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More Secure Iranian Energy System: A Markal Based Energy Security Model for Iranian Energy Demand-side

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A B S T R A C T

As the world's seventeenth-largest economy and a significant exporter of fossil fuels, the choice of future energy paths and policies that Iran will pursue over the next three decades will have a considerable impact on global energy security as a whole. Especially the eastern region. This article describes the current situation and recent trends in Iran's energy sector, including demand and supply-side fuel sector. This paper discusses the state of current energy policy in Iran, focusing on changing the situation, developing and deploying renewable energy, liberalizing energy markets, and developing Iran's energy sector. In the final part of the article, discussed Iran Long Range Alternative Energy Planning Software System dataset, several alternative energy paths for Iran's energy demand side, emphasize alternative pathways to diversify energy and power. The expansion of GHG emissions and emissions reductions and the Iranian economy's oil dependence is less - and address Iran's current energy policy issues, as reflected in inputs and modeling results.

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NOMENCLATURE

GDP	Gross domestic product	x	Share of power supply
VA	Value added	LEAP	Long range alternative energy planning
NEIR	Net energy import ratio	**Subscripts**	
SD	Service demand	k	sub-sector
SWI	Shannon-wiener index	t	year
DPED	Primary energy demand variation	0	Base year
VI	Vulnerability index	i	sector

INTRODUCTION

The supply chain is two sides of the coin policymaking option to enhance the energy security ratio restricting imports on the energy and energy supply sides. Restriction of the energy import reduces dependency on energy imports, which causes the energy sources diversity enhancement, and ultimately increases energy security while reducing energy production through efficient technology diversity mixing and combining energy sources with security [1].

Since energy is an essential element for sustainable economic development, energy demand is a critical indicator of people's standards and living qualities. Because of advances caused by technology, the demand for energy in Iran is proliferating. So someday, it may face a severe energy deficit. Therefore, energy security must be taken into account in the leading development and progress plans. It should take the necessary steps to develop alternative energy sources. Energy security (ES), especially the security of natural gas supply, has become an essential issue in the economy and foreign policy

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affairs. From a geopolitical and technological perspective, ES refers to providing a reliable and sufficient energy source at a reasonable price to sustain economic growth [2].

As a supplier of energy with rising demand rates, Iran faces the challenge and issues of ES. Several papers analyzed this issue, which only showed the region's energy status and was neglected analytically. Sovacool [3] presented an overview of ES issues from a global and regional perspective and illustrated the Asia pacific specific consequences and concerns. Also, Worldwide and regional ES is not vulnerable to the scarcity of energy resources but may be subject to disruptions in energy supply and access to Market supply and threatened by the growth of terrorism and regional conflicts. Given the precious resources of fossil fuels but the highly energy-dependent economy, a large portion of the Iranian population still lacks access to free markets and adequate living and working conditions. To overcome the potential energy shortage in the future, Iran must develop its fossil energy sources and alternative renewable sources such as mini-hydro, solar, and wind. Iran has excellent potential for water, Photovoltaic, and wind energy supply chain, which can produce enough electricity to supply the northern hills and southern and eastern deserts. That will help reduce dependency on fossil fuels and improve energy security due to the variety of energy supplies in the supply portfolio [4].

Iran has not yet made up for the shortfall between demand and supply; but, it may happen in the coming decades. To address this shortage, Iran has a very sustainable energy option, including hydro, biomass, solar, and wind. The estimated total hydroelectric potential is over 12 GW; therefore, only 6.5 GW is used. However, biofuel is a traditional energy source in Iran; it has not yet been commercialized. The sun and wind are recognized as potential energy sources, but they still do not work on a large scale [5].

The novelty of this paper is to quantities the energy security of Iran using the MARKAL method. This paper examines the effects of energy import restriction policies and the overall primary carrier supply chain on energy sources diversity, technology mix on the supply side, and demand. Energy performance and energy storage, and ES are analyzed for the Planning period of 2010-2050. A MARKAL-based partial economic model has been developed for an integrated Iranian energy system for research, and three scenarios are being developed to illustrate the future of energy security in Iran using the scenario planning procedure.

LITERATURE REVIEW

Options ES is a widespread and increasing field of research. By the late twentieth century, the energy security concept reduced oil imports and managed those uncertainties. Today, energy security considers other energy carriers (i.e., Gas carriers and LNG) and designs risks such as disasters, terrorism, underinvestment in infrastructure, and imperfect markets. All of these may limit sufficient energy resources at a reasonable price. Today, the field and meaning of ES are broader than its concept in the 1970s and 1980s. The comprehensive concept of ES includes the four critical elements of physical access to energy resources. Access to energy resources; cost-effectiveness and acceptability were important [6].

