IIIEE Theses 2019:05

Analyzing GHG Emissions Reduction Effects and Potentials of Fossil Fuels Subsidies Reform Policy in Iran

Hodjat Arabi

Supervisors

Aleh Cherp

Thesis for the fulfilment of the
Master of Science in Environmental Sciences, Policy & Management (MESPOM)
jointly operated by Lund University – University of Manchester -
University of the Aegean – Central European University

Lund, Sweden, June 2019

Erasmus Mundus Masters Course in Environmental Sciences, Policy and Management

MESPOM

This thesis is submitted in fulfilment of the Master of Science degree awarded as a result of successful completion of the Erasmus Mundus Masters course in Environmental Sciences, Policy and Management (MESPOM) jointly operated by the University of the Aegean (Greece), Central European University (Hungary), Lund University (Sweden) and the University of Manchester (United Kingdom).

Published in 2016 by IIIEE, Lund University, P.O. Box 196, S-221 00 LUND, Sweden,
Tel: +46 – 46 222 02 00, Fax: +46 – 46 222 02 10, e-mail: iiiee@iiiee.lu.se.

ISSN 1401-9191

Acknowledgements

Firstly, I would like to thank my thesis supervisor Prof. Aleh Cherp of the IIIEE at Lund University and Central European University. The Prof. Cherp office was always open whenever I ran into a trouble spot or had a question about my research or writing. He consistently allowed this thesis to be my own work but steered me in the right direction whenever he thought I needed it. I also would like to thank Prof. Cherp for his support to overcome the difficulties I have had during my MESPOM years.

Secondly, I would like to thank Prof. Naoko Tojo for her full support during my studies and especially to continue my studies remotely when I was managing my visa issue.

Thirdly, I would like to thank my mentor and friend, Prof. Alexios Antypas for his guidance and support whenever I needed it.

Fourthly, my thanks go to all MESPOM family including professors, staffs and my classmates at CEU, IIIEE (Lund University) and the University of the Aegean.

Finally, I must express my very profound gratitude to my wife; Mojgan and my parents for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you.

Abstract

Fossil fuels subsidies are intervention policies by governments to keep energy prices lower than the market price which leads to an increase in energy consumptions and GHG emissions. Iran provides the largest amount of fossil fuels consumption subsidies in the world, but it implemented the Targeted Subsidies Act to reform its subsidies and increase energy carriers' end-user prices. This thesis investigated GHG emissions reduction effects and potentials of fossil fuels subsidies reform policy in Iran. For this aim, qualitative study and quantitative research approaches were employed, existing studies were collected and reviewed with the use of a synthesis matrix. Then the reviewed studies were examined to evaluate the GHG emissions reduction effects and potentials of fossil fuels subsidies reform policy at the global level and other countries. Followingly, the results of Targeted Subsidies Act were collected and analyzed by employing environmental policy framework and economic frameworks. Findings of this thesis demonstrate that fossil fuels subsidies have environmental consequences and costs for countries and reforming them leads to GHG emissions reduction. Iran did not implement its fossil fuels subsidies reform policy as it was aimed, and energy carriers' end-user prices did not meet targets. Partial implementation of this policy did not lead to a decrease in energy consumption and GHG emissions reduction. For having a successful fossil fuels subsidies reform policy, complementary policies need to be implemented both in domestic and global level in parallel. National decision-makers need to consider their domestic social, environmental, political and economic context and implement the most appropriate package of policies. Global decision makers need to come together and design an umbrella policy for national reform policies to mitigate their reverse effects.

Keywords: Fossil fuels, Fossil fuels subsidies, Fossil fuels subsidies reform, GHG emissions, Energy consumption

Executive Summary

Background problem definition

Subsidies are financial intervention policies which are implemented by governments to promote a social policy or an economic sector. Fossil fuels subsidies are one of the governments' intervention policies to maintain the price of fossil fuels and electricity generated from these sources below the market prices. Fossil fuels subsidies are common intervention policies in many countries particularly in fossil fuels exporting countries to keep energy prices below the market rates. Iran provides the largest fossil fuels consumption subsidies in the world. (International Energy Agency, 2017)

In late 2010, Iran implemented a subsidies reform policy -Targeted Subsidies Act- in various sectors including fossil fuels subsidies to increase end-user prices of natural gas not less than 75% of Free on Board price for energy use and not less than 65% of Free on Board price for feeds of petrochemical plants, end-user prices of oil products including gasoline, kerosene, diesel fuel, fuel oil and liquid gas not less than 90% of their Free On Board prices, , and end-user price of electricity equal to its production cost by March 20, 2015 (End of Fifth Development Program). (Targeted Subsidies Act, 2011)

Several studies were conducted to evaluate the effects and potentials of fossil fuels subsidies reform policies in the global and single country levels on GHG emission reduction. A few studies also have been done to evaluate impacts and potentials of fossil fuels subsidies reform policy in Iran. But None of them fully investigated the impacts of reform policy in Iran on GHG emissions reduction. They either studied non-environmental impacts of this policy or only covered parts of its environmental impacts. Some of them only briefly have mentioned environmental impacts and others focused on potentials according to scenario modelling. Thus, there is a need to study the impacts of this policy in Iran on GHG emissions reduction.

Research Objectives and methodology

This thesis was aimed to investigate the effects and potentials of Targeted Subsidies Act on GHG emissions reduction. To achieve this aim, the following objectives were considered:

- To provide an overview of the worldwide fossil fuels subsidies reform policies and their impact on energy systems and GHG emissions and particularly on the ability to reach the 2-degree goal; this stage will also identify gaps of our understanding and knowledge in this area;
- To develop a detailed inventory of consumptions, subsidies and subsidy reforms for various fuels and carriers planned and already implemented in Iran's Targeted Subsidies Act;
- To evaluate and quantify the impacts of these reforms on GHG emissions;
- To recommend the strengthening of fossil fuels subsidies reform policy in Iran and the implication of such stronger policies on GHG emissions evaluated.

Four theoretical frameworks were employed to examine Targeted Subsidies Act' results against its targets. The first theoretical framework evaluates specifically Targeted Subsidies Act' results against its targets. The next three ones are focused on an increase in energy carriers' end-user prices by reform policy, and the effects of this increase on the potential reduction of energy consumption and GHG emissions. After selecting related studies, they were sorted and analyzed by employing a synthesis matrix. Collected data were analyzed by employing qualitative analysis

in parallel with statistical analysis. Time-series analyses were also used to evaluate energy consumption, CO_2 emissions, and emissions reduction as well as fossil fuels subsidies allocation and the price elasticity of demand.

Findings

After reviewing related literature, developing an inventory of data and applying above-mentioned methods and frameworks, this thesis concluded that:

- Reviewing all studies both in the global and single country levels demonstrate environmental consequences and costs of fossil fuels subsidies and emphasize on implementing fossil fuels subsidies reform policies. The overall outcome of reviewing these studies shows that implementing fossil fuels subsidies reform policies leads to GHG emissions reduction.
- Developing an inventory of data indicates that the Targeted Subsidies Act has not implemented as it was aimed. Except in the case of liquid gas where its end-user price met the targets of Targeted Subsidies Act in 2016.
- Applying economic frameworks displays that by assuming all other factors constant, with an increase in end-user prices of energy carriers, their consumption has not decreased except for electricity in 2015 and 2016.
- Partial implementation of this policy did not lead to a decrease in energy consumption and GHG emissions reduction.

Finally, this thesis recommended that for having a successful fossil fuels subsidies reform, it does not enough to remove subsidies and increase end-user prices. Governments need to implement many other parallel and complementary policies together to guarantee the success of fossil fuels subsidies reform. National decision-makers need to consider their domestic social, environmental, political and economic context and implement the most appropriate package of policies. Fossil fuels subsidies reform needs to be implemented when rule of law, freedom from corruption, effectiveness and regulatory quality are guaranteed. Energy market needs to be liberalised and end-user prices are determined by the law of supply and demand. And finally, every successful fossil fuels subsidies reform policy needs to adopt these steps in process of implementation: adopting best practices in subsidy measurement, eliminating inappropriate subsidies, conducting subsidy impact studies, implementing adjustment packages, learning from successful case studies and recognizing political economy.

Table of Contents

List of Figures

List of Tables

Abbreviations

CGEM-Computable General Equilibrium Model

CPED-Cross-Price Elasticity of Demand

EIA-US Energy Information Administration

FFSs-Fossil Fuels Subsidies

FFSR-Fossil Fuels Subsidies Reform

FOB-Free on Board

GDP-Gross Domestic Product

GHG-Greenhouse Gas

IEA-International Energy Agency

IMF-International Monetary Fund

INDCs-Intended Nationally Determined Contributions

MENA-Middle East and North Africa

MOE-Iran's Ministry of Energy

NIGC-National Iranian Gas Company

OECD- Organization for Economic Co-operation and Development

PED-Price Elasticity of Demand

RE-Rebound Effect

RP-Reference Price

RPC-Residential, Public and Commercial

SCI-Statistical Centre of Iran

TSA-Targeted Subsidies Act

VAT-Value Added Tax

1 Introduction

1.1 Background

In Paris Climate Change Conference in 2015, countries agreed to keep the rise in global temperature below 2 degrees Celsius above pre-industrial level and even make more efforts to maintain it further 1.5 degrees Celsius till 2100. On the other had countries have Intended Nationally Determined Contributions (INDCs) to achieve these targets (United Nation Framework Convention on Climate Change, 2015). Energy production and consumption accounts for two-thirds of global greenhouse gas (GHG) emissions (IEA, 2015). Governments' financial intervention in the production and consumption of energy through various policies affects the level of production and consumption of energy carriers. Fossil fuels subsidies (FFSs) are one of the governments' intervention policies to maintain the price of fossil fuels and electricity generated from these sources below the market prices. According to International Energy Agency (IEA) (2017), fossil fuel consumers' subsidies was more than USD 300 billion globally in 2017 with the aim to make fossil fuels cheaper for consumers and increase energy use. In 2009, Group 20 leaders committed to reform their FFSs policies and phase-out inefficient subsidies which could lead to wasteful use subsidized energies (Group 20, 2011).

FFSs are common intervention policies in many countries particularly in fossil fuels exporting countries to keep energy prices below the market rates. FFSs in Iran, Saudi Arabia, and Russia together and in China accounts for more than 40 % and 15 % of global FFSs respectively (IEA, 2017). Additionally, energy-related CO_2 emissions from markets with fossil-fuel consumption subsidies count for 13% of total CO_2 emissions (IEA. 2015). Iran has the largest fossil fuels consumption subsidies in the world with an average rate of 15%, 11% and 15% of total global FFSs for 2015, 2016 and 2017 respectively (IEA. 2017). It also counts for 10% of Iran's GDP in 2017. The CO_2 emission from fossil fuels has raised more than two times from 0.89% in 1990 to 1.80% in 2016 (World Bank. 2017).

1.1.1 Targeted Subsidies Act

In 2010, Iran implemented a subsidies reform policy -Targeted Subsidies Act (TSA)- in various sectors including FFSs to increase end-user price of natural gas not less than 75% of Free On Board (FOB) for energy use and not less than 65% of FOB for feeds of petrochemical plants, end-user prices of oil products including gasoline, kerosene, diesel fuel, fuel oil and liquid gas not less than 90% of their FOB prices, , and end-user price of electricity equal to its production cost by March 20, 2015 (End of Fifth Development Program). According to this policy, Iran aimed to spend up to 50% of its savings from TSA for introducing a comprehensive social security system for all Iranians including health insurance, employment, and housing and direct cash payments to households and up to 30% of savings for improving energy efficiency in energy production and consumption sectors, improving and expanding public transportation, producing energy from renewable resources and other infrastructure (Targeted Subsidies Act, 2011). Iran is also committed to mitigate 4% of its GHG emissions by 2030 according to its INDC (United Nations Framework Convention on Climate Change, 2015).

1.1.2 TSA political status

Except in the case of gasoline, Iran is a net energy exporting country. Iran doesn't pay direct subsidies to the domestically produced gasoline and other energy carriers because energy sources are state-owned and except in case of electricity, other energy carriers are operated by the government. However, three main reasons led Iran to reform its overall subsidies in its economy and specifically fossil fuels subsidies reform (FFSR); environmental impacts of subsidies, issue of justice and former administration (2005-2013) attitude to the policymaking. As studies show, subsidies have a negative impact on the environment and specifically leads to a rise in GHG emissions. Other studies, also demonstrate that the rich benefits more than the poor from subsidies while they were designed for the poor in the first place. There was awareness about these two issues and even previous administrations had aimed to reform subsidies, but they even didn't include it in their political-economical agendas.

But former administration and especially the former President of Iran, with his justice worldview from one side and his attitude in policy making where he was trying to implement any policy without considering its political impacts. He decided to introduce an act to the parliament and implement subsidies reform as Targeted Subsidies Act. In his first term (2005-2009), he had the full support of the Supreme Leader, parliament and other branches and departments of government to introduce and implement this act. TSA was passed in the legislative branch in 2009 and 2010 and implemented in late 2010.

1.2 Research Problem

It leads us to study the impacts of FFSs on GHG emissions and global temperature rise. Several studies have been conducted on the role of FFSs on GHG emissions, and some studies have focused on FFSR policies and their potential impacts on reducing GHG emissions. In the most recent study, Jewell and others (2018) pointed out the 1-4% potential GHG emissions reduction where there is a big difference between the effects of FFSR in oil exporting regions including MENA region, Latin America and Russia which there are potentials for emission reduction equal to or greater than their INDCs while in other regions, the potential emission reductions can be less than their INDCs. While FFFSR (2015) studies suggest 8% potential GHG emissions reduction by 2050. Merrill and others (2015) suggest 11 % potential GHG emissions reduction. Presley and others (2016) studied potential emissions for Ghana, where they conclude that there can be 1.9% GHG emissions reduction. On the other hand, Schwanitz and others (2014) suggest that if FFSR does not implement with complementary policies, it would slow down the rate of transition to the non-fossil fuel energy system.

Several studies also have been done to evaluate impacts and potentials of FFSR in Iran. Barkhordari and Fattahi (2017) explored the relationship between energy prices, energy intensity and technology development. Gharibnavaz and Waschik (2015) focused on gained welfare of households as a result of this policy. Barkhordar and others (2018) investigated the effects of this act on energy efficiency in six energy-intensive industries. Sohaili (2010) analyzed potentials of removing electricity subsidies on air pollution. Hassanzadeh (2012) concluded that according to official reports there has been a decline in energy consumption, but she only has considered short-term impacts of this policy. Mousavi and others (2017) studied driving forces of CO_2 emissions in Iran and as part of their study, they briefly reviewed TSA policy and concluded that this policy has helped to reduce emission in the transportation sector by switching from gasoline to natural gas. Farajzadeh and Bakhshoodeh (2015) examined the economic and environmental impacts of the policy with scenario modelling and concluded that there can be a great reduction in emission.

None of them fully investigated the impacts TSA on GHG emissions reduction or the potential effects of stronger FFSR. They either studied non-environmental impacts of this policy or only covered parts of its environmental impacts. Some of them only briefly have mentioned environmental impacts and others focused on potentials according to scenario modelling. Thus, there is a need to study the impacts of TSA policy in Iran on GHG emissions reduction.

1.3 Research purpose

In this thesis, I am going to identify the impacts of TSA on GHG emissions in Iran

1.3.1 Research objectives

To achieve this aim, I have the following objectives:

- To provide an overview of the worldwide FFSR and its impact on energy systems and GHG emissions and particularly on the ability to reach the 2-degree goal; this stage will also identify gaps of our understanding and knowledge in this area;
- To develop a detailed inventory of consumptions, subsidies and subsidy reforms for various fuels and carriers planned and already implemented in Iran's TSA.
- To evaluate and quantify the impacts of these reforms on GHG emissions
- To recommend the strengthening of FFSR in Iran and the implication of such stronger policies on GHG emissions evaluated.

1.4 Theoretical framework and Methodology

1.4.1 Theoretical framework

Consumer subsidies are intervention policies to lower down the price of goods and services for consumers. FFSR policies aim to decrease energy consumptions and reduce GHG emissions by making energy prices close to market prices. I employed four different theoretical frameworks for my research. The first theoretical framework evaluates specifically Targeted Subsidies Act' results against its targets. The next three ones are focused on an increase in energy carriers' prices by FFSR, and effects of this increase on the potential reduction of energy consumption and GHG emissions.

Mickwitz' policy framework is useful in analysing the results of TSA including changes in energy carriers' prices and GHG emissions reduction against its intended targets. The Price Elasticity of Demand (PED) is to measure the consumer's behaviour in relation to change in energy carriers' prices and its effects on energy demand. The Cross-Price Elasticity of Demand (CPED) is to measure the consumers' responsiveness of one energy carrier to change in a price of other energy carriers. The rebound effect (RE) is to measure the lost benefits of FFSR in comparison to the expected benefits where the direct cash payments from FFSR can potentially spend on other goods and service which can lead to the gross domestic product (GDP) growth and an increase in GHG emissions.

1.5 Methodology

This present study is a case-based study and after reviewing existing studies, the specific case is examined. Data is collected to examine results with intended targets and policy objectives. Data is extracted from national and international reports and/or statics centres including Statistical Centre of Iran (SCI), Iran's Ministry of Energy (MOE), National Iranian Gas Company (NIGC), International Energy Agency, World Bank and US Energy Information Administration (EIA). Collected data are sorted for further analysis. Data are including an inventory of different energy carriers' consumptions, CO_2 emissions data for every energy carrier before and after TSA, GDP growth rate, CO_2 intensity from 1990 to 2016 and end-user prices, reference prices, direct cash payments to households from TSA and subsidies from 1990 to 2018. For total subsidies, consumption data for 2017 and 2018 (which was not available) was considered equal to the consumptions in 2016 and then subsidies are calculated.

Data are analyzed by applying theoretical frameworks to achieve research objectives. Data analysis is done by employing qualitative analysis in parallel to the statistical analysis. Time-series analyses are also employed to evaluate energy consumption, CO_2 emissions, and emissions reduction as well as FFSs allocation and the price elasticity of demand.

1.6 Scope and Limitations

1.6.1 Scope

This study focuses on reviewing published research, studies and reports from ScienceDirect, Google Scholar, and a few international organizations from 2010 to 2018. Only studies in the English language are covered. Most of the FFSs reform policies consider social, economic and environmental aspects and impacts of reform policy, I only review their environmental aspects and impacts. For the case study, the time frame of 1990 to 2018 is covered and data are collected from both national and international statistic centres/organizations/websites.

1.6.2 Limitations

Potential barriers include the select studies for review. ScienceDirect, Google Scholar, and organizations' websites have numerous studies, selecting the best ones were problematic but by defining the above-mentioned criteria and brainstorming with the supervisor, I solved this problem. Moreover, there were difficulties in finding relevant and sufficient data about energy consumption, subsidies for different energy carriers, reduction or increase in GHG emissions especially when different sources had different data for the same variable.

1.7 Audience

From a broad perspective, anyone who is affected by GHG emissions or uses subsidized energy from fossil fuels, this study can be useful. But the main audiences of this study are two groups; researchers can have a very deep understanding of all existing studies about FFSR and might find the case study as a foundation for their future research on national FFSRs and, policymakers can use results of this study to implement FFSR at the national level and in a set of conditions which will be discussed. In the international level, also it can be used for setting climate change umbrella policies accordingly.

1.8 Disposition

The introduction will be continued by reviewing the existing studies on FFSR in both global and national level and a few studies on FFSR in Iran. The definition of subsidies, subsidies estimation approaches, the reasons for implementing reform policies and different approaches to studying FFSR will be reviewed. The third chapter will be in describing the theoretical framework which has four pillars including the framework for evaluating environmental policies; a policy for evaluating environmental policy instruments and three economic frameworks; the price elasticity of demand, the cross-price elasticity of demand and the rebound effect. In the fourth chapter, data collection and analysis method will be introduced. An inventory of different energy carriers' consumptions, their subsidies, implemented reforms, GHG emissions data for every energy carrier before and after FFSR, and GDP growth from 1990 to 2018 and direct cash payments and TSA targets from 2010 to 2018 will be collected from national and international reports and/or statics centres and presented. Data will be analysed by applying theoretical frameworks to achieve research objectives. Data analysis will be done by employing qualitative analysis in parallel with statistical analysis and time series.

In the next chapter, the results will be discussed from policy and economic perspectives. Role of Iran's power structure on implementing TSA will be elaborated. Then, the TSA will be analyzed as an environmental policy. Price elasticity of energy consumption, rebound effect of direct cash payments to households, and impacts of crude oil price and local currency fluctuations will be discussed. In the final chapter, I will conclude that TSA was not fully implemented and partial implementation of it did not result in energy consumption and GHG emissions reduction.

2 Literature review

Subsidies in general and FFSs specifically will be introduced, then different approaches to estimating the amount of FFSs will be provided. Following, different approaches to evaluating potentials or impacts of implemented reform policies will be discussed. Studies at a global level will be covered, then a few individual cases will be discussed. And finally, studies on FFSR in Iran will be reviewed.

2.1 Subsidies

Subsidies are financial incentives or support provided by governments to promote a social policy or an economic sector. Subsidies are intervention policies which are implemented by the governments to achieve specific policy targets. According to the World Trade Organization' subsidies are 'a financial contribution by a government, or agent of a government, that confers a benefit on its recipients" (Kojima and Koplow, 2015). Some of them are aimed at assisting the poor to afford energy, public transport, etc. Others are intended to help the specific economic sectors to enable them to survive or have a share in the market such as subsidizing renewable energies to promote them in an energy mix of countries. Subsidies can be in different forms including direct (interest-free loans, cash grants) and indirect (loans with a lower interest rate, tax breaks, rent rebates, insurances). Subsidies can be provided in the form of productions subsidies to lower their costs of production or in the form the consumer subsidies to shape consumers' behaviour or help them to afford specific product or service. Production subsidies are very common in developed countries while consumer subsidies are in place in developing countries. (Mynes & Kent, 2001)

FFSs also are provided to producers and consumers with the aim to ensure energy security, alleviate energy poverty, support domestic energy production and create new jobs (Schwanitz et al. 2014). Like other subsidies, FFSs also are in two main different categories; producer subsidies and consumer subsidies. Producer subsidies are provided when prices of fossil fuels or generated energy from fossil fuels received by suppliers are above a reference price (RP) or when producers are in losses if they sell their final product at the RP. Consumer subsidies are provided when the prices of fossil fuels or generated energy from fossil fuels paid by consumers are below RP (IMF, 2019).

2.2 How large are FFSs?

Amount of FFSs or in general any kind of subsidies depends on how we approach to estimate them. Sovacool (2017) has collected different types of energy subsidies from different sources in his research. According to him, subsidies can be in form of direct financial transfer including grants to producers, grants to consumers, preferential or low-interest loans, exemptions or rebates on royalties, producer levies, sales taxes and tariffs, production tax credits, investment tax credits, government sponsored loan guarantees and accelerated depreciation; in form of trade restrictions including import tariffs and duties and technical restrictions, quotas and trade embargoes; in form of energy-related services provided by government at less than RP including publicly sponsored R&D, free transport, direct investment in energy infrastructure, free storage of waste or fuel and liability insurance; and in form of regulation of the energy sector including rate caps and price controls, mandated deployment rates and demand guarantees and market-access standards and restrictions.

Sovacool (2017) identified four different approaches for estimating the amount of subsidies: program-specific estimation approach which estimates subsidies for a specific government subsidy program of policy; price-gap approach which estimates negative or positive "gaps" between the domestic price of energy and RP of energy; inventory approach which estimates not only financial transfer, it also estimates market support to particular industries; and externalities approach which in addition to inventory approach, estimates full social, environmental and economic impacts of subsidies. Coady and others (2017) discussed two different approaches for estimating the amount of subsidies with focus on subsidies in the transport sector. According to them, pre-tax subsidies which are same as price-gap approach and post-tax subsidies which is similar to externalities and takes into consideration global warming impacts, air pollution damages, broader vehicle externalities including accidents, congestion and road damage.

Price-gap approach estimates the gap between reference prices and the end-user price of energy. This approach does not cover all subsidies including hidden subsidies such as excess costs from high system losses, over-staffing, or tariff under-collection or market support industries. Thus, reliance on only the price-gap approach will understate the magnitude of FFSs. But the price-gap approach does not have the complexity of other approaches and it is easy to calculate the gap between free market prices and end-user price of energy. Estimating hidden subsidies or market support and converting them to the numbers has its own difficulties. Estimating these subsidies needs time and accurate data which are not available all the time. Most of the covered studies are based on this approach. IEA uses this approach to estimate the amount of FFSs in national and global levels. According to IEA (2017), the price-gap approach estimates subsidies to fossil fuels that are consumed as an input of feed to electricity generation or are consumed directly by end-user. This approach is very common in estimating consumer subsidies.

According to IEA (2017) price-gap approach, consumer subsidies are around hundreds of billion USD and vary from one year to another one with an increase or decrease in international energy prices. The value of global FFSs for 2017 was around USD 300 billion (IEA, 2017). The International Monetary Fund (IMF) (2019) has similar estimation according price-gap approach but with externalities approach, it estimates global FFSs around USD 5 trillion for 2015 which counts for 6.5% of global Gross Domestic Product.

