The Role of Energy Sector in Sustainable Development in Iran

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SUBMITTED TO THE MIT SLOAN SCHOOL OF MANAGEMENT IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN MANAGEMENT STUDIES

AT THE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

JUNE 2011

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on May 6, 2011 in Partial Fulfillment of the
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ABSTRACT

Generally speaking, both supply and use of energy in Iran are unsustainable. The unsustainable energy supply and use coupled with an unreliable and unsecure energy system have striking and lasing impacts on economic, social and environmental development of Iran. Natural gas and oil have dominated the total production of energy sources (TPES) in Iran for the past 50 years. Natural gas has also dominated the total final consumption (TFC) since 1999. Other alternative resources have been playing marginal roles in Iran's development. The high share of fossil fuels in energy supply and use has striking social, economic and environmental consequences. Additionally, Iran's reliance on oil and gas resources makes the energy sector in Iran vulnerable and highly unsecure. In order to address these issues, I provide indicators of energy sustainability and analyze the trends of these indicators systematically. These indicators help policy makers as well as public and private sectors get a better understanding of major driving forces that affect energy sustainability, economic prosperity as well as social and environmental well-being. Based on these indicators, I explore the impacts of energy subsidies, innovation policies, technological advancement, renewable energy development, US sanctions, international cooperation, geopolitical instability, and many other factors on Iran's sustainable development.

Based on an in depth analysis of current state of energy sector in Iran and the characteristics of a sustainable energy system, I propose strategies and policies that can result in a more sustainable energy sector which in turn contributes to the economic prosperity, social and environmental well-being and higher energy security.

Thesis Supervisor: Roberto Rigobon
Title: Professor of Applied Economics

Acknowledgements

I would like to thank my wonderful classmates, knowledgeable professors and helpful staffs at MIT for their kindness and support. I would like to acknowledge all those who provided academic and moral support for me over this year of study at MIT.

There are some people that reshape your outlook on the life. I feel lucky that I had the opportunity to redefine my vision at MIT. My hearts goes to all MIT faculties that changed my mindset positively, shaped my thoughts and opened new doors to me. MIT faculties did help me find the solutions for complicated and frustrating issues, taught me how to think, how to question and how to approach an issue. Professor Roberto Rigobon is indeed one of those professors that helped me out a lot, supported me and more importantly, reshaped my outlook on the world. I would like to thank him a lot.

I would like to dedicate this thesis to my parents, Zibandeh Ahmadi & Mohammad Taher Golabi whose unconditional love, devotion, patience, and never-ending supports have helped me study at MIT, write this thesis and enjoy a wonderful life; I cannot describe their help and support in words.

I would also like to dedicate this thesis to the memory of my best friend, Sina Masihabadi who died in a car accident at Texas when I was writing this thesis. Sina was a wonderful friend. Truly friends are hard to find and impossible to forget. It's my honor to dedicate my work to his memory.

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Chapter 1

Introduction, Motivation and Objectives

1.1 Introduction

One of the most important elements of sustainable development is the way that an energy system provides energy services. Energy services, provided by private or public sector, should contribute to social, economic and environmental development effectively. The reliability and adequacy of energy services are critical aspects of energy sustainability. Energy sector is the most important sector in Iran that has lasting and striking impacts on other sectors. By and large, both supply and use of energy in Iran are unsustainable. The unsustainable energy supply and use coupled with unreliable and unsecure energy services are constraining economic, social and environmental development in Iran. Iran's economy still relies on the oil industry and agriculture sector. These two sectors together account for over 30% of GDP. In addition, natural gas and oil have dominated the total production of energy sources (TPES) for almost 50 years. Natural gas has also dominated the total final consumption (TFC) since 1999. Other alternative resources are playing marginal roles. The high share of fossil fuels has striking social, economic and environmental consequences. The high level of Iran's reliance on oil and gas resources makes the energy sector in Iran more vulnerable and less secure. Despite this fact that Iran has undertaken a new development plan recently which implicitly emphasizes the diversity of primary energy supply, the main focus has still remained on oil and natural gas production. Increasing the capacity of oil and natural gas, increasing the capacity of oil refinement and transportation from both Caspian Sea and Persian Gulf are still the main concerns of development plan whereas there isn't a high focus on other alternative sources. Despite these facts, the nuclear energy becomes increasingly important in recent years partly because of political struggles that it has caused. Iran tries to focus on nuclear energy to meet the high demand of electricity in Iran whereas the international society doesn't trust Iran's claims which in turn causes a series of geopolitical tensions and debates and also causes problems in technology acquisition in Iran due to lasting impacts of sanctions imposed by USA and triggered by Iran' persistence on Nuclear program.

Supplying reliable and affordable energy services is critical for transforming economy from a natural resource-based economy to a diversified, industrialized and market-oriented one. In this research, I provide some indicators for energy sustainability. These indicators together provide a framework which help policy makers, public and private sector get a better understanding of elements and driving forces that may have striking impacts on energy sustainability, economics prosperity and social and environmental well-being.

In this research, I briefly introduce a set of indicators that are provided by International Atomic Energy Agency (IAEA) [1]. Because this set is comprehensive and more importantly relies on national examination rather than international benchmarking, it has been used in this research. Since each country is different from other countries and has different policies, geography, availability of resources, political point of views and economy, an international benchmark is no longer a reliable way to evaluate energy sustainability. Therefore, it is inevitable to look at each country individually and assess the energy sustainability with a set of indicators. The high emphasis of this framework on socio-economic aspects, renewable energy share in energy consumption and supply basket, energy efficiency and energy sector's information transparency in energy markets are main advantages of these indicators. However, due to limited time and available information, I try to focus mainly on economic indicators. I analyze social and environmental dimensions qualitatively and systematically, but with an in depth exploration and investigation.

In the last part of this research, I propose strategies and policies that can result in a more sustainable energy sector. Those strategies are proposed based on an elaborate analysis of current state of energy sector and the characteristics of a sustainable energy system. If executed effectively, those strategies result in an energy system that contributes to the economic prosperity, social and environmental well-being and higher energy security.

1.2 Motivation

Presently, most countries worldwide are battling significant energy-related challenges; close to 2 billion people have no access to affordable and modern energy supplies. The reliability of energy supply is vital to any country and any threat to its supply will have striking impacts on development. It is a strongly held belief that greenhouse gas emissions caused by fossil-fuel energy consumption has led to global climate change and that the fine particle emissions have led to ecosystem degradation. All of these issues have changed the context in which society views the world.

The inequitable distribution of fossil-fuel resources results in trade deficits, diplomatic tensions and even war. The volatility of gas prices may damage both importers and exporters of these energy resources. These points along with the recent growth in energy demand and consumption have forced governments and global economic institutions to think about proper energy policies to insure sustainable development. Preparing for the inevitable changes in international energy systems is undoubtedly necessary for policy makers, business leaders and every responsible citizen to shape the future sustainable development.

1.3 The Origin and meaning of "Energy Sustainability"

In 1972, the "United Nation Conference on the Human Environment (UNCHE)" addressed major environmental issues and clearly explained the importance of environment degradation on humans' well-being and economic development. The product of this conference, known as Stockholm declaration, explained the interaction between socioeconomic development and human environment and explicitly demystified the environmental impacts on future development [1]. Even though the energy sector was not explicitly explored in the Stockholm declaration, but this declaration included recommendations and policies for energy production and use, and especially highlighted the danger of non-renewable resources' exhaustion and its striking impact on future of mankind. The Stockholm declaration was one of the primary attempts to consider environmental issues in socioeconomic development and propose proper policies to overcome major issues that current energy systems are facing.

Over the past three decades, lots of studies have been done and multiple policies and strategies have been executed. Finally, the term "sustainable development" was used for the first time in a report given out by "World Commission on Environment and Development". According to this report;

"[Sustainable development is] a progress that meets the needs of the present without compromising the ability of future generations to meet their own needs....[it] is a process which the exploitation of resources, the direction of investment, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potentials to meet human needs and aspirations "[2].

This report was the first report that defined the sustainable development and its scope. In the aftermath of this report, the term "sustainable development" was widely used in economics, environmental studies, management studies, public policy, engineering, development studies, science and other related fields. Additionally, energy impacts on sustainable development were one of the indispensable chapters of this report. Four elements of energy use's sustainability including sufficient growth of supplies to meet human needs, energy efficiency and conservation measures, public health and ultimately, environmental protection (ranging from the biosphere level to the local and community level) had been included in this report [2].

In the aftermath of this report, a number of declarations and studies were done that addressed the importance of energy sector in sustainable development. Explaining these studies is not the objective of this research. For those who are eager to explore more about this topic, "Brazil profile" has provided a summery of efforts done to identify the sustainable development and energy sustainability [3].

Recently, the accessibility of affordable energy enables a relatively large proportion of world's population to enjoy the affordable energy benefits including comfort, mobility and productivity. The term "sustainable energy" refers to those ways that energy is produced and used in order to support social welfare, environmental wellbeing and economic prosperity. Long term human prosperity and ecological balance are among the main reasons that encourage sustainable energy production and use. However, unfortunately most of energy practices are not always in line with these goals. Many of these practices damage the environment and human healthiness and cause social unrest and economic stagnation. Global climate change, global warming caused by greenhouse gas emissions, air and water pollution and inequality in energy access are among some of those issues emerged and reinforced by unsustainable energy practices.

Despite the availability of energy resources for at least 50 years, current energy systems are not sustainable. The accessibility of electricity and modern fuels are inequitable universally which in turn causes political unrest, geopolitical tensions and moral issues. Furthermore, the reliability and affordability of current energy systems do not have an acceptable state. It's imperative to notice that unreliable energy supplies has economic, political and social consequences which ultimately harm social welfare and human wellbeing. In addition, the environmental impacts of unsustainable energy system have become a major global issue. Human health and ecological balance are harmed as a result of these issues spurred and strengthened by unsustainable energy systems. A sustainable energy policy should have following characteristics to address current issues and shape favorable future state of energy sector [4]:

1. Energy sector should rely on markets that are able to correct failures. Market should function properly by applying a set of appropriate regulations that enable it to correct failures including monopoly and externality and remove major obstacles including impediments toward free flow of information, technology and knowledge diffusion and so forth.
2. Energy sector should be restructured in order to form a sustainable energy system. A set of regulations is needed to achieve this goal.
3. Enhancing technological innovation, technology acquisition and diffusion, knowledge acquisition and providing incentives for both domestic and international investors are some objectives can be obtained through regulations and policies that encourage innovation.
4. Strengthening regional and international cooperation and partnership is imperative in achieving a sustainable energy system.

As pointed out earlier, technological innovation, technology acquisition and innovation are vital in achieving a sustainable energy sector. The new century is a challenging period for the Iranian economy. After playing a marginal role for centuries on the world stage, Iran is experiencing an important economic transformation. The impact of international trade, globalization, technology diffusion and rapid technology growth are creating profound changes to its economic structure, growth and productivity.

Presently, Iran has a considerable domestic market, rigorous educational system, a large number of university graduates, a relatively well-developed industrial and service foundation, a unique geopolitical position and a relatively strong economic hub in the region (Iran is placed at the strongest petroleum hub in the world). However, Iran is facing several social and economic challenges. Fiscal imbalances and high inflation considerably decreased living standards and undermined the primary incentives for entrepreneurship. Lack of transparency has led to corruption which has in turn undermined productivity. The dominance of state-owned enterprises has politicized the business environment and has tremendously reduced transparency. Government intervention in price setting, subsidies and regulations has distorted both economic and organizational decisions. Due to the relatively isolated position of Iran in the world market, infrastructure is non-modern and highly inefficient. This fact, along with the absence of competition has diminished innovation and ingenuity. An inefficient public sector alongside a weak private sector is a critical challenge as well. All of these issues compounded together increase the complexity of energy policy making in Iran. Iran's economic development in all stages in her history has been explored in details. Amuzegar [5, 6], Amouzegar and Fekrat [7], Banani [8], Bharier and Juliani [9], Karshenas [10, 11], Katouzian [12], Lenczowski [13], Mahdavy [14], Pesaran [15, 16, 17, 18], Pamuk [19], Madison [20] and Yaganegi [21] have provided elaborate assessments of economic development in Iran in all stages starting from the beginning of twentieth century to late 2000s.

In the world market, innovative-based competition plays a dominant role in regional competitiveness. Iran must strive to diversity its production base and to transfer itself to a networked economy. In order to gain rapid growth, Iran needs to focus on trade, investment, acquisition of technological know-how, expanding innovative capacity and effective adaptation of new and emerging technologies.

Technology adaptation is important, but innovative new technologies and its diffusion throughout the economy are even more critical for success in regional competition. Linking a strong science infrastructure to the other production sectors and establishing opportunities for high-tech industries is absolutely essential to gaining a competitive position in the world market. To this end, Iran needs effective policies that encourage innovation, entrepreneurship and continuous learning, which will ultimately enable it to achieve progress in advanced technologies. The points I offered can help policymakers make appropriate, effective and applicable policies for success. I will explore innovation policy more in depth in the chapter 5.

1.4 Energy sector terminology

The composition of an energy supply sector and energy end-use technologies is called "energy system". Figure 1.1 presents the architecture of an energy system [3]. Coal mines, hydropower dams, oil wells, windy areas and forests are the locations of energy sources including coal, oil, gravity, jet streams and fuel wood. Primary energy can be obtained from energy sources by using required operations and technologies. Hydropower stations, thermal and nuclear power plants, oil refineries and coal gasification plants are called conversion sites that convert primary energy, extracted from energy sources to secondary energy by using conversion technologies including turbines as well as cracking and chemical reactors. Electricity, gasoline, hydrogen and heat are secondary energy sources which take various forms called currencies [3]. Currencies are distributed through distribution networks including electricity and gas grids, vehicles and heat grid pipes. This distribution networks transmit the currencies from conversion sites to the users of secondary energies. The final energy which consumer uses goes into service technologies and benefits consumer through a wide variety of services. Energy systems deliver the benefits of energy to consumers through the process that is explained before [3].

Energy system differs from energy services. Energy services include those benefits that energy system delivers to consumers by using required technologies. Heating, cooling and electricity are among those benefits and services that have been widely used in every single entity. Another important term is "energy chain". Energy chain begins with the collection or extraction of primary energy that is converted into usable energy carriers such as electricity or gas. By and large, those usable energy carriers will be converted to another energy form using end-use technologies such as vehicles and consumer electronic goods.

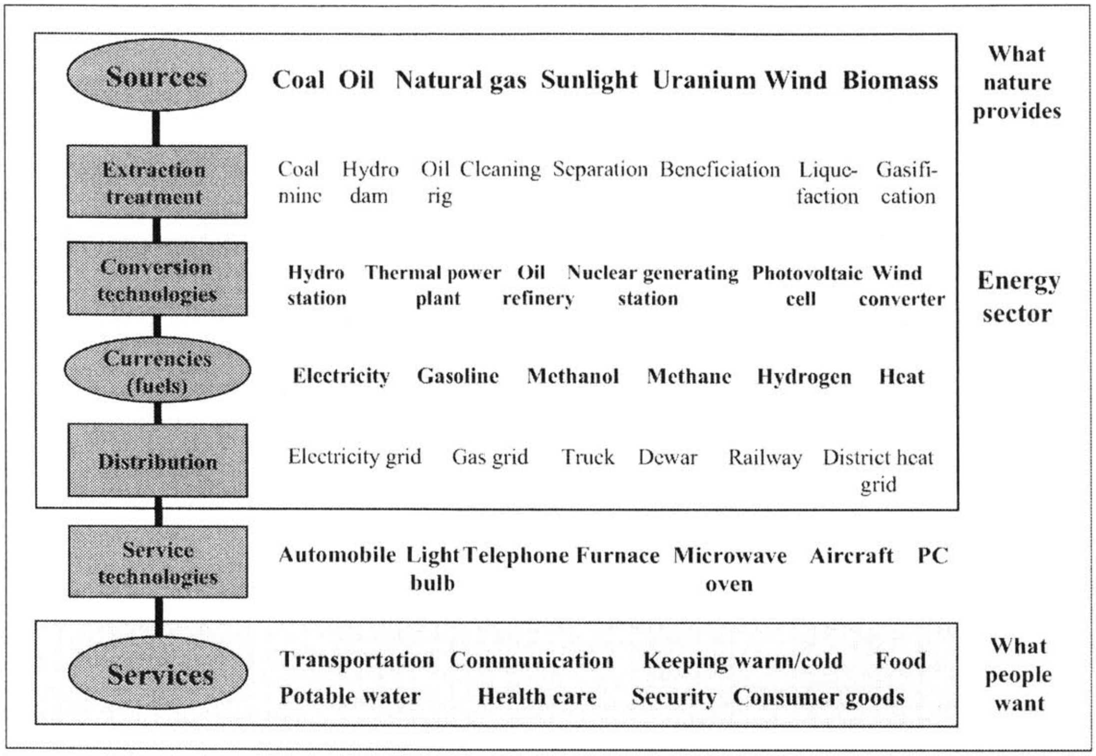


Figure 1.1 The architecture of an energy system [3]

The concept of energy chain is important for policy makers. The energy system architecture presented in the figure 1.1 can provide a clear and concise framework for understanding the energy chain. In every single stage of the energy path from extraction of primary energy to the final usable energy, some policies are proper and effective. For the primary stages including extraction and exploitation of primary energy, conversion to secondary energy and transmission of secondary energy efficiency, some factors such as price, cost and productivity are among most important factors that should be improved. Benefiting consumers through providing appropriate energy services requires technologies, capital, labor, materials, supportive industries and indeed primary energy. In order to provide energy services and meet the increasing demand, investing on efficient production delivery and changing the current energy consumption is essential.

Technology progress and innovative technologies in production, delivery and end-use side of the energy chain can increase the efficiency of energy systems. Efficiency improvements in energy supply will cause a decrease in financial barriers of investment compared to the financial barriers of previous energy systems. In addition, for the last stage of energy chain, consumer utility and behavior is more critical. Therefore, those stages that are closer to the final consumers are more complicated and require harder effort to analyze the strategic drivers and synthesize effective strategies.

1.5 An overview of the economic, social and environmental impacts of energy supply and use

The reliance of contemporary modern markets and industries on energy makes the energy sector an important sector for development and growth. Modern energy supplies are becoming more important by each passing year because the shortage of supply has inevitable adversary impacts on economic growth and prosperity. Therefore, there is a strong linkage between energy supply and development. The shortage of modern energy supplies and even the uncertainty of its availability may convince corporations not to expand their activities which in turn decreases the GDP, increases the unemployment rate and causes other unpleasant economic and social consequences. In general, it is imperative to analyze this linkage in each country based on its economic, geographical, political, social, technological and cultural context. The geopolitics of the country, current and previous policies, institutional structure, demographic status, natural resources, culture and social norms, income distribution, development stage and many other factors are important to find out if there is a weak or strong linkage between energy and development. In order to get a comprehensive understanding of this linkage, it's absolutely critical to expose the driving forces behind energy systems that affect other systems. In this research, I try to qualitatively conceptualize these systems to find out how different variables interact within them, why they behave in a certain way and what effective policies should be made to achieve sustainable energy systems.

One of the most important indicators of energy sustainability is energy intensity, which is equal to the ratio of energy demand to gross domestic production (GDP). Energy intensity usually depends on the development stage of a country. Even though energy demand and economic activities across a country are interconnected, but the quality of this interconnection depends on a wide variety of factors. However, the trends of historical data prove that as economy progresses, the energy intensity will decrease as a result of development advancement. A study done by world energy assessment reveals that common pattern of energy use is derived by the following factors [4]:

> "1. The shift from non-commercial to commercial forms of energy, industrialization, and motorization initially increase the commercial energy-GDP ratio. (In the 1990s this ratio increased in transition in economies, mainly because of slower economic growth.)
>
> 2. As industrialization proceeds and incomes rise, saturation effects, as well as an expansion of the service sector (which is less energy intensive), decrease the ratio of commercial energy to GDP after it reaches a peak. This maximum energy intensity has been passed by many countries, but not by low-income developing countries.

3. As a result of worldwide technology transfer and diffusion, energy efficiency improvements can be the main limiting factor in the growth of energy demand arising from increasing populations and growing production and incomes.

4. The more efficient use of materials in better-quality, well-designed, miniaturized products, the recycling of energy-intensive materials, and the saturation of bulk markets for basic materials in industrialized countries contribute to additional decreases in energy intensity.

5. In developing countries, technological leapfrogging to the use of highly efficient appliances, machinery, processes, vehicles, and transportation systems offers considerable potential for energy efficiency improvements."

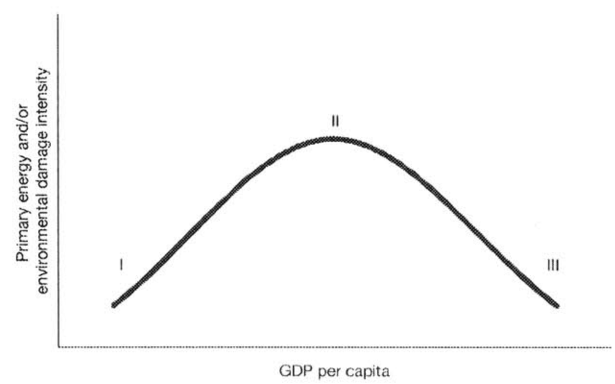


Figure 1.2. Energy-environmental Kuznets curve [3]

Figure 1.2, known as Energy-environmental Kuznets curve, presents three economic development stages; stage 1 presents the evolution from traditional to industrial society, stage 2 indicates the industrial societies' maturation and stage 3 displays a shift from an industrial to information and networked societies [3]. Even though the interconnection between GDP per capita and energy use is very complicated, this curve clearly states that economic development stage is a relevant factor affecting the primary energy use and environmental damage intensity. Presently, developing countries can take the advantages of global technological progress and shape more effective environment-sensitive industries that benefit both economy and environment. Therefore, these steps in Energy-environmental Kuznets curve are not necessarily replicable over time and leapfrogging over these steps is possible by making proper technology acquisition decisions and innovation policies. Developing countries have the opportunity of getting the turning point with relatively lower primary energy and environment intensity by taking the advantages of technology diffusion. Therefore, by each passing year, this curve becomes flatter [3].

Another important energy variable is energy price, which have great impact on consumer behavior. From the consumer's viewpoint, the utility or the economic value of energy services matters a lot. Since the energy price relates to the perceived utility of energy service, it is a factor that affects the consumer choice and behavior and affects development and economic growth. For instance, high prices of energy may lead to efficient use of end-use technologies or the use of efficient technologies which in turn affects other economic sectors including industrial, commercial and residential, transportation and agricultural sectors. On the other side, high prices of energy may degrade social welfare. In the next chapter, we introduce more energy sustainability indicators that are related to economic activities across a country. Generally speaking, studies have proved that the price change has deeper impacts on consumer behavior than price per se [3]. Other factors including fuel mix, reserves to production ratio, technology efficiencies, per capita energy use and import dependence are addressed in this research briefly.

In order to develop energy sector, capital investment is inevitable. Investment in energy system infrastructure including plants and equipments will lead to structural development of energy system. Despite this fact that energy supply creates early revenues and is attractive for private businesses, many companies may not decide to invest in developing countries mostly because of high perceived risk due to political instability, technical difficulties, administrative and regulatory hurdles and social and cultural resistance, just a few to say. The absence of major private businesses will lead to lack of capital investment, because the public funds are not usually adequate to afford capital investments. Therefore, attracting capital for investment in energy sector is vital for energy system development and difficulties in absorbing capitals may burden economic development. Foreign direct investment (FDI) is important in attracting foreign financial resources and required capital for capital investment in energy systems. In order to spur the FDI, the investors' perceived risk should be managed through effective regulations of energy and financial market and through clear and positive messages given out to foreign investors.

Poverty, demographic change and population growth, inequality and quick urbanization are major social issues that affect energy system and are affected by energy systems. The reliance of poor people on traditional energy sources especially in rural areas makes them impoverished. Most of poor people in rural areas don't have access to electricity, mostly because they cannot afford related costs or because of electricity unavailability. Lack of access to electricity has major impacts on human health because traditional energy fuels cause major health problems. Furthermore, lack of electricity has an adversary impact on education, entrepreneurship, nutrition, employment and ultimately life quality. Table 1.1 presents energy-related options to address social issues [4]:

Table1.1 Energy-related options to address social issues

ENERGY-RELATED OPTIONS TO ADDRESS SOCIAL ISSUES	
Social challenge	Energy linkages and interventions
Alleviating poverty in developing countries	1. Improve health and increase productivity by providing universal access to adequate energy services—particularly for cooking, lighting, and transport—through affordable, high-quality, safe, and environmentally accept- able energy carriers and end-use devices. 2. Make commercial energy available to increase income-generating opportunities.
Increasing opportunities for women	1. Encourage the use of improved stoves and liquid or gaseous fuels to reduce indoor air pollution and improve women's health. 2. Support the use of affordable commercial energy to minimize arduous and time-con- summing physical labor at home and at work. 3. Use women's managerial and entrepreneurial skills to develop, run, and profit from decentralized energy systems.
Speeding the demographic transition (to low mortality and low fertility)	1. Reduce child mortality by introducing cleaner fuels and cooking devices and providing safe, potable water. 2. Use energy initiatives to shift the relative benefits and costs of

	fertility—for example, adequate energy services can reduce the need for children's physical labor for household chores. 3. Influence attitudes about family size and opportunities for women through communications made accessible through modern energy carriers.
Mitigating the problems associated with rapid urbanization	1. Reduce the 'push' factor in rural-urban migration by improving the energy services in rural areas. 2. Exploit the advantages of high-density settlements through land planning. 3. Provide universal access to affordable multi-modal transport services and public transportation. 4. Take advantage of new technologies to avoid energy-intensive, environmentally unsound development paths.

Those energy interventions and linkages that are proposed to face social challenges introduced in table 1.1 can increase the household productivity and income-generation potential, mostly because it can increase affordability and accessibility of modern energy. The increased productivity and income-generation potential help household alleviate poverty, lower mortality and fertility, create opportunities for women, improve education for household members, create jobs and businesses, improve health state of household members and as a result of these improvements, increase quality of life [4].

It's also imperative to notice that social issues and challenges are important from a political standpoint. Social inequality along with poverty can cause sever political instability and may lead to even bloody revolutions and civil wars. Therefore, facing social challenges are imperative for achieving political stability, decreasing perceived risk and increasing upstream investments.

Ecological balance and biological diversity are both affected by energy supply and consumption. Despite the inevitable advantages of affordable and accessible modern energy and its impact on human well-being, the environmental impacts and degradation is a critical challenge threatening human health, quality of life and our ecosystem itself. For instance, Energy subsidies in Iran exceed $60 billion which is equivalent to nearly 20% of the GDP. These subsidies have halted economic development, decreased efficient energy consumption and increased government expenditures significantly for more than three decades. Some of the consequences of these energy subsidies in Iran include: high energy consumption, inefficient energy consumption, unreliable energy supply, fuel/electricity rationing, fuel smuggling, air/water pollution, higher noxious gas emission, land spoil, shrinking water supplies and social inequality. Currently, Capital-intensive investment in constructing dams to meet the high demand of electricity has resulted in one of the saltiest lakes in the Middle East to shrink which is on its way to meeting the same fate as the Aral Sea. The left over salt is spread by the winds over the surrounding arable land which has significantly reduced the lands fertility and productivity. My hometown of Mahabad is located 40 kilometers from Lake Oroumieh and this adverse effect has touched the livelihood of my family who are farmers in the region. This environmental calamity may undermine their life and the live of the local population dramatically which in turn result in unpleasant social consequences.

Environmental insults related to energy systems have significant impact on overall quality of life. Lead emissions to atmosphere, oil added to oceans, cadmium emissions to atmosphere, methane flow to atmosphere, nitrogen fixation, mercury emissions to atmosphere, Nitrous oxide flows to atmosphere, particulate emissions to atmosphere, non-methane hydrocarbon emissions to atmosphere and carbon dioxide flows to atmosphere are among those insults that have been created by human activities and unsustainable energy systems [4].

A sustainable energy system is an energy system that supports both environmental and human well-being. The future energy systems should benefit both ecosystem and quality of life and should keep emissions in an acceptable healthy level over the long run. Despite the increasing environmental challenges related to current energy systems, it is still possible to make policies that positively improve environment, society and economy. For instance, clean energies' development and commercialization are among those strategies that positively impact ecosystem, human prosperity, health and social welfare.

