

An Overview of the USA Energy Market

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Abstract

The USA energy market is a complex and evolving system that profoundly impacts the nation's economy and environmental landscape. This literature review offers a concise overview of the USA energy market, drawing insights from existing research. The review explores energy consumption trends, the diversity of energy sources, the influence of policies and regulations, market competition, pricing dynamics, and the challenges faced by energy infrastructure. The transition towards sustainable and resilient energy solutions in the face of growing demand and climate concerns remains a key challenge. This paper provides a glimpse into the USA energy market's multifaceted nature and its significance for policymakers, stakeholders, and researchers working towards a more sustainable future. In this article, the author tries to make an overview of USA electricity market from market from its appearance until today. The electricity market legislation and the authorities which assure market regulation are identified and presented. Federal and states transport and distribution system is overview and their connection. Finally, it is presented the market situation is shown together with the legal steps which was taken in order to promote the renewable energies.

Keywords: USA energy market, energy price evolution, USA energy mix

JEL classification: K32, L94, L95

DOI: 10.24818/RMCI.2023.4.499

1. Introduction

The USA energy market stands as a pivotal pillar of the nation's economy, shaping its growth trajectory, and influencing its environmental footprint. As one of the largest consumers of energy worldwide, the United States' energy landscape is characterized by dynamic complexities, intricate market structures, and a growing emphasis on sustainability. This academic paper aims to provide a comprehensive overview of the USA energy market, drawing on a synthesis of existing research and scholarly work.

Energy, as the lifeblood of modern societies, fuels industries, powers homes, and propels technological advancements. The USA's energy consumption has historically displayed an upward trend, closely linked to population growth, industrial expansion, and technological innovation. Examining these consumption

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trends can offer valuable insights into the nation's energy needs and the factors that influence them.

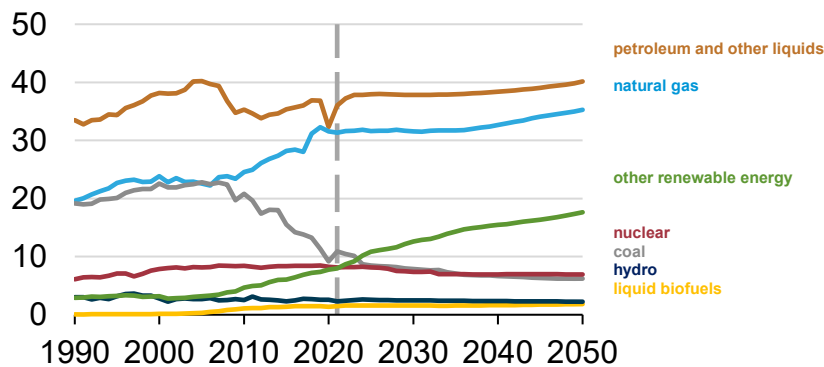
Diversity within the USA energy market lies at the heart of its resilience and adaptability. The energy mix comprises various sources, including fossil fuels such as coal, oil, and natural gas, alongside nuclear power, hydroelectricity, and an increasing contribution from renewables like wind and solar. The dynamics of this diverse energy mix and its impact on sustainability and environmental goals have attracted considerable attention from researchers and policymakers alike.

Government policies and regulations wield significant influence over the energy market's trajectory, directly shaping its evolution and sustainability efforts. Throughout the years, legislative acts, such as the Energy Policy Act of 2005 and the Clean Power Plan, have sought to drive energy independence, diversify energy sources, and reduce greenhouse gas emissions. Understanding the implications and effectiveness of these policies is essential in comprehending the direction and potential challenges of the USA energy market.

Market competition and pricing dynamics are critical elements of the USA energy landscape. Deregulation in some regions has fostered a competitive environment, where energy providers vie for market share, offering consumers an array of choices. However, balancing competitive forces with the need for stable pricing and grid reliability remains an ongoing challenge for energy market stakeholders.

Speaking about energy and energy market beginnings in USA, we should start, like also in other places in the world, with the sun and the wind. Starting with 1775 the wood became the first source of energy until 1850s when it was replaced by coal.

