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Creating favourable conditions for effective transformation of electricity systems

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Note by the secretariat

Summary

Electricity grids are vital in the transition to cleaner, sustainable energy, enabling the integration of renewable sources into power systems and providing the necessary flexibility to manage their variability. The grids support energy storage technologies to balance supply and demand and ensure efficient transmission from generation sources to end-users, aided by smart technologies such as advanced metering and automation. This document provides an overview for policymakers, regulators, and other stakeholders on steps needed for transformation to more sustainable, efficient, and resilient electricity systems.

Challenges to effective grid transformation include significant financial investments, outdated regulatory frameworks, and the resilience of aging infrastructures against climate change and cyber threats. The document highlights the urgency of modernizing grids to incorporate smart technologies, manage distributed energy resources, and support the increasing electricity demand from sectors like transportation and heating. Successful examples underscore the importance of coordinated regulatory reforms, innovative market designs, and sustainable financing mechanisms. Multi-stakeholder engagement and strategic policy alignment are essential to overcoming barriers and ensuring a fair, inclusive transition to sustainable energy systems.

I. Introduction

1. Electricity grids play a crucial role in facilitating the transition to cleaner and more sustainable energy sources. They enable the integration of renewable energy sources, such as solar and wind, into the power system. They can provide the flexibility needed to manage the variability of renewable energy sources and ensure a reliable supply of electricity to consumers. Grids also support the deployment of energy storage technologies, which can help to store excess renewable energy when supply exceeds demand and release it when needed. Electricity grids enable the efficient transmission of power from generation sources to end-users, minimizing energy losses and maximizing the utilization of renewable energy resources. The deployment of smart grid technologies, such as advanced metering and grid automation systems, can further enhance the efficiency and reliability of electricity grids.

2. This document outlines the essential steps needed for transformation to more sustainable, efficient, and resilient electricity systems. The purpose is to provide an overview for policymakers, regulators, utilities, and other stakeholders to navigate the complexities of transforming electricity systems in line with global energy and climate goals.

3. The document can serve as a resource for initiating next steps and elaborating the guiding principles for decision-makers and stakeholders on creating favourable conditions for the effective transformation of electricity systems and contribution to a just transition.

II. The Electric Grid and Secure Energy Transition

4. In the modern era of clean energy transitions, the importance of electricity grids cannot be overstated. As outlined in the IEA Report "Electricity Grids and Secure Energy Transitions"[1] and "Electricity 2024,"[2] grids serve as the backbone of today's electricity systems and play a crucial role in facilitating the transition towards cleaner and more sustainable energy sources. However, despite their critical significance, grids often do not receive the attention and investment required to support the rapid growth of electrification and renewable energy deployment.

5. The increasing prominence of electricity in society and economies underscores the vital role that grids play in connecting new electricity supply sources, such as renewable energy installations, with the growing demand for power. Without adequate grid infrastructure to support this transition, there is a real risk that clean energy initiatives will face significant hurdles and potential stagnation.

6. To meet national energy and climate goals, it is projected that global electricity demand will need to grow at a rate 20 per cent faster in the next decade compared to the previous one.[3] This exponential growth underscores the critical need for substantial grid expansion and modernization to accommodate the anticipated surge in electricity consumption.

7. A key challenge facing countries worldwide is the substantial investment required to add or refurbish over 80 million kilometers of grids by 2040.[4] This task represents the equivalent of completely overhauling the existing global grid infrastructure and highlights the urgent need for increased grid investment on a global scale.

8. In order to meet national climate targets and foster sustainable energy transitions, it is imperative that grid investment nearly double by 2030, reaching over USD 600 billion

[1] IEA, 2023. Electricity Grids and Secure Energy Transitions, Paris: International Energy Agency. Available at: https://iea.blob.core.windows.net/assets/ea2ff609-8180-4312-8de9-494bcf21696d/ElectricityGridsandSecureEnergyTransitions.pdf;

[2] IEA, 2024. Electricity 2024, Paris: International Energy Agency. Available at: https://iea.blob.core.windows.net/assets/18f3ed24-4b26-4c83-a3d2-8a1be51c8cc8/Electricity2024-Analysisandforecastto2026.pdf;

[3] Ibid;

[4] See: https://www.iea.org/commentaries/the-clean-energy-economy-demands-massive-integration-investments-now

annually.[5] This heightened investment focus should prioritize digitalization and modernization of distribution grids to ensure efficiency, reliability, and resilience in the face of evolving energy demands.

