Protection and Privacy?*, CLOUDIAN, <https://cloudian.com/guides/data-protection/data-protection-and-privacy-7-ways-to-protect-user-data/> [https://perma.cc/Z5UX-FNWD].

249. *See What Is Data Privacy and Why Should You Care?*, NAT'L CYBERSECURITY ALLIANCE (Jan. 9, 2025), <https://www.staysafeonline.org/articles/what-is-data-privacy-and-why-should-you-care> [https://perma.cc/YS2N-94CF].

250. *See generally Qatar Data Protection Law*, PWC, <https://www.pwc.com/m1/en/services/consulting/technology/cyber-security/navigating-data-privacy-regulations/qatar-data-protection-law.html> [https://perma.cc/Q3MD-AJLF].

251. *See Law No. 13 of 2016: Personal Data Privacy Protection*, COMPLIANCE & DATA PROT.

Security Committee (NISC) oversees the implementation and enforcement of the PDPL.²⁵²

The PDPL ensures the protection of personal data and regulates its processing within the country.²⁵³ It establishes principles for fair and lawful processing of personal data and mandates the implementation of appropriate measures to prevent unauthorized access, use, or sharing of personal information.²⁵⁴ The law also outlines the rights of individuals regarding their personal data, while also prohibiting the transfer of personal data outside of Qatar without adequate safeguards.²⁵⁵ The PDPL enables competent government entities to regulate acts or procedures pertinent to personal data processing, thus ensuring that people's privacy rights are protected.²⁵⁶

Smart metering—with its ability to collect and transmit detailed energy usage data—will undoubtedly have an impact on existing data protection laws in Qatar. The introduction of smart meters raises concerns regarding the confidentiality and safety of the collected data.²⁵⁷ Consequently, Qatar's data protection laws may need to be updated to address the specific challenges posed by smart metering. It is essential to guarantee that the precautions are established to safeguard the confidentiality and security of data gathered by smart meters and that they adhere to existing data protection regulations. Additionally, guidelines may need to be implemented to supervise the access, storage, and distribution of this data to prevent any unauthorized use or access. As smart metering technology progresses, Qatar's data protection laws will need to evolve to ensure the effective protection of data and consumer privacy.

Controlling third parties' handling of personal data is another important aspect of data protection. The country's data protection laws, particularly Law No. 13 of 2016 on the Protection of Personal Data, provide a robust framework for governing the gathering, handling, and sharing of personal data, including provisions that extend to third-party

DEP'T (Mar. 11, 2016), <https://assurance.ncsa.gov.qa/sites/default/files/library/2020-11/Law%20No.%20%2813%29%20of%202016%20on%20Protecting%20Personal%20Data%20Privacy%20-%20English.pdf> [<https://perma.cc/QR9J-MHLR>].

252. See *Personal Data Privacy*, NAT'L CYBER SEC. AGENCY (2024), <https://assurance.ncsa.gov.qa/en/privacy> [<https://perma.cc/9EFM-RA2T>].

253. *Qatar Personal Data Privacy Protection Law (PDPL)*, AZPIRANTZ TECH., <https://azpirantz.com/services/qatar-pdpl-consulting-services/> [<https://perma.cc/4NMP-A4PW>].

254. *Id.*

255. *Id.*

256. *Id.*

257. *Privacy and Security Considerations in Smart Metering: Safeguarding Smart Meter Data Privacy*, NERO ELECTRONICS (June 29, 2025), <https://neroelectronics.com/content/about/news/privacy-and-security-considerations-in-smart-metering-safeguarding-smart-meter-data-privacy/> [<https://perma.cc/PJ8V-HUJG>].

entities.²⁵⁸ Organizations often rely on third-party service providers to manage personal data for them. The PDPL requires organizations to enter into agreements with these providers to ensure that adequate data protection measures are in place.²⁵⁹ However, the effectiveness of such control mechanisms depends on the inclinations and capacities of organizations to implement them.²⁶⁰

Additionally, the Qatar Financial Centre (QFC) has implemented regulations to oversee the activities of third-party data processors and controllers, further strengthening the control over data protection.²⁶¹ Thus, it is crucial for organizations to conduct due diligence when selecting third-party service providers and regularly assess their compliance with data protection requirements. While challenges may still exist in enforcement and compliance, Qatar's efforts in regulating third parties demonstrate a commitment to bolstering data protection measures in the country.

The effectiveness of legislation in protecting consumers can be evaluated based on its ability to safeguard individuals' rights and provide remedies in case of data breaches or privacy violations. The PDPL establishes individuals' rights to access, rectify, and delete their personal data.²⁶² It also introduces notification requirements for data breaches and empowers the competent authorities to impose penalties for non-compliance.²⁶³ However, the effectiveness of legislation can be further enhanced by raising awareness among individuals about their rights and promoting a culture of data protection and privacy.

Qatar has a long-standing committee responsible for cybersecurity and supports efforts to boost public knowledge about cybercrimes and how to stay safe from them.²⁶⁴ The country has faced politically motivated cyberattacks, which have even caused strained diplomatic relations.²⁶⁵ The country has also experienced sophisticated and high-profile cyberattacks on its media, government web sites, and energy

258. See *Law No.13 of 2016: Personal Data Privacy Protection*, *supra* note 251.

259. *Qatar Data Privacy Law (Law No 13): A Detailed Guide (2025)*, WATTLECORP (May 24, 2025), <https://www.wattlecorp.com/qatar-data-privacy-law/> [<https://perma.cc/7ZE2-QYLH>].

260. *Id.*

261. See *QFC Law*, QATAR FIN. CTR. REGUL. AUTH. (2020), <https://qfcra-en.thomsonreuters.com/> [<https://perma.cc/8UBY-XE5G>].

262. See *Law No.13 of 2016: Personal Data Privacy Protection*, *supra* note 251.

263. State of Qatar National Cyber Security Agency, *Personal Data Breach Notifications Guidelines for Regulated Entities*, at 10 (Nov. 2020), [https://assurance.ncsa.gov.qa/sites/default/files/library/2022-09/Personal%20Data%20Breach%20Notifications%20-%20Guideline%20for%20Regulated%20Entities%20\(English\)_0.pdf](https://assurance.ncsa.gov.qa/sites/default/files/library/2022-09/Personal%20Data%20Breach%20Notifications%20-%20Guideline%20for%20Regulated%20Entities%20(English)_0.pdf) [<https://perma.cc/PK5E-EKK6>].

264. Qatar National Cyber Security Committee, *National Cyber Security Strategy at v* (May 2014), https://www.itu.int/en/ITU-D/Cybersecurity/Documents/National_Strategies_Repository/Qatar_2014_national_cyber_security_strategy.pdf [<https://perma.cc/M2M8-T737>].

265. See *id.* at 4.

industry networks.²⁶⁶ Protection against cyberattacks is thus an increasingly significant concern in Qatar. To address these threats, Qatar has implemented measures to protect its ICT products and services, emphasizing the need for a global response to cybercrime.²⁶⁷ With the growing reliance on digital systems and the increasing sophistication of cyber threats, robust measures are essential to defend against potential attacks.

To this end, Qatar has established entities such as Q-CERT (Qatar Computer Emergency Response Team), E-SHIELD, and a Cyber Security Center (CSC) to safeguard its digital networks and be prepared for cyberattacks.²⁶⁸ The Q-CERT plays a critical role in preventing and responding to cyber incidents in the country. This entity collaborates with various stakeholders, including government entities and critical infrastructure providers, to enhance the cybersecurity posture of Qatar.²⁶⁹ Efforts such as regular vulnerability assessments, incident response planning, and cybersecurity awareness campaigns contribute to strengthening protection against cyberattacks.²⁷⁰ The country has also enacted cybercrime legislation, demonstrating its commitment to combating cybercrimes and ensuring cybersecurity.²⁷¹

In the context of cybersecurity in smart grids, several initiatives are underway in Qatar, including:

- **Research and Development.** Qatar University has conducted extensive research on cybersecurity standards and technical countermeasures for smart grids.²⁷² This work includes reviewing the latest developments in cybersecurity to standardize smart grids and integrate current technologies, as well as highlighting key areas of research going forward and ways to partner with both government and industry.²⁷³

266. *See id.*

267. *Id.* at vi.

268. Nabeela, *Cyber crimes in Qatar: The law and how to report them* (Oct. 13, 2021), <https://www.iloveqatar.net/guide/laws/cyber-crimes-in-qatar> [<https://perma.cc/SN7P-D3MA>].

269. *See Q-Cert*, CYBER SEC. INTEL., <https://www.cybersecurityintelligence.com/q-cert-1975.html> [<https://perma.cc/97QE-AWLM>].

270. *Id.*

271. *See generally* Tamim bin Hamad Al-Thani, *Promulgating the Cybercrime Prevention Law*, STATE OF QATAR MINISTRY OF JUST. (2014), <https://www.almeezan.qa/EnglishLaws/142014.pdf> [<https://perma.cc/Y5LB-G95Q>].

272. *See, e.g.*, Shahbaz Hussain et al., *Smart Grid Cybersecurity: Standards and Technical Countermeasures* (Paper Presented at the 2018 International Conference on Computer and Applications (ICCA)), <http://dx.doi.org/10.1109/COMAPP.2018.8460390> [<https://perma.cc/L46F-J322>].

273. *See, e.g., id.*

- Collaborative Projects. The SGC is running projects focused on multi-layer cybersecurity and situational awareness to increase the resilience of Qatar's power grid.²⁷⁴ These projects aim to develop smart asset management systems with health degradation identification and estimations of the grid's estimated remaining useful lifetime.²⁷⁵
- International Collaboration. An international research collaboration led by Texas A&M University at Qatar has received a \$3.2 million grant from the Qatar National Research Foundation (QNRF) for a cluster project on smart grid cybersecurity infrastructure.²⁷⁶ The goal is to make the country's energy supply more reliable and secure.²⁷⁷
- Machine Learning for Cybersecurity. Qatar is also exploring the use of machine learning for cybersecurity in smart grids. This involves securing cyber-physical connectivity and protecting confidential information that is vulnerable to cyber threats.²⁷⁸

Qatar's overall approach to protecting against cyberattacks involves a combination of legislative measures, the establishment of specialized entities, and efforts to raise awareness about cybercrimes and cybersecurity. The country has made significant strides in the field of data protection through the implementation of the PDPL and the establishment of the DPA, which underscore the country's commitment to safeguarding its digital infrastructure and addressing the evolving challenges posed by cyber threats. The government, organizations, and individuals will need to work together to continuously evaluate and enhance data protection measures to ensure privacy and security in the digital landscape. By doing so, Qatar can position itself as a leader in data protection and set an example for other nations.

274. See, e.g., *Kahramaa Signs as Agreement with Tees Cybersecurity Center at Texas A&M at Qatar*, TEXAS A&M UNIV. AT QATAR (Sept. 23, 2018), <https://www.qatar.tamu.edu/news-and-events/news/2018/09/23/kahramaa-signs-an-agreement-with-tees-cybersecurity-center-at-texas-a-and-m-at-qatar/> [https://perma.cc/7XBT-CZVF].

275. See, e.g., *id.*

276. Rahul Vaimal, *Qatar's Texas A&M leads \$3.2m cybersecurity project for Power Grids*, GCG BUS. NEWS (July 31, 2020), [https://www.gccbuisinesnews.com/qatars-texas-am-leads-3-2m-cybersecurity-project-for-power-grids/#:~:text=Qatar's%20National%20Research%20Foundation%20\(QNRF\)%20has%20given,the%20country%20with%20the%20ultimate%20goal%20of](https://www.gccbuisinesnews.com/qatars-texas-am-leads-3-2m-cybersecurity-project-for-power-grids/#:~:text=Qatar's%20National%20Research%20Foundation%20(QNRF)%20has%20given,the%20country%20with%20the%20ultimate%20goal%20of) [https://perma.cc/S7JB-346C].

277. *Id.*

278. See, e.g., Dabeeruddin Syed, Shady S. Refaat, & Othmane Bouhali, *Privacy Preservation of Data-Driven Models in Smart Grids Using Homomorphic Encryption*, 11 INFO. 357 (2024), <https://doi.org/10.3390/info11070357> [https://perma.cc/R7JP-LPYS].

G. *Electric Vehicles*²⁷⁹

In an effort to address climate change and honor their pledges to lower greenhouse gas emissions, nations are swiftly shifting their local transportation infrastructures from fossil fuel-powered vehicles to electric vehicles (EVs).²⁸⁰ This movement is driven by the fact that transportation is responsible for roughly 25% of global carbon dioxide emissions, coupled with the collective resolve of over 160 countries under the 2015 Paris Agreement to stop global temperatures from rising above 2°C.²⁸¹ To achieve this, each country has outlined its own decarbonization strategy through nationally determined contributions (NDCs).²⁸² In the context of EVs and the overhaul of transportation systems, governments have established various time-sensitive goals, complemented by a mix of incentives and deterrents such as subsidies, tax reliefs, tariffs, prohibitions, gradual phase-outs, and sales targets to facilitate this transition.²⁸³

Qatar is actively embracing the shift towards EVs as a part of its broader environmental and economic goals outlined in the National Vision 2030.²⁸⁴ The nation's strategy is focused on reducing greenhouse gas emissions and fostering economic diversification.²⁸⁵ It has already achieved significant milestones in revamping its transportation sector, in line with its sustainability ambitions that were set in advance of the FIFA 2022 World Cup.²⁸⁶ Notably, a new metro system was constructed to link the urban areas with the sports venues, and the supplementary buses to the metro were replaced with electric buses.²⁸⁷

EVs are gaining traction in Qatar as part of the country's National Vision 2030, which aims to reduce carbon emissions and diversify the

279. See generally R. Leal-Arcas, *Exploring energy decentralization: The promotion of electric vehicles and storage*, in FINANCING THE ENERGY TRANSITION: STATUS AND FUTURE CHALLENGES 25–50 (A. Metaxas ed., 2020); R. Leal-Arcas, *Electric vehicles, sustainability, and decarbonization*, in MOVILIDAD URBANA SOSTENIBLE Y ACCIÓN ADMINISTRATIVA PERSPECTIVA SOCIAL, E STRATEGIAS JURÍDICAS Y POLÍTICAS PÚBLICAS DE MOVILIDAD EN EL MEDIO URBANO 257–82 (A. Fortes Martin ed., 2019).