There can be an apparent contradiction between affordability and acceptance because the low energy cost will result in higher energy demand and a threat to environmental issues and resource shortages. On the other hand, getting to environmental and ecological goals will result in higher energy costs. From a developing perspective, ES is an essential component of its development path. Energy increases people's productivity and income. Lighting improves their health, enables them to cooperate in education, and connects them to the world market [3].

The IEA, the World Bank, and many others expect the world's energy consumption to rise at a minimum rate of 60% for the next two decades. Two-thirds of global energy demand growth comes from developing countries. The main drivers of this global energy demand are the steady growth of the population in developing countries. Urbanization and Expected Mobility Progress [4] with the fast growth in energy consumption and prices, policymakers, researchers, and stakeholders at various institutions such as the IEA, etc., believe that energy security will be the essential indicator for the future development of energy policies in different countries. The critical question for policymakers is: how to enhance ES, and what are the various policies and strategy options? In the literature on ES studies, several consumption-demand and supply-side options for improving a country's energy security are discussed. The main options are initial reduction of primary energy, reduction of energy imports, increase in renewable energy and carbon tax, energy storage and performance, energy sources diversity, and supply sources. These options may vary for developed, developing, and least developed regions depending on energy sources, energy sources, and economic resources [5]. Various ES factors are used to evaluate and differentiate alternative policymaking options in the ES landscape [6]. These states are categorized into simple indices or indices, total indices, and some indices related to ES's different elements.

Numerous studies have been conducted to introduce energy security indicators concerning existing concerns [7, 8].

Takase and Suzuki [9] introduced long-term energy security indicators and, while classifying energy security indicators in terms of globalization, economic productivity, environmental acceptability, and regional flows. They pointed out that although the application of energy security indicators in instruments Analytical is very important, these indicators are not applied in energy policy. Only the output of the models is used to calculate the (quantitative) indicators.

Kiriyama and Kajikawa [10] examined the impact of energy security on energy supply models. According to them, to fully calculate the impact of energy security, a combined method is needed to consider the definite and random parameters. This article has tried to develop the energy security coefficient and use this coefficient to evaluate energy security. The problem that exists in the development of the energy security coefficient is part of the same problem that exists in other indicators of energy security. The financial relationship of the index is calculated by two criteria: 1) No significant price change due to supply fluctuations; 2) Sustainable energy supply and non-interruption of energy supply.

Initially, energy supply models were solved as deterministic models, but they were not considered a complete answer to energy problems' needs. The uncertainties in energy supply were not among the items that could be easily simplified. Thus, stochastic models found more influencial on energy supply models.

In gas prices, Muñoz et al. [11] stated the importance of entering random parameters indefinite energy supply models, uses the Monte Carlo method of random programming with scenario design to introduce gas price uncertainty in the energy model. These are uncertainties in cases where historical data exist. They compared the stochastic model results with the definitive model results and calculates the benefits of solving the problem randomly in reducing costs [11]. Some stochastic models evaluate the interaction between policy and energy price uncertainty to measure new investments [12].

In general, the following methods have been developed to achieve an active approach to energy security:

The first method is to use expert surveys to determine energy security indicators and add constraints to the energy supply model to achieve the desired result.

The second method is to enter random price parameters for cases where there is historical information.

The third method calculates new energy security indicators based on energy supply models that showed the energy supply system's resilience.

Table 1 summarized the comparison between calculating the impact of energy security on energy supply models in terms of advantages and disadvantages.

Given the nature of the problem, we need to consider energy security considerations with the least weaknesses. When a definitive energy supply model is implemented under uncertain conditions, it will be difficult to obtain a reliable result. Therefore, scenario analysis is usually used to obtain the uncertainty parameter's effect on the definite model results.

Iranian energy sector review

Iran's primary energy consumption has increased by more than 50% over the past decades. A policy of energy subsidy was adopted to limit energy use and domestic demand and raise domestic oil, natural gas, and electricity prices. The first phase of reform was adopted in late 2010, and phase two began in early 2014. The total end-use of energy in Iran by various sources is illustrated in Figure 1. As can be seen, the composition of Iran's energy portfolio is currently the majority of oil and gas resources [6].