Bellow graphic, figure 1, issued by Energy Information Associations shows the history of energy consumption in United States 1990-2021 and the projections until 2050.



**Figure 1. Energy consumption by type of fuel in 2021
(Quadrillion British thermal units)**

Source: Energy Information Associations

Discovery of electricity in the middle of eighteenth century followed by electric bulb discovery open new horizons for electric public lightening of American cities.

In the late 19th century, hydropower was used as an electricity source.

The first electric transmission line in the U.S. was constructed in 1889, between the generating station at Willamette Falls in Oregon City, Oregon, and downtown Portland, Oregon. The line transmitted electricity over a 13-mile span, which is very small in comparison to today's standards, but was considered a major technological breakthrough at the time. (Pricopoaia et al., 2022).

As electricity was introduced in 1882, natural gas was no longer needed to light homes, causing the industry to shift to heating and cooking. (Grasu et al., 2023).

The energy infrastructure underpinning the USA's power generation and distribution faces a confluence of challenges. Aging assets, natural disasters, and cybersecurity threats pose risks to the nation's energy security and grid resilience. Addressing these challenges necessitates forward-thinking strategies, including the adoption of smart grid technologies and the integration of energy storage solutions.

In this context, this paper endeavors to present a comprehensive literature review, distilling key insights from various scholarly sources to provide an encompassing understanding of the USA energy market. By exploring energy consumption trends, the diversity of energy sources, the role of policies and regulations, market competition, pricing dynamics, and the challenges faced by energy infrastructure, this study aims to contribute to a deeper comprehension of the USA's energy landscape. Armed with this knowledge, policymakers, industry stakeholders, and researchers can collectively pave the way for a sustainable and resilient energy future, aligning economic prosperity with environmental stewardship.

2. Literature review

The energy market in the USA is a complex and dynamic system that plays a vital role in powering the nation's economy and shaping its environmental landscape. This literature review aims to provide a concise overview of the USA energy market, highlighting key factors that influence its development, challenges faced, and potential solutions, based on existing research and scholarly work.

The USA has historically been one of the largest consumers of energy globally. According to the U.S. Energy Information Administration (EIA), the country's energy consumption has experienced a steady growth trend over the years (EIA, 2021a). This demand growth is driven by population expansion, industrialization, and technological advancements.

The energy mix in the USA is diverse, comprising fossil fuels, nuclear power, renewables, and hydroelectricity. Historically, the USA has heavily relied on fossil fuels like coal, oil, and natural gas for electricity generation and transportation (EIA, 2021b). However, there has been a shift towards cleaner energy sources, such

as wind and solar, due to concerns over climate change and environmental sustainability (Wiser et al., 2019).

Government policies and regulations significantly influence the USA energy market. The Energy Policy Act of 2005, for instance, aimed to promote energy independence and diversify energy sources through tax incentives for renewables and the expansion of nuclear power (EPA, 2005). The Clean Power Plan, introduced in 2015, set targets to reduce carbon emissions from power plants, accelerating the transition to cleaner energy (EPA, 2015). However, policies can also face opposition and challenges from various stakeholders, affecting their implementation (Sovacool & Dworkin, 2015).

The USA energy market operates in a competitive environment, with regional and national electricity markets. Market deregulation, as seen in some states, has led to increased competition among energy providers, offering consumers more choices but also facing challenges in maintaining reliability and grid stability (Bushnell, 2019). Market prices fluctuate due to supply-demand dynamics, regulatory changes, and geopolitical factors, impacting both producers and consumers (EIA, 2021c).

The USA's energy infrastructure faces challenges concerning aging assets, natural disasters, and cybersecurity threats (Brinkman et al., 2019). Ensuring grid resilience is crucial to prevent widespread power outages and maintain energy security during emergencies. Research on smart grid technologies, microgrids, and energy storage solutions has gained attention to enhance the grid's robustness (DOE, 2021).