280. See Hannah Ritchie, *Cars, Planes, Trains: where do CO₂ emissions from transport come from?*, OUR WORLD IN DATA (Oct. 6, 2020), <https://ourworldindata.org/co2-emissions-from-transport#article-citation> [<https://perma.cc/GH2H-ERP6>].

281. *Id.*

282. *Id.*

283. *Id.*

284. See *Qatar National Vision 2030*, STATE OF QATAR, GOV'T COMMC'NS OFF., <https://www.gco.gov.qa/en/state-of-qatar/qatar-national-vision-2030/our-story/> [<https://perma.cc/TP95-YY67>].

285. *Qatar Electric Vehicle Market Research Report: Forecast (2024-2030)*, MARKNTEL (July 2024), <https://www.marknteladvisors.com/research-library/qatar-electric-vehicle-market.html> [<https://perma.cc/T86L-B3H6>] [hereinafter *Electric Vehicle Report*].

286. *Id.*

287. *Id.*

economy. The government has been proactive in facilitating the adoption of EVs through various strategies and policies.²⁸⁸ While the exact number of EVs in Qatar is not specified, the market is expected to grow significantly. In April 2023, Qatar's Ministry of Transport announced a goal to change 35% of its fleet of vehicles and 100% of its public buses to electric-powered vehicles by 2030.²⁸⁹ This is expected to increase passenger EV sales by 302.8% in 2023, reaching annual sales of just under 600 units.²⁹⁰

Qatar set ambitious targets for EV adoption, including making 25% of the public transit bus fleet electric-powered by 2022, which resulted in 700 such buses operating in the country.²⁹¹ To support this, the government is encouraging foreign investors through schemes such as land ownership, income tax exemption, and customs duty exemption for machinery, equipment, and raw materials.²⁹² To facilitate the adoption of EVs, Qatar plans to install over 600 charging stations and has already begun switching out its public buses for electric ones.²⁹³

Qatar is not only expanding its charging infrastructure, but it is also partnering with global firms to produce EV chargers domestically, reflecting its commitment to technological innovation in the EV sector.²⁹⁴ In Qatar, the legislation to support EVs includes a range of guidelines and initiatives aimed at establishing a robust infrastructure for EVs and promoting their widespread adoption.²⁹⁵ The Qatar General Electricity & Water Corporation, also called Kahramaa, through its National Program for Conservation and Energy Efficiency (Tarsheed), has launched a comprehensive guideline for EVs and charging infrastructure.²⁹⁶ This guideline provides detailed information on the installation of EV charging units, including the selection of chargers, types of charging equipment, and general specifications that must be met. It also addresses

288. *Qatar Master Plan for Transport 2050*, MINISTRY OF TRANSPORT (2023), <https://mot.gov.qa/ar> [<https://perma.cc/9C3G-FJYB>].

289. See *Qatar to switch 35% vehicles, 100% buses to electric by 2030*, THE PENINSULA (Apr. 26, 2023), <https://www.zawya.com/en/business/energy/qatar-to-switch-35-vehicles-100-buses-to-electric-by-2030-qkpzlghe> [<https://perma.cc/J23C-7N47>].

290. MINISTRY OF COMMERCE AND INDUSTRY (2023), <https://www.moci.gov.qa/> [<https://perma.cc/UG6P-AZUL>].

291. See *Delivery of Qatar's Electric Bus Fleet for FIFA World Cup 2022 Completed*, STATE OF QATAR MINISTRY OF TRANSPORT (Apr. 25, 2022), <https://www.mot.gov.qa/en/news/delivery-qatars-electric-bus-fleet-fifa-world-cup-2022-completed> [<https://perma.cc/K58H-3YGS>]; *Electric Vehicle Report*, *supra* note 285.

292. See *Electric Vehicle Report*, *supra* note 285.

293. *Id.*

294. *Id.*

295. *Id.*

296. *KAHRAMAA Launches the Electric Vehicle and Charging Infrastructure Guideline in the State of Qatar*, KAHRAMAA (Nov. 23, 2020), <https://www.km.qa/MediaCenter/Pages/NewsDetails.aspx?ItemID=372> [<https://perma.cc/UL9H-2QUG>].

the different capacities of charging stations and their suitability according to each location.

Kahramaa has approved technical specifications for chargers and infrastructure equipment related to EVs.²⁹⁷ This approval is a supportive step to inform those who wish to install charging units for EVs, whether in the governmental, commercial, or industrial sectors.²⁹⁸ To encourage the transition to EVs, Qatar offers a range of incentives. These include subsidies for purchasing electric vehicles, tax exemptions, and investment in charging infrastructure. By creating a favorable economic environment, the government aims to speed up EV usage across the country.²⁹⁹

Qatar has also created regulations to support the EV ecosystem, including guidelines to govern charging station installation, safety standards, and vehicle certification. These regulations will have an important impact on EV usage in Qatar going forward. Qatar's Ministry of Transport has developed the Transportation Master Plan for Qatar-2050.³⁰⁰ This comprehensive plan is a roadmap for investing in land transportation infrastructure, ensuring alignment with land use, urbanization, population rise, and future transportation needs.³⁰¹ Sustainability is a cornerstone of this plan, balancing economic growth with environmental protection.³⁰² It aims to achieve financial sustainability by executing transportation demand management policies and public-private partnerships.³⁰³ Qatar's National Vision 2030 also emphasizes sustainable development, including EV adoption.³⁰⁴

EVs can also be leveraged to enable the smart grid. Charging EVs during excess renewable energy production (e.g., solar and wind) helps flatten demand curves and reduces system costs.³⁰⁵ San Diego Gas and Electric has reported that installing EV charging stations can make the grid stable and absorb excess power.³⁰⁶ Qatar is in a strong position to

297. See *Smart Meters: For a Modern, Smart Electricity Grid*, *supra* note 158.

298. *Id.*

299. *Smart EV Charging*, TASMU (2023), <https://tasmu.gov.qa/the-playbook/smart-ev-charging> [<https://perma.cc/7NLM-36LP>].

300. *Transportation Master Plan for Qatar 2050*, Ministry of Transport, <https://www.mot.gov.qa/en/land-transport/transportation-master-plan-for-qatar-2050> [<https://perma.cc/C62Z-XU8T>].

301. *Id.*

302. *Id.*

303. *Id.*

304. Gen. Secretariat for Dev. Planning, *Qatar National Vision 2030* at 5 (July 2008), <https://www.diwan.gov.qa/-/media/diwan-amiri/files/qatar-national-vision-2030-en.ashx> [<https://perma.cc/R98D-CMGX>].

305. Cal. Energy Commission, *Demonstrating Plug-in Electric Vehicles Smart Charging and Storage Supporting the Grid* at 1 (Aug. 2018), <https://www.energy.ca.gov/sites/default/files/2021-06/CEC-500-2018-020.pdf> [<https://perma.cc/9BG7-5BMZ>].

306. *Id.* at ii.

transition to EVs. Government policies, ambitious targets, and support mechanisms drive EV adoption in the country. For example, in terms of charging infrastructure, Qatar aimed to install over 600 charging stations to support electric buses before the 2022 FIFA World Cup.³⁰⁷

Moreover, Kahramaa has established guidelines for promoting the use of fast chargers. These guidelines provide comprehensive information on the installation of EV charging units, including the selection of chargers, types of charging equipment, and general specifications that must be met.³⁰⁸ Carmakers are increasingly viewing Qatar as an effective platform to showcase their newest EVs, and are offering their latest luxury EV models in the country.³⁰⁹ Ecotranzit, a company dedicated to sustainable mobility, recently showcased its VIM EV prototypes, and other car manufacturers are expected to follow suit due to increased visibility following the 2022 FIFA World Cup.³¹⁰ Qatar has also signed agreements to establish local EV assembly plants, aiming to boost domestic production and reduce carbon emissions.³¹¹

H. Storage

The energy storage sector in Qatar faces challenges such as regulatory clarity, integration with the existing grid, and compatibility with current infrastructure. The construction and operation of energy storage facilities in Qatar require adherence to regulations and obtaining necessary permits from entities like Kahramaa and the Ministry of Energy and Industry. Qatar's Energy Law does encompass some provisions for the connection and supply of electricity, which includes energy storage systems, thereby ensuring safe and efficient energy services.

The landscape of energy storage systems in Qatar is evolving to support the nation's sustainable energy goals. The country is investigating various energy storage technologies such as battery storage, thermal storage, and mechanical storage systems to bolster its renewable energy initiatives.³¹² In this context, the Qatar Investment Authority has been instrumental in funding energy storage solutions, including a

307. See *Electric Vehicle Report*, *supra* note 285.

308. *Tarsheed Photo Voltaic Energy Storage & EV Charging Station*, KAHRAMAA (2023), <https://www.km.qa/Tarsheed/Pages/TarsheedDetails.aspx?ItemID=7> [<https://perma.cc/W4EQ-F4R5>].

309. *Qatar Automotive Sector and Electric Vehicles*, INT'L TRADE ADMIN. (Sept. 14, 2022), <https://www.trade.gov/market-intelligence/qatar-automotive-sector-and-electric-vehicles> [<https://perma.cc/5S2B-UVXM>].

310. *Id.*

311. *Id.*

312. Shahbaz Hussain et al., *Smart Grid Cybersecurity: Standards and Technical Countermeasures*, 2018 INT'L CONF. ON COMPUT. AND APPLICATIONS (Aug. 2018), <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8460390> [<https://perma.cc/5774-7HX9>].

significant investment in a global energy storage company.³¹³ Additionally, Kahramaa has initiated pilot projects with Tesla batteries.³¹⁴ This project is the first of its kind in Qatar and involves batteries connected to a substation linked to the local Nuaija station.³¹⁵ The batteries have a total capacity of 1 MW / 4 MWh and are aimed at ensuring production capacity during peak hours to improve energy efficiency and sustainability.³¹⁶

Continuing its mission to reduce carbon emissions, Kahramaa also launched the Tarsheed Photovoltaic Station for Energy Storage and Charging Electric Vehicles.³¹⁷ This station represents a significant step towards promoting environmentally friendly practices in the transportation sector.³¹⁸ Qatar is also developing other advanced storage solutions to enhance grid resilience and manage energy fluctuations through various initiatives, including a collaboration between Kahramaa and the Qatar Research Development and Innovation Council (QRDI).³¹⁹

The country's first solar and storage project features Tesla Powerpack batteries.³²⁰ This initiative is part of Qatar's broader strategy to diversify its energy sources and enhance sustainability.³²¹ If successful, this pilot project could lead to the deployment of batteries in larger projects connected to high-load stations in the system and integrated with key renewable energy projects like the Al Kharsaah Solar Power Project.

Another project is the Tarsheed Smart EV charging platform, led by the Ministry of Communications and Information Technology (MCIT).³²² The project is a comprehensive solution that empowers EV

313. *QIA Leads Series D Funding for Ascend Elements to Accelerate Production of Recycled EV Battery Materials*, QATAR INV. AUT. (Sept. 6, 2023), <https://www.qia.qa/en/Newsroom/Pages/QIA-leads-Series-D-funding-for-Ascend-Elements-to-accelerate-production-of-recycled-EV-battery-materials.aspx> [https://perma.cc/U99C-GC7X].

314. *Kahramaa Launches Pilot Project to Store Electrical Energy Using Batteries*, KAHRAMAA (Dec. 8, 2020), <https://www.km.qa/MediaCenter/pages/NewsDetails.aspx?ItemID=359> [https://perma.cc/5SLZ-CWQY].

315. *Id.*

316. *Id.*

317. *Tarsheed Photo Voltaic Energy Storage & EV Charging Station*, KAHRAMAA, <https://www.km.qa/Tarsheed/Pages/TarsheedDetails.aspx?ItemID=7> [https://perma.cc/CAZ7-Z7T7].

318. *Id.*

319. *See generally QRDI Council and Kahramaa Sign MoU to Support Sustainability in Qatar*, KAHRAMAA (Feb. 2, 2022), <https://www.km.qa/MediaCenter/Pages/NewsDetails.aspx?ItemID=416> [https://perma.cc/MWB8-4NAS].

320. Emiliano Bellini, *Qatar's first storage project relies on Tesla batteries*, PV MAG. (Aug. 14, 2020), <https://www.pv-magazine.com/2020/08/14/qatars-first-storage-project-relies-on-tesla-batteries/> [https://perma.cc/6PBR-8HYZ].

321. *Id.*

322. *KAHARAMAA and the Ministry of Communications and Information Technology Launch "Tarsheed" Smart EV Charging Platform*, KAHRAMAA (Dec. 12, 2023), <https://www.km.qa/MediaCenter/Pages/NewsDetails.aspx?ItemID=451> [https://perma.cc/J3FX-JMUP].

owners to easily find charging stations.³²³ This platform is a collaborative effort from Tasmu and Tarsheed teams and aligns with Qatar Vision 2030 for enhanced sustainability.³²⁴

In summary, Qatar recognizes the importance of modern storage solutions to help enable smart grids and modernize its electricity delivery system. However, the effectiveness of policies and regulations supporting these upgrades is a critical consideration.

I. Conclusion

Qatar has made significant progress on implementing smart grid technologies and promoting renewable energy. The country has created efficient laws and policies to help develop and integrate smart grids. The current regulatory frameworks offer incentives for both public and private sector investment in and support of smart grid technologies.

One of the most significant achievements in the country's energy sector is the increase in renewables and distributed generation. Dependence on fossil fuels has been reduced and the country has diversified its energy mix. Qatar's commitment to renewable energy and smart grids is evident in that the country has a goal of producing 20% of its electricity from renewable sources by 2030 and to having a carbon neutral footprint by 2050.³²⁵ Wind and solar energy are examples of renewable energy sources that Qatar has already embraced and successfully incorporated into its grid infrastructure.

For example, the Al Kharsaah solar energy plant, with over 1.8 million solar panels, generates around 2 TWh of electricity annually.³²⁶ Two additional solar plants are set to launch by the end of 2024.³²⁷ Solutions for converting waste into energy are also being explored to further diversify the energy portfolio.³²⁸ The Domestic Solid Waste Management Centre in Mesaieed currently generates 50 MW of electricity per day.