9. Moreover, there is a growing recognition of the need for significant research and development efforts towards innovative energy technologies, grid integration strategies, and market design enhancements to drive the transformation of electricity systems.

10 Furthermore, the importance of knowledge sharing and dissemination of best practices cannot be overstated. By learning from successful market transformations in other countries and leveraging lessons learned, countries can accelerate their progress towards achieving sustainable and secure energy transitions.

III. Issues and Challenges for Effective Transformation of Electricity Systems

11. The need for grid modernization and expansion is crucial for integrating renewable energy sources and accommodating the growing demand for electricity. In the United States, for example, the American Society of Civil Engineers' 2021 Infrastructure Report Card gave the country's energy infrastructure a grade of C-, highlighting the urgent need for investment in grid upgrades, refurbishments and sustainability.[6] The challenge lies in updating aging infrastructure, implementing smart grid technologies, and enhancing grid flexibility to support the transition to a clean energy future.

12. The transition to sustainable energy systems requires significant financial investment. According to the International Energy Agency (IEA), the global energy investment in 2020 fell by 20 per cent,[7] with funding for the electricity sector experiencing a decline. Securing funding for renewable energy projects, grid upgrades, and technology innovation remains a challenge, especially in developing countries where financial resources are limited.

13. Inconsistent or outdated regulations can also create barriers to the deployment of new technologies and impede the progress of energy system transformation. The complexity of regulatory frameworks across different regions and countries can hinder investments in clean energy projects and innovative solutions. Streamlining regulations, providing clarity on policies, and creating supportive frameworks are essential for driving effective transformation.

14. The resilience and reliability of electricity grids are increasingly at risk due to climate change, cyber threats, and aging infrastructure. Extreme weather events, such as hurricanes, wildfires, and heatwaves, can disrupt power supply and damage infrastructure. Enhancing grid resilience through measures like grid hardening, increased cybersecurity, and decentralized energy resources management is crucial to ensuring the uninterrupted electricity supply.

15. The integration of distributed energy resources, including solar PV, wind power, and energy storage, presents technical challenges for grid operators. Managing the variability and intermittency of renewable energy sources, optimizing grid operations, and maintaining system stability require advanced grid management solutions. Some countries like Germany, for example, are the leading examples of distributed energy resources integration through grid modernization and demand response programs.

16. The electrification of transportation and heating sectors is expanding, driven by the transition to electric vehicles and heat pumps. Managing the increased demand for electricity from these sectors poses challenges in grid planning, infrastructure upgrades, and load management. Countries like Norway and the Netherlands are at the forefront of electric

[5] See: https://www.iea.org/reports/electricity-grids-and-secure-energy-transitions/executive-summary

[6] See: https://infrastructurereportcard.org/

[7] IEA, 2020. World Energy Investment 2020, Paris: International Energy Agency. Available at: https://iea.blob.core.windows.net/assets/ef8ffa01-9958-49f5-9b3b-7842e30f6177/WEI2020.pdf

vehicle adoption, demonstrating the need for coordinated planning to support electrification efforts.

17. The digitalization of electricity systems is generating vast amounts of data that require robust management systems. Smart grid technologies, and advanced metering systems produce real-time data that can optimize grid operations and enhance energy efficiency. However, ensuring data security, privacy, and interoperability among different systems are critical challenges that require careful consideration.

18. Engaging with stakeholders across the energy ecosystem is needed for successful transformation of electricity systems. Utilities, policymakers, regulators, consumers, technology providers, and communities all play crucial roles in shaping the energy transition. Collaborative approaches, multi-stakeholder dialogues, and community engagement initiatives, can be crucial to overcoming challenges and fostering supportive environment for sustainable energy transformation.

IV. Creating Favourable Conditions

19. As explained above, the transformation of electricity systems is crucial for the shift towards a sustainable and low-carbon future. This transition involves various interconnected factors and requires a comprehensive approach to address diverse challenges.

20. The creation of conditions to favour the transformation of the electricity systems are many and covers many different areas. To create favourable conditions, the following goals and desired outcomes must be taken into considerations.