Iran's energy portfolio is highly dependent on fossil fuels, and global trends indicate that energy demand will increase globally. What emerges in the global energy portfolio scenarios presented by reputable organizations and institutions is that the world draws its portfolio against energy demand-supply and issues such as energy security, the environment, and technology development. The high dependence on fossil resources and the lack of diversification in the energy portfolio to meet demand will not provide a sustainable future for Iran's current energy portfolio. As energy security and the development of non-fossil fuel-related technologies are expanding, and these macroeconomic trends are reflected in global

Table 1. Comparison between methods for calculating the impact of energy security on energy supply models

Title	Disadvantages	Advantages
First method	Low accuracy, in line with policymakers' mentality, ambiguous sensitivity analysis - requires historical information, only applies to variables from which accurate historical information is available.	Simplicity, fast calculations, low cost
Second method	Complex Scenario Design - Introducing a new indicator that requires a new interpretation of energy security.	Accurate calculations based on real information
Third method	Failure to review existing energy security indicators and their aggregation	Calculation of the index from the output of the supply model, taking into account fluctuations and threats, considering the indicators based on supply interruption and price changes

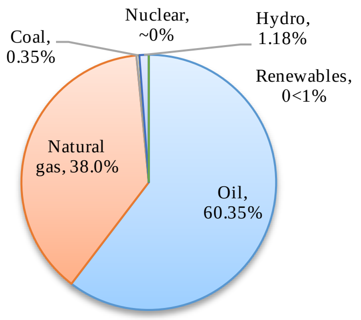

Figure 1. Total energy consumption by various Iran sources (adopted from literature [2])

scenarios, it is essential to pay attention to the variability in the Iranian energy portfolio for a sustainable future in energy meeting-demand [3].

The following is a detailed description of the country's current state of energy, and generally used data from the Iranian Statistics Center, the hydrocarbon balance sheet of the country, central bank statistics and information, and statistical reports from the Ministry of International Energy Information Institute. Oil - and the energy balance sheet - have been extracted from the Power Research Institute [2]. Energy carriers produced in post-operating processing and conversion systems are extracted from operating consumption and energy production process losses for end-user sectors, including the home-business, transportation, industry, agriculture, petrochemical feeds, non-energy consumables, and other consumables. Energy carriers in the final energy sector include petroleum products, abundant gas, light gas, liquids, condensates, hydropower, wind and solar, renewable and coal energy, and traditional fuels. The energy carriers consumed in the final energy sector are shown in Figure 1 from 2006 to 2016. By 2016 About 96% of all energy consumed in the country is natural gas and petroleum products, including liquefied petroleum, gasoline, petroleum, petroleum gas, stove oil, and air fuels. Petrochemical feed intake was 488.28 million barrels, and without petrochemical feed equivalent to 470.86 million barrels of crude oil, of which 186.1 million barrels were equivalent to petroleum crude oil (38.1 percent), and 142.5 million barrels equivalent to gasoline engine oil (29.2 percent). 98.47 million barrels of crude oil equivalent (20.2 percent), 19.53 million barrels of crude oil equivalent (4.0 percent), 15.14 million barrels of liquefied petroleum crude oil (3.1%), 9.15 million barrels of crude oil (1.9%), and 17.42 million barrels of crude oil, platform and industrial crude oil consumed to As a petrochemical feed (3.6%), due to an increase in gas supplies especially to power plants, petroleum products consumption decreased by about 12.2% per year. Oil and gas had a significant share of the process's decline, down by 2016 [7].

Consumption of light gas has been on the rise since 2006, with a growth of 6.27% in the period of 2006-2016. Coal consumption has experienced a 1.36% growth over 2006-2016, except for industry, declining in other consumer segments. Figure 1 shows the energy carriers' consumption by sectors over a decade [8].

As can be seen in Figure 1, the final energy consumption has grown by 2.95% over the past ten years. During these ten years, petrochemicals had the highest growth rate, from 80.05 million barrels of crude oil in 2005 to 150.59 million barrels of crude oil in 1994, upto 6.25%. Subsequently, agriculture with the growth of 4.36%, industry with the growth of 3.48%, households with the growth of 2.31%, and transportation with the growth of 1.88% was next in terms of consumption growth over ten years [10].