323. *Id.*

324. *Id.*

325. Deepak John, *Qatar taking proactive steps to reduce carbon footprint*, THE PENINSULA QATAR (Sept. 24, 2024), <https://thepeninsulaqatar.com/article/24/09/2024/qatar-taking-proactive-steps-to-reduce-carbon-footprint> [https://perma.cc/6WKQ-WHFA]; see also *Qatar National Vision 2030: Environmental Development*, STATE OF QATAR, GOV'T COMM'NS OFFICE, <https://www.gco.gov.qa/en/state-of-qatar/qatar-national-vision-2030/environmental-development/> (last visited Dec. 16, 2025) (under *Achieved to date*, expand 03 — *Third National Development Strategy (2024 – 2030)*); *Statement by the Shura Council of the State of Qatar On the occasion of the sixth anniversary International Day of Parliamentary Work*, THE SHURA COUNCIL (June 29, 2023), <https://www.shura.qa/en/Pages/MediaCenter/Press-Releases/29062023> [https://perma.cc/U3KT-SFT2].

326. *Qatar's plans for renewable energy*, DENTONS (May 10, 2023), <https://www.dentons.com/en/insights/alerts/2023/may/10/qatars-plans-for-renewable-energy> [https://perma.cc/K7ZR-36M9].

327. *Id.*

328. *Id.*

Wind energy potential is also being studied, with a focus on large-scale wind farm projects in the northern part of the country.³²⁹ By lowering reliance on conventional energy sources, Qatar's move toward renewable energy not only supports international efforts to mitigate climate change but also assures operational security.

Moreover, Qatar has made it possible for customers to effectively participate in the smart grid ecosystem and has actively included them in the energy sector. Smart meters and sophisticated metering infrastructure have given consumers greater insight into and control over their usage habits. This gives them the ability to optimize their energy use, make well-informed decisions, and advance overall energy efficiency. Consumer participation in the smart grid system has grown, which has enhanced resource management, decreased waste, and increased energy efficiency.

The cooperative efforts of numerous government agencies and regulatory bodies are responsible for the success of Qatar's smart grid policies and regulations. Through the creation of specialized departments in charge of digitalization and smart grids, the government is showing a commitment to sustainability, energy efficiency, and digitalization. Responsible agencies are working to make sure that the advantages of smart grid technologies are distributed across the country by supervising research, development, and funding for smart grid projects.

Furthermore, Qatar has made cybersecurity and consumer data protection top priorities within the smart grid framework. Current data protection laws and regulations provide a strong foundation for protecting consumer information. Furthermore, controls over third parties are guaranteed, and safeguards are in place to protect consumers from possible cyber threats. This comprehensive approach to data protection instills confidence among consumers and promotes the widespread adoption of smart grid technologies.

Looking ahead, Qatar is positioned to fulfil its goals of providing smart meters to a sizable portion of its population by 2030. A clear implementation and expansion roadmap for smart metering systems is provided by the nation's legislative portfolio. The dedication to maximizing the advantages and improving the functionality of smart metering systems is further evidenced by ongoing trials and regulatory changes. Consequently, Qatar is poised to attain better energy governance, increased effectiveness, and financial benefits for both users and utility companies.

Integrating smart grid technologies, including microgrids and distributed generation, requires robust regulatory frameworks. Regulatory measures can help promote smart grids and boost flexibility.

329 *Id.*

They can also create mechanisms such as carbon pricing, green bonds, and renewable energy certification that can incentivize investment in smart grid technologies. Regulatory frameworks should also facilitate high-speed connectivity and interoperability while ensuring reliability and security.

Qatar's current regulatory framework does offer some favorable incentives for investing in smart grid technologies, resulting in a rise in the integration and uptake of distributed generation and renewable energy sources. Incentives, effective integration, and consumer participation are crucial for attaining a sustainable and efficient energy future in the country. Thanks to improved metering infrastructure and more control over their energy use, consumers can now engage in the energy sector more successfully and economically. This is crucial, because smart grids empower consumers by offering opportunities to generate their own electricity through rooftop solar, reduce usage of smart devices, participate in demand response efforts, increase renewable power capacity, enhance energy efficiency, and reduce peak load through active engagement with smart grid technologies. As Qatar continues its transition, collaboration between regulators, industry stakeholders, and consumers will be crucial for continued and greater success.

IV. MOROCCO AS A CASE STUDY³³⁰

A. General Overview

Morocco, a country located in North Africa known for its diverse culture, rich history, and strategic position, is making efforts to lower greenhouse gas (GHG) emissions and integrate renewable energy in its energy sector. The nation has set ambitious goals of reducing emissions by 18.3% below business-as-usual levels by 2030, irrespective of any international assistance, and by up to 45.5% with assistance.³³¹ These objectives form part of the country's broader plans to raise the share of clean power sources in its electricity mix to 80% by 2050,³³² and, in the shorter-term, to higher than 52% by 2030. Ongoing investments in wind and solar power further demonstrate this commitment towards sustainability, which has positioned Morocco as a regional pioneer in green energy.³³³ Furthermore, technological improvements are underway

330. This section was researched and written by Leen Albawardi, Lama Al-Asheikh, Sara Albulaihid, Albandary Almershed, and Haya Alsaud.

331. *Morocco Targets*, CLIMATE ACTION TRACKER (Apr. 17, 2023), <https://climateactiontracker.org/countries/morocco/targets/> [https://perma.cc/9NC8-NZ9V].

332. *Id.*

333. Khouloud Haskouri, *Morocco Renews Commitment to Reducing Greenhouse Gas Emissions*, MOROCCO WORLD NEWS (July 14, 2021, 2:32 PM), www.moroccoworldnews.com/2021/07/343407/morocco-renews-commitment-to-reducing-greenhouse-gas-emissions [https://perma.cc/5THX-WY2E].

within Morocco's energy sector, alongside the introduction of better distribution methods such as smart grids. According to the country's updated Nationally Determined Contribution (NDC) submitted to the United Nations Framework Convention on Climate Change (UNFCCC), these innovations are critical for improving efficiency and sustainability in the country's energy sector and will not only help meet Morocco's climate goals but will also contribute towards global endeavors against climate change.

B. Energy Profile

The energy profile of Morocco reflects a deliberate shift towards renewables and diversification, away from fossil fuels to foster environmental friendliness, while ensuring that all sectors remain adequately supplied with power, as depicted in Table 2. This commitment can be seen through its revised NDCs, where it pledges to significantly cut GHG emissions by 2030; independently by 18.3%, and with international support by up to 45.5% compared with a business-as-usual (BAU) scenario.³³⁴ Another important approach includes increased investments in different types of renewable sources. Morocco is aiming for more than three quarters of its energy to come from clean energy sources by 2030.

Moreover, the country's long-term plan aims for an 80% renewable energy contribution to electricity generation by mid-century.³³⁵ In light of these targets, major projects such as those involving solar panels, wind farms and hydroelectric dams have been established so as to enhance energy security while at the same time reducing carbon emissions within the country.³³⁶ The energy sector in Morocco also places great emphasis on improving efficiency across regions and sectors.³³⁷ Thus, the government has implemented various policies aimed at promoting savings through reduced energy consumption mainly within industries, residential areas, and commercial buildings.³³⁸ All these initiatives are part of Morocco's wider sustainable development strategy, in alignment with global climate action goals.³³⁹

Additionally, smart grid technology has witnessed significant growth within Morocco's electricity industry over recent years, due its ability to optimize the intermittent performance associated with renewable sources

334. *Morocco Targets*, *supra* note 331.

335. *See id.*

336. Hamza El Hafaoui, Ahmed Khallaayoun, & Salah Al-Majeed, *Renewable Energies in Morocco: A Comprehensive Review and Analysis of Current Status, Policy Framework, and Prospective Potential*, 26 ENERGY CONVERSION & MGMT.: X 100967, Apr. 2025, at 12.

337. *See id.* at 19.

338. *See id.*

339. *See id.* at 23.

such as solar or wind power generation.³⁴⁰ This advantage allows it to match demand supply more effectively, thereby stabilizing overall system reliability.³⁴¹

Table 2: Energy Targets in Morocco³⁴²

Category	Details	Sources
GHG Reduction Target (2030)	Unconditional: 18.3% below BAU Conditional: 45.5% below BAU	Climate Action taken
Renewable Energy Target (2050)	80% of electricity mix from renewable sources	UNFCC
Key Renewable Energy Projects	Solar, wind, and hydroelectric power facilities	News
Energy Efficiency and Integration	Policies to reduce consumption across sectors	News
Smart Grid Development	Implementation to manage renewable energy sources	News

1. Energy Consumption Patterns

In Morocco, energy consumption is influenced by factors such as economic activity and the country's unique climatic zones and geography. The residential sector ranks second after the industrial sector in terms of power consumption within Morocco, while commercial establishments follow closely behind, showing there exists some level of parity between these two categories. The country's efforts to diversify its energy mix have seen massive investments in solar panels and wind turbine farms, due to their reliability when compared with fossil fuels such as coal or oil. The latter's frequently fluctuating prices affect supply continuity.³⁴³

Variations experienced throughout the year play a key role in shaping demand levels for various forms of electricity used domestically. For example, most people tend to use air conditioning during hot summer months while heating appliances are widely adopted in the winter, especially in colder regions.³⁴⁴ Urbanization has led to higher per capita consumption rates being recorded in urban centers as compared with rural

340. *Id.* at 31.

341. Haskouri, *supra* note 333.

342. R. Leal-Arcas, Vishakha Joshi, & Dyuti Pandya, Energy Targets in Morocco (on file with author).

343. *Morocco energy report*, ENERDATA (Feb. 2024), www.enerdata.net/estore/country-profiles/morocco.html [<https://perma.cc/4AZU-5ZEM>].

344. Leila Benali, *How Morocco stays the course on a just energy transition towards sustainable development*, WORLD ECON. F. (June 26, 2023), <https://www.weforum.org/stories/2023/06/morocco-energy-transition-lng-renewables/> [<https://perma.cc/RN9R-33MS>].

areas, because those living in urban centers tend to have higher living standards and more access to power-consuming goods and services such as refrigerators, televisions, and computers.³⁴⁵ Additionally, across the board, efforts have been put in place to save both money and resources as far as possible. This involves promoting the use of energy-efficient machines, building insulating materials, and encouraging behavioral change such as turning off unused lights, reducing unnecessary trips, or adopting minimal wastage practices.³⁴⁶

2. Energy Efficiency and Conservation

Morocco's energy policy is based on energy efficiency as well as conservation, which are seen as key drivers towards meeting the country's ambitious renewable energy targets while at the same time reducing overall energy usage.³⁴⁷ The government has put various programs and policies in place that are aimed at enhancing energy efficiency in all sectors including industry, residential and commercial.³⁴⁸ Much work has been done to upgrade infrastructure so as to promote the use of energy efficient appliances and also enhance building codes with the goal of curbing wastage.³⁴⁹ For instance, the government has introduced labelling programs for popular electrical gadgets, to encourage people to switch to power saving products.³⁵⁰ The government is also running public awareness campaigns and offering incentives for households and businesses to reduce energy consumption. To improve energy efficiency, Morocco is also exploring advanced technologies such as smart grids plus metering systems. These enable better management of the supply and demand sides of electricity, cutting down losses within transmission lines or distribution networks besides providing subscribers with detailed information about their electricity consumption, thus promoting overall savings.³⁵¹

345. *See Energy Profile: Morocco*, INT'L RENEWABLE ENERGY AGENCY 1, 1 (July 31, 2024), https://www.irena.org/-/media/Files/IRENA/Agency/Statistics/Statistical_Profiles/Africa/Morocco_Africa_RE_SP.pdf [<https://perma.cc/Y5UA-7WDX>].

346. *Id.*

347. *Morocco energy report*, *supra* note 343.

348. Fatima Zohra Gargab et al., *Regional Development Assessment and Policy Perspectives on Urban Residential Energy Efficiency Program in Morocco by 2030*, 9 URB. SCI. 149, 153 (2025), <https://doi.org/10.3390/urbansci9050149> [<https://perma.cc/Q87C-CGSF>].

349. *See id.* at 151.

350. *Climate Resilience for Energy Transition in Morocco*, INT'L ENERGY AGENCY (July 2023), www.iea.org/reports/climate-resilience-for-energy-transition-in-morocco [<https://perma.cc/K4PC-JU24>].

351. CLIFFORD CHANCE, *Renewable Energy Sector Reform in Morocco – How Will it Impact the Market?* (Apr. 2023), <https://www.cliffordchance.com/content/dam/cliffordchance/briefings/2023/04/renewable-energy-sector-reform-in-morocco.pdf> [<https://perma.cc/WM5J-DX99>].

3. Role of Natural Gas in Energy Transition

The United Nations Sustainable Development Goals (SDGs) are a set of seventeen goals that the international community developed for a more sustainable and prosperous world. SDG 7 focuses on affordable and clean energy. In the context of Morocco, solar and wind energy have been receiving much attention due to their being clean forms of energy. However, natural gas is also considered important, as it can help achieve SDG 7, according to a World Bank report.³⁵² It is cleaner compared to coal, with fewer carbon emissions during combustion. Hence, it can play a stabilizing role within national electricity grid systems, where intermittent renewables comprise the largest share.³⁵³

LNG terminals are expected to be constructed within Moroccan territory as part of the country's diversification strategy to reduce petroleum dependency and broaden its energy mix. In the absence of sunshine- or wind-based energy, gas-fired power plants can quickly respond by ramping up their output, acting as backup generation facilities and ensuring continuity of supply during peak periods.³⁵⁴ Apart from considerations about cleaner fuels and power generation, Morocco's interest in natural gas extends towards its economic potential. Natural gas can support industrial growth in Morocco, while becoming a catalyst for new market segments, e.g., for heating and for vehicles using this type of fuel.³⁵⁵

4. Climate Resilience in Energy Infrastructure

a. Overview

Climate resilience is an increasing concern in Morocco as it undergoes a rapid transition towards clean energy, while also taking adaptation measures to prepare for the impacts of global warming. The country is therefore developing energy systems that can withstand variations attributed to climate change such as extreme temperatures, water scarcity and flooding.³⁵⁶ Projects being implemented to develop climate resilient infrastructure include strengthening grids against extreme weather conditions such as storms or hurricanes, integrating advanced weather

352. *New Report Tracks Oil and Gas Industry Efforts on the SDGs*, WORLD BANK GROUP (Aug. 23, 2017), <https://www.worldbank.org/en/news/feature/2017/08/23/new-report-tracks-oil-and-gas-industry-efforts-on-the-sdgs> [https://perma.cc/5NZD-3SZJ].

