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Highlights

- Introduces "green energy synergy" via multi-method foresight to balance Yazd's energy.
- Highlights disparities: Yazd's surplus shrinks by 2035, while Ashkezar and Bafgh face deepening deficits.
- Proposes four scenarios from "Synergistic Development" to "Energy Isolation."
- Recommends county-specific solar strategies, smart grids, and investment funds.
- Converts regional inequalities into scalable green growth opportunities.

Graphical Abstract

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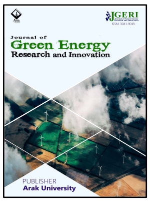

Regional Planning for Green Energy Synergy: A Foresight Analysis of Policies and Infrastructure in Yazd Province

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ABSTRACT

This study aims to enhance regional planning for green energy synergy in Yazd Province by addressing energy imbalances and promoting sustainable development. Significant disparities in production and consumption persist, with Yazd County exhibiting an 8.4-million-kWh surplus in 2022, while counties such as Ashkezar and Bafgh show deficits of approximately 1 million kWh. The analysis indicates that, without intervention, surpluses will decrease and deficits will increase by 2035. Using quantitative trend analysis in MATLAB and participatory Delphi-based scenario development, the study constructs four scenarios: synergistic development, which maximizes renewable energy use; foreign dependency, which sustains disparities; local self-sufficiency, which supports localized solutions; and energy isolation, which exacerbates imbalances. Proposed strategies include decentralized solar power plants, smart grid systems, and a green investment fund. The concept of "green energy synergy" offers a novel framework for transforming regional disparities into opportunities for renewable energy development. This research provides a scalable model for sustainable planning in Yazd and comparable regions, contributing to more effective energy policy formulation.

1. Introduction

Rising global energy demand, reliance on fossil fuels, and inadequate infrastructure have intensified regional energy disparities, threatening economic efficiency, environmental sustainability, and social stability [1,2]. Regional planning for green energy development, as a systemic approach to coordinating resources, infrastructure, and policies, is critical for achieving sustainability and mitigating these disparities [3]. Energy imbalance—defined as the disparity between energy production and consumption—reduces economic efficiency, increases environmental pollution, and amplifies spatial inequalities [4,5]. This imbalance often stems from differences in production and consumption across counties, driven by centralized planning and limited integration of local resources. Yazd Province, located in Iran's central plateau, exemplifies this challenge. While Yazd County benefits from a significant surplus due to its solar energy potential and industrial base, counties such as Ashkezar, Bafgh, and Taft face persistent deficits, exacerbated by rapid industrial and residential demand growth as well as infrastructural limitations [6]. Existing studies in Iran [7], [8-11] have primarily focused on national-level energy strategies or technical assessments of renewable potential, overlooking the importance of spatial coordination in regional planning. This gap underscores the need for an approach that integrates spatial planning with energy management to transform disparities into opportunities for green development. This study aims to develop a framework for green energy synergy in Yazd Province, emphasizing coordinated regional planning that aligns policies, infrastructure, and renewable energy resources.

Using a multi-method foresight approach—combining quantitative trend analysis with participatory scenario development through the Delphi method—the research forecasts energy trends and evaluates alternative pathways under uncertainty. By addressing the root causes of energy imbalance and proposing decentralized, context-specific strategies, the study contributes both theoretically and practically to regional energy planning. It provides not only a model for Yazd but also a scalable approach for other regions facing similar challenges related to energy justice and sustainability.

2. Literature review

2.1. Theoretical Foundations and Key Concepts

The origins of modern regional planning principles can be traced back to responses to the harsh and unjust conditions created by the Industrial Revolution in 19th-century England and France [12]. Since 1933, regional planning theories have undergone significant transformation. Walter Christaller's Central Place Theory (1933), and August Lösch's expansion of it in 1954 [13], provided a foundational framework for analyzing urban spatial patterns. Earlier, in 1929, Alfred Weber introduced Industrial Location Theory [14], which Walter Isard later expanded in 1956 by focusing on optimizing industrial locations on the basis of transportation costs [15]. In 1957, Gunnar Myrdal introduced the concept of cumulative causation, demonstrating how developed regions benefit from economies of scale [16-18]. This perspective was complemented by François Perroux's Growth Pole Theory in 1950 [19,20] and further refined by Jacques-René Boudeville in 1966, emphasizing the role of large corporations in strengthening regional growth [21,22]. In 1965, Jeffrey Williamson argued that regions initially diverge during early development stages but tend to converge over time.

In the 1980s, influenced by globalization and economic recessions, regional planning shifted toward entrepreneurial and market-driven approaches, highlighting regional competitiveness [23]. The 1990s marked the rise of regional networks and economic clusters, as proposed by Michael Porter and Annalee Saxenian [24,25], while the Rio Summit in 1992 introduced sustainable development as an effort to balance economic, environmental, and social objectives. Since 2000, Richard Florida's Creative Class Theory (2002) has emphasized attracting creative individuals as a driver of regional development [26], although it has faced criticism for reinforcing inequalities. From 2010 to 2025, challenges such as climate change, smart-city expansion, and energy shortages have reinforced the need for sustainable planning, digital development, and green growth.

Energy imbalance, referring to the disparity between energy production and consumption, is a structural challenge that intensifies in regions with weak infrastructure or uncoordinated policies [27]. It describes a condition in which the equilibrium between energy supply and demand is disrupted, resulting in insufficient production to meet existing demand [28]. This imbalance creates multi-dimensional challenges, including reduced industrial efficiency, increased production costs, and environmental degradation [4,5]. In Iran, due to heavy dependence on fossil fuels and unequal resource distribution, energy imbalance has become a serious threat to regional stability [29].

In contrast, the concept of synergy—rooted in systems science—refers to coordination and value creation through the interaction of system components. More specifically, synergy represents functional interactions that generate complex outcomes, playing a critical role in the evolution of complex systems [30]. In the energy sector, synergy involves achieving balance and efficiency through collaboration among resources, infrastructure, and policies. Unlike resilience, which focuses on adapting to shocks, or energy security, which emphasizes maintaining a continuous supply, synergy highlights sustainable value creation [31,32].

This study applies the synergy concept to propose an innovative framework for regional planning, aiming to transform regional inequalities into opportunities for green development. Table 1 compares the current study with previous research.

Table 1. Classification of past scientific research.

Study	Focus	Key Findings	Difference with Current Study
[33]	Energy justice in planning	Emphasized procedural justice in energy projects	Focused on social dimensions; the current study integrates technical foresight.
[34]	Rural electrification via renewables	Advocated renewable systems for rural energy access and carbon reduction	The current study addresses spatial imbalance at the county level.
[35]	P2P microgrids	Reduced imbalance and improved prosumer benefits	This study uses forecasting combined with policy-based foresight.
[36]	Regional strategic energy planning	Developed renewable energy models through local government–university collaboration	Similar participatory elements, but different modeling tools.
[37]	Citizen-driven energy transition	Introduced renewable energy communities, highlighting legal and incentive barriers in France	Focused on social participation; the current study emphasizes quantitative forecasting and regional synergy.
[38]	Decentralized renewable planning	Advocated bottom-up planning to align renewable resources with local needs in Greece	Focused on resource mapping; the current study integrates multi-method foresight and green synergy.
[39]	Infrastructure and inequality	Identified interprovincial disparities	Did not address energy balance or green synergy.
[40]	Biomass energy potential	Identified significant biomass resources (agricultural, animal, and municipal) for reducing fossil-fuel reliance	Focused on a single renewable type; the current study addresses broader energy imbalances with a solar emphasis.
[41]	Infrastructure and inequality	Identified interprovincial disparities in Iran's infrastructure, with high transport inequality	Did not address energy balance; the current study focuses on energy synergy and county-level solutions.
[42]	Energy consumption inequality	Found rising inequality in oil and gas consumption, and stability in electricity use, driven by efficiency patterns	Focused on consumption trends; the current study forecasts energy imbalances and proposes green solutions.
[43]	Energy justice	Highlighted energy colonialism and inequality	The current study is quantitative and future-oriented.
Current Study	Regional energy imbalance + synergy	Forecasts imbalances and proposes spatial solutions	Introduces "green energy synergy" and a multi-method foresight framework.