Energy sustainability, sustainable development and energy security are interrelated. Energy security refers to the availability of various forms of energy with adequate amount and affordable prices. Therefore, availability, adequacy and affordability of various energy forms are main dimensions of energy security. Energy security is a critical concept, especially because uneven distribution of fossil resources and global reliance on oil make the energy supply vulnerable. This uneven distribution combined with world's reliance on oil has major geopolitics implications and may lead to unpleasant events including war, conflict, sabotage and trade disruption. The inequitable distribution of fossil-fuel resources results in trade deficits, diplomatic tensions and even war. The volatility of gas prices may damage both importers and exporters of these energy resources. These points along with the recent growth in energy demand and consumptions have forced governments and global economic institutions to think about proper energy policies to insure sustainable development. By and large, in order to enhance national energy security, following options proposed by world energy assessment and mentioned below are useful [4];

> "1. Avoiding excessive dependence on imports by increasing end-use efficiency and encouraging greater reliance on local resources (particularly those whose development will have other positive externalities such as job creation, capacity building, and pollution reduction), provided these do not involve disproportionate costs or waste scarce resources.
>
> 2. Diversifying supply (including both suppliers and energy forms).
>
> 3. Fostering greater political stability through international cooperation and long-term agreements among energy-importing countries and between importing and exporting countries. Examples might include wider adoption—and more effective implementation of—the Energy Charter Treaty, as well as increased sharing of infrastructure for transporting natural gas.
>
> 4. Encouraging technology transfers (for example, through joint ventures and public-private partnerships) to developing countries, so they can develop local resources and improve energy efficiencies.
>
> 5. Increasing national and regional strategic reserves of crude oil and oil products through increased investment and advanced exploration technologies.

Current energy system in Iran is extremely vulnerable. The centralized energy system compound with its complexity and the presence of multiple external and internal forces make it even more vulnerable. Applying systematic approach help us reveal these forces and understand the system despite its complexity. Considering the experience of Japan in facing with Tsunami in 2011, we can see how a natural disaster may endanger the supply of energy. Therefore, energy security range from short term time scale (ex. Rare events) to long term one (ex. fossil fuel exhaustion in coming 50 years) [3]. The emergence of low carbon industries effects energy security in long run compared to current fossil fuel based industries. The use of efficient end-use technologies and the use of renewable resources and nuclear energy can lead to a low carbon economy. However, the geopolitical constraints in developing nuclear energy in the case of Iran shouldn't be forgotten and marginalized. Additionally, security issues are still constraining the development even in a low carbon economy. The security risks in distribution network, pipelines and transmission technologies should be clearly determined to lesson the risk of supply disruption. The case of Japan's tsunami proved that a striking natural disaster could not only disrupt energy supply but also endanger the human life.

Oil crisis in 1970, a series of wars in middle east, middle east uprisings, the 1990's convention on global climate change and liberalization of energy markets are among those events that have made energy security a buzzword in energy-related studies.

There are two perspectives for energy security; physical security and strategic security [3]. Physical security refers to those issues emerged because of an unanticipated event such as tsunami or war. The strategic perspective includes those policies and strategies that make the energy systems more flexible in responding to the fluctuations and oscillations. The degree of energy security depends on the operational complexity, the degree of subsystems independence and the degree of fuels, equipment and suppliers' demand diversification. [3]

Chapter 2.

Framework and Methodology

2.1 Overview

One of the most important elements of sustainable development is the way that an energy system provides energy services. Energy services, provided by private or public sector, should contribute to social, economic and environmental development and positively affect sustainable development. The reliability and adequacy of energy services are other aspects of energy sustainability. Energy sector is one the most critical yet complicated sector in Iran which has considerable impacts on other sectors. However, both supply and use of energy in Iran are unsustainable. The unsustainable energy supply and use along with unreliable and unsecure energy services are constraining economic, social and environmental development in Iran.

As mentioned before, Iran's economy still relies on the oil industry and agriculture sector. This two sectors together accounts for over 30% of GDP. Supplying reliable and affordable energy services is critical for achieving economy transformation from a natural resource-based economy to a diversified, industrialized and market-oriented economy.

In this chapter, I provide some indicators for energy sustainability. These indicators provide a framework which help policy makers and public and private sector get a better understanding of elements that have impacts on energy, social well-being, economic prosperity and environmental well-being. Moreover, historical data help us realize patterns and trends and as a result, policy makers can find out how to improve those trends and patterns to reach adequate, reliable and affordable energy sources. Those indicators are important for policy makers because they enable them to monitor past policies and strategies by observing the trend of the indicators and as a result, they can improve policies by interpreting the trend, patterns, causes, effects and driving forces.

In this part, I briefly introduce a set of indicators that are provided by International Atomic Energy Agency (IAEA) [24]. The reason this set of indicators is used comes back to this fact that this set is comprehensive and relies on national examination rather than international benchmarking. Since each country is different from other countries in terms of policies, geography, availability of resources, political point of views and economic nature, an international benchmark is no longer a reliable way to evaluate energy sustainability. Therefore, it is inevitable to look at each country individually and assess the energy sustainability with a set of indicators. Meanwhile, these indicators are able to clarify energy related issues for countries. Countries' policy makers can use these indicators to evaluate their energy policies over time. Therefore, I choose this set of indicators to get a better insight of factors that effect energy sustainability in a country. The emphasis of this framework on socio-economic aspects, renewable energy and its share enhancement, energy efficiency and information transparency of energy sector in energy markets are some advantages of these indicators.

2.2 The IAEA framework

In this part, I introduce ISED (Indicators for Sustainable Energy development) known as IAEA framework. This comprehensive set of indicators considers all required drivers of sustainable development including economic, social, environmental and institutional dimensions of sustainable development. The framework shows that these dimensions are interrelated. Figure 2.1 presents the framework applied for assessing energy sustainability in Iran [25].

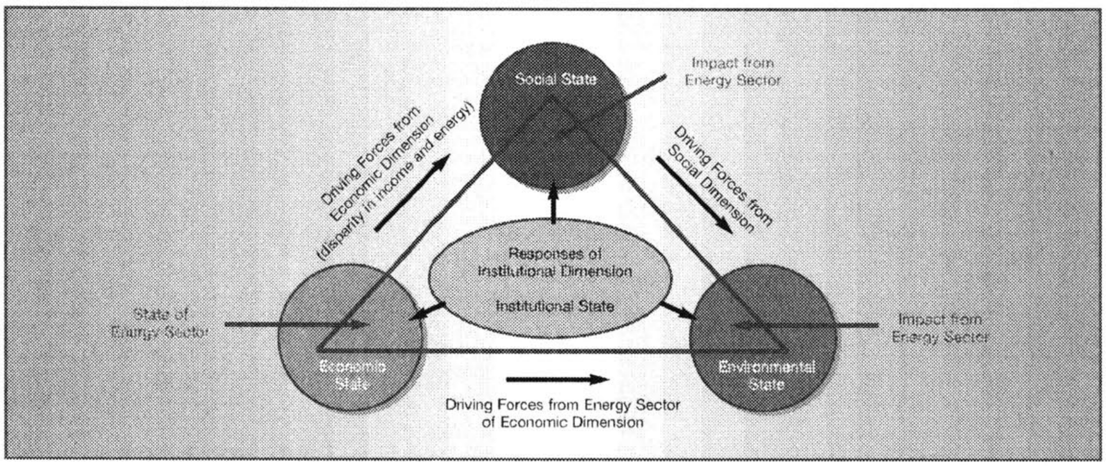


Figure 2.1. Indicators for Sustainable Energy development [25]

As it can be implied from figure 2.1, the environmental state is affected by driving forces of both economic and social dimensions. Driving forces of economic dimension affect social state of energy system. Finally, the institutional state affects all three dimensions by using policies and strategies that accelerate energy sustainable development. These dimensions are explained below [24];

Economic dimensions; Indicators related to economic dimension evaluate energy supply and use, energy service quality and the impact of current energy sector's state on economic sustainable development over time. These indicators illustrate how energy sector affects industrial, residential, agricultural, commercial, service and transportation sectors. Therefore, these indicators cover energy use and supply, the efficiency of energy production and supply, energy intensity, energy pricing, taxation and subsidies, energy security and energy diversity. These indicators show how energy systems effect employment, productivity and income generation and how it is affected by these key variables [24].

Social Dimension: Those indicators related to social well-being are used to evaluate the impact of energy services on social sustainability. Energy sector affects major variables and concepts about which society is concerned including poverty, employment, education, demographic transition, health care and culture. Accessible and affordable energy services are critical for social sustainability. Clean, safe, reliable and affordable energy services have tremendous social consequences. One of the difficulties of this part is lack of reliable information and data to find the trends and patterns [1].

Environmental dimension: These indicators can measure the impact of energy sector on environment in the household, workplace, city, and also national, regional and worldwide levels. These indicators expose the trend of energy production, use and supply and its influence on global climate change, water pollution, air pollution, land degradation, deforestation, and wastes. Regularity actions, pricing structure and production and use of energy result in major environmental consequences [24].

Institutional dimension: Those indicators related to the institutional dimension link policies and strategies to the economic, social and environmental issues. In other word, those indicators measure the efficiency of the institutional framework that is necessary to makes policies and shape strategies for making an efficient and sustainable energy system. These indicators can expose the effectiveness of legislative policies, regulatory activities, and economic strategies for developing sustainable energy system including educational programs, research and development, technology acquisition, capacity building, investments and so forth [25].

Unfortunately, Institutional dimension addresses those issues that are hard to quantify because they refer to the future not the trend of the past. Meanwhile, those variables assessed by this dimension depend on the current sustainable development policies which is hard to evaluate now [1].

Table 2.1 presents all 41 indicators that are categorized in three classes: Indirect driving forces, direct driving forces and state (The core IESD are shown in bold) [25].

Table 2.1 Indicators for Sustainable Energy development [25]

Indirect driving forces	Direct driving forces	State
1. Population: total; urban 2. GDP per capita **3. End-use energy prices with and without tax/subsidy** 4. Shares of sectors in GDP value added 5. Distance traveled per capita: total, by urban public transport mode 6. Freight transport activity: total, by	**14. Energy use per unit of GDP** **15. Expenditure on energy sector: total investments, environmental control, hydrocarbon exploration & development, RD&D, net energy import expenses** **21. Fraction of disposal income spent on fuels (total population, 20% poorest)**	**16. Energy use per capita** **17. Indigenous energy production** **18. Net energy import dependence** 22. Fraction of households: heavily dependent on non- commercial energy; without electricity 24. Ambient concentration of pollutants in urban areas: SO_2, NO_x, suspended particulates, CO, ozone

mode 7. Floor area per capita 8.Manufacturing value added by selected energy intensive industries **9. Energy intensity: manufacturing, transportation, agriculture, commercial & public services, residential sector** 10. Final energy intensity of selected energy intensive products **11. Energy mix: final energy, electricity generation, and primary energy supply** **12. Energy supply efficiency: fossil fuel efficiency for electricity generation** 13. Status of deployment of pollution abatement technologies: extent of use, average performance 19. Income inequality **20. Ratio of daily disposable income/ private consumption per capita of 20% poorest population to the prices of electricity and major household fuels**	**23. Quantities of air pollutant emissions (SO_2, NO_x, particulates, CO, VOC)** **26. Quantities of greenhouse gas emissions** 27. Radionuclide in atmospheric radioactive discharges 28. Discharges into water basins: waste/storm water, radionuclide, oil into coastal waters **29.Generation of solid waste** **31. Generation of radioactive waste** **33. Land area taken up by energy facilities and infrastructure** **35. Fraction of technically exploitable capability of hydropower currently not in use** **36. Proven recoverable fossil fuel reserves** 38. Proven uranium reserves **40. Intensity of use of forest resources as fuel wood**	25. Land area where acidification exceeds critical load **30. Accumulated quantity of solid wastes to be managed** **32. Quantity of accumulated radioactive wastes awaiting disposal** **34. Fatalities due to accidents with breakdown by fuel chains** 37. Life time of proven fossil fuel reserves 39. Life time of proven uranium reserves 41. Rate of deforestation

2.3 The modified ISEA

In 2005, International Atomic Energy Agency (IAEA), United Nations Department of Economic and Social Affairs (UNDESA), International Energy Agency (IEA) and Eurostat and European Environment Agency (EEA) published a document titled “Energy indicators for sustainable development” [26]. Based on their experiences and studies, they changed, combined and modified some of the indicators. They reduced the 41 indicators to 30 indicators. The new set of indicators called EISD that stands for Energy indicators for sustainable development. Here is the list of modified indicators [26]:

Social Dimension

SOC1: Share of households (or population) without electricity or commercial energy, or heavily dependent on non-commercial energy

SOC2: Share of household income spent on fuel and electricity

SOC3: Household energy use for each income group and corresponding fuel mix

SOC4: Accident fatalities per energy produced by fuel chain

Economic Dimension

ECO1: Energy use per capita

ECO2: Energy use per unit of GDP

ECO3: Efficiency of energy conversion and distribution

ECO4: Reserves-to-production ratio

ECO5: Resources-to-production ratio

ECO6: Industrial energy intensities

ECO7: Agricultural energy intensities

ECO8: Service/commercial energy intensities

ECO9: Household energy intensities

ECO10: Transport energy intensities

ECO11: Fuel shares in energy and electricity

ECO12: Non-carbon energy share in energy and electricity

ECO13: Renewable energy share in energy and electricity

ECO14: End-use energy prices by fuel and by sector

ECO15: Net energy import dependency

ECO16: Stocks of critical fuels per corresponding fuel consumption

Environmental Dimension

ENV1: Greenhouse gas (GHG) emissions from energy production and use, per capita and per unit of GDP

ENV2: Ambient concentrations of air pollutants in urban areas

ENV3: Air pollutant emissions from energy systems

ENV4-1: Contaminant discharges in liquid effluents from energy systems

ENV4-2: Oil discharges into coastal waters

ENV5: Soil area where acidification exceeds critical load

ENV6: Rate of deforestation attributed to energy use

ENV7: Ratio of solid waste generation to units of energy produced

ENV8: Ratio of solid waste properly disposed of to total generated solid

ENV9: Ratio of solid radioactive waste to units of energy produced

ENV10: Ratio of solid radioactive waste awaiting disposal to total generated solid radioactive waste

Table 2.2 presents EISD indicators

Table 2.2 Energy indicators for sustainable development [24]

Social				
Theme	**Sub-theme**	**Energy Indicator**		**Components**
Equity	Accessibility	SOC1	Share of households (or population) without electricity or commercial energy, or heavily dependent on non-commercial energy	– Households (or population) without electricity or commercial energy, or heavily dependent on non-commercial energy – Total number of households or population
	Affordability	SOC2	Share of household income spent on fuel and electricity	– Household income spent on fuel and electricity – Household income (total and poorest 20% of population)
	Disparities	SOC3	Household energy use for each income group and corre-sponding fuel mix	– Energy use per household for each income group (quintiles) – Household income for each income group (quintiles) – Corresponding fuel mix for each income group (quintiles)
Health	Safety	SOC4	Accident fatalities per energy produced by fuel chain	– Annual fatalities by fuel chain – Annual energy produced

Economic				
Theme	**Sub-theme**	**Energy Indicator**		**Components**
Use and Production Patterns	Overall Use	ECO1	Energy use per capita	– Energy use (total primary energy supply, total final consumption and electricity use) – Total population
	Overall Productivity	ECO2	Energy use per unit of GDP	– Energy use (total primary energy supply, total final consumption and electricity use) – GDP
	Supply Efficiency	ECO3	Efficiency of energy conversion and distribution	– Losses in transformation systems including losses in electricity generation, transmission and distribution
	Production	ECO4	Reserves-to-production ratio	– Proven recoverable reserves – Total energy production
		ECO5	Resources-to-production ratio	– Total estimated resources – Total energy production
	End Use	ECO6	Industrial energy intensities	– Energy use in industrial sector and by manufacturing branch – Corresponding value added
		ECO7	Agricultural energy intensities	– Energy use in agricultural sector – Corresponding value added
		ECO8	Service/ commercial energy intensities	– Energy use in service/ commercial sector – Corresponding value added
		ECO9	Household energy intensities	– Energy use in households and by key end use – Number of households, floor area, persons per household, appliance ownership
		ECO10	Transport energy intensities	– Energy use in passenger travel and freight sectors and by mode – Passenger-km travel and tonne-km freight and by mode

Economic				
Theme	**Sub-theme**	**Energy Indicator**		**Components**
	Diversification (Fuel Mix)	ECO11	Fuel shares in energy and electricity	– Primary energy supply and final consumption, electricity generation and generating capacity by fuel type – Total primary energy supply, total final consumption, total electricity generation and total generating capacity
		ECO12	Non-carbon energy share in energy and electricity	– Primary supply, electricity generation and generating capacity by non-carbon energy – Total primary energy supply, total electricity generation and total generating capacity
		ECO13	Renewable energy share in energy and electricity	– Primary energy supply, final consumption and electricity generation and generating capacity by renewable energy – Total primary energy supply, total final consumption, total electricity generation and total generating capacity
	Prices	ECO14	End-use energy prices by fuel and by sector	– Energy prices (with and without tax/subsidy)
Security	Imports	ECO15	Net energy import dependency	– Energy imports – Total primary energy supply
	Strategic Fuel Stocks	ECO16	Stocks of critical fuels per corresponding fuel consumption	– Stocks of critical fuel (e.g. oil, gas, etc.) – Critical fuel consumption

Environmental				
Theme	**Sub-theme**	**Energy Indicator**		**Components**
Atmosphere	Climate Change	ENV1	GHG emissions from energy production and use per capita and per unit of GDP	– GHG emissions from energy production and use – Population and GDP
	Air Quality	ENV2	Ambient concentrations of air pollutants in urban areas	– Concentrations of pollutants in air
		ENV3	Air pollutant emissions from energy systems	– Air pollutant emissions
Water	Water Quality	ENV4	Contaminant discharges in liquid effluents from energy systems including oil discharges	– Contaminant discharges in liquid effluents
Land	Soil Quality	ENV5	Soil area where acidification exceeds critical load	– Affected soil area – Critical load
	Forest	ENV6	Rate of deforestation attributed to energy use	– Forest area at two different times – Biomass utilization
	Solid Waste Generation and Management	ENV7	Ratio of solid waste generation to units of energy produced	– Amount of solid waste – Energy produced
		ENV8	Ratio of solid waste properly disposed of to total generated solid waste	– Amount of solid waste properly disposed of – Total amount of solid waste
		ENV9	Ratio of solid radioactive waste to units of energy produced	– Amount of radioactive waste (cumulative for a selected period of time) – Energy produced

Environmental				
Theme	**Sub-theme**	**Energy Indicator**		**Components**
		ENV10	Ratio of solid radioactive waste awaiting disposal to total generated solid radioactive waste	– Amount of radioactive waste awaiting disposal – Total volume of radioactive waste

Chapter 3

Current status of energy sector in Iran

3.1 Iran's profile

With population of over 74 million in 2010, Iran is the 18th most populous country in the world, with the population estimated to gradually reach 105 million by 2050 [27]. Those under the age of 30 constitute approximately 75 % of the population with a median age of 26. Iran spent 4.8% of GDP in 2008 on education. The literacy level reached 83% in 2009[28]. In higher education, women have comprised over half of the incoming students. Iran is home to more than one million refuges (one of the world's largest refugee populations) mostly from Afghanistan and Iraq. According to the UNHCR, about five million Iranian citizens have immigrated to other countries, mostly since the Iranian Revolution in 1979 [29].

Surrounded by Armenia, Azerbaijan, Pakistan, Afghanistan, Turkmenistan, Turkey and with access to the Caspian Sea and the waters of the Persian Gulf and the Gulf of Oman, Iran enjoys a strategic location and a status of a region power. Iran's political, economic, and social order is defined by the 1979 Constitution. The document establishes Shi'a Islam of the Twelver (Jaafari) sect as the main religion of the country. "The country is governed by secular and religious leaders through governing bodies, whose duties often overlap" [30]. The Constitution defines the Supreme Leader of Iran as having say on all domestic, foreign, and security policies: "The Supreme Leader is the final arbiter on nearly all disputes among the various branches of government" [30]. The political system consists of several intricately connected governing bodies with the President as the highest state authority responsible for implementation of the Constitution and for the exercise of executive powers. Since August 2005, Mahmoud Ahmadinejad has held the office.

As defined by purchasing power parity, Iran is the world's 16th largest economy with GDP reaching $335.7 billion in 2009 [30]. The Iranian government has reported an 11.8% unemployment level in 2009, with the actual estimates hovering around 20% and 34% for those between 15-24 years old. According to the CIA World Factbook "Iran's economy is marked by an inefficient state sector, reliance oil sector, which provides the majority of government revenues, and statist policies, which create major distortions throughout the system. Most economic activity is controlled by the state. Private sector activity is typically limited to small-scale workshops, farming, and services" [28].

Iran holds one of the largest oil and gas reserves in the world and, as a result, holds an important position in the international energy security and the world economy. Proved oil reserves amount to 132.5 billion barrels (11.1% of global reserves - fourth largest in the world). In 2006, Iran was the world's fourth largest oil producer. With proved gas reserves of 27.5 trillion cubic meters (15.3% of global reserves – second largest in the world) Iran ranked number five in the world in terms of gas production. Approximately 45% of total energy gas and oil production is consumed domestically [31].

Presently, Iran has a considerable domestic market, rigorous educational system, a large number of university graduates, a relatively well-developed industrial and service foundation, a unique geopolitical position and a relatively strong economic hub in the region (Iran is placed at the strongest petroleum hub in the world). However, Iran is facing several social and economic challenges. Fiscal imbalances and high inflation considerably decreased living standards and undermined the primary incentives for entrepreneurship. Lack of transparency has led to corruption which has in turn undermined productivity. The dominance of state-owned enterprises has politicized the business environment and has tremendously reduced transparency. Government intervention in price setting, subsidies and regulations has distorted both economic and organizational decisions. Due to the relatively isolated position of Iran in the world market, infrastructure is non-modern and highly inefficient. This fact, along with the absence of competition has diminished innovation and ingenuity. An inefficient public sector alongside a weak private sector is a critical challenge as well.

3.2 BB-NN Analysis for current economic state of Iran

As Roberto Rigobon describes:

"This model allows us to determine the real exchange rate for an economy. What is the real exchange rate? What is the nominal exchange rate? What are the differences and the similarities? The nominal exchange rate refers to the price at which two currencies are exchanged (1800 Italian Liras for 1 US dollar). On the other hand, the real exchange rate refers to the relative costs of similar goods in two different countries. In general, we are interested in the relative wages, since we almost always assume that capital has a high international mobility (e.g., we are assuming that capital is rewarded at the same risk-adjusted rate in all countries.) This simplifying assumption allows us to focus the model on the labor market. However, there are generalizations that include external capital, and the conclusions are practically the same.

The equilibrium real exchange rate is defined as the rate that results in equilibrium both in the labor market and in the balance of payments. It is important to understand that the real exchange rate refers to a certain extent to the degree of competitiveness of the economy. Therefore, it is a relative rather than a nominal price." [32]

I use this model to present a comprehensive image of current state of most important macroeconomic variables that indeed have great impacts on energy market, use, production, efficiency and ultimately sustainability.

Iran's economy was one of the fastest growing in the world during the 1960s and 1970s with real economic growth rates of nearly 10% resulting from a series of economic, social and administrative reforms backed by the country's large oil reserves. Economic growth resulted in the country maintaining a favorable trade balance even with a growing current account deficit due to increases in imports. One of the key drivers of economic growth in the period was capital inflow from foreign governments leading to a net trade surplus of over $17 million by the mid 1970s. However, the Islamic revolution of 1979 resulted in the country suffering negative growth during the 1980s. Iran's debt had rapidly increased to over $30 billion by 1993. There was post war recovery in the early 1990s with increased government spending to develop the country's infrastructure. Since the late 1980s, high rate of unemployment has been a persistent problem for the country with medium unemployment at approximately 14% since the late 1980s.

The economy's path can be illustrated in the BBNN framework below. The economy was at point A in the 1960s with a trade surplus, however with unemployment. With a period of economic growth, the trade surplus increased leading up to the 1970s and unemployment was on the decline, moving to point B. As the economy was moving toward equilibrium (E), the revolution of 1979 and the consequent economic sanctions imposed on the country caused a negative shock to the economy, resulting in the BB curve shifting up. The new equilibrium (E') level moved to a lower real exchange rate and lower aggregate demand. With negative growth in the 1980s, the country suffered a deficit and an increasing rate of unemployment (Figure 3.1), moving above the social peace curve P.

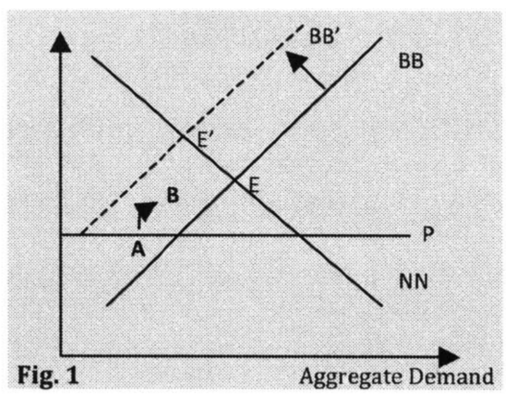


Figure 3.1. The BB-NN graph at early 1980s

After the Gulf War, Iran's government adopted fiscal and monetary policy to increase GDP growth that led to gradual increases in aggregate demand, moving to point C. Heavy reliance on the production and export of oil have also moved the economy to the right of the Sustainability Curve E. The second half of the 1990s saw a sharp decline in oil prices, which resulted in another shock to Iran's economy as protectionist policies had made the country highly dependent on its oil exports. The shock caused the BB curve to shift further upwards by the mid 1990s. On the other hand, a young population (30% of the population estimated under 30 and 5% over 64 in 2004) has resulted in an estimated 750,000 Iranians entering the job market each year, causing a gradual shift in the NN curve to the right. Decreasing pressure on real wages and a resulting decline in the real exchange rate has caused pressure on the government to create jobs, however facing the highest "brain drain" rate in the world according to the IMF. By the end of the 1990s, the new equilibrium level had shifted to E* (Figure 3.2) and the government was under tremendous pressure to adopt liberalization policies to diversify away from the country's reliance on oil exports. Increasing downward pressure on the real exchange rate and a decreasing trade balance have also cause the Social Peace curve, P, to move up as the standard of living decreased.

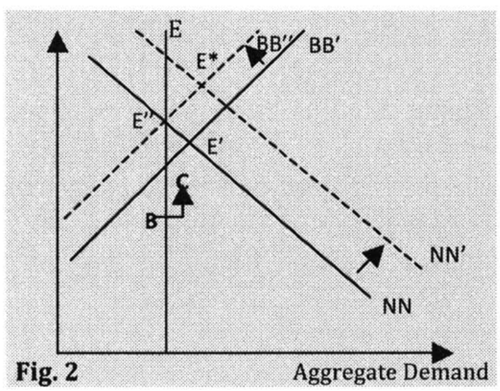


Figure 3.2. The BB-NN graph at late 1990s

In 2000, Iran's government implemented its third 5year plan involving new tax policies and foreign investment laws to spur aggregate demand. Together with a recovery in oil prices, the country saw economic growth over the period of the new plan and by the early 2000s and the deficit decreased from $30 billion to approximately $8billion in 2002. By 2005, the country had reached a surplus on its balance of payments of approximately $12 billion, however, still facing high levels of unemployment, moving to point D (Figure 3.3). However, the country has not been able to move away from its oil export dependency and the Sustainability curve has shifted to the left, resulting in a further disparity between the current and sustainable state.

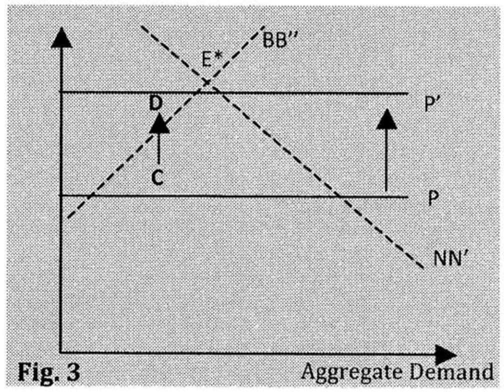


Figure 3.3. The BB-NN graph at early 2000s.

Although unemployment had seen a decline over the past decade to approximately 11% by 2008, the effect of the recent global economic crisis resulted in unemployment to rise to 14% in 2010. The current account balance is estimated at $15.7 billion in 2010, with the economy having moved to point X over the past 5 years. However, the current account balance is estimated to decline to $11 billion by 2012 (Figure 3.4).