353. Benali, *supra* note 344.

354. U.S. DEP'T OF COMMERCE, *Int'l Trade Admin. Morocco – Country Commercial Guide: Market Overview* (Jan. 1, 2024), www.trade.gov/country-commercial-guides/morocco-market-overview [https://perma.cc/456C-Z257] [hereinafter *Morocco – Country Commercial Guide: Market Overview*].

355. *Morocco energy report*, *supra* note 343.

356. *Climate Resilience for Energy Transition in Morocco*, *supra* note 350.

monitoring tools into management systems used by utilities so that they can anticipate likely disruptions caused by severe weather patterns, and designing renewable generation facilities taking into account expected climatic changes and their impacts.³⁵⁷ In addition to national targets set under the Paris Agreement, Morocco has also made other international commitments geared at promoting sustainable development through resilience-building within its power sector, especially in relation to environmental protection.³⁵⁸ Such initiatives not only help safeguard energy supply but will also help achieve global objectives on poverty eradication, improving health, and helping to reduce greenhouse gas emissions.

b. The Role of the European Investment Bank

Morocco has developed a significant partnership with the European Investment Bank (EIB) over the years. This relationship has been instrumental in supporting Morocco's economic development, fostering sustainable growth, and enhancing cooperation in various sectors. The collaboration between Morocco and the EIB has played a crucial role in financing projects that contribute to the country's infrastructure, energy, transportation, and private-sector development.

The EIB, as the financing institution of the European Union, provides financial assistance to promote sustainable development and economic growth in partner countries like Morocco.³⁵⁹ The Bank offers loans, grants, and technical assistance to support projects that align with its priorities and objectives.³⁶⁰ In Morocco, the EIB has been involved in funding a wide range of initiatives aimed at boosting the country's infrastructure, improving the business environment, and enhancing the quality of life for its citizens.³⁶¹

In the energy sector, the EIB has played a vital role in supporting Morocco's transition to a more sustainable and environmentally friendly energy system. The Bank has provided financing for renewable energy projects in Morocco, such as solar and wind farms.³⁶² These projects contribute to reducing the country's reliance on fossil fuels, promoting clean energy sources, and mitigating the impacts of climate change.³⁶³ The EIB's investments in renewable energy projects help Morocco

357. CLIFFORD CHANCE, *supra* note 351.

358. Benali, *supra* note 344.

359. *EIB Group at a Glance*, EURO. INV. BANK GROUP, <https://www.eib.org/en/about/at-a-glance/index> [<https://perma.cc/ENN6-TDLV>].

360. *See id.*

361. *See Morocco and the EIB*, EURO. INV. BANK GROUP, <https://www.eib.org/en/projects/country/morocco> [<https://perma.cc/7TKS-84LB>].

362. *The European Investment Bank in Morocco*, EURO. INVS. BANK, Mar. 2022, at 6, https://www.eib.org/files/publications/la_bei_au_maroc_en.pdf [<https://perma.cc/N8EF-5HFL>].

363. *See id.* at 21.

achieve its climate and energy goals, while also creating opportunities for economic growth and innovation in the sector.³⁶⁴

The partnership between Morocco, the EIB, and the EU represents a comprehensive and multi-faceted collaboration that spans economic, political, and social dimensions. Through their joint efforts, these entities contribute to sustainable development, economic growth, and social progress in Morocco. The financial support, technical expertise, and political backing provided by the EIB and the EU help Morocco implement projects that drive its economic development, improve infrastructure, create jobs, and promote sustainable growth.³⁶⁵

Looking ahead, the relationship between Morocco, the EIB, and the EU is expected to continue evolving as they collaborate on new initiatives and projects to address emerging challenges and opportunities. Sustainable development, climate change mitigation, renewable energy, digital transformation, and job creation are likely to remain key areas of focus for future cooperation between the parties. The relationship between Morocco, the EIB, and the EU is a vital partnership that benefits all parties involved. Through their cooperation and joint efforts, these entities contribute to the economic development, social progress, and sustainable growth of Morocco. The support and collaboration of the EIB and the EU play a crucial role in shaping the future trajectory of Morocco's development as the country strives to achieve its long-term goals and aspirations for a prosperous and inclusive society as well as a transition to clean energy.

C. Governance System

1. Relevant Institutions

In Morocco, various institutions are responsible for managing the energy sector, as depicted in Table 3. These organizations work together to oversee and regulate the sector to ensure its smooth operation. The Ministry of Energy, Mines and Sustainable Development (MEMDD) oversees all energy-related policies. It concentrates on areas such as electricity markets, public/private enterprises, and managing security of supply, among others. On the other hand, private power distribution companies are supervised by the Ministry of Interior, while state-owned energy enterprises including the National Agency for Electricity and Water (ONEE), the Moroccan Agency of Energy Efficiency (AMEE), and the Energy Engineering Company (SIE) fall under the control of the Ministry of Finance.

364. *See id.* at 3.

365. *See id.* at 6.

Table 3: Relevant Institutions and Their Role³⁶⁶

Institution	Role
Commission Interministérielle des Prix	Determines tariffs; involves several ministries, including MAGG.
Independent power producers	Private operators that produce electricity under PPAs with public entities like ONEE.
Ministry of Energy, Mines, and Sustainable Development (MEMDD)	Supervises energy sector policy, including the electricity market and energy security.
Ministry of Energy, Mining, Water and Environment (MEMWE)	See sector policy.
Ministry of Interior (MoI)	Oversees private electricity distribution and tariff subsidies.
Ministry of Economy and Finance	Provides financial supervision, including managing state-owned energy enterprises financially.
Ministry of Governance and General Affairs (MAGG)	Chairs the Interministerial Price Commission for tariff determination
National Agency for Electricity and Water (ONEE)	Public utility and system operator; manages generation transmission, and distribution of electricity.
Moroccan Agency for Energy Efficiency (AMEE)	Promotes energy efficiency programs.
Moroccan Agency for Sustainable Energy (MASEN)	Leads the development and management of renewable energy projects.
Municipal distribution companies (DistCos)	Operates regional electricity distribution under the supervision of the Ministry of Interior.
Renewable Energies IPP	Private renewable energy generation companies that engage in PPAs with public entities.

366. R. Leal-Arcas, Vishakha Joshi, & Dyuti Pandya, Relevant Institutions and Their Role (on file with author).

ONEE is tasked with being a national authority that undertakes most electricity generation activities, supervises transmission and distribution, and acts like a utility company. AMEE deals with promoting energy efficiency programs while MASEN heads projects concerning renewables. Local municipalities also share responsibilities when it comes to distributing electricity with private entities that operate under financial oversight from the Ministry of Finance.³⁶⁷

2. Political Decentralization and Energy Competences

This move aims to give regions the autonomy to design their own energy strategies based on specific needs and circumstances, such as initiatives for renewable energy development or energy efficiency programs, as well as investments in particular areas within the region's power systems. The idea behind this is to create flexible systems where decision-making takes into account local factors vis-à-vis the national policy framework on the one hand and also responds more quickly due to localized knowledge about best practice in terms of supply options in a given area.³⁶⁸

D. Electricity Market

1. Regulatory Framework

The electricity market in Morocco is governed by different laws, government strategies and institutions. All these processes were put in place to update and open up the sector so as to meet the growing need for power, decrease import reliance and utilize the country's vast renewable energy potential.³⁶⁹ Historically, Morocco has mainly relied on imported hydrocarbons, which account for around 90% of its total energy consumption,³⁷⁰ thereby leading to an energy insecurity situation. Morocco's reliance on imported hydrocarbons needs to be addressed

367. Jawad Moustakbal, *The Moroccan energy sector – A permanent dependence*, TRANSNAT'L INST. (Dec. 2, 2021), <https://www.tni.org/en/article/the-moroccan-energy-sector> [https://perma.cc/AWK6-GFLB].

368. *Id.*; see also Zainab Usman & Tayeb Amegroud, *Lessons from Power Sector Reforms the Case of Morocco*, 1, 1–60 (World Bank Group, Pol'y Rsch. Working Paper No. WPS8969, 2019), <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/471511565200281012/lessons-from-power-sector-reforms-the-case-of-morocco> [https://perma.cc/YY5F-CB4H].

369. Wacef Bentalbl et al., *Electricity regulation in Morocco: overview*, THOMSON REUTERS PRACTICAL L., Jan. 1, 2021, at 2–5, https://www.gide.com/sites/default/files/electricity_regulation_in_morocco_overview_w-019-30581.pdf [https://perma.cc/M57L-22ZS].

370. Manal Shehabi, *Just Energy Transitions? Lessons from Oman and Morocco*, CARNEGIE ENDOWMENT FOR INT'L PEACE (May 30, 2024), <https://carnegieendowment.org/research/2024/05/morocco-oman-energy-transition-oil-exporting-renewable?lang=en> [https://perma.cc/BB3E-5UZA].

through diversification by making greater use of the sustainable energy sources within its borders.

Over the years there has been a steady increase in primary energy demand, with an average annual growth rate standing at 5% since 2004. This growth in demand makes efficiency a priority.³⁷¹ Morocco's electricity production in 2022 came from coal (37.25%), hydroelectricity (16.70%), fuel oil (7.03%), natural gas (17.72%), and wind and solar (21.30%).³⁷² ONEE generates most electricity because it controls over half the country's installed capacity, including production plants and transmission networks. Independent Power Producers (IPPs) are mandated by law to sell their output exclusively ONEE.³⁷³

The Moroccan Government's energy policy emphasizes the need for renewable sources, hence their inclusion in the country's electricity generation mix stands at around 38%, equaling 4154MW until the end of 2022.³⁷⁴ The Moroccan Agency for Sustainable Energy supports this program and so do various laws, including Law No. 13-09 relating to renewable energy, Law No. 82-21 relating to self-production legislation, and Law No. 48-15 concerning the creation of the National Electricity Regulatory Authority of Morocco (ANRE), among others.³⁷⁵

As far as foreign investment and participation are concerned, the Moroccan energy sector has been opened up to global companies and investors, specifically in the case of renewables.³⁷⁶ The government has had to review some of its laws to attract private sector involvement in renewable energy projects.³⁷⁷ In doing so, the government has ensured that such changes create an environment that guarantees stability while, at the same time, it enhances clarity on the investment needed to successfully establish power generating facilities across the country.

The energy sector of Morocco comprises various sub-sectors, including electrical components and engineering, procurement, and construction (EPC) contracting, generators, solar water heaters, batteries, chargers, and grid applications, among others.³⁷⁸ In 2009, the Moroccan National Energy Strategy was adopted along with the Paris Agreement NDC target, with the aim of significantly increasing the percentage share of renewables in the country's electricity mix, to higher than 52% by

371. *Id.*; U.S. DEP'T OF COMMERCE, INT'L TRADE ADMIN., *Morocco – Country Commercial Guide: Energy* (Jan. 1, 2024), <https://www.trade.gov/country-commercial-guides/morocco-energy> [<https://perma.cc/2NQC-7U3Q>] [hereinafter *Morocco – Country Commercial Guide: Energy*].

372. *Morocco – Country Commercial Guide: Energy*, *supra* note 371.

373. *Id.*

374. *Id.*

375. *Id.*

376. *Id.*

377. *See id.*

378. *Morocco – Country Commercial Guide: Energy*, *supra* note 371.

2030.³⁷⁹ To achieve this, ONEE aims at having minimum installed capacity from renewable sources estimated to be around 10GW by 2030, with solar comprising half the share, wind about one quarter, and hydro power comprising the rest.³⁸⁰

Moreover, the country's energy efficiency strategy seeks to achieve at least 20% improvement by 2030, coupled with specific consumption reduction targets for different sectors.³⁸¹ For example, industry is expected to reduce consumption by 22% in this period, transport by 24%, construction by 14%, and public lighting by 13%.³⁸² Morocco is not intending to completely transition away from fossil fuels during its energy diversification efforts, because fossil fuels still account for more than 90% of the country's total energy demand. However, plans are underway on how to best utilize LNG.

Thus far, this option has not been explored much, apart from a recent call by the National Office of Hydrocarbons and Mines (ONHYM), requesting proposals concerning the development of an integrated floating storage regasification unit (FSRU) terminal off the Atlantic coast, to be followed by future public private partnerships (PPPs) and tenders.³⁸³ Overall, Morocco is making positive moves in its electricity market sector and has created strong regulation that will enhance economic growth and support sustainability. The country's current international commitments on environment indicate that Morocco is working towards greening its power systems.³⁸⁴

The government of Morocco has embraced an agile and flexible approach towards regulating the electricity market to ensure sustainable supply of power resources for the country. The laws are designed to be dynamic so that they can adapt to changing situations, thus promoting sustainable development within the sector. These legislative reforms, combined with institutional frameworks and strategic government policies, demonstrate a proactive approach in Morocco towards managing its energy resources and planning for future needs, with the goal of achieving self-sufficiency while being environmentally friendly.³⁸⁵

Achieving consumer self-sufficiency in the power sector can be envisioned in two ways at this time:

379. *Id.*

380. *Id.*

381. *Id.*

382. *Morocco – Country Commercial Guide: Energy*, *supra* note 371.

383. *See id.*

384. *Id.*

385. *Id.*

Type 1: Supply with Self-Consumption

This is a combination of both on-grid and off-grid systems, where individuals can generate their electricity from renewable sources primarily for their own use, but they remain connected to a national power supply. The system also allows consumers to sell back any excess energy they produce to the grid. It represents an attempt towards self-sufficiency in terms of power, while still being connected to a network. This approach has been made possible by recent changes in Moroccan law which have simplified procedures relating to energy production and distribution, thus making it easier for people to adopt this model.³⁸⁶

Type 2: Generation with Self-Consumption

The second variety lays emphasis upon generating electrical power meant only for self-consumption, with an added bonus of producing additional watts that are beyond one's need, especially among big manufacturers operating within industries. Any surplus units generated can be sold off to other users usually at very high voltages but not necessarily so. Sometimes, even medium voltage may suffice depending on certain conditions. These types open up more opportunities for decentralized generation facilities, leading us closer towards achieving full coverage under the national grid system as well as reducing over-reliance on traditional sources.