2.3 Why do we need to reform FFSs?

While subsidies intended to protect consumers by keeping energy prices low and promoting specific economic sectors by decreasing the production costs, but they have cost both for the government and society. Subsidies not only could reach their intended targets, but they are also a burden for governments and therefore for the taxpayers. Governments have to increase taxes or allocate a bigger share of national incomes (especially in oil and gas exporting countries where oil and gas are nationalized) to finance subsidy plans and reduce budget deficits. Subsidies not only consume a big share of the budget but also redirect budgets from other public sectors including infrastructure, health, and education. While subsidies are intended to protect the poor from higher prices, all consumers; both poor and rich benefits from subsidies by paying lower prices for the energy. Subsidies are intended to reach a specific set of policy targets, but they prevent investment in energy efficiency and renewable energies. They also foster energy consumption. (International Monetary Fund, 2019)

FFSs distort markets and discourage the production and consumption of clean energies. FFSs do not only cause economic inefficiencies, but they also cause energy inefficiencies and are a barrier to a transition towards a sustainable provision of energy (Schwanitz et al. 2014). FFSs lead to over-consumption of environmentally harmful energies which cause GHG emissions (Wesseh & Lin, 2016). Whitley and Burg (2018) have listed the consequences of FFSs. In addition to the above-mentioned costs and consequences, they discussed that subsidies can worsen inequalities especially in countries where most people lack access to the grid or commercial energy and as a result, these people are not benefited from subsidies. Subsidies can prevent households from investing in energy efficient appliances and equipment. In some countries, the level of FFSs may be equivalent or even more than government investment in other public sectors including health, education, and infrastructures. It not only shrinks government budgets and wastes them, but it also causes health problems due to air pollution and road transport by fossil fuels consumption and environmental problems.

2.4 Different approaches to study fossil fuels subsidies reform

Different researchers and institutions have conducted numerous studies with different approaches. Covered studies can be categorized in two different ways; Firstly, according to their approach where they evaluated implemented reform policies and their impacts on GHG emissions reduction or potentials of future reform policies with future scenario/modelling and secondly, according to their coverage and scope where some of them tried to evaluate the potentials of reform policies on the global level or at least in some of the countries together or for each specific country. Here, I will focus only on their second approach and review them according to their coverage and scope.

2.5 Studies on the effects of global FFSR on GHG emissions

In this category, most of the studies are based on estimating the potential impacts of reform policies with future scenario/modelling tools. For this aim, each of studies defines a set of assumptions and develop its scenario/modelling accordingly. Burniaux and Chateau (2014) discussed that different assumptions can lead us to different results. They argued that country coverage, reference years, methodological approaches, the context of implementation and values of fossil fuels supply elasticities can give us different outcomes. They also argue that the selection of FFSs estimation approach can also affect the results. Some of these studies have covered global level while others covered a specific set of countries.

There is a strong trend in the results of these scenarios/models show that FFSR can lead to GHG emission reduction. But some of the studies are reluctant regarding the potentials for GHG emission reduction or see it is dependent on the other conditions or implementing other parallel policies. Burniaux and Chateau (2014) covered 37 non-Organisation for Economic Co-operation and Development (OECD) countries with the use of OECD General Equilibrium ENV-Linkages model. They used the price-gap approach for estimating the subsidies. Their modelling results show that if all 37 covered countries remove all their subsidies from 2013 to 2020, GHG emissions will be reduced by 8% by 2050. This reduction will be 25% in Russia, 45% in the oil exporting countries and it will remain unchanged in OECD countries. The reason for this in OECD countries is that with the reform of FFSs in non-OECD countries, the prices of energy will increase, and consumption of energy will decline in these countries. International fossil fuel prices will decline. The decline in international fossil-fuel prices will increase fossil fuel consumption in countries without FFSs or in countries that do not reform their subsidies. This reverse impact is called "carbon leakage" which causes an increase of 12% in CO_2 emissions in OECD countries by 2050 in comparison to the baseline.

Merrill and others (2015) have covered 20 countries in their modelling with the use of GSI-Integrated Fiscal Model. They also covered three individual countries in their study which will be discussed in the next section. Their modelling shows an 11 % reduction in national average GHG emissions by 2020 in 20 covered countries and 18% reduction with investing 30% of savings from subsidies reform toward energy efficiency and renewable energies. GHG emissions can be affected by both the change to the fuel mix and the fall in demand. They suggest cash transferring of 50% of savings toward poorest of the population, investing of 10% renewables, 20% energy efficiency, and allocating 20% toward budget deficit and debt. They also used the price-gap approach for estimating subsidies thus they argued that the effects of reform policies are underestimated. They also emphasized on effects and importance of crude oil price in short-term modelling, but they put emphasizes on quality and quantity of subsidies from different fuel types than crude oil prices in the long-term modellings. They also suggest that countries can put a reform policy in their INDCs.

Merrill and others (2017) in their other study suggested that CO_2 emission reduction can be between 6.4% to 8% by 2050 according to different scenarios. Their general idea is that FFSs removal is not enough, the savings should be directed to energy efficiency, renewable energies, and sustainable development (helping poor, investing on education and health) which can help us to both reduce emissions and achieve sustainable development goals. There is a need for a global shift or SWAP. They argued that in lower oil price, reform is easier since the increase in energy price will not be so high and it is easier for consumers to adapt to it. Political pressures may force policymakers to reintroduce subsidies. Well-structured reform policies with a transparent pricing mechanism and appropriate carbon taxation policies will prevent the return of subsidies in the presence of high oil prices.

Schwanitz and others (2014) assessed potentials of subsidy reform for the low-carbon transformation of the energy system and the mitigation of climate change with using of the global energy–economy model REMIND. They tried different scenarios with different assumptions. All of their scenarios show GHG emissions reduction from 0.6% to 15.6%. They emphasized on short-term effects of reform policies in GHG emissions reduction by 2050 but they argued that the GHG emissions will go back to the reference level if required climate policies are non-existent or weak. They even claimed that if reform policies do not complement by other climate policies, they can have a reverse effect on the global transition towards a sustainable energy system. They also have discussed carbon leakage effect, but they did not consider it as a counter-argument for reform policies.

Jewell and others (2018) investigated the effects of FFSR scenarios. They compared these effects for different regions including oil and gas exporters and importers. They identify a big difference between the effects of FFSR; in oil exporting countries including the Middle East and North Africa (MENA) region, Latin America and Russia, where GHG emissions reduction will be equal to or greater than their INDCs and in other regions, where GHG emissions reductions from FFSR will be less than their INDCs.

Coady and others (2017) used externalities approach to estimated subsidies at USD 5.3 trillion in 2015 (6.5% of global GDP). They argue that reform of FFSs would have reduced global CO_2 emissions in 2013 by 21%. Mundaca (2017) has studied FFSR potentials in different World Bank regions. She argued that FFSs reduction by USD 20 cents per litre for both gasoline and diesel can help on CO_2 emissions reduction in all the regions with a significant reduction in the MENA region. Stefanski (2016) has used a unique method to collect FFSs from patterns in countries' carbon emission-to-GDP ratios. According to him, the world without subsidies would have had 36% lower CO_2 emissions than they actually were in 2010.

Gerasimchuk and others (2017) have done the only study on production FFSR. According to their modelling, CO_2 emission reduction can be 37 Gt from 2017 to 2050 or 1.1 Gt CO_2 per year. It can vary according to the different assumption of oil price and can increase up to 175 Gt for the same period of time. Their focus is on the sensitivity of oil prices and their effects on the amount of reduction. They conclude that at the lower market prices for fossil fuels, climate benefits of producer FFSR can be greater.

Table 2-1 Summary of studies on the effects of global FFSR on GHG emissions

Study	Scope	Findings
Burniaux and Chateau (2014)	37 non-OECD countries consumption subsidies removal (price-gap approach) for all fossil fuels by 2050	Global effect: 8% reduction in GHG emissions Regional effects: 25% reduction in Russia, 45% in oil exporting countries and unchanged in OECD countries
Merrill et al. (2015)	20 countries consumption subsidies removal (price-gap approach) for all fossil fuels by 2020	11% GHG emissions reduction by 2020 in 20 covered countries and more reduction up to 18 % with investing 30 % of savings toward energy efficiency and renewable energies
Merrill et al. (2017)	Global consumption subsidies removal (price-gap approach) for all fossil fuels by 2050	Global effect: a reduction of 6.4% to 8.2% in GHG emissions according to the different scenarios
Schwanitz et al. (2014)	Global consumption subsidies removal (price-gap approach) for all fossil fuels by 2050 and 2100	Global effect: a reduction of 0.6% to 15% in GHG emissions according to the different scenarios and time frames, with higher reduction by 2050 and returning to the baseline level by 2100
Jewell et al. (2018)	Global consumption subsidies removal (price-gap approach) for all fossil fuels under low- and high-oil prices by 2030 divided by global region	Global effect: a reduction of 1% to 4% in GHG emissions Regional effects: in oil exporting countries (MENA region, Latin America and Russia), GHG emissions reduction will be equal to or greater than their INDCs and in other

		regions, GHG emissions reduction from will be less than their INDCs
Coady et al. (2017)	Global consumption subsidies removal (externalities approach) for all fossil fuels by 2013	Global effects: 21% reduction in CO_2 emissions
Mundaca (2017)	An increase of 20 US$ cents per litre in diesel fuel and gasoline prices in regions (World Bank regions) over 16 years by a focus on price elasticity	Regional effects: CO_2 emissions reduction in all regions with a significant reduction in the MENA region
Stefanski (2016)	Global consumption subsidies removal (price-gap approach) for all fossil fuels by 2010	Global effects: 36% reduction in CO_2 emissions
Gerasimchuk et al. (2017)	Global production subsidies removal for all fossil fuels excluding subsidies for generating electricity under different assumptions of crude oil prices by 2050	Global effects: CO_2 emission reduction can be 37 Gt from 2017 to 2050 or 1.1 Gt per year and can be increased up to 175 Gt.

2.6 Single country reform policies and their effects

At the national level, two types of studies have done. The first type of studies is based on the evaluation of implemented FFSR policies. The second type of studies are scenario based and predict the potentials of reform policies. Some of the second types of studies are done for only one single country and some of them are done through global level scenarios/modelling but with individual results. Price-gap approach is also a widely used approach for single country reform studies as it was for global level studies.

Despite the fact that according to the price-gap estimate, China does not provide the largest consumer FFSs, most of the single country reform studies have been done for this country. Li and Sun (2018) argued that during the periods with positive FFSs, FFSR alone cannot lead to CO_2 emission reduction because it would cause the switch from low-emitted fuels to high-emitted coal. They also suggested that complementary policies will be needed to move toward a low carbon economy. Jiang and Lin (2014) claimed that FFSR will lead to a significant decline in energy demand, consumption and CO_2 emissions, but it can have reverse impacts on the macro-economy. They also suggested complementary policies to prevent negative impacts of reform policy. Lin and Ouyangc (2014) has evaluated potentials for reform from 2006 to 2010 and concluded that if the subsidies had been removed, potential CO_2 emissions reduction could be 2.59% to 4.96%. Lin and Li (2012) have simulated the potential impacts of subsidy reform in China and argued that subsidies reform in China would affect disproportionally the welfare, output, competitiveness and emissions of different world regions. It also can cause negative economic and externalities to China, and positive economic and environmental externalities to other world regions where subsidies are in place yet but are preventive to global emissions reduction. Liu and Hong (2011) also argued up to 4% CO_2 emissions reduction according to their scenario.

Wesseh and Lin (2016) have used a multi-region Computable General Equilibrium Model (CGEM) for their empirical studies for Ghana and concluded that with FFSR, there will be welfare losses. They also argued that even with 1.9% overall improvement in environmental quality, the rate of CO_2 will increase. Yusoff and Bekhet (2016) have studied subsidies reform in Malaysia. They also employed CGEM and developed three different scenarios; FFSR, fossil fuels tax subsidies reform and reform of both FFSs and fossil fuels tax subsidies. Their results showed that the third scenario has a stronger effect of reducing energy demand and potentials for energy savings. Gelan (2018) investigated Kuwait subsidies reform potentials and concluded that with different scenarios, CO_2 emissions will decline but it will be less than 1%.

Acar and Yeldan (2016) have studied subsidies reform for Turkey. They used CGEM for 2015-2030. Their results indicated that by the reform of the coal subsidies, GHG emissions can be reduced by 5% without a significant shrink in GDP. Wang and others (2016) have done a CGEM for United Arab Emirates (UAE) utility subsidies and their results showed that subsidies reduction alone will increases GDP of the UAE and with decreasing carbon-intensive utility and industrial productions CO2 emissions will reduce. According to Mundaca (2017), if FFSs reduced in MENA region by USD 20 cents per litre for both gasoline and diesel, for Saudi Arabia the GHG emissions could be reduced 30% and 60% from diesel fuel and gasoline consumption, respectively.

Merrill and others (2015) have studied a few individual cases with GSI-Integrated Fiscal Model in addition to a global level study. The Philippines successfully removed all consumer subsidies in the late 1990s. It combined this reform policy with other complementary policies including targeted direct cash payments, regulated subsidies for specific sectors, poor, and for certain kinds of fuels, renewable energy act, rural electrification program, feed-in tariff, renovation of hydropower facilities, investment in domestically produced clean electricity and a universal charge on grid electricity. In result despite an increase in electricity consumption; energy efficiency improved, energy intensity decreased by 2%, energy use per capita decreased, and CO_2 emission declined 10.4% per unit of GDP. In Morocco and Jordan, FFSs count %6.6 in 2012 and 5.8% in 2005 of GDP respectively. They have implemented subsidies reform policies with complementary policies including cash transfer, health insurance and excluding fuels which benefit poor from reform policies.

Merrill and others (2017) also have studied a few individual countries. In Bangladesh, subsidies are around 3.2% of GDP and 32% of government revenue expenditure. Despite a large amount of subsidies, 26% of the population do not have access to electricity. If subsidies reform policy implemented, there will be 8.67% GHG emissions reduction and it can reach to 13.56% with redirecting of savings for reform to energy efficiency and renewables. In Indonesia, subsidies before reform were around USD 7.5 billion for electricity, USD 15.6 billion for transport, USD 644 million producer subsidies, and USD 3.91 billion for LPG. If all subsidies removed, there will be 6.97% GHG emissions reduction and with investing 30% of savings to renewables and energy efficiency, emissions reduction will be 12.14% by 2020 and 19.28% by 2025 (reform policy is ongoing in Indonesia). In Morocco, subsidies counted for 12.6% of government expenditure (2005-2012). Subsidies reform has started and from 2008 to 2016 it has been decreased from USD 2.985 billion to USD 1.132 billion. Subsidies are mostly focused on oil products, electricity, and butane. If the reform policy is completed, GHG emissions reduction from 2012 to 2030 will be 7.5%. If SWAP happens from fossil fuels to solar energy, the reduction will be even higher.

Table 2-2 Summary of single country reform policies and their effects

Study	Scope	Findings
Li and Sun (2018)	China, consumption subsidies, all fossil fuels	FFSR alone cannot lead to CO_2 emission reduction because it would cause the switch from low-emitted fuels to high-emitted coal
Jiang and Lin (2014)	China, consumption subsidies, all fossil fuels	a significant decline in energy demand, consumption and CO_2 emissions with reverse impacts on macroeconomy variables
Lin and Ouyangc (2014)	China, consumption subsidies, all fossil fuels from 2006 to 2010	CO_2 emission reduction could be 2.59% to 4.96%.
Lin and Li (2012)	China, consumption subsidies, all fossil fuels	Disproportional effects on the welfare, output, competitiveness, and emissions of different world regions. Negative economic and externalities to China, and positive economic and environmental externalities to other world regions where subsidies are in place yet but are preventive to global emission reduction
Liu and Hong (2011)	China, consumption subsidies, all fossil fuels	4% CO_2 emissions reduction
Wesseh and Lin (2016)	Ghana, consumption subsidies, all fossil fuels	1.9% overall improvement in environmental quality, with an increase in the rate of CO_2 emissions
Yusoff and Bekhet (2016)	Malaysia, consumption subsidies, all fossil fuels	FFSR will lead to energy demand reduction but combining it with removing fossil fuels tax subsidies will have a stronger effect on energy demand
Gelan (2018)	Kuwait, consumption subsidies, 30% reduction in electricity sector subsidies	CO_2 emissions will decline but it will be less than 1%
Acar and Yeldan (2016)	Turkey, consumption subsidies, coal subsidies over 2015-2030	GHG emissions can be reduced by 5% without a significant shrink in GDP
Wang and others (2016)	UAE, consumption subsidies, electricity subsidy	A decrease in carbon-intensive utility and industrial productions will reduce CO_2 emissions

Mundaca (2017)	Saudi Arabia, consumption subsidies, an increase of 20 USD cents per litre in diesel fuel and gasoline prices over 16 years by a focus on price elasticity	30% and 60% GHG emissions reduction from diesel and gasoline consumption, respectively
Merrill et al. (2015)	Philippines, consumption subsidies removal of all fossil fuels in the late 1990s	CO_2 emission declined 10.4% per unit of GDP
Merrill et al. (2015)	Jordan, consumption subsidies, removal of all fossil fuels subsidies excluding fuels which benefits poor	Ongoing reform
Merrill et al. (2015)	Morocco, consumption subsidies, removal for all fossil fuels excluding fuels which benefits poor	Ongoing reform
Merrill et al. (2017)	Bangladesh, consumption subsidies, all fossil fuels	8.67% GHG emissions reduction and it can reach 13.56% with redirecting of savings from reform to energy efficiency and renewables
Merrill et al. (2017)	Indonesia, consumption subsidies, all fossil fuels by 2025	6.97% GHG emissions reduction and with investing 30% of savings from reform to renewables and energy efficiency, 12.14% reduction by 2020 and 19.28% by 2025
Merrill et al. (2017)	Morocco, consumption subsidies, all fossil fuels over 2012-2030	7.5% GHG emissions reduction

2.7 Studies on FFSR in Iran

Several studies also have been done to evaluate impacts and potentials of FFSR in Iran. According to Mundaca (2017), if FFSs reduced in MENA region by USD 20 cents per litre for both gasoline and diesel, in Iran, the GHG emissions reductions could be 10% and 50% from diesel fuel and gasoline consumption, respectively. Barkhordari and Fattahi (2017) explored the relationship between energy prices, energy intensity and technology development in the industrial sector and not all sectors and they have not explored the relationship between FFSR and GHG emissions. Gharibnavaz and Waschik (2015) focused on gained welfare of households as a result of this policy. Barkhordar and others (2018) investigated the effects of TSA on energy efficiency in six energy-intensive industries. Sohaili (2010) analyzed potentials of removing electricity subsidies on air pollution. He used price elasticity of demand and analyzed the effects of an increase in electricity price in reducing environmental pollution. Hassanzadeh (2012) concluded that according to official reports there has been a decline in energy consumption, but she only has considered short-term impacts of this policy. Mousavi and others (2017) studied driving forces of CO_2 emission in Iran and as part of their study, they briefly reviewed TSA policy and concluded that this policy has helped to reduce emission in the transportation sector by switching from gasoline to natural gas. Farajzadeh and Bakhshoodeh

(2015) examined the economic and environmental impacts of the policy with scenario modelling and concluded that there can be a great reduction in emission. None of these studies has done a comprehensive analysis of FFSR's impacts on GHG emissions reduction or their aim was to investigate other impacts of FFSR and they briefly have mentioned or overviewed its impacts on GHG emissions reduction.

2.8 Summary

In this literature review, I intended to give a comprehensive review of existing literature since the existing reviews including Sovacool (2017), Whitley and Burg (2018) and Ellis (2010) had not covered different studies with different types and approaches. This review gives a comprehensive and holistic review of the main existing studies covering different types and approaches. All the reviewed studies both in the global and single country levels agreed on the environmental consequences and costs of FFSs and emphasized on implementing FFSR policies. There was also a general agreement on potentials of FFSR on GHG and/or CO2 emissions reduction except in case of Wesseh and Lin (2016) where they argued for an increase in the rate of CO_2 emissions.

Disagreements have risen when they came to define the conditions in which FFSR should be implemented. Different studies have chosen a different assumption. Results were different based on their different approaches for defining and estimating FFSs. Even those who had chosen a similar approach to estimate subsidies, reached different results because they had chosen different assumption or different method/model for their study. One of the differences in their assumptions was country scope; some of them based on the global level, some multi-region, some multi-country, and other single country studies. The other differences in their assumptions were on fuel selection; multi-fuel studies reached different results than single-fuel studies. The time frame was another determinant factor. Another factor was different assumptions of crude oil price in the international markets. Choosing base years was also played a role in determining the results of the studies.

Even with employing the same methods, approach and assumptions, results varied from one study to another one. It was based on that either FFSR implemented as a single policy or there were complementary policies in place to mitigate reverse or negative effects of reform policy. Different studies assumed different complementary policies or the same policies with different assumption for scenario/modelling. But some of the complementary policies were common in most of the studies. Most of them included or suggested to include the following parallel policies: direct cash payment to poor for compensation an increase in energy prices, investing savings from subsidies reform in health, education and infrastructure especially public transport, redirecting savings from subsidies reform to energy efficiency programs and promoting renewable energies including putting in place feed-in-tariff programs, investing in R & D, subsidizing their generation, providing free or lower interest rate loans, regulatory reform, fossil fuel taxing, emission trading etc. These policies were suggested for every single country where reform is happening. For mitigating reverse and negative effects of FFSR policy in other countries, this policy needs to be combined with emission cap to prevent carbon leakage effects which means that implementing FFSR policy in one single country is not enough and it needs to implement not only with complementary domestic policies but in parallel with FFSR policies in other countries and other global complementary policies, to be successful.

3 Theoretical framework

Consumer subsidies are intervention policies to lower down the price of goods and services for consumers. FFSR policies aim to decrease energy consumptions and reduce GHG emissions by making energy prices close to market prices.

I employed four different theoretical frameworks for my research. The forth theoretical framework evaluates specifically TSA results against its targets. The next three, are focused on an increase in the end-user price of energy carriers by FFSR, and effects of this increase on the potential reduction of energy consumption and GHG emissions.

3.1 A policy for evaluating environmental policy instruments

Mickwitz' (2003) 'A policy for evaluating environmental policy instruments' is employed to evaluate Targeted Subsidies Act effects. Every policy has impacts and effects. Some of these effects are anticipated while others are not. Some of the effects are in the target are of the policy but some others not. Some of them are beneficial-here beneficial for the environment by reducing GHG emissions- and some others are detrimental. In this study, only the environmental effects of this policy are evaluated.

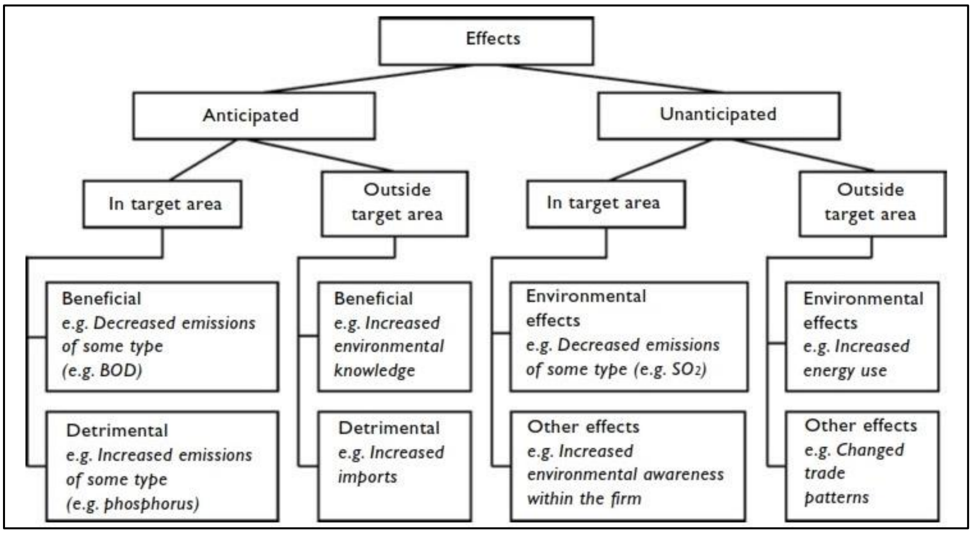

Figure 3-1 A framework for evaluating environmental policy instruments

Source: (Mickwitz, 2003, p. 28)

3.2 The Price Elasticity of Demand

The Price Elasticity of Demand measures the consumer's behaviour in relation to change in the price of a good or service. According to PED, with a change in the price of a particular good or services, demand can change. PED can measure consumers' sensitiveness from elastic to inelastic. (Guven and McPhail, 2013)

$$PED = \frac{(\mu P1-\mu P0)/\mu P0}{(P1-P0)/P0}$$

P0=Initial price

P1=New price

µP0=Demand at the initial price

µP0=Demand at the new price

Table 3-1 Interpretation of the PED coefficient

If PED is less than 1:	Demand is **inelastic**. This means that the percentage change in energy consumption is less than the percentage change in the energy carriers' end-user price.
If PED is greater than 1	Demand is **elastic**. The percentage change in energy consumption is greater than the percentage change in the energy carriers' end-user price.
If PED=0:	Demand is **perfectly inelastic**. There was no change in energy consumption resulting from a change in the energy carriers' end-user price.
If PED=1:	Demand is **unit elastic**. The percentage change in energy consumption was identical to the percentage change in the energy carriers' end-user price.
If PED = infinity:	Demand is **perfectly elastic**. The smallest increase in energy carriers' end-user price causes energy consumption to fall to ZERO.

Source: (Welker, 2019)

Table 3-2 Primary determinants of PED

Substitutes	The number of substitutes available. The more substitutes, more elastic demand, as consumers can replace a good whose price has gone up with one of its now relatively cheaper substitutes.
Proportion of income	The proportion of income the purchase of a good represents. If a good represent a higher proportion of a consumer's income, his demand tends to be more elastic.
Luxury or necessity?	Luxury or necessity? If a good is a necessity, changes in price tend not to affect quantity demand, i.e. demand is inelastic. If it's a luxury that a consumer can go without, consumers tend to be more responsive.
Addictive?	If a product is addictive or habit forming, demand tends to be inelastic.
Time	The amount of time a consumer has to respond to the price change. If prices remain high over a longer period of time, consumers can find substitutes or learn to live without, so demand is more elastic over time.

Source: (Welker, 2019)

I use this theoretical framework to find out by implementing TSA, either energy consumption (demand) is elastic or not and will lead to a decline in energy consumption and GHG emissions or not.