The USA energy market is in a constant state of transformation, influenced by evolving demand patterns, technological advancements, policy changes, and environmental concerns. Transitioning towards a sustainable, resilient, and diverse energy landscape remains a critical challenge. Understanding the dynamics of the USA energy market is crucial for policymakers, stakeholders, and researchers to develop effective strategies that promote economic growth while addressing environmental and societal needs.

3. USA Energy Market Overview

3.1 USA energy market legislations

USA's energy market is characterized by large number of actors which are involved in production, transmission, and distribution of the energy for industrial, housekeeping, and public sectors.

The US energy policy is set up by the federal government through its Department of Energy.

The energy transmission network is controlled by Independent System Operators or Regional Transmission Organizations, which are not-for-profit organizations that are obliged to provide indiscriminate access to various suppliers to promote competition. This organization is under surveillance of Public Utilities

Commissions for inside state's networks and the Federal Energy Regulatory Commissions for inter-state transmissions segment.

3.2 USA energy market regulatory authorities

3.2.1 Federal Energy Regulatory Commission (FERC)

The activities of the Federal Energy Regulatory Commission (Commission) are organized under industry areas from electricity, continuing with natural gas and hydro and ending with oil.

In electric sector FERC oversights:

- Regulation of wholesale sales of electricity and transmission of electricity in interstate commerce.
- Mandatory reliability standards for the bulk power system.
- Promotion of strong national energy infrastructure, including adequate transmission facilities.
- Regulation of jurisdictional issuances of stock and debt securities, assumptions of obligations and liabilities, and mergers.

In natural gas sector, FERC regulate the construction of the pipelines and storage faculties. Also, it regulates the transport of natural gas and connection of the internal net with its import and export facilities. Liquefied natural gas safe operation is controlled by FERC which ensures that approved LNG terminals and associated LNG vessel traffic meet safety and environmental requirements during construction and operation.

In hydro sector Commission is issuing licenses for new hydro projects but also relicense the ones which are in function. Other duty of FERC is to undertake dam safety and environmental inspection by his engineers during construction and operation.

It overlooks also the hydroelectric generation from ocean waves, tides, and currents and from free-flowing rivers. The Commission is looking at the development of this new source of hydropower that has the potential to add a substantial amount of power to the nation's generation capacity.

In oil sector FERC regulates rates and practices of oil pipeline companies engaged in interstate transportation. His role is to assure equal service and equal access to the pipeline transport system for all the players involved.

The North American Electric Reliability Corporation (NERC).

In 2006 FERC appointed a governmental organization named North American Electric Reliability Corporation (NERC) to supervise and regulate North American electric market in order to assure the reliability of the bulk system.

After its creation NERC, was empowered by FERC to:

- develop and enforce reliability standards
- asses annually seasonal and long-term reliability
- monitories the bulk power system through system awareness
- educate, train, and certify industry personnel. NERC's area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico made up of regional reliability coordinators. (US Department of Energy, 2015).

