Macro-Policy Note

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Will renewable energies make electricity prices more or less volatile than in the oil era in Europe?

Abstract

In the oil era in Europe, the shift towards renewable energies has the potential to reduce electricity price volatility. Renewable sources like wind and solar offer stable, low-cost electricity once infrastructure is established, lessening reliance on volatile oil markets. Regulatory support, including the Paris Agreement and the European Green Deal, incentivizes renewable energy adoption, promoting market stability. However, integrating intermittent renewables into the grid poses challenges, potentially leading to short-term price fluctuations. Additionally, upfront investment costs may temporarily increase prices. Despite these challenges, continued investment and supportive policies can pave the way for a more stable and sustainable energy future, potentially reducing electricity price volatility in Europe.

Key words: :Renewable energy, electricity prices

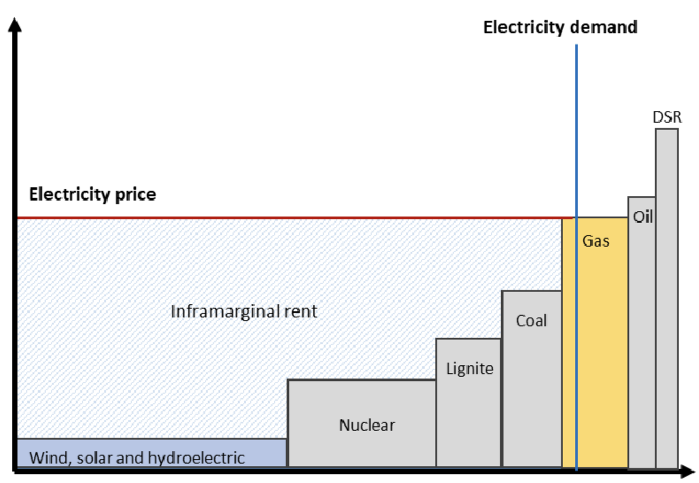
1. Introduction

The recent geopolitical tensions, such as the Ukraine-Russian war, have underscored the volatility of electricity prices in Europe, particularly through the lens of gas imports. However, this is not an isolated incident. There have been numerous instances where electricity prices have surged due to various factors, ranging from geopolitical tensions to supply-demand dynamics. The looming threat of climate change further complicates this picture, potentially leading to increased price volatility in the future. Despite this volatility, it's important to note that while prices fluctuated, they generally remained low, underscoring the importance of transitioning to more sustainable energy sources. In 2021, renewable energy accounted for the largest share of primary energy production in the EU, at 40.8%, followed closely by nuclear heat (31.2%). This shift towards renewable energy sources, such as wind, solar, and hydropower, has had a profound impact on electricity price volatility. Historically, electricity prices were tied to oil prices, but the characteristics of renewable energy have the potential to alter these pricing dynamics. For instance, once the infrastructure for renewable energy is in place, the marginal costs are relatively low, potentially leading to stable, predictable prices compared to the volatile oil markets. Looking ahead, the forecast for electricity and renewable energy sources is crucial in the context of the Paris Agreement and the Green Deal imposed by European institutions. The EU's dependency on energy imports reached 60%, with petroleum oils representing 61.1% of total energy imports. Despite a long-term decrease, oil remains the most significant energy source for the European economy, followed by natural gas. However, the energy intensity of the economy is expected to improve by 1.9% in 2021 but remains below the targets of the Net Zero Emissions by 2050 Scenario. As we transition to a more sustainable energy future, it's essential to strike a balance to ensure a reliable, resilient energy system. This will involve considering various factors, including the energy source mix, market structure, regulatory frameworks, and technological advancements.

2. The EU Electricity Market

The European electricity market operates on a wholesale basis, facilitating electricity exchanges between countries and promoting price convergence. Due to the nature of electricity, which cannot be stored in large quantities, there is a constant need to balance supply and demand. This balance is achieved through a marginal pricing system. In this system, power plants submit bids for quantity and price, forming a 'merit order'. The price for all electricity produced is determined by the highest accepted bid, also known as a uniform price auction. There are several types of electricity markets within the European framework. The day-ahead market involves electricity being traded for delivery on the next day, with hourly prices set for each market area. This allows for a degree of predictability in pricing. In contrast, intraday markets, also known as UE markets, involve electricity being bought and sold closer to real-time, up to one hour before delivery. This results in more volatile prices due to the shorter time frame and the immediate need to balance supply and demand.