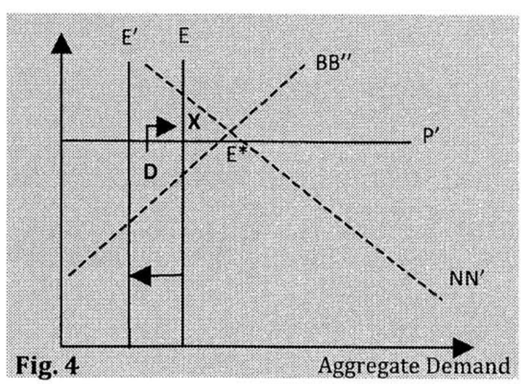


Figure 3.4. The BB-NN graph at late 2000s

3.3 Current Status of Energy sector in Iran

In this chapter of this research, the current state of energy sector in Iran is explored. In this part, I take a close look at the most important statistics and facts in Iran's energy sector by placing a high emphasis on recent policies. I get back to the current policies in the next chapters and explain energy policies in Iran elaborately.

The demand for energy in Iran is rapidly increasing. Additionally, we can see a transformation of energy consumption from traditional energy consumption (specially in rural areas) to consumption of modern energy sources including electricity and natural gas. This shift in energy consumption pattern is critical because it requires heavy investments in energy sector to meet the consumers' demand (i.e., demand in industrial & commercial, residential and transportation sectors) and to insure economic growth and development.

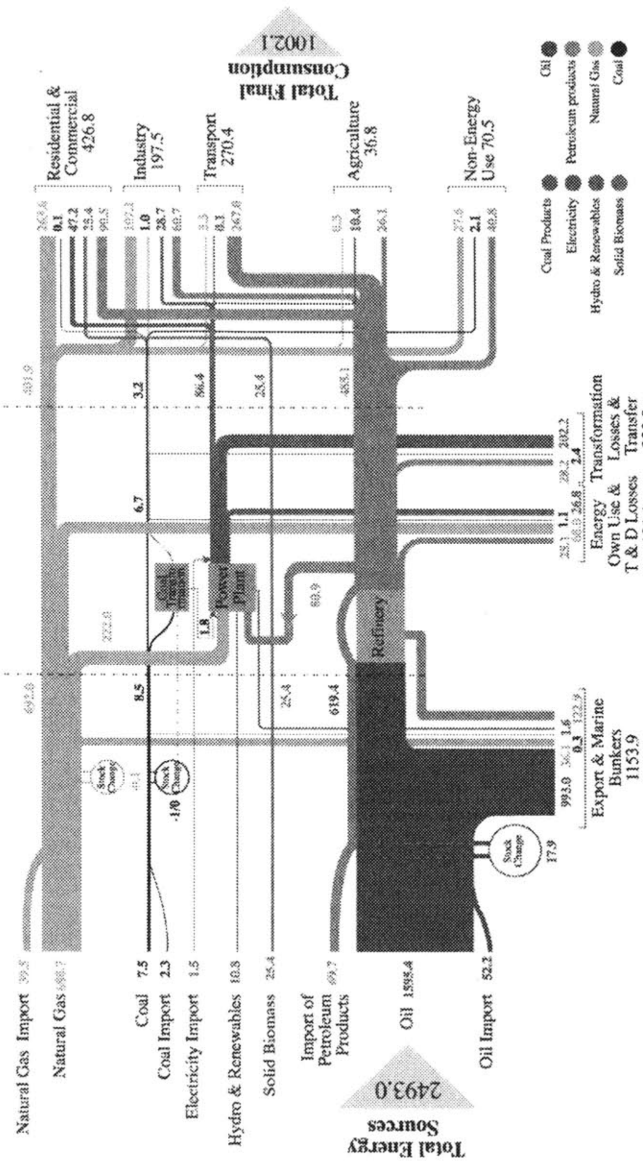
This chapter is highly important in proposing strategies for improving energy sustainability in Iran, simply because the current status of energy sector affects energy sector's future state. The future of energy sector depends on the various economic, technological, legal, political, institutional, cultural, environmental and social facts of the past. Therefore, to shape a sustainable future, it's imperative to look back and explore the way Iran has taken till now.

Iran's total primary energy supply (TPES) is growing fast, even faster than annual economic growth, mainly because of a relatively high growth rate of natural gas and oil supply which together account for almost 98% of TPES. The TPES in 2005 was 1289 Mboe. Growth rate of 10% leads TPES to reach 1420.5 at 2007. Primary energy supplies including solid biomass, hydro and renewable energies provide almost 2% of TPES. While oil and natural gas are dominant, the share of other primary energies is going down slightly. The share of oil and natural gas grew from 95% at 2005 to 98% at 2007. Figure 3.5 presents Iran's energy flow in 2007 and the share of each energy sources in final consumption [33].

The primary energy supply in Iran over a period of 20 years is dominated by oil and natural gas and the share of other primary energies is considerably low. Furthermore, the share of natural gas and its growth in TPES is tremendously higher compared to other energy carriers (See figure 3.6) [33].

The share of natural gas grew over time as a result of Iran's energy policy which aimed to decrease the high consumption of oil and replace a cheaper and cleaner energy used in residential, industrial and transportation sectors. As a result of rapid urbanization and domestic immigration form rural areas to urban one which caused a quick change in the residential sector's consumption pattern, the overall consumption grew rapidly.

The low share of other primary energies proves that Iran couldn't make appropriate policies to increase the share of other resources which in turn makes energy sector vulnerable in close future as the reserves of oil and gas are diminishing over time and new uncertainties in market and technology are emerging. Additionally, other countries are trying to reduce their reliance on oil imports and making policies to switch to other energy resources which creates the potential to decrease the overall oil demand in long-run and make the Iran's oil-revenue stock shrinking as time goes ahead.



Source: Iran Energy Balance, 2007 Edition.

Figure 3.5 Iran Energy Flow, 2007 [33]

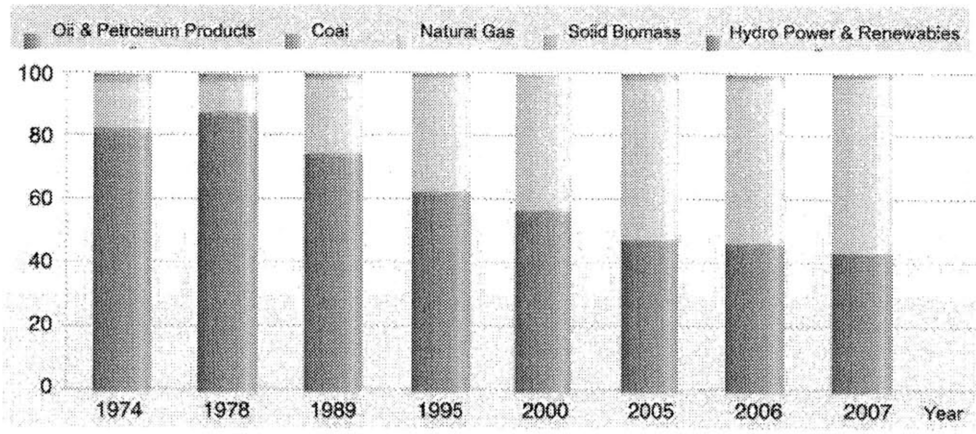


Figure 3.6 Shares of Energy Carriers in Primary Energy Supply of Iran [33]

The dominance of oil and natural gas in Iran's TPES should be considered as a threat. Therefore, policies for enhancing the share of other primary energies can lead to a change in the pattern of primary energy shares. Reducing the extent of natural gas and oil dominancy and increasing the share of other primary energies are two ways to improve Iran's energy security by heightening energy diversity. Diversification and flexibility have an inevitable impact on energy security as they increase the capability of affordable and accessible energy production and enable country to switch between alternative energy carriers based on the dimensions of possible future scenarios.

The high share of oil and natural gas in Iran is critial for the energy sector's supply side assessment. Oil and Gas industry is among the most influential industries in the Middle East and North Africa (MENA) region. The current trend of global energy demand has made this industry even more critical in supplying required energy for other industries in a global scale. Iran is the second oil producer among OPEC members with tremendous oil and gas reserves and very high hydrocarbon resources. Oil sector plays a major role in economics development in Iran. Current statistics show that a huge proportion of GDP, government's budget, international trade, foreign investment, employment and national capital are directly or indirectly related to oil and gas sector.

Given the trend of crude oil, NGL and condensate barrels over a period of 4 years, Despite the growth of oil reserves, we can see that the reserves/production ratio has been decreased which clearly proves the growth of production in recent years [33].

However, these statistics are related to domestic oil fields and do not account for shared oil fields which are offshore. Iran has also shared oil fields with countries located in her neighborhood including Azerbaijan, Qatar, UAE and Iraq.

As mentioned before, Iran accesses both Caspian Sea and Persian Gulf resources. Despite the large reservations of oil in Caspian sea, specially in Iran's territories, Iran is still unable to take the advantages of over 32900 million barrels oil mostly because of political debate over the share of countries around Caspian see and partly because of the technical difficulties in exploiting oil in Caspian sea. High level of sulfur, high pressure of water in deepest part of the Caspian Sea and many other technical problems increases the cost of exploitation that in turn make it less attractive compared to Persian Gulf resources. However, recent technological progress may help Iran in close future to exploit the oil in southern part of Caspian Sea. Additionally, it's also imperative that Iran is proven to be the cheapest, fastest and safest route from Caspian Sea to Open Seas through Persian Gulf. Therefore, the cost of transportation will be less compared to other countries around Caspian Sea which in turn makes the location more strategic.

As noted before, natural gas and oil dominated the TPES. Despite this fact that Iran has undertaken a new development plan recently which implicitly emphasizes the diversity of primary energy supply, the main focus has still remained on oil and natural gas production. Increasing the capacity of oil and natural gas, increasing the capacity of oil refinement and transportation from both Caspian Sea and Persian Gulf are still the main concerns of development plan whereas there isn't a high focus on other alternative sources. Despite these facts, the nuclear energy becomes increasingly important in recent years partly because of political struggles that it has caused. Iran tries to focus on nuclear energy to meet the high demand of electricity in Iran whereas the international society doesn't trust Iran's claims and asserts that Iran is on her way to become a nuclear power in the region which in turn causes a series of geopolitical tensions and debates.

By the end of 2006, Iran had nine refineries with nominal capacity of close to 1400 thousands barrels per day. However, the actual capacity even exceeded the nominal capacity and reached 1608 thousands barrels per day, equal to 120% of nominal capacity. It's imperative to take this fact into account that despite of international sanctions on energy-related technologies, Iran could improve the mix of petroleum outputs' quality and decrease the share of fuel oil. The recent development plan has highlighted the petroleum production and refinery as a major issue to focus on. The reason that Iran is trying to increase the capacity is to face the challenges that international sanctions and geopolitical instability have caused. Iran is heavily reliant on gasoline imports which makes it vulnerable against international sanctions. Therefore, to become less reliant on gasoline imports, Iran has placed a high emphasis on petroleum products' capacity enhancement in general and gasoline capacity enhancement in particular. This fact that Iran couldn't acquire the advanced technologies required for producing high quality petroleum mix has in turn caused major environmental issues. Due to sanctions imposed by USA and USA's allies on Iran, the process of technology acquisition is costly, inefficient and time-consuming. Therefore, Iran needs to rely on less advanced technologies to meet the domestic demand. But the quality of gasoline that mostly feeds in transportation system causes air pollution and gradually endangers human health. On the other side, Iran doesn't aim to rely on gasoline imports any longer as it can make it vulnerable in the region and reduces its bargaining power in political conflicts. The environmental issues along with international politics have made the case of gasoline complicated. Presently, Iran has focused more on self-efficiency rather than human health and environmental well-being.

One of the energy policies that changed the petroleum production mix was the replacement of gas with other hydrocarbon fuels that makes the import of kerosene unnecessary. Therefore, in 2005, the import of kerosene was practically stopped as a result of this policy. Table 3.1 presents the petroleum mix export and imports during 2000-2005 [33].

Table 3.1 the petroleum mix export and imports during 2000-2006

Product/ year	2000	2001	2002	2003	2004	2005	2006
Export:							
Fuel oil	43.87	39.16	42.22	40.89	37.27	36.87	38.86
Gas oil	3.26	2.01	2.10	0.61	3.35	1.46	-
Kerosene	0.81	0.76	1.97	1.51	0.60	0.32	0.27
Import:							
Motor gasoline	5.25	7.79	10.42	15.11	22.67	24.81	27.50
Aviation fuel	6.300	5.20	7.40	3.20	5.60	4.20	5.00
LPG (1000 ton/d)	-	354	595	910	827	796	638
Gas oil	-	-	-	-	0.17	.29	5.09

Figure 3.7 displays the production of petroleum mix during 1971-2005.

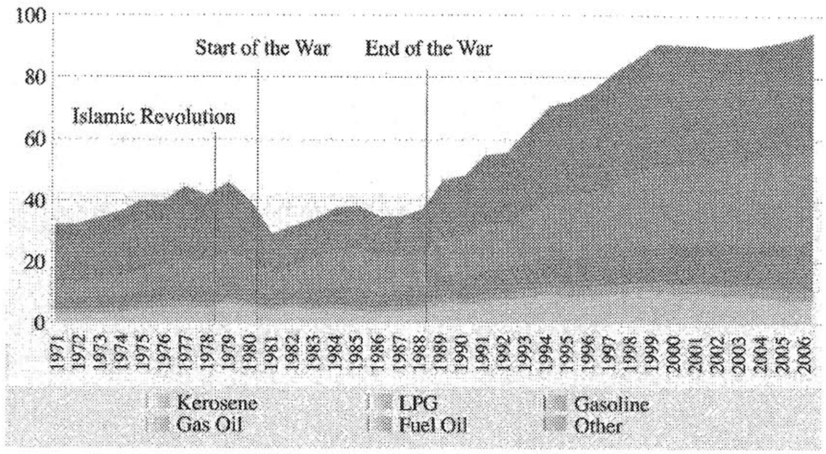


Figure 3.7 production of petroleum mix during 1971-2006 [33]

The substitution policy not only changed the petroleum production mix, but also changed the consumption pattern of this mix. This policy coupled with the electricity grid and gas network expansion resulted in a huge drop in kerosene consumption in all part of the country. The main consumer of kerosene was residential sector demanding the kerosene to provide energy to meet the basic needs of residents such as heating and cooking. Gas fuel is another petroleum product that is used for industrial purposes. It feeds in industrial and agricultural machineries and equipments as well as power utilities. Table 3.2 displays the consumption of petroleum products by each sector over a period of 6 years.

Table 3.2 Consumption of petroleum products, 200-2006

Year	LPG	Gasoline	Kerosene	Gas oil	Fuel oil	Total
Consumption of petroleum products (10^6 liters)						
2000	4338	15517	9185	24265	14737	67742
2001	4165	16737	8973	25083	152554	70214
2002	4355	18440	8683	25880	14771	72128
2003	4305	20538	7889	26234	13601	72567
2004	4199	22159	7753	27348	13740	75200
2005	5032	24396	7531	28659	14486	80115
2006	5107	26867	7234	31429	15669	86307
Average of annual growth (%)	3.99	9.58	3.90	4.41	1.03	4.12
Share of the petroleum products (%)						
2000	5.96	22.91	13.56	35.82	21.75	100
2001	5.93	23.84	12.78	35.73	21.72	100
2002	6.04	25.57	12.04	35.88	20.48	100
2003	5.93	28.30	10.87	36.15	18.74	100
2004	5.58	29.47	10.31	36.37	18.27	100
2005	6.28	30.45	9.40	35.79	18.08	100
2006	5.92	31.13	8.38	36.42	18.16	100

As mentioned earlier, the extent of natural gas dominancy on TPES is increasing by each passing year. Natural gas is a cleaner fossil fuel and its utilization's enhancement has become an important issue in Iran. Iran is among those countries with high natural gas reserves. Presently, Iran has been ranked 2nd after Russia (See Table 3.3). By the beginning of 2007, the natural gas reserves were 28.13 (10^{12} m^3). Additionally, the ratio of production/reserves declined from 177 (10^{12} m^3) at 2006 to 166 (10^{12} m^3) at 2007 that clearly proves the enhancement of natural gas utilization [33].

Table 3.3 Natural Gas Reserves at the Beginning of 2006 and 2007 [33]

Natural Gas Reserves at the Beginning of 2006 and 2007		$(10^{12} m^3)$
	March 2006	March 2007
Reserves	28.08	28.13
R.P Ratio (year)	177	166

Similar to the case of oil sector, Iran has both shared offshore and onshore fields with countries in her neighborhood. Due to the sanctions against Iran, Iran couldn't have exploited natural gas from shared fields partly because the required technologies aren't available for Iran as a result of geopolitical instabilities and conflicts and consequent trade constraints. But one of the primary energy plans in Iran which explicitly has been highlighted in the last development plan is to exploit as much natural gas as possible from shared fields. South Pars, BiFarsi and Salman are among those fields with highest reserves. Natural gas exploitation from these fields is among the most highlighted energy plans in Iran. Additionally, considering this fact that most of the gas fields are located in the developing or undeveloped areas of Iran with lack of required infrastructures and industrial clusters, Iran is trying to exploit natural gas by enhancing capital investment in these independent fields through cooperation with foreign corporations. However, due to the limitation caused by sanctions, well-known players are reluctant to exploit these high potential fields, mostly because of the costs associated with sanctions.

Gas export is an important source of revenue for Iran. Presently, Iran exports her gas to those countries located in her neighborhood. However, in recent years, Iran aims to expand her gas export capacity through LNG and GTL plans in oil industry. Additionally, Iran is in her way to enter a broader market including Europe, India, Pakistan and Oman. Expanding export capacity and broadening the targeted markets are among primary objectives of energy sector in Iran. In addition, Iran likes to increase her gas refineries rapidly. Therefore, Iran has undertaken huge capital investments to implement construction of refineries; most of them are located in South-Pars region. Figure 3.8 displays the capacity of gas refineries and dehydration units in Iran during a period of 6 years [33].

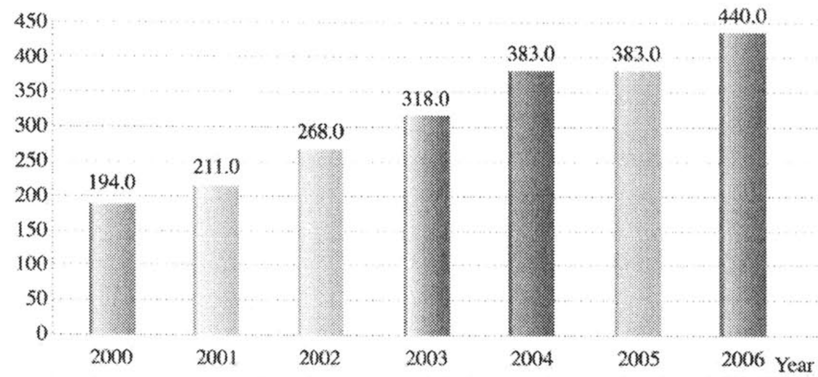


Figure 3.8. Capacity of gas refineries and dehydration units in Iran (10^6 m^3/day) [33]

Although TPES is dominated by fossil fuels, electricity plays a major role in energy sector in Iran. Iran's capabilities in constructing different types of power plants are considerable. Theses capabilities have enabled Iran to position herself among top 10 countries in construction capabilities. The distribution network, the electricity transmission and the related industries including device manufacturers and engineering services are self-sufficient in Iran. Iran currently meets the domestic demand and even exports related devices and engineering services to other countries located in her territory. Table 3.4 presents electricity imports and exports in Iran over a period of 6 years [33].

Table 3.4 Iran Electricity Export and Import [33]

Iran Electricity Export and Import		(GWb)
Year	Export	Import
2000	1001	279
2001	1049	745
2002	799	977
2003	919	1489
2004	1937.1	2169.6
2005	2759.4	2083.7
2006	2775.0	2540.0

Table 3.5 displays the nominal capacity of the power plants in Iran over a period of 6 years [33]. Total nominated install capacity hits almost 45139 MW with a close to 10% annual growth rate. However, the actual capacity of the power plants in Iran, presented in table 3.6 is lower than nominal capacity and reached 90% of nominal capacity.

Table 3.5. Nominal Capacity of power Plants in Iran [33]

Table 4.1 Nominal Capacity of power Plants in Iran					**(MW)**
Year	MOE	Large industry	Private sector	Other organization	Total
2000	26287.0	901	-	18.6	37306.6
2001	28032.0	901	-	19.5	289525
2002	30604.6	901	-	19.6	31525.2
2003	33415.3	901	-	16.4	34332.7
2004	36290.1	1009	-	21.1	37300.2
2005	38213.1	1594	1213	-	41020.1
2006	40896.8	2342	1900	-	45138.8

Table 3.6. Actual Capacity of power Plants in Iran [33]

Actual Capacity of power Plants in Iran					**(MW)**
Year	MOE	Large industry	Private sector	Other organization	total
2000	2414171067.0	840	-	18.6	25005.6
2001	25645.0	840	-	19.5	26504.5
2002	28008.6	840	-	19.6	28868.2
2003	30439.6	840	-	16.4	31296.0
2004	32850.3	840	-	21.1	33801.4
2005	34624.2	1380	1067	-	37071.2
2006	37289.0	1908.1	1547	-	40744.2

Figure 3.9 presents the nominal capacity of the Iranian power plants by four different types including hydro & renewable, gas & combined cycle, steam and diesel [33]. Gas and combined cycle has the highest share in nominal capacity of Iranian power plants, accounts for almost 55% of nominal capacity of power plants in Iran. However, it's imperative to see how during six years, the share of gas & combined cycle grew faster than that of steam in nominal capacity of power plants.

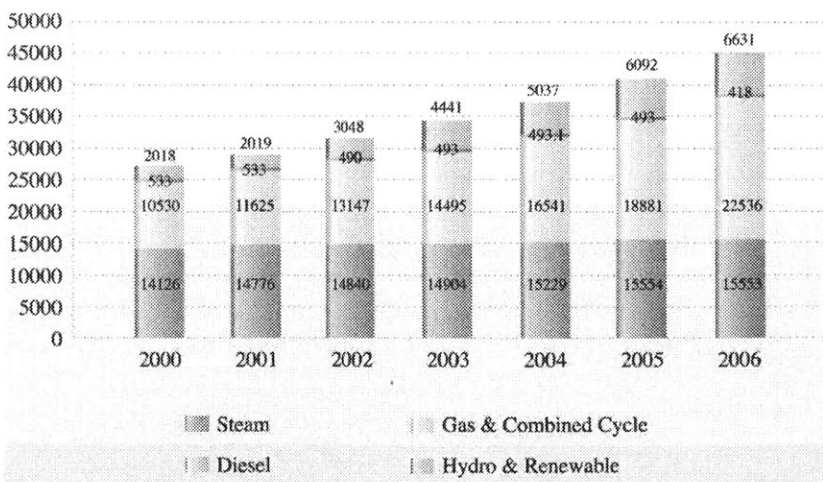


Figure 3.9. Nominal capacity of the Iranian power plants by type [33]

One of the energy plans in Iran, related to the electricity sector is to change steam units to combined cycle power plants which are more efficient, more productive and less environmentally harmful because they consume less fossil fuels. In order to achieve this goal, steam units need to be installed close to gas turbines. Another energy plan in electricity sector is to remove financial impediments toward capital investment of private sector in Iran. For instance, the first and the largest power plant run by private sector is Rood-e-Shoor power plant with a total capacity of 2112 MW, accounted for close to 4% of total capacity of the country [33].

Figure 3.10 compares the nominal capacity of the power plants in Iran and world [33]. As it can be inferred, both in Iran and world, the dominant share belongs to thermal (fossil fuels). However, Iran still has a higher share of fossil fuels in overall nominal capacity compared to the world. Since Iran is trying to expand her nominal capacity by investing in nuclear energy, this policy makes the nominal capacity pie different in close future. However, the geopolitical instability and political conflicts shouldn't be forgotten and their roles shouldn't be marginalized in any situation.

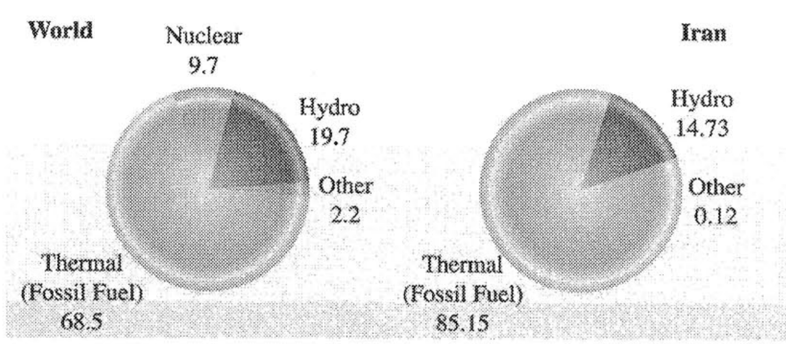


Figure 3.10. The nominal capacity of the power plants in Iran and world [33]

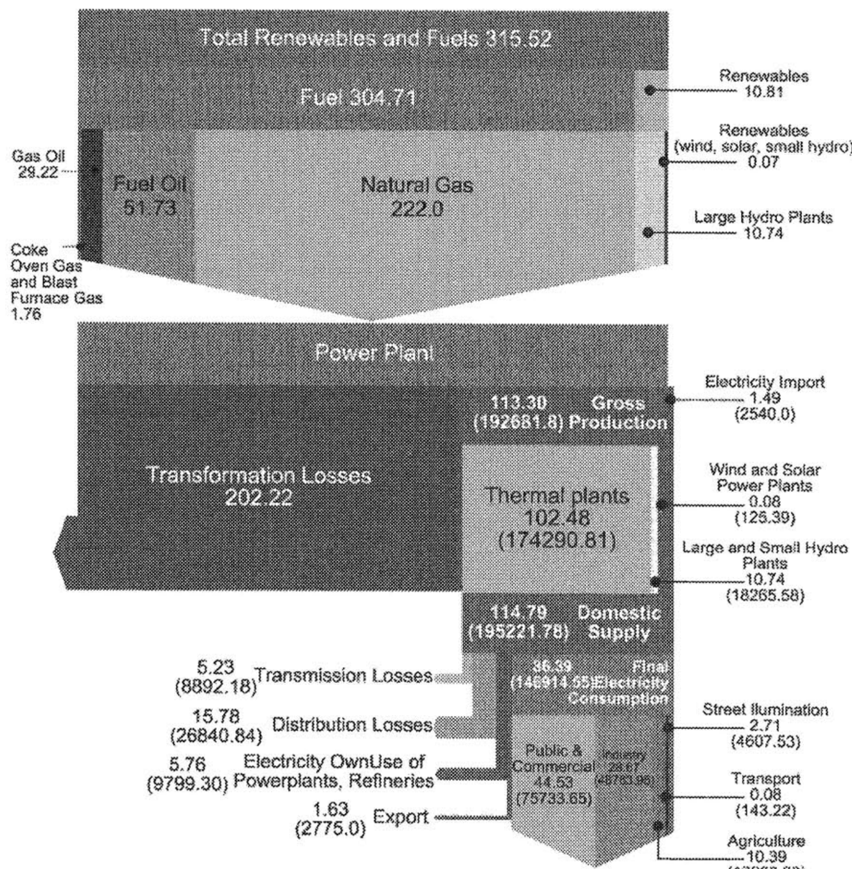
Expanding electricity capacity by investing in nuclear energy and increasing the efficiency of power plants are the cornerstone of recent energy strategies in electricity sector. As the average efficiency of power plants is a function of plants' age, quality and type of fuel, operational factors, outage ratio of the power plants and so forth, Iran is spending a relatively high public R&D to increase the efficiency of power plants by improving these relevant factors. Despite of these efforts, the average efficiency of power plants in Iran is declining as a result of difficulties in acquiring advanced technologies, aging of plants and relatively high maintenance cost mostly due to international sanctions. Table 3.7 presents electricity generation in Iran over a period of 6 years [33].

Table 3.7. Iran Electricity Generation 2000-2006 [33]

Iran Electricity Generation 2000-2006						(GWh)
	MOE	Large, medium and small industries	Private sector	Ministry of agriculture	Iran atomic energy agency	Total
2000	115708.3	5624.0	-	14.5	36.6	121383.4
2001	124275.0	5870.1	-	20.2	33.8	130199.0
2002	105146.1	5870.1	-	35.1	30.2	141081.4
2003	146962.7	6888.7	-	-	27.5	153878.9
2004	159988.0	6888.7	-	-	39.7	166916.5
2005	171173.5	4524.4	2390.9	-	-	178088.8
2006	181685.1	5510.1	5486.6	-	-	192681.8
Steam	88961.7	2146.9	1372.3	-	-	92481.0
Gas	33758.0	3363.2	4114.2	-	-	41235.3
Combined Cycle	40342.9	-	-	-	-	40342.9
Hydro	18265.6	-	-	-	-	18265.6
Wind & solar	125.4	-	-	-	-	125.4
Diesel	231.6	-	-	-	-	231.6

Another important plan related to electricity sector is electricity transmission expansion. Developing optical fiber network is one of the most important national plans which in turn help Iran expand the transmission capacity and enrich the distribution networks by taking the advantages of technological progress in communication systems.