MATERIAL AND METHODS

MARKAL model

This study uses the MARKAL low-cost energy system model downstream as a partial model for analyzing Iran's energy security [9]. It models energy flow in a system of economy and energy from the primary energy source, converting primary sources into secondary energy and eventually delivering different energy types to end-user services. These energy flows have been described in the framework by the careful representation of technologies that deliver end-consumer demand. Figure 2 illustrates the simple concept of the partial MARKAL modeling framework through the Iranian Reference Energy System. Iran's power system framework is made of four modules. Primary sources supply chain, conversion devices and methods, end-user devices, and energy service demand and consumption. Primary energy sources include hydro, crude oil, natural gas (NG), oil imports, nuclear, solar wind, etc.; while module conversion technologies include electricity production and grid lines, crude petroleum refineries, NG processing, and systems. It is a transition. Energy demand for services is divided into agricultural, residential, commercial and industrial, and transport (see Figure 2). End-use demand is a measure of useful power generation provided by consumption devices in each end-use demand category. At MARKAL, it is assumed that energy demand is essential for some services (either cooking or heating), while the primary demand sector is fixed, it can be supplied with different mixes of equipment and fuel. The application technologies for the final use and conversion are defined in the next sections [9]. Targeted system performance is the lowest cost-minimizing the entire discount over the planning horizon. Total cost includes the net capital cost of salvage value, fuel cost, operation, and upkeeping costs. The framework's best solution must fulfill energy consumption satisfaction, capacity, and energy supply-demand equilibrium constraints. Energy demand services are predicted through three different methods using econometric frameworks and identity-related energy demand services in a specific sector to Gross Domestic Product (GDP) and specific sector value-added. In the econometric and financial approach, we consider dependent parameters such as the number of energy services and technologies, passenger kilometers, tonne-kilometers, etc., dependent on independent parameters such as GDP and population, while other approaches consider service demand. A particular sector in a particular year is multiplied by the demand for that sector in the base comparing year and multiplied by the ratio of current state year GDP and the base year GDP [7, 10]. Segment service demand in a particular year is multiplied by the segment-based service demand in terms of value-added year and base year value-added. The econometric approach was used to forecast energy demand in the transportation and residential sectors, while energy demand in the industrial, commercial, and agricultural sectors was predicted through the economic value-added and GDP approach. Forecast service demand for fans, air conditioning, and cooking based on GDP growth by the following formula [11]:

$$SD_{i,k,t} = SD_{i,k,0} * \frac{GDP_t}{GDP_o} \quad (1)$$

where $SD_{i,k,t}$, $Sd_{i,k,0}$ are service demand of sector i sub-sector k, in year t and a base year, respectively. GDP_t and GDP_0 represent GDP in year t and GDP in the base year. Service or section demand forecast for agriculture and food industry, commercial and public industry, and industrial sector are calculated and estimated from the formulation introduced below [9, 12]:

$$SD_{i,k,t} = SD_{i,k,0} \cdot \frac{VA_{i,k,t}}{VA_{i,k,0}} \quad (2)$$

where $SD_{i,k,t}$ is service demand of sector i subsector k in year t, $SD_{i,k,0}$ is service demand of industry i subsector k in the base year, $Va_{i,k,0}$ is the ith sector kth subsector value-added and income in the base year and $Va_{i,k,t}$ is the ith sector kth subsector total value added in the year t. Electricity-based service demand and supply were considered in six-time periods along with two seasons (summer and winter) and two-time types (peak and off-peak) so that the difference of electrical loads on the energy system can be reflected.

The main purpose of the current paper is to identify policy options to improve Iran's energy security. The basic criterion for classifying policy options is estimating ES indicators for the entire planning horizon 2010-2050. Four energy security indices were used in this study, namely Net Energy Import Ratio (NEIR), Shannon-Wiener Index (SWI), Primary Energy Demand Variation (DPED), and Vulnerability Index (VI) using the MARKAL model, Which is an energy system model that shows the long-term development of the energy system. These indicators are described as follows [7]:

$$NEIR\% = \frac{Net\,Importers * 100}{(Domestic\ production + Net\ Imports)} \quad (3)$$

NEIR value close to 1 indicates that the country's energy system is largely dependent on energy imports [6].

$$SWI = -\sum_i x_i \ln x_i \quad (4)$$

where x_i represents the share of power supply from each source, a higher SWI value means diversified energy sources that ultimately lead to improved energy security, while lower values indicate less variation in energy resources and weaker energy security [11].

$$DPED = \frac{\sqrt{Coal^2 + Oil^2 + Hydro^2 + Biomass^2 + Renewables^2 + natural\ gas^2}}{Total\ Primary\ Energy\ Demand} \quad (5)$$

where a DPED value close to 1 shows that the economy relies on one energy source while an amount close to 0 amount means that energy resources in the economy are distributed evenly across multiple energy sources [12–16].

