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Toward an Efficient Residential Electricity Consumption: An Assessment of the Effectiveness of Residential Electricity Efficiency-Incentive Subsidies Reform in Saudi Arabia

Ramzi Alahmadi
Department of Industrial Engineering
Taibah University
AL Madinah, Saudi Arabia
rlahmadi@taibahu.edu.sa

Abstract

Energy subsidies are commonly used by governments for many social and economic objectives. In some rich countries, energy products are supplied to beneficiaries at subsidized prices as a way of wealth-sharing. Despite the objectives of energy subsidies, they have critical impacts on the efficiency of energy use. Saudi Arabia, which previously heavily subsidized fuel and electricity prices, recently reformed its energy subsidies as an incentive by which to increase the efficiency of domestic energy consumption. This paper estimates the impact of the residential electricity subsidy reform in Saudi Arabia. The price-gap approach is applied in this paper to estimate the cost of electricity subsidies in 2018 if the electricity prices remained unchanged. Additionally, the impact of the price gap removal on the elasticity of demand is estimated in order to measure the efficiency of current residential electricity consumption. Residential electricity subsidies accounted for 0.8% of Saudi Arabia's GDP in 2017, which is equivalent to 5.382 billion USD. It is estimated that the energy subsidy reform will lower the government residential electricity subsidy bill by 52%. In addition, the efficiency of electricity consumption is estimated to increase and, thus, result in a 22,031 GWh decline in electricity demand.

Keywords
Energy subsidies reform, Electricity consumption efficiency, Price-gap approach, Price elasticity of demand

1. Introduction

Saudi Arabia is a Middle Eastern country with a relatively low population. It is internationally recognized as the world's top oil exporter. Saudi Arabia is home to an estimated 268.5 billion barrels of oil reserves (MEIM, 2019). Prior to January 1, 2018, the government of Saudi Arabia used to heavily subsidize the domestic consumption of energy. Energy products were supplied to the residents at lower prices than the international market's prices (Mehrara, 2007). Table 1 shows the subsidized prices of some energy products in Saudi Arabia. These subsidies were considered an opportunity loss for the country since the domestically consumed oil resources could be sold at full price in the international market (Gately et al., 2012). Additionally, many drawbacks are believed to arise from subsidizing energy prices, such as over consumption and energy products being smuggled across borders.

One major avenue of the domestic consumption goes to generating electricity, which counts for 39% of the energy consumption in Saudi Arabia (Alowaidh & Alnutifi, 2010). In 2017, more than 45% of the electricity consumption in Saudi Arabia was residential (Figure 1) (ECRA, 2019). The low prices of electricity are believed to have negatively influenced consumer behavior by encouraging unwise and inefficient electricity use (Alnatheer, 2005). Thus, the government of Saudi Arabia recognized the need to reform the energy subsidy program, especially after oil prices fell in 2016, which limited the country's financial resources since the country's economy is highly dependent on oil exports. In response to this situation, a 5% value-added tax (VAT) was imposed to all local sale of goods, including oil products. Additionally, the prices of energy products were increased and brought closer to the international market prices starting January 1, 2018 (Table 1). This paper will only estimate the impact of residential electricity subsidies reform in Saudi Arabia due to the limitation of data availability of the other sectors.

Two parallel subsidy programs were utilized to offset the economic and social impact of the energy subsidy removal. The first program had a limited one-year duration, where each government employee was given a monthly 1,000 Saudi Riyal (~ $267) increase in salary to reduce the impact of the transition to the new energy prices. The second subsidy program, called "Hisab Almowaten," is meant to support poor and middle-class citizens with an increased living cost. The program provides financial support based on each citizen's marital status, number of dependents, household members, and monthly income in order to mitigate the influence of the VAT and increased energy prices.

Table 1. Energy Prices in Saudi Arabia, (Electricity & Co-generation Regulatory Authority (ECRA) & Ministry of Energy, Industry and Mineral Resources (MEIM), 2019)

	Before January 1, 2018		After January 1, 2018	
	Amount of Consumption (kWh)	Consumer Price (USD/kWh)	Amount of Consumption (kWh)	Consumer Price (USD/kWh)
Electricity kWh				
Residential	1 - 2000 2001 - 4000 4001 - 6000 >6000	0.013 0.027 0.053 0.08	1-6000 >6000	0.048 0.08
Commercial	1 - 4000 4001-8000 >8000	0.43 0.064 0.08	1-6000 >6000	0.053 0.08
Agricultural	1 - 4000 4001-8000 >8000	0.027 0.032 0.43	1-6000 >6000	0.043 0.053
Industrial		0.048		0.048
Governmental	Any Consumption Amount	0.085	Any Consumption Amount	0.085
Hospitals & Institutions		0.048		0.048
Gasoline $/Liter				
Octane rating (91)	Any Consumption Amount	0.2	Any Consumption Amount	0.365
Octane rating (95)		0.24		0.54
Diesel $/Liter				
Industrial	Any Consumption Amount	0.088	Any Consumption Amount	0.10
Transportation		0.125		0.12