21. **The transition to a greater use of electricity in the energy mix** is a fundamental component of the global shift towards a sustainable, low-carbon future. This transition will affect the whole primary energy consumption and is expected to be gigantic. As electricity becomes the dominant form of energy, according to IEA, accounting for over 50 per cent of total final energy consumption in net-zero scenarios by 2050,[8] countries need to prioritize the integration of renewable energy sources to achieve this transition. For example, Europe plans to reduce greenhouse gas emissions by 55 per cent by 2030,[9] significantly increasing the share of electricity from renewable sources.

22. **A just energy transition for all**: It is essential to ensure a just energy transition that benefits all stakeholders, including people, states, and systems. Initiatives such as the European Union Just Transition Mechanism, which mobilizes funds (over 55 billion Euros over the period 2021-2027)[10] to support regions most affected by the transition, demonstrate a commitment to ensuring that the transition is fair and inclusive for all.

23. **Building a resilient network** with robust infrastructure capable of withstanding climate impacts is crucial for the effective transformation of electricity systems. This includes integrating advanced grid technologies, ensuring reliable energy supply, and preparing for challenges posed by climate change. It can ultimately lead to the enhancement of grid reliability.

24. **Designing and implementing market reforms in support of transformation to a cleaner and more affordable energy system**: Such market reforms play a vital role in this. Initiatives such as Germany's Energiewende (Energy Transition), which introduced feed-in tariffs to incentivize renewable investments,[11] demonstrate how market reforms can drive the adoption of renewable energy technologies and accelerate the transition towards a low-carbon energy system.

[8] See: https://www.iea.org/reports/world-energy-outlook-2022/an-updated-roadmap-to-net-zero-emissions-by-2050

[9] See: https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2030-climate-targets_en

[10] See: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism_en

[11] See: https://www.bmwk-energiewende.de/EWD/Redaktion/EN/Newsletter/2015/01/Meldung/topthema-the-energy-transition.html and https://www.iea.org/policies/12392-germanys-renewables-energy-act

25. **Accelerating the implementation of projects and the development of new projects** is essential for driving the transition to cleaner energy sources. In the United States, for instance, initiatives like the Investment Tax Credit have provided incentives for the development of renewable energy technologies,[12] helping to increase renewable energy capacity and reduce carbon emissions.

26. **Improving long-term grid planning for a higher share of renewable and increased electrification** is important too. The example of Denmark's Energy Strategy 2050, which aims for 100 per cent renewable electricity by 2030,[13] includes detailed grid planning to support the integration of wind energy and achieve a more sustainable energy system.

27. **Introducing/implementing policies prioritizing the transformation of electricity systems**, setting ambitious renewable energy targets, and implementing market reforms can drive the transition towards a cleaner and more sustainable energy future. Examples can include the European Union's goal of achieving a 40 per cent share of renewable energy in its overall energy mix by 2030[14] and California's Senate Bill (SB) 100, which sets a target for 100 per cent zero-carbon electricity by 2045.[15]

28. **The introduction of regulatory incentives for forward-looking grid build-out**: Regulatory incentives can play a significant role in encouraging the development of forward-looking grid infrastructure. For example, the United Kingdom’s (UK) national grid has received regulatory support for the construction of offshore wind transmission networks,[16] aiming to deliver low-carbon electricity from offshore wind farms to the mainland.

29. **Encouraging the development of competitive electricity markets that allow for a diverse range of energy resources** can foster innovation and drive the transition to cleaner energy sources. The wholesale electricity market allows for various energy resources, including solar, wind, hydro, and battery storage, to participate, promoting competition and driving investment in clean energy technologies.

30. **Building a sustainable, digitalized, and resilient grid that is more decentralized and has more interaction with customers** is critical for advancing the transformation of electricity systems. Digitalization acts as an enabler for a smarter, more flexible and resilient grid by, among other benefits, facilitating the integration of renewables and distributed resources, by making data available to improve operations, maintenance and asset management, by better and smarter load management, including electric vehicle (EV) charging and storage and by facilitating an active customer participation. Countries like Norway, which are leading in smart grid implementation, are incorporating advanced metering infrastructure to enable better demand-side management and enhance consumer engagement.