Scenario planning model

Three main scenarios are being studied in this paper: (i) baseline, (ii) reduced energy imports, and (iii) reduced primary energy. The scenario details are described in the next sections.

Baseline scenario

In the baseline scenario, it was assumed that Iran's GDP growth rate at 7.0% annual growth rate and the population growth rate at 1.07% annual growth rate is estimated based on the Gross domestic product and data gathered for the period. At baseline, the maximum reserves available in fossil energy sources (e.g., coal, petroleum products, and petroleum and natural gas) were calculated as the total amount of proven resource reserves, potential reserves, and potential reserves. In the electricity industry, alternative source options (hydro, wind, and solar), NG-based electricity generating units, and Atomic and nuclear electricity plants are added to the framework. Options for the transport sector include road transport, weather.

Oil dependency reduction scenario

To categorize policy making options to improve Iran's energy security, we proposed three variant forms of resources export restrictions on the MARKAL partial framework for Iran. We analyzed the economic dependence, diversification of energy sources, and energy source diversity, vulnerability, and energy consumption intensity index for the entire planning horizon based on these constraints. Limitations include: (A) The IESC05 limit is the energy export limit of alternatives to 95% of the base energy export by 2050. (B) IESC10 - The export limit for alternative energy is 90% of base energy export by 2050. (C) IESC15 - Alternative energy export limit is 85% of base energy export by mid 21st century (2050).

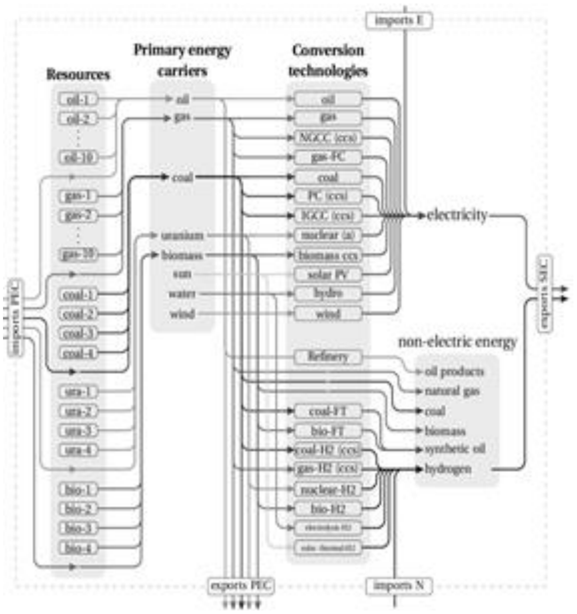

Figure 2. Reference energy flow system framework for Iran (developed by the author)

Primary energy demand reduction scenario

The primary fuel and carrier demand reduction policy is aimed to target energy performance throughout the energy sector. With an ES and energy performance development approach, other cases with different total core energy demand goals are analyzed to evaluate policy performance. Apart from each item's specific limitation, all other items are kept the same as the original. Limitations include (A) TPEC95 - The goal is to limit alternative energy demand to 95% of the overall primary fuel and carrier consumption by 2050. (B) The TPEC90 aims to limit the overall primary fuel and carrier consumption of the alternatives to 90% of the overall primary fuel and carrier consumption by 2050.

RESULTS AND DISCUSSION

Energy framework advancement of Iran in the planning period of 2010-2050 in the base scenario is explained as follows: In the first step, we applied LW clustering on the raw data, then after using PCA to have dimension reduction, the LW method is applied. Finally, we use our new method (i.e., CS algorithm) for clustering this dataset based on the following steps.

Primary energy supply in the base year

Primary fuel and carrier Supply chain in baseline scenario as can be known from Figure 3, the baseline primary energy supply illustrates a growing trend in the entire planning period 2010-2050, indicating an increase in energy and access to energy per capita. Iran's Primary fuel and carrier Supply has grown from 1,600 MTOE in

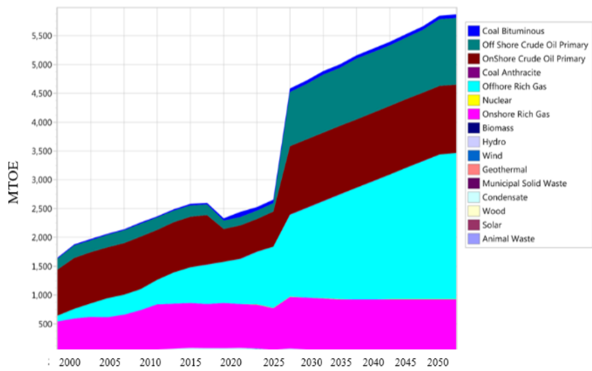

Figure 3. Primary energy supply in base case (developed by the author)

the base, comparing year to 2000 to 5700.6 MTOE in 2050. The model simulation results illustrate that NG is a major part of the primary carrier supply-chain along the planning period, while oil, renewables, and hydro also play a role in the primary fuel and carrier supply-chain.