Figure 1. European Electricity market



Source: EC JRC

Lastly, capacity markets play a crucial role in ensuring sufficient capacity to meet demand. In these markets, power plants are paid for availability, regardless of actual production. This provides a financial incentive for power plants to ensure they can produce electricity when needed, thereby contributing to the overall reliability and resilience of the electricity system. One of the advantages of this system is that it allows for low-cost energy sources to make profits. Since the price for all electricity produced is determined by the highest accepted bid, power plants that can produce electricity at lower costs can make significant profits. This incentivizes the use of low-cost, renewable energy sources, which can help drive the transition to a more sustainable energy future. However, there are also drawbacks to this system. For instance, when the electricity demand exceeds the supply from low-cost, renewable sources, more expensive sources such as gas may be needed to meet the demand. This can result in higher electricity prices for consumers. Additionally, the reliance on gas can make the entire electricity market vulnerable to fluctuations in gas prices, which can be influenced by a variety of factors including geopolitical tensions and supply-demand dynamics. This can lead to increased electricity price volatility, particularly in regions heavily reliant on gas.

3. The Issues of Electricity Supply and Demand

Non-EU Countries Dependence

The European Union's (EU) energy system is heavily dependent on non-EU countries, which poses several challenges. One of the most significant issues is the EU's reliance on Russian gas. Supplies of Russian gas, critical for heating, industrial processes, and power, have been cut by more than 80 percent. This has led to a surge in wholesale prices of electricity and gas, severely affecting households and businesses.

The dependence on Russian gas has also led to a loss of sovereignty for the EU. The weaponization of gas exports by Russia was a dominant element in EU gas markets from July to September 2022. This has propelled wholesale gas prices and had a massive impact on the electricity market, causing significant increases across the EU.

In the transition to clean energy, the EU will also face future dependence on minerals. Clean energy technologies, such as solar photovoltaic (PV) plants, wind farms, and electric vehicles, generally require more minerals to build than their fossil fuel-based counterparts. The shift to a clean energy system is set to drive a huge increase in the requirements for these minerals, meaning that the energy sector is emerging as a major force in mineral markets. This could potentially lead to new dependencies on non-EU countries that are rich in these minerals, posing additional challenges for the EU's energy transition.

Rising Consumption Demand

The demand for electricity in the European Union (EU) is on the rise. This increase is driven by the electrification of transport and a ramp-up in the production of green hydrogen through electrolysis, requiring renewable power. However, this growing demand poses challenges for the resilience of the EU's energy system.

One of the strategies to manage this rising demand is the concept of energy sobriety. Energy sobriety means reducing our energy consumption by changing our consumption styles, uses, and behavior. It is a socio-cultural approach that relies on individual and collective behavior changes to prioritize essential energy needs and reduce demand. These changes may include limiting waste, reducing speed on the road, using objects tailored as closely as possible to our needs, and more.

Another strategy is the implementation of "Heures Pleines/Heures Creuses" (Peak Hours/Off-Peak Hours), a tariffication system for electricity in France. The way this system works is that the price of each kWh consumed depends on the time of day, with one price set during the "Heures Pleines" and a cheaper one set during the "Heures Creuses". The goal of this system is to encourage consumers to shift their consumption hours later or earlier in the day, to quieter times, to smooth out electric consumption on a regional and national level.

Importance of Green Investments in the Markets

Green investments refer to the allocation of financial resources to projects or companies that focus on sustainable practices, environmentally friendly technologies, and the conservation of natural resources. They play a crucial role in the transition to a low-carbon economy, helping combat climate change and promote sustainable development. These investments also have the potential to create new jobs, drive innovation, and foster long-term economic growth.

There are different ways to promote green investing in a portfolio, including investing in individual stocks as well as exchange-traded funds (ETFs), mutual funds, and green bonds.

The sector faces challenges such as the lack of standardized criteria for defining green investments, potential greenwashing, and the need for more extensive disclosure and reporting.

Merit Order System and Renewable Energies

The merit order system is a way of ranking available sources of energy, especially electrical generation, based on ascending order of price and used to meet demand. In this system, renewable energy sources, such as wind and solar, often have lower operational costs compared to fossil fuel power plants, and thus, are dispatched first.

The challenge arises when the supply of electricity from renewable sources exceeds the demand. Since renewable energy has near-zero marginal cost, it can lower the wholesale electricity price when it enters the market. This phenomenon, known as the "merit order effect," can lead to lower revenues for all power producers in the market, including those operating renewable energy plants, when the supply of renewable energy is high.