2.2. Research Background on Energy and Regional Planning

Global studies on regional planning and energy have primarily focused on resource allocation and reducing inequalities. For example, study [33] examines inequality in energy access between rural and urban communities and emphasizes the need for regional planning based on energy justice. It proposes integrating the social dimension into technical–economic planning and establishing a social contract that involves all stakeholders in energy decision-making. Article [34] shows that renewable energy systems should be adopted to address the lack of electricity access in rural communities while simultaneously reducing carbon emissions, rather than increasing production from existing power plants. This conclusion is supported through a two-level optimization model designed to balance policymakers (leaders) and industry operators (followers), tested in two case studies in Malaysia.

Study [35] proposes a new peer-to-peer (P2P) energy-trading method for interconnected microgrids, which enhances prosumer economic benefits and reduces supply–demand imbalances at the regional scale. Article [36] explains how strategic planning in Spain's Jaén Province has been used for regional development and redesign of the energy system, with a focus on solar and biomass resources. This process involved collaboration between the provincial government and the University of Jaén, using SWOT analysis and business-management tools to design a sustainable energy model. Study [37] investigates the role of citizens in regional energy policies and the energy transition in France, introducing models such as "renewable energy communities" that enable citizens to produce, consume, and sell renewable energy. It also analyzes key implementation challenges—including legal constraints and insufficient incentives—contributing to the broader debate on energy decentralization.

In study [38], researchers argue that a shift from centralized planning to regional planning is essential for renewable energy development. They employ a bottom-up approach to align regional renewable resources with the specific energy needs of each region, demonstrated through a case study involving two regions in Greece.

In Iran, studies such as [39,40] have examined infrastructural inequalities across regions but have paid less attention to energy as a central focus of planning. For example, study [41] evaluated the infrastructural development of Iran's 31 provinces using 20 indicators and ranked them through principal component analysis and TOPSIS. The results showed that inequality in transportation infrastructure was the highest, while rural infrastructure inequality was the lowest, with Tehran and Sistan–Baluchestan ranking first and last, respectively. Study [42] analyzed inequality in CO_2 emissions and energy consumption (oil, gas, electricity) in the household sector across provinces from 2000 to 2017 using the Theil index and the Kaya identity. The findings indicated rising inequality in oil and gas consumption, stability in electricity consumption, and declining CO_2 emissions inequality, with energy efficiency identified as the primary driver and energy consumption as a potential future determinant.

Additionally, study [43], using an energy justice framework, examined conditions in Khuzestan—the first oil-producing region in the Middle East and a cornerstone of Iran's energy sector. It assessed increasing inequalities, poverty, and unemployment, alongside a history of energy colonialism and extractivism. The study also evaluated community-based efforts toward energy justice and democracy, emphasizing the need for justice-oriented analysis and international alliances.

Regarding green energy development in Iran, several studies have explored renewable potential. Study [44] assessed the country's renewable energy resources, highlighting challenges arising from pollution and the depletion of non-renewable reserves due to reliance on cheap fossil fuels. It introduced Iran's diverse renewable options—biofuels, hydropower, wind, solar, and geothermal—as complementary strategies to reduce fossil-fuel dependence and support sustainability. Study [45] focused on biomass energy, categorizing biomass into agricultural residues, animal waste, and municipal waste. It identified 8.78 million tons of agricultural residues, 7.7 million tons of animal waste, and 3 million tons of municipal waste annually as potential resources capable of reducing fossil-fuel reliance and promoting green fuel use. Study [46] examined the necessity of renewable energy adoption due to heavy fossil-fuel dependence and its associated environmental and regional inequalities. Focusing on sustainable rural development, it identified infrastructural, managerial, socio-cultural, and economic barriers and highlighted the need for innovative policymaking.

Global and domestic research demonstrates that regional planning grounded in green energy and energy justice can reduce inequalities and enhance sustainability; however, this approach has been applied only to a limited extent in Iran. Case studies of provinces such as Khuzestan and Yazd indicate both significant infrastructural disparities and substantial renewable potential, yet policy fragmentation and weak infrastructure remain major obstacles. This research addresses these gaps by applying a forward-looking analysis in Yazd Province and proposing strategies to promote synergy between green energy development and sustainable regional planning.

2.3. Key Factors and Uncertainties

Key factors and future uncertainties in regional planning for green energy synergy play a crucial role in shaping policies, decision-making, and the overall development trajectory of this sector. Key factors include supportive government policies, investment levels, technological progress, distribution network capacity, social acceptance, and market competition, which together form the main foundations of this transition. In contrast, future uncertainties—such as sudden policy shifts, economic fluctuations, emerging technologies, climate change, and the level of international cooperation—can alter the development path and create unpredictable outcomes. These elements are derived from findings in the existing research literature and are categorized in Table 2 to present a clear overview of the opportunities and challenges associated with green energy development.

Identifying and analyzing key factors and future uncertainties in regional green energy planning helps policymakers and decision-makers formulate more effective strategies for sustainable development. This classification enables the anticipation of various scenarios and preparation for potential changes, thereby preventing unexpected obstacles. In foresight studies, these factors serve as a foundation for designing development scenarios, assessing risks, and formulating flexible and sustainable policies.

Table 2. Classification of Key Factors and Future Uncertainties.

Category	Key Factors	Future Uncertainties
Policy and Law	Government policies	Policy and legal changes; sanctions
Economy and Investment	Investment and financing	Economic fluctuations, energy price volatility
Technology and Infrastructure	Technology and innovation, infrastructure, and distribution networks	Technological advancements
Social	Social acceptance	Public acceptance
Environmental	Climate change	Impacts of climate change
Market and Competition	Green energy competitiveness	International cooperation and sanctions

2.4. Scientific Contribution and Innovation of the Research

This research introduces the concept of "green energy synergy" as a novel framework for regional planning, advancing the literature on energy and sustainable development. Unlike previous studies that often focus solely on technical aspects of energy management, this study emphasizes coordination among green energy resources, infrastructure, and policies to create sustainable added value at the regional level. The primary innovation lies in integrating regional planning with green energy strategies, reframing regional inequalities not merely as technical problems but as opportunities for developing decentralized green infrastructure, such as local solar power plants.

The study employs a multi-method foresight approach, combining quantitative trend analysis using MATLAB with participatory scenario development based on local stakeholder input. This approach enables precise prediction of energy imbalances and the formulation of practical, locally tailored strategies in Yazd Province, while offering a framework adaptable to other regions with similar conditions. Emphasizing decentralized infrastructure to reduce regional inequalities—particularly in Iran, with challenges such as sanctions and reliance on fossil fuels—adds a practical and original contribution to energy planning knowledge.

From a scientific perspective, this research fills a gap in Iran's energy studies, which have largely been limited to macro-level or technical analyses and have paid less attention to regional coordination emphasizing green energy. Consequently, the study not only provides solutions for Yazd's sustainable development but also offers a model for policymaking in regions with high renewable energy potential and spatial inequalities.

3. Research Methodology

This study, focused on regional planning for green energy synergy in Yazd Province, employs a multi-method foresight approach that integrates quantitative trend analysis with participatory scenarios, providing both accurate predictions and consideration of stakeholders' qualitative perspectives. This approach enhances the comprehensiveness and reliability of the analysis by combining numerical data with expert input, making it well-suited for examining regional inequalities and informing policymaking under conditions of uncertainty. Figure 1 presents a flowchart of the research process, offering an overview of the study.

3.1. Case Study

Yazd Province, located on Iran's central plateau (Figure 2), covers 6.3% of the nation's total land area [47]. Renowned for its abundant mineral resources and major industries, including steel and ceramics, Yazd is a key industrial hub and a frontrunner in adopting renewable energy, particularly solar power. This study selected Yazd as a case study for several reasons. With exceptional geographic and climatic conditions, it ranks among Iran's hottest and driest regions, facing significant challenges in ensuring a stable energy supply. A major concern is its high energy consumption, especially in the industrial and household sectors [48,49], which amplifies regional energy imbalances. Additionally, as a densely populated industrial center, Yazd's diverse economic activities strongly influence energy demand and overall efficiency.