Base fuel consumption is shown in Figure 4, as sharing of Compressed natural gas, Gas oil, gasoline, fuel oil, jet oil, kerosene, Liquified natural gas, and more. In the planning period, fuel consumption mix results from the calculated framework illustrate that NG and petroleum products have the main share of overall fuel demand by 2050, followed by coal, LPG, and other fuels. Although gas had the largest share of fuel demand in the baseline year of the scenario, the NG's share in fuel demand increased from 39% in 2005 to 57% in 2050.

As shown in Figure 5, sector-wise fuel demand in 2000 is dominated by transportation followed by residential, Industrial, and Commercial sectors, and the same trend prevails in all of the planning period 2010-2050.

Oil dependency reduction policy

To categorize policymaking alternatives and options to improve Iran's energy security, we have put forward three variant forms of restrictions (e.g., IESC5, IESC15, and IESC20). These limitations are briefly described in the

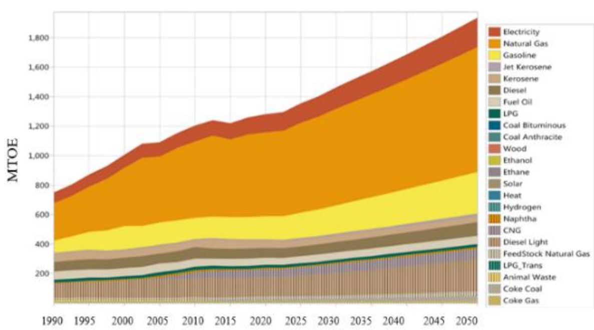

Figure 4. Fuel demand in the base case (developed by the author)

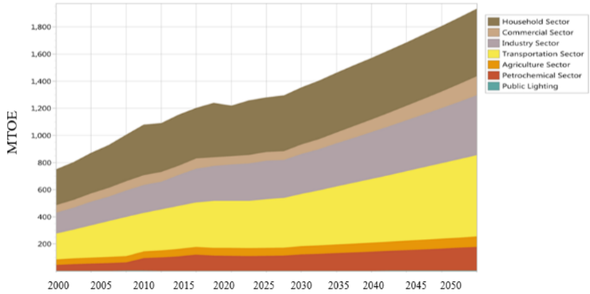

Figure 5. Sector-wise fuel demand in base case (developed by the author)

MARKAL partial framework for Iran. We analyzed export dependence, diversity in energy resources, vulnerability, and energy consumption intensity for the entire planning period based on these constraints. As shown in Figure 6, the primary fuel and carrier supply-chain decreased by less than 5% and the 10% decrease in export energy compared to the baseline scenario, while the primary fuel and carrier supply–chain less than 15% decrease in energy import compared to the year 2000 case increased [12].

The Net Energy Import Ratio (NEIR) is an essential indicator used for energy security analysis and an approximation measure for energy imports dependence. As can be detected from Figure 7, NEIR from other parts of the world, as shown by NEIR, are reduced. The cause for this dependency is the decline in imports of increased stocks of indigenous (coal and renewable) energy sources in the energy framework. Finally, Iran's energy security will improve from 2010 to 2050.

Diversity in energy sources supply plays a key role in improving energy security. DPED and SWI are used to illustrate the diversity of diversity in different energy resources. As can be detected from Figure 8, the amount of DPED decreased from 0.8 in 2010 to 0.3% in 2050,

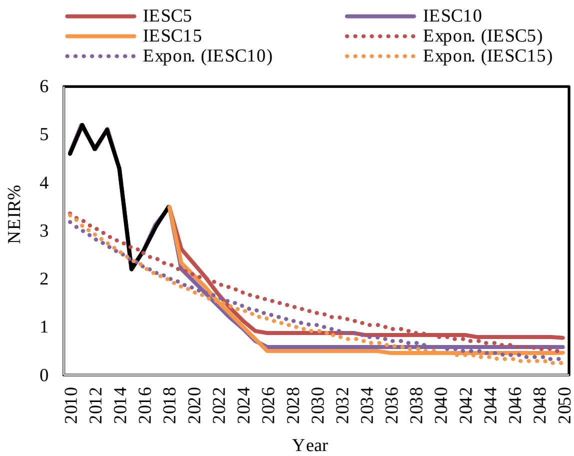

Figure 7. Import dependency under each policy (developed by the author)

below 5% of energy. The decline in exports indicates a better diversification of different energy sources than the baseline. Diversity can also be analyzed through the Shannon-Wiener Index (SWI).