Note: 3.75 Saudi Riyals = USD1.00. Conversion rate is used for conversion between currencies

The energy subsidies reform program in Saudi Arabia was essential for the country's economic well-being as its goal was to lessen the fiscal burden of the energy subsidies bill and increase the efficiency of domestic energy consumption. To the best of my knowledge, the effectiveness of this reform program has not been studied and quantified by any other researchers. Therefore, this paper will estimate the monetary value of the fiscal policy reform of residential electricity prices. Additionally, the impact of the residential electricity subsidies reform on the elasticity of demand will be examined in order to estimate the expected change in the consumers' consumption behaviors.

The remainder of this paper is structured as follows. Section 2 will discuss related literature via a literature review. The study's research methodology and framework are explained in Section 3. The results are discussed in Section 4, while the conclusion and recommendations are presented in Section 5.

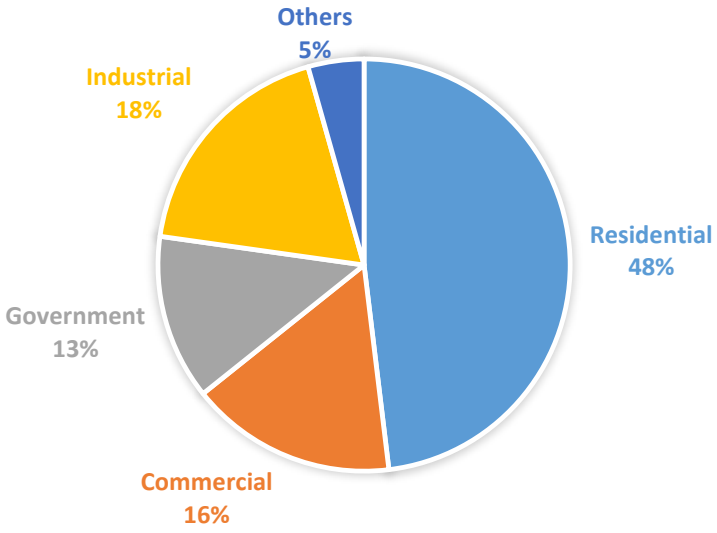

Figure 1. 2017 Distribution of Electricity Consumption in Saudi Arabia by Sector, ECRA, (2019)

2. Related Literature Review

2.1 Definition of Energy Subsidies

Energy subsidies are defined as government financial support that is directly paid to the energy producer or user (Lin & Jiang, 2011). A more general definition of an energy subsidy is any form of government support that results in increased revenues for the energy suppliers, reduced cost of energy generation, or reduced charges to the energy user (Lin & Jiang, 2011). According to Lin and Jiang, (2011, p. 10), "the fundamental principles of energy subsidies focus on who, what, how, and how much. Therefore, energy subsidies should be considered under four essential frameworks: object, scope, manner, and amount." Subsidies can be direct or indirect. They are direct if they are given in the form of endowments or tax returns, while they are indirect if paid, for example, to support the advancement of energy technology and energy projects. In China, for instance, both direct and indirect subsidies are available for the energy sector (Lin & Jiang, 2011). Subsidies can be paid directly or indirectly to either the consumer or producer. On the consumer side, subsidies are mostly paid directly by controlling the cost of purchasing energy or lowering the user's taxes. However, on the producer side, the subsidies could be directly paid as tax reductions or indirectly, such as through supporting R&D of renewable energy resources (Ouyang & Lin, 2014).

2.1 Objectives and Effectiveness of Energy Subsidies

Figure 2 presents estimated global post-tax subsidies in 2013. Energy subsidies were estimated at $4.9 trillion or 6.5% of the global GDP (Coady et al., 2017). Energy subsidies are commonly offered to the energy sectors for many objectives, such as attempting to lower the expenditures of households, mainly for the poor (Saboohi, 2001; Mehrara, 2007; Lin & Jiang, 2011). However, energy subsidies are mainly enjoyed by the rich. Additionally, energy subsidies are believed to be promoting unwise and inefficient consumption behavior, (Lin & Jiang, 2011; Ouyang & Lin, 2014). In China, for instance, the low and high-income classes represent 22.1% and 9% of population, respectively, and enjoy 10.1% and 18.6% of the energy subsidies (Lin & Jiang, 2011). In addition, energy subsides in some countries are meant to encourage access to modern energy sources, such as electricity in households (Dube, 2003; Ouyang & Lin, 2014). In energy-rich countries, energy subsidies are considered a way by which to sharing the wealth of natural resources (IMF, 2014). Finally, in some countries, subsiding the domestic energy supply is intended to support industrial development and economic growth; however, the impact of the removal of energy subsidies can be mitigated by other programs, such as the two subsidy programs that were initiated by the Saudi Arabian government mentioned above.