Marsh illustrates how such models could be facilitated through new regulations that enable independent power producers to enter the market easily, aligning them with Morocco's strategic objectives concerning energy mix diversification and sustainable development.³⁸⁷ All these forms of self-consumption represent stages in Morocco's energy transition process, which seeks greater deployment of renewable resources within its power supply mix while lowering the carbon footprint associated with fossil fuels. The two provide a framework for balancing personal independence in relation to public utility reliability, thus giving the chance to any individual or organization to actively contribute to a clean green future. The success of such initiatives will largely depend upon continuous adjustments made within legal frameworks aimed at stimulating investments into renewables and ensuring the protection of consumer rights.³⁸⁸

386. *Morocco: A New Legal Framework for Independent Power Producers*, WHITE & CASE LLP (Apr. 19, 2023), www.whitecase.com/insight-alert/morocco-new-legal-framework-independent-power-producers [https://perma.cc/UBK3-EP7H].

387. *Id.*; see also Jacob Marsh, *Self-Consumption: What You Need to Know*, ENERGY SAGE (Feb. 27, 2024), www.energysage.com/energy-storage/self-consumption/ [https://perma.cc/4GJD-GYDV].

388. Marsh, *supra* note 387.

2. Energy Pricing and the Shift Towards Deregulation

Morocco's successive moves towards energy deregulation is driven by a two-fold goal: attracting more capital investment to the power generation industry, while reducing the burden placed upon the state through subsidies granted to consumers at higher levels than their incomes can sustain over time.³⁸⁹ This process involves the gradual freeing up of prices charged per unit of electricity produced, mainly targeting industrial users who should pay for real costs incurred during production.³⁹⁰ Such an approach will ensure an efficient system that guarantees fair sharing among all players involved, including producers themselves.

However, socio-economic factors complicate matters when it comes to determining appropriate rates applicable across different sectors within the national economy such as the residential sector, which consumes significant volumes of energy compared with other areas such as commercial establishments or public institutions.³⁹¹ For instance, certain forms, such as electricity or liquefied petroleum gas, are considered basic necessities. Their costs, therefore, must be heavily subsidized to ensure lower income earners can afford them. Moreover, opening up the power sector for more players has also brought about an influx of private investments, mainly focusing on renewable energy sources. IPPs are now allowed to generate and sell electricity on mutually agreed terms, unlike before when ONEE used to control price setting as well as the distribution process.³⁹²

3. Social and Ethical Dimension

Within the wider context of the Moroccan energy sector, social equity has played a prominent role in the context of the country's commitment to mitigating climate change by reducing GHG emissions and promoting its renewable energy capacity.³⁹³ The adoption of these policies and strategies brings about questions related to fairness when it comes to access to clean and affordable power for all. From a social perspective, a green transformation in Morocco's energy industry is expected to create new economic opportunities with the potential for job creation within the clean energy sector.³⁹⁴ However, this transition also raises concerns around how to best manage the transition so that there are no losers

389. CLIFFORD CHANCE, *supra* note 351.

390. *Id.*

391. *Climate Resilience for Energy Transition in Morocco*, *supra* note 350.

392. *Morocco – Country Commercial Guide: Market Overview*, *supra* note 354; *Morocco – Country Commercial Guide: Energy*, *supra* note 371.

393. *Morocco Targets*, *supra* note 331.

394. Haskouri, *supra* note 333.

among those working traditional energy sector jobs. This could be achieved by putting programs in place aimed at re-skilling affected employees and providing them adequate social protection during any jobless periods. From an ethical standpoint, it is important to ensure that benefits or burdens associated with a shift towards wind energy are shared fairly across different societal groups, thus ensuring the equal participation of disadvantaged rural areas.

Furthermore, the UNFCCC asserts that as governments strive to build greener economies through promoting solar energy, they need to address some ethical matters relating to the land utilization rights of local communities.³⁹⁵ According to Marsh, large-scale photovoltaic or wind installations require massive tracts of land, and hence interfere with the lives and livelihoods of people living nearby.³⁹⁶ People in these situations may, therefore, be adversely affected by such projects, unless appropriate measures are taken to protect them and their rights. The demand for self-consumption models in renewable energy reflects the need to share power fairly, so that everyone can be a producer as well as a consumer of electricity—individuals and communities alike. This could give people more control over their own lives and democratize access to energy, but it will only happen if legal systems are put in place which make fair use of technology obligatory and stop new kinds of energy poverty from occurring. Morocco is demonstrating a commitment to sustainable development within the context of an energy transition guided by regulatory reforms and targets. However, this presents complex social and ethical challenges for the country as it seeks a sustainable and inclusive energy future.

E. *Market Characteristics and Idiosyncrasies of Morocco*

1. Geographical Connections

Geographical location is a key factor affecting Morocco's energy sector and market structure. Being strategically positioned at the crossroad between Europe and Africa and serving as an entrance point into the Atlantic Ocean through the Mediterranean Sea creates unique geographical links which are important for development of its energy market.³⁹⁷ Political stability combined with its geographical advantages

395. See *Thematic Areas: Land Use*, UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, <https://unfccc.int/resource/climateaction2020/tep/thematic-areas/land-use/index.html> [https://perma.cc/YA88-EAQQ].

396. See Jacob Marsh, *Solar power plants and utility-scale solar: An overview*, ENERGY SAGE (Feb. 3, 2021), <https://www.energysage.com/community-solar/utility-scale-solar-panel-installations/> [https://perma.cc/PBS5-67FZ].

397. *Renpower North Africa Storage*, OXFORD BUS. GRP. (July 13, 2023), oxfordbusinessgroup.com/event/renpower-north-africa-storage/ [https://perma.cc/U7FW-8JW2].

make it an attractive destination for foreign direct investments in the energy industry.

For Morocco, proximity to European markets enables exportation of power, mainly generated from renewable resources, especially wind and solar energies.³⁹⁸ In addition to existing interconnections with Spain, plans are underway to create interconnections with Portugal too, which would enhance surplus renewable exports and contribute to regional power security.³⁹⁹ In geographical terms, Morocco has great potential for solar power generation that can be distributed all over the country, but concentrated mostly in southern areas such as Ouarzazate, while northern/southern coastal regions offer the best conditions for harnessing wind energy.⁴⁰⁰

Different locations within Morocco have different resources when it comes to renewable energy distribution, based on where they are located geographically.⁴⁰¹ For instance, large-scale solar parks situated in sunny regions, such as those around Ouarzazate in the south of Morocco, contribute significantly towards meeting overall demand.⁴⁰² Conversely, some of the biggest wind farms across Africa can be found along Morocco's windy coastlines, which helps to realize the country's aim of increasing the share of wind energy in its energy mix by 2030.⁴⁰³

Morocco's internal geography also influences how energy is retailed and distributed throughout the country, especially in terms of market areas served by different vendors. The fact that many factories are concentrated near major cities means there will always be high consumption points where more reliable transmission networks should be installed. Furthermore, the country's uneven landscape, coupled with dispersed rural settlements, makes it difficult for people living outside towns or villages to access electric power, thus necessitating the establishment of mini-grids powered through renewable resources so that all citizens have equal rights to energy services.⁴⁰⁴ These connections go beyond physical interconnection; they include socio-economic linkages between development of electricity infrastructure and community welfare. Large-scale investments made by the Moroccan government into

398. *Climate Resilience for Energy Transition in Morocco*, *supra* note 350.

399. *Id.*

400. IRENA Case Study 2013: Morocco Wind Atlas, Int'l Renewable Energy Agency (2013), https://rcreee.org/wp-content/uploads/2013/11/irena_case_morocco.pdf [<https://perma.cc/J5TE-XTFB>]; see also *North Africa's Renewable Potential and Strategic Location Reinforce Its Role in Energy Transition*, INT'L RENEWABLE ENERGY AGENCY (Feb. 26, 2024), <https://www.irena.org/News/articles/2024/Feb/North-Africa-Renewable-Potential-and-Strategic-Location-Reinforce-Its-Role-in-Energy-Transition> [<https://perma.cc/8ECB-NCAL>].

401. CLIFFORD CHANCE, *supra* note 351.

402. *Id.*

403. *Climate Resilience for Energy Transition in Morocco*, *supra* note 350.

404. *Morocco energy report*, *supra* note 343.

clean green technologies have wider social economic benefits, including job creation and technology transfer among others, which trickle down even at the grassroots level within society.⁴⁰⁵

2. The Different Market Roles

A range of players operate in the Moroccan energy market, which are essential in shaping the structure and overall landscape of the sector. The government is the key player that sets policy through institutions such as the MEMEE. MEMEE oversees all policies on energy, including electricity production. Thus, Morocco has a centralized approach to energy governance.⁴⁰⁶

Another major player is MASEN, which implements renewable energy strategies in the country. MASEN shoulders most responsibilities concerning renewable projects in Morocco, for which it manages the financing, planning and development of solar, wind and hydroelectric power facilities among others—an indication of Morocco's strategic shift towards green energy sources and its commitment to increasing them up to 52% by 2030.⁴⁰⁷ ONEE remains the backbone of the electricity market in Morocco, handling the majority of power capacity plus the transmission network.

Independent producers play an increasingly large role, especially after the rules were changed to allow them to sell excess power they generate into the grid, thus further diversifying the energy mix while at the same time making supply chain more resilient.⁴⁰⁸ According to Clifford Chance, government reforms aimed at opening up markets so that the private sector can participate more actively have stimulated growth, particularly within renewable sectors such as wind, hydropower and solar which previously had been monopolized by state owned enterprises (SOEs).⁴⁰⁹ Wind energy alone has seen huge investments flowing into the country, resulting in Morocco's emerging position as a leader in Africa in terms of installed capacity.⁴¹⁰

Though not very prominent when compared with solar and wind energy, hydropower does play a vital role. Enerdata states that Pumped

405. Benali, *supra* note 344.

406. *Morocco – Country Commercial Guide: Market Overview*, *supra* note 354.

407. *See Morocco and Irena Partner to Boost Renewables and Green Hydrogen Development*, INT'L RENEWABLE ENERGY AGENCY (June 10, 2021), <https://www.irena.org/News/pressreleases/2021/Jun/Morocco-and-IRENA-Partner-to-Boost-Renewables-and-Green-Hydrogen-Development> [<https://perma.cc/C6MN-BU9E>]; *see also* Omar Sinaceur, *Morocco: A new legal framework for Independent Power Producers*, WHITE & CASE (Apr. 19, 2023), www.whitecase.com/insight-alert/morocco-new-legal-framework-independent-power-producers [<https://perma.cc/GX6M-4U8H>].

408. CLIFFORD CHANCE, *supra* note 351.

409. *Id.*

410. *See id.*

Storage Transfer Stations are among a few projects capable of generating and storing large amounts of electricity simultaneously, thus making them an important part of Morocco's energy mix strategy.⁴¹¹ Solar power constitutes a milestone achievement towards Morocco meeting the targets set under the national renewable plan, thanks to high levels of sunlight experienced across much of the country.⁴¹² The International Renewable Energy Agency (IRENA) notes the Noor Ouarzazate complex as a landmark example of a large-scale park built using concentrated solar thermal technology that can store heat for use when needed even during nighttime hours.⁴¹³

The penetration of electric vehicles, demand response services, and smart home systems in the Moroccan market are still relatively low compared to developed markets,⁴¹⁴ but there has been growing interest coupled with gradual adoption supported by government policies that seek to modernize energy infrastructure within the country. Morocco's Minister of Energy Transition and Sustainable Development, Leila Benali, acknowledges this will also lead to improved efficiency.⁴¹⁵ All of these actors and projects contribute towards making the Moroccan energy market unique, by making strategic use of the country's geographical advantages alongside political goodwill aimed at realizing sustainable self-reliance in power supply. These initiatives are aligned with Morocco's domestic objectives for clean energy development as well as international obligations concerning climate change mitigation.⁴¹⁶

3. Structure

Morocco's energy market is structured in a way so as to smoothly switch to renewable power, while ensuring the country's energy security as well as economic growth. This configuration lies at the heart of the national strategy for energy that seeks diversification of sources and reduction in dependence on imported hydrocarbons. MEMD forms part of this framework as it oversees policymaking related to anything concerning electricity generation and strategic direction setting for this

411. *Morocco energy report*, *supra* note 343.

412. *See id.*

413. *See IRENA Director-General, Adnan Z. Amin Visits World's Largest CSP Site in Morocco*, INT'L RENEWABLE ENERGY AGENCY (Aug. 6, 2018), <https://www.irena.org/news/articles/2018/aug/irena-director-general-visits-worlds-largest-csp-site-in-morocco> [<https://perma.cc/2HZ7-SXBE>]; *Energy Profile: Morocco*, *supra* note 345.

414. *See Sam Metz, Morocco's Automotive Industry Shifts Gears to Prep for Electric Vehicle Era*, AP NEWS (May 15, 2024, 11:06 AM), <https://apnews.com/article/morocco-automobile-industry-electric-vehicles-2981a049578c411b95b525752d243f93> [<https://perma.cc/7K5T-P9E4>].

415. Benali, *supra* note 344.

416. *Morocco – Country Commercial Guide: Market Overview*, *supra* note 354.

sector.⁴¹⁷ It is responsible for formulating laws regulating sustainable development projects within its jurisdiction and it controls all activities associated with fossil fuels exploration or exploitation, including licensing them out to private companies under certain conditions.⁴¹⁸

ONEE represents another important actor within Morocco's energy architecture. As the main utility company managing the production, transmission, distribution, and sale of power throughout the Kingdom, ONEE plays a crucial role towards achieving stability, reliability, and affordability of electric service delivery across different regions in Morocco.⁴¹⁹ Clifford Chance states that almost all grid systems are owned, operated, managed, maintained, or controlled directly by either one or more subsidiaries of wholly-owned entities associated with this state-owned enterprise.⁴²⁰ In recent times, MASEN has emerged as one major player involved in driving investments toward clean energies such as solar photovoltaic (PV) plants, wind farms, et cetera. White & Case reports that not only does MASEN spearhead these types of projects, but it also provides financial support and undertakes the necessary steps for their integration into the national grid.⁴²¹

Additionally, IPPs have become critical actors within the power industry's new look in Morocco, following liberalization reforms. IPPs are encouraged to inject capital into construction, operation, management, maintenance, or retirement of any renewable energy resource-based plant generation facility, so long as it meets certain criteria set out by law. Clifford Chance argues that legal changes have allowed them to connect large quantities of electricity directly onto national grids to sell excess supplies at competitive prices to utilities under special circumstances, thereby fostering innovation among suppliers while improving market competitiveness.⁴²² Moreover, Morocco's energy market structure is becoming more technologically advanced, with such systems as demand response services, smart homes, and electric vehicles being gradually introduced into the mix. Innovations such as these help modernize power sectors, improve efficiency, and reduce environmental impacts associated with traditional forms of energy production, distribution, and consumption. These advantages point to the need for flexible responsive markets capable of meeting current needs.⁴²³

417. *Morocco – Country Commercial Guide: Energy*, *supra* note 371.