31. **Securing the necessary financing** for renewable energy projects is a critical component of the effective transformation of electricity systems. The Asian Development Bank (ADB), for example, has been at the forefront of funding renewable energy projects across Asia, providing financial support for solar, wind, and hydropower initiatives. By investing in these projects, the ADB helps to advance the deployment of renewable energy technologies and also contributes to reducing carbon emissions and promoting sustainable development in the region.

32. **Financing mechanisms to support the development and implementation of renewable energy projects and attract investments in clean energy technologies**: Such mechanisms as green bonds, feed-in tariffs, and renewable energy auctions are essential to attract investments in clean energy technologies. Green bonds, which have gained

[12] See: https://www.irs.gov/pub/irs-pdf/i3468.pdf
[13] See: https://www.iea.org/policies/5122-energy-strategy-2050
[14] See: https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-targets_en
[15] See: https://www.energy.ca.gov/sb100
[16] See: https://www.nationalgrid.com/electricity-transmission/network-and-infrastructure/infrastructure-projects/sealink

prominence globally, have seen issuance levels reach around USD 500 billion annually as of 2022,[17] with major issuers, including the European Union and the People's Bank of China.

33. These financial instruments provide investors with opportunities to fund projects, including renewable energy initiatives, and contribute to accelerating the transition to a low-carbon economy. Germany has also successfully used mechanisms like feed-in tariffs and renewable energy auctions to foster investments in renewable energy.

34. **Investing in research and development (R&D):** R&D that focus on innovative energy technologies, grid integration, and market design to advance the transformation of electricity systems is another crucial aspect of advancing the transformation of electricity systems. The United States Department of Energy (DOE), for example, funds numerous projects through ARPA-E (Advanced Research Projects Agency-Energy) to develop new energy technologies.[18] Similarly, the Horizon Europe program allocates significant funding to energy innovation,[19] focusing on areas such as smart grids and energy storage.

35. **Ensuring stakeholders engagement**: Stakeholder engagement is also essential for the successful transformation of electricity systems. Multi-stakeholder initiatives like the Renewable Energy Buyers Alliance in the USA bring together utilities, corporations, renewable energy developers, and other key stakeholders[20] to collaborate and drive the transition to clean energy.

36. **Sharing best practices and lessons learned from successful market transformations** is crucial for accelerating progress in other countries. Organizations like the International Renewable Energy Agency (IRENA) facilitate global collaboration and knowledge sharing, to help countries implement best practices and successful strategies for renewable energy integration. The country example of German Energiewende program serves as a reference model for many countries seeking to transition to cleaner energy sources.

37. By addressing these elements comprehensively, countries can accelerate the adoption of renewable energy, enhance grid resilience, and move towards effective transformation of energy systems. At the same time, to delve deeper into the efforts and conditions supporting such effective transformation one can acknowledge further aspects:

(a) **Increasing investments in battery storage technology** are critical to addressing the intermittency of renewable energy sources like wind and solar power. For example, California state of USA has been a leader in deploying utility-scale battery projects, ensuring grid stability and reliability;[21]

(b) **Interconnectivity and cross-border cooperation** is important. For example, the European Network of Transmission System Operators (TSO) for Electricity facilitates cross-border electricity trade and grid interconnectivity within Europe,[22] enhancing the integration of renewable energy and improving grid reliability;

(c) **Public-private partnerships** play a very important role in advancing energy projects. For example, the United States' Clean Energy Partnership with countries, among others, aims to accelerate the deployment of clean energy technologies through collaborative investment and innovation;[23]

[17] See: https://www.statista.com/topics/9217/green-bonds-market-worldwide/

[18] See: https://www.energy.gov/advanced-research-projects-agency-energy-arpa-e and https://arpa-e-foa.energy.gov/

[19] See: https://horizoneurope.ie/

[20] See: https://www.americaspledgeonclimate.com/opportunity-agenda/electricity/renewable-energy-buyers-alliance/

[21] See: https://www.energy.ca.gov/news/2023-10/california-sees-unprecedented-growth-energy-storage-key-component-states-clean

[22] See: https://eepublicdownloads.entsoe.eu/clean-documents/nc-tasks/ENTSO-E_Market_Report_2023.pdf

[23] See examples: https://www.state.gov/joint-statement-on-the-second-annual-japan-u-s-energy-security-dialogue/ and https://www.energy.gov/ia/articles/2024-us-france-bilateral-clean-energy-partnership-joint-statement-0