3.3 The Cross-Price Elasticity of Demand

The Cross-Price Elasticity of Demand measures the consumers' responsiveness of one good or service to change in a price of related good or service, this good or service can be either substitute or a complement one. According to the CPED, if the end-user price of energy carriers' changes, consumer's behaviour changes to that energy carrier will change. For example, if the price of electricity increases, consumers might look for substitution for cooking such as biomass.

This side theoretical framework helps us to evaluate any potential switch between energy carriers.

3.4 Rebound effect

The rebound effect is stated as a ratio of the lost benefit in comparison to the expected benefit (Grubb, 1990). There are three types of RF including direct rebound effect, indirect rebound effect (IRE) and economy-wide effect. For this study, I employ IRE. According to the IRE, the lower cost of a service or good leads to increased household consumption of other services and goods. In this study, I examine the RE of TSA where direct cash payments to the households from FFSR can be spent on other services and goods that can lead to GDP growth and followingly more GHG emissions. There are five different RFs according to their rate (Saunders, 2008):

- Negative rebound or Super conservation ($RE < 0$): the actual savings are higher than expected ones. This occurs if the FFSR reduces GHG emissions more than expected targets.
- Zero rebound ($RE = 0$): The actual savings are equal to the expected one. This occurs if the GHG emissions reduction from FFSR is equal to expected targets.
- Partial rebound ($0 < RE < 1$): The actual savings are less than expected ones. This occurs if the GHG emissions reduction from FFSR is less than the expected targets.
- Full rebound ($RE = 1$): The actual savings are zero. This occurs if the GHG emissions reduction from FFSR is equal to the emissions caused by households' savings from FFSR.
- Backfire ($RE > 1$): The actual savings are negative. This occurs if the GHG emissions reduction from FFSR is less than the emissions caused by households' savings from FFSR.

4 Methodology

This study is a case-based study and after reviewing existing studies, the specific case is examined. Data is collected to examine results with intended targets and policy objectives.

4.1 Methods of literature and data creation and collection

4.1.1 Literature

For this study, the literature is including case-based studies, general studies, and future scenario-based studies and globally accepted reports by IEA or similar organizations from 2010 to 2018. For academic studies, I use ScienceDirect and Google Scholar and for reports, I use publisher organizations websites. Research keywords are exclusively in English language including 'fossil fuels subsidies', 'fossil fuels subsidies phase out', 'fossil fuels subsidies reform', 'fossil fuels subsidies removal', 'fossil fuels subsidies and GHG emissions', 'fossil fuels subsidies and GHG emissions reduction', 'fossil fuels subsidies phase out and GHG emissions reduction', 'fossil fuels subsidies removal and GHG emissions reduction', 'fossil fuels subsidies and Iran', 'fossil fuels subsidies phase out and Iran', 'fossil fuels subsidies reform and Iran', 'fossil fuels subsidies removal and Iran', 'fossil fuels subsidies and GHG emissions and Iran', 'fossil fuels subsidies and GHG emissions reduction and Iran', 'fossil fuels subsidies phase out and GHG emissions reduction and Iran', and 'fossil fuels subsidies removal and GHG emissions reduction and Iran'. After selecting papers and reports, they are discussed with the supervisor to direct focus in the right direction. Finally, studies are collected for review with considering their relevance to my study, quality, whether the study is recent or not, whether it is seminal or not. And an appropriate balance between academic papers, scenario-based studies, and reports was considered. Selected studies are overviewed and summarized by using a synthesis matrix. Summarized literature are analyzed by finding their agreements and disagreements in relation to my research objectives.

4.1.2 Data

Data are extracted from national and international reports and/or statics centres including Statistical Centre of Iran, Iran's Ministry of Energy, National Iranian Gas Company, the National Iranian Oil Products Distribution Company, International Energy Agency, World Bank and US Energy Information Administration. Collected data are sorted for further analysis. Data are including an inventory of different energy carriers consumptions, CO_2 emissions data for every energy carrier before and after TSA, GDP growth rate, CO_2 intensity from 1990 to 2016 and end-user prices, reference prices, direct cash payments to households from TSA and subsidies from 1990 to 2018. For total subsidies, consumption data for 2017 and 2018 (which was not available) was considered equal to the consumptions in 2016 and then subsidies are calculated. All energy consumption, CO_2 emissions, subsidies, end-user prices and direct cash payments are collected according to the Iranian calendar and then transferred to the Gregorian calendar. While Gregorian calendar year starts 80 days earlier than the Iranian calendar year, but because the data are available only in the yearly bases, the year 1369 in the Iranian calendar is assumed as 1990 in the Gregorian calendar and so on.

Energy carriers' consumptions: Data of energy consumption for natural gas, gasoline, diesel fuel, kerosene, fuel oil, liquid gas and electricity in residential, public and commercial (RPC), transport, industrial, agriculture sectors and also petrochemical's energy use from 1990 to 2016.

CO_2 emissions: Data of CO_2 emissions from fuel combustion for natural gas, gasoline, diesel fuel, kerosene, fuel oil, liquid gas and electricity from 1990 to 2016.

End-user prices: End-user prices of all carriers are collected in local currency (IRR) and then converted to the USD in the market exchange rate from 1990 to 2018.

Reference prices: FOB prices of natural gas and oil products were not available at the nearest international hub, thus FOB prices at the New York harbour were used. For calculating reference prices of natural gas and oil products, the cost of internal distribution and marketing was added to the FOB prices. From 2008, Value Added Tax (VAT) has been implemented in Iran and were added to the FOB prices. For calculating electricity reference price, electricity generation costs, internal distribution, marketing and VAT were added to the FOB prices of input fuels for electricity generation.

Reference price =FOB price+ the cost of internal distribution and marketing (and generation costs in case of electricity) + VAT

Fossil fuels subsidies: Whenever a subsidy is paid in cash or grant to the recipient, it is called direct subsidy. Any non-cash benefits a recipient receives considered an indirect subsidy. Estimating indirect subsidies needs data and time which was not possible to do it for this study. Thus, I use the price-gap approach to estimate only amounts of direct subsidies.

Iran is a net fossil fuel/energy exporting country. For fossil fuel/energy exporting economies where they export fossil fuel/energy at FOB prices but charge less for it in their domestic market, they do not have a direct budget for subsidies; their domestic subsidies are implicit and is considered as the opportunity cost of pricing domestic selling of energy at a lower price. The reference price for net exporter economies is the price of energy at the closest international hub minus the cost insurance, freight and plus marketing, domestic distribution and VAT. For electricity, the reference price is based on the cost of production, transmission, distribution on annual average-cost pricing in each country. (IEA, 2017)

After having end-user and reference prices of energy carriers, here I only collect direct subsidies according to the below formula. FFSs are converted to USD at the same year exchange rates.

Subsidies= reference price of energy carrier – end-user price of energy carrier

Note: In calculating electricity subsidies, the share of fossil fuels sources in electricity generation was considered to avoid overestimation due to the share of non-fossil fuel sources in electricity generation.

Direct cash payments to the households from FFSR: This data is collected in local currency and converted to the USD in the market exchange rate.

GDP: GDP data is collected in USD and in the constant prices.

CO_2 intensity: CO_2 intensity of GDP is 1 kg of emitted CO_2 per 1 USD of GDP and CO_2 intensity of energy use is 1 kg of emitted CO_2 per 1 kg of oil equivalent energy use.

4.2 Methods for data analysis

Data are analyzed by applying theoretical frameworks to achieve research objectives. Data analysis is done by employing qualitative analysis in parallel with statistical analysis. Time-series analyses are employed to evaluate energy consumption, CO_2 emissions, and emissions reduction as well as FFSs allocation and the price elasticity of demand.

For Mickwitz' policy framework, the results of TSA are measured against its intended targets and Iran's INDC. For this, two main criteria are applied, the first increase in energy carriers' prices are examined according to the yearly exchange rates against intended targets, and second potential CO_2 emissions reductions are evaluated against on INDC. Time-series analysis is also employed to conduct these comparisons.

According to the PED and CPED theoretical frameworks; demand for energy from fossil fuels sources needs to be analysed in two different prices (in subsidized price and after FFSR) to find out an increase or decrease in demand. There is also a need to find out the shift from one fossil fuel to another one in case of a change in prices. Qualitative analysis is done by applying theoretical frameworks to the statistical data and their analysis.

Time-series analysis of direct cash payments, and spending of them in other goods and services and GDP growth rate is done to find out their trends and possible correlations before and after FFSR.

4.3 Limitations

Potential barriers were on the selecting studies for review. ScienceDirect, Google Scholar, and organizations' websites provide many studies, selecting out them were problematic but by defining the mentioned criteria and brainstorming with the supervisor, I could get around this problem. Also, there was difficulties in finding relevant and enough data about energy consumption, subsidies for different energy carriers, reduction or increase in CO_2 emissions especially when different sources had different data for the same variable.

5 Results and Analysis

Iran's total primary energy supply and consumption is heavily dependent on fossil fuels where 100% of transport and heating rely on fossil fuels and about 83 to 93% of electricity generation is from fossil fuel sources including oil products and natural gas sources with less than 0.4% share of coal sources (World Bank, 2019). For this reason, here we only have results of main energy sources including natural gas, gasoline, diesel fuel, kerosene, fuel oil, liquid gas and electricity.

In the first section of this chapter, consumption of each above-mentioned energy carriers for different sectors including RPC, industrial, transport, agriculture, petrochemical energy use and others will be given. End-user price and reference price of each energy carrier will be presented, and finally, the total amount of end-user price and total subsidies for each energy carrier will be shown. Following total energy consumption for each sector and for each energy carrier will be displayed and overall energy consumption will be demonstrated. And finally, CO_2 emission from fuel combustion against energy consumption will be shown.

In the second section; total subsidies against crude oil price in the international market and end-user price of energy carrier will be given. GDP growth rate against energy consumption will be presented. CO_2 intensity of GDP and CO_2 intensity of energy use will be given where CO_2 intensity of GDP is 1 kg of emitted CO_2 per 1 USD of GDP and CO_2 intensity of energy use is 1 kg of emitted CO^2 per 1 kg of oil equivalent energy use. Following direct cash payments to the households from TSA and CO_2 emission resulted from spending them will be displayed.

In the last section of this chapter, the results of TSA will be evaluated against its targets. Where the targets had been set to achieve a determined percentage of FOB price in case of oil products and natural gas and generation cost in case of electricity, the ratio of results per targets and crude oil price will be given for them.

5.1 Energy carriers' consumptions and emissions

5.1.1 Natural gas

Iran has the second largest natural gas reserves in the world (BP, 2018) which leads Iran to rely on this source of energy for heating, electricity generation, cooking and even transport energy needs.

Natural gas consumption has been increasing since 1990 with small drops in 1998 and 2012. There is no sign of steady change in natural gas consumption pattern after implementing the TSA. (Figure 5-1)

End-user price of natural gas sharply increased after implementing TSA in late 2010 and 2011 then dropped again from 2012. There is another sharp drop in end-user price in 2018. These drops in end-user price are the result of a decline in IRR value against USD while it had increased or remained at the same level in local currency. Reference price has raised and fell according to the crude oil price and accordingly natural gas FOB price in international markets. (Figure 5-2)

Natural gas total annual end-user price had been less than 1 billion USD for all years before

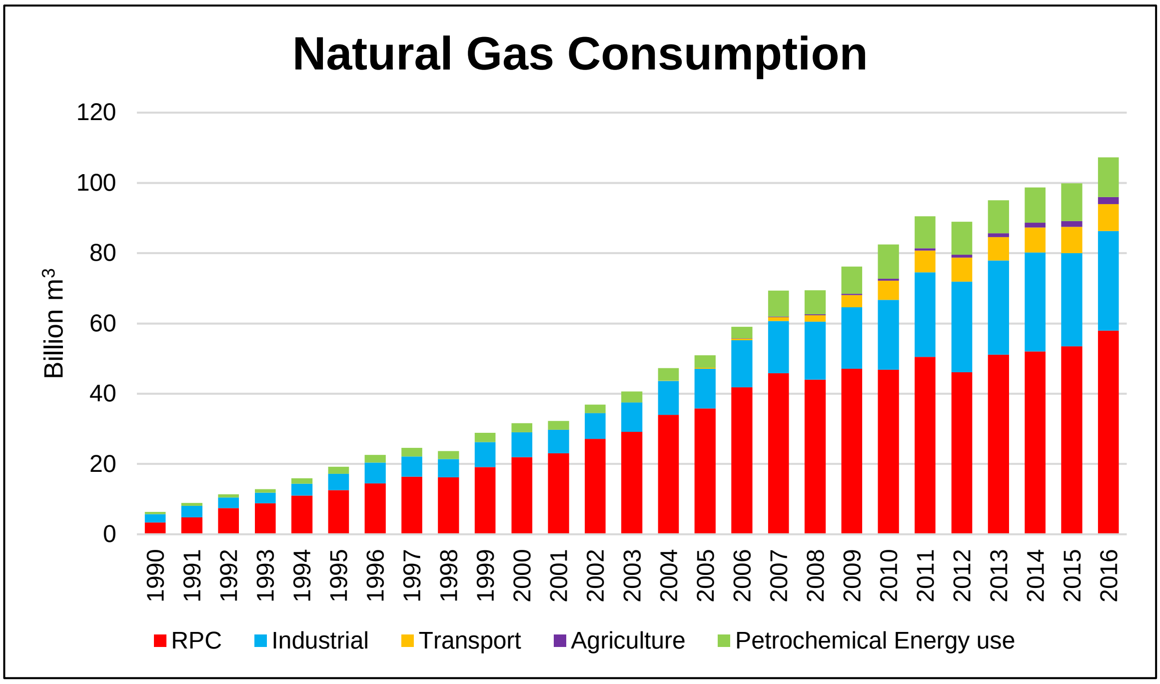

Figure 5-1 Natural gas consumption in different sectors 1990-2016

Source: Data is collected from (National Iranian Gas Company, 2019 and Iran's Ministry of Energy, 2019)

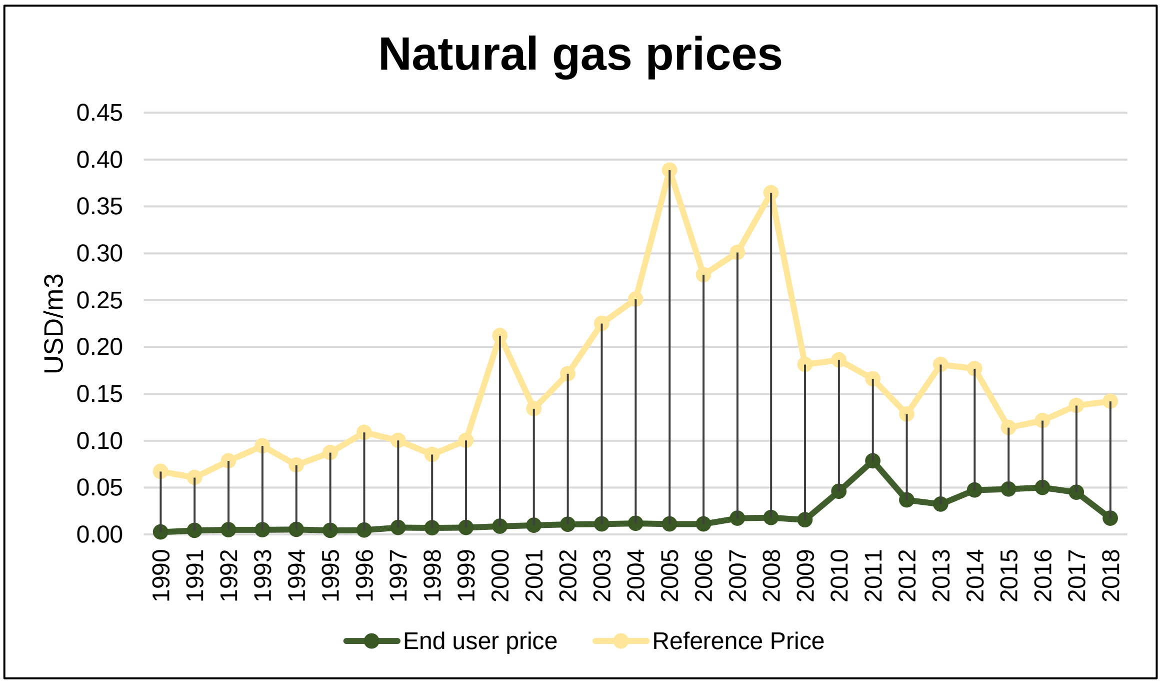

Figure 5-2 Natural gas end-user price and reference price 1990-2018

Source: Data is collected from (NIGC, 2019, Iran's MOE, 2019, Statistical Centre of Iran, 2019 and US Energy Information Administration, 2019)

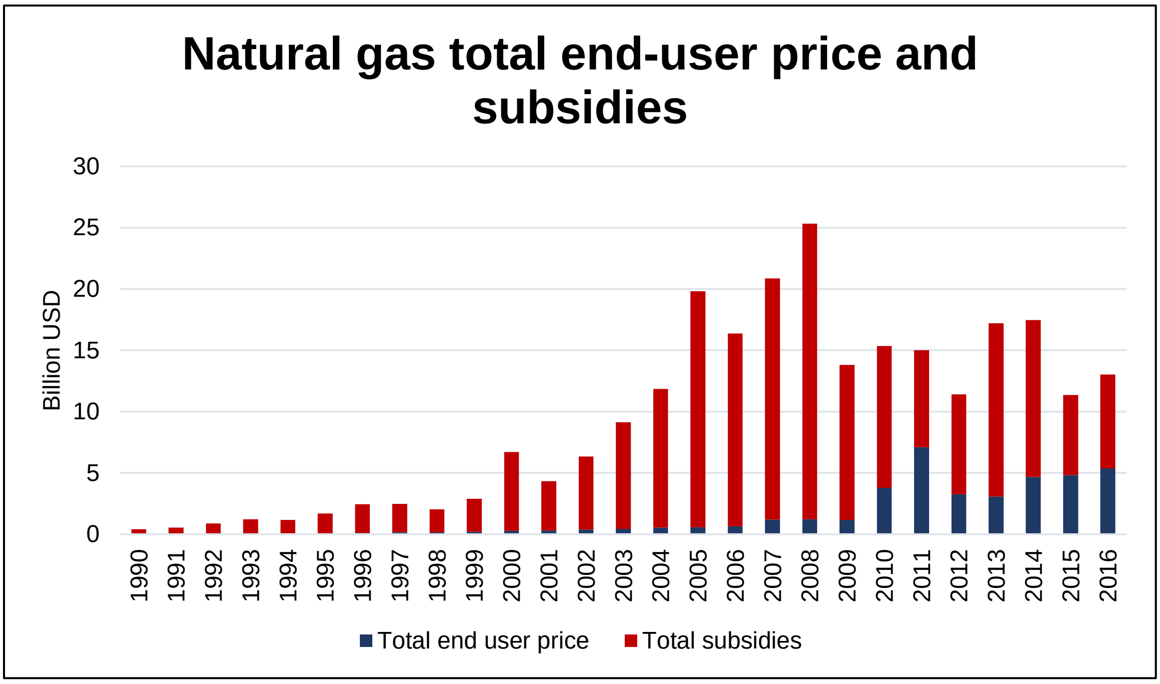

Figure 5-3 Natural gas total annual end-user price and total subsidies 1990-2016

Source: Data is collected from (NIGC, 2019, Iran's MOE, 2019, SCI, 2019 and US EIA, 2019)

implementing TSA except from 2007 to 2009. By implementing TSA, it has been increased sharply more than three times. There is a decline in annual total end-user price for 2012 and 2013 and estimated there will be a similar decline from 2018 onward again. These declines are the result of a decline in IRR value against USD while it had increased or remained at the same level in local currency. Total annual subsidies have not had a steady trend. While it is a gap between end-user price and reference price, crude oil price and accordingly natural gas FOB price plays the main role in the amount of subsidies. (Figure 5-3)

5.1.2 Gasoline

Iran has a relatively weak public transport and transportation mostly relies on road transports with private vehicles which consume domestic and imported gasoline.

Gasoline consumption has been increasing since 1990 with a sharp slope but it has started to decline from 2007 till 2011 but has increased again from 2012. While there is a decreasing trend in gasoline consumption before implementing TSA, one year after implementing it, the consumption has started to rise again even there was another increase in end-user price in 2014. (Figure 5-4)

End-user price of gasoline sharply increased after implementing TSA in late 2010 and early 2011 then declined again from 2011. There is another sharp increase in end-user price in 2014 and again another drop from 2015 with a sharp slope from 2018. These drops in end-user price are the result of a decline in IRR value against USD while it had increased or remained at the same level in local currency. Reference price has raised and fell according to the crude oil price and

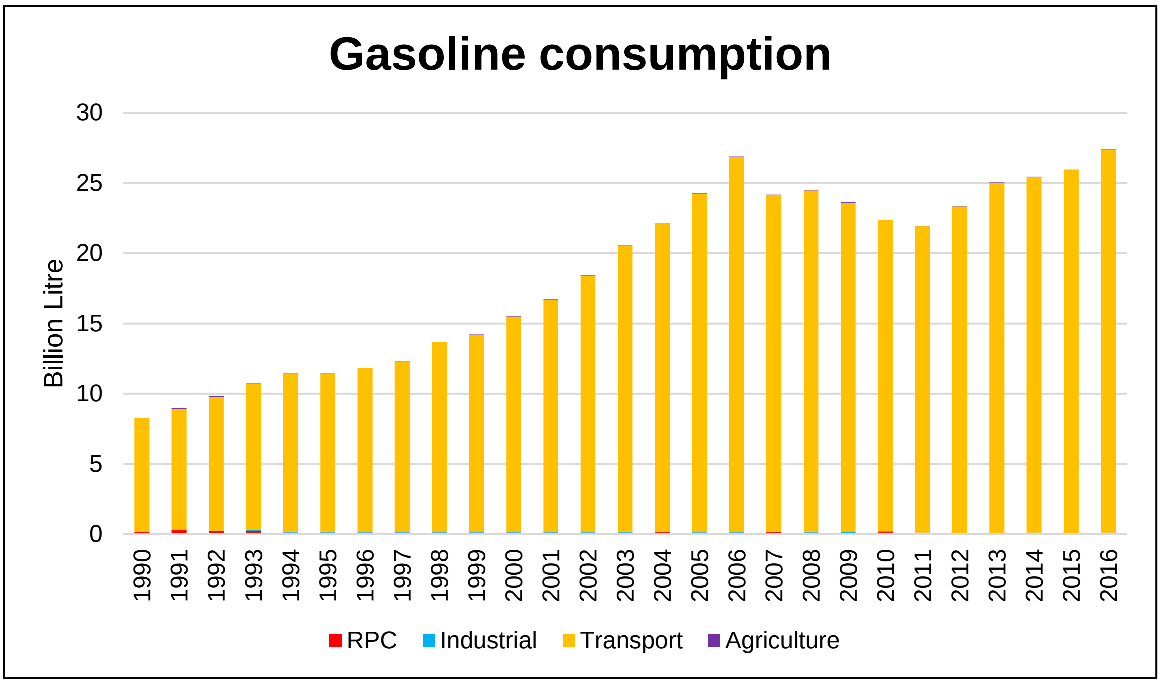

Figure 5-4 Gasoline consumption 1990-2016

Source: Data is collected from (National Iranian Oil Products Distribution Company, 2019 and Iran's MOE, 2019)

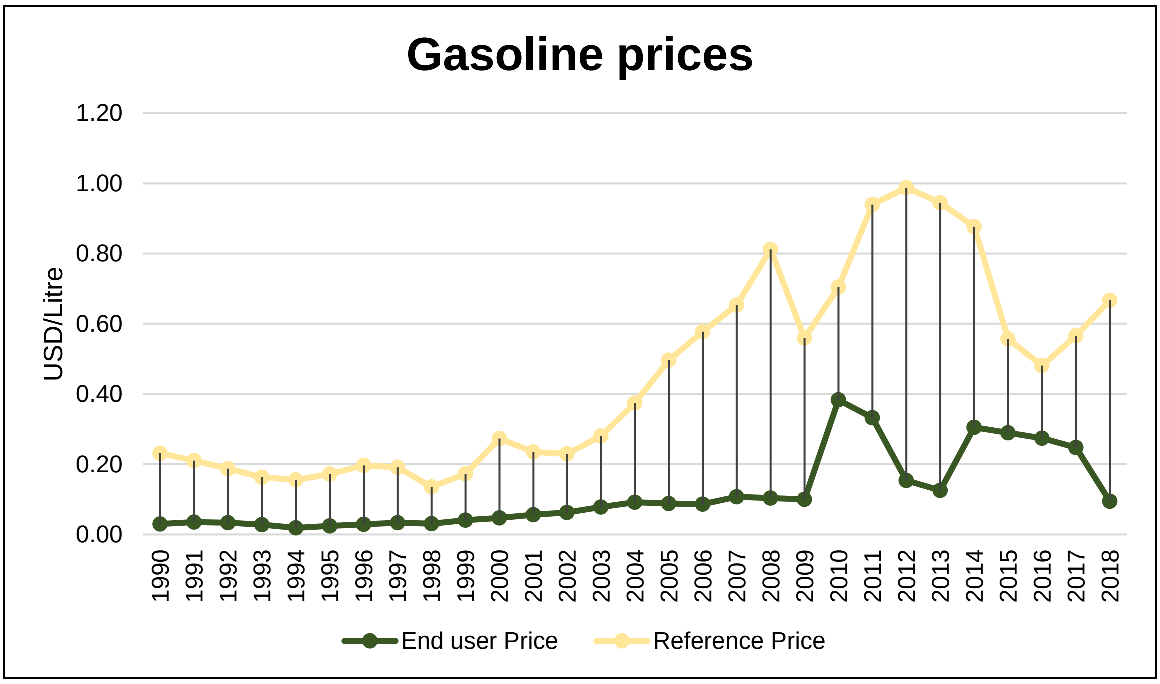

Figure 5-5 Gasoline end-user price and reference price 1990-2018

Source: Data is collected from (Iran's MOE, 2019, SCI, 2019 and US EIA, 2019)

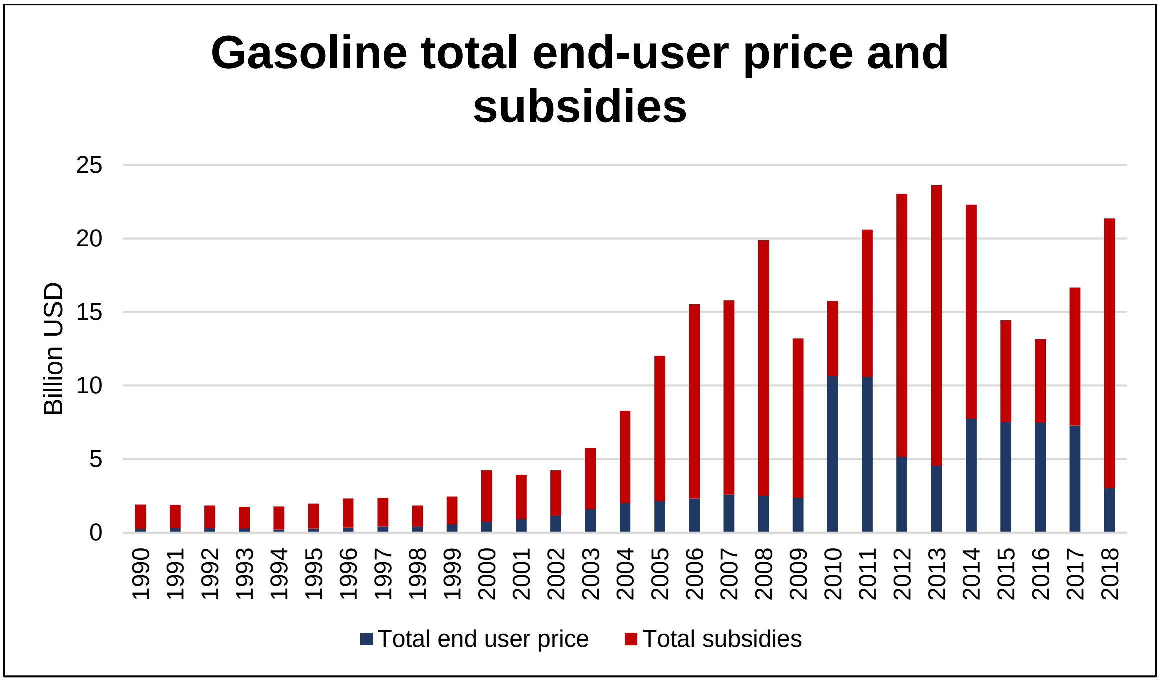

Figure 5-6 Gasoline total annual end-user price and total subsidies 1990-2016

Source: Data is collected from (Iran's MOE, 2019, SCI, 2019 and US EIA, 2019)

accordingly gasoline FOB price in international markets. (Figure 5-5)

Gasoline total annual end-user price had been less than 3 billion USD for all years before implementing TSA except from 2007 to 2009. By implementing TSA, it has been increased sharply more than four times. There is a decline in annual total end-user price for 2012 and 2013 and estimated there will be a similar decline from 2018 onward again. These declines are the result of a decline in IRR value against USD while it had increased or remained at the same level in local currency. Total annual subsidies have not had a steady trend. While it is a gap between end-user price and reference price, crude oil price and accordingly gasoline FOB price play the main role in the amount of subsidies. (Figure 5-6)

5.1.3 Diesel Fuel

Iran has a relatively weak rail transport and transportation of goods mostly relies on road transports with diesel vehicles.