418. *Id.*

419. CLIFFORD CHANCE, *supra* note 351.

420. *Id.*

421. *Energy Profile: Morocco*, *supra* note 345; *see also* Sinaceur, *supra* note 407.

422. CLIFFORD CHANCE, *supra* note 351.

423. Benali, *supra* note 344.

4. Transmissions

Electricity distribution within Morocco is done through the transmission system which distributes electricity from power plants to different networks of supply throughout the country, under the management of ONEE. Being a single TSO in Morocco, ONEE also has a monopoly over the high voltage transmission grid, because it is the best way to ensure coordination and stability of electric power supply all over the nation. The system addresses local requirements and supports possible exports beyond national borders.⁴²⁴

Morocco's location at the crossroads of Europe and Africa makes it a key player in international energy trade. The current interconnections with Spain and proposals for Portuguese connections form part of a wider scheme aimed at boosting energy commerce within the region.⁴²⁵ These links will enable Morocco to better balance its power needs with available capacities, thereby allowing it to participate in the European electricity market where, among other things, there might be sales of excess renewable energies produced from massive solar and wind potential.⁴²⁶

Morocco's transmission infrastructure is being expanded and improved to allow it to integrate more renewable sources. There are many challenges involved in integrating large-scale renewables into national grids, including managing intermittent behavior exhibited by solar and wind, coupled with grid stability requirements. To address these issues effectively, new energy types must be efficiently accommodated on stronger grids. Achieving this goal calls for efforts by ONEE as well as MASEN towards enhancing capacity and reliability levels in such facilities.⁴²⁷

5. Distribution

Private enterprises as well as municipal power organizations operating under the government's regulations are responsible for the distribution of electricity in Morocco, with ONEE playing a central role. This system allows for private companies or municipalities to be given distribution rights in certain areas, ensuring efficient and dependable energy supply at the local level.⁴²⁸ In large urban centers such as Casablanca, Rabat, and Marrakech, among others, electrical distribution is typically managed by privately owned firms through concessions.⁴²⁹ Regulations outline the

424. CLIFFORD CHANCE, *supra* note 351.

425. *Climate Resilience for Energy Transition in Morocco*, *supra* note 350.

426. *Id.*

427. *Energy Profile: Morocco*, *supra* note 345; *Morocco energy report*, *supra* note 343.

428. CLIFFORD CHANCE, *supra* note 351.

429. Wacef Bentaibi, Benoit Pape, Gide Loyrette Nouel, *Electricity Regulation in Morocco: Overview*, THOMSON REUTERS (Jan. 1, 2021), https://www.gide.com/sites/default/files/electricity_regulation_in_morocco_overview_w-019-30581.pdf [<https://perma.cc/F67K-ZN4A>].

terms and conditions under which electricity will be distributed, setting minimum requirements that service providers must meet in their operations.⁴³⁰ On a more direct level, ONEE conducts distribution, especially in rural places. The arrangement reflects the government's efforts to ensure universal access to power throughout the country.⁴³¹

The Moroccan distribution network has been continually upgraded so that it can support greater integration of distributed energy resources such as solar panels for home or commercial use and enable demand response programs and smart grid implementation. Such modifications involve advanced metering infrastructure installation, which enhances demand management, thus making electricity delivery more efficient.⁴³² Moreover, self-consumption models have increasingly been adopted due to growing microgrid systems resulting from devolved incentives-based energy policy-making by the state. These efforts form part of wider plans aimed at boosting local-level energy independence while providing environmentally friendly and power stabilizing alternatives that target far flung off-grid locations.⁴³³

Morocco faces several challenges during this phase of expanding and modernizing its infrastructural base for supplying electricity. These include, but are not limited to, large investments required in grid technologies and proper regulation management necessary to ensure equitable access into competitive markets. Ongoing reforms combined with sustained investments within the energy sectors will help create a vibrant, dynamic and responsive electric market in Morocco that is capable of meeting different customer expectations.⁴³⁴

6. Retail

The retail electricity market in the state is regulated mainly by ONEE, which controls distribution and sales of power to domestic, commercial and industrial consumers. As Morocco opens up its energy market for more private sector involvement and competition, especially in renewable energies such as wind and solar power, this sector is undergoing significant transformation.⁴³⁵ Recent reforms include allowing IPPs to supply electricity directly to clients subject to certain conditions, aimed at promoting generation from clean sources. This is starting to create variety in retailing, although ONEE still dominates as the main retailer.⁴³⁶

430. *Id.*

431. *Morocco energy report*, *supra* note 343.

432. Benali, *supra* note 344.

433. Sinaceur, *supra* note 407.

434. *Morocco – Country Commercial Guide: Market Overview*, *supra* note 354.

435. CLIFFORD CHANCE, *supra* note 351.

436. *Climate Resilience for Energy Transition in Morocco*, *supra* note 350.

The new rules are meant to create an environment where all players can compete fairly, leading to lower tariffs through increased efficiency and better service delivery within the retail sector. To this end, smart meters along with advanced metering infrastructure have been introduced, which are changing how customers interact with electrical suppliers. These technologies enable moment-by-moment monitoring of power consumption, while also facilitating time-of-use pricing. Such systems help users manage their energy consumption more efficiently during peak hours when demand is high or during off-peak hours when demand is low.⁴³⁷ These changes mark a key shift towards customer-centricity in retail markets, where saving becomes a priority.

Another driver behind the changes taking place in Morocco's retail space has been its push for greater use of renewables such as wind turbines or PV panels. Renewables are key to achieving sustainable development goals on energy security across different regions worldwide, including Africa. Renewables can thus help foster green economies globally besides serving national interests in line with international conventions on climate change mitigation strategies.⁴³⁸

F. Generation

1. Overview

In Morocco, fossil fuels have traditionally served as the main source of energy for electricity generation. This approach is, however, being challenged by an increasing need to bring different energy sources to the mix, resulting in massive investments in renewable power. Historically, ONEE has been responsible for generating most of the country's electricity, but this is changing with IPPs entering into agreements with ONEE and with MASEN expanding its portfolio through other projects such as wind farms.⁴³⁹ Renewable energies have gained significant ground within Morocco's electricity generation sector, mainly solar energy, wind power and hydroelectricity.

For example, the Noor Ouarzazate Solar Complex is among the world's biggest solar stations and represents a big move towards achieving a more than 52% share for renewables in Morocco's total power mix by 2030.⁴⁴⁰ Similarly, siting windfarms along the windy Atlantic coast demonstrates a further shift towards maximizing the

437. *Morocco energy report*, *supra* note 343.

438. Benali, *supra* note 344.

439. CLIFFORD CHANCE, *supra* note 351; *see also Energy Profile: Morocco*, *supra* note 345.

440. REUTERS, *Breakdown at Saudi Solar Plant in Morocco Costs Firm \$47 Million* (Mar. 24, 2024, 9:26 AM), <https://www.reuters.com/business/energy/breakdown-saudi-solar-plant-morocco-costs-firm-47-million-2024-03-24/> [<https://perma.cc/AM5G-Z39B>].

potential of clean energy sources.⁴⁴¹ This switch towards green energy did not only come about due to Morocco's favorable geographic position, but also because of its policy frameworks and commitment towards carbon emission reductions. The legislative reforms that have made it easier for IPPs to enter the market were also aimed at integrating more renewable energy into the national grid, thereby allowing IPPs to supply the system with electricity whilst still engaging in innovation across their sectors.⁴⁴² Furthermore, clean electricity generation forms part of wider plans for Morocco to enhance its energy safety margin while lowering reliance on imported fossil fuels. Through upgrading interconnections between different parts of its national network, the country can balance out supplies against demands, thus optimizing utilization levels for various resources within these areas.⁴⁴³

2. Renewable Energy Sources

a. Wind

Morocco has made major steps in using wind power to produce energy and is now considered Africa's top producer of wind-generated electricity. The country's geographical location makes it one of the most suitable places for setting up wind farms due to its high-speed winds which are found along the Atlantic coast, as well as in its northern and southern regions.⁴⁴⁴ This potential has been tapped into under Morocco's national energy policy that seeks to increase renewable sources' contribution to its overall energy mix.⁴⁴⁵ The biggest wind farm in Africa by capacity was located at Tarfaya, where it stood until recently when another facility surpassed it.⁴⁴⁶ However, this project alone significantly contributes power to national grid systems across Morocco.⁴⁴⁷

In addition, Tangier's and Midelt's windfarms are also worth mentioning since they account for half a gigawatt each.⁴⁴⁸ Local efforts have been boosted through international partnerships that have attracted private investments and foreign capital towards building the necessary infrastructure to efficiently harness, store and transmit electricity produced from turbines on windy sites all over Morocco.⁴⁴⁹ Widening access points should improve reliability and will contribute to sustainable

441. *Climate Resilience for Energy Transition in Morocco*, *supra* note 350.

442. CLIFFORD CHANCE, *supra* note 351.

443. *Morocco energy report*, *supra* note 343.

444. *Energy Profile: Morocco*, *supra* note 345.

445. *Id.*

446. *Id.*

447. *Id.*

448. *Morocco energy report*, *supra* note 343.

449. CLIFFORD CHANCE, *supra* note 351.

development by creating jobs in target areas and increasing energy availability and affordability. These benefits will help create energy security across different parts of Morocco, according to an IEA report.⁴⁵⁰

b. Hydroelectricity

Hydroelectricity accounts for only a small fraction of total renewable output in Morocco relative to solar PV panels or, even more so, wind farms.⁴⁵¹ Mountains combined with river systems provide ideal conditions required for tapping into hydro-power's potential, which mainly involves constructing dams across the country along with utilization pumped storage technologies.⁴⁵² The latter not only generates electricity but also acts as an energy storage device where surplus power produced during periods when demand is low can be saved for use at high-demand times.⁴⁵³ The system helps to balance grid supply during intermittent periods caused by variations in solar radiation levels and wind speeds.⁴⁵⁴

Abdelmoumen Pumped Storage Hydroelectric Plant represents one key project within this domain as it forms part of wider plans aimed at improving stability within national grids while increasing capacity associated with renewable sources of energy such as solar since these systems require reliable backup supply whenever they fail due to their intermittent nature. In addition, excess power generated at off-peak hours gets stored here until needed during peak time, thereby boosting efficiency across the entire electricity system.⁴⁵⁵ Hydroelectricity complements other forms of renewables such as solar or wind, thus providing a continuous stream of electricity capable of compensating for fluctuations exhibited by these alternative sources. Additional dams are expected to be constructed in different parts of Morocco to help achieve further diversification goals set forth by authorities concerned about pollution resulting from burning fossil fuels.⁴⁵⁶

450. INT'L ENERGY AGENCY, *Clean Energy Transitions in North Africa*, 1, 1–99 (Oct. 2020), https://iea.blob.core.windows.net/assets/b9c395df-97f1-4982-8839-79f0fdc8c1c3/Clean_Energy_Transitions_in_North_Africa.pdf [<https://perma.cc/5E6N-QZ88>].

451. See *Morocco energy report*, *supra* note 343.

452. See Shaima A. Alnaqbi et al., *Applicability of Hydropower Generation and Pumped Hydro Energy Storage in the Middle East and North Africa*, 15 ENERGIES 2412, 2435 (2022), <https://doi.org/10.3390/en15072412> [<https://perma.cc/AH5D-YW6L>].

453. See *Morocco energy report*, *supra* note 343.

454. Benali, *supra* note 344.

455. *Morocco energy report*, *supra* note 343.

456. CLIFFORD CHANCE, *supra* note 351.

c. Solar

Given that the Sahara region experiences particularly high levels of solar irradiance, PV technology plays a crucial role in Morocco's sustainable power generation strategy. The Noor Ouarzazate Concentrated Solar Power Complex ranks among the largest facilities of its kind worldwide, signifying the country's desire to become a global leader in terms of harnessing sun rays and converting them into electricity.⁴⁵⁷ The complex utilizes concentrated solar power (CSP), which not only produces but also stores energy during the daytime for night-time use, thus enabling continuous supply irrespective of weather conditions prevailing year-round.⁴⁵⁸ Other projects are underway, such as the Noor Midelt, that combines CSP and PV technologies for better efficiency and productivity.

The Moroccan government supports these initiatives through favorable policies and international funding, which, in turn, attract both domestic and foreign investments into the sector.⁴⁵⁹ Promotion of solar power generation is in line with Morocco's commitment towards lowering carbon emissions as well as reducing reliance on imported fuels for electricity production. In addition, another argument could be made that apart from creating job opportunities during construction phases, investing in renewable energy also helps create more jobs during operational stages when maintenance staff is required. These initiatives can thereby help promote socio-economic growth within communities adjacent to such facilities and can help reduce poverty levels among residents living in those areas. Moreover, the facilities may provide employment opportunities to individuals who may not have formal skills or education related to solar energy development, but come from other sectors such as manufacturing, in the case of producing the components used in building these plants.⁴⁶⁰

3. Self-Consumption

Self-consumption of electricity, which enables individuals or businesses to produce and consume their own electricity by setting up solar panels or other renewable generation methods in their home, property, or community, has become increasingly popular in Morocco, especially due to the greater availability of renewable energy technologies such as PV systems. The country's legislative changes support this trend by encouraging the generation and use of renewable

457. *Energy Profile: Morocco*, *supra* note 345.

458. *Id.*

459. *Climate Resilience for Energy Transition in Morocco*, *supra* note 350.