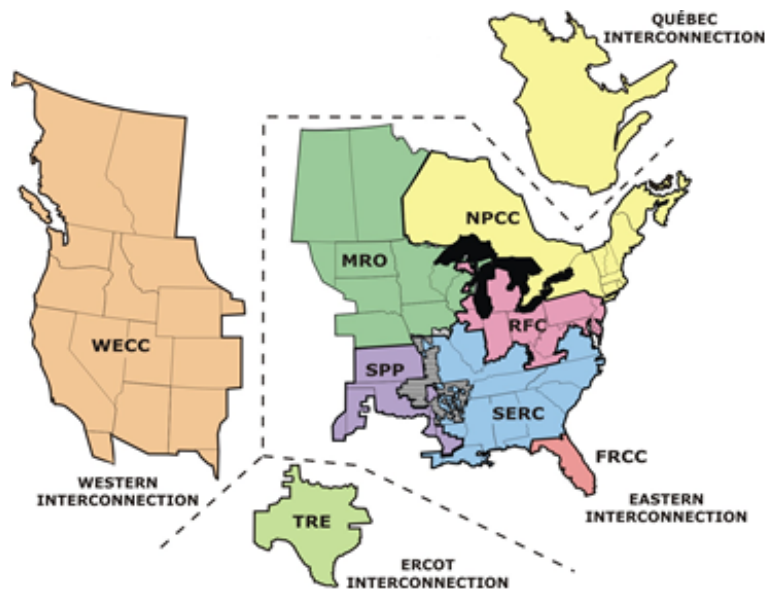


Figure 2. Map of Regional Reliability Councils Under NERC
Source: NERC

3.2.2 States Public Utilities Commissions (PUCs)

In federal states, utilities like electricity, gas and water are under regulation of state commission which is generally called Public Utilities Commissions (PUCs).

Usually one commission regulates all utilities, but there are some states where their attribution are spited in two more agencies.

This commissions are appointed by governors or elected depending, state's policy.

PUCs main role is to assure that companies and housekeeping have non discriminated access to utilities and at the fair and reasonable prices. Their activities include price surveillance and regulation, quality survey of the services offered, resource planning, etc.

Public Utilities Commissions (PUCs) are regulatory bodies established at the state level in the United States. Their primary responsibility is to oversee and regulate the utilities operating within their respective states. These commissions play a crucial role in ensuring fair and efficient utility services, setting rates, and protecting consumers' interests.

It's important to note that the structure and scope of PUCs can vary from state to state, as each state has its own regulatory framework and laws governing utility regulation. Despite these differences, the overarching goal of PUCs remains the same: to protect consumers, promote the public interest, and ensure the reliable and efficient delivery of essential utility services.

3.3 USA energy market transport and system operators and distribution system

North American electric transmission system has more the 360.000 miles of transporting lines (180.000 miles high voltage lines) connecting about 7.000 electric producers.

The USA energy market is a complex system that involves various entities responsible for the transportation and distribution of energy. These entities play essential roles in ensuring the smooth and reliable flow of electricity and other forms of energy to consumers.

There are currently 4 RTOs within North America:

- PJM—PJM Interconnection
- MISO—Midcontinent Independent System Operator; also, an RTO
- SPP—Southwest Power Pool; also, a Regional Reliability Council
- ISONE—ISO New England; also, an RTO

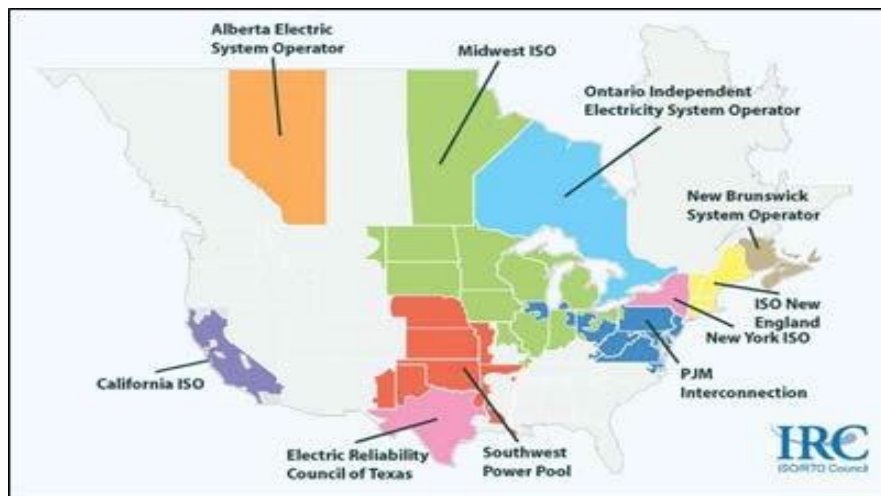


Figure 3. Map of North American Transmission Operators

Source: IRC ISO/RTO Council

An independent system operator (ISO) is an organization created based on the recommendations of FERC. When established in specific regions, an ISO is responsible for coordinating, controlling, and monitoring the operation of the electrical power system, typically within a single U.S. state, and occasionally spanning multiple states. Regional Transmission Organizations (RTOs) have similar functions to ISOs but operate over a larger geographical area.