Diesel fuel consumption had been increasing since 1990 till 2008 with a steady trend with drops in 1995, 1998 and 1999 but it has started to decline from 2009. The decline in diesel fuel consumption had started 2 years before implementing the TSA. There is no sign of TSA implementation effects on consumption decline. The dependency of other sectors especially RPC on diesel fuel has decreased with substituting natural gas because of accessibility natural gas and/or its price (cross-price elasticity of demand) for households and economic degrowth because of sanctions. (Figure 5-7)

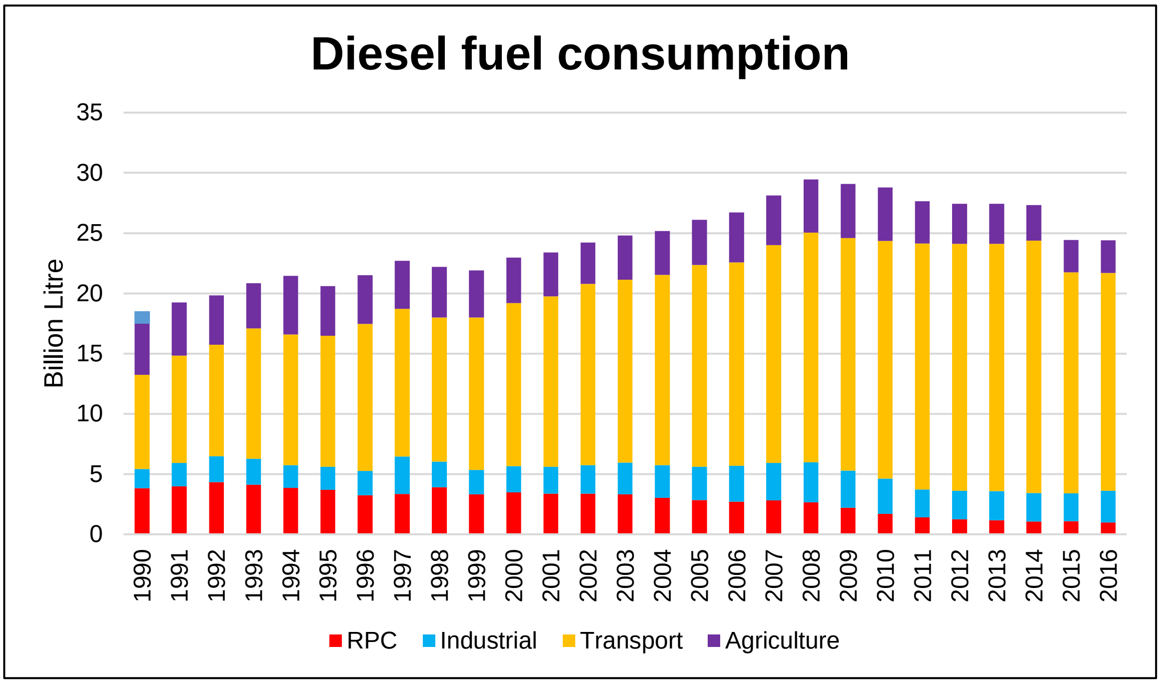

Figure 5-8 Diesel fuel consumption in different sectors 1990-2016

Source: Data is collected from (Iran's MOE, 2019)

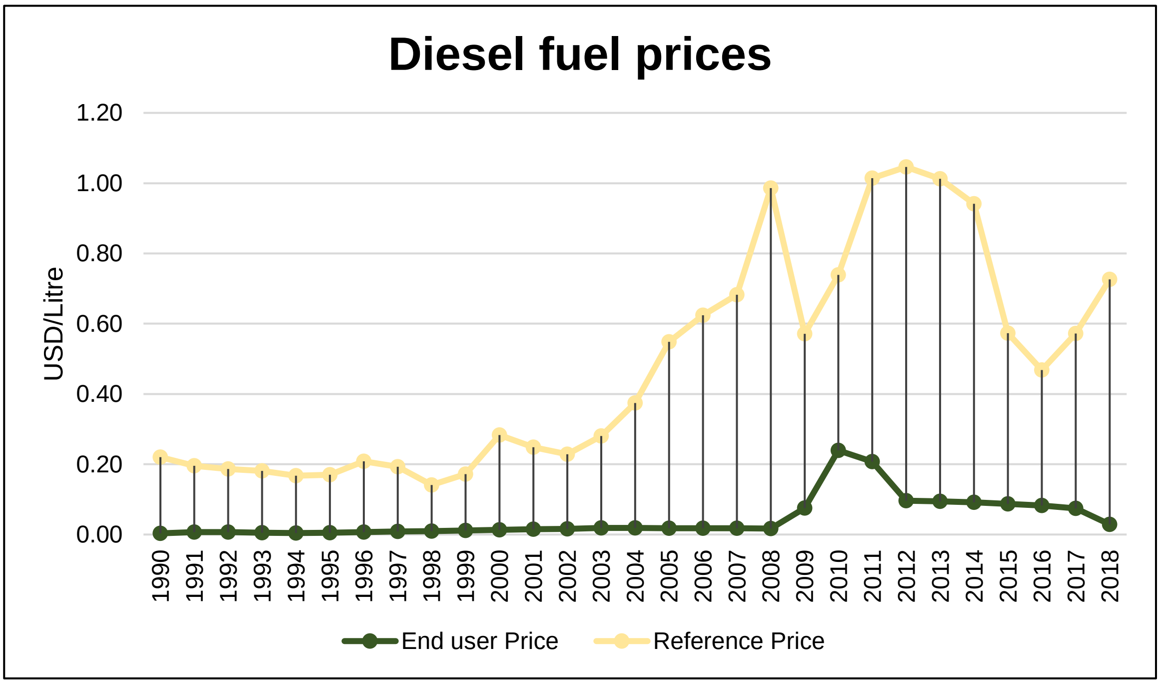

Figure 5-7 Diesel fuel end-user price and reference price 1990-2018

Source: Data is collected from (Iran's MOE, 2019, SCI, 2019 and US EIA, 2019)

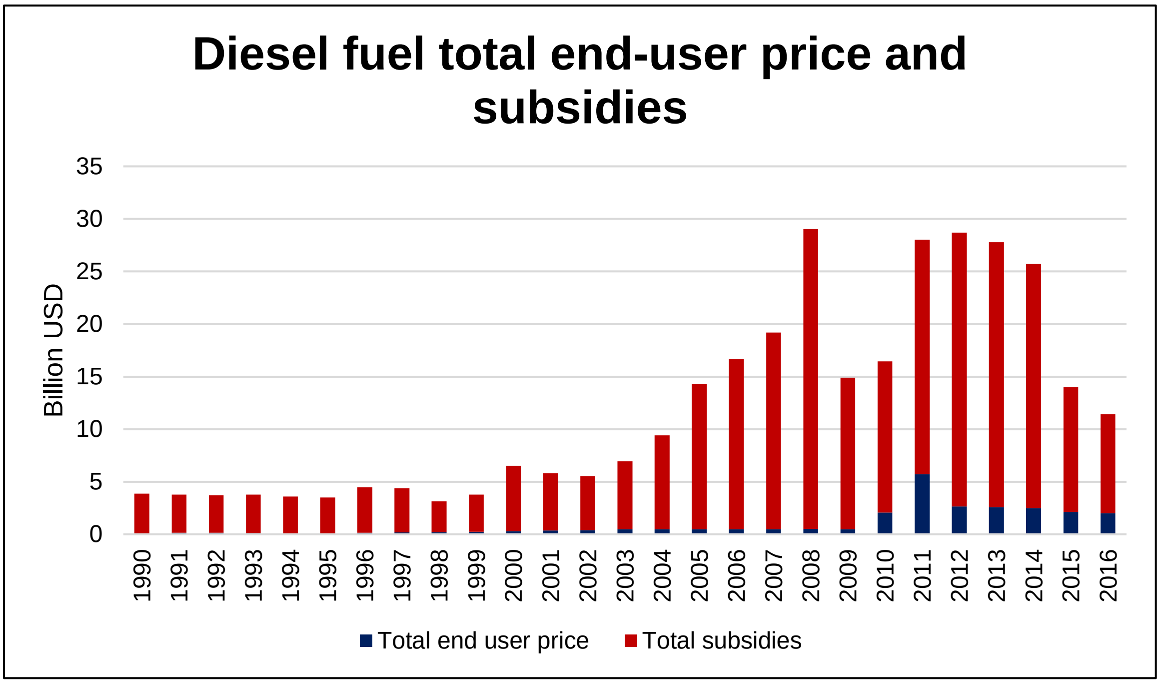

Figure 5-9 Diesel fuel annual total end-user price and total subsidies 1990-2016

Source: Data is collected from (Iran's MOE, 2019. SCI, 2019 and US EIA, 2019)

2011 then declined again from 2011. There is another sharp increase in end-user price in 2014 and again another drop in end-user price from 2015 with a sharp slope from 2018. These drops in end-user price are the result of a decline in IRR value against USD while it had increased or remained at the same level in local currency. Reference price has raised and fell according to the crude oil price and accordingly diesel fuel FOB price in international markets. (Figure 5-8)

Diesel fuel total annual end-user price had been less than 0.5 billion USD for all years before implementing the TSA. By implementing the TSA, it has been increased sharply more than four times in 2010 and ten times in 2011. There is a decline in annual total end-user price from 2012 and estimated there will be a similar decline from 2018 onward again. These declines are the result of a decline in IRR value against USD while it had increased or remained at the same level in local currency. Total annual subsidies have not had a steady trend. While it is a gap between end-user price and reference price, crude oil price and accordingly diesel fuel FOB price plays the main role in the amount of subsidies. (Figure 5-9)

5.1.4 Kerosene

Kerosene has been used widely for heating and cooking in the RPC sector and is still used for central heating in some buildings and remote areas where there is no access to natural gas.

Kerosene consumption has been decreasing since 1994 with a steady trend with a rise in 2007, but it has started to decline again from 2008. The decline in kerosene consumption had started many years before implementing the TSA. After implementing of TSA, there is no change in consumption decline trend. Thus, there is no sign of TSA implementation effects on

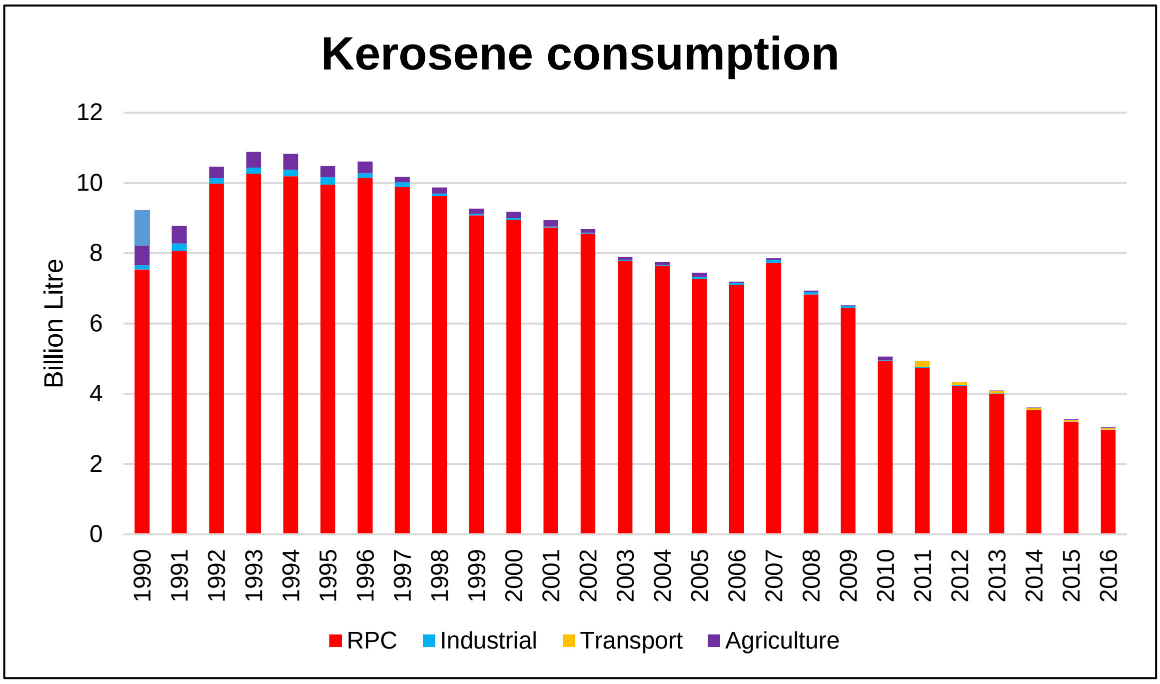

Figure 5-10 Kerosene consumption in different sectors 1990-2016

Source: Data is collected from (Iran's MOE)

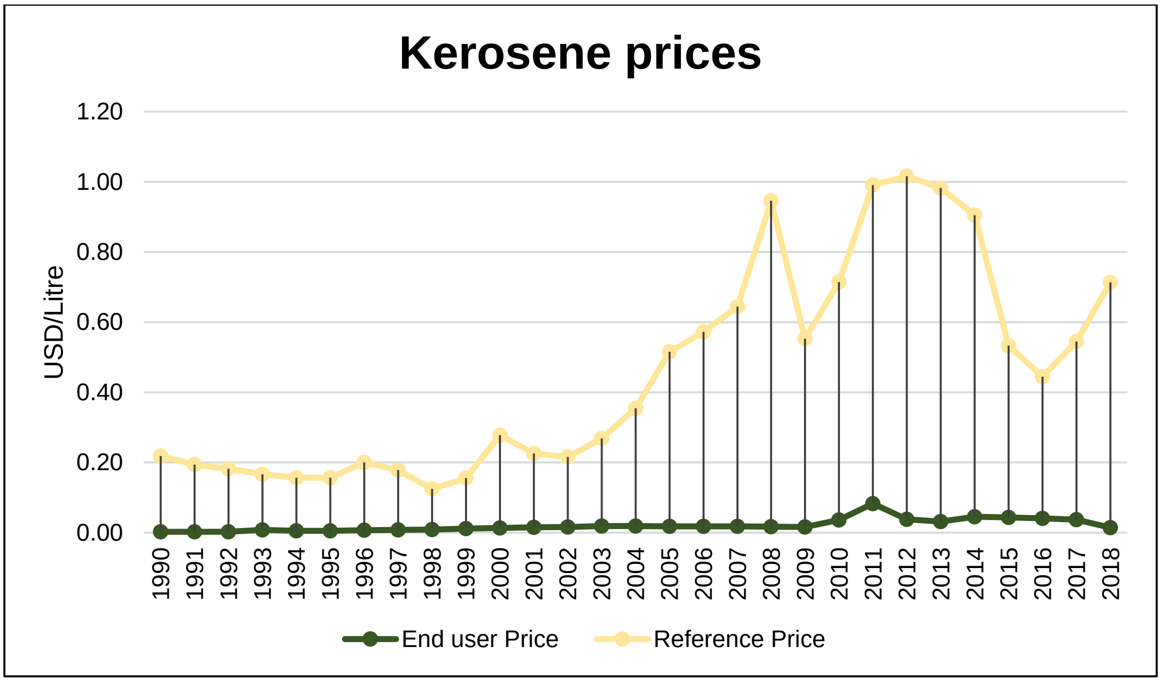

Figure 5-11 Kerosene end-user price and reference price 1990-2018

Source: Data is collected from (Iran's MOE, 2019, SCI, 2019 and US EIA, 2019)

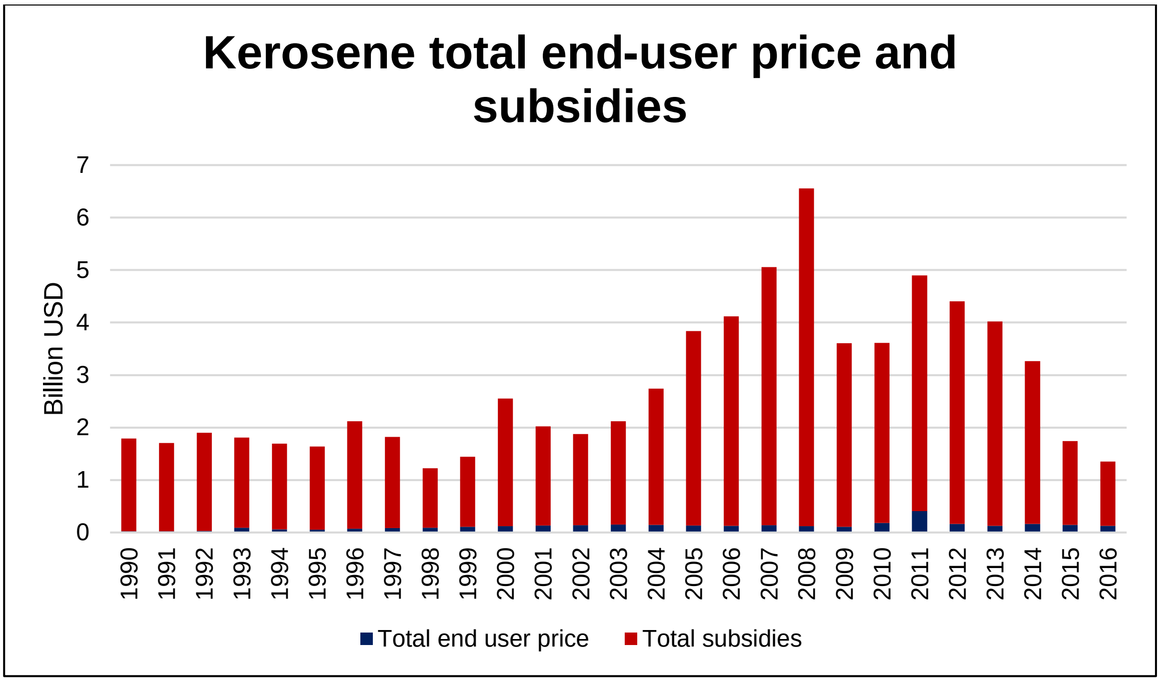

Figure 5-12 Kerosene annual total end-user price and total subsidies 1990-2016

Source: Data is collected from (Iran's MOE, 2019, SCI, 2019 and US EIA, 2019)

decline. The dependency of RPC sector on kerosene has decreased with substituting natural gas because of the accessibility of natural gas and/or its price (Cross-price elasticity of demand) for households. (Figure 5-10)

End-user price of kerosene sharply increased after implementing the TSA in late 2010 and early 2011 then declined again from 2012. There is another increase in end-user price in 2014 and again another drop from 2015 with a sharp slope in 2018. These drops in end-user price are the result of a decline in IRR value against USD while it has increased or remained at the same level in local currency. Reference price has raised and fell according to the crude oil price and accordingly kerosene FOB price in international markets. (Figure 5-11)

Kerosene total annual end-user price had been less than 0.02 billion USD for all years before implementing TSA. By implementing TSA, it has been increased sharply more than two times in 2010 and five times in 2011. There is a decline in annual total end-user price from 2012 and estimated there will be a similar decline from 2018 onward again. These declines are the result of a decline in IRR value against USD while it has increased or remained at the same level in local currency. Total annual subsidies have not had a steady trend. While it is a gap between end-user price and reference price, crude oil price and accordingly kerosene FOB price plays the main role in the amount of subsidies. (Figure 5-12)

5.1.5 Fuel Oil (Mazut)

Fuel oil or as it is called in Iran and Russia; Mazut has been used widely for heating in RPC sector, electricity generation in the industrial sector and for marine transport.