(d) **Decentralization and community energy projects**: there are examples of countries like Germany and Denmark, where community energy projects empower local communities to generate, consume, and sell renewable energy, fostering local engagement and ensuring energy production;[24]

(e) **Providing clear and stable regulatory frameworks** is important to attract long-term investments. The UK's Contracts for Difference scheme, which offers longer-term price guarantees for renewable energy projects,[25] can serve as a model of policy certainty;

(f) **Improving energy efficiency across all sectors** of the economy can significantly reduce the demand for primary energy. The European Union's Energy Efficiency Directive sets the goal of reducing EU final energy consumption by 11.7 per cent by 2030;[26]

(g) **Educational programs**: scaling up the clean energy transition requires a well-trained workforce. Programs like Germany's vocational training in renewable energy technologies can serve as example for equipping the workforce with necessary skills.

38. Finally, to create favourable conditions for effective transformation of electricity systems, the following considerations should be taken into account:

(a) Encouraging competition and diversity in the energy market can drive innovation and investment in clean energy technologies. By allowing various energy suppliers to enter the market, consumers can have more choices in sourcing their electricity from clean and sustainable sources. This can create a more resilient and sustainable energy system while driving down costs for consumers;

(b) Developing a resilient energy supply chain is essential for the effective transformation of electricity systems. This includes adopting robust infrastructure, such as smart grids and energy storage systems, to enhance grid reliability and stability. Enhancing cybersecurity measures to protect the energy infrastructure from potential threats needs to be taken into account in building a resilient energy supply chain;

(c) While renewable energy sources, like solar and wind, are essential for decarbonizing the electricity system, they are intermittent in nature and may not always meet the demand for energy. It is imperative to complement these intermittent sources with baseload power generation, such as nuclear or geothermal, to provide a stable and reliable energy supply. Additionally, investing in flexible generation sources, such as energy storage and demand-response technologies, can help manage fluctuations in renewable energy generation and ensure grid stability;

(d) While transitioning to a more decentralized energy system with storage and demand-side flexibility is desirable, ensuring a continuous and reliable energy supply is paramount for industries and society. Implementing measures to maintain grid reliability, such as grid modernization, energy efficiency improvements, and demand forecasting, can help ensure a stable energy supply while integrating more renewable energy sources into the electricity system.

V. Key Levers

39. To create favourable conditions many stakeholders and many different areas must come together in the entire spectrum of the electric grid from policies to utilities. This section highlights some levers that can be used.

[24] See examples: https://pub.norden.org/nordicenergyresearch2023-03/germany.html and https://pub.norden.org/nordicenergyresearch2023-03/denmark.html

[25] See: https://www.gov.uk/government/news/over-1-billion-budget-for-renewable-energy-auction

[26] See: https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-targets_en

A. Policy

40. Governments have a significant influence on shaping electricity systems and driving the transformation of electricity systems. Coordinated policies across different levels, including local, regional, and national governments, are essential for creating a supportive regulatory framework and facilitating the deployment of renewable energy technologies. Policy alignment ensures that the objectives of different governmental entities are harmonized, leading to a coherent approach towards achieving net-zero emissions targets in the electricity sector.

41. To enable and accelerate policy action, Governments should provide sustained and predictable financial support for clean energy initiatives. This includes incentives such as feed-in tariffs, tax credits, grants, and subsidies for renewable energy projects. By offering financial incentives, governments can stimulate investment in clean energy infrastructure, drive innovation in energy technologies, and create an opportunity for renewable energy sources to compete with traditional fossil fuels.

42. Policy makers should provide forward visibility of policies affecting the power sector. By engaging with industry stakeholders and experts, policy makers can gather valuable insights and feedback to inform the development of effective energy policies. Incorporating inputs from various authorities and stakeholders into the policy-making process helps ensuring that the policies are well-informed, balanced, and reflective of diverse perspectives and interests.

B. Regulation

43. Regulation plays a crucial role in transforming the electricity sector towards sustainability and achieving net-zero emissions goals.[27] Effective regulatory frameworks can provide the necessary incentives, guidelines, and support to facilitate the transformation of electricity systems.

44. Towards a More Dynamic Regulation for Energy Network report published by CERRE[28] emphasizes the need for regulation to adapt to the challenges of achieving net-zero goals in the energy sector. The importance of dynamic, responsive, and adaptive regulation to address the uncertainties and complexities associated with transitioning to a sustainable energy system is emphasized. By embracing dynamic approaches to regulation, stakeholders can learn from past experiences, respond to new information, and plan for the future effectively.