Figure 3.11 displays a clear image of electricity flow in Iran [33]. As seen in this figure, there are huge transformation losses in Power plants that indicate the inefficiency of power plants in Iran.



a. Units of the figures in paranthesis are (GWh).

Figure 3.11. Iran electricity flow, 2007 [33]

Solid fuels are another important energy carrier in Iran. Iran has close to 1.2 billion tons of proved coal's reserves. Due to recent attention of public sector to other energy carriers, investment in coal's exploitation increased with a 10% annual growth rate, reached almost 3000 thousands tons of raw coal. Public sector accounts for over half of this exploitation. The inefficiency of coal exploitation is a major issue mostly caused by Iran's difficulties toward acquisition of proper technologies due to international sanctions and low incentives for private investment. Steel industry is the main consumer of solid fuels in general and coal in particular. To meet the demand of solid fuels, Iran imports over 900 thousands tons of solid fuels, over half of this amount belongs to coal. Table 3.8 and table 3.9 present the coal production and consumption in world and in Iran, respectively [33].

Table 3.8. Coal Production, Import and Export, consumption, 2006 [33]

Coal Production, Import and Export, consumption, 2006				
Regions	Production	Import	Export	Consumption
North America	1140.4	61.3	72.7	1019.7
S. & Cent. America	78.5	20.4	67.2	32.6
Europe & Eurasia	1221.4	290.5	155.6	1354.5
Middle East	1.4	8.5	-	9.9
Africa	250.6	7.9	69.3	189.1
Asia Pacific	3608.2	443.2	454.6	3596.1
Total World	6300.5	831.8	819.5	6273.9
Australia	380.6	-	231.3	142.7
China	2481.5	37.5	63.3	2455.7
France	0.5	20.4	0.1	22.4
Germany	200.2	41.3	0.3	241.0
India	456.9	40.5	1.6	495.8
Indonesia	169.0	-	129.3	39.6
Japan	-	177.9	-	177.9
Russian federation	309.0	25.8	92.1	242.7
Saudi Arabia	244.4	1.0	68.8	176.5
South Korea	2.8	79.7	-	88.8

Turkey	64.9	13.2	-	78.1
UK	17.8	51.3	0.4	68.2
US	1066.0	32.9	45.0	1017.6

Table 3.9. Coal Trends in Iran During 2000-2006 [33]

Coal Trends in Iran During 2000-2006					
Year	Cole oven gas (10^6 m^3)		Blast Furnace Gas (10^6 m^3)		Coke (10^3 ton)
	Production	Consumption	Production	Consumption	Consumption
2000	465.0	420.2	3794.8	2915.6	-
2001	469.3	424.7	3828.9	2759.4	-
2002	468.4	426.1	4012.5	2937.0	-
2003	416.1	380.3	4014.3	2901.9	-
2004	421.1	380.3	4219.2	2837.9	-
2005	391.8	365.5	4124.8	3188.2	1233.9
2006	399.1	381.1	4145.7	3214.3	1170.9

With an average annual rate of 7% in a period of 10 years, Iran total final consumption (TFC) and total final energy consumption has reached respectively close to 975.2 MBOE and 1052.7 MBOE in 2007.

In 2007, the consumption of petroleum products was highest among others with 480.3 MBOE which most of this consumption was dedicated to transportation sector. Natural gas's final consumption is close to final consumption of petroleum products, with a higher growth rate that made it the highest by 2010. Natural gas's consumption of residential, public and commercial sector has reached 289 Mboe which is higher than the share of other sectors. Natural Gas's share has been followed closely by transportation sector. Additionally, the growth rate of the residential, public and commercial sector's consumption is higher than other sectors' growth rate which evidently makes this sector dominant in energy consumption in close future. The share of other energy carriers including renewable energies, solid biomass and coal is extremely smaller than the share of fossil fuels in consumption basket. This small share can be even neglected compared to high fossil fuels' consumption [34].

Recently, Iran has undertaken a highly disputable energy policy known also as subsidy reform plan under the governance of president Mahmoud Ahmadinezhad to change the consumption pattern, reform subsidies, reduce high energy consumption and decline high government expenditures. The subsidy reform policy was and still is the most critical and disputable energy-related decision in Iran.

As it can be implied from consumption pattern in Iran, the consumption of electricity, natural gas and petroleum product have grown rapidly in the last two decades. The highest share of energy carriers in total final consumption (TFC) in Iran is devoted to natural gas, closely followed by petroleum products which together account for over 90% of total final consumption. The share of fossil fuels in total final consumption is close to 60% of the total final consumption, lower than Iran's share of these energy carriers in the total final consumption (TFC) [33].

As mentioned earlier, Iran undertook a policy to replace other petroleum products with natural gas. The reason that Iran undertook this policy was to increase the share of gas in energy consumption. However, any increase in the share of gas in energy consumption requires development in transmission system. Therefore, Iran had to develop her transmission system to make gas available for a large proportion of population within the country. Currently Iran has a relatively rich gas distribution network that covers most of the rural and urban areas. Additionally, because of special geographic advantage of Iran, Iran can take the advantages of her special geographic opportunity to transmit gas to new markets including North and Northwest countries and as a consequence, expand her global presence.

The substitution policy resulted in a change in energy consumption basket and increased the share of natural gas in this basket. Substitution policy has been the primary and most critical energy policy in Iran for almost 12 years. Natural gas is cleaner, less environmentally harmful and cheaper. Moreover, it can easily replace other petroleum productions which are more costly and environmentally harmful.

The consumption of electricity is also important in getting a clearer image of energy sector. Industrial, residential and public sector coupled with commercial sector accounts for close to 90% of total electricity consumption in Iran. Most of the electricity demanded by these sectors is provided by government and ministry of energy (MOE) which have sold 97% of total electricity at 2009. Private sector power plants accounts for the other 3% of electricity supply.

Thermal power plants and steel industries are two major coal consumers in Iran. Isfahan steel company accounts for the consumption of over half of the coal imports in Iran by itself.

In the next chapter, I analyze the current state based on the indicators and driving forces explained in chapter 2. In order to provide more details for further exploration, appendix A presents a number of important statistics and trends related to different sectors and different energy carriers.

Chapter 4

Assessment of Energy Sustainability in Iran

As noted in chapter one, I use the IAEA framework to evaluate the energy sustainability in Iran. Those dimensions presented in this framework (economic, social, environmental and institutional) are interrelated.

In the figure 2.1, we clearly see that those dimensions affect each other. Obviously, the environmental state is affected by driving forces of both economic and social dimensions. Driving forces of economic dimension affect social state of energy system. Finally, the institutional dimension affects all three dimensions through policies and strategies for energy sustainable development.

4.1. Economic Dimension of IAEA framework

In this chapter, I try to illustrate the interaction between economic development and energy use and production. Energy sector has a great impact on economic development, wealth creation and poverty alleviation. Conversely, economic development can result in a more efficient energy production and use, in all levels of energy chain. In this chapter, I review the main economic indicators in energy sustainability as well as the relationship between economic development and energy sector.

One of the main reasons that I look to the past trend to synthesize strategies and policies for energy sector is that the extent of energy system's dependence on past trends, previous social, environmental and economic policies is critical in formulating and implementing energy policies and strategies in the future. This concept is called "path dependency" in management and economic studies which means that current state of a system depends on its past behavior and structure. In this chapter, I aim to expose economic driving forces in energy systems to formulate future strategies properly.

Table 4.1 presents energy indicators in Iran over a period of 33 years including population (Million), GDP (10^{12} Rials), energy production (Mtoe) and net export (Mtoe). As explained in chapter 3, the rapid urbanization coupled with rapid population and demographic changes in Iran caused a revolutionary demographic change which ultimately not only changed the overall demand, but also changed the consumption patterns.

Table 4.1 Energy Indicators in Iran [33]

Year	Population (Million)	GDP (10^{12} Rials)	Energy Production (Mtoe)	Net Export (Mtoe)
1974	32	196.6	312.8	188.3
1989	53.2	191.5	164.2	97.8
1995	59.2	267.5	242.6	137.7
2000	64.2	320.1	247.6	129.8
2005	69.4	420.9	309.5	145.5
2006	70.5	446.9	316.1	145.5
2007	71.5	477.7	331.9	136.0

Energy indicators in Iran (Continue)

Year	Primary energy supply		Final energy consumption		
	Per capita (Toe)	GDP Ratio (Toe/1000rials)	Per capita (Toe)	GDP Ratio (Toe/1000rials)	Total (Mtoe)
1974	0.8	0.1	0.5	795	15.6
1989	1.2	0.3	0.9	247.9	47.5

1995	1.8	0.4	1.2	265.4	71.0
2000	2.0	0.4	1.3	265.6	85.0
2005	2.4	0.4	1.7	273.4	115.1
2006	2.6	0.4	1.8	280.5	125.3
2007	2.7	0.4	1.9	279.1	133.3

Table 4.1 indicates that Iran couldn't enhance its energy production with a growth rate more than or equal to population consumption growth rate. By 2007, overall energy production in Iran was 331.9 (Mtoe) which is close to 312.8 Mtoe, the energy production volume of 1974. As it can be seen in table 4.1, in 1989, once Iraq-Iran war was started, the energy production fell rapidly as a result of low investment, infrastructure destruction and political instability. This trend is exactly the same for net export.

Although total energy production had been declined during 1974-1989, the energy production started to improve as a result of reconstruction and capital investment in energy sector after war. However, the total and per capita primary energy supply grew steadily over time. Besides, the ratio of primary energy supply/GDP remained constant for over 15 years.

The demand side of energy sector shows similar trend. The final and per capita energy consumption in Iran shows a steady growth over time. However, the ratio of final energy consumption/GDP grew with a relatively low annual growth rate in the last decade.

Figure 4.1 presents energy intensity indicator using exchange rates and compares it to the world, OECD and Non-OECD countries [33]. This figure shows that despite of a decline in energy intensity (using exchange rate) in OECD and Non-OECD countries, Iran energy intensity took off rapidly as of 2003. This trend is exactly the same when we use purchasing power parties instead of exchange rates.

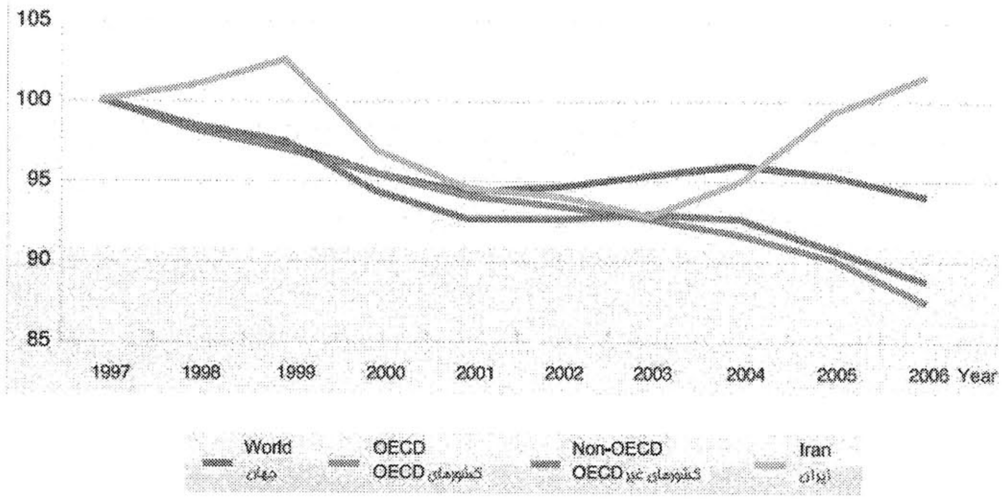


Figure 4.1 (a) Energy intensity using exchange rate (1997→100) [33]

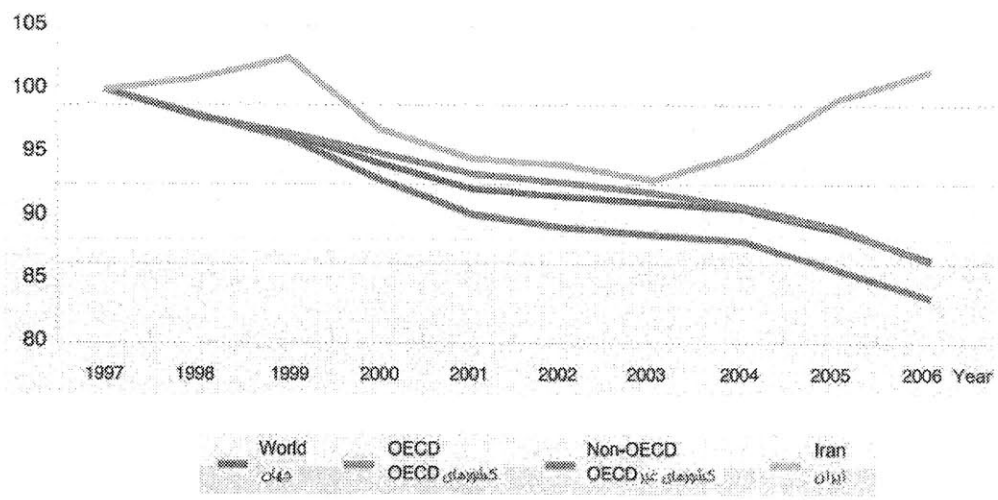


Figure 4.1 (b) Energy intensity using purchasing power parities (1997→100) [33]

Figure 4.2 displays the GDP Per Capita and Final Energy Consumption trends during 1997-2007 [31]. It indicates that these two indicators are growing consistently and are highly correlated. Comparing this trend to world trend, it can be concluded that Iran needs strategies that spur GDP growth while keeps the final energy consumption growth rate less than GDP per capita growth rate.

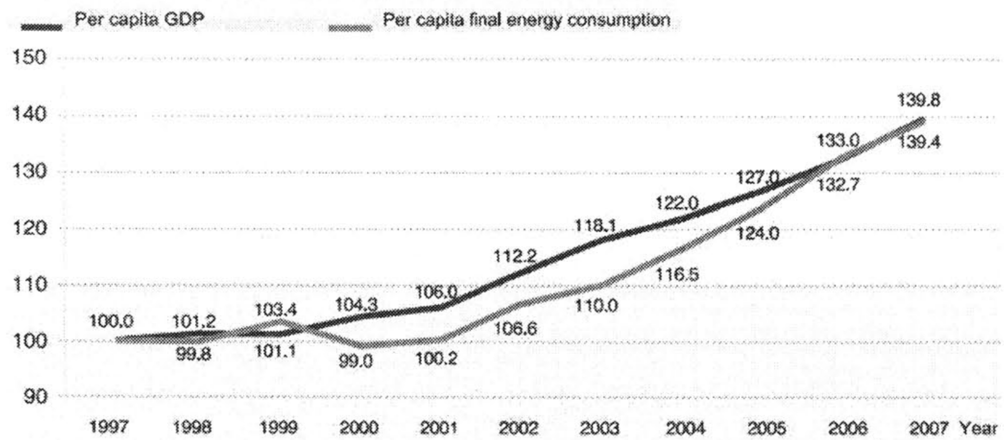


Figure 4.2. GDP Per Capita and Final Energy Consumption trends during 1997-2007 (1997→100)

Figure 4.3 proves that in the beginning of new millennium, the final energy consumption in OECD countries slightly grew while in Iran, the final consumption took off rapidly [33].

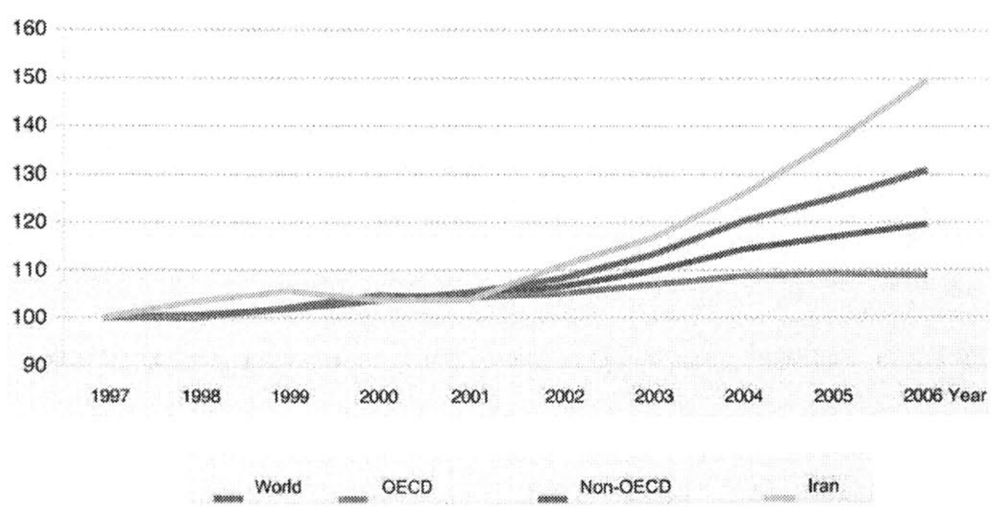


Figure 4.3. Final energy consumption in Iran and world (1997→100) [33]

Figure 4.4 presents the final energy consumption intensity in Iran by each energy carriers. Except natural gas consumption intensity, all of energy carriers' consumption intensity is declining as of 2005. However, the natural consumption intensity is increasing rapidly mostly due to substitution policy as mentioned earlier.

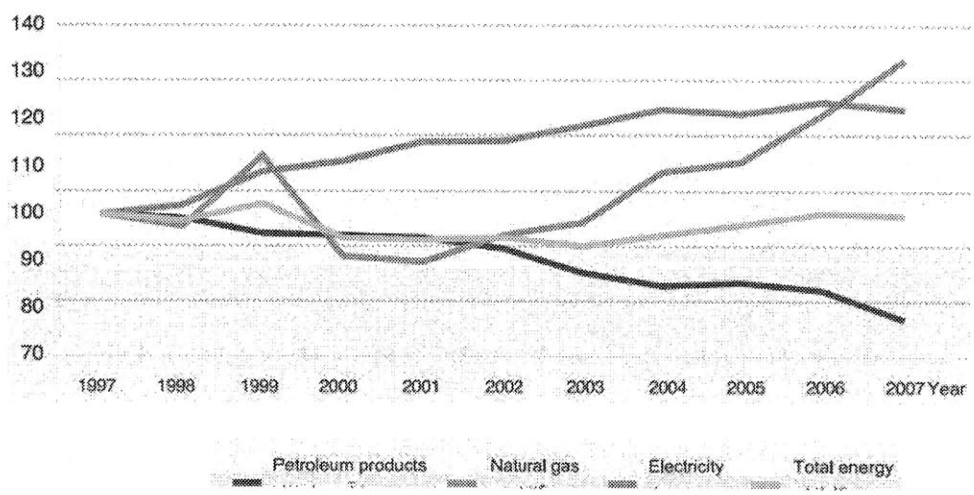


Figure 4.4 the final energy consumption intensity in Iran by each energy carrier (1997→100) [33]

While in a global scale, the electricity consumption intensity is increasing and fossil fuels consumption intensity is decreasing rapidly in Iran (See Figure 4.4) and despite of the high share of electricity consumption intensity, natural gas consumption intensity overtook the final energy consumption intensity. Despite of this fact that natural gas is relatively clean or less environmentally harmful, the high consumption's dependence on natural gas decreases energy security as it makes energy supply vulnerable against rare events (War, earthquake and etc) and against sanctions imposed by USA. Therefore, diversification of energy carriers and adjusting the share of natural gas should be taken into account to achieve energy sustainability.

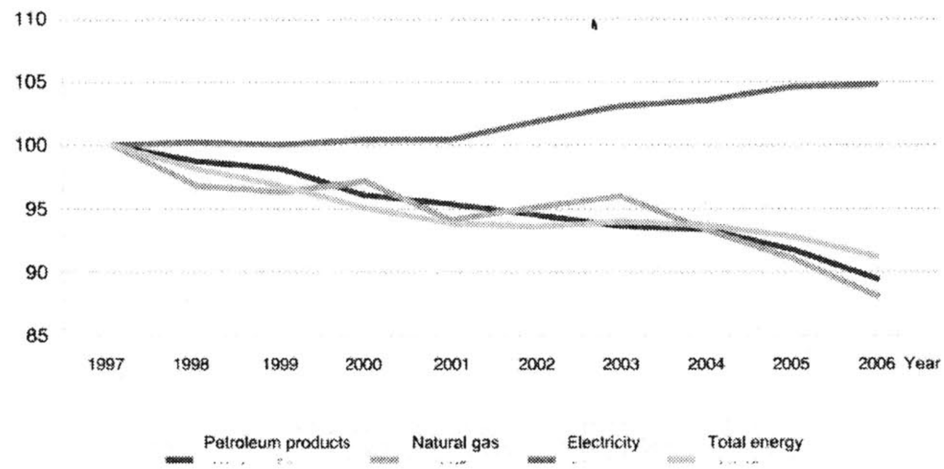


Figure 4.5 the final energy consumption intensity in the world by each energy carrier (1997→100) [33]

All this figures together prove that Iran needs to take care of demand side as its rapid growth has inevitable economic, environmental, social and political consequences.

Although these data can help us get a better understanding of the relationship between economic development and energy sustainability, but it is not sufficient to rely on these data while we are about to propose strategies to improve energy sustainability. There is a set of questions that we need to respond to provide a better insight of this relationship. What are those factors that affect energy efficiency? How does each sector contribute to final energy intensity? Why GDP and final energy consumption are highly correlated? Which factors accelerate decouple of GDP and final energy use? To accurately answer to these questions, we need to follow a systematic approach. This approach can help us reveal driving forces.

In this part of this research, I try to explain economic evolution of Iran over time. Iran's transformation from an agrarian economy into a more industrialized economy has led to an increase in income. The improvement of education, healthcare system, social insurance, infrastructure, business environment and technology progress has led to an improvement in overall quality of life. A historical overview of Iran's economy is necessary to reveal the driving forces of development once we are about to understand the relationship between economic development and energy sustainability. I try to portray a comprehensive picture of Iran's economy because the current state of economy is a function of past choices, regulations, strategies, policies and decisions as well as the performance of established institutions and infrastructures. The role of oil nationalization, Shah's white revolution, emergence of development plans, reconstruction era, Iran-Iraq war, Islamic revolution, balance payment and debt crisis, privatization and market liberalization, government interventions and the dominancy of state-owned enterprises have led to the current state of energy sector.

4.2 Iran's economy in the past millennium

The constitutional revolution/movement occurred in Iran during 1905 to 1911 in respond to government corruption and foreign manipulation, especially Russia and UK intervention and manipulation. This revolution led to conditional monarchy in Iran and parliament emergence which was the first of its kind in the MENA region. The aim of constitutional revolution was to confine royal power by establishing a parliamentary system. State modernization was the primary objective of constitutional revolution in Iran that could be acquired through confining authority of King and establishing rule of law. Most of constitutionalists were attempting to adapt Iran's social and cultural environment with modern western liberal democracy. Since Iran's social and cultural condition weren't in line with liberal democracy requirements, severe political disorder occurred at that time. The western liberal democracy principals led constitutionalists to put a high emphasis on pre-Islamic Persian identity, clergy political isolation, secularization of power and politics and intensification of modern culture by dividing nation and state. The consequence of institutional liberal democracy was political chaos because traditional elites strongly resisted modernization of culture in Iran because of the adversary impact of modernization on their diminishing dominance. Russia and England captured this opportunity and tried to expand their influence and intervention in Iran that finally led to an economic disruption and political anarchy. The political anarchy and economic turmoil were intensified by World War I and ended up with a disaster in early twentieth century. During World War I, millions of people died because of famine and lack of food in major cities in Iran.

Reza Khan was brought to power by a coup that occurred in 1921 with England cooperation. As a Cossack military commander and later as a war minister and prime minister, Reza Khan used government resources to establish an effective and modern army force and a centralized and unified country. By investing government resources on modernizing army and centralizing country, Reza Khan could strengthen government position through tax collection. This strengthened position enabled Reza Khan to begin state building and eventually enabled him to thrown away Ahmad Shah. Having been inspired by Turkish Republic of Ataturk, Reza Khan intended to create a republic similar to the republic of Turkey. Finally, due to clergy insistence, he kept monarchical form of governance and eventually, the dynasty of Pahlavi shahs began once Reza khan named himself Shah of Iran at 1926 [23].

In the aftermath of the 1921 coup, Reza Khan underwent major institutional changes in Iran by pursuing a top-down approach. After formation of new army, Reza Khan introduced new civil and panel code and an effective bureaucracy which enabled him to develop healthcare, education and infrastructure in Iran at that period of time. Reza Khan had been particularly impressed by Ataturk's statists' policy. Afterwards, Reza Khan developed state-owned enterprises and private investment promotion by using banking facilities. In 1930s, after great depression in world and protectionism emergence, by pursuing interventionism policies, Reza khan intensified government intervention in Iran. This event happened exactly in most Latin American countries. Another event that significantly influenced Reza Khan's policies in Iran was revolution in Russia. After that revolution, Reza Khan could get rid of the Czarist regime obligations. Besides all of these events, the most important event in Iran, which changed Iran for the rest of the century, was the emergence of oil [23].

One of the negative aspects of Reza Shah's regime was its trial and error approach for economic policymaking [23]. This problem was entirely related to poor and even absence of systematic economic and macro scale planning at those years. Without systematic economic and development planning, policymakers in Iran had to rely on their trials which had some adverse effects on Iran's development as a result of their short sight.

Reza Khan's reform and economic revitalization could rise opportunities for investment and ended the anarchy which had been suffering Iran for decades. After Reza Khan's reform, Iran could experience a relatively fast economic growth [23].

Another event that had a very significant impact on Iran's economic position was World War II. World War II and invasion to Iran caused considerable political and economic uncertainties, production decrease, raw material shortage, and high inflation rate that strongly declined GDP per capita and PPP in Iran. It took more than one decade for Iran to rehabilitate and came back to its pre-world war GDP-per capita [23].

Finally, Reza Shah was forced by UK to give his place to his son, Mohammad Reza Pahlavi. Mohammad Reza Pahlavi throne was another era in Iran's economy.

After Reza Shah departure, from 1941 to 1946, foreign troop became more present in Iran. These facts led to the creation of several groups engaged in politics in Iran. The emergence of different groups with various political perspectives and demands couldn't be controlled because there was no strong political institutions at that time to handle these emergent groups with various political demands. The result was political chaos. The lack of institutions for policy making along with the emergence of political perspectives were the main issues for Mohammad Reza Pahlavi who was unable to get those conflicting groups together by establishing well-organized institutions. There was just one fact that could be interesting to the multitude of conflicting groups at that time and that was to get the control of oil industry which was divided between foreign companies at that time.

In the aftermath of military occupation which ended at 1945, Iranian authorities decided to try systematic economic planning to enhance policy coherence. That was the inflection point in central economic planning approach in Iran that which has lasted since

1945. Finally, in 1945, "Plan Organization" was formed and the first development plan prepared in 1949.

Iran's First 7-years development plan: This plan was the first development plan in Iran with a credit close to 21 billion rials while 14.3 percent of this credit was assigned to Industrial sector. There was no description about government role in product market using trade and competitive policies in line with the industrial development requirements. As to factor markets, there was no explicit plan for labor market. Meanwhile, there was absolutely no plan for SME's as well as FDI development. In this plan, the oil revenue was assumed to be a resource for government's investments. The first 7 years development plan was left incomplete due to "nationalization of oil industry movement" and consequent conflicts. Even though this plan was a limited plan due to lack of macro structure consideration, it was Iran's starting point for getting to the route of economic development planning. After this plan, Iran could develop its new institution called "Plan Organization" and made it a strong bureaucracy that played a major role in Iran's economic development later on [23].

During 1945-1950, Iran could enhance its growth rate as Iran's economy was recovering from war and was using oil revenue to invest in infrastructure and industrial sector. Even though Iran's economic state give out a positive signal to the market, it didn't last so long since Iran was still suffering from political instability at the second half of 40s. Political instability which led to the assassination of prime ministers and strikes along with the increasingly conflict with western countries over controlling oil industry made that growth rate a short lasting one. Finally, in early 50s, Iran went through another important series of events which the most important one was oil industry nationalization under prime minister leadership, Mr. Mosaddegh. This movement increased both political instability and economic turmoil inside the country as well as dispute and conflict with foreign countries. At that time of Iran's history, investment had been ceased as the oil revenue had been coming down remarkably. At that time, Iran was trying to increase non-oil exports and decrease import level. Furthermore, despite these attempts, per capita income was declining over time due to the sharp struggle occurred both inside and outside of the country [23].