A Higher SWI value means better variability between different energy sources. Figure 9 shows the simulated values of the model for SWI, which shows that the SWI value increases from 0.39 in 2010 to 0.88 in 2050 under energy export constraints, indicating better variability across energy sources across horizons. Planning (2010-2020) ultimately, both indicators mean a better energy resource diversity by 2050 than 2010, causing improved ES in Iran by 2050.

Energy security and energy demand reduction

ES and fuel Demand Reduction Reducing primary carrier and fuel supply-chain load is an alternative policy making option to develop its energy security. This policy works by increasing energy performance and fuel-carrier switching, which decreases primary energy consumption.

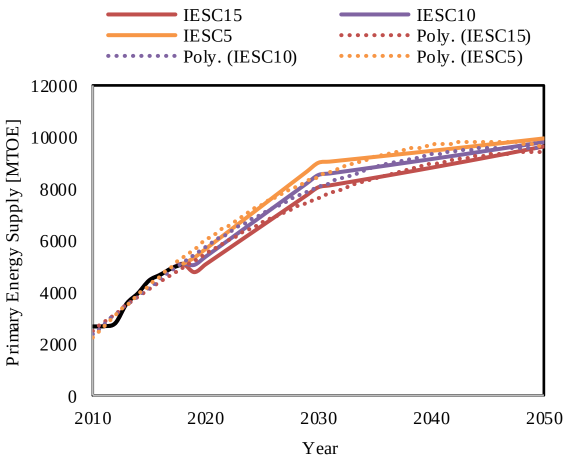

Figure 6. Primary energy supply-chain under energy export reduction (developed by the author)

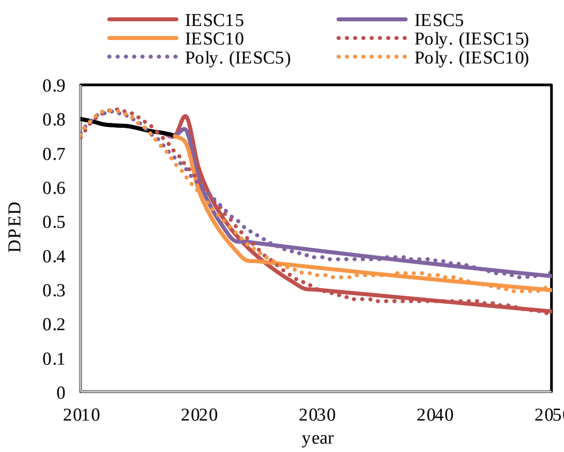

Figure 8. Energy resources diversity index (DPED) (developed by the author)

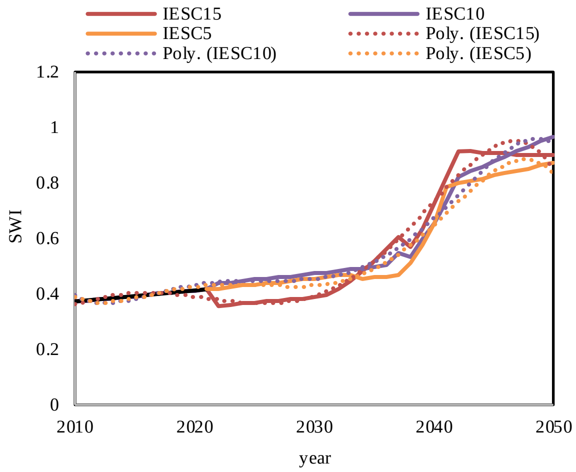

Figure 9. Shannon-wiener index (developed by the author)

More Efficient devices are chosen to reduce the initial energy supply-chain load and end-use energy consumption due to the high-performance ratio of efficient devices that will lower the primary energy demand. As can be analyzed from Figure 10, the total baseline energy demand for the baseline is higher than the others, limiting the baseline energy demand model to 95% and 90% of the baseline. Reduction of Primary Energy Intensity across all Primary Energy Reduction Limits across the entire planning horizon 2050-2010. The overall goals of primary energy reduction do not help to improve the country's energy security; but it helps to improve overall energy efficiency [12].

