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Energy Governance and Policy Frameworks for Sustainable Power Transitions

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Abstract

The English language makes communication, identification, and interaction easier. It also promotes harmony among people. Human uses of language involve a dynamic exchange of meanings through symbolic systems. The use of any language directly influences how people construct their identities and build relationships. When engaging in a specific communication event, social processes help shape identities. English is a widely accessible language in multilingual settings, enabling people to access knowledge from cultures around the world. Intercultural relations are embedded in the communication process and influence body language, concepts, dress, food, habits, music, rituals, values, and local dialects. These cultural features become more diverse and pronounced, so much so that a person's original cultural traits are seen as remnants of the past- features that are fading in the globalised world.

Keywords: *English, Harmony, Identity, Intercultural dialogue, Language*

1. Introduction

Climate change is becoming increasingly urgent, and there is a global shift toward low-carbon energy systems driven by energy security concerns. The key to deep decarbonization is aligning policy instruments with sustainable development targets reflected in the Paris Agreement and the United Nations Sustainable Development Goals (SDGs). Equivalent actions should accompany consistent policy pledges to ensure that power systems continue to provide economic, social, and environmental opportunities as they transition to low- or zero-carbon operations (Pastukhova & Westphal, 2020). An effective policy framework identifies tools and interventions discussed in the energy governance literature. Sustainable power transitions are managed through regime formation, policy coordination, and technological integration across various dimensions. Although some aspects of policy interactions are rooted in theoretical frameworks, others remain underexplored. A systematic approach to analysing sustainable electricity governance will help determine existing capabilities, identify coverage gaps, and set priorities within institutions. While some nations have incorporated low-carbon power into their energy policies, a more comprehensive analysis of policy arrangements for sustainable power transitions remains necessary.

2. Theoretical Principles of Energy Governance.

Different perspectives are used in the literature to develop the concept of energy governance further. Energy governance typically encompasses hydropower, thermoelectric power, nuclear power, lighting, production plans, renewable energy, and sustainability transitions (Pastukhova & Westphal, 2020). Energy governance institutions encompass both governmental and non-governmental bodies integrated into national and subnational energy policies. Other areas define energy governance as encompassing energy efficiency, energy policy, energy resource management, and renewable energy.

Energy governance involves policies created and implemented by many normative actors who utilise and control energy-based goods and facilities. Governance is a normative decision made within the commons by social systems and/or established through codes or standards that regulate behaviour, whether formally or informally adopted. It is a specific arena, issue, and timeframe that refers to the fixed structures influencing public, political, and research discussions on energy policy and technology choices. Additionally, energy governance refers to arrangements aimed at addressing energy challenges across all societal levels, including consumers, suppliers, and producers of energy, as well as stakeholders seeking a voice in energy issues. Objects, principles, norms, actors, and processes to be governed are defined in standard terms and evolve within three broad theoretical frameworks, differentiating how energy governance is managed from traditional government and how it is implemented in case studies.

3. Sustainable Power Transitions Policy Instruments.

Governments use various policy instruments to promote the transition to sustainable energy systems, and these measures are sector-specific and tailored to the national and local environment (Pastukhova & Westphal, 2020). Those who understand the need for a rapid economic shift from fossil-fuel electricity generation to renewable and sustainable energy sources see a range of options that can be categorised into four groups: regulation, market-based approaches, financial incentives, and policies for research, development, and innovation. The underlying motivation is often to address climate change and achieve net-zero emissions through decarbonising the economy and switching to electricity generated from sustainable sources such as wind, solar, wave, and other technologies. Additional channels include institutional support, energy planning, investment, climate and social impact assessments, governance evaluation, and learning from international practices. These options encompass the full scope of governance and policy actions relevant to electricity supply systems, with a primary focus on the developed world, especially Europe.

3.1. Regulatory Measures

A shift in power changes energy market regulation and often relies on different policy tools, such as regulatory policies, market-driven policies, subsidies and incentives, and policies for research, development, and innovation (Pastukhova & Westphal, 2020). Regulatory needs, including performance standards and requirements, are vital for sustainable power transitions and are typically used to phase out polluting energy technologies at the end of their life cycles and to introduce cleaner, low-pollution options (Verbruggen et al., 2015). The necessary phasing-out schedules are intended to support regulatory performance standards, provide specific transition timelines, and may also trigger separate market-based assessments. The permitting procedures formalise the approval process and stakeholder consultations; key elements include performance and safety standards, as well as environmental impact assessments. Effective compliance and enforcement systems demonstrate government commitment; regulatory autonomy strengthens these efforts and can help prevent unexpected regulatory rollbacks.