Coup and the emergence of Shah autocracy (1953-1979): Shah's autocracy strengthened after the CIA-coordinated coupe against Mosaddegh who tried to make oil nationalized. At early 50s, CIA in Iran coordinated a coup in 1953. The oil nationalization movement under Mossadegh leadership threatened the strong benefits of oil producers. This fact along with economic downturn at Iran led to the coup that ended up with a strengthened autocracy in Iran lasted till Islamic revolution in 1979. In the aftermath of the coup, Iran could get more technical services from US and could revitalize its infrastructure by benefiting from increasing share of oil revenue.

As mentioned before, the first development plan was left incomplete due to nationalization of oil industry movement and consequent conflicts. Three years after the coup, at 1956, second seven-year plan was prepared. This plan was more elaborate than the previous one and placed a high emphasis on private sector empowerment through providing credit channels as well as foreign direct investment (FDI). Furthermore, this plan put a high emphasis on physical and institutional infrastructure development. However, lack of macroeconomic perspective was the plan's negative aspect exactly like the previous plan. Nevertheless, this plan was relatively successful and could contribute to economic growth in Iran.

In 1960-62, IMF conducted and supported a program in Iran called "Economic stabilization program". The reason that this program was conducted related to the balance of payments crisis in 1959. This problem rose because maintaining non-oil export was costly; therefore, imports exceeded exports. In order to bring back the economy to equilibrium, authorities had to curtail governmental expenditure and credit. This plan could bring the payment of balance issue under control, but it caused a recession that lasted till 1963 [23].

The Shah's "white revolution": At early 1960s, Shah underwent a series of major reforms called "white revolution". White revolution included several reforms. Building on the credit earned in the countryside and in urban areas by the land distribution program, in January 1963 Shah determined six measures to a national referendum [23]. In addition to land reform, these measures included profit-sharing for industrial workers in private sector enterprises, nationalization of forests and pastureland, sale of government factories to finance land reform, amendment of the electoral law to give more representation on supervisory councils to workers and farmers, and establishment of a Literacy Corps to allow young men to satisfy their military service requirement by working as village literacy teachers. The Shah described the package as his White Revolution and when the referendum votes were counted, the government announced a 99% majority in favor of the program. In addition to those reforms, in February, Shah announced that he was extending the women right to vote [23].

As mentioned before, white revolution package contained several reforms including reforms in agricultural sector (redistribute agricultural land away from large landlords), Public enterprise share selling, incentives for industrial workers (profit sharing), woman's support and rights, forest nationalization and literacy corps. Since those reforms were formed based on the western cultural concepts, this reform package urged severe protests in Iran [23]. The "White Revolution" alongside daily increasing dependence on western countries including US and UK as well as the recession increased the protests that specially supported by landlords, traditional strata of Iran as well as socialists and left-side politicians in Iran [23].

In the aftermath of Shah's white revolution, during 1963-1976, Iran indicated a strong overall growth rate, which averaged 8% per year and even stronger non-oil growth rate that exceed 8% per year (The actual rate averaged 8.6% for 14 years). The per-capita income increased considerably and exceeded the average of developing countries. In figure 4.6, we can see how per-capita income grew compared to more advanced countries [23].

We can see that the gap between Iran's per-capita income and western countries at 1976 was at its minimum point in the 20th century. Despite this considerable growth, it's noteworthy that this growth didn't happen because of productivity improvement. The oil price trend in international markets had a considerable impact on the overall growth rate. Shah's little respect to income distribution intensified the income inequality. Figure 4.7 presents the trend of Gini coefficient over time [23].

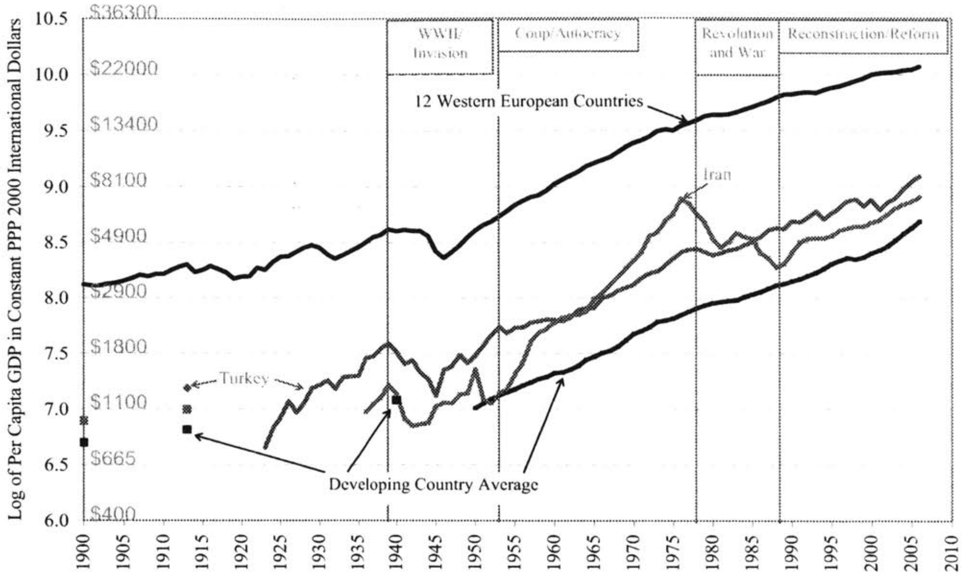


Figure 4.6 per-capita income growth compared to more advanced countries [23]

Figure 4.7 Gini Coefficient [23]

We can see that during 1970-75, Gini coefficient and ratio of 10% richest to 10% poorest increased with a high slope. The following three figures indicate that during 1970-75, Iran transformed from an agrarian economy to an industry and service oriented economy. These figures display an improvement of infrastructure, public services including transportation, education, healthcare, clean water and electricity [23].

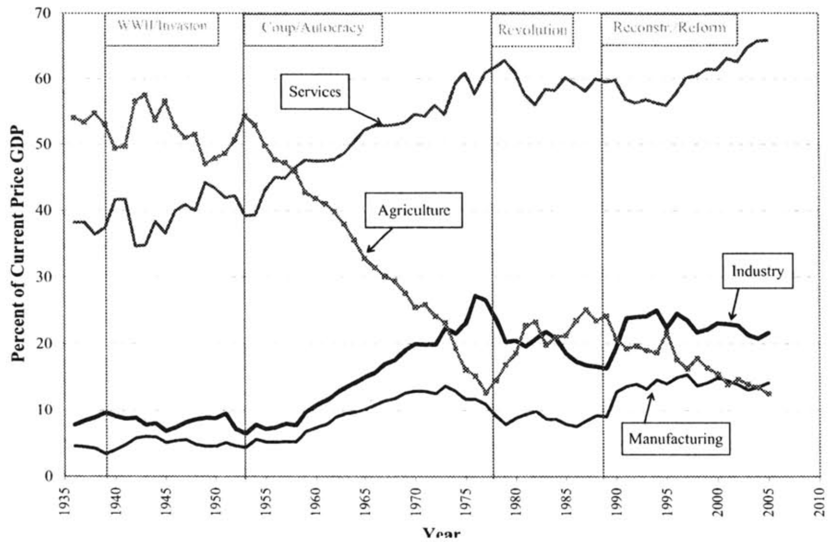


Figure 4.8. Percent of current price GDP for each economic sector [23]

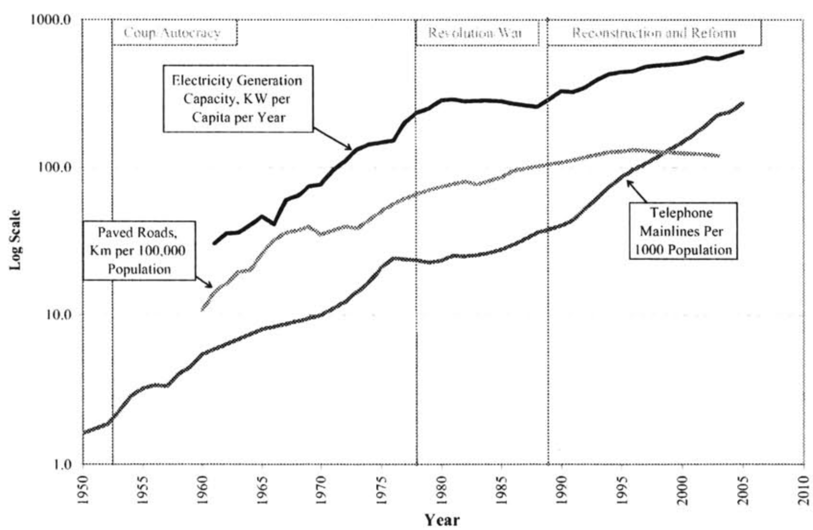


Figure 4.9. Infrastructure Development in Iran [23]

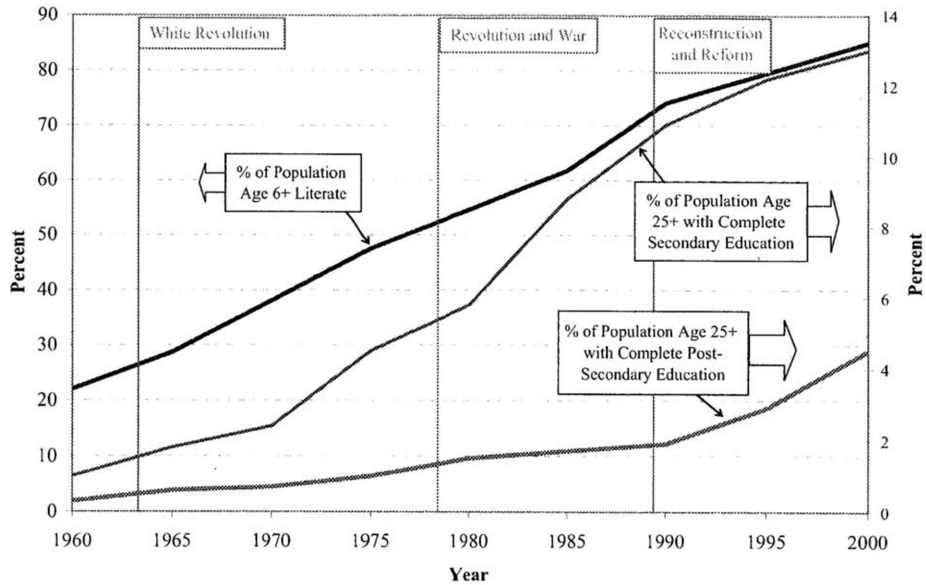


Figure 4.10 The Evolution of Schooling in Iran [23]

In 1973, due to a sharp increase in oil revenues, Shah decided to double government expenditures. Because of this decision, economy overheated and inflation increased in 1975. Figure 4.11 displays this trend [23].

Hadi Salehi Esfahani explains the inflation issue in Iran at that time in his research;

"The government's attempt to control inflation, sometime by draconian measures such as prosecuting shopkeepers for price increases, and private investors' reaction to those measures and to increased economic instability soon led to sharp declines in investment and GDP" [23].

Considering public protests against Shah's policy, specially given his insistence on western modernization led to strikes and protests that finally departed MohammadReza Shah. Finally, Islamic revolution in Iran happened under Ayatollah Khomeini Leadership.

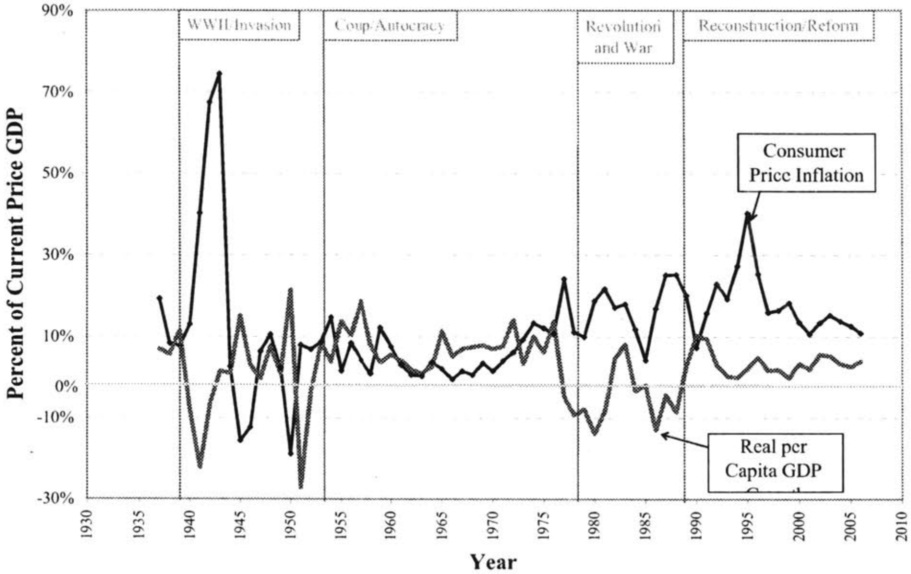


Figure 4.11 Real Per Capita GDP Growth and Inflation in Iran [23]

Islamic Revolution Era: In January 1979, The King of Iran, Mohammad Reza Pahlavi had to leave the country forever due to massive protests and demonstrations against him and was replaced by Ayatollah Ruhollah Khomeini, the leader of Iran's revolution. Since then, Iran experienced a new era in her economy, society, Foreign policy and politics. Shah's autocratic monarchy disappeared and instead, Islamic republic popped out. Since then, clerics overtook governmental positions and roles. "Velayat-e-faghih" became the essence of the new regime which means that Islamic jurists set principal rules. In this regime, the head of the state or supreme leader is a jurist who controls the country not to deviate the Islamic principal rules. After Islamic revolution in 1979, the foreign policy of Iran changed dramatically. The strong relationship between Iran and industrialized economies (US in particular) was replaced by a anti-west foreign policy. Cultural policies, regionalism, Islamic economics and populist took the place of rapid modernization. Finally, Shah's autocracy went forever and was replaced by Islamic theocracy headed by "Vali-faghih" who was Ayattolah Khomeini at first decade after revolution and is Ayatollah Khameneie after 1988 till present.

Iran's economic state at the first decade after revolution (The role of Iran-Iraq war): In the aftermath of revolution, the economic rapid growth declined rapidly. During 1979-1989 (Except for 1983 and 1984) GDP was coming down severely and Inflation was rising rapidly. Comparing the GDP per capita and non-oil GDP per capita of 1990 and 1976, we can see that these indicators came down considerably (See figure 4.12 [23]). GDP per capita became 54% of its peak in 1976 and non-oil GDP per capita dropped to 64% of 1976 non-oil GDP per capita [23]. Hadi Salehi Esfahani describes this rapid decline as below;

"Many factors account for this decline, particularly the high political risks for private investors after the Revolution, exodus of large numbers of skilled professionals, adoption of adverse economic policies, falling oil revenues, and the highly destructive war with Iraq. The roles of most of these factors are well known." [23]

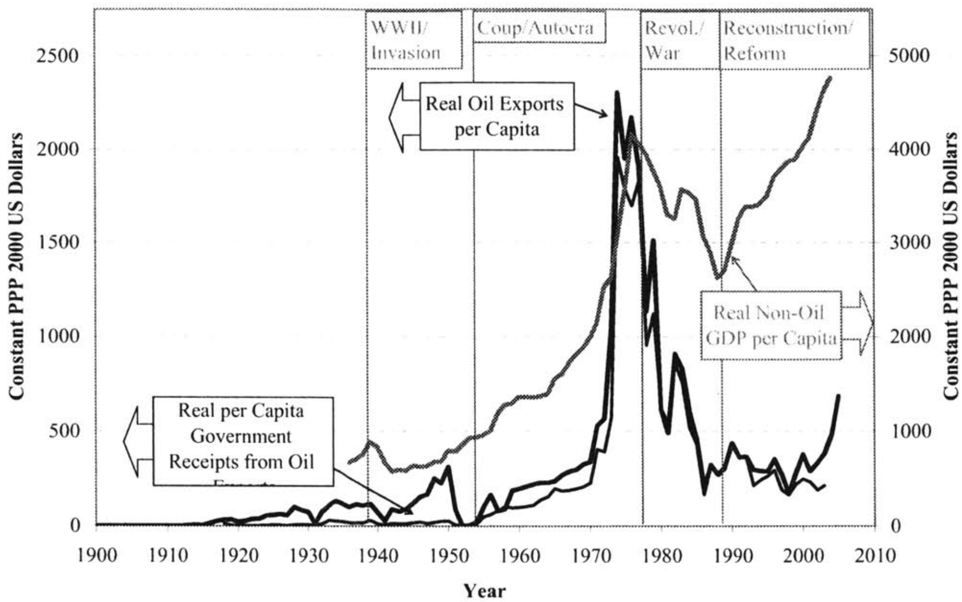


Figure 4.12. Real Per Capita Oil Exports, Government Receipts from Oil, and Non-Oil GDP [23]

In addition to these factors, Iraq army invasion just two years after revolution should not be overlooked. This war which lasted 8 years and caused a long recession in Iran's economy destroyed major infrastructures in Iran.

By taking a close look at figure 4.13 [23], we can see the trend of economic growth over time. As we can see, the gap between per capita income in Iran and major developed countries increased during the first decade of war. Benchmarking Iran GDP per capita with turkey, we see that the gap between developing countries and Iran declined during that decade. Iran could surpass turkey and average developing countries in 1960s whereas after revolution, the gap between Iran and turkey decreased and finally turkey surpassed at 1985.

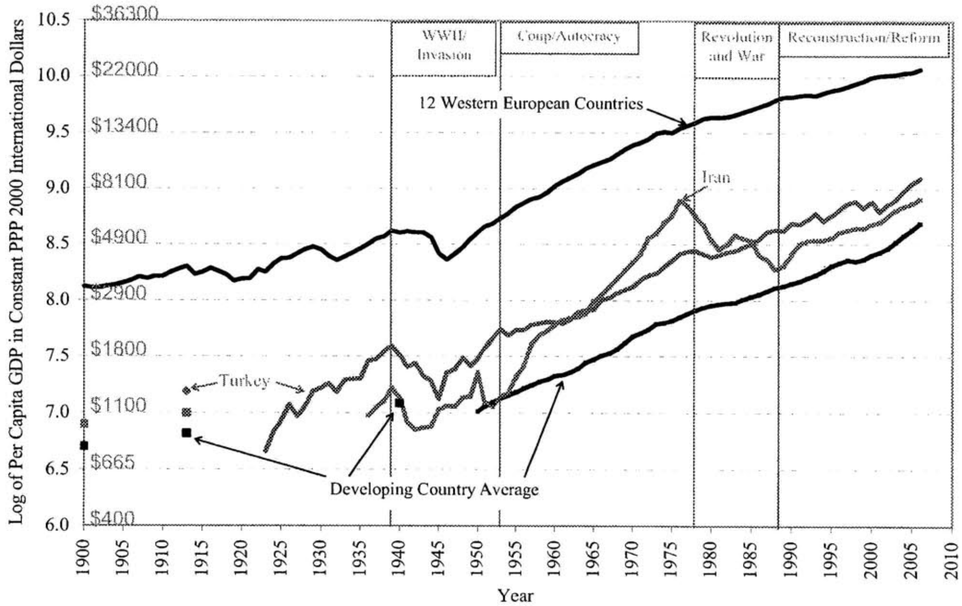


Figure 4.13. Iran's Economic Growth in Comparative Perspective [23]

After war's era, Reconstruction: Because of the 8 years war, Iran governments had to impose a harsh control on market. The government became bigger and bigger and market couldn't perform effectively due to government imposed restrictions. Right after war, oil revenue increased and led to an increase in investments. The inflation increased rapidly. It's very important here to clarify the "private" investment in Iran. Most of the investments were done under the control of state-owned foundations. These foundations, directly or indirectly are under government or office of Supreme Leader control. These state-owned foundations imposed their control over most of industries in Iran from oil and gas to textile and auto industry.

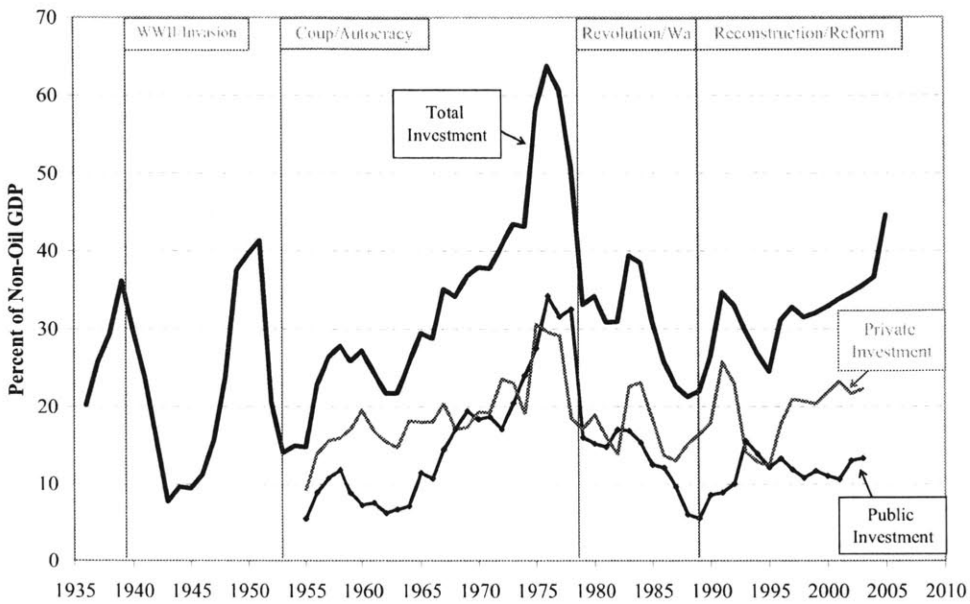


Figure 4.14. Investment as Percent of Non-Oil GDP in Iran [23]

The recovery wasn't successful by the way. There were several issues raised afterwards. Because in 1993, oil revenues began to decline, the payment of balance started to increase. Foreign short-term debt was another problem at that moment. The unified exchange rate policies were applied to reduce foreign exchange market control, but it just reinforced the issues rapidly. Due to the foreign exchange policy, Rial lost its value; therefore domestic companies couldn't pay back their foreign debt. Considering this foreign debt problem, government decided to cover the foreign debt problem which had been emerged as a result of the devaluation. These policy required large expansion of monetary base because of the public revenue decrease. The result was a rapid increase in inflation. Figure 4.11 displays that increase in inflation [23].

Figure 4.15 also presents the foreign debt trend over time. We can see that during 1989 to 1994, the foreign debt increased rapidly [23].

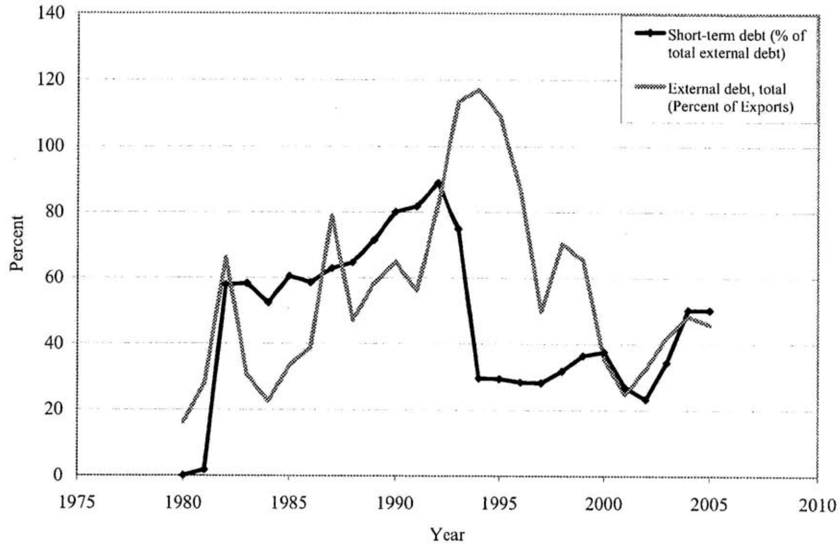


Figure 4.15 Foreign Debt [23]

Due to the economic stagnation and rapid inflation, government had to intervene quickly. A host of controls over foreign trade and domestic market was government's respond to emerged crisis. Even though, government could strengthen its control over market and reduce the risk of balance of payment crisis, it reinforced economic stagnation [23].

Government intervention in Iran; Since Iran's growth is connected strongly to oil revenues, any major change in oil price affects Iran's economic stability. In order to reduce the adverse effect of Iran's reliance on oil revenue, Iran can accumulate surpluses of oil revenue by creating a fund. Iran's government made this policy in 2000. Another policy that can makes Iran's economy more stable would be Iran's integration with world economy. Iran can capitalize on technological innovation in other parts of the world to increase the productivity. Since Iran is a natural resource based country, diversification is highly required to maintain economic stability. Recently, Iran tries to maintain its stability by being more and more isolated and it had an exactly opposite effect. This isolation had an adverse effect on domestic firm's relationship with foreign partners. This fact will adversely affect the technology and knowledge exchange and acquisition in Iran. Now, domestic products have low quality and high cost as a result of low productivity.

The reason that led governments to intervene more depends on their populist perspective. They believe that in order to bridge the gap between high income and low-income population in Iran, they have to intervene in market to reduce the inequities. As we can see in the figure 4.7, the populist policies contributed to inequity decrease [23], but by taking a closer look at the figure 4.7, it will be discovered that inequity decrease in Iran began in 1975 as a result of heavy investments and expenditures in poorer places in Iran [23]. Meanwhile, after 1985, the inequity decrease wasn't considerable and those two indicators remained approximately constant after 1985. Furthermore, the rising oil revenue didn't have an effect on Ginni coefficient, because Ginni coefficient that accounts for overall inequity remained constant over time [23].

As mentioned, Iran has to leverage its oil revenue to diversify its production. Iran has several opportunities recently. The rising demand for multiple productions in countries located in her neighborhood is an incentive that can lead Iran to join those markets and meet the rising demand.

By and large, Economic freedom in Iran has not a satisfactory advancement. In appendix B, I introduce the heritage index and methodology and display Iran's ranking in the world.

Current State of Democratic Governance in Iran: Civil rights, economic and social rights, civil and political participation, political parties, free and fair elections, rule of law, military and police control, government accountability, corruption, media and government responsibilities are among those criteria helping us in defining democracy state in a country. Despite this fact that Iranian constitution implies some of democratic principals, according to the mentioned criteria, democracy in Iran has not a satisfactory advancement.

As to civil rights, Iranians are not free of physical violation. There is a long list of physical violation done by police force especially right after 2009 presidential elections in Iran. The freedom of movement, expression and association in Iran is not in an acceptable state and it's even getting worse by the day. Furthermore, practicing your own religion, language and culture is highly confined in Iran. Religious, gender and other minorities' discriminations are among most serious human right issues in Iran. Moreover, under the constitution of Iran, every single code and law must fully comply with Islamic norms. In addition to police force in Iran, a paramilitary volunteer militia called Basij is sometimes responsible for confronting any violation against Islamic standards.

Even though, according to constitution, citizens are free to found private businesses and benefit from equal opportunities in accessing any kind of required resources, they are not free in practice. State-owned enterprises are vigorous impediments toward privatization and entrepreneurship in Iran. The presence of state-owned enterprises is a critical issue which has lessened the progress of privatization in Iran for almost twenty years.

As to civil and political participation, Iran is experiencing one of its worst days in its history. There is no freedom of assembly, demonstration and open public discussion. Most of opposition leaders believe that Iran is experiencing its second cultural revolution. Currently, Iranian authorities are trying to make social sciences fully complied with Islamic standards and strongly forbid western social science studies. Moreover, civic organization, student organizations, unions and other organization are not free of political threat. The list of students, human right and social activists in jail is quite self-explanatory.

Political parties are strongly restricted to form and recruit member and campaign the office. Any violence against Islamic standards would not be tolerated. Despite the fact that elections are held in Iran, practically they aren't free and fair elections. The council of guardians, appointed by Iran's supreme leader, determines who is qualified for candidacy which can be considered as an impediment against opposition parties.

As to women right, Iran has not a satisfactory progress. Zahra Eshraghi, granddaughter of the leader of the 1979 Iranian Revolution, Ayatollah Khomeini, once said: "Discrimination here is not just in the constitution. As a woman, if I want to get a passport to leave the country, have surgery, even to breathe almost, I must have permission from my husband." [41] That is a common experience among women in Iran.

Presently, millions of Iranians have suffered from some kind of human rights abuses. Torture, capital punishment, gender discrimination, press confinements, and limitations on artistic expression are among dozens of human rights abuses that go on.