Both ISOs and RTOs share common features, but RTOs have a more clearly defined origin, originating from the concept of ensuring electrical grid reliability. While the distinction between an ISO and an RTO may seem subtle to some, it is precise for others, as demonstrated by the similarities presented in the table below.

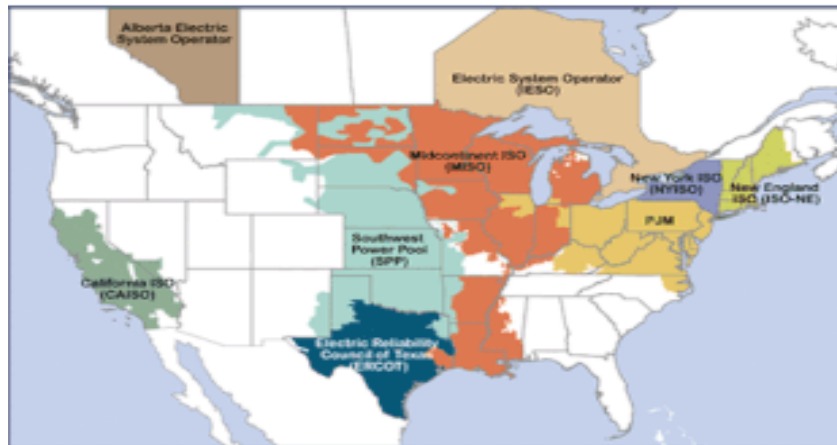


Figure 4. ISOs and RTOs of North America

Source: IRC ISO/RTO Council

The power distribution system is the final stage in the delivery of electric power, carrying electricity out of the transmission system to individual customers. Distribution systems can link directly into high-voltage transmission networks, or be fed by sub transmission networks. Distribution substations reduce high voltages to medium-range voltages and route low voltages over distribution power lines to commercial and residential customers.

(US Department of Energy, 2015 - United States Electricity Industry Primer)

3.4 Today market

In specialized language in North America the transmission and the distribution systems are generally known under the name “the grid”

Currently, the North American grid comprises two major interconnections and three smaller interconnections, outlined as follows:

- The Eastern interconnection, the first major interconnection, stretches from Central Canada eastward to the Atlantic coast (excluding Quebec), south to Florida, and then westward to the foot of the Rockies (excluding most of Texas). The USA section of this interconnection has a generating capacity of 700 GW.
- The Western interconnection, the second major interconnection, covers Western Canada south to Baja California in Mexico and extends eastward over the Rockies to the Great Plains. The USA portion of this interconnection possesses a generating capacity of 250 GW.
- The Texas Interconnection covers the majority of the State of Texas.
- The Quebec Interconnection encompasses the entire Province of Quebec and links 18 systems in the US and Canada to the electric utility company Hydro-Québec.

- The Alaska Interconnection consists of two grids, which are isolated from each other and from the rest of the North American grids.



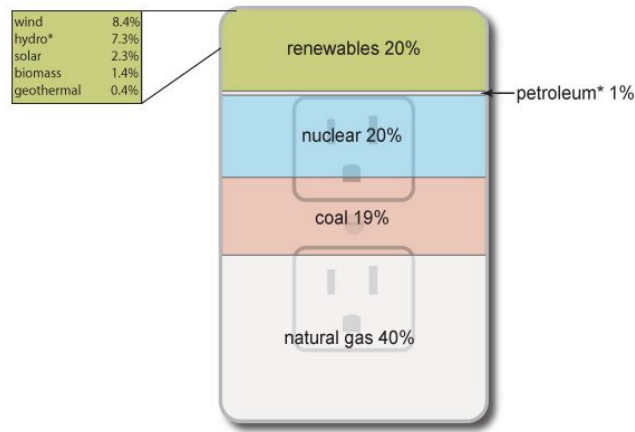
Figure 5. USA Electric Power Grids
 Source: IRC ISO/RTO Council

The electricity grid is a sophisticated system that involves the generation of electricity from both centralized power plants and decentralized units. This electricity is then transported through substations, transformers, transmission lines, and distribution lines, ultimately reaching the end-users, the consumers. Due to the inability to store large amounts of electricity, it must be generated in real-time to meet the demand.