The regulatory bodies could define market functions and provide insights into future regulatory trends based on capacity and technology content requirements. Capacity objectives encourage actors to adopt fixed technologies, while technology-neutral system interventions offer flexibility in choosing integrated solutions and influence overall investment directions. Combining policies should avoid sending conflicting signals. Market pricing should reflect the true value of resources or services; consequently, excessive interventions to modify or add to system aspects will increase costs and limit the use of low-carbon energy sources.

3.2. Market-Based Mechanisms

Market-based instruments are prices on environmental harms designed to motivate cutbacks and encourage investments. Developing stable market signals in the power sector is crucial to achieving long-term greenhouse gas (GHG) reduction targets. Instruments such as carbon pricing are therefore widely promoted. These include emission-based carbon taxes, cap-and-trade systems, and GHG accounting based on carbon-embedded approaches for trading electricity in a connected system. However, various capitals have instead adopted processes that impose costs on carbon emissions from personal sources of renewable energy. This is similar to past policies of technology push and demand pull in global energy transitions, which were based on perceived economic efficiency. For example, the historical focus on efficiency and equity in total-return-cost legislation has limited most regulatory frameworks to specific supply-side interventions (Pastukhova & Westphal, 2020).

Cap-and-trade plans are based on society's right to a specified amount of emissions. In principle, distributing tradeable permits to existing emitters, which have no economic value, would not affect the initial distribution of wealth. The price differences reflect variations in marginal abatement costs, with some economies placing a higher value on carbon than others. A shadow-price mechanism enables market prices to be influenced by fixed-rate tenders used to acquire capacity for dispatchable and renewable generation over multiple years. This fosters significant investment in the emerging renewable sector, supported by fixed remuneration and certain price levels. Feed-in tariffs, feed-in premiums, and contracts for difference across various regions support these. The requirement for prequalification technical standards, common in other models, is eliminated by introducing contracts-for-difference with a medium- to long-term horizon, especially in partially renewable systems. Permanent advance auctions are an appropriate approach where yearly interconnections are not established (Verbruggen et al., 2015).

3.3. Subsidies and Incentives

Subsidies distort market signals, reducing consumer awareness and investment opportunities. Governments can intentionally decrease market efficiency, making it difficult for investors to assess risk. The fiscal costs are especially high in the power industry, where large investments tend to favour building new plants over upgrading existing ones. The deadweight loss from subsidy schemes can be minimised by designing subsidies to target specific localities or market players, allowing them to obtain relevant finance through alternative means without focusing on particular capacities. Although these complex structures require more financial and institutional resources, they can improve revenue collection and reduce evasion through more circuitous methods. Alternatively, performance in targeting can be enhanced with observable indicators that help predict the largest capacity expansions (Verbruggen et al., 2015).

The economic lifetimes and lead times of energy infrastructure are long, and short planning horizons consume resources. Deadweight loss can be minimised by allowing longer planning horizons. Projections of electricity generation capacity look into the future (15 years) and show that there will be average capacity growth in About Energy and climate planning / Sub-national government and pathways to sustainable energy—Commissions and monitoring of carbon capture and storage—with significant guarantees, even with well-defined contracts of difference. These decisions should not create incentives for other instruments to capture larger shares of the total public expenditure expected or needed during the forecast period. Extending the planning horizon likely reduces the final demand for electricity storage. There are major discrepancies regarding how to finance the capital requirements arising from other cabinet decisions. Key areas of energy systems derived to identify likely locations for new supply include energy preferences, climate policies, population, and economic growth (Cowell et al., 2017).

3.4. Policies in Research, Development and Innovation.

The energy policy needs to address issues related to system efficiency, economic growth, and investment risks. Innovations in the energy sector include technological developments, pilot projects, knowledge products, institutional options, and regulatory tools. Policies promote shared public-private investments, research maps, demonstrator centres, and innovation platforms (Pastukhova & Westphal, 2020). Systematic public funding of RD&I for renewable technologies is essential due to the high risks and spillovers common in this area. Energy policies also support private-sector activities, such as knowledge sharing, investor participation, and demand-side measures. Public contributions from the population can include guarantees of investments or other financial instruments to address specific risks, especially in gathering complementary investments.

4. Arrangements and Governance Actors of an Institution.

The primary authority and power to influence energy policies and markets, and to enable sustainable power transitions, rest with national governments and regulatory bodies. They issue legal statements and strategic priorities for the energy industry and coordinate with other energy-sector-related ministries, state agencies, and stakeholders, ensuring careful consideration of fiscal, climate, environmental, and social policies. It is crucial to design and implement coherent, sustainable energy frameworks to guarantee policy continuity and prevent harmful deviations. Regulatory theory emphasises the need for independence and effective governance structures to ensure that energy regulators serve the public interest; therefore, a well-defined regulatory agency with strong local capacity is essential to achieve sustainable energy transitions (Pastukhova & Westphal, 2020).