45. Potential changes to regulation need to be discussed to better cope with the uncertainty surrounding net-zero energy policies. These changes include reforms to planning processes, uncertainty mechanisms, regulatory incentives, financing arrangements, stakeholder engagement strategies, innovation processes, and industry governance structures. By implementing these changes, regulators can create a more flexible and resilient regulatory framework that supports the transition to clean energy.

46. In addition, the role of regulators in providing a clear framework for power sector stakeholders should be the assigning of responsibilities for coordinated action, and ensuring the secure operation of the energy system. Regulators play a critical role in assessing market design in restructured markets, promoting flexibility and stability services, and fostering collaboration among operators of transmission and distribution systems.

47. The role of regulation in transforming electricity systems towards sustainability and net-zero goals is pivotal. By aligning policies, designing effective market mechanisms, promoting grid modernization, setting emission reduction targets, supporting innovation,

[27] See: https://www.cer-rec.gc.ca/en/about/news-room/news-releases/2023/canada-energy-regulator-projects-major-transformation-canada-energy-system-net-zero-world.html

[28] Pollitt, M., Covatariu, A. and Duma, D., 2024, Towards a More Dynamic Regulation for Energy Networks, Centre on Regulation in Europe (CERRE). Available at: https://cerre.eu/wp-content/uploads/2024/03/CERRE_Dynamic_Regulation_Report_FINAL-1.pdf

protecting consumers, developing decarbonization roadmaps, and engaging stakeholders, regulators can drive the transition to sustainable energy systems more effectively. Effective regulation also requires collaboration, adaptability, and forward-thinking.

48. IEA[29] also emphasizes the crucial role of regulators in ensuring the efficient and secure operation of the power sector. It underscores that regulators play a key role in providing a clear framework that outlines the obligations of every stakeholder in the power sector. This clarity is essential for preventing threats and ensuring that all entities are prepared to react effectively in exceptional circumstances, such as grid failures or supply disruptions.

49. The importance of regulators in assigning responsibilities is highlighted for coordinated action among operators of transmission and distribution systems. Collaboration and coordination between these operators are essential for maintaining the reliability and resilience of the grid, particularly in interconnected systems where the flow of electricity between different regions or countries is involved.

50. Moreover, in restructured markets where competition and market mechanisms play a significant role in shaping the energy landscape, the IEA stresses the importance of regulators constantly assessing the market design. Regulators need to ensure that the market structure and mechanisms in place are capable of delivering the flexibility and stability services required for the secure operation of the system. This ongoing assessment is crucial for identifying and addressing any shortcomings in the market design that may impede the efficient functioning of the electricity system.

51. Emission reduction targets provide quantitative goals that steer utilities and industry towards less polluting processes. These goals can be enforced through either punitive means, such as fines for exceeding limits, or through positive reinforcement, such as tax breaks or subsidies for those that achieve or surpass the targets. This framework helps concentrate efforts on reducing greenhouse gas emissions and paves the way for a transition to cleaner energy sources.

52. Innovation and research lie at the core of the energy transition, as advancements in technology are critical for overcoming current barriers to sustainability. Support from regulations is paramount, as it can direct funding and resources towards R&D in clean energy, energy storage, and grid optimization.

53. Consumer protection and affordability regulations balance between ensuring that energy prices remain fair and maintaining the reliability and safety of energy supply. Regulations safeguard the consumers from potential price rises, and keep energy affordable, particularly for low-income households.

54. Regulators and stakeholders can work together to establish comprehensive strategies for achieving net-zero emissions, including timelines for phasing out fossil fuels and increasing electrification across various sectors. Decarbonization roadmaps can encompass a range of activities and policies that need to be implemented over the medium to long-term and include interim milestones to track progress.

55. Stakeholder engagement is required for effective regulatory processes, as it brings transparency and builds consensus for proposed policies. Involving a wide range of stakeholders, including public, businesses, and non-profit sector, helps in ensuring that diverse perspectives and interests are considered when crafting energy regulations.

C. Financing

56. Financing is a vital condition for ensuring the effective transformation of electricity systems. It is not only about providing the necessary capital but also about establishing financial mechanisms that can address the investment requirements and operational funding needs.