However, it's important to note that these challenges do not diminish the value and importance of renewable energy. They simply represent hurdles that need to be overcome as we transition to a more sustainable energy system. Solutions could include energy storage technologies, demand response measures, and grid enhancements to manage the variable nature of renewable energy. These strategies can help ensure that renewable energy can be effectively integrated into the market and continue to provide its many benefits.

Challenges of Full Dependence on Renewable Energies

While renewable energies like solar and wind power are indeed beneficial for their potential to provide clean, sustainable energy, they also present certain challenges when it comes to full dependence.

One of the main challenges is that these energy sources are heavily dependent on weather conditions. Solar power, for instance, is inherently only available during daylight hours, and its output can change suddenly due to clouds. Similarly, wind power is only generated when it's windy. This means that renewable energy cannot always consistently produce energy at all hours of the day, a phenomenon known as intermittency.

The intermittency of renewable energy sources can pose significant challenges for the stability of the power grid. The power grid was designed around the concept of large, controllable electric generators. Because the grid has very little storage capacity, the balance between electricity supply and demand must be maintained at all times to avoid a blackout or other cascading problem. Intermittent renewables disrupt the conventional methods for planning the daily operation of the electric grid. Their power fluctuates over multiple time horizons, forcing the grid operator to adjust its day-ahead, hour-ahead, and real-time operating procedures.

Future Price Shocks / Protect the Vulnerable

Future price shocks in the electricity market can have significant impacts on both the economy and consumers. These shocks can be triggered by various factors, including fluctuations in the supply and demand of energy, geopolitical events, and changes in energy policies. They can lead to sudden and substantial increases in energy prices, causing financial stress for consumers and businesses.

Price shocks can particularly affect vulnerable individuals, who often spend a larger proportion of their income on energy5. These individuals may struggle to afford their energy bills during periods of high prices, leading to energy poverty. This can have serious consequences, including health issues related to inadequate heating or cooling.

High Entrant Costs in the Renewable Energy Market

In the renewable energy sector, the high entrant costs are primarily associated with the capital-intensive nature of renewable energy technologies. These technologies often require significant upfront investment to cover the costs of manufacturing and installing renewable energy systems.

For instance, wind and solar power systems involve high initial costs for the production and installation of wind turbines and solar panels. Additionally, there are costs related to site evaluation and preparation, system design and engineering, permitting, and grid connection.

Despite these high entrant costs, the long-term benefits of renewable energy, such as lower operational costs and environmental sustainability, can make it a worthwhile investment. Furthermore, the costs of renewable technologies have been decreasing over time, making them increasingly competitive with traditional energy sources.

However, these high entrant costs can still pose a challenge, particularly for smaller companies or projects. Difficulty in accessing finance, high financing costs, inadequate regulatory frameworks, and policy uncertainty have all played a role in hindering the deployment of renewable.

Cooperation and Transparency

Cooperation between agents and firms in the electricity market is crucial for maintaining energy security and affordability. This involves sharing information, coordinating actions, and working together to manage supply and demand. Cooperation is also key to integrating renewable energy sources into the grid and managing the variability of these sources.

The Agency for the Cooperation of Energy Regulators

(ACER) plays a significant role in promoting cooperation in the EU electricity market. It helps to ensure that the market operates efficiently and fairly and that all market participants have equal access to information.

Transparency in the electricity market is essential for preventing market manipulation and ensuring fair competition. It involves the open and timely sharing of information about market operations, including prices, volumes, and the operational status of power plants.

The EU has introduced regulations to enhance market transparency and integrity. For example, the REMIT Regulation extends the scope of data reporting on the electricity market, improves the process of inside information collection, and strengthens the supervision of reporting parties.

Role of electricity in 2050 (the Accords of Paris)

In the EU27, the use of electricity in final energy demand is projected to increase from 23% to 30-31% by 2030 and between 47% to 60% by 2050. This growth will be driven by direct electrification, replacing fossil fuels with carbon-free electric options in key sectors responsible for greenhouse gas emissions. Additionally, indirect electrification using green hydrogen and e-fuels via electrolysis will complement direct electrification in hard-to-abate sectors. Electrification offers multiple benefits beyond decarbonization, including enhanced affordability and security of supply, improved energy efficiency, better urban air quality, increased flexibility and sector coupling through digitalization, resource efficiency, and the creation of new quality jobs through a just transition process.