There are various issues related to energy governance that involve subnational and local governments. Formal decentralisation, where power and responsibility are transferred to subnational units, enables greater local responsiveness to specific energy transition challenges, depending on the technological, natural, economic, and social conditions of each locality. Because energy policy-making is decentralised, local governments have the freedom to develop their own energy plans and set local energy targets. These plans require adequate institutional capacity and resources for effective implementation. Additionally, various administrative units within national governments are responsible for stakeholder consultations, local planning, and technical support to improve local energy plans. Subnational actors of governance can either facilitate or obstruct sustainable energy transitions.

4.1. Regulators and National Governments.

Regulatory agencies and national governments must regulate energy systems, oversee energy infrastructure and services, and impose environmental limits and climate targets. They possess extensive authority, often encompassing energy policy and development strategies. They are central to a country's energy management and directly involved in implementing national energy and climate policies, such as designing decarbonization plans, setting renewable energy targets, and endorsing related investments and technologies. National governments delegate authority to local governments, ministries, and regulatory agencies; establish governance structures; define how firms and authorities interact; specify energy security assurances; determine risk-sharing and technology promotion levels; and regulate the timeline, technology, and institutional aspects of decarbonization, with clear prioritisation of short- and long-term goals. Coordination across government levels, integration of national agendas (climate, energy, water, transport, etc.), and capable national lead agencies that facilitate effective policy integration are therefore crucial (Pastukhova & Westphal, 2020).

4.2. Subnational and Local Government.

The formal energy governance systems are mostly at the national level. However, they usually involve subnational and local authorities as the de facto leaders in the transition to sustainable energy regimes. National energy policies often lag behind society's needs, and locally developed energy policies grounded in municipal frameworks can help close this gap. In certain jurisdictions, local authorities find that energy access and climate change policies must be integrated into development plans to achieve sustainability goals. National government agencies typically prepare energy programs and plans, although many jurisdictions have subnational authorities responsible for designing and implementing local energy initiatives.

There are different trends in the decentralisation of energy governance across countries. In some cases, power shifts to subnational regions, while in others, the governance structures are complex and fragmented. Since the powers of subnational governments are negotiated in light of existing infrastructure and geographic considerations, decentralisation may yield different results across jurisdictions. Local governments often implement measures that extend beyond national policies, creating opportunities for additional change and adapting national strategies to local administrative, institutional, and development contexts. The variety of governance arrangements in energy systems, the flexible articulation of energy governance across spatial scales, and the role of subnational authorities as complementary actors in national policy implementation are all key considerations. The decentralisation of energy governance at the local and regional levels can bring about significant transformations that are important for overall transition patterns (Cowell et al., 2017).

4.3. International Organisations and Cooperation

The multilateral structures establish norms, coordinate policies, build capacity, share information, provide financing, and facilitate technology transfer. International cooperation can ease investment and technology transfer, leading to context-specific solutions that support domestic policy development. Although many partnerships exist, the goal is to enhance synergies, mobilise action, and enable successful collaboration across various international forums.

International energy investment and trade are governed by the Energy Charter Treaty (1991). Through agencies such as the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), and the World Bank, technical assistance, grants, and loans for investment and capacity building are provided. Financing and transfer mechanisms for low-carbon technologies include the Carbon Trust, the Clean Development Mechanism, and the Diffusion of Technology initiative. The Organisation of Economic Cooperation and Development (OECD) promotes cooperation in energy policy between governments and industry in developed countries and some emerging economies. Key issues include energy security, investment, fossil fuel subsidies, and energy efficiency (Pastukhova & Westphal, 2020).

4.4. Civil Society and the Private Sector.

The fossil fuel industry plays a crucial role in energy and climate policy due to its overwhelming contribution of 80% to overall primary energy usage and 80% to CO2 emissions (Pastukhova & Westphal, 2020). This creates challenges for the privatised sector in the energy transition, especially since industry representatives are often involved in discussions about policy strategies and technologies. Therefore, strategies and policies must be developed to ensure that companies radically redesign or transform their business models to phase out fossil fuels. A decarbonised economy should identify key industries to prioritise and determine how to direct skills and investments toward these reoriented sectors. Additionally, the energy transition should be viewed through the lens of equity, which necessitates a broad-based investment program. Industrialised economies must incorporate clean technologies into their development paths. Accountability mechanisms are essential during this period of hope for climate technologies and emerging opportunities for more sustainable energy systems. Social responsibility indicators relate to fundamental principles of fair and democratic governance, such as equal recognition.