460. Benali, *supra* note 344.

power at residential, commercial, and industrial premises.⁴⁶¹ Individuals and businesses are incentivized under the legal framework, which amends Law 13-09.⁴⁶² They are expected to generate their own energy from solar or wind and consume it on site without transferring it through the grid.⁴⁶³ Any excess electricity can be fed into the national network.⁴⁶⁴

Ongoing regulatory changes and incentives aim to enhance self-consumption, according to the IRENA.⁴⁶⁵ This pattern is important for reducing reliance on the grid, increasing energy security, and lowering costs for consumers.⁴⁶⁶ It also contributes to global environmental goals by reducing carbon emissions and promoting sustainability.⁴⁶⁷ Self-consumption has gained significant traction in rural and remote areas with limited or no access to grids, as well as urban locations where power prices may be very high.⁴⁶⁸ Furthermore, smart grid adoption will enable wider implementation of self-consumption by the government.⁴⁶⁹ This will optimize efficient flow control during management of electricity that is necessary when dealing with distributed intermittent sources such as solar and wind into integrated systems known as grids.⁴⁷⁰

G. Market Penetration

1. Electric Vehicles

The market share of EVs in Morocco is still low but it is expected to increase significantly thanks to various government initiatives and growing awareness of the need for environmental protection. Promoting EVs is part of a wider environmental policy within the country's National Strategy for Sustainable Development (NSSD), which seeks to reduce greenhouse gas emissions.⁴⁷¹ Morocco has introduced several incentives aimed at encouraging people to use EVs such as tax rebates, purchase subsidies, and investments into charging infrastructure, among others. Electric vehicle charging stations have been set up in cities such as Casablanca and Rabat, which are vital for EV adoption.⁴⁷² Additionally, the Moroccan government is partnering with car manufacturers as well as renewable energy companies to boost local production of electric cars

461. CLIFFORD CHANCE, *supra* note 351.

462. *Id.*

463. *Id.*

464. *Id.*

465. *Energy Profile: Morocco*, *supra* note 345.

466. *Id.*

467. *Id.*

468. Benali, *supra* note 344.

469. *Morocco energy report*, *supra* note 343.

470. *Id.*

471. *Morocco – Country Commercial Guide: Market Overview*, *supra* note 354.

472. *Climate Resilience for Energy Transition in Morocco*, *supra* note 350.

and their components too.⁴⁷³ This forms part of a broader industrial initiative intended at positioning Morocco as an African hub for clean technologies within transportation and other sectors.⁴⁷⁴

2. Demand Response Services

Demand Response (DR) services within Morocco are currently underdeveloped but are considered a key tool for improving energy efficiency and grid reliability. DR programs work by modifying power demand instead of adjusting supply so as to stabilize grids. The system becomes particularly relevant when dealing with larger shares of renewables that may be intermittent in nature.⁴⁷⁵ The creation of more advanced DR schemes would be facilitated through smart grid deployment in Morocco, as smart grids require real-time information from smart meters plus other sensor devices which can enable quick response actions based on grid situation changes.⁴⁷⁶ Utilities will benefit from lower costs associated with reducing peak demand while consumers enjoy reduced bills resulting from less reliance on expensive carbon intensive peak power plants, besides the overall savings achieved through more efficient energy use fostered by DR initiatives. Furthermore, such programs contribute towards sustainable consumption patterns thereby aligning with various environmental and energy policies on efficiency.⁴⁷⁷

3. Smart Homes Systems

In Morocco, penetration of smart homes is still low and in its early stage but there are indications that this may change soon because more people are gaining access to the internet while a rising middle class seeks automation for their houses.⁴⁷⁸ “Smart home” systems enable users to remotely control their home’s lighting, temperature, entertainment devices such as radios and TVs, and appliances such as refrigerators or ovens from any part of the world where an internet connection is available.⁴⁷⁹ They have gained popularity with Moroccan upper and

473. Eva Fox, *Morocco Increases Impact on Global Electric Vehicle Market--\$10 Billion in EV Investments*, CLEANTECHNICA (Sept. 19, 2024), <https://cleantechnica.com/2024/09/20/morocco-increases-impact-on-global-electric-vehicle-market-10-billion-in-ev-investments/#:~:text=Investments%20in%20Morocco&text=In%20addition%2C%20Morocco%20has%20become,scheduled%20to%20begin%20in%202026> [https://perma.cc/8L4V-LR8G].

474. See Benali, *supra* note 344.

475. *Morocco energy report*, *supra* note 343.

476. *Energy Profile: Morocco*, *supra* note 345.

477. CLIFFORD CHANCE, *supra* note 351.

478. See *Smart Home – Morocco: Highlights*, STATISTA, <https://www.statista.com/outlook/cmo/smart-home/morocco?srltid=AfmBOopsRgYKUYFdIxDnwYzFGqJ3taUBnAuWYvIacBpBtRcKHawJ7sn> [https://perma.cc/Z7P8-XCJY].

479. *Smart Home – Morocco: Market Definition*, STATISTA, <https://www.statista.com/outlook/cmo/smart-home/morocco?srltid=AfmBOopsRgYKUYFdIxDnwYzFGqJ3taUBnAuW>

middle classes living within major towns such as Casablanca, Marrakech or Rabat due to growing awareness of energy and other benefits associated with their usage.⁴⁸⁰ Furthermore, a digitalization drive by the Moroccan government coupled with various smart city initiatives will act as catalysts towards increasing demand for domestic automation devices beyond what has already been achieved so far in this field.⁴⁸¹ These undertakings form part of wider plans aimed at promoting energy saving measures within homes, which is an integral component of Benali's National Energy Strategy for Morocco.

H. *Smart Metering Systems in Morocco*

Smart metering systems are being adopted in Morocco's electricity networks as part of its modernization efforts to achieve a more efficient and responsive energy management system.⁴⁸² These technologies are essential for the grid to effectively accommodate renewable energy sources and enable real-time energy management practices that improve grid stability and efficiency.⁴⁸³ With smart metering systems, it becomes possible to monitor power usage very closely, which is necessary for optimizing the balance between electricity supply and demand across different areas at different times.⁴⁸⁴

Currently, Morocco is testing various smart meters to evaluate their performance when integrated into the existing infrastructure for supplying power.⁴⁸⁵ Such trials are important because they help address any technical glitches that may arise while also giving an indication of how consumers will react towards them before full-scale implementation is done.⁴⁸⁶ In terms of regulatory changes, Moroccan authorities continuously revise their energy policy framework so as to facilitate wider use of these devices within the country's borders.⁴⁸⁷ These efforts

YvlacBpBtRcKHawJ7sn [https://perma.cc/WS8K-K29Y].

480. Enerdata, *Morocco Energy Market Report | Energy Market Research in Morocco* (Feb. 1, 2024), www.enerdata.net/estore/country-profiles/morocco.html [https://perma.cc/KJ7A-BBX7].

481. Firdaous Naim, *Morocco Advances Energy Transition with New Regulatory Decrees*, MOROCCO WORLD NEWS (Sept. 13, 2024), <https://www.moroccoworldnews.com/2024/09/14737/morocco-advances-energy-transition-with-new-regulatory-decrees/> [https://perma.cc/C9PP-6WXB].

482. *Id.*

483. *Id.*

484. *See id.*

485. *See, e.g.,* Younes Ledmaoui et al., *Enhancing Solar Power Efficiency: Smart Metering and ANN-Based Production Forecasting*, 13 COMPUTERS 235 (2024), <https://doi.org/10.3390/computers13090235> [https://perma.cc/ECQ8-8SLV].

486. *See* Cliff Saran, *Smart meter value eroded by tech issues*, COMPUTERWEEKLY.COM (June 14, 2023, 1:09 PM), <https://www.computerweekly.com/news/366541855/Smart-meter-value-eroded-by-tech-issues> [https://perma.cc/EF4W-A92T].

487. Naim, *supra* note 481.

involve modifying existing laws where necessary to address issues such as data protection concerns, billing modalities among multiple service providers, and interoperability requirements.⁴⁸⁸ It is through such legislative amendments that a favorable environment can be created for adopting smart metering systems which would contribute towards achieving national goals on energy efficiency besides safeguarding consumer interests.

The legislative regime governing smart metering in Morocco has been evolving over time with new enactments aimed at promoting deployment as well as effective utilization of this technology within the country. Some of these laws seek to address challenges posed by smart grids and meters such as those related to data privacy protection rules or technical compatibility between diverse types of power management systems.⁴⁸⁹ This dynamic legal environment aims to ensure both the smooth running and secure operation of smart meters connected onto the national grid, thus supporting broader sustainability objectives in energy use across Morocco.⁴⁹⁰

ONEE is the custodian of smart metering systems in Morocco, responsible for their distribution, maintenance and integration into the national grid.⁴⁹¹ This means that ONEE oversees both installation and functionality of these devices, while also ensuring collected information is fed into relevant energy management systems at country level.⁴⁹² In view of its position, ONEE plays a critical role in ensuring all customers benefit from features such as the enhanced service reliability through greater accountability associated with using intelligent metering systems.

Another area under ONEE's purview when it comes to smart meters entails financial aspects, particularly billing processes. Charging based on readings obtained from smart meters provides a more accurate representation of consumed power, thereby promoting fairness among users who will be charged according to what they actually use over specific periods.⁴⁹³ This contrasts with previous systems, where estimation was rife, leading to disputes over bills.⁴⁹⁴ Secondly, this

488. *Id.*

489. See Chaouki Chouraïk, Radouan El-Founir & Khalid Taybi, *Cyber-securing Morocco's smart cities: A case review*, 13 INT'L J. SCI. & RSCH. ARCHIVE 102, 108 (2024), <https://doi.org/10.30574/ijrsra.2024.13.1.1619> [<https://perma.cc/YJ2C-RWVV>].

490. *Id.* at 107.

491. P. Minnebo, J.-F. Vuillaume, M. Ardelean, *Sustainable Electricity Generation and Transmission in the Kingdom of Morocco* 8 (2023), https://publications.jrc.ec.europa.eu/repository/bitstream/JRC132933/JRC132933_01.pdf [<https://perma.cc/32VR-NSLF>].

492. See *id.* at 20.

493. *Advantages of Smart Grids*, CIRCUTOR (Feb. 10, 2017), <https://circutor.com/en/articles/advantages-of-smart-grids/#:~:text=One%20of%20the%20advantages%20of,of%20manual%20energy%20meter%20readings> [<https://perma.cc/HP6J-K2TS>].

494. See *id.*

method also acts as an incentive for individuals or organizations to become conscious about how much electricity they consume since the bill reflects one's real time consumption patterns.⁴⁹⁵

Morocco has ambitious targets for the deployment of smart meters, aiming to equip a significant percentage of its consumers with these technologies by 2030.⁴⁹⁶ These targets reflect Morocco's commitment to enhancing its energy infrastructure and are aligned with global trends towards greater energy efficiency and consumer empowerment in energy usage. Achieving these targets will require sustained efforts in terms of technology deployment, consumer engagement, and regulatory support.

Moroccan regulations ensure that smart meters installed across the country comply with minimum functionality standards.⁴⁹⁷ Typically consumption data for consumers updates at least every thirty minutes.⁴⁹⁸ This high frequency of data updates allows consumers to track their energy usage in near real-time, enabling more effective management of their energy consumption and potential cost savings. Compliance with these standards is crucial for the success of smart metering initiatives, as it directly impacts the ability of the system to deliver the intended benefits in terms of energy efficiency and consumer satisfaction.

I. Data Protection⁴⁹⁹

The main data protection law in Morocco is Law No. 09-08, enacted in 2009.⁵⁰⁰ It sets out people's rights over their personal data and establishes the National Commission for the Control of the Protection of Personal Data (CNDP) as the regulatory body responsible for overseeing compliance.⁵⁰¹ According to this legislation, personal information must be processed fairly and lawfully, collected for specified purposes, used in a way that is compatible with those purposes, kept accurate and up to date where necessary, as well as protected against unauthorized access or loss

495. *Id.*

496. Ikram El Abbassi et al., *Smart Grid Implementation in Morocco: Case Study*, 45 MATERIALSTODAY: PROCEEDINGS 7675, 7378 (2021).

497. See Int'l Monetary Fund, Morocco: Second Review Under the Arrangement Under the Resilience and Sustainability Facility-Press Release; Staff Report and Statement by the Executive Director for Morocco 54 (2024), <https://doi.org/10.5089/9798400292941.002> [<https://perma.cc/Q99E-6XLN>].

498. See generally Mouad Bensalah et al., *High-resolution smart meter load dataset collected from multiple cities in Morocco*, 62 DATA IN BRIEF 112067 (2025), <https://doi.org/10.1016/j.dib.2025.112067> [<https://perma.cc/L8VL-ZWFK>] (relying on dataset accumulated at a 30-minute frequency).

499. For a legal analysis of data protection issues, see generally Leal-Arcas et al., *The Digitalization of Trade and Artificial Intelligence*, *supra* note 247.

500. Law No. 09-08, *Data Privacy for Moroccan Citizens*, CASEGUARD (Oct. 12, 2021).

501. *Id.*

with appropriate security measures taken to prevent such incidents from happening.⁵⁰²

Implementing smart metering systems across Morocco may create significant challenges within existing legislation governing privacy protections. With these devices collecting detailed records about energy consumption at short intervals, there is potential for more breaches involving individuals' private data being compromised through unauthorized entry into databases, et cetera.⁵⁰³ To address this risk, it might be required that amendments be made either directly into or alongside other provisions contained within Law No. 09-08 so as to specify how information should be handled by smart meters. These amendments should address matters such as the need for minimization of particulars retained and security during transmission, among others.

Having control over third parties such as utility firms, IT companies, and other actors involved in the ecosystem where smart metering takes place is vital. This means any personal info shared by customers should be protected under strict contractual terms which bind such entities into complying with DP standards set forth by Moroccan regulations. Likewise, these pacts must ensure that third-party processors deal with client details only as prescribed through legal requirements binding upon data controllers themselves.

The success of consumer protection through data handling laws when it comes to smart metering will depend on how much effort CNDP makes to enforce them. The body gets its power from being able to detect non-compliance cases and penalize defaulters as well as review whether or not personal rights are violated during investigations.⁵⁰⁴ Moreover, there are provisions granting people access to their own records, while giving them the ability to correct or delete any inaccurate information held about themselves.⁵⁰⁵

In relation to the protection against cyberattacks, Law No 09-08 tackles security issues surrounding cyberattacks.⁵⁰⁶ According to this law, controllers of data must put in place suitable technical safeguards so as prevent accidental damage, loss, changes, unauthorized release, or access to personal information that is transmitted, stored, or managed in any other way.⁵⁰⁷ Furthermore, such measures should safeguard the

502. *Id.*

503. Manav Mittal, *Enhancing Energy Management: Tackling the Security Challenges of Smart Metering*, SECUREWORLD (Aug. 19, 2024, 8:23 AM), <https://www.secureworld.io/industry-news/security-challenges-smart-metering> [<https://perma.cc/G4LP-Z6LQ>].