4. Institutions Proposals

European Parliament Proposals

- The European Parliament proposed comprehensive reforms to the electricity market in response to the 2022 energy crisis.
- Objectives include enhancing resilience, reducing price volatility, and securing clean energy supplies.
- Proposed reforms aim to lessen electricity bill dependency on short-term fossil fuel prices by minimizing the role of gas in short-term markets and pricing inframarginal technologies based on true production costs.
- Efforts to promote renewables in the energy market include offering consumer protection against price volatility and enabling them to generate and share electricity.
- Enhancing market transparency, surveillance, and integrity is crucial to bolster consumer confidence and encourage renewable energy adoption.
- Ongoing deliberation focuses on reforming the merit order system to decouple electricity prices from gas prices, ensuring they reflect actual production costs more accurately.
- The European Commission introduced legislative initiatives in March 2023 to enhance European electricity market design and protect against market manipulation, aligning with long-term objectives outlined in the Green Deal.
- Provisions for Power Purchase Agreements (PPAs) were included, allowing member states to support the purchase of new renewable generation and maintain the voluntary nature of standardized contracts.
- In December 2023, a provisional agreement was reached to reform the EU's electricity market design, aiming to decrease dependency on volatile fossil fuel prices, shield consumers from price spikes, accelerate renewable energy deployment, and enhance consumer protection.
- This agreement is expected to reduce reliance on Russian gas and promote fossil-free energy to mitigate greenhouse gas emissions.

ACER's Assessment of Electricity Market Design

- The ACER Final Report provides an extensive analysis covering energy price levels and drivers, current wholesale electricity market design, future-proofing strategies, extreme price shocks, temporary measures, and impacts on retail markets and consumer protection.

- Key findings highlight the necessity of improving the current electricity market design to address challenges effectively.
- Proposed improvements include enhancing the functionality of short-term electricity markets universally, fostering the energy transition through efficient long-term markets, enhancing system flexibility, protecting consumers from excessive volatility while managing trade-offs, addressing non-market barriers and political obstacles, and preparing for potential high energy prices in peacetime and wartime scenarios.
- ACER proposes a comprehensive set of 13 measures for policymakers to future-proof the market design, such as prioritizing consumer protection against price volatility, encouraging market making to enhance liquidity in long-term markets, expediting electricity market integration, implementing agreed-upon measures, enhancing forward market integration, prudently considering market interventions during extreme situations, and addressing root causes if interventions are pursued.

RTE report: Futurs energetics 2050

- The RTE report "Futurs energetics 2050" provides insights into several key areas, including energy consumption, the global economy, technology, the transformation of the electricity mix, space, and the environment.
- In terms of consumption, the report underscores the necessity of prioritizing energy efficiency and moderation to meet climate goals. It anticipates a decline in overall energy consumption, coupled with a notable rise in electricity usage as a substitute for fossil fuels, especially through industrial electrification.
- Concerning the electricity mix transformation, achieving carbon neutrality relies heavily on a substantial expansion of renewable energy sources. Notably, scenarios excluding new nuclear reactors require even faster growth rates of renewables compared to leading European countries.
- Economically, the construction of new nuclear reactors remains economically viable to maintain a significant energy capacity by 2050. However, the competitiveness of renewable energies, particularly large-scale solar and wind projects, is increasing.
- Technology plays a pivotal role, with the development of a "low-carbon hydrogen system" being crucial for decarbonizing challenging sectors and storing energy in scenarios with extensive renewable adoption. Moreover, scenarios with high renewable shares or nuclear extensions beyond 60 years necessitate significant technological advancements to achieve carbon neutrality by 2050.
- The report underscores the importance of integrating potential climate change impacts into the electrical system transformation, including considerations for water resources, heat waves, and wind patterns.
- Regarding space and environmental implications, the expansion of renewable energies must carefully balance space utilization with environmental preservation efforts. Despite potential challenges, the electrification drive in France is expected to make substantial contributions to carbon neutrality by displacing fossil fuels, although potential tensions may arise from the supply of mineral resources, especially certain metals.

Balanced Regulatory Remedy Power Price Crisis

- The paper addresses the ongoing electricity price crisis in the EU, which has led to sustained and unprecedentedly high electricity prices.
- National governments have responded by implementing temporary measures to mitigate the impact on end-user electricity bills. However, some argue that broader reforms to EU electricity markets are necessary to address the root causes of the crisis.