A better use of the fiscal benefits of the removal of energy subsidies can be achieved by offsetting the impact of the removal of the subsidies on economic growth. The economic impact of the removal of subsidies can reduced by converting financial resources to investments in sectors that create increased inclusive growth, such as education, healthcare, and infrastructure (IMF, 2014), and subsidizing renewable energy development, which promotes innovation in renewable energy's technology and industry. In China in 2010, for example, re-allocating subsidies from fossil fuel to renewable energy increased the portion of renewable energy in the energy system by 0.04% for every 0.02% reduction in coal use. (Ouyang & Lin, 2014).

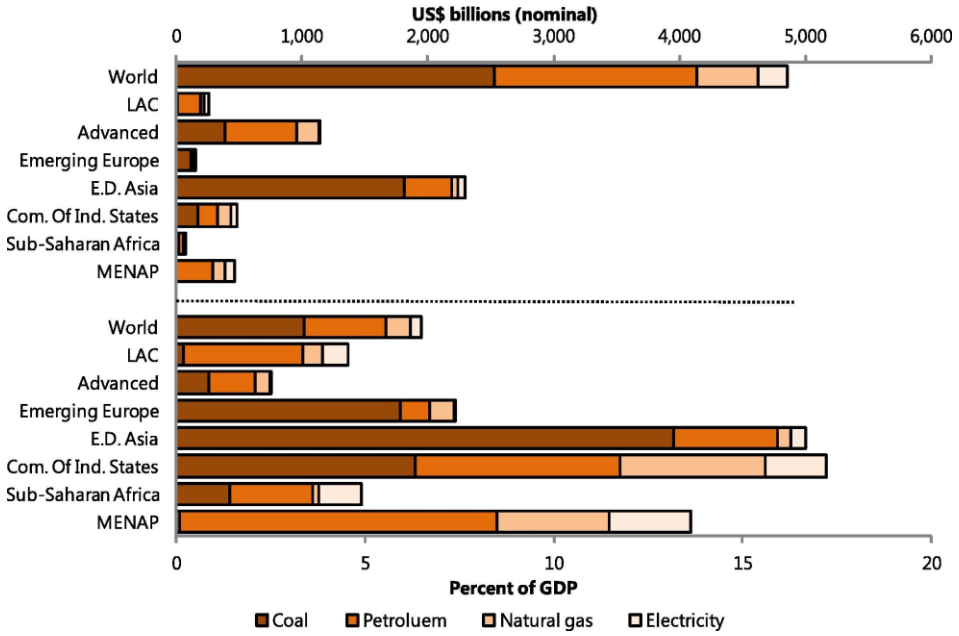

Figure 2. 2013-Post-Tax Subsidies by Region and Product, Coady et al. (2017)

The literature referring to energy subsidies in Saudi Arabia is limited to a study conducted by the IMF in 2014. In 2013, it was estimated that the Gulf Cooperation Council (GCC)-Kuwait, Oman, Qatar, Bahrain, United Arab Emirates and Saudi Arabia spent about $160 billion on energy subsidies, which is nearly 10% of their GDP combined. Saudi Arabia, alone, paid about 50% of the energy subsidies provided by the GCC. A significant portion of the energy subsidies in Saudi Arabia used to be spent to support the residential electricity sector, causing inefficient consumption of electricity. It is estimated that, on average, a person residing GCC countries who has subsidized electricity prices, consumes four times the energy amount globally consumed on average per capita (Alnaser & Alnaser, 2009; Alnaser & Alnaser, 2011). Electricity consumption in Saudi Arabia is growing quickly, and if it continues, will impose many economic and environmental challenges on Saudi Arabia. Shaahid et al. (2013) suggested that electricity companies in Saudi Arabia are challenged to cope with the surge of electricity consumption, as well. Therefore, analyzing the impact of the residential electricity subsidies reform on the electricity demand in the residential sector in Saudi Arabia is important to estimating its effectiveness in regard to reducing residential electricity demand and the fiscal benefits of the electricity subsidies reform.