As per the U.S. Energy Information Administration (EIA) data from 2016, the U.S. power grid is extensive, comprising more than 7,300 power plants, nearly 160,000 miles of high-voltage power lines, and millions of miles of low-voltage power lines and distribution transformers. These components connect a vast network of 145 million customers across the nation.

Electricity generation in the United States relies on a diverse range of resources and technologies. Conventional sources, such as natural gas, oil, coal, and nuclear, are the primary contributors to the electricity production.

The chart below, based on data reported by the EIA, illustrates the major energy sources used and their percentage shares in U.S. electricity generation at utility-scale facilities in the year 2020.



Note: Electricity generation from utility-scale generators. * Hydro is conventional hydroelectric; petroleum includes petroleum liquids and petroleum coke, other gases, hydroelectric pumped storage, and other sources.
 Source: U.S. Energy Information Administration, *Electric Power Monthly*, February 2021, preliminary data



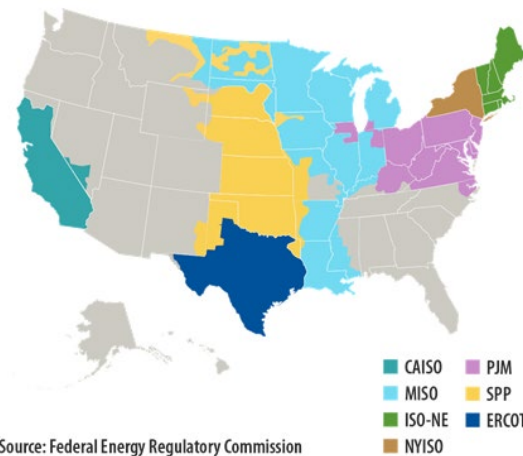
Figure 6. Sources of US Electricity generation, in 2020

Source: IRC ISO/RTO Council

In 2020, natural gas had the largest share (40 percent) in U.S. electricity generation, nuclear had the second-largest share (20 percent), and coal had the third largest (19 percent). Renewable energy sources contribution rises to about 20 percent of U.S. electricity production at utility-scale facilities. Of this share, 8.4 percent came from wind and 7.3 percent from hydropower.

3.5 Wholesale Electricity Markets

Like other world energy market, in US the electricity is sell via electricity traders or directly to the end-user. Both situation, wholesale or retail sale can be traditionally regulated or competitive markets. Bellow we can see wholesale market.



Source: Federal Energy Regulatory Commission

Figure 7. Wholesale Electric Power Markets

Source: IRC ISO/RTO Council

Certain segments of the U.S. wholesale electricity market adhere to traditional regulation (depicted in gray areas), where vertically integrated utilities oversee the entire electricity supply chain for consumers. These utilities possess ownership of the generation, transmission, and distribution systems essential for delivering electricity to end-users.

In contrast, other regions of the wholesale market, namely the Northeast, Midwest, Texas, and California, operate under a restructured competitive market model. These competitive markets are managed by independent system operators (ISOs), which encompass both regional transmission organizations (RTOs) and ISOs. Within restructured competitive markets, ISOs utilize competitive market mechanisms that enable independent power producers and non-utility generators to engage in power trading. In this scenario, "utilities" are generally responsible for offering retail electricity services to customers and are less likely to own generation and transmission resources.

3.6 Retail Electricity Markets

Retail markets operate at the state level and can be categorized into two types: traditionally regulated or competitive. Traditionally regulated retail electricity markets (depicted in gray below the chart) do not grant consumers the freedom to choose their electricity supplier; instead, they are obligated to purchase electricity from the utility serving their area. These traditionally regulated electricity markets are predominant in the Southeast, Northwest, and a significant portion of the West, with the exception of California. In these states, the investments in power plants are done mainly by utility companies and the access for renewables other than those which are developed by utility companies is very difficult.