Total fuel oil consumption has not had a steady trend and there are fall and raise in consumption from one year to another one. But after a sharp increase in consumption from 2007 to 2009, there is a sharp decrease in consumption from 2010 and another one in 2016. Fuel oil consumption in the RPC sector has been decreasing since 1995 and drop in the industrial sector has started in 2009, one year before implementing TSA. The decline in fuel oil consumption had started many years before implementing the TSA. Thus, there is no sign of TSA implementation effects on consumption decline. The dependency of RPC sector on fuel oil has decreased with substituting natural gas because of accessibility natural gas and/or its price (Cross-price elasticity of demand) for households. (Figure 5-13)

End-user price of fuel oil sharply increased after implementing TSA in late 2010 and early 2011 then declined again from 2012. There is another increase in end-user price in 2014 and again another drop from 2015 with a sharp slope in 2018. These drops in end-user price are the result of a decline in IRR value against USD while it has increased or remained at the same level in local currency. Reference price has raised and fell according to the crude oil price and accordingly fuel oil FOB price in international markets. (Figure 5-14)

Fuel oil total annual end-user price had been less than 0.1 billion USD for all years before implementing the TSA. By implementing TSA, it has been increased sharply more than three times in 2010 and ten times in 2011. There is a decline in annual total end-user price from 2012

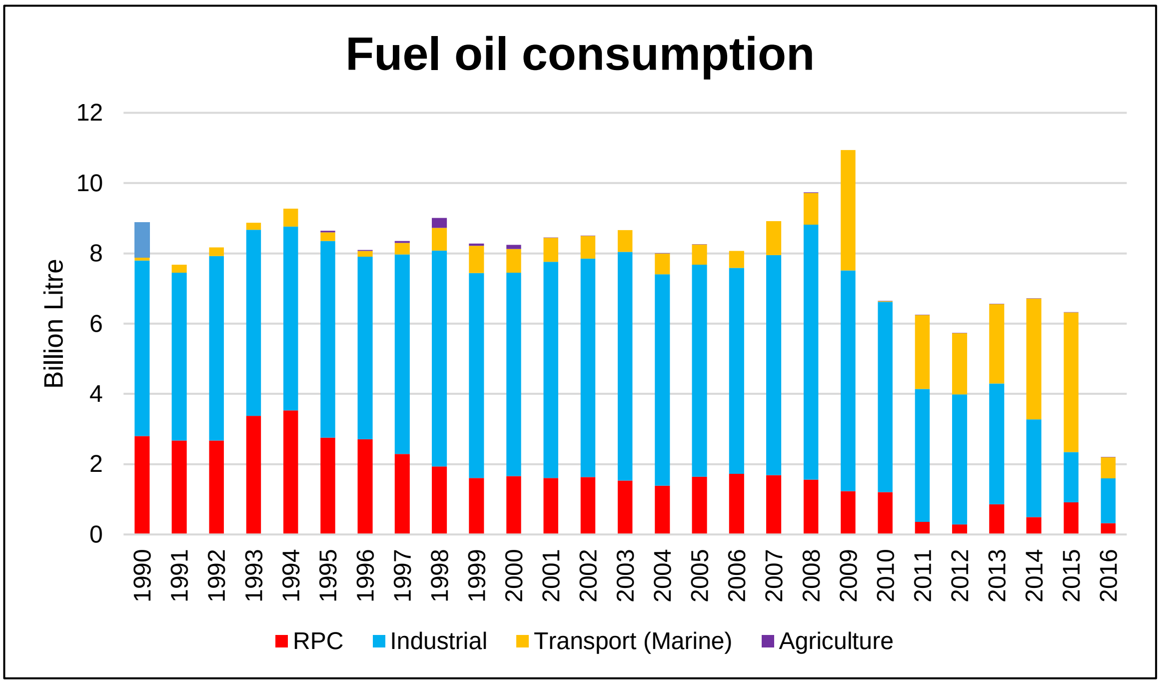

Figure 5-13 Fuel oil consumption in different sectors 1990-2016

Source: Data is collected from (Iran's MOE, 2019)

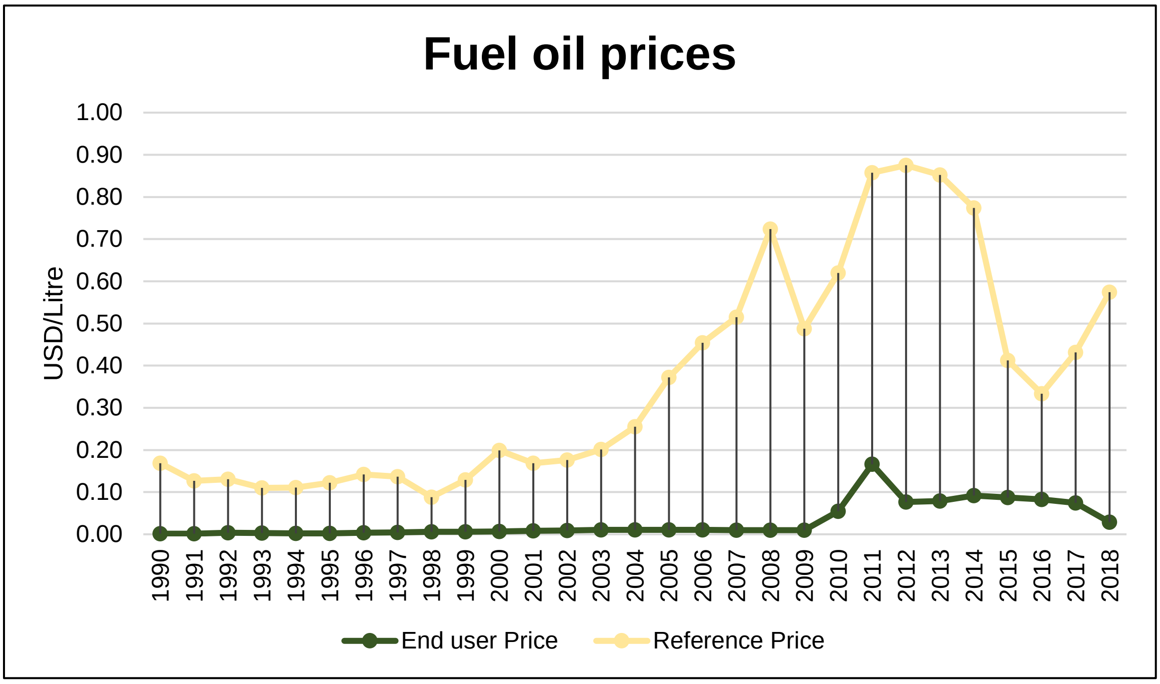

Figure 5-15 Fuel oil end-user price and reference price 1990-2018

Source: Data is collected from (Iran's MOE, 2019, SCI, 2019 and US EIA, 2019)

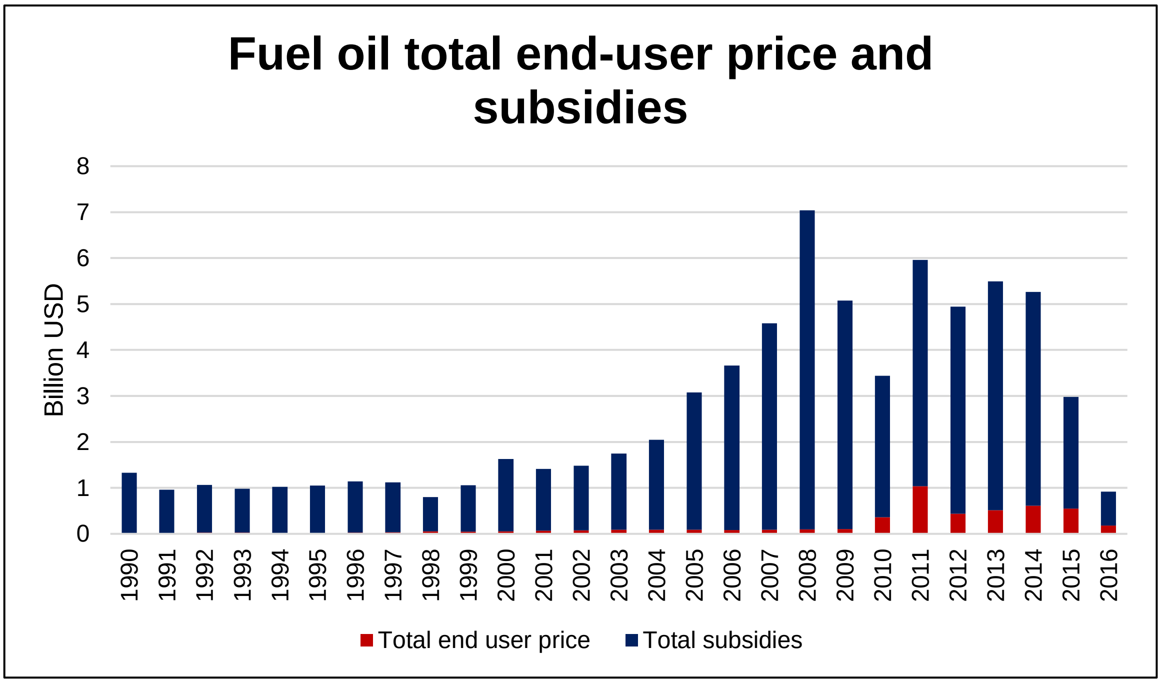

Figure 5-14 Fuel oil annual total end-user price and total subsidies 1990-2016

Source: Data is collected from (Iran's MOE, 2019, SCI, 2019 and US EIA, 2019)

and estimated there will be a similar decline from 2018 onward again. These declines are the result of a decline in IRR value against USD while it had increased or remained at the same level in local currency. Total annual subsidies have not had a steady trend. While it is a gap between end-user price and reference price, crude oil price and accordingly fuel oil FOB price play the main role in the amount of subsidies. (Figure 5-15)

5.1.6 Liquid gas (LPG and LNG)

Liquid gas including liquid petrol gas and liquid natural gas is used widely for heating and cooking in the RPC sector.

Liquid gas consumption does not follow a steady trend and there are fall and raise in consumption from one year to another one. While from 1990 to 2006, there is an increasing trend except for some years, from 2007, there is a sharp decrease in consumption. Liquid gas consumption in RPC sector follows a relatively steady trend and remained at the same level. While there is a sharp drop in consumption in 2011, from 2012, there is another increase in consumption and again consumption remained at the same level. The sharp drop in consumption can be the impacts of a sharp increase in end-user price. (Figure 5-16)

End-user price of liquid gas sharply increased after implementing TSA in late 2010 and early 2011 then sharply declined in 2012. There is another sharp increase in end-user price in 2013 and again another drop in end-user price from 2014 with a sharp slope from 2018. These drops in end-user price are the result of a decline in IRR value against USD while it had increased or remained at the same level in local currency. Reference price has raised and fell according to the crude oil price and accordingly liquid gas FOB price in international markets. (Figure 5-17)

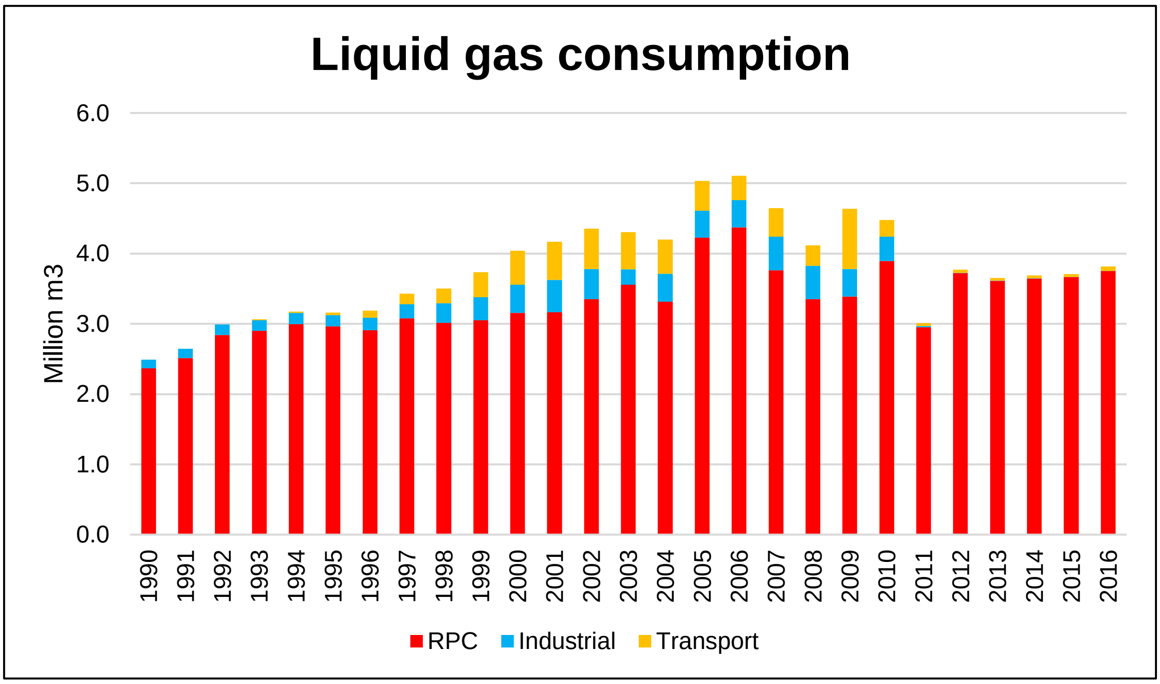

Figure 5-16 Liquid Gas consumption in different sectors 1990-2016

Source: Data is collected from (Iran's MOE)

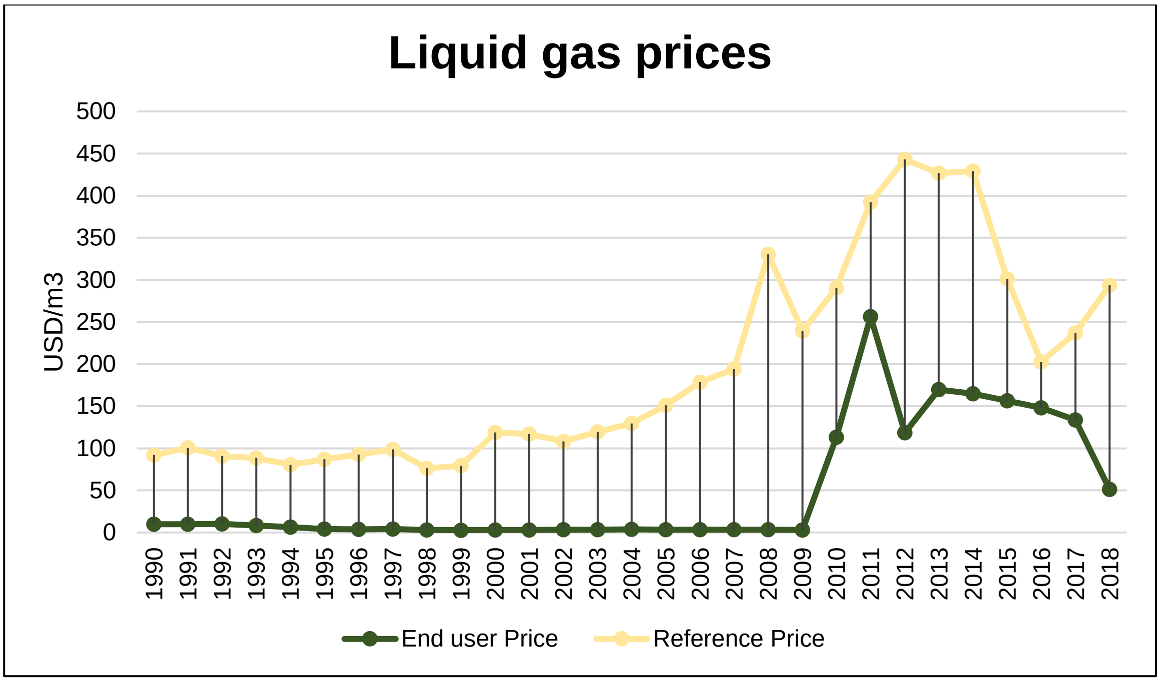

Figure 5-17 Liquid Gas end-user price and reference price 1990-2018

Source: Data is collected from (Iran's MOE, 2019, SCI, 2019 and US EIA, 2019)

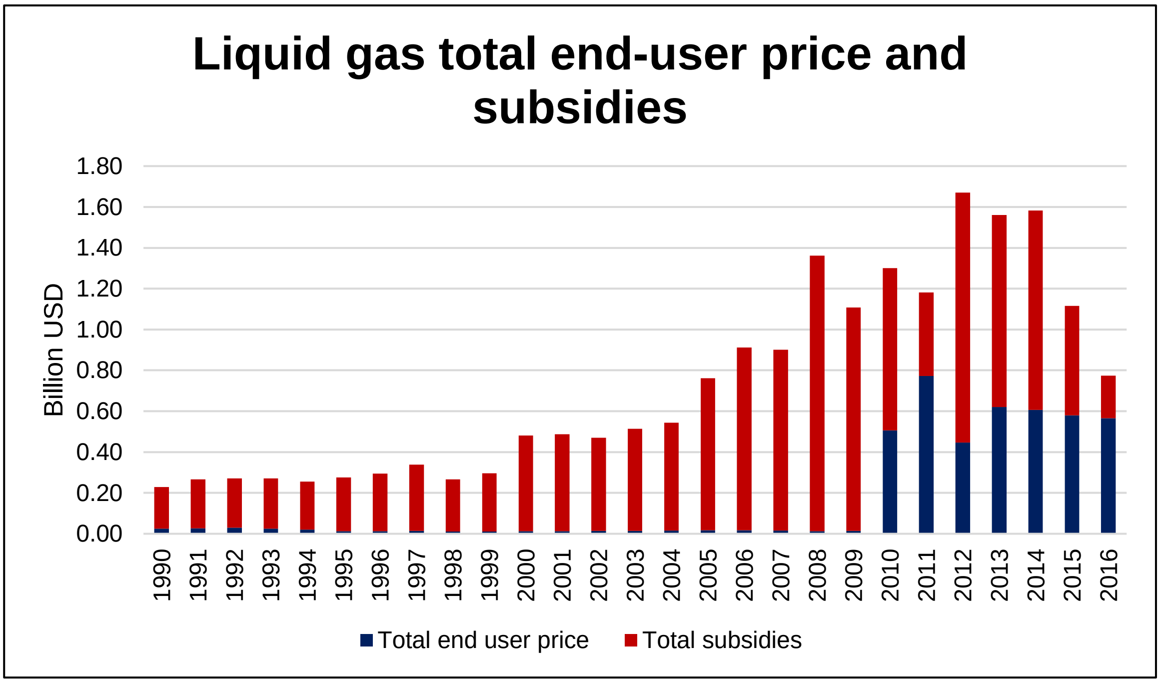

Figure 5-18 Liquid gas annual total end user price and total subsidies 1990-2016

Source: Data is collected from (Iran's MOE, 2019, SCI, 2019 and US EIA, 2019)

Liquid gas total annual end-user price had been less than 0.015 billion USD for all years before implementing TSA. By implementing TSA, it has been increased sharply more than three times in 2010 and five times in 2011. There is a decline in annual total end-user price from 2012 and estimated there will be a similar decline from 2018 onward again. These declines are the result of a decline in IRR value against USD while it has increased or remained at the same level in local currency. Total annual subsidies have not had a steady trend. While it is a gap between end-user price and reference price, crude oil price and accordingly liquid gas FOB price play the main role in the amount of subsidies. (Figure 5-18)

5.1.7 Electricity

Electricity is widely used in RPC, industrial and agriculture sectors for lightning.

Electricity consumption has been increasing over the years except in 2011 where there is a small decline in consumption in RPC sector and total consumption and again it has increased and follows an increasing trend. (Figure 5-19)

End-user price of electricity sharply increased after implementing TSA in late 2010 and early 2011 then sharply declined in 2012. There is another increase in end-user price from 2014 and again another drop in end-user price from 2017 with a sharp slope from 2018. These drops in end-user price are the result of a decline in IRR value against USD while it had increased or remained at the same level in local currency. Reference price has raised and fell according to the crude oil price in international markets and accordingly electricity generation costs. (Figure 5-20)

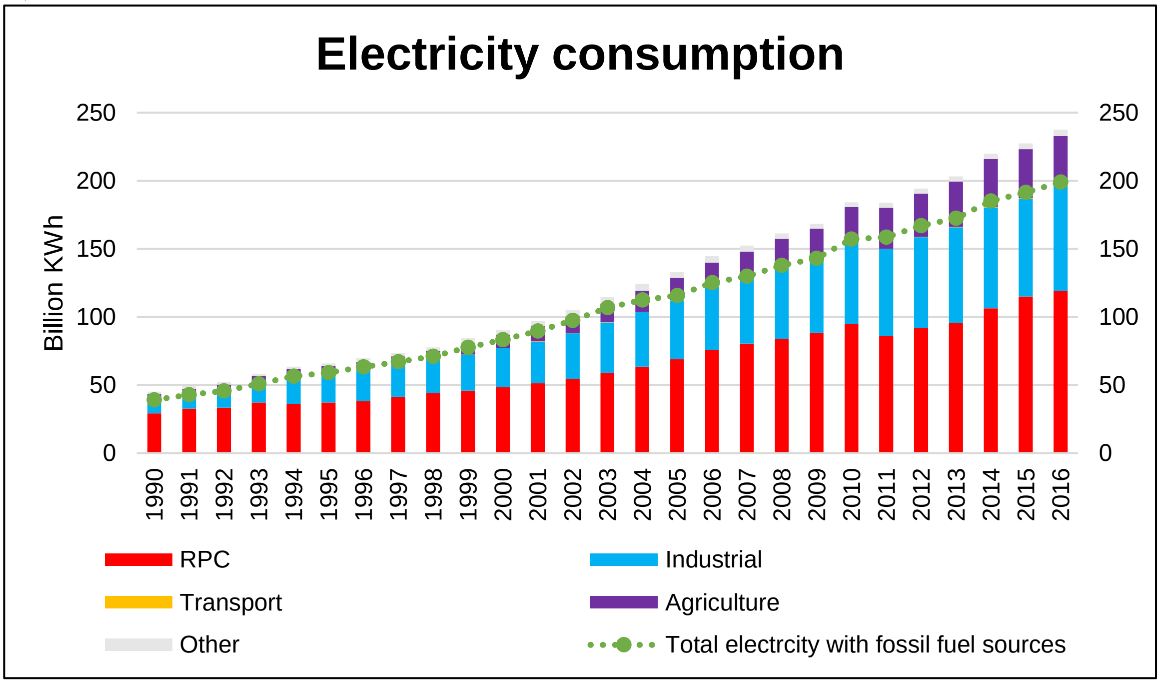

Figure 5-19 Electricity consumption in different sectors 1990-2016

Source: Data is collected from (Iran's MOE)

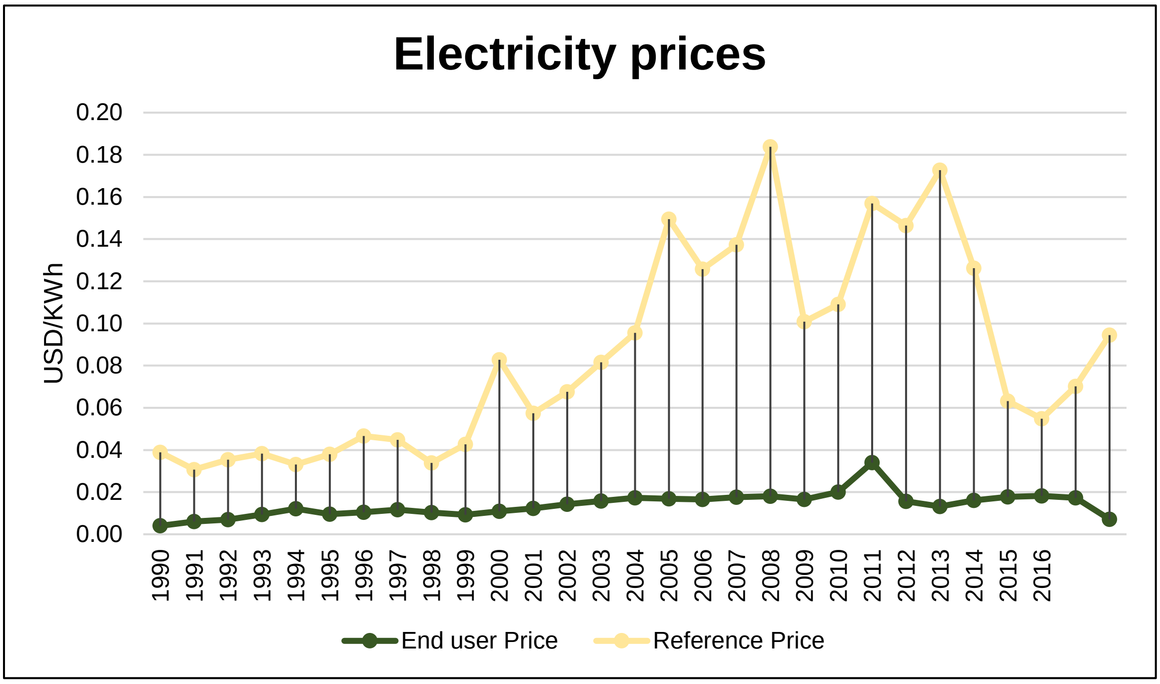

Figure 5-20 Electricity end-user price and reference price 1990-2018

Source: Data is collected from (NIGC, 2019, Iran's MOE, 2019, SCI, 2019 and US EIA, 2019)

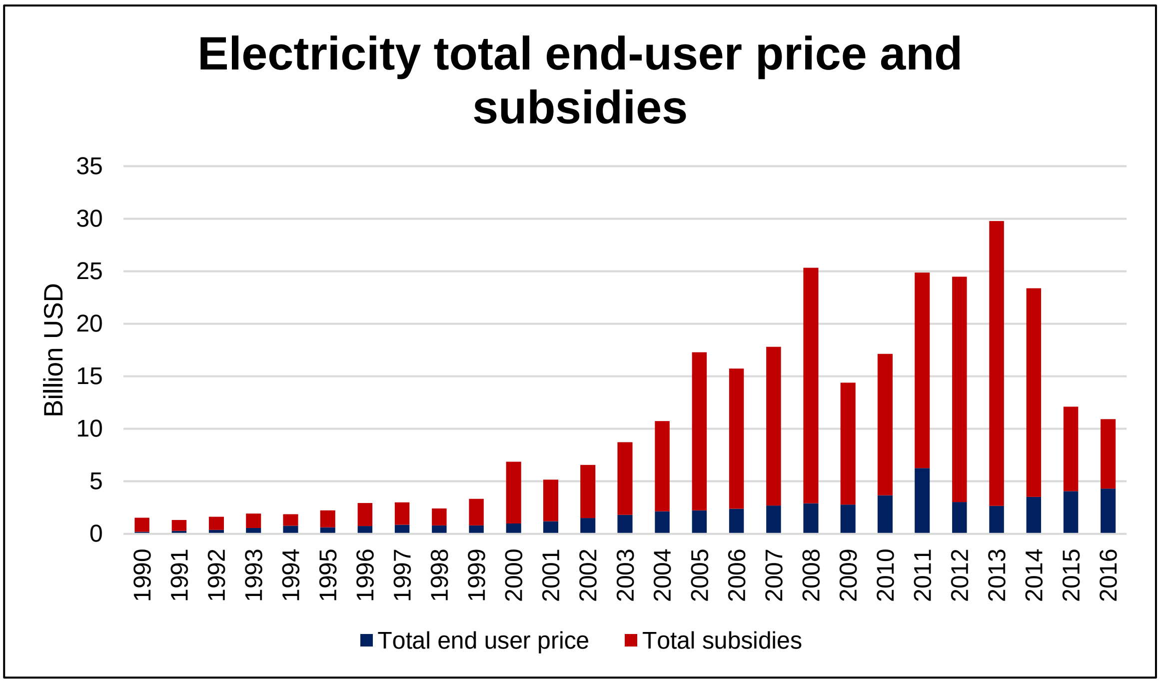

Figure 5-21 Electricity annual total end-user price and total subsidies 1990-2016

Source: Data is collected from (NIGC, 2019, Iran's MOE, 2019, SCI, 2019 and US EIA, 2019)

Electricity total annual end-user price had been increasing for all years before implementing TSA in a steady trend. By implementing TSA, it has been increased sharply more than two times in 2011. There is a decline in annual total end-user price from 2012 and estimated there will be a similar decline from 2018 onward again. These declines are the result of a decline in IRR value against USD while it had increased or remained at the same level in local currency. Total annual subsidies have not had a steady trend. While it is a gap between end-user price and reference price, crude oil price and accordingly electricity generation costs play the main role in the amount of subsidies. (Figure 5-21)