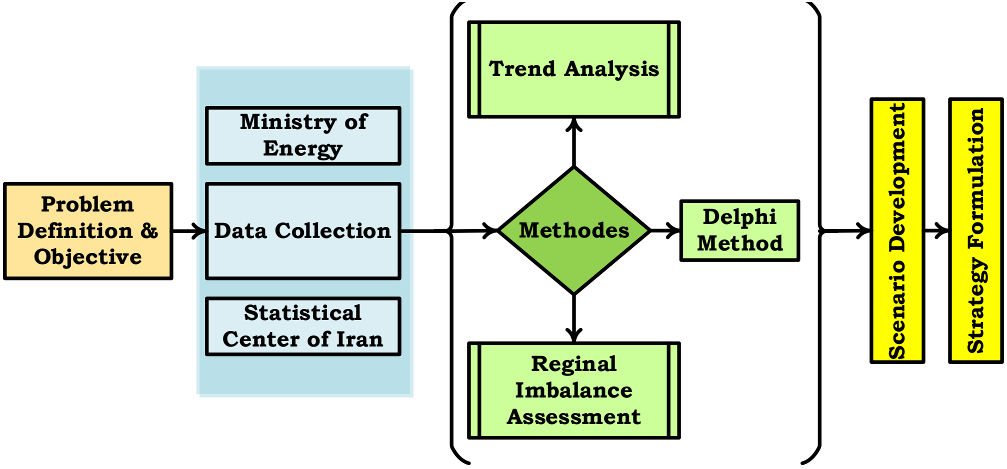


Figure 1. Research process flowchart.

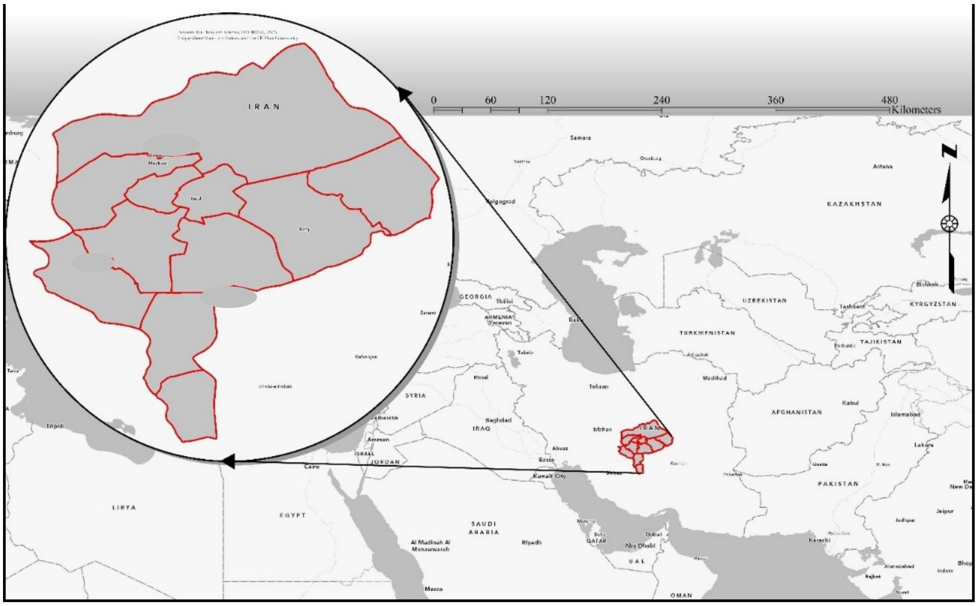


Figure 2. Yazd province's location in Iran.

3.2. *Quantitative Trend Analysis*

To examine historical patterns and forecast future trends in energy production and consumption in Yazd Province, quantitative trend analysis was conducted using MATLAB. Historical electricity production and consumption data, disaggregated by county, were collected for the period 1394–1401 (Iranian calendar years, equivalent to 2015–2022) from the annual reports of the Ministry of Energy and the Statistical Center of Iran. These sources are considered reliable for regional energy statistics; however, potential limitations include inconsistencies in data reporting across counties and occasional gaps due to incomplete records.

To address missing data, linear interpolation was applied, recognizing that this method assumes linear trends and may oversimplify the nonlinear dynamics of energy systems, particularly in industrially volatile regions such as Yazd. To mitigate this limitation, data were cross-verified with provincial energy audits where available, and only gaps affecting less than 10% of the dataset were interpolated. Using linear regression in MATLAB, trends in production and consumption were projected up to 1414 (2035). To account for uncertainties in long-term forecasting, a sensitivity analysis was performed by varying key inputs (e.g., annual growth rates of consumption and production) by ±10%. Error margins for projections were estimated at approximately ±8%, based on historical data variability.

Additionally, MATLAB simulations were conducted to model interactions among key variables and identify points of regional imbalance, with a particular focus on counties exhibiting significant inequalities.

3.3. *Scenario Development*

To formulate future scenarios for green energy synergy in Yazd Province, considering key factors and uncertainties, the Delphi method was employed. This method was chosen for its ability to systematically and anonymously gather expert opinions and build consensus under conditions of uncertainty. A panel of 15 experts was assembled, including professors from the University of Yazd, managers from the Yazd Regional Electricity Company, provincial planners, and industry representatives, each with at least five years of experience in energy or regional planning.

The Delphi process was conducted over three rounds. In the first round, an open-ended questionnaire was distributed to collect expert insights on key drivers, uncertainties, and potential scenarios for green energy development in Yazd Province. Questions addressed topics such as renewable energy adoption, technological advancements, policy frameworks, and socio-economic factors. Responses were analyzed qualitatively to identify common themes and divergent views, which informed the design of a structured questionnaire for the second round.

The second-round questionnaire included Likert-scale and ranking questions to prioritize drivers and uncertainties (e.g., "To what extent will solar energy adoption impact energy synergy by 1414?"). Feedback from this round was summarized and shared anonymously with the panel, highlighting areas of agreement and disagreement. In the third round, experts reviewed the aggregated results and refined their responses to converge on three plausible scenarios. Consensus was measured using a threshold of 70% agreement on Likert-scale items and a reduction in the interquartile range for ranked items between rounds. Divergent opinions were addressed by allowing experts to provide written justifications, which were shared anonymously in subsequent rounds to encourage constructive dialogue.

The final scenarios were developed based on the prioritized drivers and uncertainties, ensuring a robust and reproducible process.

4. Results

4.1. Analysis of the Current Situation and Future Trends of Energy Production, Consumption, and Imbalance in Yazd Province

Figure 3 illustrates the energy imbalance across the ten counties of Yazd Province from 1394 to 1401 (2015–2022), providing a foundation for regional planning aimed at green energy synergy. These charts analyze energy supply and demand in each county, revealing clear patterns of regional inequality. Energy imbalance during this period fluctuated significantly due to factors such as weak transmission infrastructure, rising industrial and domestic consumption, and differences in local production capacities.

Yazd County, with a surplus of 8.4 million kWh in 1401, serves as the province's primary energy supplier and, given its geographical location and high solar radiation, has the potential to generate 12 MW of solar energy. In contrast, counties such as Ashkezar (-1.65 million kWh), Meibod (-1.03 million kWh), and Bafgh (-0.55 million kWh) face severe deficits, largely due to high industrial consumption (Ashkezar and Meibod) and insufficient local production (Bafgh). Ardakan has seen its imbalance decline from a surplus of 0.78 million kWh in 1394 to a deficit of 0.35 million kWh in 1401, driven by population growth and industrial concentration.

Linear regression analysis predicts that Yazd's surplus will decrease to 7 million kWh by 1414 (2035) (Figure 4), indicating a higher growth rate in consumption compared to production. Sensitivity analysis suggests that these projections are robust within a ±8% error margin, with Yazd's surplus potentially ranging from 6.5 to 7.5 million kWh and deficits in counties such as Ashkezar varying between -2.5 and -2.9 million kWh, depending on consumption growth and infrastructure investments. Deficits in other areas are projected to worsen at an annual growth rate of 5–10% due to urban population growth and industrial consumption, unless investments in decentralized solar power plants and distribution network optimization are prioritized. Based on quantitative trend analysis of historical energy production and consumption data from 1394 to 1401, with projections up to 1414, the energy situation in Yazd Province reveals pronounced regional inequalities and structural imbalances that, if unaddressed, threaten the region's sustainability. Figure 4 illustrates trends in energy production and consumption across the ten counties during this period.