- The central proposition is to link consumer electricity prices to the average cost of generation, rather than being determined by the marginal generation technology, typically gas-fired plants, as is currently the case.
- However, the paper highlights the lack of clarity regarding how governments intend to achieve this objective without fundamentally redesigning electricity market structures and without compromising short-term and long-term power system efficiency.
- Upon reviewing existing approaches, the authors identify two main strategies being implemented or proposed to align consumer prices with the average cost of generation:
    1. Taxing alleged windfall profits in countries such as Spain, Romania, and Italy.
    2. Mandating auctions for bilateral contracts with insufficient demand-side pressure or regulated prices in countries including France, Spain, Bulgaria, Portugal, and Italy.
- These measures extend beyond the European Commission's prescribed toolbox for addressing and supporting actions related to the electricity market crisis, as outlined in October 2021.

5. Researchers Ideas

The Role of Renewable Energy Sources

Key Economic Factors

The market share of the largest generator in the electricity market (Electricity Generation Concentration) is a significant factor affecting electricity prices. An increase in market share leads to higher electricity prices. Based on Moreno et al. (2012) paper, the main factors influencing electricity prices in the European Union include: *Market concentration in electricity generation:* and *Electricity generated from renewable sources* The percentage of electricity generated from renewable sources (RES-E) has a positive estimated effect on electricity prices. The introduction of renewable energies into the electricity generation market can lead to higher electricity prices, as the generation of electricity from renewable energy sources is often driven by public renewable support schemes, which are usually paid for by consumers; *Gross Domestic Product (GDP) per capita*: The general economic activity, as measured by GDP per capita, can also impact electricity prices. A positive effect of GDP per capita on electricity prices is expected; *Greenhouse gas emissions by energy industries:* The total greenhouse gas emissions from energy industries can affect electricity prices. Emission trading schemes can increase the short-term marginal cost of energy industries, leading to higher wholesale electricity prices and, consequently, higher household electricity prices; *Energy dependency*: The European Union's high dependence on imported resources such as crude oil and natural gas means that electricity prices are linked to international energy raw material prices. Increased energy dependency can lead to higher electricity prices.

These factors reflect the complex interplay of market dynamics, environmental considerations, and economic indicators that influence electricity prices in the European Union.

Market liberalization on electricity prices

Market Concentration: Despite the liberalization of the generation sector in many EU countries, the market structure remains concentrated, with the market share of the largest generator in the electricity market not experiencing significant decreases for the majority of EU countries. This lack of a significant decrease in market concentration may limit the expected reduction in electricity prices for households; *Retail Competition*: While competitive retail markets aim to transfer electricity from the wholesale to the retail level at competitive margins, electricity reforms have been criticized for not passing the benefits through to domestic customers. Research has pointed out that reforms affect low-income households more than others; *Consumer Switching Costs*: Consumers face significant switching costs, which may hinder the realization of competitive electricity prices. Overcoming these costs may require costly investments in new knowledge or regulations; *Renewable Energy Support Schemes*: The public support schemes for renewable energies, financed via the electricity market, can lead to an increase in the final price paid by consumers. However, the increased use of renewable energies could potentially reduce household electricity prices, compensating for the price increase due to subsidies

Impact of Renewable Energy in EU Electricity Markets

The primary conclusion of this article is that the future electricity market and supply system will undergo significant changes, with known fundamentals persisting. The increasing integration of renewable, particularly higher quantities of wind and photovoltaic (PV) energy in the EU, will lead to heightened variability in generation. This variability will result in several effects on electricity market prices, including: Increased Price Volatility, Growing Importance of Intraday Markets Higher Prices for Fossil Capacities and Storage Technologies, Expansion of Balancing Markets, The key question arises about the feasibility and timeline for achieving an electricity market predominantly supplied by renewable. This is attributed to the substantial need for flexible generation, extensive storage, or large demand-side resources in a system heavily reliant on renewable.

Renewable Energy and Electricity Consumption

In the paper of Papież et al.(2019) the relationship between electricity consumption and economic growth depends on the maturity of the renewable energy sector. Countries with a higher share of the renewable energy sector experience more pronounced connections between economic growth and renewable electricity consumption. Notably, in countries with well-developed renewable energy sectors, an increase in renewable electricity consumption is found to boost the economy, contrary to previous Granger causality-based studies. Policy implications suggest that promoting renewable energy sources does not hinder economic growth and is likely to significantly contribute to future economic growth.