In contrast with traditionally regulated electricity markets, competitive retail electricity markets (blue color in bellow chart) give the possibility of the clients/consumers to choose between competitive retail suppliers. There are 24 states which implemented competitive retail market, starting with California, Texas and most of Northeast states.

Within these competitive markets, municipally owned utilities might not provide their customers with the option of retail choice. It is essential to recognize that the market division between traditionally regulated and competitive states is not always straightforward. Certain states, such as California, fall into the category of partially restructured markets, where only specific consumers are allowed to participate in retail choice options.

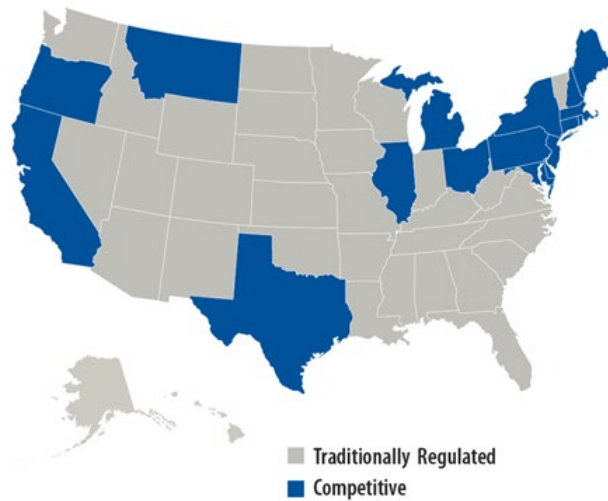


Figure 8. Retail Electric Power Market
Source: IRC ISO/RTO Council

3.7 US Renewables industry forecast

The compound annual growth rate for renewable energy market in US for 2022-2027 is expected to increase with 6%.

This optimistic growth is stimulated by increase of solar and wind new installation which is sustained by the decrease of the cost per megawatts for solar panels and wind turbines but also by the government which is expected to rise and diversify the subsidies for these energy sources.

In order to support this industry, government has announced its support for neutral and clean industry and adopted an investment fund of about USD 555 billion.

4 Conclusions

Today US energy market is an enormous and difficult market which tries to evaluate to from a regulated market to a complete competitive market. The transition is difficult and US government create agencies in order to overview the electricity market and to assure general and free access to the electricity for all end –users.

Transport and distribution operators are very well interconnected in order to bring the service to the final consumers.

Although US power sector is vulnerable to various disruptive events, measure and mechanism were created for reducing the impacts and reactivating service in the shortest time.

Numerous states have established policies aimed at facilitating a gradual shift towards cleaner and more sustainable energy sources, such as wind and solar power. As renewable energy generators gain prominence in the grid's energy mix,

certain challenges may emerge within the existing wholesale market structure in deregulated states. The distinct advantage of renewable sources lies in their independence from fuel inputs, as they harness energy directly from natural sources like the sun and wind. Consequently, these renewable generators can submit bids as low as \$0 in the energy and capacity markets. As their share in the grid grows over time, these \$0 bids can significantly drive down wholesale prices for energy and capacity, potentially deterring long-term investments across all types of resources. To address this evolving landscape, wholesale markets may need to adapt in the future to accommodate a diverse range of resources more effectively. The competitive nature of the energy market and its influence on pricing dynamics have been discussed, emphasizing the need for a delicate balance between market-driven efficiency and grid stability. Additionally, the challenges faced by the USA energy infrastructure, including aging assets and cybersecurity threats, underscore the urgency of investing in modernization and resilience measures.

Looking ahead, continued research and collaborations will be crucial in driving advancements in energy technologies, grid management, and policy frameworks. The pursuit of a sustainable, resilient, and diversified energy market will not only bolster the nation's energy security but also contribute significantly to global efforts in combating climate change.

In conclusion, the USA energy market is at a critical juncture, offering both challenges and opportunities. By leveraging knowledge, innovation, and collective determination, the nation can chart a transformative path towards a greener and more sustainable energy future, benefiting society, the economy, and the environment alike.

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