Currently, energy production is concentrated in counties such as Ardakan and Yazd due to industrial infrastructure and large power plants. For instance, Ardakan recorded an average annual production of approximately 3 million kWh in 1401, while Yazd reached around 10 million kWh. In contrast, counties such as Behabad and Bafgh have negligible local production, remaining near zero through 1401.

Energy consumption, however, exhibits an upward trend across all counties, particularly in urban areas such as Yazd (around 2.9 million kWh) and Ashkezar (1.7 million kWh in 1401), driven by population growth and industrial development. This widening gap between production and consumption has made energy imbalance a critical challenge for the province.

Figure 5 illustrates the projected changes in energy imbalances by county. Projections up to 1414 indicate that counties such as Abarkouh, Bafgh, and Ashkezar—characterized by high consumption and minimal local production—will experience sharply negative imbalances, reaching approximately -0.4 million, -1 million, and -2.84 million kWh, respectively. This trend is intensified in Abarkouh and Bafgh due to complete reliance on energy transmission from other areas, and in Ashkezar due to heavy industrial consumption.

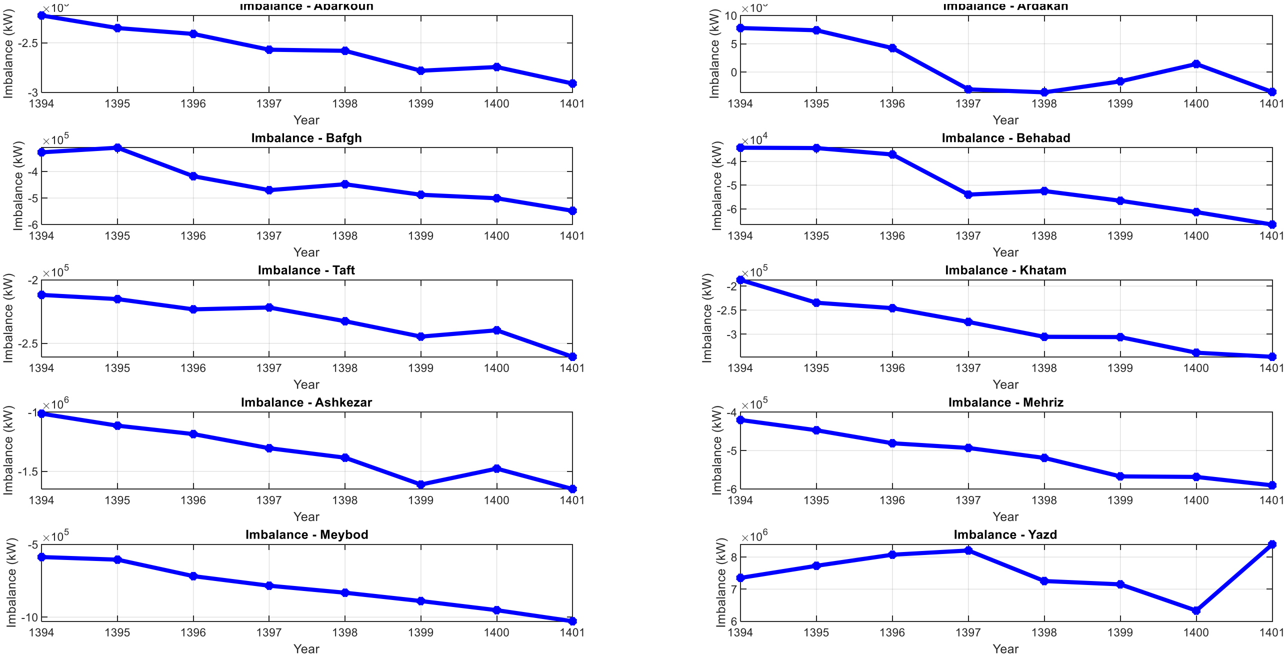
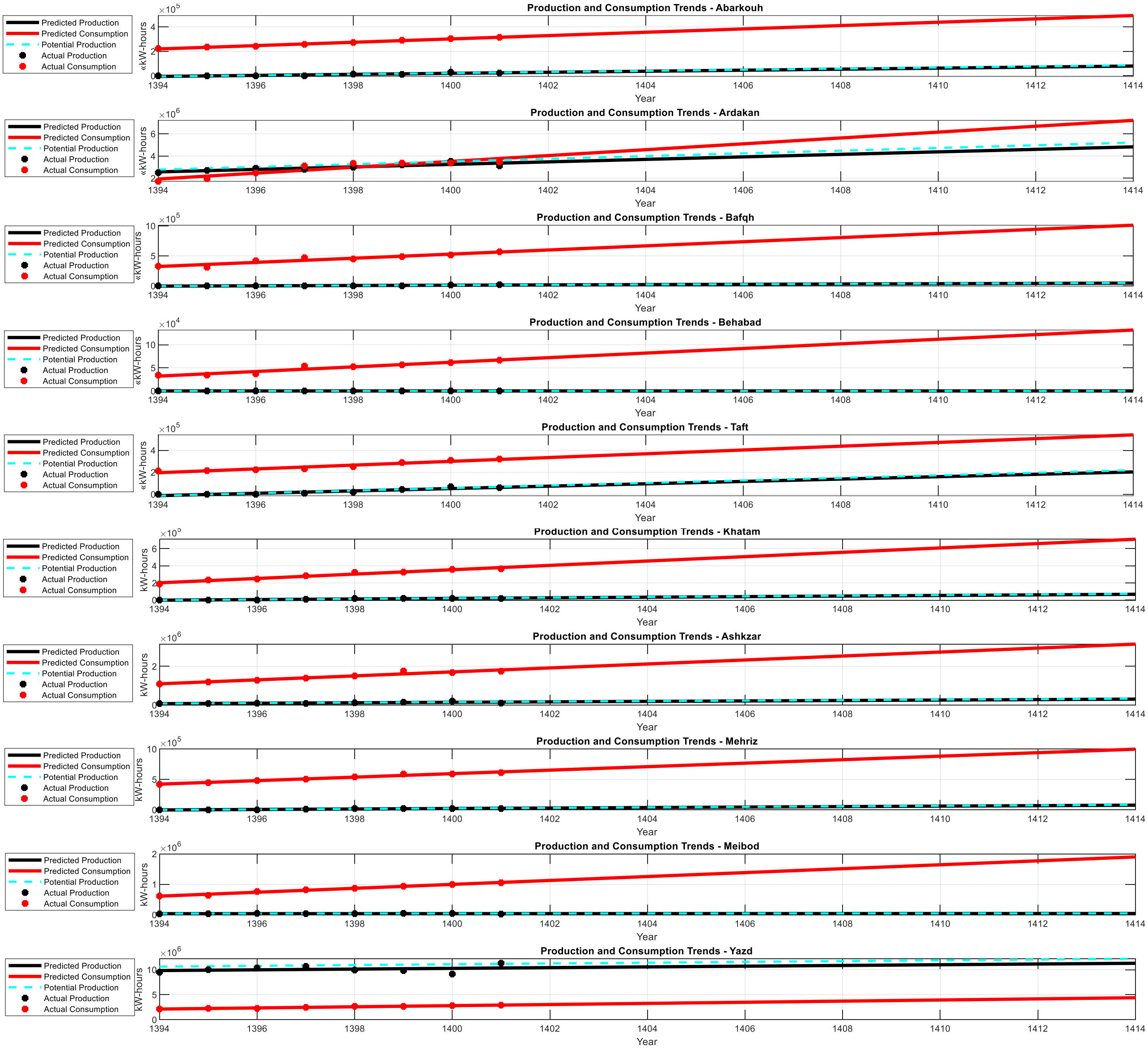


Figure 3. Energy Balance Changes from 1394 to 1401.

In contrast, Yazd maintains a relative production surplus of around 7 million kWh in 1414; however, this surplus is insufficient to fully offset deficits in other counties. Taft and Behabad are projected to experience moderate negative imbalances, reaching approximately -0.3 million and -0.1 million kWh by 1414.

The production trend during the forecast period indicates relative stability in energy-producing regions such as Ardakan and Yazd, while in other counties, particularly Behabad and Bafgh, local production remains negligible. Energy consumption across all regions is projected to increase at an annual rate of approximately 3–6%, with growth more pronounced in industrial and urban areas such as Ashkezar and Yazd.