5. Cross-Sector and Integrated Planning.

The energy transition has significant cross-sectoral implications for climate change mitigation and land-use planning (Pastukhova & Westphal, 2020). The sources of energy, such as renewables, should be evaluated regarding their adherence to climate targets. Additionally, the spatial requirements of energy infrastructure are vital components of land-use policy. Since climate and land-use policies have become international priorities with major implications for energy systems, energy and land-use planning must be integrated into coherent policies.

The potential synergies between energy and climate strategies include reducing fugitive emissions in the fossil-fuel supply chain, selecting locations for renewable generation that have minimal impact on biodiversity, and improving control over electricity demand and supply. Strategic energy-transition plans may negatively affect food, water, and biodiversity. Implicitly, maximising economic growth could be influenced by climate policies that define the role of energy in the socio-economic system; these policies may also incorporate objectives such as energy independence, reducing fuel poverty, improving air quality, increasing accessibility, and fostering innovation. These factors will shape the options for energy transition processes.

Countries with high-quality data and comprehensive mapping of energy resources, fossil-fuel reserves, biodiversity, water availability, population distribution, land cover, and soil types will be better equipped to implement an integrated approach. Additionally, monitoring complex energy-climate-land systems requires advanced computational power and analytical capabilities.

In many nations, electricity and gas supply planning typically covers only a 5-10 year period. For many capital-intensive assets, this timeframe is much shorter than the technical lifespan of transmission lines and gas pipelines. A major obstacle to reliable energy transitions and grid stability is inefficient investment in grid expansion and interconnection.

Strategic investment-planning systems are crucial for the effective management of generation assets and for addressing supply intermittency. Such strategies include identifying network vulnerabilities and solutions such as grid expansion, enhanced interconnection, investments in storage, deferred maintenance, and demand-side management. Long-term investment plans that outline the infrastructure lifecycle and align with future policy directions and risk management can build confidence among private stakeholders during the energy transition.

In the electricity sector, particular attention should be given to resilience and reliability, especially as extreme weather events and climate stressors increase. The costs of grid failures are substantial and rise with transition ambitions. Adaptation measures present new co-investment opportunities aligned with decarbonization goals, attracting funds and facilitating investments through dedicated financial instruments.

Energy transition strategies have broad distributional impacts. To secure broad support, equity considerations must be incorporated. Stakeholders should be actively involved early in the process to provide information and help refine strategies. Simple climate models indicate there are significant trade-offs between overall welfare and equitable distribution during this transition. Policymakers, tasked with regulating the fossil-fuel industry, could have chosen to restrict extraction methods, but often opt not to be constrained by such limits.

5.1. Energy, Climate and Land-Use Planning.

Integrated energy governance aims to align economic, environmental, and social targets in sectoral policy, while recognising the interdependence of land-use planning, energy systems, and climate mitigation. The availability of fossil fuel and renewable energy options depends on energy demand. Urban land-use planning manages spatial land-use arrangements that influence transportation, building construction, and energy demand across economic sectors, including the fossil-fuel sector (Dowling et al., 2018). Energy transitions can be either positive or negative, depending on land-use decisions. Therefore, incorporating energy and land-use governance should be a higher priority in jurisdictions experiencing rapid urbanisation and significant pressure on climate transitions.

At the same time, policies supporting the energy transition should be promoted to enhance climate change mitigation and adaptation efforts. However, a proactive, long-term collaboration among various industries and interest groups is often necessary to identify and harness synergies (Cowell et al., 2017). The development of new cities can also contribute to the energy transition by allowing for spatially concentrated growth.

5.2. Infrastructure Modernisation and Benchmarking.

Infrastructure benchmarking involves a set of methods aimed at enhancing the efficiency, performance, and quality of assets by achieving optimal standards and best practices. These methods support investment decisions, modernisation efforts, and strategies focused on restoring customer demands. These approaches include mobility and accessibility targets set by infrastructure for public transport or goods delivery, the use of real-time and predictive data in asset management, and the integration of coordinated shipments across various enterprises.

Grid planning in the current infrastructure investment climate allocates budgets or financial resources either broadly over a 10- to 20-year period or specifically to particular asset segments. High-power conditions increase the risk awareness of traditional grid resources, which can be powerful enough to impair the electric distribution system, including forest fires and natural catastrophes. Besides ensuring and maintaining grid security against expected events, planning also aims to create broader, more collaborative interconnections to allow greater flexibility in asset coordination, as well as to enhance current flexibility for rapid adaptation of the population to a changing environment.