Despite the growing demand for gender equality we have not been experiencing a satisfactory progress in Iran. On top of everything, the educational system of Iran supports gender discrimination by using a male-oriented discourse. In the educational textbooks men and women are described to be equal yet different, and each group should play a predefined social role: "These differences do not mean that one is intrinsically better than the other, but they exist so that men and women perform their complementary roles in family and society, on the basis of their biological and psychological characteristics and appropriate utilization of their different capabilities" [40].

The role of energy subsidies: Iran's energy subsidies are about $37 billion, the second largest of their kind in the world [34]. This is equal to 19% of Iran's GDP. Considering energy subsidies consequences, we argue that all sectors are affected by energy subsidies adversely.

The following points are economic consequences of Energy Subsidies in Iran [34]:

- Decreasing consumer's energy payments by charging lower prices will encourage them to consume more and motivate them to consume energy less efficiently.
- One of the most common energy subsidies in Iran is that the government intervene to reduce the price that producers receive. The reduced price has an adversary effect on companies return on investment, thus companies invest less for R&D and technology acquisition. As a result, it may discourage domestic energy producers to invest on state of the art technologies and in the long-run decreases economic productivity. On the other hand, Subsidies that aid producers by providing extra-services in lower costs decrease the competition pressure. The decreased competition pressure leads companies to pay a little attention to their cost side and efficiency. As a result, energy producers will be reluctant to acquire new technologies and in turn, the efficiency of energy supply will decrease.

- Another form of energy subsidies is a price ceiling. It means that the price of energy that consumers pay should be below market price. One of the consequences of this subsidy is lack of energy which leads to ration agreements. For example, in August 2010, the electricity in Iran was rationed due to heavy electricity consumption and physical shortage of electricity.
- The high energy consumptions caused by energy subsidies adversely affect both energy import and export. The high energy consumption reduces the energy available for export. Meanwhile, the increased demand for energy will lead to higher energy imports. As a consequence, the balance of payment will be negatively affected. Besides, increased energy imports make the country reliant on the foreign energy supply and as a result, it decreases the "energy security". For example, Iran had to import more than 45% of required gasoline in 2009 (more than $6 billion) just to provide fuel to meet the heavy demand caused by large energy subsidies
- The fuel price difference between Iran and countries located in her neighborhood (specially turkey and Iraq) led to fuel smuggling. The daily rate of fuel smuggling is close to 40000 barrels/day. To deal with this issue, the fuel consumption in Iran was rationed.

All these consequences prove that subsidies halt economic development, decrease efficient energy consumption and increase government expenditures significantly.

The effects of the energy subsidies can be analyzed by further developing the mentioned BBNN framework for the country. The subsidies have caused the Sustainability curve to shift even further to left as lower cost of oil to consumers spurs demand, but at an environmentally unsustainable level (See Figure 4.16). On the other hand, the net impact has also been a decline in oil exports, causing the BB curve to shift to the left, which is also evidenced by estimates of a decreasing surplus over the next few years.

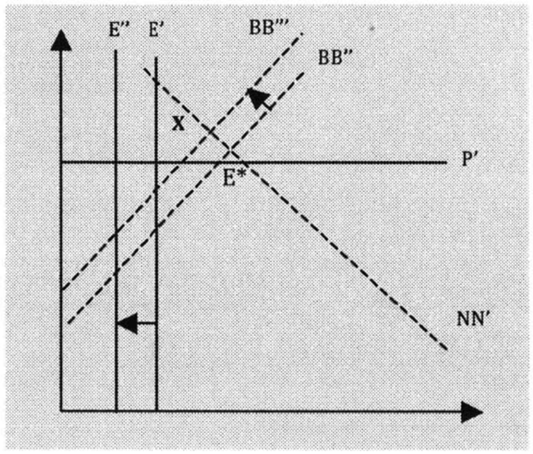


Figure 4.16. BB-NN and energy subsidies

4.3 Environment dimension of IAEA framework in Iran

The emission of CO2 has the highest rank among other fuels. Natural gas accounts for close to 50% of CO2 emissions in Iran, followed by gasoline and gas oil [33]. Residential sector has the highest emission volume followed closely by transportation sector.

Figure 4.17 presents the share of SO2, NO_x and CO_2 in Iran at 2007 by each energy carrier and each sector. As it can be seen, natural gas has the highest share, close to 50% in CO_2 emission. Fuel oil and gas oil has respectively the highest share in SO_2 and NO_x emissions. Additionally, residential, commercial and public sector account for about 29% of CO2 emissions, closely followed by power plants. The highest share of NOx emissions belongs to transportation that accounts for over 60% of NOx emissions [33].

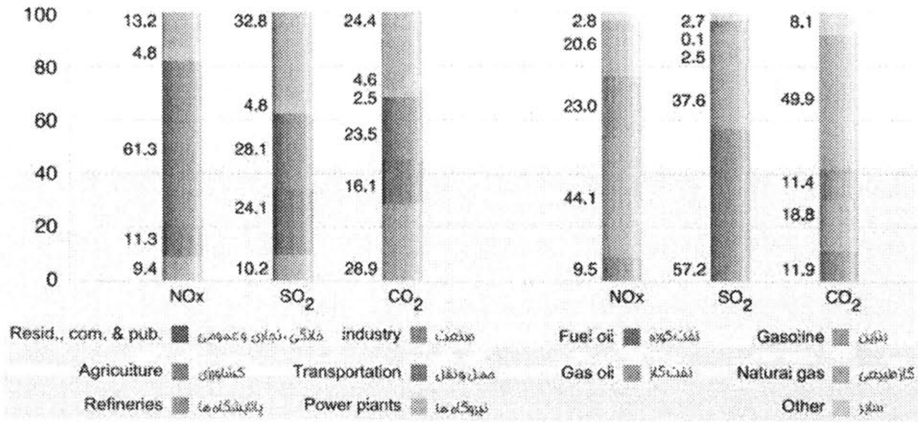


Figure 4.17. Share of SO2, NO_x and CO_2 in Iran at 2007 [33]

Figure 4.18 presents pollutant and CHG emissions' trend in Iran by each sector. This graph clearly shows the steady growth of CO2 emissions over time. However, the emissions of other CHG are declining recently, mostly because of the substitution policy and natural gas capacity expansion and natural gas consumption boom.

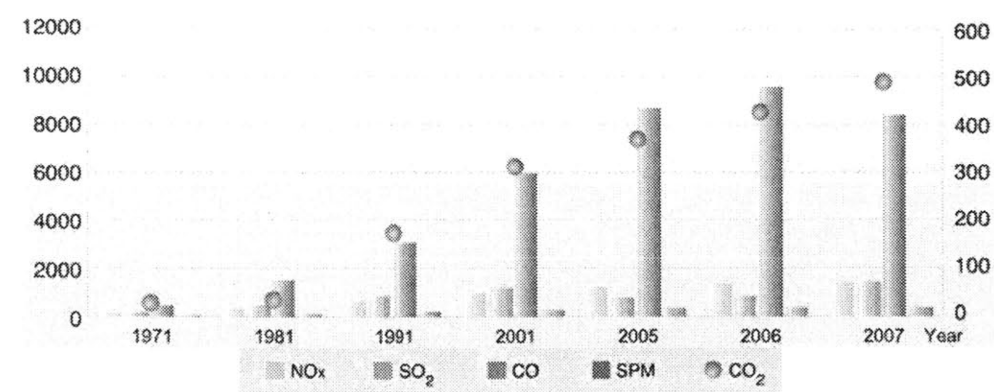


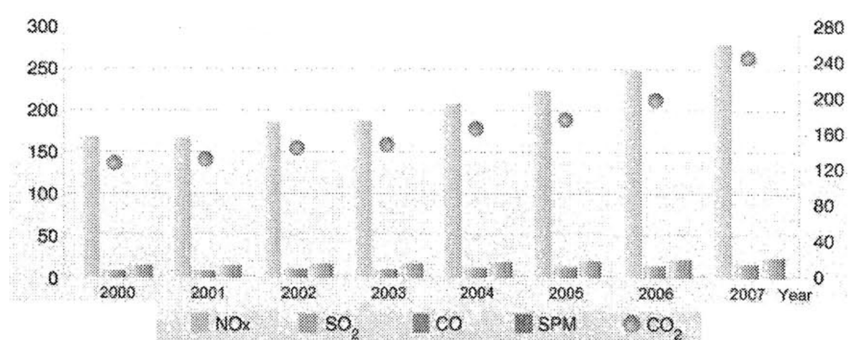
Figure 4.18. Pollutant and CHG emissions' trend in Iran by each sector (CO_2 million ton) [33]

Figure 4.19 presents the trends of CHG emissions from each energy carrier over a period of three years [33].

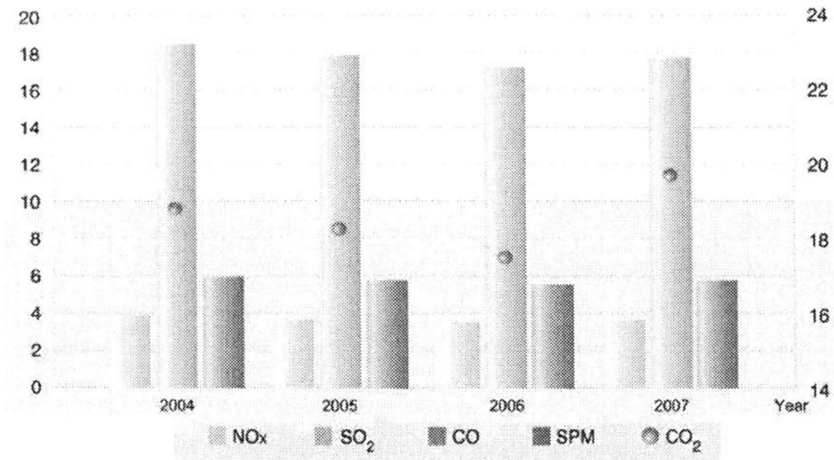
Iran is ranked third after Saudi Arabia and Russia at CO2 emissions/ GDP ratio [33]. However, Russia's ratio is declining over time while Iran's ratio is increasing recently.

The social cost of emissions in Iran is relatively high. The highest share of social costs of emissions is for transportation sector which account for over 45% of this cost. The social cost of emissions in Iran reached over 9 billion dollars that is a significant cost in Iran. Any policy that decreases the costs associated with negative environmental impacts positively affects Iran's energy sustainability. High social costs of CHG are the main incentives toward investment in renewable energies.

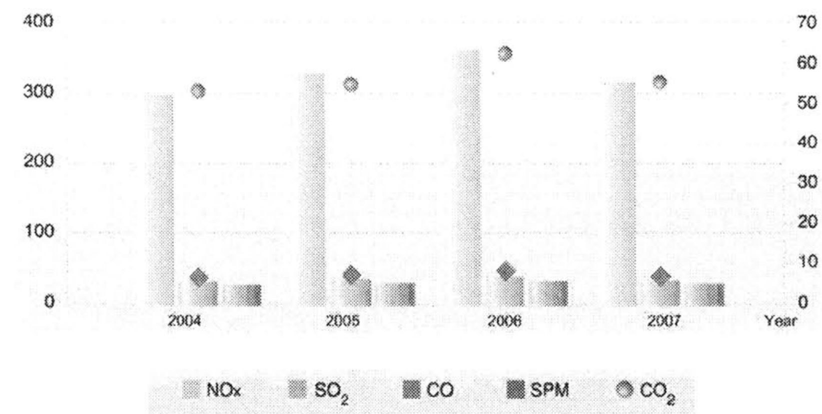
As mentioned in chapter 1, ecological balance and biological diversity are both affected by energy supply and consumption. Despite the inevitable advantages of affordable and accessible modern energy and its impact on human well-being, the environmental impacts and degradation is an critical challenge threatening human health, quality of life and ecology.



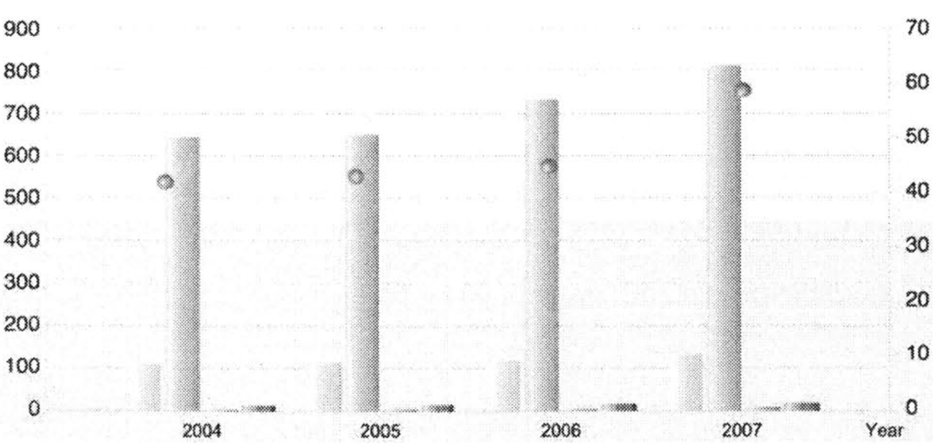
Trends of GHG Emissions From Natural Gas Combustion



Trends of GHG Emissions From Kerosene Combustion



Trends of GHG Emissions From Gasoline Combustion



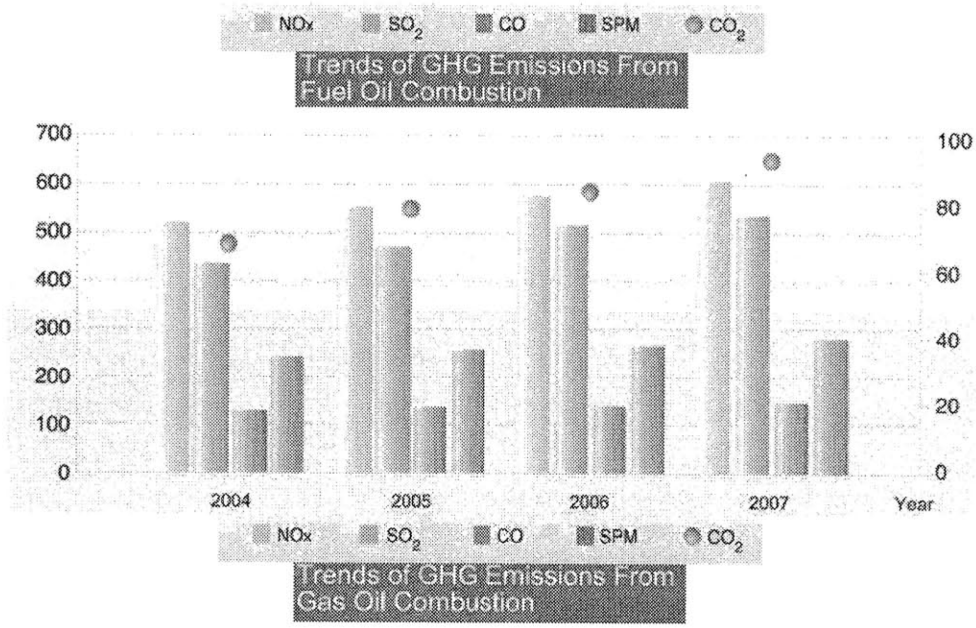
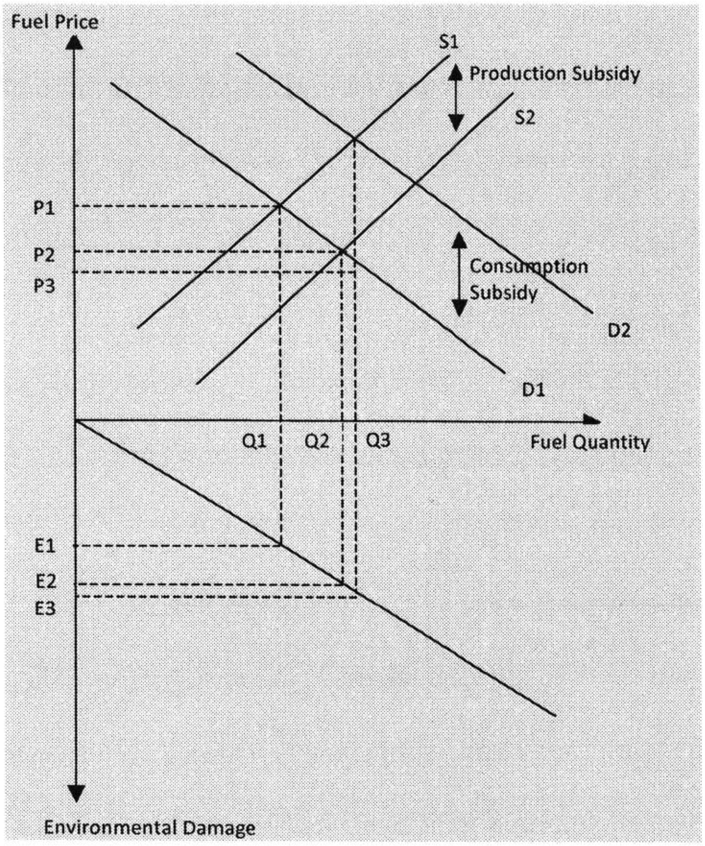


Figure 4.19 Trends of CHG emissions from each energy carrier [33]

In order to further analyze the environmental effects of energy subsidies, figure 4.20 is prepared [35]. As it can be inferred, subsidies that increase fuel consumptions have harmful influence on environment by increasing harmful gas emission. Higher noxious and green gases emission will lead to higher air pollution. Water Pollution and land spoil are other environmental consequences of increased fuel consumption.

Not all of the energy subsidies are harmful. Sometimes, energy subsidy can even have positive effects on economy, society and environment. Some types of energy subsidies can increase the accessibility of the sustainable energies on one hand and enhance the efficiency of energy consumption on the other. According to Iran's stage of economic development, the available public finance, the geopolitical location, policymakers' plans and the institutional structure, a reform policy is highly required [34].



Production Subsidy effects:

1. Supply curve shifts from S1 to S2
2. Price decreases from P1 to P2 and
3. Quantity increases from Q1 to Q2
4. Environmental damage increases from E1 to E2

Consumption Subsidy effects:

1. Demand curve shifts from D1 to D2
2. Price decreases from P1 to P3
3. Quantity increases from Q1 to Q3
4. Environmental damage increases from E1 to E3

Severity of the impact is dependent on the shapes of the Demand, Supply and Environmental Damage curves (price elasticity of demand and supply).

Figure 4.20. Environmental impacts of energy subsidies [34]

4.4 Energy and social issues

Before the exploitation of oil and its distribution in Iran in 1940, the main energy carrier in Iran was fuel wood which accounted for over 60% of total consumption. Fuelwoods weren't largely available for a large proportion of people specially those who located in desert areas. Fuelwood was affordable and cheap in rural areas (It is still an energy resource in some rural areas in Iran). However, the environment advocators find fuelwood a major cause in deforestation. The high rate of deforestation in Northern and Northwestern part of Iran reduces the accessibility of this energy source, mostly because public attention becomes increasingly focused on ecological balance in Iran. Another primary energy source is coal. Coal is one of the main inputs for steel industry. Currently, Iran is an importer of coal. Coal is accessible in Iran, however domestic production cannot meet the high demand of steel industry, cement plants and coal powers. One of the major environmental issues is about degraded mined areas and their recovery.

Diesel is an important secondary energy resource which serves as an input for transportation sector. Diesel was heavily subsidized and therefore easily affordable in Iran, but the subsidy reform policy in Iran may have strong impacts on diesel price and make it less affordable. Diesel is available through import, however since the geopolitical instability and sanctions force USA's allies not to sell diesel to Iran, it may lead to difficulties in providing diesel for domestic use and may makes it less accessible. Diesel is an energy source that contributes to overall CHG emission and pollution and as the public place becomes sensitive to health and environmental issue, especially in populated cities such as Tehran or Isfahan, diesel becomes less acceptable.

One of the most important primary energy sources is natural gas. Natural gas has become the dominant primary energy source in Iran's consumption as of 1998 when Iran undertook a substitution policy. Because of a rich distribution network, natural gas is available all over the country. Natural gas was heavily subsidized and affordable for a large proportion of people; however, the subsidy reform may have striking impacts on natural gas price. Natural gas has a higher extent of acceptability compared to other fusil fuels because it is less environmentally harmful. Vehicle natural gas is a secondary energy source. The accessibility of vehicle energy source is a current issue in Iran, as the established stations cannot meet the high demand. Despite this issue, Iran is rapidly expanding its vehicle natural gas capacity and distribution system. One of the policies in Iran is to provide incentives for vehicle owners to switch to those products that consume vehicle natural gas, because it is cleaner, cheaper and less environmentally harmful. Before subsidy reform, vehicle natural gas was easily affordable, however the subsidy reform may increase the vehicle natural gas price and make it less affordable. In any case, it has a lower price compared to the gasoline. Additionally, government provides incentives for Taxis including price-cut to motivate them to switch to the vehicle natural gas. Vehicle natural gas is more environmental friendly and more socially acceptable. Another secondary energy source is LPG. Iran has a rich distribution system which covers all parts of the country. LPG is easily accessible. Again, before subsidy reform policy, it was extremely cheap, but it is a strongly held belief that subsidy reform will increase the price of LPG and the cost of consumer and makes it hard to afford. LPG is relatively clean and cheap and socially acceptable. Another important energy source is hydropower plants. Construction of dams, mostly to meet the high and increasing electricity demand caused several environmental and social issues. As mentioned in chapter 1, Capital-intensive investment in constructing dams to meet the high demand of electricity has resulted in an environmental calamity which may undermine Iranian's life and the live of the local population dramatically, which in turn result in unpleasant social consequences.

Another energy resource is electricity. Electricity is accessible in Iran through grids and transmission system that are available almost in all part of Iran. Electricity was heavily subsidized just same as other secondary sources. Current subsidy reform policy may result in a notable increase in electricity price and less affordability.

Another energy source is nuclear energy power. Nuclear energy is neither accessible nor affordable in Iran till now. The acceptability of nuclear energy seems paradoxical. Some people believe that nuclear energy is not worth geopolitical instabilities and international struggles. Some believe that nuclear energy is a clean, modern energy required for meeting the increasingly electricity demand. It is also imperative that government is trying to make nuclear energy a" national symbol".

The social consequences of energy subsidies are imperative. Energy subsidies affect energy accessibility, affordability and acceptability. Authorities claim that subsidies are designed to provide energy for the poor segment of society especially in remote and rural areas. But results prove that energy subsidies not only didn't boost the poor's purchasing power and low price energy access, but also made it even worse. The energy subsidies haven't targeted a certain segment of population, but have encompassed the entire population. The poor segment of society may not even access the required energy, thus energy subsidies won't benefit those people. Meanwhile, since poor's consumption is less than richer segment, richer people benefit more from subsidies and it increases the gap between poor and rich parts of society and this inequality has severe negative impact on socio-economic development. Besides energy subsidies may lead to rationing as it has happened frequently in this decade in Iran. The rationing can encourage the corruption as it has done already. The black market for fuel is a major issue in Iran especially in the transportation sector. Moreover, for those people living close to plants or refineries (eg. Asaluye), the pollution and safety is a major problem. The pollution in Asaluye has increased the death rate incredibly and affected the social well being there. Meanwhile, capital-intensive investment in constructing dams to generate electricity damaged the environment and farms too. For example, the biggest lake in Iran called Urmia which is the largest salt lake in the Middle East, has been shrinking with a high rate and as a result, the spread of salt has damaged the people healthiness as well as income of farmers due to heavy negative impact of salt on lands fertility and productivity. The lower productivity of agriculture has led to social turmoil as well.

1.4 Sustainability and Energy security

As mentioned in chapter 1, Energy security refers to availability of various forms of energy in adequate amount and affordable prices. Therefore, availability, adequacy and affordability of various energy forms are main dimensions of energy security. There are different definitions for energy security that each, encompass some aspects of energy securities. These definitions commonly imply [3]:

1. A reliable, affordable and environmentally sound energy system;
2. The continuous availability of energy in varied forms, in sufficient quantities and at reasonable prices;
3. Security of energy supply, competitiveness and protection of the environment.

The most comprehensive definition of energy security is provided by world energy assessment [4];

"Energy security—the continuous availability of energy in varied forms, in sufficient quantities, and at reasonable prices—has many aspects. It means limited vulnerability to transient or longer disruptions of imported supplies. It also means the availability of local and imported resources to meet, over time and at reasonable prices, the growing demand for energy. Environmental challenges, liberalization and deregulation, and the growing dominance of market forces all have profound implications for energy security. These forces have introduced new elements into energy security, affecting the traditionally vital role of government.

[...] Energy security can be ensured through local adequacy—abundant and varied forms of indigenous energy resources. But for countries that face local shortages, as most do, energy security can be enhanced through:

- The ability, of the state or of market players, to draw on foreign energy resources and products that can be freely imported through ports or other transport channels and through cross-boundary energy grids (pipelines and electricity networks). This is increasingly aided by energy treaties and charters and by investment and trade agreements.
- Adequate national (or regional) strategic reserves to address any transient interruption, shortages, or unpredictably high demand.
- Technological and financial resources and know-how to develop indigenous renewable energy sources and domestic power generating facilities to meet part of local energy requirements.
- Adequate attention to environmental challenges.
- Diversification of import sources and types of fuels." [4]

Over the past century, a series of events has highlighted the importance of energy security. According to Brazil profile research, these events include [3];

"1. The first oil crisis in the 1970s;

2.The war between Iraq and the Islamic Republic of Iran (Iran) in the 1980s, Iraq's invasion of Kuwait in the 1990s, the war in Iraq in 2003 and the political instabilities in the Middle East, the region with the largest oil reserves in the world;

5 Studies of global climate change and the United Nations Framework Convention on Climate Change in the 1990s

6 Worldwide electricity supply uncertainties resulting from the liberalization of the energy markets at the turn of the 21st century." [3]

The energy security became a buzzword as most of the countries realized the threat of supply disruptions and its economic, social and environmental consequences. The traditional approaches for assessing energy security mostly consider the supply side and try answer following questions [3];

1.How to provide affordable energy to meet the demand side?

2. How to make the energy available continuously for everyone?

3. How to insure the adequacy of energy supply?

Currently, demand-side of energy systems has been considered in researches and practices. The efficient and effective use of energy by consumers has become an indispensable element of energy security studies. Additionally, the reliability and vulnerability of energy supply became important in assessing the supply of energy services. The renewable, more diverse and less vulnerable energy options play a major role in energy security assessment [3].

Energy security in Iran is a major energy-related issue. Given the extent of vulnerability and unreliability of energy systems in Iran in all energy system levels as well as the degree of centralization and complexity of energy systems in Iran, we need a systematic approach to figure out the driving forces of energy supply security and to propose appropriate policies and strategies for enhancing the overall energy security.

In this research, I don't study energy security in depth, mostly because of complex situations in middle-east and high geopolitical instability. I just mention the highlights and some proposed strategies for improving energy security.

The role of Iran-Us relationships: The imposition of sanctions has a great effect on technology acquisition and therefore it's significant impact on both the volume of energy productions and the efficiency of production, transformation, transmission and consumption.

Technology adaptation is important, but innovative new technologies and its diffusion throughout the economy are even more critical for success in regional competition. Linking a strong science infrastructure to the other production sectors and establishing opportunities for high-tech industries is absolutely essential to gaining a competitive position in the world market. To this end, Iran needs effective policies that encourage innovation, entrepreneurship and continuous learning, which will ultimately enable it to achieve progress in advanced technologies. However, US sanctions serve as an impediment toward all of these stages and generally affect the energy supply reliability, efficiency, vulnerability, centralization and price.

High dependency on fossil fuels: Despite unpleasant environmental consequences, the energy supply's high dependency on fossil fuels make the energy sector in Iran less flexible to price and production volatility. The volatility of oil and gas prices has a great impact on all energy sector and endanger the energy security because Iran couldn't diversify her energy options and still highly rely on oil and natural gas in providing demanded energy. Any threat toward continuous production of oil and natural gas has striking impact on the whole economy.

The dominant share of natural gas in consumption basket: as mentioned in chapter one, natural gas account for the majority of consumption basket. Although natural gas surpass oil in terms of cleanness and price, but the high dependency of energy consumption on one energy carrier is making the energy consumption vulnerable and any disruption in natural gas production may halt the whole economy. In addition, natural gas is cleaner and less harmful for environment than other petroleum products, but it doesn't mean that it doesn't have striking impact on environment. Natural gas has the highest share of CO_2 emissions among others. Shifting toward more renewable energies will increase the energy security, a policy that doesn't have received an acceptable attention from policymakers in Iran.

Nuclear energy: Although nuclear energy is a good option for meeting the increasing demand of electricity sector, the geopolitical instabilities and conflicts have made it extremely costly. However, in a political context, authorities in Iran are persisting on Iran's nuclear program and assert that they use nuclear program for peaceful purposes while international society is pessimistic and afraid of the emergence of a new nuclear power in MENA region that can strengthen WMD. These geopolitical debates have put this program in the heart of Iran's foreign policy and have a great impact on the whole economy, mostly because of the role that this program plays in strengthening sanctions against Iran and constraining technology diffusion.