This pattern underscores a heavy dependence on energy transmission from producing to consuming regions. Given weak infrastructure, transmission constraints, and existing spatial inequalities, this dependence further exacerbates energy imbalances. For example, Mehriz and Meibod, with annual consumption of 0.611 million and 1.054 million kWh in 1401 and minimal production of 21,000 and 26,000 kWh, respectively, exhibit significant negative imbalances, projected to reach approximately -1 million and -2 million kWh by 1414.



Production and Consumption Trends - Abarkouh

Production and Consumption Trends - Ardakan

Production and Consumption Trends - Bafqh

Production and Consumption Trends - Behabad

Production and Consumption Trends - Taft

Production and Consumption Trends - Khatam

Production and Consumption Trends - Ashkzar

Production and Consumption Trends - Mehriz

Production and Consumption Trends - Meibod

Production and Consumption Trends - Yazd

Figure 4. Trends in Energy Production and Consumption from 1394 to 1414.

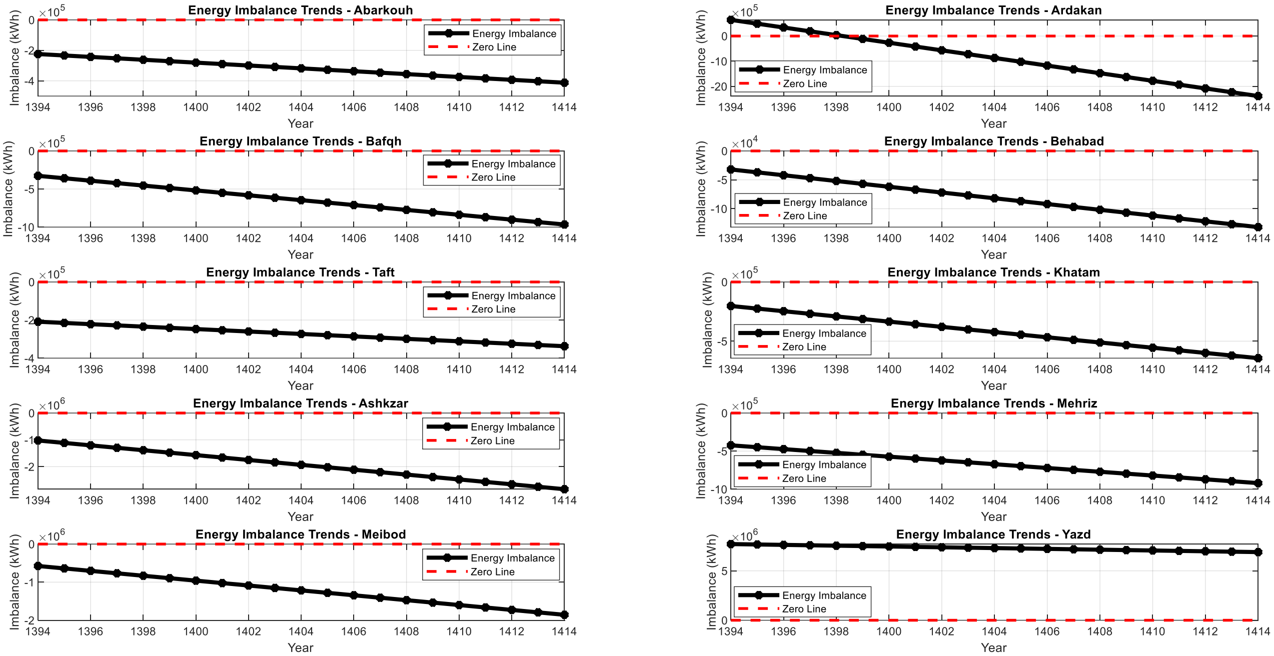


Figure 5. Trends and Forecast of Energy Imbalance Changes by County (1394–1414).

These findings reveal a structural pattern of regional inequality in Yazd Province, where regions with high production potential (e.g., Ardakan and Yazd) contrast sharply with areas lacking infrastructure (e.g., Behabad and Bafgh). The observed imbalances not only threaten energy stability but also highlight opportunities to harness local potential, particularly solar energy in desert regions. Without targeted infrastructure and policy reforms, the production-consumption gap is likely to widen, jeopardizing the region's long-term sustainability.

These spatial variations can be categorized into three regional types:

- **Energy Surplus Areas** (e.g., Yazd and Ardakan), where industrial infrastructure and high solar capacity enable self-sufficiency and potential energy export.
- **Transitional Zones** (e.g., Taft and Mehriz), which have moderate deficits and potential for solar expansion but currently lack sufficient infrastructure investment.
- **Critical Deficit Areas** (e.g., Ashkezar, Meibod, and Bafgh), where industrial activity exceeds local generation, leading to growing dependence on external energy supply.

This classification supports the prioritization of investment strategies and the targeting of counties based on both urgency and capacity for renewable energy integration.

4.2. Future Scenarios

This study developed four future scenarios for green energy synergy in Yazd Province by 1414 (2035), using the Delphi method and responses from 15 experts. The scenarios were constructed around two key uncertainties: the intensity of sanctions (horizontal axis: reduced to severe) and the level of international cooperation (vertical axis: high to low). These uncertainties were identified during the Delphi rounds as the most influential and unpredictable factors.

The findings integrate quantitative forecast data (energy production and consumption from 1394 to 1414) with qualitative expert consensus. Key factors—including government policies, investment, technology, infrastructure, social acceptance, climate change, and market competitiveness—were incorporated into each scenario to comprehensively reflect regional dynamics. To enhance scenario robustness, MATLAB simulations were performed, combining quantitative forecasts from Section 3.2 with scenario-specific assumptions. For each scenario, key variables (e.g., solar energy adoption rates, infrastructure investment levels, and consumption growth) were adjusted to reflect conditions of reduced or severe sanctions and high or low cooperation. For example, in the Synergistic Development scenario, solar capacity was assumed to grow by 15% annually with high investment, whereas in the Energy Isolation scenario, growth was limited to 2% due to resource constraints.

Table 3. 2 × 2 Matrix of Future Scenarios for Green Energy Synergy in Yazd Province.

	Reduced Sanctions	Severe Sanctions
High International Cooperation	Scenario 1: Synergistic Development	Scenario 3: Local Self-Sufficiency
Low International Cooperation	Scenario 2: External Dependency	Scenario 4: Energy Isolation

Table 4 summarizes the quantitative results of these scenarios for 1414, including sensitivity analysis, stress testing, and system dynamics modeling. In the Synergistic Development scenario, Yazd shows a substantial surplus of 156.58 million kWh, while Ashkezar's deficit decreases to -1.96 million kWh, representing approximately a 30% improvement over the baseline value of -2.84 million kWh.

Conversely, the Energy Isolation scenario exacerbates deficits, with Ashkezar reaching -3.04 million kWh and Ardakan -3.39 million kWh. Stress testing, assuming a 50% reduction in production growth and a 20% increase in consumption growth, highlights system vulnerability: Yazd shifts to a deficit of -76.45 million kWh, and Ashkezar's deficit worsens to -40.11 million kWh. Sensitivity analysis confirms a wide range of outcomes (e.g., Yazd: -19.37 to 33.16 million kWh), emphasizing the need to account for uncertainties.

The system dynamics model, which incorporates consumption feedback on production, produces results close to the baseline (Yazd: 6.88 million kWh; Ashkezar: -2.86 million kWh), partially mitigating the limitations of the linear model. Additional stress tests indicate that the Synergistic Development scenario remains viable even under reduced investment, whereas the Energy Isolation scenario collapses under increased consumption. Sensitivity analysis of strategic interventions—such as decentralized solar plants and smart grids—demonstrates their effectiveness when at least 70% of the proposed capacity is deployed. These findings are summarized in the 2 × 2 matrix of Table 3 and detailed numerically in Table 4.

5. Discussion

The quantitative findings indicate that energy imbalance in Yazd Province arises from the uneven distribution of production and consumption capacities. Yazd County, with a surplus of 8.4 million kWh in 1401 and a projected 7 million by 1414, serves as the primary production hub, while regions such as Ashkezar (-1.65 million in 1401 and -2.84 million in 1414) and Bafgh (-0.55 million in 1401 and -1 million in 1414) experience severe deficits due to limited local production and dependence on energy transmission. This pattern is consistent with previous studies in Iran, such as [41], and reflects a widespread structural challenge in the country.