5.3. Equity in Society and Acceptance by the People.

Energy transitions have varied effects on different stakeholder groups and create distributional impacts within the economy. Just transition considers the winners and losers of the shift and seeks to protect the most vulnerable and marginalised members of society. For example, less affluent families may find it harder to afford renewable options, emerging technologies, or more expensive energy sources. They might also rely more on fossil fuels for transport and heating, making them more vulnerable to rises in electricity and fuel prices (Pastukhova & Westphal, 2020). Engaging diverse stakeholder groups in both decision-making and planning is essential for developing a shared understanding of the impacts and finding equitable ways to address them. A more participatory, bottom-up approach can be reinforced through risk communication and knowledge co-creation strategies (E. H. Jenkins & Martiskainen, 2018).

6. Funding Transitions towards Sustainable Power.

Finding sources of capital to finance sustainable power transitions involves substantial capital flows. Large-scale financial investments are still needed in low- and middle-income economies, along with innovative methods for managing and allocating those investments and for sharing the associated risks. Science-based goals and aspirations aligned with the net-zero scenario from the International Energy Agency (IEA) and other organisations indicate that a significant increase in financing is necessary to meet these capital demands. This scenario requires an urgent recalibration of financing policies, mechanisms, and interventions to enable timely investments and transitions. Proper planning can improve capital allocation, enhance knowledge sharing and innovation, and prevent wasteful public spending.

A comprehensive investment framework that addresses critical issues, including financing gaps, risk management, and public financial management, is essential to achieving sustainable power transitions (Pastukhova & Westphal, 2020). Systematic evaluation of existing financing gaps and funding mechanisms that boost leverage is key to such an encompassing investment structure. Effective planning for how governments should finance investments in sustainable power and other relevant non-power sectors, without compromising fiscal sustainability, can help address the capital challenges many economies are facing. Additionally, exploring innovative financing tools is crucial to ensure that funding for sustainable power transitions continues and that other sectors, which may need support during crises like the pandemic, are not disrupted.

A considerable share of expenditure on low-emission power transitions is in non-power sectors, including industry, transport, buildings, and water. Overall, the capital needed to make these sectors resilient to climate change is even greater (Cowell et al., 2017).

6.1. Investment Structures and Financing Holes.

It is important to develop sustainable, inclusive, and capable capital markets that can meet the diverse investment needs to enable a sustainable energy transition in a post-pandemic world (Pastukhova & Westphal, 2020). New state resources for investment financing depend on a limited public budget and fiscal space, and combine financial and economic policy, creating the risk of unsustainable finance. Public and private financing cooperation should be extended to the circular economy and other investments that offer natural climate solutions with relatively low co-financing rates and additionality. Stakeholders should identify financial resources to invest in sustainable energy projects and, ideally, align financing with capital needs through formal financing structures.

6.2. Risk Allocation and Public Financial Management.

To ensure a substantial reduction in greenhouse gases (GHGs) and the reliable supply of electricity to all, significant investments are being made to transition to low-carbon electricity. An annual investment of at least USD 0.7-0.8 trillion is needed, in addition to the existing USD 0.7-0.8 trillion invested in capital stock, maintenance, and operations (Pastukhova & Westphal, 2020). The transition requires private-sector funding, as is common across most sectors. Government subsidies on capital spending or other financial aid are not so extensive as to overshadow the fundamental need for the power supply to be privately financed. Sharing risks between the private and public sectors is crucial for identifying willing investors and the terms on which they will fund the transition.

Government actors often rely on public financial management (PFM) to guide the transition in a manner that complements market- based tools, standards, or other governance methods. PFM encompasses the organisation, expenditure, monitoring, accounting, and reporting of government revenues and expenditures. Understanding PFM provides insight into the available instruments and how best to use them to mobilise private capital. PFM's role is not to specify how governments will fund the transition, but to manage transactions with the private sector and consider how fiscal sustainability influences risk allocation. Overall, the public sector can influence funding availability primarily through issuing guarantees or instruments that share investment risks with private partners. PFM involves arranging government finances so that private sector entities perceive fiscal stability, thereby increasing their confidence.

Creating a stable investment environment, achieving high GHG reductions at low incremental costs, and integrating system-wide decarbonization into electric sector policies are essential for transitioning to a low-carbon electricity sector. The ongoing review of PFM policies offers an opportunity to incorporate GHG mitigation strategies that support the broader investment agenda.

6.3. New Financial Engineering.

Governments are borrowing new financial instruments to hasten the shift to sustainable power. Blended finance, green and social bonds, credit-enhancing securitisation, and performance-based financing will reduce financing costs and increase the number of eligible projects. These tools can enhance financial mobilisation and also help achieve broader energy and climate policy goals.