57. Upgrading the existing grids to accommodate renewable energy sources requires substantial amount of capital. Finance helps in the instalment of smart meters, energy storage

[29] See: https://www.iea.org/reports/power-systems-in-transition/recommendations

systems, and upgraded transmission lines that can manage the intermittent nature of renewable energy.

58. It is also important for the development of new renewable energy projects, such as solar and wind farms. Such funding can come from public sources (government grants and loans) or private investment (venture capital, private equity), and project finance.

59. Access to capital helps driving the innovation in clean energy technologies and allows companies to invest in R&D and commercialize new technologies that can reduce costs and improve efficiency.

60. Financing mechanisms can also help promoting energy-saving measures, which are often more cost-effective than generating additional power. Low-interest loans can incentivize households and businesses to invest in energy-efficient appliances, building retrofits, and industrial processes.

61. Financial support from Governments can bridge the gap between policy goals and practical implementation. This may be done in the form of subsidies for renewables or penalties for high-carbon emitters, shifting the economic balance in favour of the sustainable practices. Financial incentives can attract investments into the sustainability practices and combine the strengths of public and private sectors.

62. Special funds and programs can ensure that the transition to clean energy is fair, providing support to communities transitioning away from fossil fuel industries and subsidizing renewable energy access to underserved populations leading to a just energy transition.

63. Investments in green energy can lead to job creation in new industries, from manufacturing components for renewable energy systems to servicing and maintaining the infrastructure, also promoting economic development.

64. Effective financing for the energy transition is not just about quantity but also about the strategic allocation of funds. Financing should allow for the long-term horizons of renewable energy projects to align with investment recovery.

65. To ensure that sustainable energy initiatives are accessible and cost-effective, financial instruments should be flexible to accommodate different technologies and projects. Development finance institutions and micro-finance initiatives can play an important role in providing tailored solutions that address the financial and operational challenges faced by renewable energy projects.

66. A focus on financial education can enable stakeholders to develop, evaluate, and invest in sustainable energy projects. Creating an informed community of investors and policymakers can accelerate the transition by making financing more efficient and impactful.

67. The examples of financing of Net Zero, New Green Deal or EU Green Deal show the importance of the work in this area. "Net Zero" refers to the goal of achieving a balance between the amount of greenhouse gases emitted into the atmosphere and the amount removed or offset by various means. This is seen as crucial in addressing climate change and reducing global warming. The "Green New Deal" is a proposed set of economic stimulus programs in the United States that aims to address climate change and economic inequality. It calls for transitioning to a low-carbon economy and creating new jobs in clean energy industries. The "EU Green Deal" is a set of policy initiatives by the European Union aimed at making the EU's economy sustainable and creating a carbon-neutral environment by 2050 and includes measures to reduce GHG emissions, increase renewable energy use, and promote energy efficiency.

68. Financing of initiatives such as Net Zero, the Green New Deal, and the EU Green Deal is necessary as they support the development and deployment of renewable energy sources, energy-efficient technology, and other green technologies that are essential for achieving carbon neutrality and addressing climate change.

69. Adequate financing is required to fund the transition to a low-carbon economy and achieve the climate targets set out in international agreements such as the Paris Agreement.

This is essential for mitigating the impacts of climate change and ensuring a sustainable future for the planet.

D. Emission Market

70. The emissions market can create favourable conditions for the effective transformation of electricity systems by putting a price on carbon and making fossil-fuel-based electricity generation more expensive. This makes renewable energy sources, like wind, solar, and hydro, more competitive, accelerating their adoption. A well-designed emissions market provides flexibility to electricity producers as they can choose the most cost-effective way to reduce emissions, whether by directly reducing their carbon output, investing in cleaner technology, or purchasing emission allowances. The revenue generated from the sale of emission allowances can be used to fund renewable energy projects, research and development in clean technologies, and other initiatives aimed at reducing GHG emissions.

71. The European Union's experience highlights the importance of implementing a market-based system to monetize carbon emissions. And it is important to establish a global emissions payment scheme based on the purchasing power of ECE member States to ensure fairness. However, the current allowance pricing system in the EU is not equitable, with citizens in different countries facing significantly varied costs. This disparity in carbon pricing is a major issue for the EU economy and drives production shifts to regions with lower carbon costs. Such "carbon leakage" undermines competitiveness and should be addressed by creating a fair and just carbon pricing system.