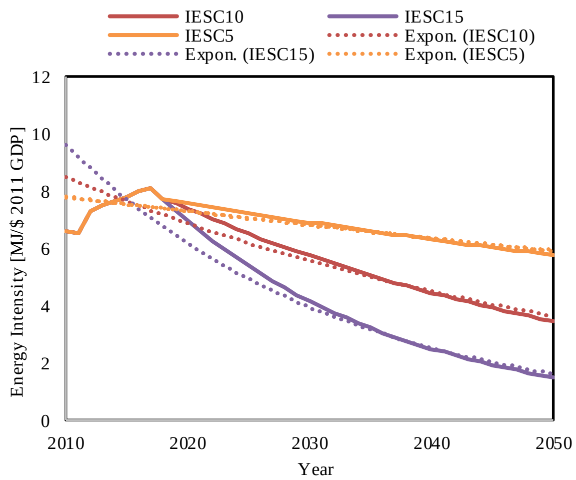

Figure 10. Primary Energy intensity under primary energy demand reduction (developed by the author)

CONCLUSION

This paper examines the effects of energy export restriction policies and overall primary fuel carrier consumption on the energy source diversity index, technology mix on the supply side, and demand. Energy performance and Energy storage; and ES in the Planning Horizon 2010-2050. To this end, a MARKAL-based model has been developed for an integrated Iranian energy system. The study also provides a brief overview of various policy options to enhance ES. Restricting energy exports and imports and primary energy supply-chain load are two policy options proposed in the MARKAL framework for Iran to analyze energy security. The impact of these two alternative policy options on Iran's energy security was analyzed by estimating the ES indicates for the baseline and these two alternative policymaking options with the planning period of 2000-2050. Restricting energy exports is a direct policy option and a guideline for improving energy security and effectiveness in the Iranian case. Looking at the ES factors, all ES factors point to a decline in energy exports relative to the baseline. The ratio of net energy exports reduces, energy source diversity index improves. Therefore, reducing energy exports may be one of the best alternative policy options to improve Iran's energy security and economic situation. Decreasing Primary fuel and carrier consumption is also an alternative policy making option to enhance ES and increase energy performance, and fuel-carrier is switching and decreasing primary energy consumption. By limiting primary energy demand, energy imports' dependency has reduced in all scenarios relative to 2000. And by 2050, the energy intensity will be significantly reduced. Diversification in energy sources shows significant improvement over the baseline scenario. All the mentioned facts suggest that lower primary energy demand can be used as a policy option to enhance energy security for Iran.

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Persian Abstract

چکیده

به عنوان هفدهمین اقتصاد بزرگ جهان و صادرکننده قابل توجه سوخت‌های فسیلی، انتخاب مسیرها و سیاست‌های انرژی آینده که ایران طی سه دهه آینده دنبال خواهد کرد، تأ ثیر قابل توجهی بر امنیت جهانی انرژی خواهد داشت. به خصوص در منطقه شرقی آسیا این نشانه‌ها به وضوح حس خواهد شد. این مقاله وضعیت فعلی و روندهای اخیر در بخش انرژی ایران، از جمله تقاضا و عرضه در کنار سوخت و بر اساس بخش‌های مختلف را توصیف می‌کند. در این مقاله وضعیت سیاست فعلی انرژی در ایران، با تمرکز بر تغییر وضعیت، توسعه و استقرار انرژی‌های تجدیدپذیر، آزادسازی بازارهای انرژی و توسعه بخش انرژی ایران مورد بحث قرار گرفته است. در قسمت پایانی مقاله، مجموعه داده‌های LEAP برای ساختار انرژی ایران (سیستم نرم‌افزاری برنامه‌ریزی انرژی جایگزین طولانی مدت)، چندین مسیر انرژی جایگزین برای تقاضای انرژی ایران که بر مسیرهای جایگزین برای تنوع بخشیدن به انرژی و نیرو تأکید دارند را پیشنهاد می‌دهد. کاهش انتشار گازهای گلخانه‌ای و کاهش وابستگی نفتی اقتصاد ایران و پرداختن به به موضوعات فعلی سیاست انرژی پیش روی ایران از مهم‌ترین موضوعات مورد بحث در این مقاله می‌باشد.