504. Marc Veuillot, *Flash info Morocco | Scope of Data Protection Legislation in Morocco: Law n° 09-08*, CMS (Mar. 22, 2012), <https://cms.law/en/fra/publication/flash-info-morocco-scope-of-data-protection-legislation-in-morocco-law-n-09-08> [<https://perma.cc/HE9N-L82X>].

505. *Id.*

506. *See id.*

507. *Id.*

integrity, availability, and confidentiality of personal data during transit, especially in situations where large volumes get sent frequently which may expose data more to interception by malicious actors such as hackers.⁵⁰⁸

J. *Electric Vehicles and Storage*

1. Electric Vehicles

Morocco is quickly becoming a major player in the global EV market, with an emphasis on acting as an EV manufacturing base. This initiative is in line with wider environmental and industrial goals of the country that seek to lower carbon emissions as well as diversify its economy. Large investments have been made into factories for producing these vehicles, along with policies aimed at creating conducive environments both for their production and adoption.⁵⁰⁹

By 2021, significant steps had already been taken towards establishing Morocco as a hub for manufacturing electric cars.⁵¹⁰ This move has been strategic, using the country's existing automobile industry know-how to tap into the growing market of EVs globally.⁵¹¹ In collaboration with leading international carmakers, Moroccan authorities have initiated projects which see to it that there are units solely dedicated to producing electric automobiles within their borders not just for local consumption but also targeting exportation, especially across Europe where demand for such vehicles is rising fast.⁵¹²

The government has been proactive about creating an enabling environment that supports growth in this sector. Among other things, there have been tax incentives as well as subsidies designed to lower entry costs so that people can afford EVs easily or find them attractive for business purposes.⁵¹³ Furthermore, by investing heavily in renewable energy such as solar power and windmills, Morocco could supply green electricity required by charging points, thus reducing further carbon footprints associated with electric transportations.⁵¹⁴

Technology plays a key role toward the adoption of EVs because, without it, EVs cannot function. Therefore, countries need to invest

508. *Id.*

509. See Michaël Tanchum, *Renewable Energy and Morocco's New Green Industries: How Morocco's Green Energy Ecosystem Can Expand Women and Youth Employment Through Sustainable Development*, MIDDLE E. INST. (Oct. 22, 2024), <https://mei.edu/publications/renewable-energy-and-moroccos-new-green-industries-how-moroccos-green-energy-ecosystem> [https://perma.cc/EYV3-39V5].

510. *See id.*

511. *See id.*

512. Haskouri, *supra* note 333.

513. *Id.*

514. *Climate Resilience for Energy Transition in Morocco*, *supra* note 350.

heavily in infrastructure such as streets lined with charging stations everywhere across cities. For instance, if one wants his or her car battery fully charged, he/she should be able to park outside any building with an electricity supply and, within a few hours, have their vehicle ready for the next trip. Morocco has been putting in place these necessary infrastructural requirements, including installing chargers all over the country, which will help address range anxiety among potential consumers and reassure them that indeed these cars can work well both within towns as well as for long distance travelling. Fast charging stations are being set up on a priority basis so that convenience can be achieved, where travelling using electric vehicles becomes similar to traditional fuel-based vehicles.

In the future, Morocco is looking to have many more electric cars on its roads. The public sector's desire for greener economic development and private sector investment in EV technology both support this goal. However, there are still some barriers; notably: scaling up production capacity to meet domestic and international demand as well as improving battery technology so that EVs can become cost-competitive with internal combustion engine (ICE) vehicles.

2. Energy Storage

Morocco's energy storage landscape boasts a range of systems which cater to different needs within the country's growing renewable industry, including:

1. Pumped Hydroelectric Storage: this is where electricity generated using water stored at height (potential energy) is released through turbines when it is needed.⁵¹⁵

2. Battery Storage Systems: lithium-ion batteries are commonly used due to their high efficiency and quick response times;⁵¹⁶ they can be paired with solar or wind farms to even out supply from intermittent sources.

3. Thermal Energy Storage: frequently employed by concentrated solar power (CSP) plants such as Oxford Business Group or Noor Ouarzazate complex, where molten salts store heat collected during daylight hours so that electricity can be produced overnight or when overcast skies prevent direct sunlight reaching panels after sunset.⁵¹⁷

In Morocco, energy storage projects are funded by the combination of governmental funds, international loans, and private investments. Global

515. *Energy Profile: Morocco*, *supra* note 345.

516. *Morocco Energy Report*, *supra* note 343.

517. *Id.*

bodies such as the World Bank and the European Investment Bank (EIB) have contributed substantial amounts to help Morocco in its endeavor to have a renewable-dominated electricity grid.⁵¹⁸ The private sector is increasingly investing in this industry because of favorable policies coupled with the government's strategic emphasis on energy security enhancement and integration of renewable sources.⁵¹⁹

The legal framework on energy storage in Morocco exists within the broader context of energy law, which promotes the use of renewable energy and its associated technologies, such as storage. Storage solutions are seen as an integral part of power systems under the Energy Law, which provides for their integration with particular emphasis laid on stabilizing grids and load management.⁵²⁰ Building permits as well as operating licenses for these facilities need to be acquired through set guidelines aimed at ensuring environmental compliance and technical safety measures. Pertinent authorities involved in this process include the Ministry of Energy and other government departments whose roles entail overseeing applications up to the approval stage, to ensure they align with national energy objectives.⁵²¹

In relation to contracts, typically energy storage services form part of Power Purchase Agreements (PPAs) in Morocco. PPAs also cover capacity guarantees and energy management among other matters. The main purpose of signing such agreements lies in financial sustainability, where operators need steady incomes while utilities require cost effective ways for storing large amounts of electric power.⁵²²

Energy storage technology advances in Morocco align closely with growth patterns seen around renewable sources throughout the nation. Currently, research on batteries involves exploring more advanced types, such as flow batteries or sodium-sulfur batteries, which can store power for longer than conventional lithium-ion setups. These studies receive backing from local researchers and through collaborations with international technology providers.⁵²³

Morocco has made progress on energy storage, but there are still some problems to solve, such as the scaling up of technology and reducing costs. Although the legal framework is supportive, it needs to be updated continuously so as not to fall behind technological advances or market

518. INT'L BANK FOR RECONSTRUCTION AND DEVELOPMENT, *The World Bank Group's Engagement in Morocco, Fiscal Years 2011–21* 41 (2023), <https://documents1.worldbank.org/curated/en/099445305182323280/pdf/SECBOS0941e8cb0520b7060244f58dca781.pdf> [https://perma.cc/PLT8-MY2S].

519. Moustakbal, *supra* note 367.

520. Sinaceur, *supra* note 407.

521. *Morocco – Country Commercial Guide: Energy*, *supra* note 371.

522. Benali, *supra* note 344.

523. Marsh, *supra* note 396.

changes. Nevertheless, energy storage offers great opportunities for Morocco, given that the country has a great deal of renewable energy sources that can significantly reduce dependency on fossil fuels while ensuring reliability and flexibility of the grid. With further improvement of these facilities' performance and decrease in their prices, they will play an increasingly important role within the Moroccan power sector.⁵²⁴

3. Conclusion

The policies and regulations implemented by Morocco were strategically designed to support smart grids' deployment across different parts of the country. These measures form part of national initiatives aimed at promoting energy efficiency by using sustainable sources such as wind power or solar panels, while also enhancing stability within electricity networks. The regulatory environment has proven instrumental when it comes to setting the stage for the introduction of advanced metering infrastructure systems that enable consumers to monitor their usage more effectively, thus facilitating informed decisions about improving power management both individually and collectively, depending on prevailing circumstances. This notwithstanding, there ought to be regular reviews of these instruments considering the advancements witnessed within this industry over time, along with changes experienced within various segments of the market.

Regulatory models adopted by Morocco have generally provided the right incentives needed to attract investments in smart grid technologies. Through taxation relief packages, subsidies, and favorable rules governing smart grid infrastructure deployment activities, Morocco has succeeded in attracting both internal and external players who have invested significant amounts of capital towards realizing these projects. This approach has enabled rapid modernization of grid networks, enabling them to cope better when faced with fluctuating loads arising from renewable sources of energy supply. There should be continuous improvements made on such incentives, especially areas such as data privacy protection and distributed generation incorporation, so that more funds can be channeled into this sector.

Moreover, the use of renewable sources and distribution generation has increased significantly within Morocco, a move that aligns with the country's national energy strategies and climate change mitigation commitments under international agreements. This growth shows compliance with operational security standards, which indicates effective monitoring control systems put in place by relevant regulatory bodies in collaboration with private sector players operating within different fields related to power generation transmission distribution. In addition to this,

524. *Morocco Targets*, *supra* note 331.

Morocco has taken flexible approaches towards integrating renewable energy into the national grid, ensuring stability even during times when there is substantial increase or decrease of sunlight intensity, for instance.

When it comes to consumer participation, with the rollout of smart meters and customer relationship management systems, consumers have been empowered with access to real-time information about their consumption patterns, thereby encouraging them to make informed choices. Their energy-saving habits have also improved.⁵²⁵ Therefore, it is important to provide the necessary tools required to enable active participation of end users, in order to enhance satisfaction levels while also advancing overall efficiency across the entire electricity value chain.

In general, Morocco's regulatory and policy frameworks have been successful in terms of underpinning the shift towards a more sustainable and efficient energy model. Making policy proactively and revising regulations have created an environment where smart grid technology can flourish along with greater use of renewable energy sources. As for what comes next, the country should concentrate on three areas: increasing customer participation, securing smart grids against cyber threats, and maintaining flexibility within regulations to ensure the long-term sustainability of its power sector.

CONCLUDING REMARKS

Decentralization broadly refers to the activities or actions taken for a sustainable and resilient energy system, using decentralized energy resources, including renewable sources like wind, solar, hydropower, geothermal, biomass gasification, and access methods such as smart grid, power storage, and efficiency.⁵²⁶ According to the Intergovernmental Panel on Climate Change (IPCC), the energy sector is leading as the highest contributor towards emitting greenhouse gases worldwide. Increased deployment of renewable energy and decarbonization of this sector can result in substantial reduction of carbon emissions. To achieve the target of reaching net zero by 2050, investments made in renewables—i.e., towards clean energy—must grow by three-fold to \$1.3 trillion yearly by the year 2030, according to the IEA.⁵²⁷ Improvement in energy technologies, particularly renewable energy sources, makes it affordable and desirable for on-site generation of electricity. Examples of

525. See *Morocco – Country Commercial Guide: Energy*, *supra* note 371.

526. John Cooper, *Decentralization and the Energy Transition*, EEPower (Apr. 6, 2023), <https://eepower.com/tech-insights/decentralization-and-the-energy-transition/#> [<https://perma.cc/S3NB-WUC6>].

527. Int'l Energy Agency, *Net Zero by 2050: A Roadmap for the Global Energy Sector* 1, 1–222 (Oct. 2021), https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroBy2050-ARoadmapfortheGlobalEnergySector_CORR.pdf [<https://perma.cc/WQ3T-7F6L>].

decentralized energy systems, also called distributed energy resources (DERs) are as follows:

- Solar panel or Rooftop Solar;
- Wind turbine;
- Battery (for storage);
- Pumped hydro storage or micro-hydro power stations;
- Thermal energy;
- Heat pump;
- Hybrid power generators or power plants;
- Biomass gasification; and
- District heating and cooling.

The efforts towards energy decentralization have been pursued by all states and governments, as well as various authorities and organizations by laying down policies, incentives programs and schemes, technological developments, and digitalization. In addition, digitalization has gained massive popularity in the last decade, in supporting energy decentralization in numerous ways. The following are the digital systems that revolutionize digitalization and particularly help in energy decentralization:

- Energy Management Systems;
- Digital Energy Platform;
- Energy Trading Platforms;
- Smart Grids;
- Energy Internet of Things; and
- Blockchain Technology.

The constant efforts have led to progress; the global transition to decentralized distributed energy systems from centralized grid networks is gaining momentum. These efforts include the utilization of micro-grids, small renewable energy setups, integrated heat and power systems, distributed power storage technologies and many other technologies that are emerging to address and actualize the decentralization.⁵²⁸ The main aim is to provide electricity that is affordable, climate resilient, easily accessible, and not fossil fueled. The Energy Compact of the World Bank has pledged to support several countries—which are their clients—to provide and supply electricity to approximately sixty million people by

528. See Arnaud de Giovanni et al., *Can decentralized energy get good enough, fast enough?*, EY (Nov. 15, 2022), https://www.ey.com/en_gl/insights/energy-resources/can-decentralized-energy-get-good-enough-fast-enough [<https://perma.cc/MWX8-EQ38>].

2025 and to help these nations to implement strategies for improving electricity access.⁵²⁹

To conclude, by analyzing the current trend and observations, the usage of renewable energy needs balancing by further energy storage systems or power generation capacity, and presently, smart grids seem to be the most favorable option for transition in the energy landscape.⁵³⁰ There is still hope for a rapid energy transition picking up further pace in the future by adoption of the new technologies, as the statistics laid out by the International Renewable Energy Agency suggest that the renewable energy contribution in the power sector is set to rise to 85% in 2050, as compared to 25% in 2017.⁵³¹

529. *Catalyzing Private Investments and Climate Finance to Turn Energy Transition Ambitions to Reality*, WORLD BANK GROUP (Aug. 4, 2023), <https://www.worldbank.org/en/results/2023/08/04/catalyzing-private-investments-and-climate-finance-to-turn-energy-transition-ambitions-to-reality> [<https://perma.cc/3L5Q-UBVB>].

530. de Giovanni et al., *supra* note 528.

531. See INT'L RENEWABLE ENERGY AGENCY, *Executive Summary*, in GLOBAL ENERGY TRANSFORMATION: A ROADMAP TO 2050, 1, 1–15 (2018), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Apr/IRENA_Report_GET_2018.pdf [<https://perma.cc/SB5T-UTSL>].