5.1.8 Total consumption

Total energy consumption has been increasing over the years except with two small drops in 2012 and 2015. Energy consumption in RPC sector also has been increasing over the years till 2007, but since 2008, it has started to fall and rise again till 2013. From 2013 onward, it has had an increasing trend. Energy consumption in the industrial sector has been increasing except with two small drops in 2009 and 2015. Energy consumption in the transport sector also has had an increasing trend over the years except with small drops in 1995, 2007, 2010, 2015 and 2016. Agriculture sector energy consumption has not had a steady trend until 2002. From 2002 onward, it has been increasing over the years except with a small drop in 2011. Other energy consumption also has been increasing over the years with some exceptions. (Figure 5-22)

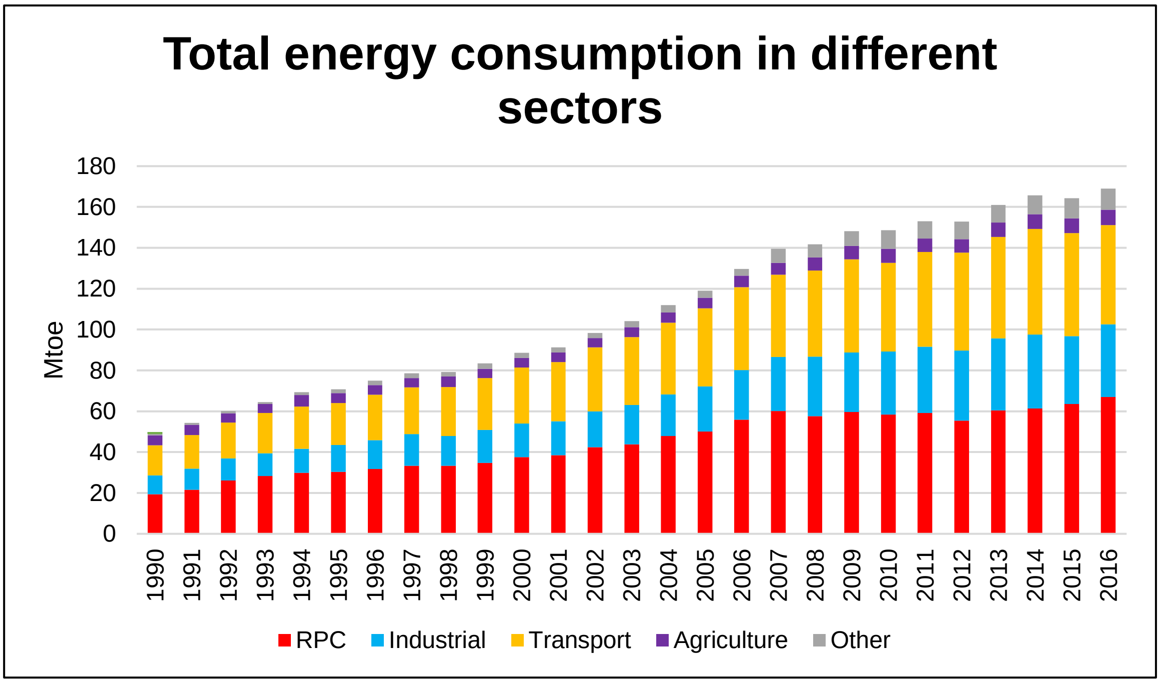

Figure 5-22 Total energy consumption in different sectors for the given energy carriers 1990-2016

Source: Data is collected from (Iran's MOE, 2019)

Figure 5-23 gives a clear picture of the share of each energy carrier over the years. The natural gas share has increased from 11% in 1990 to 56% in 2016. For gasoline, it has remained relatively unchanged and only 0.6 % drop over the years. Diesel fuel share has decreased from 35% in

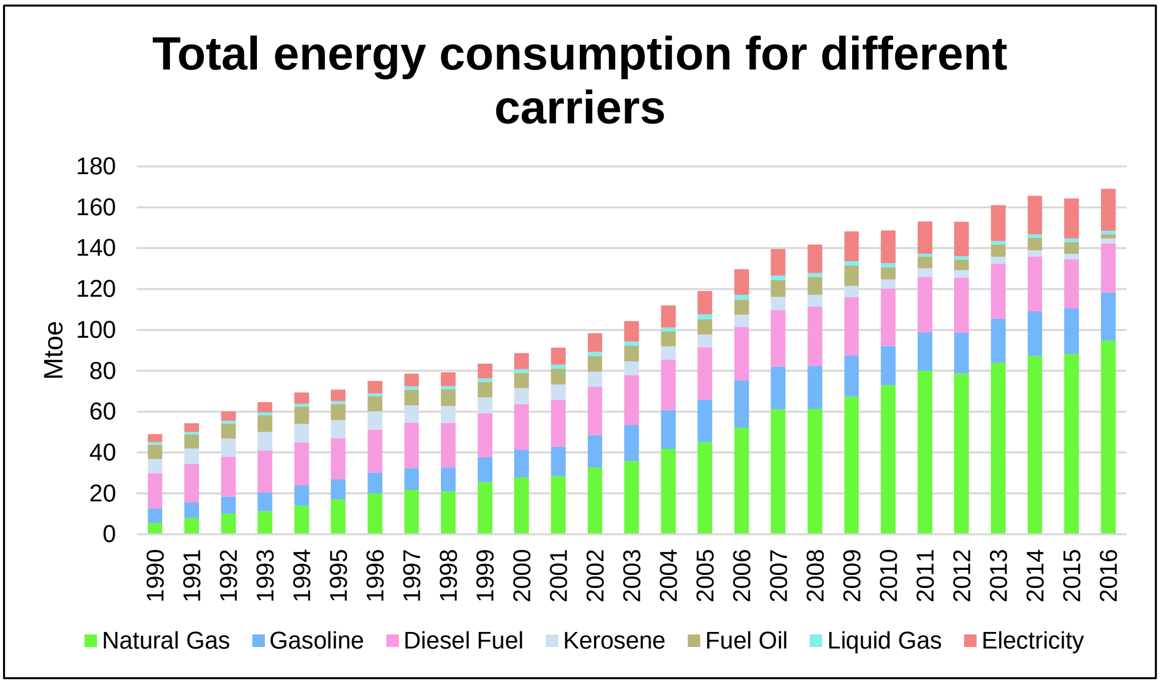

Figure 5-23 Total energy consumption for different carriers 1990-2016

Source: Data is collected from (Iran's MOE, 2019)

1990 to 14% in 2016. Electricity share has increased from 8% in 1990 to 12% in 2016. Kerosene also has experienced a sharp drop in consumption share; from 14% in 1990 to 1.5% in 2016. The same has happened for fuel oil, 14.55% in 1990 and 1.18% in 2016. Liquid gas consumption share has decreased from 2.4% in 1990 to 1% in 2016. This picture displays the substitution of oil products (diesel fuel, kerosene, and fuel oil) with natural gas.

5.1.9 CO_2 emissions

CO_2 emissions follow energy consumption. CO_2 emissions have been increasing over the years steadily with small drops in 2010 and 2015. Where there is a small drop in energy consumption, there is a decline in emissions. It shows that even a small drop in consumption can reduce emissions. (Figure 5-25)

5.2 Total subsidies, GDP and other results

Estimated subsidies are very close to the estimations by IEA. For example, while estimated subsidies are 37.6, 31.3 and USD 45.75 billion USD for 2015, 2016 and 2017, IEA estimations are 46, 29 and 45 billion USD respectively. According to this estimation, Iran has subsidised these seven energy carriers 1202 billion USD from 1990 to 2018. Total subsidies amount follows crude oil price in international markets and end-user price of energy carriers. While from 1991 to 2009, the amount of subsidies had been increased with an increase in crude oil price in international markets. But from 2010 to 2014, the increase in end-user prices was the main factor which played a determinative role. By implementing TSA, end-user prices and accordingly differences between the end-user prices and reference, prices have been decreased which has

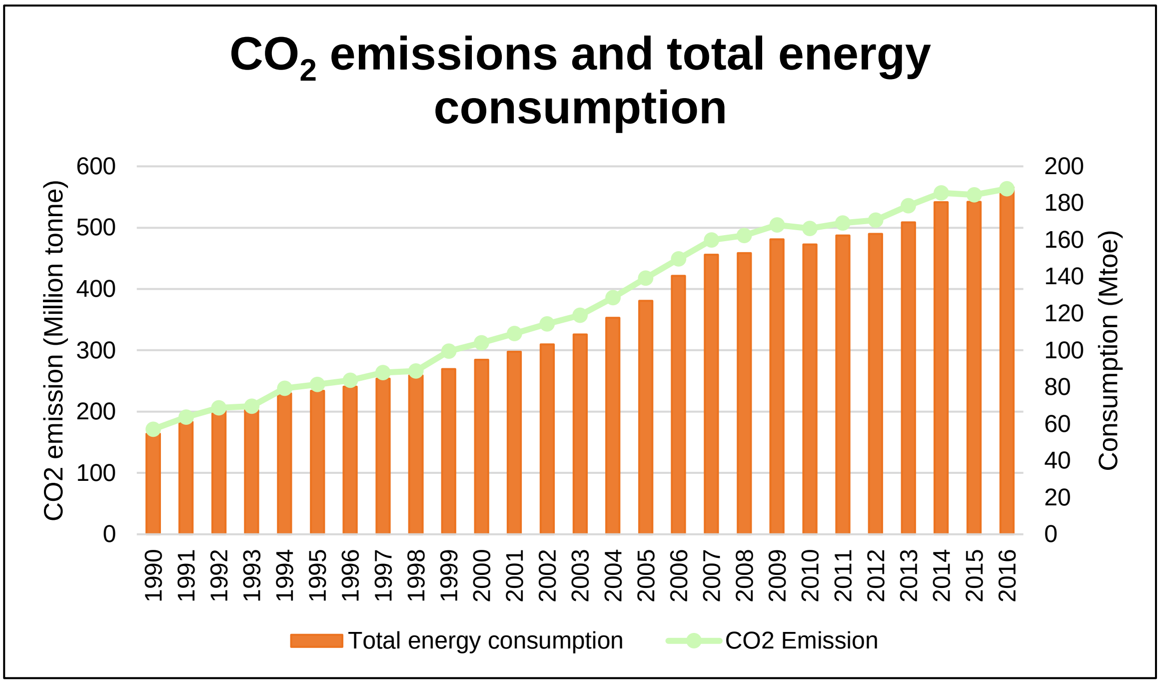

Figure 5-25 CO2 emission from fuel combustion and total energy consumption 1990-2016

Source: Data is collected from (Iran's MOE, 2019, SCI, 2019 and World Bank, 2019)

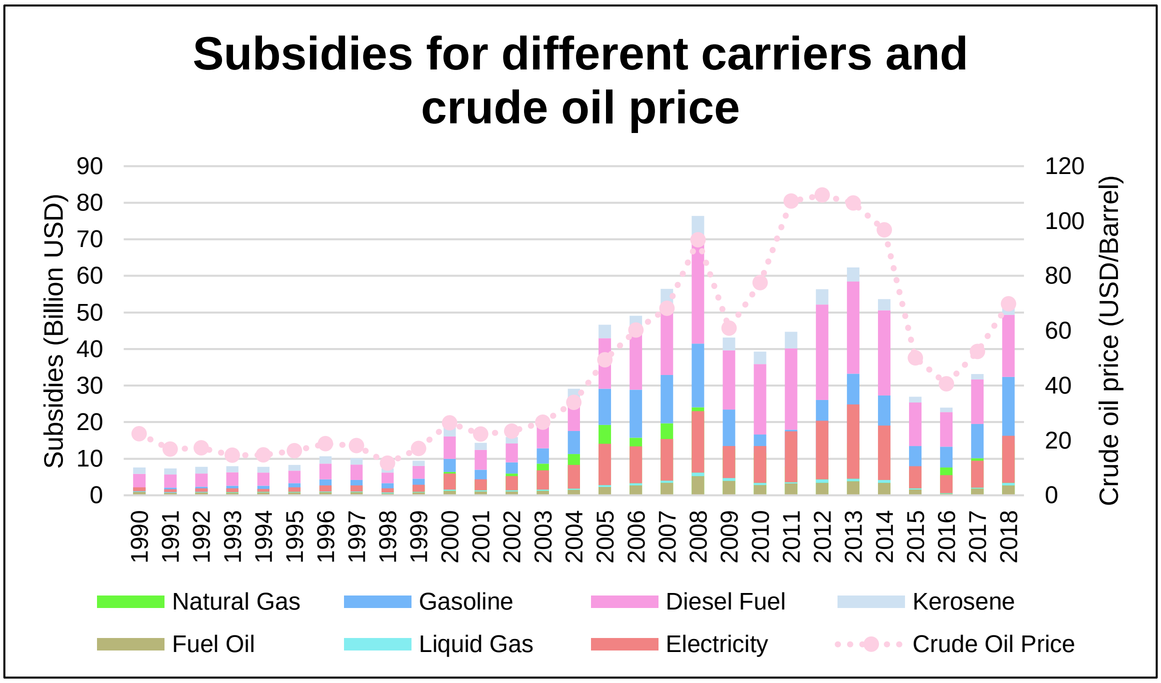

Figure 5-24 Total Subsidies for different carriers and crude oil price 1990-2018

Source: Data is collected from (NIGC, 2019, Iran's MOE, 2019, and US EIA, 2019)

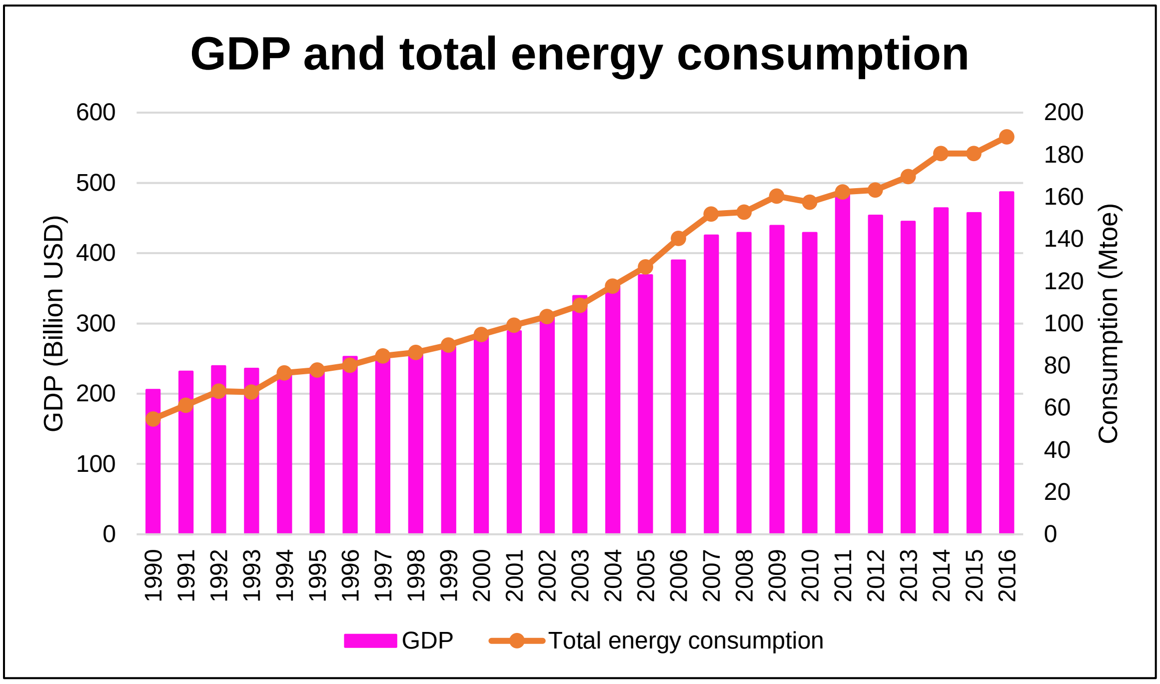

Figure 5-27 GDP and total energy consumption 1990-2016

Source: Data is collected from (Iran's MOE, 2019, SCI, 2019 and US EIA, 2019)

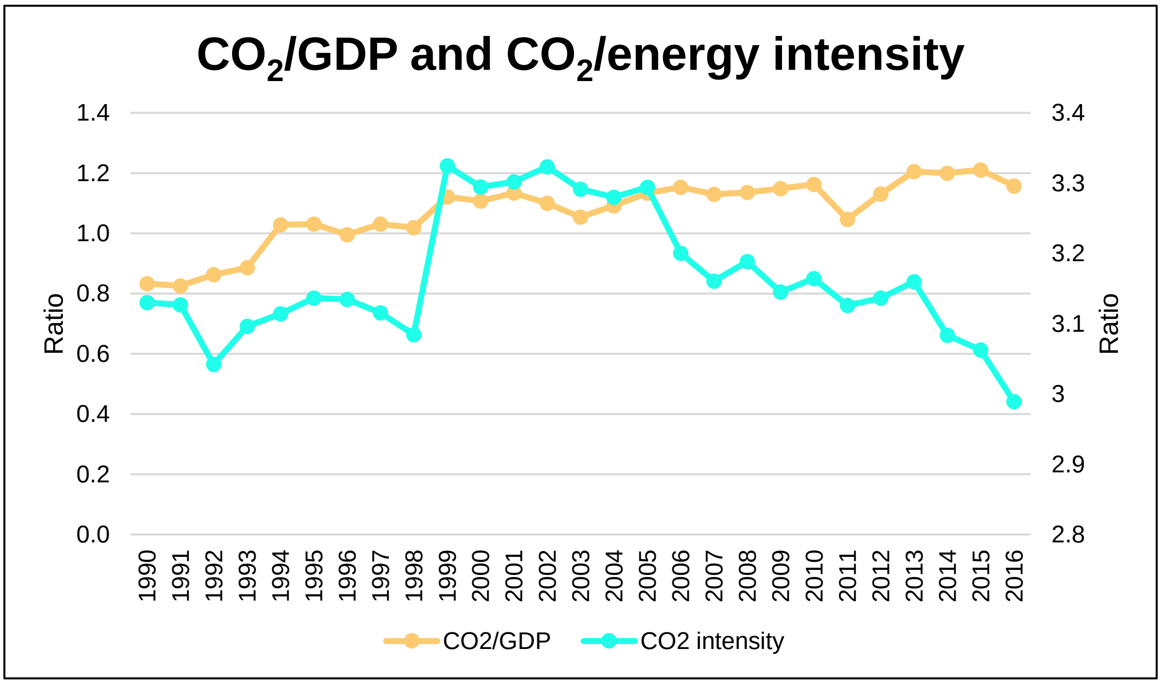

Figure 5-26 CO2/GDP and CO2/energy consumption intensity

Source: Data is collected from (Iran's MOE, 2019, SCI, 2019, US EIA, 2019 and World Bank, 2019) resulted in a decline in subsidies amount. From 2015, by a drop in end-user prices, the amount of subsidies has been following again mainly crude oil price in international markets. (Figure 5-24)

Energy consumption has been following GDP growth rate trend from 1995 to 2005 but from 2006 onward, rate of increase in energy consumption has been more than GDP growth rate except for 2010, where TSA was implemented, energy consumption has dropped and in 2011 GDP growth rate has experienced a higher growth rate than increase in energy consumption. From 2012, the gap between these two rates has been increasing again. (Figure 5-27)

As it was given, the CO_2 intensity of GDP has a steady increasing trend over the years with a few exceptions. It shows that with an increase in GDP, CO_2 emissions increases. CO_2 intensity of GDP has been less than 1 till 1993 but from 1994 onward it was more than 1. This shows that per 1 USD of GDP, CO_2 emissions is more than 1 kg. CO_2 intensity of energy does not follow a steady trend. While it was around 3.1 from 1990 to 1998, there is a sharp increase from 1990 which continues till 2005. From 2006 onward, the CO_2 intensity of energy use has been raising and falling but after that has been facing a decreasing trend. Which demonstrates that while total energy consumption has had an increasing trend, CO_2 emissions has had a decreasing trend from 2006 onward. This shows that per 1 kg of oil equivalent energy use, CO_2 emissions is more than 3 kg. (Figure 5-26)

5.3 TSA targets

TSA has implemented in December 2010 and January 2011 where these targets were set:

Target year: End of the fifth development program, 19 March 2016

Targets:

- Natural gas end-user price should reach to the minimum 75% and maximum equal to the FOB price.
- Oil products end-user price should reach to the minimum 90% and maximum equal to the FOB price.
- Electricity end-user price should be equal to the electricity generation cost.

5.3.1 Natural gas

By implementing TSA in late 2010, natural gas end-user price increased to the 60% of target price in 2011, with a sudden drop in IRR value against USD, the end user price sharply dropped again. There was another wave of getting closer to the TSA targets from 2013 to 2015 which was not only because of increase in end-user prices but mostly it was the result of a drop in crude oil price and accordingly natural gas FOB price in international markets. From 2016 to 2018, the gap between end-user price and TSA target has increased which was the result of both an increase in crude oil price in international markets and another sudden drop in IRR value against USD. (Figure 5-28)

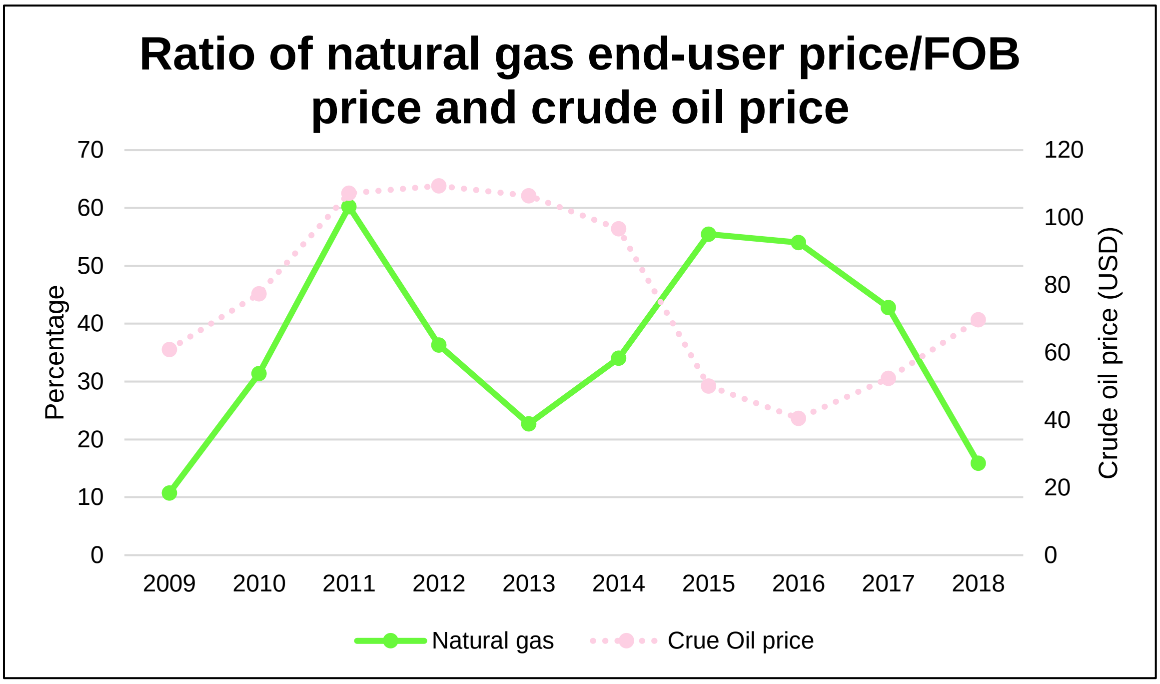

Figure 5-28 Ratio of natural gas end-user price/ natural gas FOB price and crude oil price over 2009-2018

Source: Data is collected from (NIGC, 2019, SCI, 2019, Iran's MOE, and US EIA, 2019)

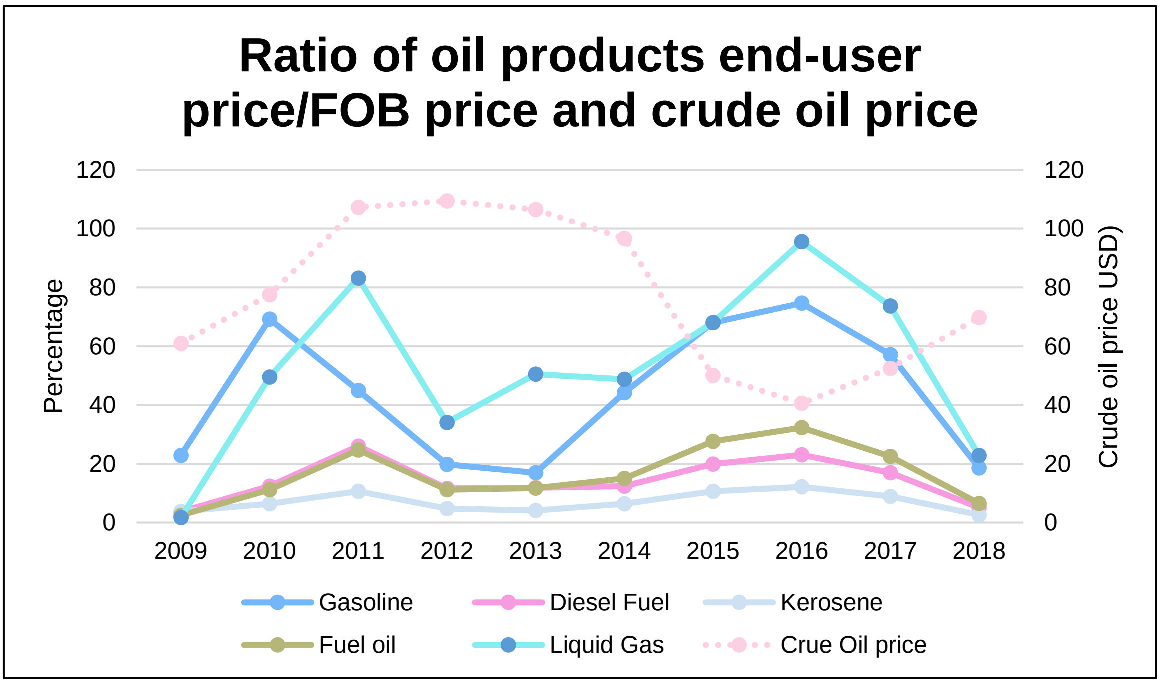

Figure 5-29 Ratio of oil products end user price/ oil products fob price and Crude oil price over 2009-2018