What distinguishes this research is its focus on transforming these inequalities into opportunities through decentralized green infrastructure. The identified potential of 12 MW of solar energy in Yazd and 10 MW in Bafgh aligns with global examples, such as strategic energy planning in Jaén, Spain, demonstrating that local renewable resources can help offset deficits. Nevertheless, the projected intensification of imbalances—5–10% annual deficit growth under current conditions—serves as a warning for regional sustainability. This trend aligns with findings from [41] regarding increasing inequality in oil and gas consumption in Iran. However, unlike [42], which emphasized energy efficiency as the primary factor, this study identifies industrial demand growth and weaknesses in the distribution network as key drivers. This perspective underscores the need to reconsider centralized energy transmission policies and promote local production, transforming green energy synergy from a theoretical concept into a practical strategy.

The future scenarios, developed based on the intensity of sanctions and the level of international cooperation, illustrate a broad spectrum of possibilities for green energy development in Yazd. Scenario 1 (Synergistic Development) represents the optimal pathway, reducing imbalances and expanding solar capacity. This outcome aligns with global studies, including peer-to-peer microgrid models that improved supply-demand balance and renewable energy communities in France that emphasized decentralization, highlighting the importance of international cooperation in accessing technology and capital.

In contrast, Scenario 4 (Energy Isolation) predicts the worst-case outcome, with exacerbated deficits and continued dependence on fossil fuels, consistent with Iran's historical experience under severe sanctions and infrastructural constraints.

Table 4. Integrated Results Table for 1414 (kWh).

	Base Imbalance	Sens-Low	Sens-High	Stress Test	Synergistic Dev.
Abarkouh	-412325.21	-2940412.44	2115762.01	-7266299.68	-575200.35
Ardakan	-2385165.03	-55689823.93	50919493.86	-156843232.83	34852164.22
Bafgh	-966002.64	-6191348.74	4259343.45	-12477194.84	-1085152.06
Behabad	-131811.92	-836818.86	573195	-1541825.79	-131811.92
Taft	-337266.39	-4296530.35	3621997.57	-12831094.32	-745062.39
Khatam	-643194.99	-4731850.06	3445460.06	-10282480.13	-735173.37
Ashkzar	-2841614.46	-18996505.54	13313276.61	-40111506.63	-1966775.93
Mehriz	-919905.53	-5533228.66	3693417.59	-11808001.8	-1022569.21
Meibod	-1857191.96	-10999230.53	7284846.6	-20257419.09	-1283861.91
Yazd	6892622.21	-19375981.30	33161225.73	-76452109.81	156589225.64

	External Dep.	Local Self-Suff.	Energy Isolation	System Dynamics
Abarkouh	-526201.91	-505491.38	-499557.35	-427176.54
Ardakan	10079034.74	-392004.53	-3392192.11	-2411795.21
Bafgh	-1041776.39	-1023442.48	-1018189.40	-984322.61
Behabad	-131811.92	-131811.92	-131811.92	-131811.92
Taft	-624574.42	-573646.89	-559055.02	-359328.13
Khatam	-720714.82	-714603.51	-712852.49	-657282.69
Ashkzar	-2662232.48	-2956186.17	-3040410.5	-2869121.85
Mehriz	-1007307.41	-1000856.59	-999008.28	-940212.02
Meibod	-1646932.32	-1800393.94	-1844364.13	-1858839.71
Yazd	61777243.59	21702371.76	10220022.28	6888224.34

The intermediate scenarios (2 and 3) illustrate more fragile balances. Scenario 2 (External Dependency) forecasts concentrated growth in Yazd and Ardakan while maintaining regional inequalities, reflecting Myrdal's Cumulative Causation theory, in which developed regions benefit from accumulated advantages. Scenario 3 (Local Self-Sufficiency) demonstrates the potential of domestic resources by moderately reducing imbalances and expanding solar capacity, though its scale is insufficient to fully meet growing demand.

These findings not only reflect regional disparities identified in previous Iranian studies—such as [41] and [42] on infrastructure and energy consumption inequality—but also provide a new perspective by quantifying future imbalances at the county level. While [42] emphasized energy efficiency as the primary driver of inequality, our results identify industrial demand and infrastructural limitations as the key factors, particularly in counties such as Ashkezar and Meibod. This supports the arguments for decentralized planning made by Shahrom et al. [34], who advocated the use of renewable energy to reduce rural energy gaps, and aligns with Terrados et al. [36], who highlighted the importance of local collaboration in regional energy transitions. Furthermore, the emphasis on "green energy synergy" extends the conceptual frameworks of energy justice discussed by Khayat and Teron [43], offering a quantitative model to operationalize their justice-oriented recommendations.

The findings of this study carry significant implications for multiple stakeholders. For grid operators, identifying high-deficit counties—such as Ashkezar and Meibod—enables targeted infrastructure upgrades, prioritizing smart grid deployment and decentralized generation to stabilize supply-demand dynamics. Policymakers can leverage the foresight scenarios to design adaptive strategies that account for geopolitical and economic uncertainties. For example, under severe sanctions, emphasis on local self-sufficiency and rural solar investments becomes critical, whereas in cooperative conditions, foreign investment and technology transfer can accelerate green energy transitions.

Provincial planners and municipalities can use the model's spatial detail to allocate resources efficiently across the ten counties. The study directly supports its initial objective of creating a regional planning framework to enhance green energy synergy. By combining quantitative forecasting with scenario planning, the results demonstrate that spatial inequalities can be mitigated through tailored strategies, validating the hypothesis that decentralization and synergy improve energy balance. Moreover, the "green energy synergy" model introduced here provides a scalable approach for other regions with similar characteristics—high renewable potential, regional energy imbalance, and centralized policy systems. Provinces in Iran (e.g., Kerman, Khuzestan) or other semi-arid regions in the Global South facing infrastructure gaps can adapt this methodology. Future research could further expand the model by integrating economic cost-benefit analysis, carbon reduction impacts, and social equity indicators.

6. Conclusion

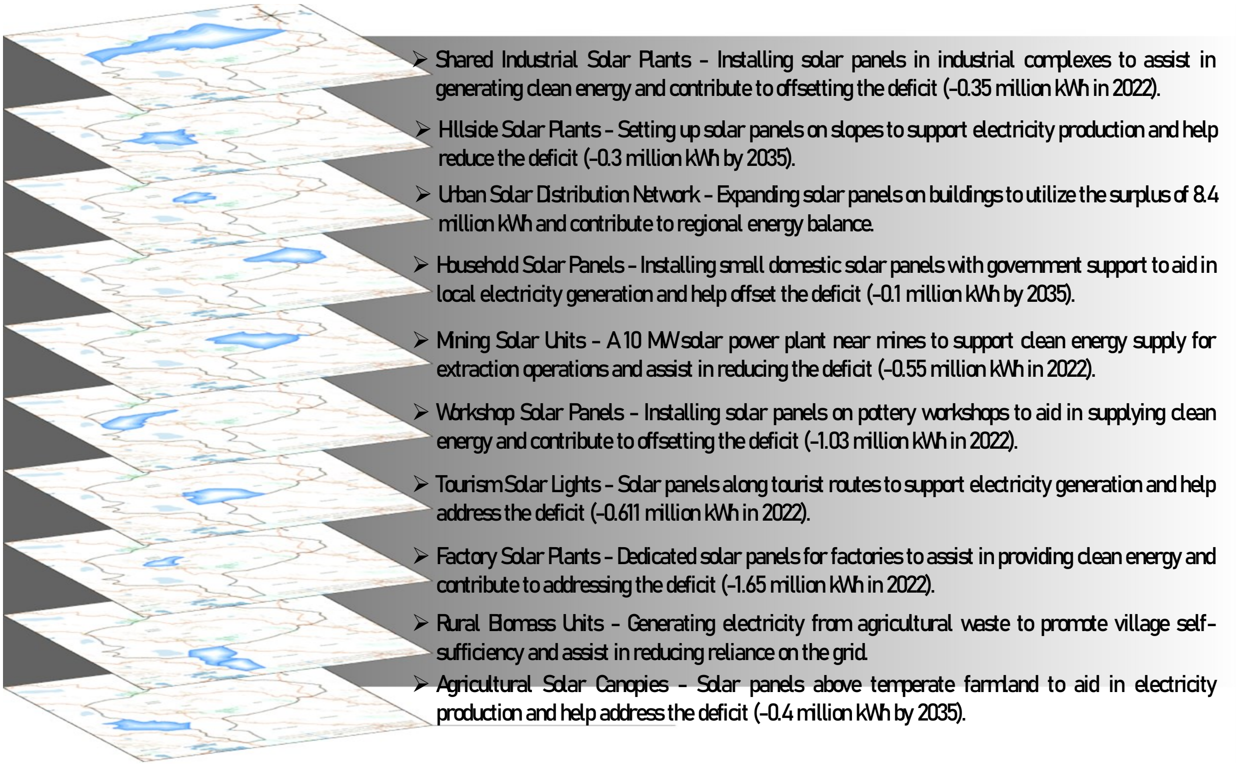
This study advances the concept of "green energy synergy" as an innovative framework for regional planning, reframing energy inequalities in Yazd Province as opportunities for developing decentralized green infrastructure rather than as impediments. By integrating quantitative trend analysis with participatory scenario development, the research leverages the province's substantial solar potential—12 MW in Yazd and 10 MW in Bafgh—to demonstrate its capacity for mitigating energy imbalances and fostering sustainable development.