Energy subsidies: As mentioned earlier, energy subsidies are important for both energy supply and energy use across the energy chain. In this chapter and chapter 3, I explained the main consequences of energy subsidies. Because of the high importance of these consequences, I mention them again here. Here are those consequences related to energy security which addresses both supply and demand side of the energy system:

- Decreasing consumer's energy payments by charging lower prices will encourage them to consume more and motivate them to consume energy less efficiently.
- One of the most common energy subsidies in Iran is the government action to reduce the price that producers receive. The reduced price has an adversary effect on companies return on investment, thus companies invest less for R&D and technology acquisition. As a result, it may discourage domestic energy producers to invest on state of the art technologies and in the long-run decreases economic productivity. On the other hand, Subsidies that aid producers by providing extra-services in lower costs decrease the competition pressure. The decreased competition pressure leads companies to pay a little attention to their cost side and efficiency. As a result, energy producers will be reluctant to acquire new technologies and in turn, the efficiency of energy supply will decrease.
- Another form of energy subsidies is a price ceiling. It means that the price of energy that consumers pay should be below market price. One of the consequences of this

subsidy is lack of energy which leads to ration agreements. For example, in August 2010, the electricity in Iran was rationed due to heavy electricity consumption and physical shortage of electricity.

- The high energy consumptions caused by energy subsidies adversely affect both energy import and export. The high energy consumption reduces the energy available for export. Meanwhile, the increased demand for energy will lead to higher energy imports. As a consequence, the balance of payment will be negatively affected. Besides, increased energy imports make the country reliant on the foreign energy supply and as a result, it decreases the "energy security". For example, Iran had to import more than 45% of required gasoline in 2009 (more than $6 billion) just to provide fuel to meet the heavy demand caused by large energy subsidies
- The fuel price difference between Iran and neighbor countries (specially turkey and Iraq) led to fuel smuggling. The daily rate of fuel smuggling is 40 000 barrels/day. To deal with this issue, the fuel consumption in Iran was rationed.

The highlighted facts are extremely important in assessing energy security in Iran. In the next chapter, I propose strategies and policies for improving Iran's energy security which is an indispensable component of energy sustainability.

Chapter 5

Strategies For Achieving Energy Sustainability

As mentioned in previous chapters, energy production and use in Iran need to be revised and a set of strategies is required to move to a more sustainable energy system. In this chapter, I try to propose approaches that lead energy system in Iran to a sustainable future.

As explained in chapter 2, energy sustainability and economic development are interrelated. A stable macroeconomic space is imperative because this stability can improve business environment, increase upfront investments, strengthen competition, improve technological innovation, diffusion and acquisition, increase overall GDP, reduce unemployment and enhance income generation which in turn makes energy market more efficient and increase the affordability and accessibility of energy sources. Interest rate, balance of payment, public debt, exchange rate, inflation rate and unemployment are among key macroeconomic indicators that need to be considered in a strategy for macroeconomic stabilization. A stabilized macroeconomic space increases the attractiveness of Iran's domestic market which in turn results in higher FDI and capital investment. As mentioned in introduction, Iran is facing several social and economic challenges. Fiscal imbalances and high inflation considerably decreased living standards and undermined the primary incentives for entrepreneurship. Lack of transparency has led to corruption that has in turn undermined productivity. The dominance of state-owned enterprises has politicized the business environment and has tremendously reduced transparency. Government intervention in price setting, subsidies and regulations has distorted both economic and organizational decisions. Due to the relatively isolated position of Iran in the world market, infrastructure is non-modern and highly inefficient. This fact, along with the absence of competition has diminished innovation and ingenuity. An inefficient public sector alongside a weak private sector is a critical challenge as well. Macroeconomic stabilization can mitigate these issues. However, macroeconomic stabilization is not enough and some other strategies should be taken into account.

Another important macro scale strategy is to provide a set of regulations that strengthen competition in the market. As mentioned earlier, in the world market, innovative-based competition plays a dominant role in regional competitiveness. Iran must strive to diversity its production base and to transfer itself to a networked economy. In order to gain rapid growth, Iran needs to focus on trade, investment, acquisition of technological know-how, expanding innovative capacity and effective adaptation of new and emerging technologies. One of the barriers toward effective competition in energy market is energy subsidies. The other barrier is the extent of state-owned enterprises dominance on energy market. Energy subsidy reform and effective privatization are two ways to spur competition in energy market. Table 5.1 presents all types of subsidies.

Table 5.1. Various types of subsidies [34]

Government intervention	Example	How the subsidy usually works		
		Lowers cost of production	Raises price to producer	Lowers price to consumer
Direct financial transfer	Grants to producers	●		
	Grants to consumers			●
	Low-interest or preferential loans	●		
Preferential tax treatment	Rebates or exemptions on royalties, sales taxes, producer levies and tariffs	●		
	Tax credit	●		●
	Accelerated depreciation allowances on energy-supply equipment	●		
Trade restrictions	Quotas, technical restrictions and trade embargoes		●	
Energy-related services provided directly by government at less than full cost	Direct investment in energy infrastructure	●		
	Public research and development	●		
	Liability insurance and facility decommissioning costs	●		
Regulation of the energy sector	Demand guarantees and mandated deployment rates	●	●	
	Price controls		●	●
	Market-access restrictions		●	

Figure 5.1 presents the share of countries in energy subsidies [34].

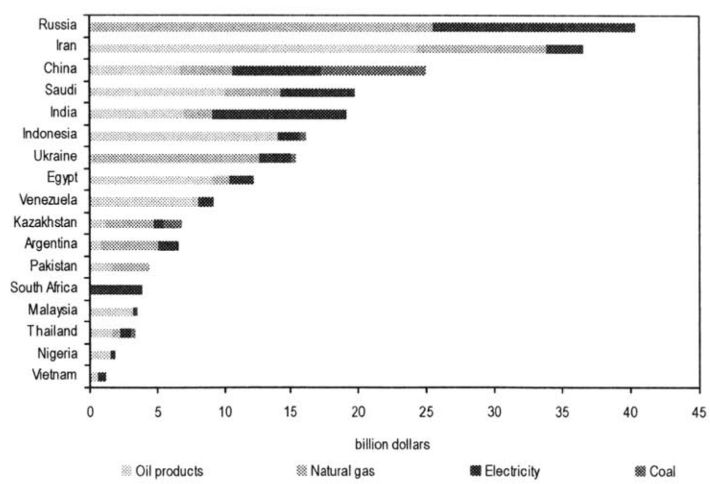


Figure 5.1. Share of countries in energy subsidies [34]

Why energy subsidies can be considered as an impediment toward energy efficiency, competition and sustainable energy use and production? I responded this question in chapter 4. However, the following items are general responds provided by UNDP [34]:

1. Subsidies often lead to increased levels of consumption and waste, exacerbating the harmful effects of energy use on the environment.
2. They can place a heavy burden on government finances, weakening the potential for economies to grow and reducing the potential to invest in social equity.
3. They can undermine private and public investment in the energy sector, which can impede the expansion of distribution networks and the development of more environmentally harmful energy technologies such as decentralized renewable energy technologies.
4. They do not always end up helping the people who need them most.

As mentioned earlier, not all of the energy subsidies are harmful. Sometimes, energy subsidy can even have positive effects on economy, society and environment. Some types of energy subsidies can increase the accessibility of state of the art and sustainable energies on one hand and enhance the efficiency of energy consumption on the other. According to Iran's stage of economic development, the available public finance, the geopolitical location, policymakers' plans and the institutional structure, we propose a reformed energy subsidy by pursuing following rules.

The subsidies should target those segments that deserve the subsidies. In designing subsidies, policymakers take several facts into consideration including income, location, dependence on energy and so forth. Current subsidies lead consumers consume less efficiently. The reformed subsidies should take this fact into account and remove the incentive for high consumption.

The overall energy subsidies should decrease gradually. Currently equal to 19% of total GDP, they should become less than 4% by 10 years. In order to reach this target, investment on new technologies including renewable energies is essential.

Instead of reducing the energy price, Iran's authority can distribute oil & gas share profit among population. It is estimated to be about $80/month for each Iranian. The amount of share can be different based on their income, household population and etc. For example, a person with five family members with $150/month income will get 10th time more share than a person with two family members and $10000/month income. Because the price of the energy is equal to actual market price, consumers will consume more efficiently to decrease their expenses. It has positive impact on environment. Meanwhile, the real price of energy decreases the incentive for smuggling as well. The decreased inequality because of well-targeted subsidy will increase sense of social justice and definitely it increases social capital and mutual trust between government and citizens.

Our proposed reform can address major challenges that we explained but simultaneously it has some effects on inflation.

To avoid this problem, authorities should reform the subsidies gradually. In the transition period, they can have both subsidies at the same time. Therefore, they should gradually increase the price of energy and amount of direct payment to consumers. In the meantime, it requires a high investment on data processing and information gathering. Therefore, before undertaking this policy, Iran needs to prepare a unified integrated information system to effectively discover those groups in need. In order to do that, Iran needs to invest on IT infrastructure, change the organizational structure of her ministries to increase consistency and compatibility among various divisions that have a responsibility in energy policy reform execution.

A subsidy reform policy is essential in providing a better energy price-setting which can have significant impact on competition, innovation and in turn, sustainable development. As pointed out earlier, sustainable energy policies should have following characteristics [34]:

1. Energy sector should rely on markets that are able to correct failures. Market should function properly by applying a set of appropriate regulations that enable it correct failures including monopolies and externalities and remove major obstacles including impediments toward free flow of information, technology and knowledge diffusion and so forth.
2. Energy sector should be restructured in a way that forms a sustainable energy system. To do so, a set of suitable regulations is needed.
3. Enhancing technological innovation, technology acquisition and diffusion, knowledge acquisition and providing incentives for both domestic and international investors are some objectives can be obtained through appropriate regulations and policies that encourage innovation, global partnership and cooperation.
4. Strengthening regional and international cooperation is imperative in achieving a sustainable energy system.

A set of regulations that strengthen competition in the market can lead to those markets that handle market failure, and spurring technological innovation and knowledge spillover and provide a business environment that can strengthen cooperation. Energy market liberalization is one of the policies for strengthening competition especially for electricity market. However, we need to be aware of the danger of these policies. Without a strong institutional context, these policies all fail as a result of lack of transparency, monitor and coordination. Iran needs to improve those institutions related to energy market to implement electricity liberalization perfectly.

As concluded, energy subsidies and price distortion should be revised. However, it's important to enable low-income group access affordable energy. Accessibility and affordability are two essential measures need to be expanded to cover low-income group. To increase the accessibility, Iran needs to expand her distribution network and grids. Additionally, rural areas have a great potential of local energy production. Providing incentives for them and enabling them generate local modern energy is not only extent the accessibility, but also has inevitable social, environmental and economic consequences. To solve the problem of affordability, Iran should target the low-income group, empower them through a set of regulations and policies including targeted subsidies, direct income transfer and public financial aids. The case of Brazil is a great example of the effectiveness of these policies [3]:

"...After the oil market liberalization when subsidies were removed, the Brazilian Government established the liquefied petroleum gas (LPG) grant to offset negative economic impacts for low income families.6 This sort of 'subsidy' is much more efficient and focused on low income groups than a wide subsidy system, although monitoring problems can arise (efficient monitoring schemes are needed to prevent distortions). Extensive subsidy systems waste public resources by giving subsidies to those that can pay for modern energy carriers (here, LPG), stimulating wasteful, excessive or inappropriate use of such carriers. Furthermore, since people with low incomes receive money rather than LPG bottles or coupons, they may decide to use LPG more rationally by preventing wasteful and excessive habits and investing in more efficient stoves and pans (such as pressure cookers) in order to save money to buy other things. In this sense, besides being more cost effective for the Government, this kind of mechanism may even encourage energy efficiency.

In the case of electricity, the prices are structured so that consumers that use up to 100 kW·h per month and monophasic connections receive price discounts. This arrangement works as a subsidy for low-income groups (actually a cross- subsidy, because other consumers are overcharged). However, such mechanisms do not stimulate energy efficiency or prevent the loss of the proper social focus (protecting low income groups) due to their general approach. As argued before, broad subsidy approaches generally lead to a loss of focus, which leads to excessive economic costs for reaching the policy objective. For instance, there are people with high incomes that own countryside and beach houses in Brazil that fit the price discount conditions established by the Brazilian Government (electricity usage below 100 kW·h/month and monophasic connections)."[3].

Another strategy is to expand investment in energy infrastructure and enhancing capital investment. For improving accessibility, affordability and efficiency capital investment in energy infrastructure is required. A set of regulations and policies that provides incentives for foreign investors as well as private and public domestic investors to invest in energy infrastructure result in efficient production expansion as well as low waste, efficient transmission and accessible affordable energies for all types of people across the country. Providing a context in which investor could insure expected ROI is essential. To this end, capital market, labor market, financial market and business environment should be in harmony in order for energy sector to become attractive for both domestic and foreign investors. Due to high opportunity cost of capital in Iran, Iran can not rely on private capital market. Iran has to rely on public or foreign fund to insure infrastructure investment. This fact has led to the dominance of state-owned enterprises and most importantly, corruption. Decreasing the opportunity cost of capital and engaging private sector in infrastructure investment can lead to more efficient investment in long-run.

Another strategy is to improve technological innovation and knowledge acquisition. As mentioned before, In order to gain rapid growth, Iran needs to focus on trade, investment, acquisition of technological know-how, expanding innovative capacity and effective adaptation of new and emerging technologies.

The UNACTED approach for oil and gas is a strategy for enhancing technology acquisition [35]. A general approach for spurring technological innovation and technology acquisition is recommended here. The following points provide a general approach for such an endeavor that can be applied for electricity, renewable energies, and any type of energy sources [35]:

1) *Shaping innovation strategy*: placing high emphasis on learning and linkage between science and business as well as removing barriers to entrepreneurship and investor creativity. In order to formulate the innovation strategy and monitor implementation progress, short, medium and long-term objectives must be identified.

2) *Placing a high emphasis on policy measures;* Policy measures are required to support transparency and accountability. Signals, provided by information flow, increase policymaking adaptability and flexibility. In order to strengthen knowledge and information flow, a set of policies and programs measures are required. Those measures facilitate the economic information gathering. Information on science and technology inputs and outputs increase transparency and help government to make more effective policies.

3) *Implementing innovation strategy in each economic sector:* a clear action plan is necessary to implement the innovation strategy within the designated time period. Measureable (and relevant) objectives must be formulated for each sector that can be obtained on schedule.

4) *Upgrading innovative capacity and research facilities while facilitating technology diffusion through joint ventures and licensing*: This will require Iranian authorities to take a pragmatic approach to foreign policy as well as placing emphasis on innovation and learning rather than production. For example, transferring

technology may be undermined due to the fear of spillovers. Host country policies like foreign policy or taxation can decrease the risk of spillover and increase technology transfer.

5) *Upgrading innovative capacity through strengthening a robust legal framework*: A robust legal framework to defend the "property rights" is the cornerstone of development of the private sector and reduction of barriers to entrepreneurship.

6) *Highlighting small and medium enterprises (SMEs) and their role in industrial development*: SMEs have an integral role in advancing economic growth in industrialized countries; Iran should prioritize the development of SMEs in order to enhance national innovative capacity. This role entails the following facts: participation in existing production networks, through contracting relationships and joint ventures, participation in industrial clusters for which the small and medium industries manufacture the final products (such as the agricultural and textile industries) and the development of effective, knowledge-based small enterprises (namely those involved in providing information technology services). Appropriate policy measures should be clarified as well.

As explained before, times of dramatic economic disruption can clear the way for monumental technological change. Heightened pressure on consumers and businesses can force needs-based innovation, or shift consumer attitudes and desires, casting shadows of uncertainty in front of established market players, and opening up windows of opportunity for emergent competition. One area primed for this type of transformation is the alternative energy markets including renewables and the effort to substitute conventional fuel supply with novel fuels derived from abundant and readily-available renewable energy resources.

Discussion and debate among global energy policymakers, researchers, and environmental advocates has been centered on finding practical solutions for breaking our dependence on non-renewable fossil fuels for several years. Recent advancements in several key technologies have increased the prospects for the development of a safe, cost-effective, and environmentally friendly production process for producing carriers with energy and power density comparable to gasoline and natural gas.

Large established oil companies and countries with high proved reserves of natural resources have been slow or otherwise reluctant to enter the game in developing next generation fuel technologies. There are several natural explanations for this. For one, oil production and distribution is a large, mature industry with massive barriers to entry, which has given rise to an oligopolistic industry structure. Incumbents have tremendous expertise invested in conventional methods of discovering and extracting oil, but are not well suited to the needs of alternative fuel innovation. On the early portion of the technology lifecycle -- the period of ferment, before a dominant design has emerged – there are great risks that make large, public companies hesitant to enter the competitive arena. The demand for short term profit increases the likelihood of a myopic decision to refrain from a full, committed R&D effort. Moreover, oil companies have felt the sting of the economic downturn in the form of decreased demand and volatile oil prices. This will likely further distract their resources away from research and into operations that give short-term profit. If they adopt this conservative strategy as many firms in similar circumstances historically have, a tremendous opportunity exists for new startup firms.

Indeed, the innovation in novel fuels demands a radically different competency: fundamental life science research, closely combined with practical engineering implementation. Accordingly, research institutions allover the world, MIT included, have invested significant human and economic capital focused on creating renewable energy technologies that could rival oil in the near future. Several companies, spun-off from research in labs, are currently developing processes to create cheap, renewable fuels. Given the environmental, economic, and political risks of continued oil dependence, Iran has to closely follow recent progresses to take the advantages of these innovations in a right time.

The cost of oil is one of the most important global economic variables. Fluctuations in oil prices reverberate across the entire economic system affecting the cost of manufactured goods, electricity, vehicle fuels, food production, and many other relevant commodities. In a time when consumer spending power is limited, tolerance for ever-increasing oil prices is low, and the appetite for a cost-effective substitute high. Similarly, as we have increasingly seen, geopolitical instability is an unfortunate correlate to the global economic downturn. There are many interests invested in untangling this knot. Emerging competition within the space should seek out these interests, and offer themselves as a potential solution, and worthy recipient of funding, press, and other forms of support which will help position them for long-run competitive advantage.

In order to decide how to invest, Iran needs to develop possible scenarios along key elements including oil price, economic growth (severity and longevity of the downturn), government policies and regulations (i.e. carbon tax, ethanol subsidies, vehicle fuel efficiency, trade restrictions), and optimize her general payoff in the energy market.

Thus, while the opportunity is large, there are technical and commercial risks associated with emerging renewable fuel technologies, driven by factors including the cost and availability of feedstock supply, the scalability of the process by which the fuel is created, and the broad range applicability of the end fuel produced. From an investment fund's perspective, the proper approach to exploiting this technological shift involves building a portfolio which covers the range of technologies contending to energy as the dominant design going forward.

According to UNCTAD report on science, technology and innovation in Iran [35];

"Iran has pursued a development strategy of self-reliance with some success. Endowed with abundant oil and natural gas resources, Iran did not face an import constraint. Yet, Iran adopted an import substitution policy and used its oil revenues to acquire foreign technologies to industrialize. Iran is today a middle-income developing country, with a significant industrial base, a relatively well-developed science and technology infrastructure and good human development.

However, unlike other middle-income countries, Iran is still largely a natural resource-based economy. Diversification is an imperative, not only because natural resources are exhaustible but also because export success in world markets increasingly demands knowledge-intensive production and innovation-based competition. Above all, there is need to provide quality jobs for the 800,000 literate Iranian men and women that enter the labor market every year.

The shift to a more knowledge-based economy will require creating a national innovation system that can not only import and adapt technologies, but also improve upon them, innovate new technologies and diffuse them economy wide. There is need to better link the science and technology infrastructure to the needs of the productive sector generally, and in particular to build up capabilities in high technology areas such as biotechnology, petrochemicals and new materials. That is the central message of this report." [36]

Shaping innovation strategy is critical for improving the technological innovation, strengthening entrepreneurship, increasing GDP and income and through this process, provide affordable, accessible, less environmental harmful energy sources for all type of people.

Chapter 6

Conclusion

The demand for energy in Iran is growing rapidly and transforming itself. The demand for energy is expected to increase at a pace more than supply growth rate, while the consumption is being transformed from traditional energy consumption (specially in rural areas) to consumption of modern energy sources including electricity and natural gas. This shift in energy consumption pattern is critical because it requires heavy investments in energy sector to meet the consumers' demand (i.e., demand in industrial & commercial, residential and transportation sectors) and to insure overall growth and development. In addition, Iran's total primary energy supply (TPES) is growing fast, even faster than annual economic growth, mainly because of a relatively high growth rate of natural gas and oil supply which together account for almost 98% of TPES. The primary energy supply in Iran over a period of 20 years is dominated by oil and natural gas and the share of other primary energies is considerably low. Furthermore, the share of natural gas and its growth in TPES is tremendously higher compared to other energy carriers (See figure 3.6). The share of natural gas grew over time as a result of Iran's energy policy which aimed to lessen the high consumption of oil and replace a cheaper and cleaner energy used in residential, industrial and transportation sectors. As a result of rapid urbanization and domestic immigration form rural areas to cities which caused a quick change in the residential sector's consumption pattern, the overall consumption grew fast as well. The low share of other primary energies proves that Iran couldn't make appropriate policies to increase the share of other resources which in turn makes energy sector vulnerable in close future as the reserves of oil and gas are diminishing over time and new uncertainties in market and technology are arising. Additionally, other countries are trying to reduce their reliance on oil imports and making policies to switch to other energy resources which creates the potential to decrease the overall oil demand in long-run and make the Iran's oil-revenue stock shrinking as time goes. The dominance of oil and natural gas in Iran's TPES should be considered as a threat. Therefore, policies for enhancing the share of other primary energies can lead to a change in the pattern of primary energy shares. Reducing the extent of natural gas and oil dominancy and increasing the share of other primary energies are ways to achieve Iran's flexibility's improvement by heightening diversity. Diversification and flexibility have an inevitable impact on energy security as they increase the capability of affordable and accessible energy production and enable country to switch between alternative energy carriers based on the dimensions of future scenarios.

The high share of oil and natural gas in Iran is critical for the energy sector's supply side assessment. Oil and Gas industry is among the most influential industries in the Middle East and North Africa (MENA) region. The current trend of global energy demand has made this industry even more critical in supplying required energy for other industries in a global scale. Iran is the second oil producer among OPEC members with tremendous oil and gas reserves and very high hydrocarbon resources. Oil sector plays a major role in economics development in Iran. Current statistics show that a huge proportion of GDP, government's budget, international trade, foreign investment, employment and national capital are directly or indirectly related to oil and gas sector. This fact proves that all sectors in Iran are effected by high volatility of oil and gas price.

There are other issues that encourage us to even look further and consider a more systematic approach. Iran has to not only deal with her internal issues, but also with issues that are caused by external forces in the region. For instance, the imposition of sanctions has a great effect on technology acquisition and therefore it's significant impact on both the volume of energy productions and the efficiency of production, transformation, transmission and consumption.

In order to overcome these challenges, five major strategies are proposed based on the elaborate analysis of the current state of energy systems and characteristics of sustainable energy systems.

The first strategy is macroeconomic stabilization. A stable macroeconomic space is imperative in a sense that this stability can improve business environment, increase upfront investments, strengthen competition, improve technological innovation, diffusion and acquisition, increase overall GDP, reduce unemployment and enhance income generation which in turn makes energy market more efficient and increase the affordability and accessibility of energy sources. Interest rate, balance of payment, public debt, exchange rate, inflation rate and unemployment are among key macroeconomic indicators that need to be considered in a strategy for macroeconomic stabilization.

The second strategy is to provide a set of regulations that strengthen competition and innovation in the market. In order to gain rapid growth, Iran needs to focus on trade, investment, acquisition of technological know-how, expanding innovative capacity and effective adaptation of new and emerging technologies. One of the barriers toward effective competition in energy market is energy subsides. The other barrier is the high extent of state-owned enterprises dominance on energy market. Energy subsidy reform and effective privatization are two ways to spur competition in energy market. Establishing appropriate institutions for monitoring the energy subsidy reform and privatization progress is critical.

The third strategy is to expand investment in energy infrastructure and enhancing capital investment. For improving accessibility, affordability and efficiency capital investment in energy infrastructure is required. A set of regulations and policies that provides incentives for foreign investors as well as private and public domestic investors to invest in energy infrastructure result in efficient production expansion as well as low waste, efficient transmission and accessible affordable energies for all types of people across the country.

The forth strategy is to improve technological innovation and knowledge acquisition. Shaping innovation strategy, Placing a high emphasis on policy measures; Implementing innovation strategy in each economic sector, Upgrading innovative capacity and research facilities while facilitating technology diffusion through joint ventures and licensing, Upgrading innovative capacity through strengthening a robust legal framework and ultimately Highlighting small and medium enterprises (SMEs) and their role in industrial development are some steps toward more innovative energy system with higher innovative capacity.

The fifth strategy is to look at the opportunities that alternative and renewable energies create. Recent advancements in several key technologies have increased the prospects for the development of a safe, cost-effective, and environmentally friendly production process for producing carriers with energy and power density comparable to gasoline and natural gas. In order to decide how to invest, Iran needs to develop possible scenarios along key elements including oil price, economic growth (severity and longevity of the downturn), government policies and regulations (i.e. carbon tax, ethanol subsidies, vehicle fuel efficiency, trade restrictions), and optimize her general payoff in the energy market.