Source: Data is collected from (Iran's MOE, 2019, SCI, 2019 and US EIA, 2019)

5.3.2 Oil products

By implementing TSA in late 2010, oil products end-user prices increased and in case of gasoline and liquid gas, end-user prices were very close to the targets, 69% and 83% respectively, with a sudden drop in IRR value against USD, the end user prices sharply dropped again. There was another wave of getting closer to the TSA targets from 2014 to 2016 which was not only because of increase in end-user prices but mostly it was the result of a drop in crude oil price in international markets and accordingly oil products FOB prices. From 2016 to 2018, the gap between end-user prices and TSA target has increased which was the result of both an increase in crude oil price in international markets and accordingly oil products FOB prices and another sudden drop in IRR value against USD. (Figure 5-29)

5.3.3 Electricity

By implementing TSA in late 2010, electricity end-user price increased and got closer to the target only 5%, with a sudden drop in IRR value against USD, the end user price sharply dropped again from 2012. There was another wave of getting closer to the TSA targets from 2014 to 2016 which was not only because of increase in end-user price but mostly it was the result of a drop in crude oil price in international markets and accordingly oil products and natural FOB prices (electricity generation costs). From 2016 to 2018, the gap between end-user price and TSA target has increased which was the result of both an increase in crude oil price in international markets and accordingly FOB prices and another sudden drop in IRR value against USD. (Figure 5-30)

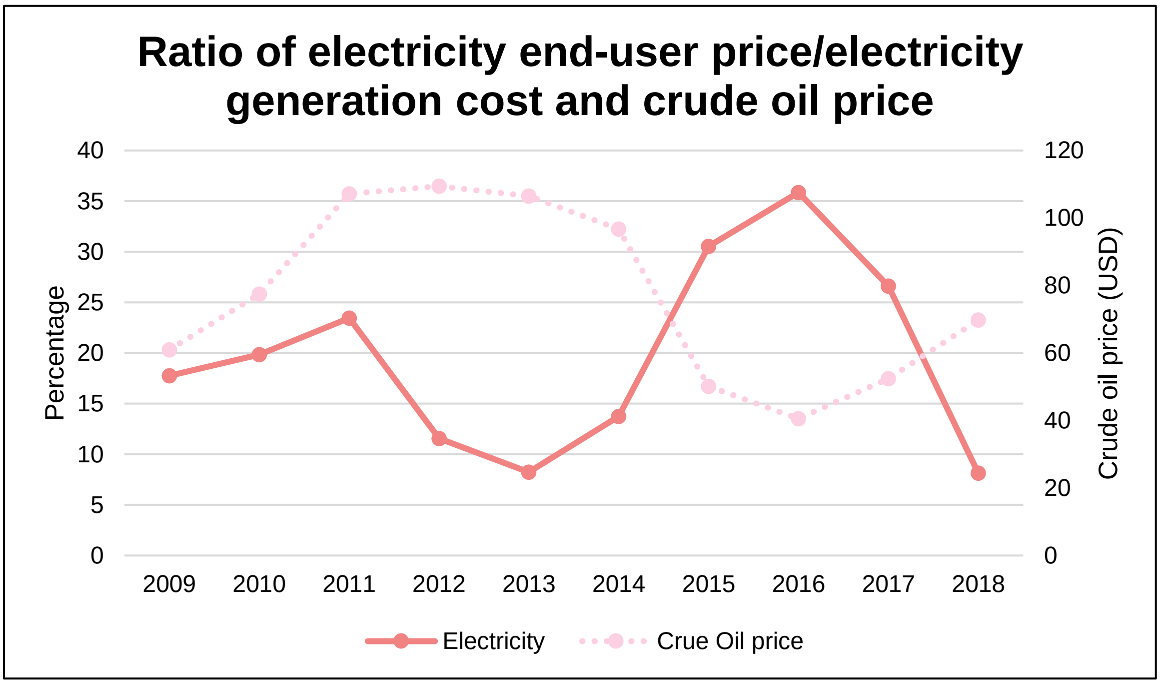

Figure 5-30 Ratio of electricity end-user price/ electricity generation cost and crude oil price 2010-2018

Source: Data is collected from (NIGC, 2019, Iran's MOE, 2019, SCI, 2019, and US EIA, 2019)

5.4 Economic results

5.4.1 The Price Elasticity of Demand

With employing the Price Elasticity of Demand for the years after implementing TSA for different energy carries, the consumer's behaviour in response to changes in the price of an energy carrier will be demonstrated. In Table 5-1; prices and consumption in 2009 are considered as base price and consumption and in Table 5-2; prices and consumption in the year before every given year are considered as base prices and consumption. All other factors are assumed constant.

As Table 5-1 shows:

- Natural gas: Demand for all years was inelastic. The percentage decrease in natural gas consumption was less than the percentage increase in its end-user price (if there was any).
- Gasoline: Demand from 2010 to 2012 was perfectly inelastic. There was no change in gasoline consumption resulting from its end-user price change. Demand from 2013 to 2016, was inelastic. The percentage decrease in gasoline consumption was less than the percentage increase in its end-user price (if there was any).
- Diesel fuel: Demand for all years was perfectly inelastic. There was no change in diesel fuel consumption resulting from its end-user price change.
- Kerosene: Demand for all years was perfectly inelastic. There was no change in kerosene consumption resulting from the end-user price change.
- Fuel oil: Demand for all years was perfectly inelastic. There was no change in fuel oil consumption resulting from its end-user price change.
- Liquid gas: Demand for all years was perfectly inelastic. There was no change in liquid gas consumption resulting from its end-user price change.
- Electricity: Demand from 2010 to 2011 was inelastic. The percentage decrease in electricity consumption was less than the percentage increase in its end-user price (if there was any). Demand from 2012 to 2014 was perfectly inelastic. There was no change in electricity consumption resulting from its end-user price change. Demand from 2015 to 2016, was elastic. The percentage decrease in electricity consumption was greater than the percentage change in its end-user price (if there was any).

Table 5-1. Change in consumption relative to change in price in the given year in relation to 2009

Energy carrier / Year	Natural Gas	Gasoline	Diesel fuel	Kerosene	Fuel oil	Liquid gas	Electricity
2010	0.04198	-0.01881	-0.00309	-0.19251	-0.08239	-0.00096	0.44772
2011	0.04580	-0.03111	-0.00431	-0.06015	-0.02591	-0.00428	0.08697
2012	0.12126	-0.02294	-0.01180	-0.25385	-0.06705	-0.00500	-2.72054
2013	0.22417	0.23363	-0.01213	-0.41361	-0.05480	-0.00393	-1.00334
2014	0.14202	0.03755	-0.01344	-0.25287	-0.04454	-0.00392	-9.88243
2015	0.14495	0.05194	-0.03757	-0.30573	-0.05152	-0.00404	4.50748
2016	0.17976	0.09160	-0.04056	-0.35837	-0.10380	-0.00377	4.14987

Note: datapoints with elastic price are highlighted

Source: Data is collected from (NIGC, 2019, Iran's MOE, 2019, and SCI, 2019)

As Table 5-2 shows:

- Natural gas: Demand from 2010 to 2012 and 2014 to 2015 was inelastic. The percentage decrease in natural gas consumption was less than the percentage increase in its end-user price (if there was any). Demand in 2013, was perfectly inelastic. There was no change in natural gas consumption resulting from its end-user price change. And demand in 2016 was elastic. The percentage decrease in natural gas consumption was greater than the percentage change in its end-user price (if there was any).
- Gasoline: Demand in 2010, from 2012 to 2013 and from 2015 to 2016 was perfectly inelastic. There was no change in gasoline consumption resulting from its end-user price change. Demand in 2011 and 2014, was inelastic. The percentage decrease in gasoline consumption was less than the percentage increase in its end-user price (if there was any).
- Diesel fuel: Demand from 2010 to 2011, was perfectly inelastic. There was no change in diesel fuel consumption resulting from its end-user price change. Demand from 2012 to 2014 and in 2016 was inelastic. The percentage decrease in diesel fuel consumption was less than the percentage increase in its end-user price (if there was any). And demand in 2015 was elastic. The percentage decrease in gasoline consumption was greater than the percentage change in its end-user price (if there was any).
- Kerosene: Demand from 2010 to 2011 and in 2014, was perfectly inelastic. There was no change in kerosene consumption resulting from its end-user price change. Demand from 2012 to 2013 was inelastic. The percentage decrease in kerosene consumption was less than the percentage increase in its end-user price (if there was any). And demand from 2015 to 2016 was elastic. The percentage decrease in kerosene consumption was greater than the percentage change in its end-user price (if there was any).
- Fuel oil: Demand in 2010 and 2011, was perfectly inelastic. There was no change in fuel oil consumption resulting from its end-user price change. Demand in 2012 and 2014

was inelastic. The percentage decrease in fuel oil consumption was less than the percentage increase in its end-user price (if there was any). And demand in 2013 and from 2015 to 2016 was elastic. The percentage decrease in fuel consumption was greater than the percentage change in its end-user price (if there was any).

- Liquid gas: Demand for all years was inelastic. The percentage decrease in liquid gas consumption was less than the percentage increase in its end-user price (if there was any).
- Electricity: Demand in 2010 and from 2014 to 2015 was inelastic. The percentage decrease in electricity consumption was less than the percentage increase in its end-user price (if there was any). Demand from 2011 to 2013 was perfectly inelastic. There was no change in electricity consumption resulting from its end-user price change. And demand in 2016 was elastic. The percentage decrease in electricity consumption was greater than the percentage change in its end-user price (if there was any).

Table 5-2. Change in energy consumption relative to the change in energy price in relation to the previous year

Energy carrier / Year	Natural Gas	Gasoline	Diesel fuel	Kerosene	Fuel oil	Liquid gas	Electricity
2010	0.04198	-0.01881	-0.00309	-0.19251	-0.08239	-0.00096	0.44772
2011	0.13633	0.14954	-0.02105	-0.01719	-0.02834	-0.25792	-0.00214
2012	0.03227	-0.11974	0.01333	0.22812	0.15515	-0.46902	-0.10298
2013	-0.58018	-0.39981	0.02345	0.30921	6.11197	-0.07159	-0.29184
2014	0.08332	0.01153	0.14267	-0.25999	0.14126	-0.30822	0.37594
2015	0.58479	-0.40677	2.14000	1.89284	1.18738	-0.11081	0.30490
2016	1.90211	-1.04297	0.03080	1.33439	12.24977	-0.55083	2.26745

Note: datapoints with elastic price are highlighted

Source: Data is collected from (NIGC, 2019, Iran's MOE, 2019, and SCI, 2019)

5.4.2 Direct cash payments to households

With implementing the TSA, Iran's government committed to transfer 50% savings from FFSR to households as the direct cash payments. This direct cash payment is IRR 455000 per person per month and is transferred to the account of households' head. It was equal to USD 37.77 per person per month in 2011 but has decreased to USD 4.32 per person per month in 2018 while remaining at the same level in local currency. Following this decline, the total amount of direct cash payments has also dropped from USD 34.2 billion in 2011 to USD 4.25 billion in 2018. This cash payments and spending of them causes CO_2 emissions. With multiplying CO_2 intensity of GDP ratio in these direct cash payments, the resulted CO_2 emissions from them is given. (Figure 5-31)

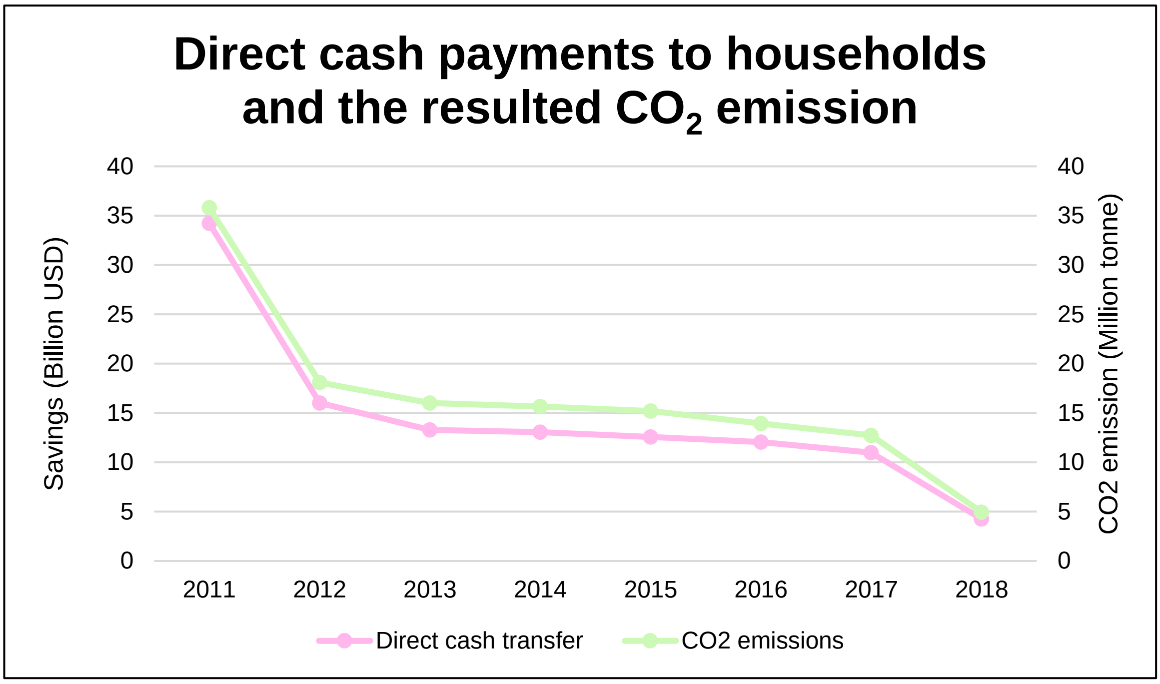

Figure 5-31 Direct cash payments to households and the resulted CO_2 emission

Source: Data is collected from (SCI, 2019, Targeted Subsidies Act, 2011 and World Bank, 2019)

6 Discussion

Every policy, including environmental policies, has both intended and unintended social, economic and environmental impacts. For example, subsidies may help the poor by lowering energy prices, but they also increase consumption and thus increase GHG emissions. In this chapter, I will first discuss whether TSA has implemented as it was aimed in the late 2010s. I will start the evaluation of the TSA policy by discussing the role of Iran's power structure in implementing of TSA and then by applying Mickwirz's framework for evaluating environmental policies to evaluate implemented policy's anticipated and unanticipated effects. Following TSA will be discussed by employing economic frameworks including Price Elasticity of Demand, Cross- Price Elasticity of Demand and Rebound Effect, the role of crude oil prices in international markets on subsidies and finally currency fluctuations in Iran.

6.1 TSA as a policy

Targeted Subsidies Act aimed to increase end-user prices of energy carriers. But as the results of this study show, none of the targets has been reached (except for liquid gas in 2016) to the aimed targets. This means that the TSA has not implemented as it was aimed. Preliminary thought was to check either by achieving TSA targets through an increase in energy end-user prices, whether energy consumption and followingly GHG emissions has decreased or not. But Iran subsidies reform policy has not reached to that point to check this preliminary assumption in relation to reform in FFSs.

6.1.1 Role of Iran's power structure in the implementation of TSA

For discussing the reasons behind this partial implementation of TSA, we need to discuss power structure in Iran. As Figure 6-1 shows, Iran has a very complicated system where the executive branch has not the final call. Both in the policymaking process and influence of economic players, the executive branch does not play the main role. There are many other branches and departments in Iran's power structure which make it difficult to achieve whatever president aims. Above all of these complex branches and departments, Supreme Leader has the final call directly through the official command of orders or through his influences on government's branches and departments because of his role in appointing or confirming most of them directly or indirectly.

After implementing the first phase of TSA, the President lost the Supreme Leader's support and followingly support of other branches and departments. Parliament did not let him implement TSA as it was aimed, and in 2013 with the new administration, an increase in end-user prices of energy carries was stopped. And the amount of direct cash transfer remained at the same level in local currency. This complexity of power structure demonstrates that successful implementing policies such as TSA which might have economic, social and political impacts, needs many considerations including having support from main players in Iran's power structure and persistence implementation over time.

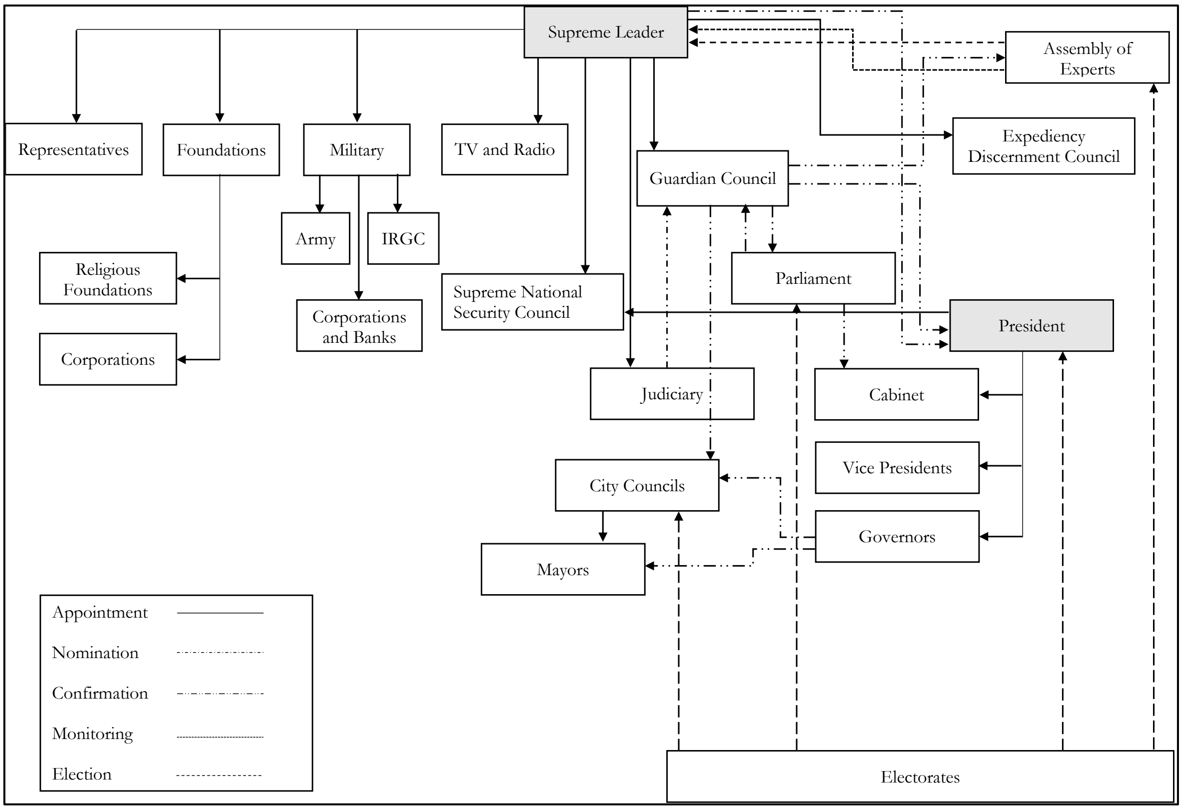

Figure 6-1 Iran's Power Structure

Source: Iran's Constitution (Islamic Parliament Research Centre of the Islamic Republic of Iran, 2019)

6.1.2 Evaluating TSA as an environmental policy

According to Mickwirz's framework for evaluating environmental policies, every environmental policy has anticipated and unanticipated effects. In anticipated effects, and in target area-GHG emissions reduction-; as the results of total energy consumptions and CO_2 emissions from fuel combustions show, with implementing TSA, there is a decline in energy consumption and following a reduction in GHG emissions in 2012. There is no evidence for detrimental effects in this area according to the results of this study. Anticipated effects outside target area are increased environmental knowledge, awareness about the wastefulness of subsidies and necessity of FFSR. The poor benefit from direct cash transfer and can spend it as they want instead of indirect subsidies to the energy carriers where the rich benefits more. Provision of health insurance for those do not have any health insurance from savings from FFSR and other social supports are other anticipated effects outside the target area.

Since this study covers only effects of TSA on energy consumptions and GHG emissions; unanticipated effects are only related to this area. With direct cash payment to households, they spend them in the economy which leads to GDP growth, and followingly an increase in GHG emissions either as a result of fuel combustion or other economic activities.

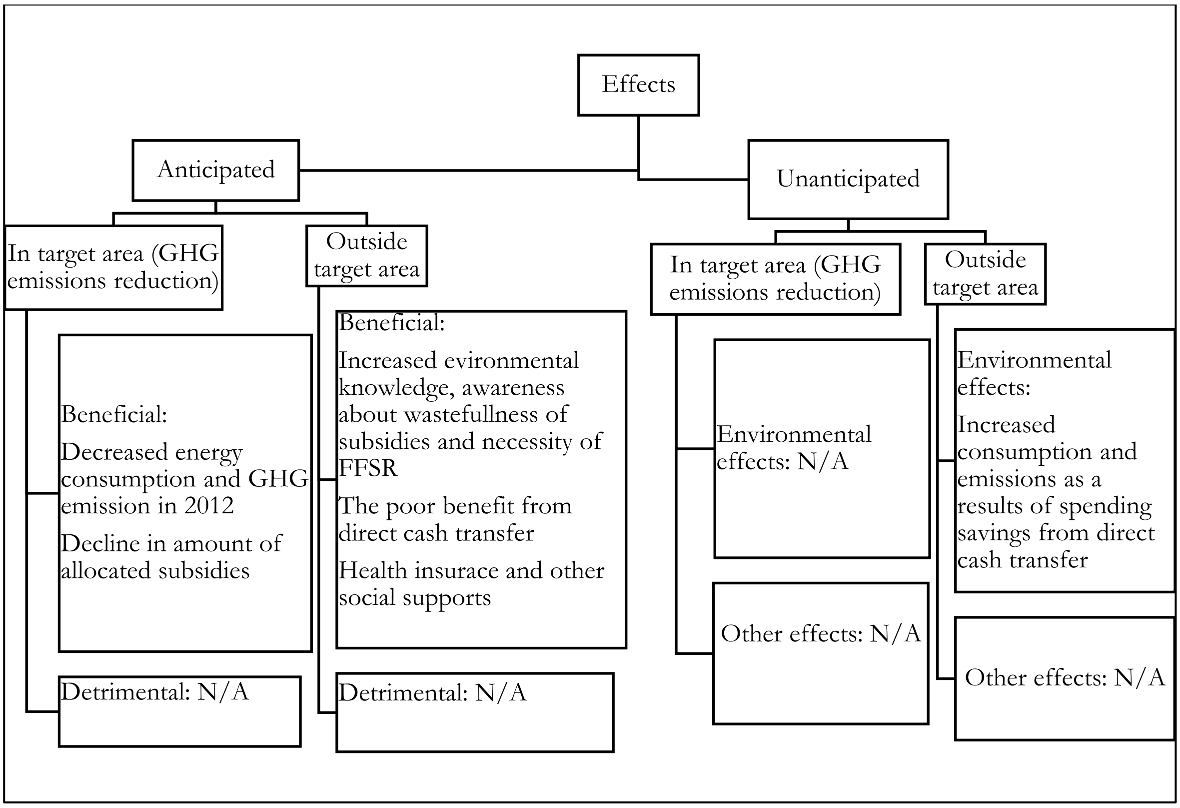

Figure 6-2 TSA as an environmental policy according to the Mickwirz's framework

Source: Data is qualitative analysis of results chapter

6.2 The economy of fossil fuels subsidies reform

Fossil fuels subsidies reform is mainly an economic policy where energy carriers' prices play the main role. End-user prices, FOB prices, subsidies, and direct cash payments are the main component of TSA.

6.2.1 Price elasticity of energy consumption

Price elasticity of energy consumption even with assuming other factors constant, has a swinging trend over years for energy carriers in both scenarios; prices and consumptions in 2009 are considered as initial prices and consumptions and prices and consumptions in the year before every given year is considered as initial prices and consumptions. With considering 2009, as a base year, for all carriers over all years, demand was inelastic or perfectly inelastic except for electricity in 2015 and 2016 which was elastic. This means that the percentage decrease in the energy consumption was less than the percentage increase (if there was any) in the end-user prices or there was no change in energy consumption resulting from the end-user price change. Only in the case of electricity and for the years 2016 and 2016, the percentage change in electricity consumption was greater than the percentage change in the price.

With the second assumption, PED is inelastic except for a few cases. While there was a sharp increase in energy prices in 2010 and 2011, demand for energy is inelastic or perfectly inelastic for these years for all energy carriers in both assumptions. It shows that with increasing energy carriers' end-user prices, consumption has not decreased followingly. It's not obvious that if there was more increase in the prices, demand would be elastic, and consumption will be dropped.

Here I discuss the main determinants of PED. In addition to this point that TSA has not implemented as it was aimed, there are other factors which affect the change in energy consumption.

- The first factor is the availability of substitutes. As we know, TSA was implemented for all energy carriers (fossil fuels) and price of none of them left unchanged. Thus, since was not any substitute to replace them. For example, if Iran had cheaper renewable energy carriers, consumers could replace fossil fuels with cheaper renewables.
- The second factor is the proportion of income the purchase of energy represents. While energy carriers' end-user prices have increased but because of currency fluctuations, and inflations in Iran, the proportion of income that consumers might spend for energy carriers has not only increased, even it has decreased.
- The third factor is whether the energy carrier is a luxury or necessity. Energy is a necessity for consumers. Thus, change in the end-user prices doesn't affect the quantity of demand for energy.
- The fourth factor; consumption of energy carriers became addictive because of their lower prices for years. For this reason, it is difficult for consumers to decrease their consumption.
- The last factor is time. For seeing an elastic in demand of energy carriers, end-user prices need to remain high for a long time. Since TSA has implemented 8 years ago and even during this time period, the end-user prices have not remained high and even in some cases, they decreased, demand for the energy consumption is inelastic and has not decreased.