This approach departs from prior investigations, which predominantly focused on technical or macro-level dimensions, and fills a critical gap in Iran's energy literature by employing a multi-method foresight framework tailored to regional dynamics. The findings reveal pronounced disparities across Yazd's ten counties, with Yazd exhibiting a surplus of 8.4 million kWh in 2022 (projected to decline to 6.89 million kWh by 2035), while counties such as Ashkezar (-1.65 million kWh in 2022, projected to -2.84 million kWh by 2035) and Bafgh (-0.55 million kWh in 2022, projected to -0.96 million kWh by 2035) face escalating deficits, as detailed in Table 4. To address these imbalances, county-specific strategies, carefully delineated in Figure 6, were formulated.

In Ardakan, shared industrial solar plants leverage existing industrial infrastructure to enhance clean energy output, helping to mitigate its 2022 deficit of -0.35 million kWh. Abarkouh employs agricultural solar canopies to integrate electricity generation with temperate farming, offsetting its projected -0.4 million kWh deficit by 2035. Bafgh's mining solar units, utilizing a 10 MW capacity, bolster energy supply for extraction activities, reducing its -0.55 million kWh shortfall. Yazd's urban solar distribution network optimizes its surplus through rooftop installations, facilitating regional energy balance.

Behabad's household solar panels, supported by subsidies, promote local generation to address its modest -0.1 million kWh deficit by 2035, while Ashkezar's factory solar plants target industrial demand to alleviate its substantial -1.65 million kWh shortfall. Taft utilizes hillside solar plants to counter its projected -0.3 million kWh deficit, and Khatam adopts rural biomass units that convert agricultural waste into energy to enhance self-sufficiency. Meibod equips pottery workshops with solar panels to mitigate its -1.03 million kWh deficit, and Mehriz integrates solar lighting along historic tourism routes to support its -0.611 million kWh shortfall.

As illustrated in Figure 6, these strategies are embedded within a cohesive regional framework that employs smart distribution networks to optimize supply-demand dynamics, leveraging Yazd's surplus to support deficit areas. A proposed green investment fund mobilizes resources from governmental, private, and potentially international sources, prioritizing underserved regions. Furthermore, adaptive policymaking—responsive to sanctions and cooperation scenarios—ensures resilience by incentivizing solar adoption or emphasizing local solutions as needed. Collectively, these measures integrate technical innovation, community engagement, and policy adaptability to not only rectify energy disparities in Yazd but also establish a robust, scalable blueprint for green regional planning in Iran and beyond. Realizing this vision requires concerted efforts from policymakers, industry stakeholders, and local communities to position Yazd as a leader in sustainable green development in the region.



- Shared Industrial Solar Plants – Installing solar panels in industrial complexes to assist in generating clean energy and contribute to offsetting the deficit (-0.35 million kWh in 2022).
- HIllside Solar Plants – Setting up solar panels on slopes to support electricity production and help reduce the deficit (-0.3 million kWh by 2035).
- Urban Solar Distribution Network – Expanding solar panels on buildings to utilize the surplus of 8.4 million kWh and contribute to regional energy balance.
- Household Solar Panels – Installing small domestic solar panels with government support to aid in local electricity generation and help offset the deficit (-0.1 million kWh by 2035).
- Mining Solar Units – A 10 MW solar power plant near mines to support clean energy supply for extraction operations and assist in reducing the deficit (-0.55 million kWh in 2022).
- Workshop Solar Panels – Installing solar panels on pottery workshops to aid in supplying clean energy and contribute to offsetting the deficit (-1.03 million kWh in 2022).
- Tourism Solar Lights – Solar panels along tourist routes to support electricity generation and help address the deficit (-0.611 million kWh in 2022).
- Factory Solar Plants – Dedicated solar panels for factories to assist in providing clean energy and contribute to addressing the deficit (-1.65 million kWh in 2022).
- Rural Biomass Units – Generating electricity from agricultural waste to promote village self-sufficiency and assist in reducing reliance on the grid.
- Agricultural Solar Canopies – Solar panels above temperate farmland to aid in electricity production and help address the deficit (-0.4 million kWh by 2035).

Figure 6. Specific strategies for each county.

This study, while comprehensive in its regional analysis and foresight modeling, has several limitations. First, the energy data were limited to electricity production and consumption, excluding other forms such as gas or heating, which may also influence regional energy balance. Second, although expert opinions were gathered through the Delphi method, the relatively small panel of 15 participants may not fully capture perspectives across all relevant sectors. Third, the financial feasibility and implementation costs of the proposed strategies were not quantitatively assessed.

Future research could address these limitations by incorporating multiple energy sources, conducting cost-benefit analyses of proposed strategies, and employing agent-based models to simulate stakeholder behavior. Additionally, replicating this framework in regions with different climatic, economic, or policy contexts would help evaluate its applicability and generalizability.

References

[1] C. Bhowmik, S. Bhowmik, and A. Ray, "Green Energy Sources Selection for Sustainable Planning: A Case Study," *IEEE Transactions on Engineering Management*, vol. 69, no. 4, pp. 1322–1334, 2022.
[2] C. Bhowmik, S. Bhowmik, A. Ray, and K. M. Pandey, "Optimal Green Energy Planning for Sustainable Development: A Review," *Renewable and Sustainable Energy Reviews*, vol. 71, pp. 796–813, 2017.
[3] K. Wang, H. Li, S. Maharjan, Y. Zhang, and S. Guo, "Green Energy Scheduling for Demand Side Management in the Smart Grid," *IEEE Transactions on Green Communications and Networking*, vol. 2, no. 2, pp. 596–611, 2018.
[4] "Commodity and Energy Balances," *Studies in Methods (Ser. F)*, pp. 81–119, 2022.
[5] "Concepts and Definitions," *Energy Balances and Electricity Profiles (Ser. W)*, pp. viii–xxiii, 2023.
[6] Ministry of Energy, "Energy Imbalance in Yazd province,"
[7] A. Soltani, and M. A. Imani, "Overcoming Implementation Barriers to Renewable Energy in Developing Nations: A Case Study of Iran Using MCDM Techniques and Monte Carlo Simulation," *Results in Engineering*, vol. 24, 103213, 2024.
[8] J. Nematian, and I. Rahimi, "Feasibility Study of Using Renewable Energies in Iranian Seas: A Comparative Study," *Renewable Energy*, vol. 189, pp. 383–391, 2022.
[9] M. Ghouchani, M. Taji, A. S. Cheheltani, and M. S. Chehr, "Developing a Perspective on the Use of Renewable Energy in Iran," *Technological Forecasting and Social Change*, vol. 172, 121049, 2021.
[10] M. Maleki Tehrani, M. Akhtari, et al., "Techno-Economic Investigation of a Hybrid Biomass Renewable Energy System to Achieve the Goals of SDG-17 in Deprived Areas of Iran," *Energy Conversion and Management*, vol. 291, 117319, 2023.
[11] M. Pourmoosavi, and T. Amraee, "Stochastic Approaches to Sustainable Energy in Iran: Enhancing Power System Flexibility and Renewable Integration," *Sustainable Energy Technologies and Assessments*, vol. 74, 104145, 2025.
[12] D. A. Johnson, "Regional Planning, History of," *International Encyclopedia of the Social & Behavioral Sciences*, pp. 141–145, 2015.
[13] R. Bustin, "Christaller's Central Place Theory Theory," *Teaching Geography*, vol. 45, no. 1, pp. 12–14, 2020.
[14] R. L. Church, "Alfred Weber (1868–1958): The Father of Industrial Location Theory and Supply-Chain Design," *Footprints of Regional Science*, pp. 89–107, 2023.
[15] D. Boyce, "Walter Isard (1919–2010): Founding Father of Regional Science," *Footprints of Regional Science*, pp. 15–24, 2020.
[16] N. Fujita, "Myrdal's Theory of Cumulative Causation," *Evolutionary and Institutional Economics Review*, vol. 3, no. 2, pp. 275–284, 2007.
[17] N. Fujita, "Myrdal's Theory of Cumulative Causation," *Evolutionary and Institutional Economics Review*, vol. 3, no. 2, pp. 275–284, 2007.
[18] H. Westlund, "Gunnar Myrdal (1898–1987): Cumulative Causation Theory Applied to Regions," *Footprints of Regional Science*, pp. 121–134, 2020.
[19] M. Mønsted, "Francois Perroux's Theory of "Growth Pole" and "Development" Pole: A Critique," *Antipode*, vol. 6, no. 2, pp. 106–113, 1974.
[20] E. M. Dobrescu, and E. M. Dobre, "Theories Regarding the Role of the Growth Poles in the Economic Integration," *Procedia Economics and Finance*, vol. 8, pp. 262–267, 2014.
[21] D. C. Lambert, and J. R. Boudeville, "Aménagement Du Territoire Et Polarisation," *Revue économique*, vol. 25, no. 2, 321, 1974.