Appendix A. Useful information

(Source: Ministry of Energy, Islamic Republic of Iran [33])

Table A.1 electricity Sale to Different Selectors by MOE During 2001- 2006 (GWh)

Year	Residential	Public	Commercial	Industry	Transport	Agriculture	Other	Total*
2000	31266	11271	5991	28924	13	9147	3754	90366
2001	32891	11951	6394	30721	18	11079	4117	97171
2002	34946	12630	6925	33456	13	12435	4671	105076
2003	37967	13714	7461	36937	14	13859	4672	114910
2004	40564	15021	7863	40248	90	15489	5188	124462
2005	44108	16350	8542	43015	108	16469	4305	132897
2006	48085	18329	9320	46431	143	17666	4608	144582

Table A.2 Share of Sectors in Final Consumption of Iran
(%)

Year	Residential & commercial	Industry	Transport	Agriculture	TFEC	Non-energy use	TFC
1974	31.8	25.6	25.5	5.7	80.5	11.5	100.0
1976	31.8	22.6	29.7	6.3	90.3	9.7	100.0
1989	33.2	28.4	24.2	7.6	93.3	6.7	100.0
1995	38.2	23.5	25.3	5.5	92.5	7.5	100.0
2000	40.0	19.7	28.9	4.5	91.1	8.9	100.0
2005	41.1	20.3	28.2	3.7	93.3	6.7	100.0
2006	41.9	19.9	27.4	3.7	92.9	7.1	100.0
2007	41.3	22.6	25.2	3.6	92.6	7.4	100.0

Table A.3 Share of Energy Carriers in Total Final Consumption of Iran
(%)

Year	Petroleum product	Natural gas	Coal	Solid biomass	Electricity	TFC
1974	81.1	11.0	0.2	2.6	5.1	

1976	86.6	6.9	0.2	1.6	4.8	100.0
1989	76.0	15.5	0.7	1.0	6.9	100.0
1995	61.6	30.5	0.2	0.7	7.1	100.0
2000	59.3	32.0	0.2	0.4	8.1	100.0
2005	51.1	38.3	0.4	1.3	8.8	100.0
2006	49.1	40.6	0.3	1.2	8.8	100.0
						100.0
2007	45.6	44.6	0.4	0.5	8.7	100.0

Table A.4 Solid Biomass Consumption in Residential Sector of Iran, 2007

Provenance	Shrubs &scrubs Ton	Animal wastes ton	Charcoal Kg	Fire wood M^3
East Azarbaijan	1836	182899	1794	413637
West Azarbaijan	1278	86806	.	293079
Ardabil	890	31518	95	8592
Esfehan	3353	122992	1200	48169
Ilam	8968	128	.	64384
Boushehr	2024	.	877	12360
Tehran	.	.	.	.
khuseztan	281473	647	45401	653756
Khorasan	275177	154885	2000	33600
Charmahal & bakhtiari	4878	3413	.	1593082
Zanjan	103191	86239	.	77582
Semnan	10289	1109.43	5802	23520
Sistan & balouchestan	9486	1426	1700	441279
Fars	35058	52228	20404	212955
Qazvin	851	25364.2	.	13298
Kordestan	.	197215	.	745602
Kerman	165377	.	150	1682151
Kermanshah	53	23432.4	3965	84533
Kohglouye &boyerahmad	.	.	.	1118739
Golestan	27100	375	.	436138
Gilan	.	.	696000	12991
Lorestan	9357	3287	46284	887443
Mazanddaran (sari &noshahr)	.	770	125167	184185
Markazi	.	.	.	.
Hormozgan	1017	,	1156	63323
hamedan	.	.	.	.
Yazd	1631	.	.	28891
Total	944375	863621.23	951005	9127862
Fuel consumption after	500000	86360	951005	5000000

implementation of fuel substitution plan 2007

Table A.5 Natural Gas Transmission, distribution and Number of Consumers

	Unit	(March 2006)	2005-2007
Length of high pressure natural gas pipeline	1000 k	22.0	2.2
Total length of gas network	1000 k	118.2	13.6
Total connection	1000 connection	5706.6	462.6
Consumers (number)	1000 consumers	8404.4	919.1

Table A.6 Natural Gas final Consumption in Some Selected Countries, 2004 (10^6 m^3)

Countries	Residential, public and commercial	Industry	Transport	Agriculture and other	Total final consumption
China	10563	20188	61	-	30812
France	19862	16306	48	2320	38536
Germany	45349	23981	-	9559	78889
India	679	9562	-	144	10385
Indonesia	4339	13325	25	-	17689
Japan	55292	53069	41676	1709	151749
Russian federation	55295	53069	41676	1709	151749
Saudi Arabia	-	24020	-	-	24020
Korea	11520	4398	255	25	16198
Turkey	5856	2513	126	516	9111
UK	43718	13137	-	3003	59858
US	225982	146386	16774	18167	407309
Word total	666735	634665	82517	90973	1474890

Table A.7 Average Sale Price of Natural Gas in Iran During 2000-2005

Sector	2000	2001	2002	2003	2004	2005
Residential (average)	55.0	60.5	67.8	75.0	80.0	80.0
Commercial	121.0	133.0	153.3	174.5	199.4	200.0
Public	121.0	133.0	154.6	174.5	198.7	200.0
Industry	104.5	115.0	121.7	131.0	139.8	138.5
Transport	55.0	60.5	86.3	60.0	60.0	60.0
Power plant	20.0	22.0	22.4	27.0	29.4	29.3

Table A.8 Production, SWAP Imports & Net Export of Crude Oil & Pet. Product in Iran

Mboe

Year	Production	Net export of oil & petroleum products	SWAP import
1974	2195.3	2052.0	-
1978	1833.0	1639.3	-
1989	1075.1	715.2	-
1995	1433.4	984.5	-
2000	1373.0	949.0	4.6
2005	1498.5	1018.1	27.2
2006	1478.8	940.9	45.4
2007	1497.8	941.4	38.4

Table A.9 World Production, consumption, Import and Export of Oil by Region, 2007

1000 barrels/day

Regions	Production	Consumption	Import	Export
North America	13885	25024	11082	3830
S. & Cent. America	6633	5493	847	2313
Europe & Eurasia	17835	20100	10691	6945
Middle East	25176	6203	117	17262
Africa	10318	2955	762	7812
Asia Pacific	7937	25444	15157	1284
Total World	81533	85220	39836	39836

Table A. 10 Light and Rich Gas Production, Export and Import of Natural Gas in Iran
(10^6 m^3)

Year	Production Rich gas	Light gas	Import of light gas	Export of light gas
1995	53546	79336	-	-
2000	109767	85684	3287	-
2001	113964	93825	4515	357
2002	122598	105230	5278	1274
2003	137968	110860	5731	3413
2004	149149	126420	5858	3510
2005	159374	131707	5176	4735
2006	169539	137789	6263	5727
2007	184581	146117	6169	5621

Table A.11 World Production, consumption, Import and Export of Oil by Region, 2007
Billion m^3

Regions	Production	Consumption	Import	Export
North America	775.8	130.9	130.9	801.0
S. & Cent. America	15.8	14.4	14.4	134.5
Europe & Eurasia	1075.7	375.8	333.8	1155.7
Middle East	356.8	10.8	7.9	299.4
Africa	190.4	1.3	45.5	83.5
Asia Pacific	391.5	17.1	17.1	447.8
Total World	2940.0	549.7	549.7	2921.9

Table A.12 Coal Production, Export and Import in Iran
(10^6 m^3)

Year	Production of processed goal	Import	Export
1974	242.0	14.0	0.6
1978	451.0	19.1	-
1989	848.0	277.9	17.8
1995	914.0	412.7	12.0
2000	931.9	1178.1	61.7
2005	930.4	520.1	36.4
2006	1024.5	558.1	53.7
2007	1039.4	389.6	17.0

Table A. 13 Production and Consumption of Coke, Coke Oven Gas and Blast Furnace Gas in Iran

Year	Coke (10^6 ton)		Coke oven gas(10^4m^2)		Blast furnace gas (10^4m^2)	
	Production	consumption	Production	consumption	Production	consumption
1989	-	-	34.0	309.7	2607.1	1945.0
1995	-	-	378.8	316.0	2713.6	1941.8
2000	-	-	486.0	420.2	3794.8	2915.8
2005	1.23	1.23	391.8	365.6	4124.8	3188.2
2006	1.17	1.17	414.0	399.1	4252.5	4145.5
2007	1.21	1.21	391.9	383.6	4348.2	4330.2

Table A. 14 Legal Amount of Firewood and Charcoal Production in Iran

Year	Coke (tone)	Firewood (m^3)
1974	-	97767
1978	76182	185513
1989	43862	518192
1995	30010	635710
2000	18252	493212
2005	3704	308547
2006	1858	294843
2007	1628	309579

Table A. 15 Installed Capacity and Electricity Generation of Hydro power and Renewables in Iran

year	Hydro power		Renewable (wind&solar)	
	Production(GWh)	Capacity (MW)	Production (MWh)	Capacity (MW)
1974	3421.0	804.0	-	-
1978	6249.0	1804.0	-	-
1989	7522.0	1953.0	-	-
1995	7288.2	1958.0	3901.3	1.0
2000	3564.5	2007.0	35627.0	1.9
2005	16100.2	8043.9	70955.2	47.7
2006	18265.6	6572.2	125392.6	58.9
2007	17986.9	7422.5	143425.7	74.1

Table A.16 Installed Capacity and Electricity Generation and Direct use of Geothermal Energy, 2006

Regions	Installed capacity(MW)	Gross electricity generation (TWh)	Direct use (TJ/year)
North America	3234	23.27	602414
S. & Cent. America	-	2.67	95976
Europe & Eurasia	1142	8.80	409395
Africa	-	0.80	32400
Asia Pacific	978	23.61	825092
Total World	5654	59.24	1964977

Table A.17 crude Oil Imports From Caspian Ports During 200-2006

Year	2000	2001	2002	2003	2004	2005	2006
Barrel/day	12489	5521	19715	71764	88027	74501	124389
Thousand/year	4571	2015	7196	26194	32218	27193	45402

Table A.18 Mix of Petroleum Production, 2000-2006

Year	LPG	Motor gasoline	Kerosene	Gas oil	Fuel oil	Other	Total
2000	3.4	14.8	10.9	28.5	33.4	9.0	100.0
2001	3.4	15.1	11.1	28.8	32.6	9.2	100.0
2002	3.6	15.8	10.2	29.5	32.8	8.1	100.0
2003	3.5	16.3	10.2	29.9	31.6	8.5	100.0
2004	3.4	16.3	9.6	31.2	30.3	9.2	100.0
2005	3.3	16.9	8.3	31.6	30.3	9.6	100.0
2006	3.2	17.3	8.2	31.2	29.6	10.4	100.0

Table A.19 Export and Import of Petroleum Products During 2000-2006

Product/ year	2000	2001	2002	2003	2004	2005	2006
Export:							
Fuel oil	43.87	39.16	42.22	40.89	37.27	36.87	38.86
Gas oil	3.26	2.01	2.10	0.61	3.35	1.46	-
Kerosene	0.81	0.76	1.97	1.51	0.60	0.32	0.27
Import:							
Motor	5.25	7.79	10.42	15.11	22.67	24.81	27.50

gasoline							
Aviation fuel	6300	5.20	7.40	3.20	5.60	4.20	5.00
LPG	-	354	595	910	827	796	638
Gas oil	-	-	-	-	0.17	.29	5.09

Table A.20 Consumption of petroleum products, 200-2006

Year	LPG	Gasoline	Kerosene	Gas oil	Fuel oil	Total
Consumption of petroleum products (10^6 liters)						
2000	4338	15517	9185	24265	14737	67742
2001	4165	16737	8973	25083	152554	70214
2002	4355	18440	8683	25880	14771	72128
2003	4305	20538	7889	26234	13601	72567
2004	4199	22159	7753	27348	13740	75200
2005	5032	24396	7531	28659	14486	80115
2006	5107	26867	7234	31429	15669	86307
Average of annual growth (%)	3.99	9.58	3.90	4.41	1.03	4.12
Share of the petroleum products (%)						
2000	5.96	22.91	13.56	35.82	21.75	100
2001	5.93	23.84	12.78	35.73	21.72	100
2002	6.04	25.57	12.04	35.88	20.48	100
2003	5.93	28.30	10.87	36.15	18.74	100
2004	5.58	29.47	10.31	36.37	18.27	100
2005	6.28	30.45	9.40	35.79	18.08	100
2006	5.92	31.13	8.38	36.42	18.16	100

Table A.21 consumption of petroleum products by sectors, 2006 (10^3 liters)

Sectors		Gasoline	Kerosene	Gas oil	Fuel oil
	MOE power plants	-	???	4361805	7587135
Industry	Other power plants	-	-	339492	-
	Other	37922	60545	297976	5853445

	industries				
Residential		-	6705494	848894	-
Public		107550	278686	1181896	375584
Commercial		148	108347	684578	1352820
Agriculture		12572	38904	4150757	-
	Shipping	39477	-	475239	490687
Transportation	Other	266669302	-	16407472	-
Non-energy use		-	????	-	??
Total		266660971	7234319	3143909	15559157

Table A.22 I.P.G consumption by Sectors, 2006 Ton

Sectors	Consumption
Residential and commercial	2424330
Transport	193085
Others	213160
Total	2830575

Table A.23 Light and Heavy fuel Oil Export Prices in Iran During 2000-2006 Dollars/barrels

Year	Light fuel oil	Heavy fuel oil
2000	26.75	26.02
2001	22.90	21.67
2002	23.52	23.09
2003	26.89	26.33
2004	34.77	31.67
2005	50.60	47.93
2006	61.04	58.88

Table A.24 Nominal Sale Price of the Major Petroleum Products During 2000-2006 Rials/liter

Year	Gasoline	Premium gasoline	Kerosene	Gas oil	Fuel oil	LPG
2000	386	550	110	110	55	24
2001	450	605	120	120	64.2	24

2002	500	665	130	130	70	26
2003	650	900	160	160	88.2	28.6
2004	800	1100	165	165	94.5	31.7
2005	800	1100	165	165	94.5	31.7
2006	800	1100	165	165	94.5	31.7

Table A.25 Nominal Sale Price of the Major Petroleum Products During 2000-2006

(dollar /barrel)				(dollar/metric ton)		
Year	Motor gasoline (95 RON)	Kerosene	Gas oil	CST 280 fuel oil	CST 380 fuel oil	Naphtha
2001	-	25.07	24.14	121	-	192
2002	29.47	29.20	28.76	155	153	238
2003	33.20	30.86	30.24	153	149	254
2004	46.16	48.54	46.07	173	164	367
2005	61.52	69.13	64.23	273	262	468
2006	70.28	77.04	74.06	294	285	551

Table A.26 Consumption of other Petroleum Products, 2006 (10^3 m^3)

Petroleum Products	Consumption
Aviation gasoline 100 LL	1.8
Slveat	84.0
Light gasoline type jet (JP4)	98.9
Heavy gasoline type jet (ATK)	1155.6
Lubricant	1668.6
	4202
Other products	166.8
Total	73.77.7

Table A.27 Natural Gas Transmission, Distribution and Number of Consumers

	Unit	March 2007	2006-2007
Length of high pressure Natural gas pipeline	100 0km	24.9	2.9
Total length of gas network	1000km	131.3	12.8
Connection	1000 connection	6170.5	461.6

Consumers (number)	1000 consumers	9292.2	887.0

Table A.28 Natural Gas Consumption in Different Sectors by Type of Consumption (2000-2006) (10^6 m^3)

			2000	2001	2002	2003	2004	2005	2006
Nominal gas final consumption	Final energy consumption	Residential, public and commercial	21.9	23.0	27.2	29.2	34.0	35.8	41.8
		Petrochemical fuel	2.5	2.5	2.4	3.0	3.5	3.5	3.4
		Industry	7.4	7.0	7.6	8.6	9.8	11.3	13.6
		Transport	0.002	0.004	0.01	0.01	0.1	0.3	0.5
		Agriculture	-	-	-	-	-	-	0.1
	Non energy use	Petrochemical fuel stock	2.8	3.4	3.3	3.4	3.6	3.6	4.4
		Acid gas	0.8	0.7	1.3	1.5	3.2	3.1	-
	Total		35.5	36.6	41.8	45.7	54.2	57.6	32.8
Energy own use		Oil refineries	2.6	3.0	3.9	4.1	4.1	5.5	6.5
		Fuel consumption of gas refineries and pressure station	2.0	1.7	2.0	2.9	4.1	3.2	3.7
		Power plates	23.8	26.0	27.6	30.3	32.7	35.1	35.2
		?????	0.1	0.4	0.3	0.3	0.4	0.5	0.5
		Total	28.5	30.1	33.8	37.6	41.3	44.3	46.0
Export			-	0.3	1.3	2.4	3.5	4.7	5.7
Total			**64.0**	**67.0**	**76.9**	**86.7**	**99.0**	**106.6**	**115.5**

Table A.29 Natural Gas final Consumption in Some Selected Countries, 2005 (10^6 m^3)

Countries	Residential, public and commercial	Industry	Transport	Agriculture and other	Total final consumption
China	11573	13235	94	8763	33670
France	23264	14300	54	2427	40045
Germany	45264	24234	-	7203	77202
India	766	6145	798	9121	16832
Indonesia	50	6559	15	7949	14573
Japan	26679	6141	-	414	33234

Russian federation	51626	37285	41898	27716	158525
Saudi Arabia	-	-	-	15260	15260
Korea	12802	4652	361	27	17842
Turkey	8106	3255	127	584	12072
UK	42181	10459	-	2897	58537
US	222565	133515	17189	17950	391219
Word total	681054	317315	86358	201243	1486000

Table A.30 Average Sale Price of Natural Gas in Iran During 2000-2006 Rial/m^3

Sector	2000	2001	2002	2003	2004	2005	2006
Residential (average)	55.0	60.67	67.8	75.0	80.0	80.0	80.0
Commercial	121.0	133.0	153.3	174.5	199.4	200.0	200.0
Public	121.0	133.0	154.6	174.5	198.7	200.0	200.0
Industry	104.5	115.0	121.7	131.0	139.8	138.5	138.5
Transport	22.0	60.5	86.3	60.0	60.0	60.0	60.0
Power plant	20.0	22.0	22.1	27.0	29.1	29.3	29.3

Table A.31 Nominal Capacity of power Plants in Iran **(MW)**

Year	MOE	Large industry	Private sector	Other organization	Total
2000	26287.0	901	-	18.6	37306.6
2001	28032.0	901	-	19.5	289525
2002	30604.6	901	-	19.6	31525.2
2003	33415.3	901	-	16.4	34332.7
2004	36290.1	1009	-	21.1	37300.2
2005	38213.1	1594	1213	-	41020.1
2006	40896.8	2342	1900	-	45138.8

Table A.32 Actual Capacity of power Plants in Iran **(MW)**

Year	MOE	Large industry	Private sector	Other organization	total
2000	2414171067.0	840	-	18.6	25005.6
2001	25645.0	840	-	19.5	26504.5
2002	28008.6	840	-	19.6	28868.2
2003	30439.6	840	-	16.4	31296.0
2004	32850.3	840	-	21.1	33801.4

2005	34624.2	1380	1067	-	37071.2
2006	37289.0	1908.1	1547	-	40744.2

Table A.33 Countries, 2005 (10^6 m^3)

Countries	Residential, public and commercial	Industry	Transport	Agriculture and other	Total final consumption
China	329.5	105.2	6.8	0.8	442.4
France	27.8	21.0	63.4	0.6	1127
Germany	78.4	4.1	20.6	17.3	120.4
India	99.8	31.0	2.8	4.0	137.6
Indonesia	17.9	4.6	-	0.8	23.2
Japan	177.5	22.0	47.1	1.3	247.9
Russian federation	148.3	45.5	23.3	0.1	217.2
Saudi Arabia	30.5	-	-	-	30.5
South Korea	43.8	1.6	16.7	0.1	62.2
Turkey	24.1	12.6	-	0.1	36.8
UK	62.0	1.5	11.9	2.8	78.1
US	757.1	77.5	100	22.1	956.7
Word total	2652.3	761.9	347.2	83.6	3872.0

Table A.34 Gross Electricity Generation in some Countries, 2005 (TWb)

Countries					
China	2044.8	397.0	53.1	2.5	2497.4
France	55.5	61.1	450.2	7.7	574.5
Germany	382.1	27.9	167.3	55.9	633.2
India	573.6	100.0	17.3	8.1	699.0
Indonesia	110.0	10.8		6.6	127.4
Japan	651.0	97.5	304.1	20.5	1073.2
Russian federation	626.0	174.6	149.5	3.0	953.1
Saudi Arabia	176.1	-	-	-	176.1
Korea	252.8	5.2	148.8	0.6	407.4
Turkey	131.4	44.2	-	0.3	175.9
UK	299.6	8.4	75.2	15.6	398.7
US	3037.3	307.8	815.3	116.6	4227.1

Table A.35 Iran Electricity Export and Import (GWb)

Year	Export	Import
2000	1001	279
2001	1049	745
2002	799	977
2003	919	1489
2004	1937.1	2169.6
2005	2759.4	2083.7
2006	2775.0	2540.0

Table A.36 electricity Sale to Different Selectors by MOE During 2001- 2006 (GWh)

Year	Residential	Public	Commercial	Industry	transport	Agriculture	Other	Total*
2000	31266	11271	5991	28924	13	9147	3754	90366
2001	32891	11951	6394	30721	18	11079	4117	97171
2002	34946	12630	6925	33456	13	12435	4671	105076
2003	37967	13714	7461	36937	14	13859	4672	114910
2004	40564	15021	7863	40248	90	15489	5188	124462
2005	44108	16350	8542	43015	108	16469	4305	132897
2006	48085	18329	9320	46431	143	17666	4608	144582

Table A.37 Average Price of Electricity in Different Consuming Sectors

Year	Residential	Public	Agriculture	Industry	Other	Total*
2000	65.11	83.54	12.81	121.0	247.00	89.36
2001	72.92	99.59	11.49	133.59	273.86	98.52
2002	85.14	124.49	12.65	146.94	342.31	104.10
2003	97.00	152.00	14.00	162.91	412.01	131.76
2004	107.08	175.89	16.01	185.02	505.25	151.06
2005	102.74	176.81	21.56	201.57	539.74	152.08

2006	102.92	181.70	21.25	200.41	541.16	152.78

Table A. 38 Capacity of hydro power plants in Iran, 2006 (MW)

Type of hydro plants	Installed capacity
Operating hydro plants	6572.219
Under Construction hydro plants	5927.100
Desgned and ready to construct	12310.100
Siting	10618.270
Total	35427.689

Table A.39 Electricity Generation and Wind Turbines Capacity in Some Countries, 2006

Countries	Capacity (MW)	Generation (GWh)
France	1585	2150
Germany	20652	30500
IR.Iran	58.8	125
Japan	1457	2262
Korea	??	234
Turkey	??	129
UK	1967	4233
USA	11635	25865

Table A.40 Electricity Generation and capacities, 2006

Countries	Capacity (MW)	Gross Generation (Gwh)
France	43.9	22
Germany	2863.0	2000
Japan	1708.5	7
Korea	34.7	7
UK	14.0	8
USA	624.0	14

Appendix B. Index of Economic Freedom

Table B.1 displays Index of Economic Freedom provided and developed by Heritage Foundation [42].

Table B.1. The Heritage Foundation, *Index of Economic Freedom*

	Trade Policy		Fiscal Burden: Taxation				Fiscal Burden:	Monetary
			Income Tax Rate		Corporate Tax		Government	Policy
Score	Average Tariff Rate	Non-Tariff Barriers	Average Rate	Marginal Rate	Average Rate	Marginal Rate	Consumption as Percent of GDP	Inflation Rate
1	< 4%	Very Low	< 10%	< 10%	Close to 0	Close to 0	< 10	< 6%
2	5-9%	Low	10-20%	< 25%	< 25%	< 25%	11-25	7-13%
3	10-14%	Moderate	15-20%	< 35%	< 25%	26-35%	26-35	14-20%
4	15-19%	High	15-20%	36-50%	> 25%	36-45%	36-45	21-30%
5	> 20%	Very High	> 20%	> 50%	> 25%	> 46%	> 46	> 30%

	Foreign Investment Policy		Banking		Wage & Price Controls		Property Rights	
Score	Legal Restrictions	Government Attitude	Entry Barriers	Government Controls	Prices	Wages	Legal Guarantees	Judicial Enforcement
1	Very Few	Encouraging	Very Few	Light	None	None	Complete	Efficient
2	Some Sectors	Neutral	Few	Some	Some	May Have Min.	Complete	Lax
3	Many Sectors	Neutral	Many	Tight	Many	Many	Incomplete	Efficient or Lax
4	Case-by-Case	Discouraging	High	Very Tight	Common	Common	Very Limited	Absent
5	Case-by-Case	Actively Discouraging	Very High	Chaotic	Complete	Complete	Nonexistent	Irrelevant

	Government Intervention and Public Ownership	Regulation			Black Market
Score	Level of Government Intervention in the Economy:	Rules	Restrictiveness	Enforcement	Share of GDP
1	*Very Low*: Less than 10 percent of GDP; virtually no government-owned enterprises.	Straight-forward	Very Low	Efficient and Uniform	< 10%
2	*Low*: 11 percent to 25 percent of GDP; a few government-owned enterprises, like the postal service; aggressive privatization program in place.	Simple	Low	Mostly Efficient and Uniform	11-15%
3	*Moderate*: 26 percent to 35 percent of GDP; several government-owned enterprises like telecommunications, some banks, and energy production; stalled or limited privatization program.	Complicated	Substantial	Haphazard	16-20%
4	*High*: 36 percent to 45 percent of GDP; many government-owned enterprises like transportation, goods distributors, and manufacturing companies.	Complicated	High	Haphazard and Partly Corrupt	21-30%
5	*Very High*: 46 percent or more of GDP; mostly government-owned industries; few private companies.	Ubiquitous	Extreme	Very Haphazard and Corrupt	> 30%

Table B.2 presents Iran economic freedom rank in the world [43].

Table B.2. Index of Economic Freedom, World Rankings

RANKING THE WORLD BY ECONOMIC FREEDOM

Rank	Country	Overall Score
1	Hong Kong	89.7
2	Singapore	87.2
3	Australia	82.5
4	New Zealand	82.3
5	Switzerland	81.9
6	Canada	80.8
7	Ireland	78.7
8	Denmark	78.6
9	United States	77.8
10	Bahrain	77.7
11	Chile	77.4
12	Mauritius	76.2
13	Luxembourg	76.2
14	Estonia	75.2
15	The Netherlands	74.7
16	United Kingdom	74.5
17	Finland	74.0
18	Cyprus	73.3
19	Macau	73.1
20	Japan	72.8
21	Austria	71.9
22	Sweden	71.9
23	Germany	71.8
24	Lithuania	71.3
25	Taiwan	70.8
26	Saint Lucia	70.8
27	Qatar	70.5
28	Czech Republic	70.4
29	Georgia	70.4
30	Norway	70.3
31	Spain	70.2
32	Belgium	70.2
33	Uruguay	70.0
34	Oman	69.8
35	South Korea	69.8
36	Armenia	69.7
37	Slovak Republic	69.5
38	Jordan	68.9
39	El Salvador	68.8
40	Botswana	68.8
41	Peru	68.6
42	Barbados	68.5
43	Israel	68.5
44	Iceland	68.2
45	Colombia	68.0
46	The Bahamas	68.0
47	United Arab Emirates	67.8
48	Mexico	67.8
49	Costa Rica	67.3
50	Saint Vincent and the Grenadines	66.9
51	Hungary	66.6
52	Trinidad and Tobago	66.5
53	Malaysia	66.3
54	Saudi Arabia	66.2
55	Macedonia	66.0
56	Latvia	65.8
57	Malta	65.7
58	Jamaica	65.7
59	Panama	64.9
60	Bulgaria	64.9
61	Kuwait	64.9
62	Thailand	64.7
63	Romania	64.7
64	France	64.6
65	Cape Verde	64.6
66	Slovenia	64.6
67	Turkey	64.2
68	Poland	64.1
69	Portugal	64.0
70	Albania	64.0
71	Belize	63.8
72	Dominica	63.3
73	Namibia	62.7
74	South Africa	62.7
75	Rwanda	62.7
76	Montenegro	62.5
77	Paraguay	62.3
78	Kazakhstan	62.1
79	Guatemala	61.9
80	Uganda	61.7
81	Madagascar	61.2
82	Croatia	61.1
83	Kyrgyz Republic	61.1
84	Samoa	60.6
85	Burkina Faso	60.6
86	Fiji	60.4
87	Italy	60.3
88	Greece	60.3
89	Lebanon	60.1
90	Dominican Republic	60.0
91	Zambia	59.7
92	Azerbaijan	59.7
93	Morocco	59.6
94	Mongolia	59.5
95	Ghana	59.4
96	Egypt	59.1
97	Swaziland	59.1
98	Nicaragua	58.8
99	Honduras	58.6
100	Tunisia	58.5
101	Serbia	58.0
102	Cambodia	57.9
103	Bhutan	57.6
104	Bosnia and Herzegovina	57.5
105	The Gambia	57.4
106	Kenya	57.4
107	Sri Lanka	57.1
108	Tanzania	57.0
109	Mozambique	56.8
110	Gabon	56.7
111	Nigeria	56.7
112	Vanuatu	56.7
113	Brazil	56.3
114	Mali	56.3
115	The Philippines	56.2
116	Indonesia	56.0
117	Benin	56.0
118	Tonga	55.8
119	Malawi	55.8
120	Moldova	55.7
121	Senegal	55.7
122	Côte d'Ivoire	55.4
123	Pakistan	55.1
124	India	54.6
125	Djibouti	54.5
126	Niger	54.3
127	Yemen	54.2
128	Tajikistan	53.5
129	Suriname	53.1
130	Bangladesh	53.0
131	Papua New Guinea	52.6
132	Algeria	52.4
133	Haiti	52.1
134	Mauritania	52.1
135	China	52.0
136	Cameroon	51.8
137	Guinea	51.7
138	Argentina	51.7
139	Vietnam	51.6
140	Syria	51.3
141	Laos	51.3
142	Seychelles	51.2
143	Russia	50.5
144	Ethiopia	50.5
145	Micronesia	50.3
146	Nepal	50.1
147	Bolivia	50.0
148	Burundi	49.6
149	Sierra Leone	49.6
150	São Tomé and Príncipe	49.5
151	Guyana	49.4
152	Central African Republic	49.3
153	Togo	49.1
154	Maldives	48.3
155	Belarus	47.9
156	Lesotho	47.5
157	Equatorial Guinea	47.5
158	Ecuador	47.1
159	Guinea–Bissau	46.5
160	Liberia	46.5
161	Angola	46.2
162	Solomon Islands	45.9
163	Uzbekistan	45.8
164	Ukraine	45.8
165	Chad	45.3
166	Kiribati	44.8
167	Comoros	43.8
168	Republic of Congo	43.6
169	Turkmenistan	43.6
170	Timor-Leste	42.8
171	Iran	42.1
172	Democratic Republic of Congo	40.7
173	Libya	38.6
174	Burma	37.8
175	Venezuela	37.6
176	Eritrea	36.7
177	Cuba	27.7
178	Zimbabwe	22.1
179	North Korea	1.0
n/a	Afghanistan	n/a
n/a	Iraq	n/a
n/a	Liechtenstein	n/a
n/a	Sudan	n/a

ECONOMIC FREEDOM SCORE

80–100	FREE
70–79.9	MOSTLY FREE
60–69.9	MODERATELY FREE
50–59.9	MOSTLY UNFREE
0–49.9	REPRESSED

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