There is a switch from one energy carrier to another one especially from kerosene and fuel oil to natural gas over the years which has started from the 1990s. Iran has invested heavily in natural gas extraction and refining natural gas and building transmission pipelines across the country from the 1990s. Accessibility and cleanness of natural gas made it better choice especially in RPC sector where households substitute it with kerosene and fuel oil for heating and cooking. Thus, this switch from kerosene and fuel oil to natural gas is not the result of changes in the end-user price of these energy carriers.

6.2.2 Impacts of direct cash payments to households on GHG emissions

While FFSR was implemented to reduce GHG emissions, direct cash payments to the households have led households to spend them in the economy including consuming more energy or other economic activities. TSA not only did reduce GHG emissions but also caused more emissions. As the results shows, households spending from these cash payments on the economy caused more than 132 tonne CO_2 emissions. Thus, the rebound effect is bigger than 1 or it is a backfire.

6.2.3 Crude oil prices and fossil fuels subsidies reform

Crude oil price in international markets is dependent on the law of supply and demand and other economic and political factors. As crude oil price changes, FOB prices of energy carriers also change. According to TSA, the Iranian government aimed to make end-user prices of energy carriers close to the FOB prices over five years.

In the case of natural gas: with implementing of TSA, end-user prices got closer to the target. In 2011, it reached to the 60% of FOB price which was only 15% below the target and created hope that with continuing this trend, prices will be reformed and be closer to the market prices. But from next year, the gap between end-user price and FOB price has increased again and reached 22% of the FOB price. This swinging trend happened one more time again. It shows that natural gas end-user price which was aimed to reach the minimum 75% its FOB price, did not follow the FOB price changes over the years.

In the case of oil products: with implementing of TSA, end-user prices increased and got closer to the FOB prices. Over time, the gap trend between end-user prices and FOB prices of oil products is similar to the natural gas case. But for gasoline and liquid gas, this gap was very small in two periods, once from 2010 to 2011 and the second time from 2015 to 2017. In the case of liquid gas, the end-user price was more than FOB prices in 2016.

Since electricity generation cost is dependent on the prices of input fuels, it changes as crude oil prices and FOB prices of input fuels change. For this reason, the gap between electricity end-user prices and generation costs follows a similar trend as natural gas and oil products.

For all these energy carriers, the gap between end-user prices and FOB prices/generation costs in case of electricity follows the crude oil prices. Whenever crude oil price goes up in the international markets, the gap gets larger and whenever it goes down, the gap gets smaller. While FOB prices of energy carriers have been following the crude oil price in international markets, end-user prices remain at the same level. Determination of the end-user prices by the government on yearly bases which even sometimes does not change and remain constant for several years is in contradiction with the law of supply and demand or even does not follow other factors which might affect energy carriers' end-user prices in a free and liberalized energy market.

6.2.4 Currency fluctuations and subsidy reform

The Iranian energy market is not a liberalized market and government determines energy carriers' end-user prices in local currency. Both official exchange rates and energy carriers' end-user prices are kept artificially lower than the market rate and sometimes, these rates remain constant for several years while IRR loses its value against USD in market and energy carriers' FOB prices change.

Iranian Rials has been losing its value against USD over the years. There are at least four sharp declines in IRR value against USD. The first two happened in the 1990s, one in 2011 and 2012 and the other one in 2018. While with two first declines, there is no sign of a big decline in end-user prices or an increase in the amount of subsidies, but the last two ones have affected both end-user prices and amount of subsidies.

As Figure 6-3 shows, by implementing TSA, energy carriers' end-user prices first increased in 2010 and 2011 and then in 2013 and 2014 in local currency and did not decrease. But Figure 6-4 shows that while energy carriers' end-user prices increased in USD at the same time periods but after both waves, their prices decreased. This demonstrates that as the FOB prices are in USD, changes in end-user prices also need to follow changes accordingly which needs government stop pricing energy carriers and let them determined in the market according to the supply and demand and also their FOB prices.

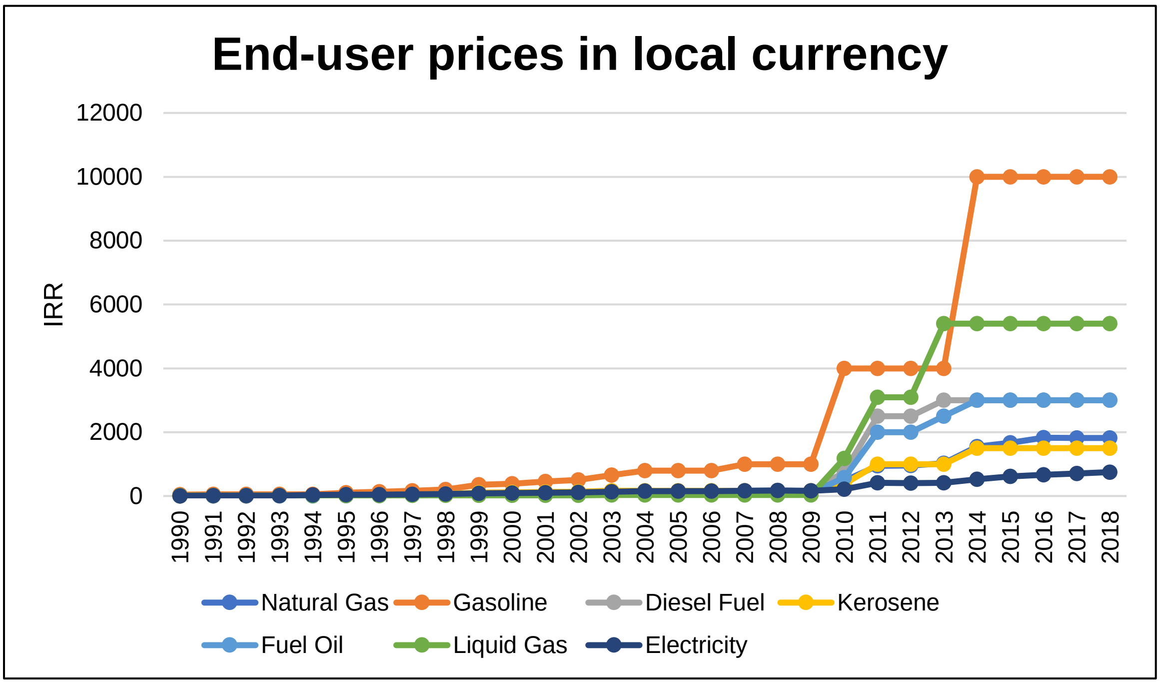

Figure 6-3 End-user prices of energy carriers in local currency 1990-2018

Source: Data is collected from (NIGC, 2019, Iran's MOE, 2019, and SCI, 2019)

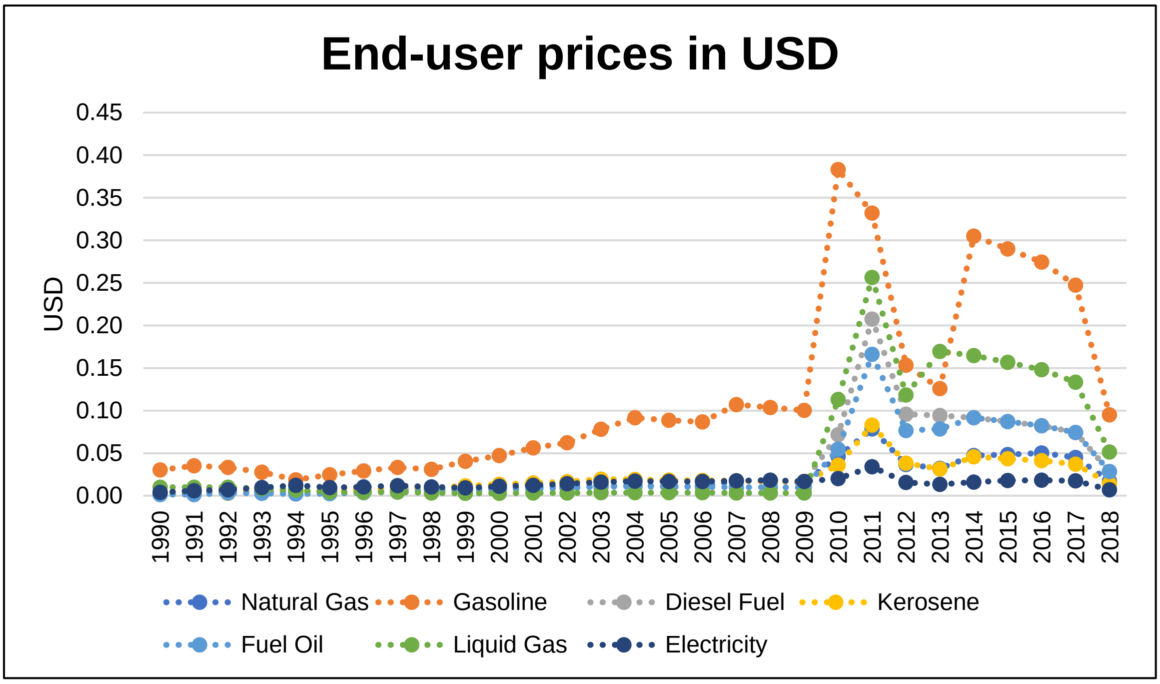

Figure 6-4 End-user prices of energy carriers in USD 1990-2018

Source: Data is collected from (NIGC, 2019, Iran's MOE, 2019, and SCI, 2019)

7 Conclusions

Subsidies are financial intervention policies which are implemented by governments to promote a social policy or an economic sector. FFSs are one type of these intervention policies in many countries particularly in fossil fuels exporting countries to keep energy prices below the market rates. Iran provides the largest fossil fuels consumption subsidies in the world. Iran implemented its first subsidies reform policy in late 2010 and early 2011. TSA was a general reform policy but with a focus on reforming fossil fuels subsidies.

This thesis investigated two main research gaps: firstly, to identify gaps of our understanding and knowledge about whether fossil fuels subsidies reform policies would lead to a decrease in energy consumption and followingly GHG emissions or not, secondly, whether Iran's fossil fuels subsidies reform policy -TSA- has achieved its targets and reduced energy consumption and GHG emissions?

For investigating these gaps: firstly, an overview of worldwide FFSR studies is conducted and their impact on energy consumptions and GHG emissions is evaluated, secondly, a detailed inventory of energy consumptions, subsidies, CO_2 emissions and subsidies reforms is developed, and thirdly, TSA policy is examined against its targets according to the collected data.

Four theoretical frameworks are employed to examine TSA results against its targets. The first theoretical framework evaluates specifically Targeted Subsidies Act' results against its targets. The next three ones are focused on an increase in energy carriers' prices by FFSR, and effects of this increase on the potential reduction of energy consumption and GHG emissions. After selecting related studies, they are sorted and analyzed by employing a synthesis matrix. Collected data are analyzed by employing qualitative analysis in parallel with statistical analysis. Time-series analyses are also used to evaluate energy consumption, CO_2 emissions, and emissions reduction as well as FFSs allocation and the price elasticity of demand.

After reviewing related literatures, developing an inventory of data and applying above-mentioned methods and frameworks, this thesis concludes that:

- Reviewing all studies both in the global and single country levels demonstrate environmental consequences and costs of FFSs and emphasize on implementing FFSR policies. The overall outcome of reviewing these studies shows that implementing FFSR policies leads to GHG emissions reduction.
- Developing an inventory of data indicates that the TSA has not implemented as it was aimed. Except in the case of liquid gas where its end-user price met the targets of TSA in 2016.
- Applying economic frameworks displays that with assuming all other factors constant, with an increase in end-user prices of energy carriers, their consumption has not decreased except for electricity in 2015 and 2016.
- Partial implementation of this policy did not lead to a decrease in energy consumption and GHG emissions reduction.

Recommendations

Reviewing literature shows how different methods, approach and assumptions can lead to different results. Scope, time period, base year, multi-fuel or single fuel reform, approach to estimate subsidies, and implementation of reform policy as a single policy or there were complementary policies in place to mitigate reverse or negative effects of reform policy are the main variables in reaching to different results.

Thus, this thesis recommends:

- For having a successful FFSR, it does not enough to only remove subsidies and increase end-user prices. Governments need to implement many other parallel and complementary policies together to guarantee success of FFSR. These complementary policies are direct cash payment to poor for compensation an increase in energy prices, investing savings from subsidies reform in health, education and infrastructure especially public transport, redirecting savings from subsidies reform to energy efficiency programs and promoting renewable energies including putting in place feed-in-tariff programs, investing in R & D, subsidizing electricity generation from renewable sources, providing free or lower interest rate loans, regulatory reform, fossil fuel taxing, emission trading and emission caps.
- National decision-makers need to consider their domestic social, environmental, political and economic context and implement the most appropriate package of policies. Global decision makers in IEA, United Nations Framework Convention on Climate Change, United Nations Environment Program and other international bodies need to come together and design an umbrella policy for national FFSR policies to mitigate their reverse effects.
- Good governance plays a critical role in successful implementing of reform FFSR. As Iran's power structure demonstrates, administrative branch needs to have full support from other governmental branches and departments to implement FFSR. Thus, like other policies, FFSR needs to be implemented when rule of law, freedom from corruption, effectiveness and regulatory quality are guaranteed.
- Energy market needs to be liberalised and end-user prices are determined by the law of supply and demand.
- Every successful FFSR policy needs to adopt these steps in process of implementation: adopting best practices in subsidy measurement, eliminating inappropriate subsidies, conducting subsidy impact studies, implementing adjustment packages, learning from successful case studies and recognizing political economy.

Implications

Researchers can use the findings of this thesis in their future studies. Researchers can benefit both from the literature review and case study results. This study gives a comprehensive understanding of different approaches to study subsidies reform policies and the set of the condition in which these policies can be implemented successfully. The case study can be applicable to study FFSR policies in other countries especially energy exporting countries with a large amount of oil and natural gas sources. I suggest other researchers to work on these kinds of case studies which can help to understand drivers, barriers and implications of FFSR policies in practice.

Policy makers in Iran can use the results of this study to know the strengths and weaknesses of TSA, improve its strengths and resolve its weaknesses. Policy makers in other countries, especially energy exporting countries can use findings of this thesis in designing their FFSR policies.

Bibliography

Acar, S., & Yeldan, A. E. (2016). Environmental impacts of coal subsidies in Turkey: A general equilibrium analysis. *Energy Policy*, *90*, 1–15. https://doi.org/10.1016/j.enpol.2015.12.003

Barkhordari, S., & Fattahi, M. (2017). Reform of energy prices, energy intensity and technology: A case study of Iran (ARDL approach). *Energy Strategy Reviews*, *18*, 18–23. https://doi.org/10.1016/j.esr.2017.09.004

British Petroleum. (2018). BP Statistical Review of World Energy. https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2018-full-report.pdf

Burniaux, J.-M., & Chateau, J. (2014). Greenhouse gases mitigation potential and economic efficiency of phasing-out fossil fuel subsidies. *International Economics*, *140*, 71–88. https://doi.org/10.1016/j.inteco.2014.05.002

Coady, D., Parry, I., Sears, L., & Shang, B. (2017). How Large Are Global Fossil Fuel Subsidies? *World Development*, *91*, 11–27. https://doi.org/10.1016/j.worlddev.2016.10.004

Ellis, J. (2010). The Effects of Fossil-Fuel Subsidy Reform: A Review of Modelling and Empirical Studies. IISD. https://www.iisd.org/library/effects-fossil-fuel-subsidy-reform-review-modelling-and-empirical-studies

Farajzadeh, Z., & Bakhshoodeh, M. (2015). Economic and environmental analyses of Iranian energy subsidy reform using Computable General Equilibrium (CGE) model. *Energy for Sustainable Development*, *27*, 147–154. https://doi.org/10.1016/j.esd.2015.06.002

Friends of Fossil Fuel Subsidy Reform (FFFSR). (2015). Fossil Fuel Subsidy Reform and the Communiqué: Briefing Note. http://fffsr.org/wp-content/uploads/2015/06/fffsr_information_for_policymakers-1.pdf

Gharibnavaz, M. R., & Waschik, R. (2015). Food and energy subsidy reforms in Iran: A general equilibrium analysis. *Journal of Policy Modeling*, *37*(5), 726–741. https://doi.org/10.1016/j.jpolmod.2015.07.002

Gelan, A. (2018). Economic and environmental impacts of electricity subsidy reform in Kuwait: A general equilibrium analysis. *Energy Policy*, *112*, 381–398. https://doi.org/10.1016/j.enpol.2017.10.032

Gerasimchuk, I., Bassi, I., & Merril, L. (2017). Zombie Energy: Climate benefits of ending subsidies to fossil fuel production. IISD. https://www.iisd.org/library/zombie-energy-climate-benefits-ending-subsidies-fossil-fuel-production

Group 20. (2011). Joint report by IEA, OPEC, OECD and World Bank on Fossil-Fuel and Other Energy Subsidies: An Update of the G20 Pittsburgh and Toronto Commitments. Technical Report. www.oecd.org/site/tadffss/49006998.pdf

Grubb, M. J. (1990). Communication Energy efficiency and economic fallacies. *Energy Policy*, *18*(8), 783–785. https://doi.org/10.1016/0301-4215(90)90031-X

Guven, S., & Mcphail, M. (2013). *Beyond the Cost Model : Understanding Price Elasticity and Its Applications*. https://www.casact.org/pubs/forum/13spforum/Guven_McPhail.pdf

Hassanzadeh, E. (2012). Recent Developments in Iran's Energy Subsidy Reforms. https://www.iisd.org/gsi/sites/default/files/pb14_iran.pdf

International Energy Agency (IEA). 2015. World Energy Outlook Special Report: Energy and Climate Change. www.iea.org/publications/.../WEO2015SpecialReportonEnergyandClimateChange.pdf

International Energy Agency (IEA). 2017. Fossil-fuel subsidies. https://www.iea.org/weo/energysubsidies/

International Monetary Fund. 2019. Reforming Energy Subsidies. https://www.imf.org/external/np/fad/subsidies/

Iran's Ministry of Energy. (2019). Energy data. http://pep.moe.gov.ir/

Islamic Parliament Research Centre of the Islamic Republic of Iran. (2019). Iran's Constitution. http://rc.majlis.ir/fa/content/iran_constitution

Jewell, J., McCollum, D., Emmerling, J., Bertram, C., Gernaat, D. E. H. J., Krey, V., … Riahi, K. (2018). Limited emission reductions from fuel subsidy removal except in energy-exporting regions. *NATURE*, *554*(7691), 229–233. https://doi.org/10.1038/nature25467

Jiang, Z., &Lin, B. (2011). The perverse fossil fuel subsidies in China—The scale and effects. Energy. 70, 411-419 https://doi.org/10.1016/j.energy.2014.04.010

Kojima, M., Koplow, D. (2015). Fossil fuel subsidies: approaches and valuation.World Bank Group Policy Research Working Paper 7220 (March). https://www.iea.org/weo/energysubsidies/

Li, J., & Sun, C. (2018). Towards a low carbon economy by removing fossil fuel subsidies? *China Economic Review*, *50*, 17–33. https://doi.org/10.1016/j.chieco.2018.03.006

Lin, B., & Jiang, Z. (2011). Estimates of energy subsidies in China and impact of energy subsidy reform. *Energy Economics*, *33*(2), 273–283. https://doi.org/10.1016/j.eneco.2010.07.005

Lin, B., & Li, A. (2012). Impacts of removing fossil fuel subsidies on China: How large and how to mitigate? *Energy*, *44*(1), 741–749. https://doi.org/10.1016/j.energy.2012.05.018

Lin, B., & Ouyang, X. (2014). A revisit of fossil-fuel subsidies in China: Challenges and opportunities for energy price reform. *Energy Conversion and Management*, *82*, 124–134. https://doi.org/10.1016/j.enconman.2014.03.030

Liu, W., & Li, H. (2011). Improving energy consumption structure: A comprehensive assessment of fossil energy subsidies reform in China. *Energy Policy*, *39*(7), 4134–4143.

https://doi.org/10.1016/j.enpol.2011.04.013

Merrill, L., Bridle, R., Klimscheffskij, M., Tommila, P., Lontoh, L., Sharma, S., … Gerasimchuk, I. (2017). *Making the switch: from fossil fuel subsidies to sustainable energy*. Copenhagen: Nordic Council of Ministers.

Merrill, L., Harris, M., Casier, L., & Bassi, A. M. (2015). *Fossil-Fuel Subsidies and Climate Change : Options for policy-makers within their Intended Nationally Determined Contributions*. Nordisk Ministerråd. Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:norden:org:diva-3744

Mickwitz, P. (2006). Environmental policy evaluation: Concepts and Practice. Published by The Finnish Society of Sciences and Letters https://tampub.uta.fi/bitstream/handle/10024/67570/978-951-44-9424-6.pdf?sequence=1

Mousavi, B., Lopez, N. S. A., Biona, J. B. M., Chiu, A. S. F., & Blesl, M. (2017). Driving forces of Iran's CO2 emissions from energy consumption: An LMDI decomposition approach. *Applied Energy*, *206*, 804–814. https://doi.org/10.1016/j.apenergy.2017.08.199

Mundaca, G. (2017). How much can CO2 emissions be reduced if fossil fuel subsidies are removed? *Energy Economics*. 64, 91-104.

https://www.sciencedirect.com/science/article/pii/S0140988317300804

Myers, N., Kent, J. (2001). Perverse subsidies: how tax dollars can undercut the environment and the economy. Washington, DC: Island Press. ISBN 1-55963-835-4 https://www.imf.org/external/np/fad/subsidies/pdf/note.pdf

National Iranian Gas Company. (2019). Natural Gas prices. http://mgd.nigc.ir/Portal/Home/ShowPage.aspx?Object=NEWS&CategoryID=00ed3328-ac75-4562-8072-ac0e3b0c3762&WebPartID=8b739096-145e-4156-a8cd-16557d943053&ID=1810243f-a202-4a75-b61e-a80aa060d647

Saunders, H. D. (2008). Fuel conserving (and using) production functions. *Energy Economics*, *30*(5), 2184–2235. https://doi.org/10.1016/j.eneco.2007.11.006

Stefanski, R. (2016). Into the mire: A closer look at fossil fuel subsidies. *The School of Public Policy Publications, Vol 9, Iss 10, Pp 1-45 (2016)*, (10), 1. https://doi.org/10.11575/sppp.v9i0.42575

Schwanitz, V. J., Piontek, F., Bertram, C., & Luderer, G. (2014). Long-term climate policy implications of phasing out fossil fuel subsidies. *Energy Policy*, *67*, 882–894. https://doi.org/10.1016/j.enpol.2013.12.015

Sohaili, K. (2010). Analysis of Electricity Subsidies Removing in Iran on Air Pollution by Using of VECM. *Procedia Environmental Sciences*, *2*, 252–255. https://doi.org/10.1016/j.proenv.2010.10.030

Sovacool, B. K. (2017). Reviewing, Reforming, and Rethinking Global Energy Subsidies: Towards a Political Economy Research Agenda. *Ecological Economics*, *135*, 150–163. https://doi.org/10.1016/j.ecolecon.2016.12.009

Statistical Centre of Iran. (2019). Energy and Emission Data.

https://www.amar.org.ir/%D9%BE%D8%A7%DB%8C%DA%AF%D8%A7%D9%87-%D9%87%D8%A7-%D9%88-%D8%B3%D8%A7%D9%85%D8%A7%D9%86%D9%87-%D9%87%D8%A7/%D8%B3%D8%B1%DB%8C%D9%87%D8%A7%DB%8C-%D8%B2%D9%85%D8%A7%D9%86%DB%8C/agentType/ViewType/PropertyTypeID/1

United Nations Framework Convention on Climate Change. (2015). What is the Paris Agreement? https://unfccc.int/process-and-meetings/the-paris-agreement/what-is-the-paris-agreement

US Energy Information Administration. (2019). Free on Board prices of crude oil, oil products and natural gas https://www.eia.gov/dnav/pet/PET_PRI_SPT_S1_A.htm

Wang, Y., Ali Almazrooei, S., Kapsalyamova, Z., Diabat, A., & Tsai, I.-T. (2016). Utility subsidy reform in Abu Dhabi: A review and a Computable General Equilibrium analysis. *Renewable and Sustainable Energy Reviews*, *55*, 1352–1362. https://doi.org/10.1016/j.rser.2015.07.099

Welker, J. (2013). Introduction to Elasticities and Price Elasticity of Demand https://econclassroom.com/lesson/3-1-introduction-to-elasticities-and-price-elasticity-of-demand/

Wesseh, P. K., & Lin, B. (2016). Refined oil import subsidies removal in Ghana: A 'triple' win? *Journal of Cleaner Production*, *139*, 113–121. https://doi.org/10.1016/j.jclepro.2016.08.010

Whitley, S., & van der Burg, L. (2018). Reforming Fossil Fuel Subsidies: The Art of the Possible. In H. van Asselt, J. Skovgaard (Ed.), *The Politics of Fossil Fuel Subsidies and their Reform* (1st ed., pp. 47–65). Cambridge University Press. https://doi.org/10.1017/9781108241946.005

World Bank. (2019). Country Data: Iran, Islamic Rep. https://data.worldbank.org/country/iran-islamic-rep?view=chart

Yusoff, N. Y. bte M., & Bekhet, H. A. (2016). The Effect of Energy Subsidy Removal on Energy Demand and Potential Energy Savings in Malaysia. *Procedia Economics and Finance*, *35*, 189–197. https://doi.org/10.1016/S2212-5671(16)00024-1