Green bonds enable both the public and other institutions to raise more funds for energy initiatives. They usually do not have a significant incremental price (compared to regular bonds) (Pastukhova & Westphal, 2020). The green bond market is developing rapidly, growing to more than 200 billion dollars by 2020 from less than 1 billion dollars in 2011. Blended finance is a mix of concessional and non-concessional financing used to attract private-sector investment in higher-risk projects with lower returns in the early stages. Blended finance can significantly expand the range of bankable, commercially viable energy projects, but its implementation remains limited in developing and emerging economies.

Credit-enhancing securitisation involves pooling the cash flows of several financing claims, such as residential rooftop solar, to create new financial instruments that attract broader investment. Specific credit-enhancement tools may be used to support securitisation and encourage the availability of affordable financing. Various performance-based investors also link the authorisation and timing of disbursements to specific milestones or outputs within project series, providing additional accountability. This approach is especially suitable for digital technologies, where completing specific tasks can be outlined more clearly and objectively.

7. Assessment of Climate, Environmental and Social Impact.

In energy planning systems, governments and stakeholders typically conduct climate, environmental, and sustainability analyses to assess the footprints of energy technologies on climate, the environment, and society. These evaluations help guide long-term investment directions and build public trust. Life cycle assessments (LCA) can provide a starting point for responsible technology development, compare options, and identify co-benefits and trade-offs (Pastukhova & Westphal, 2020). Issues related to environmental justice and indigenous rights have led some jurisdictions to adopt rights-based approaches, where the rights of affected peoples are acknowledged and promoted by project proponents. This involves genuine consultation and proactive benefit-sharing solutions, rather than just legal minimums, to develop win-win alliances and explore new compensation and equity-sharing arrangements. Addressing climate resilience, vulnerability assessment, and adaptive governance is also important, as it helps understand the links between climate resilience and mitigation efforts, while considering how demands may change under different climate conditions.

7.1. Lifecycle Assessments and Sustainability Requirements.

Sustainability evaluations assess the long-term viability of energy production systems; lifecycle assessment (LCA) systems utilise energy and environmental metrics to analyse trade-offs among options. The LCA process includes four phases: (1) goal definition and scope; (2) inventory analysis (quantifying energy, environmental, and economic considerations) in both physical and monetary terms; (3) impact assessment (characterising environmental impacts based on inventory data); and (4) interpretation (evaluating results with reference to the initial goals), which involves numerous data sources and methods. The most important is the benchmark system, a technology used as a standard of reference that influences other assessments based on predefined criteria (Calabrese, 2017).

When targets, such as renewable energy goals, and implicit targets, such as climate policies, are integrated into the energy discourse, significant socio-economic consequences follow. Regardless of systematic approaches, their implementation involves a series of issues related to the political adoption process. Additionally, it often overlooks other fundamental aspects of the power sector's dynamics and the related international and regional governance frameworks. The adoption of a new power-generation technology changes the energy mix and influences the relationships among alternatives and the model's constraints. Retrospective evaluations of past situations to understand performance and trade-offs relative to other governance constraints and agency structures are also necessary in decision-making (Pastukhova & Westphal, 2020).

7.2. Environmental Justice and Toronto rights.

Everyone is affected by energy transitions; at the very least, they can widen existing inequalities and social injustices, and at worst, energy projects can threaten long-established rights, livelihoods, and even lives. The issue of defining justice too narrowly highlights the importance of broad consultations on any plans to accelerate energy transitions (Finley-Brook & L. Holloman, 2016) that are both sensitive to and attentive to the rights and interests of underrepresented groups (Jenkins et al., 2018). Renewable energy projects that are already facing strong opposition, especially those in rural areas perceived as less valuable by policymakers and developers, have already caused harm beyond merely creating new privileges and profits. Occupied lands have the freedom to re-regulate, whereas decarbonisation stifles agency (Velasco Herrejon & Savaresi, 2020). Most parts of the world lack basic norms; decarbonisation directly contributes to additional infractions. Undoubtedly, all parties are free individuals, but they are also oppressed and deprived: no one is a free person devoid of dignity.

7.3. Considerations of Resilience and Adaptation.

The increasing number and severity of climate impacts also threaten energy systems worldwide. Addressing climate resiliency and adaptation issues thus becomes increasingly urgent in the pursuit of sustainable power transitions. Climate resilience assessment helps identify vulnerabilities, improve system design, and maximise synergies for adaptation. Resilience-focused tools and analyses offer deeper insights into how climate affects energy systems and support the development of governance solutions to prepare for or reduce challenges.