E. Market Design

72. Market design and incentives are crucial for cultivating an environment that supports the uptake of renewable energy. Tools such as Renewable Portfolio Standards in USA impose an obligation on electricity providers to produce a specific proportion of their power from renewable resources.[30] This impels companies to increase their own green energy generation or purchase renewable energy certificates. The feed-in tariffs offer long-term contracts to renewable energy producers, guaranteeing more favourable payment rates for the energy they feed into the grid. This certainty encourages new investments in renewable technologies by ensuring a stable return on investment.

73. Eurelectric, a leading trade association representing the European electricity industry, recently (March 2023) issued the policy recommendations on electricity market design fit for a net-zero economy.[31] The report emphasizes the importance of proper implementation of existing EU legislations and regulations, the removal of barriers and obstacles, and market-based solutions to incentivize stakeholders in contributing to the challenges faced by the power system and achieving the transition towards a net-zero economy.

74. The policy recommendations put forward by Eurelectric are structured around three main pillars. Firstly, a consumer contracting and engagement framework is proposed, focusing on enhancing forward hedging opportunities and retail price structures to empower consumers with choice and control over their energy consumption. Secondly, an investment framework is suggested, underpinned by enhanced long-term hedging and contracting opportunities to provide market-compatible incentives for investments in clean energy infrastructure. Thirdly, in addition to consumer empowerment and investment incentives, the policy recommendations also highlight the need for a framework to coordinate future system needs to ensure security of supply. This security of supply framework aims to address the challenges of integrating intermittent renewable energy sources into the grid while maintaining reliability and stability.

[30] See: https://www.ncsl.org/energy/state-renewable-portfolio-standards-and-goals

[31] Eurelectric, 2023. Electricity Market Design. Available at: https://market-design.eurelectric.org/

VI. Conclusions and Recommendations

75. This document can serve as a resource for initiating next steps and elaborating the guiding principles for decision-makers and stakeholders on creating favourable conditions for the effective transformation of electricity systems and contribution to a just transition. It provides an overview of the goals and considerations that are needed to create favourable conditions for an effective transformation of the electricity system, so it continues to contribute to the decarbonation, just energy transition, adaptation to climate changes and increase of reliability and resiliency.

76. Many stakeholders have a role to play to design and implement such favourable conditions, including:

(a) Policy makers;

(b) Regulators;

(c) Electricity utilities and operators;

(d) Industry groups;

(e) Consumers;

(f) Academics;

(g) Research and innovation centers;

(h) Civil society.

77. These stakeholders should act in a concerted way to create the conditions that will favour a transition of the electricity system to a cleaner one.

78. The main recommendations could include the following:

Policy:

(a) Policy makers across jurisdictions and different levels, including local, regional, national and supra-national should coordinate to create supportive framework of legislations;

(b) Governmental authorities should provide sustained and predictable financial support for clean energy initiatives;

(c) Governmental authorities should provide forward visibility of policies and engage with stakeholders;

(d) Policy makers should ensure that integrated resources planning is performed with all stakeholders over both short-term and long-term horizons.

Regulation:

(a) Regulation needs to adapt to the challenges of decarbonation and sector transformation by making regulations more dynamic, responsive and adaptative to address the uncertainties and complexities;

(b) Regulators should align policies and market mechanisms and engage stakeholders;

(c) Regulators should provide a clear framework for power sector stakeholders outlining the obligations of every stakeholder.

Financing:

(a) Access to capital should be designed to help driving the innovation in clean technologies and allow investments in research and development;

(b) Financial support should contribute to bridge the gap between policy goals and implementation;

(c) Special funding and programs should ensure that the transition to clean energy is fair.

Emission Markets:

(a) Emission markets have proven the importance of implementing market-based systems to monetize carbon emissions and favour non-emitting sources;

(b) Emission markets should be designed to provide flexibility to electricity generators to choose the most cost-effective and reliable way to reduce emissions;

(c) Emission markets should favour the adoption of renewable sources;

(d) Global emissions payment scheme should be based on the purchasing power of states.

Electricity Markets:

(a) Market design should favour investment in the electric grid and its transition to a cleaner electricity system;

(b) Markets should be designed to remove obstacles and barriers to system transition.