[22] J. Boudeville, "Un Modèle De Croissance Polarisée Fondé Sur Le Complexe Agricole Du Rio Grande Do Sul," *Caravelle*, vol. 5, no. 1, pp. 71–91, 1965.

[23] E. W. Soja, "Regional Planning and Development Theories," *International Encyclopedia of Human Geography*, pp. 331–341, 2009.

[24] M. E. Porter, "Clusters and the New Economics of Competition," *Harvard Business Review*, vol. 76, no. 6, 1998.

[25] A. Saxenian, *Culture and Competition in Silicon Valley and Route 128, With a New Preface by the Author*, Harvard University Press, 1996.

[26] J. Merkel, "Richard Florida: The Rise of the Creative Class," *Schlüsselwerke der Stadtforschung*, pp. 69–90, 2016.

[27] "World Energy Balances (Edition 2021)," *IEA World Energy Statistics and Balances*, 2021.

[28] Y. He, Y. Zhou, J. Liu, Z. Liu, and G. Zhang, "An Inter-City Energy Migration Framework for Regional Energy Balance Through Daily Commuting Fuel-Cell Vehicles," *Applied Energy*, vol. 324, 119714, 2022.

[29] Z. Dehghan Shabani, and R. Shahnazi, "Energy Intensity Convergence in Iranian Provinces: Evidence from Energy Carriers' Consumption Intensity," *Environmental Science and Pollution Research*, vol. 28, no. 21, pp. 26697–26716, 2021.

[30] P. A. Corning, "Synergy and Self-organization in the Evolution of Complex Systems," *Systems Research*, vol. 12, no. 2, pp. 89–121, 1995.

[31] P. Li, Q. He, J. Zhang, and Q. Xia, "Analyzing the Impact of Energy Synergy and Renewable Energy Generation on Energy Security: Empirical Evidence from China's Yangtze River Delta Region," *Energy*, vol. 302, 131868, 2024.

[32] B. Li, H. Xu, et al., "Optimized Field Synergy Analysis Strategy for Heat Transfer Mechanism in Latent Heat Storage: Based on the Front-Tracking Algorithm and the Segmentation Thinking," *Energy*, vol. 315, 134281, 2025.

[33] N. E. L. Anku, "The Power of Procedural Justice in the Planning of Energy Projects," *Just Transitions*, pp. 63–68, 2023.

[34] S. F. Shahrom, K. B. Aviso, et al., "Regional Planning and Optimization of Renewable Energy Sources for Improved Rural Electrification," *Process Integration and Optimization for Sustainability*, vol. 7, no. 4, pp. 785–804, 2023.

[35] J. Sim, D. Lee, and K. Yoon, "Trustful Double Auction Design for Peer-To-Peer Energy Trading Between Interconnected Micro-Grids with Supply–Demand Imbalance," *International Journal of Electrical Power & Energy Systems*, vol. 160, 110117, 2024.

[36] J. Terrados, G. Almonacid, and L. Hontoria, "Regional Energy Planning Through SWOT Analysis and Strategic Planning Tools.," *Renewable and Sustainable Energy Reviews*, vol. 11, no. 6, pp. 1275–1287, 2007.

[37] M. Aras, "The Concept of Energy Communities as Per the Clean Energy for All Europeans Package: Contribution to the Energy Transition in France," *Palgrave Studies in Energy Transitions*, pp. 543–565, 2024.

[38] Y. Sarafidis, D. Diakoulaki, L. Papayannakis, and A. Zervos, "A Regional Planning Approach for the Promotion of Renewable Energies," *Renewable Energy*, vol. 18, no. 3, pp. 317–330, 1999.

[39] M. Zolfaghari, M. Kabiri, and H. Saadatmanesh, "Impact of Socio-Economic Infrastructure Investments on Income Inequality in Iran," *Journal of Policy Modeling*, vol. 42, no. 5, pp. 1146–1168, 2020.

[40] B. Badakhshan, A. Sharifi, and T. Karami, "Is Life Green on the Other Half? Linking Urban Green Infrastructure to Socio-Economic Inequality and Spatial Segregation in Tehran, Iran," *Applied Geography*, vol. 177, 103562, 2025.

[41] N. Fallah Haghighi, G. Ramezanpour Nargesi, G. Abdollahzadeh, and Z. Sharifi, "Development Assessment of Provinces of Iran Based on Infrastructural Indicators," *Journal of Geography and Planning*, vol. 27, no. 83, pp. 103–116, 2023.

[42] B. Ata, P. Pakrooh, A. Barkat, R. Benhizia, and J. Pénzes, "Inequalities in Regional Level Domestic CO2 Emissions and Energy Use: A Case Study of Iran," *Energies*, vol. 15, no. 11, 3902, 2022.

[43] F. Khayat, and L. Teron, "Energy Justice in Southwest Iran: Mitigating the Socio-Economic and Environmental Impacts of the Fossil Fuel Sector and Building the Principles of Equity-Guided Development," *Handbook on Energy Justice*, pp. 269–289, 2023.

[44] S. E. Hosseini, A. M. Andwari, M. A. Wahid, and G. Bagheri, "A Review on Green Energy Potentials in Iran," *Renewable and Sustainable Energy Reviews*, vol. 27, pp. 533–545, 2013.

[45] Y. Hamzeh, A. Ashori, B. Mirzaei, A. Abdulkhani, and M. Molaei, "Current and Potential Capabilities of Biomass for Green Energy in Iran," *Renewable and Sustainable Energy Reviews*, vol. 15, no. 9, pp. 4934–4938, 2011.

[46] N. Afsharzade, A. Papzan, et al., "Renewable Energy Development in Rural Areas of Iran," *Renewable and Sustainable Energy Reviews*, vol. 65, pp. 743–755, 2016.

[47] A. Mostafaeipour, "Feasibility Study of Harnessing Wind Energy for Turbine Installation in Province of Yazd in Iran," *Renewable and Sustainable Energy Reviews*, vol. 14, no. 1, pp. 93–111, 2010.

[48] A. Sadeghi, T. Larimian, and A. Molabashi, "Evaluation of Renewable Energy Sources for Generating Electricity in Province of Yazd: A Fuzzy MCDM Approach," *Procedia - Social and Behavioral Sciences*, vol. 62, pp. 1095–1099, 2012.

[49] A. Dehghan, "Status and Potentials of Renewable Energies in Yazd Province-Iran," *Renewable and Sustainable Energy Reviews*, vol. 15, no. 3, pp. 1491–1496, 2011.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, have been completely observed by the authors.

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