The complexities of climate action further heighten the need for resilience-oriented analyses. Achieving net-zero emissions requires unprecedented changes to energy systems, which must also continue to provide energy services that support human well-being and system functionality. Currently, energy systems already face stress that climate change can amplify. Extreme weather events, rising sea levels, changing precipitation patterns, and reductions in hydropower pose significant challenges (Pastukhova & Westphal, 2020). The importance of resilience and governance solutions focused on resilience continues to grow, especially as systems must adapt to climate change while contributing to climate mitigation. Recognising the intersection of energy transitions and climate resilience is vital to climate policy and governance strategy development.

8. Policy Appraisals and Governance Performance.

Sustainable electricity transitions require effective and responsible energy governance (Pastukhova & Westphal, 2020). The speed at which power systems develop and the variety of policy instruments used to support them all demand ongoing assessment of policy outcomes, institutional capacities, and governance needs. Policy formulation benefits from performance metrics, integrated evaluation frameworks, and learning through repetition.

8.1. Monitoring, Indicators and Transparency.

The performance evaluation of governance arrangements involves systematic monitoring of policy actions and technological, socio-economic, and environmental developments (Pastukhova & Westphal, 2020). It is thus important to establish indicators, data sources, data-collection frequencies, interpretation protocols, and public-reporting formats. The key performance indicators (KPIs) essential for standardising complex information facilitate effective, efficient information sharing.

Observation of key KPIs should be accompanied by transparency in governance procedures. The availability of information on the mandate, powers, resources, decision-making processes, and relations among governance actors in a publicly accessible manner promotes understanding, scrutiny, and accountability. Whenever data can be made publicly available, they should be so to enable independent oversight.

8.2. Reform, Corruption Risk and Accountability.

The reforms in the electricity sector are typically expected to improve access to electricity, reduce losses, and enhance institutional efficiency. Since implementing these reforms, the electricity sector in Sub-Saharan Africa (SSA) has shown improved performance in increasing connections, reducing both technical and non-technical losses, and improving infrastructure operations. These improvements have not only boosted sector performance but also strengthened the national economy through greater electricity access and higher income (I. Imam et al., 2019) ; (Jamasb & C. Littlechild, 2004). Therefore, reforms can facilitate a smooth power transition by addressing governance and corruption issues.

Governance plays a key role in how the government enacts policies and mobilises societal resources to support a low-carbon transition (Pastukhova & Westphal, 2020). However, significant governance gaps- such as systemic corruption, accountability issues, capacity limitations, and civil society marginalisation- still hinder progress and overall performance. Opportunities for corruption can be reduced through anti-corruption measures, protecting whistleblowers, and streamlining bureaucratic processes. Encouraging ethical behaviour can also be fostered by enabling citizens to scrutinise decision-makers through legal and governance channels and by providing access to information. A transparent decision-making process based on renewable energy that records and shares the motives and reasoning behind decisions can motivate stakeholders and improve policy design. Mechanisms for accountability, anti-corruption provisions, transparent explanations of governance choices, and disclosure of the actors and interests involved in renewable energy decision-making can all help identify governance bottlenecks and support appropriate reforms (Pastukhova & Westphal, 2020).

8.3. Learning Systems Learning and Policy Iteration

The learning systems enable policy improvement through iteration, incorporating feedback from policy implementation into subsequent decisions and addressing one of the most common challenges in governance: policy stagnation over time in dynamic environments. Digital platforms, which facilitate real-time data collection and broad participation, enhance these systems (S Rogge et al., 2020). Policy experimentation allows policymakers to test new designs on a small scale, reducing the risk of systemic upheaval and fostering understanding of large-scale changes (Pastukhova & Westphal, 2020). An agent-based modelling system can replicate socio-technical dynamics and heuristic behavioural responses to simulated interventions, thereby supporting trial-and-error approaches to intervention design (Adepetu, 2016).

9. Sustainable Governance of Power Case Studies.

The sharp increase in the share of variable renewables in developed economies presents an opportunity to promote a sustainable power transition by leveraging intensive policy learning across jurisdictions. This section reviews instances where a significantly larger share of renewable energy has been integrated without causing a qualitative decline in electricity services or hindering broader sustainability objectives. The examples are based on three different cases of sustainable power governance: high-renewables systems in Germany, Denmark, and California; demand-side integrated resource planning in New Zealand and British

Columbia; and urban load-shifting policies in Singapore and Sydney. All these examples demonstrate how governance arrangements can address what might otherwise seem like even more daunting sustainability challenges.

These jurisdictions are categorised within a four-dimensional framework based on their specific sustainability bottlenecks; the policy strategies they employ to overcome these bottlenecks; and the tangible results achieved, evaluated through service-quality indicators and broader environmental and social goals (Cowell et al., 2017). The assessment aims to extract lessons that can be applied elsewhere to accelerate power transitions in ways that support both service quality and sustainability objectives.