The study contributes to the ongoing debate on promoting renewable energy sources in the EU by delivering a clear message to policymakers about the low risks and high potential benefits of such development. Policymakers are encouraged to focus on stimulating sectors with low greenhouse gas emissions while reducing sectors with high emissions.

Market Design under Increasing Renewable energy

The current debate on the design of the electricity market in the European Union (EU) primarily questions the relevance of the existing wholesale market design. The analysis of Peng and Poudineh (2019), reveals discrepancies in the integration of renewable energies across various aspects of the market, from wholesale to retail and network regulation. Misalignments exist between national support for renewable and EU-level coordination mechanisms, such as market coupling and the Emissions Trading System (ETS). Disregarding these systemic frictions undermines the effectiveness of reform proposals.

The EU, particularly Denmark, Germany, Italy, and Spain, leads in commercially integrating renewable for decarbonization. The modular design of liberalized markets requires a collective evaluation to avoid suboptimal outcomes. Five key misalignments in the EU electricity market call for a holistic approach to reform, both at the national and European levels. Evaluation of the EU Clean Energy Package shows progress but highlights limitations, emphasizing the need for a comprehensive and forward-compatible approach. The development of quantitative simulation tools is recommended for a thorough analysis of market coordination modules. Lastly, addressing misalignments is necessary but insufficient; effective design must anticipate emerging trends to avoid new challenges.

Do Project of renewable on Electricity Scheme?

Renewable support schemes play a pivotal role in shaping the behavior of renewable in electricity markets, influencing market dynamics, price formation, and overall integration of renewable energy sources. The choice of support scheme significantly impacts electricity markets, affecting trading behavior and plant design. Various support schemes result in different levels of market participation, long-term investment decisions, and short-term generation adaptations by renewable plant operators. Winkler et al. (2014), highlight that fixed feed-in tariffs, for instance, guarantee a set payment to plant operators for each unit of electricity produced, regardless of market demand. This shields them from market price fluctuations. Conversely, market-oriented support schemes like market premiums, quota systems, and capacity-based payments can reduce the market impact of renewable. The choice of support scheme also influences the merit-order effect, leading to lower electricity prices due to renewable' low marginal costs.

One specific market-oriented support scheme, sliding premiums, combines market integration with productive risk allocation in renewable energy support policies. Similar to feed-in tariffs, sliding premiums vary based on the market price of electricity. This incentivizes renewable energy generators to adjust their generation according to market conditions, receiving a higher premium during high prices and a lower one during low prices. Sliding premiums also allocate risk effectively, sharing it between renewable energy generators and electricity consumers. In times of high electricity prices, generators receive a higher premium, while consumers pay a lower price. Conversely, during low prices, generators receive a lower premium, and consumers pay a higher price. This risk-sharing mechanism encourages renewable energy generators to invest in more efficient technologies, aiming to reduce variable costs and enhance profitability.

6. Policy Recommandations

Policy 1: Optimize Renewable Energy

- **Issue**: Existing renewable energy support schemes contributing to increased electricity prices.
- **Recommendation**: Conduct a comprehensive review of renewable energy support mechanisms to ensure they strike a balance between promoting renewable energy adoption and minimizing cost burdens on consumers. This may involve phasing out or restructuring subsidies that disproportionately impact electricity prices while incentivizing investments in innovative renewable technologies and grid integration solutions.

Policy 2: Enhance Market Diversification

- **Issue**: High electricity prices due to market concentration.
- **Recommendation**: Implement measures to reduce market concentration in electricity generation, promoting diversification of suppliers and enhancing competition. This can be achieved through regulatory incentives for new market entrants and measures to facilitate access to infrastructure for smaller players.

Policy 3: Promote Welfare and Empowerment

- **Issue 1**: Ineffective retail market reforms negatively impact consumers, particularly low-income households.
- **Issue 2**: High switching costs hindering consumer choice and competition.
- **Recommendation 1**: Develop targeted policies to ensure that retail market reforms benefit all consumers. This could involve establishing consumer protection mechanisms, such as price caps or targeted subsidies, to safeguard vulnerable consumers while encouraging competition and innovation in the market.
- **Recommendation 2**: Introduce initiatives to simplify the process of switching electricity suppliers, including standardized procedures and increased transparency in tariff structures. Additionally, implement consumer education campaigns to raise awareness about the benefits of switching and empower consumers to make informed choices.

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