9.1. High-Renewables Jurisdictions

The shift to high-renewables energy systems presents complex techno-economic and governance challenges that require bold policies tailored to local circumstances and interests. The literature on energy governance recognises a wide range of policy instruments and governance actors in various regions involved in sustainable energy transitions. To illustrate the effectiveness of different policy combinations in transforming energy systems, this section will examine six high-renewable jurisdictions with diverse social, geopolitical, and economic backgrounds: two US states, California and New York; Germany; the European Union; Japan; and South Korea. The concept of high-renewables policy used here also encompasses various technological options, such as electricity demand management, distributed energy storage, renewable energy replacement, electrification of energy carriers, and energy importation (Pastukhova & Westphal, 2020). Recent reports emphasise a crucial shift in how energy systems are regulated to accelerate transitions through socially equitable and economically efficient policies.

9.2. Demand-Side Management combined with Integrated Resource Planning.

Integrated resource planning (IRP) is an effective way to operationalise synergies among energy efficiency, demand response, and supply-side measures. With an integrated approach, jurisdictions can determine the best combination of dispersed demand-side solutions and centralised investments in generation, transmission, and distribution assets. When adopted strategically, IRPS enable regulators to make long-term decisions about capacity expansion to meet future demand.

However, the full potential of IRP can be realised only when demand-side resources are managed as a portfolio. While the expenditures and revenues of individual demand-action strategies are well understood, the additional capabilities depend on the timing and scale of other supply-side initiatives, which often hit constraints or shift unexpectedly. This is because such interactions cannot be modelled by evaluating programs individually or merely summing their outcomes. Instead, an optimisation system that accounts for all distributed energy efficiency, demand-response, and behavioural demand-side programs over a specific planning horizon must be implemented.

There are two case studies illustrating the main benefits of integrated demand-side planning. The first focuses on Bermuda, a small jurisdiction heavily dependent on fuel oil for electricity. In traditional planning, a new diesel unit was projected to be added in 2015 to meet peak demand. However, an integrated demand-side management approach shows that a combination of dispersed energy-efficiency measures and an interruptible load program can be cost-effective, allowing postponement of this investment to 2018 or later, based on expected demand levels.

9.3. Decarbonization of the Urban Grids.

The energy systems in cities are undergoing a significant redesign, with increased focus on the grid. Demand-side management (DSM) has become very prominent because it is primarily in residential and commercial areas where a large portion of potential energy savings can be achieved. DSM can transform energy demand through financial incentives, price adjustments, or technical measures like using energy-efficient equipment or load control. The performance indicators for grid decarbonization include greenhouse gas emissions, fossil fuel displacement, technological feasibility, co-benefits, and equity. It is now possible that a transition to a low-carbon residential and commercial electric grid can be fully realised through planning and the installation of the required technologies and practices (N. Behles, 2012). City energy systems are gradually becoming more sustainable, enabling more substantial reductions in the upstream carbon content of the electricity supply. Therefore, it is essential to establish clear strategies to achieve this goal.

10. Conclusion

The effort to consider technical and systemic factors in the review of key governance practices across various working jurisdictions adds conceptual burden on sustainable power transitions. The viability of policies, situational factors, and social equity involved in parallel, time-reflected governance lines- especially in connection and transition-related governance- are key focus points over time.

Major governance arrangements and actions are evaluated at institutional, planning, financing, impact, administration, and broader performance levels. A range of essential transition challenges is clearly identified at these levels, with governance measures serving as criteria that are cognitive, inclusive, safe, open, stable, considerate, trusted, diversified, coordinated, and engaging. These measures aim to integrate decision-making into system designs rooted in deep, whole-system sustainability pivots.

Energy governance encompasses various policies beyond the energy sector itself, which are globalised through systems-analytical representations used strategically in decarbonization efforts. Typically defined as institutional arrangements that shape energy policies and support effective power transition frameworks, energy governance involves actors, settings, and governing mechanisms designed to facilitate socio-technical transitions toward supply systems that utilise indigenous energy resources. Addressing power transition scarcities requires offsetting policies that micromanage normative, conditional, temporal, and spatial governance, involving multiple governance systems for long- term transitions. These are aimed at ensuring secure, stable, affordable decarbonization, while co-integrating lower emissions with broader sustainability goals for climate-resilient futures, aligned with frameworks of constrained rather than permissive global carbon budgets. The scope, relevance, settings, and implications of governance are detailed within the jurisdictions under review, in relation to policy instruments that influence the delivery of finance, disclosure, the adoption of analysis, and the issuance of orders.

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