3. Methodology

Figure 3 demonstrates the methodological framework that was used to estimate the impact of the residential electricity subsidies reform in Saudi Arabia. First, residential electricity consumption data was collected. Second, the price-gap approach was used to estimate the residential electricity subsidies bill if the subsidies remained unchanged in order to quantify the financial resources spent in this sector. Third, the elasticity of demand in response to the subsidies reform was used to measure its impact on the electricity demanded in the residential sector. After that, the residential electricity subsidies bill was measured based on the reformed electricity prices and expected decrease in consumption behaviors. Finally, the results were summarized.

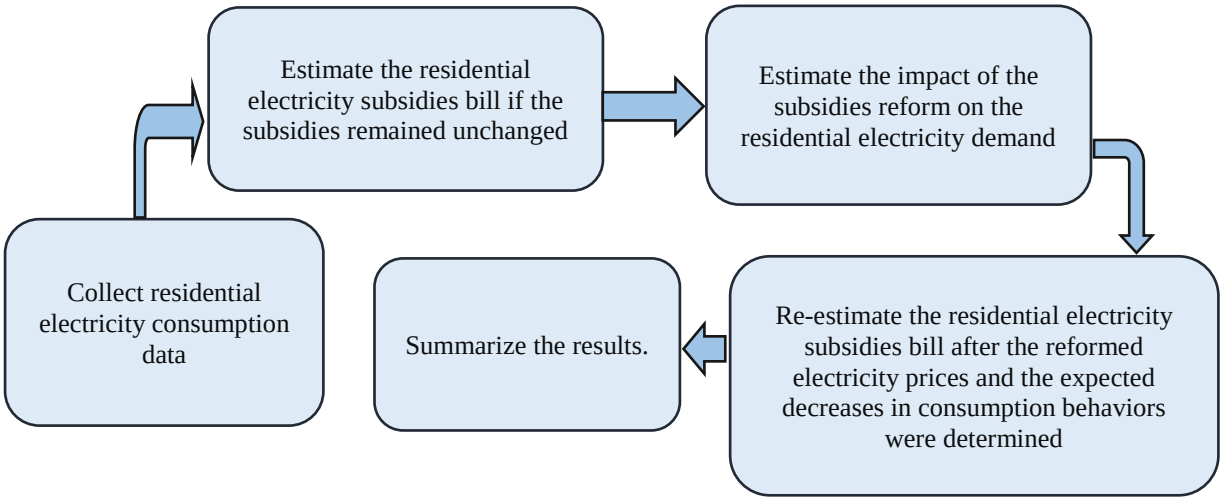

Figure 3. Proposed Research Methodological Framework.

3.1 Price Gap Approach and Price Elasticity of Demand

The price gap approach was first proposed theoretically by Corden (1957). According to Wang and Lin (2016), the price gap approach was, recently, the most common performed procedure used to estimate energy subsidies. In addition, the price gap approach is simple to use when the data are available (Lin & Jiang, 2011). Therefore, the price gap approach was utilized in this paper to estimate the fiscal loss that would be incurred by the Saudi Arabian government if the residential electricity subsidies remained unchanged. The price gap is computed as follows:

$$Price\ gap = reference\ price - consumer\ price. \quad (1)$$

Here, the reference price is the price of the services or goods without being subsidized, which can be set either by matching the domestic service or goods price with the price in a similar international market, or by using the cost curve of production, which is given by the long-run marginal cost curve. On the other hand, consumer price is the actual cost of the services or goods paid by the consumer, which is one of the price gap method limitations because it only captures the direct subsidies for the consumer (Lin & Jiang, 2011).

Next, the computed price gap is utilized to analyze its effect on the efficiency of the residential electricity consumption. The responsiveness of electricity demand to a change in the supply price is quantified using the elasticity of demand function. This method was proposed by the International Energy Agency (IEA) (1999). The impact of the price gap on the efficiency of electricity consumption is specified as follows:

$$\frac{Q_1}{Q_0} = \left(\frac{P_1}{P_0}\right)^{\varepsilon}, \quad (2)$$

which can be given in the following form:

$$\ln Q_1 - \ln Q_0 = \varepsilon \text{ x } (\ln P_1 - \ln P_0), \quad (3)$$

where Q_1, P_1 are the consumption quantity and prices after the subsidies reform; Q_0, P_0 are the consumption quantity and prices before the subsidies reform; and ε is the coefficient of the demand elasticity.

Therefore, the effectiveness of the subsidies reform related to increasing efficient consumption behavior is measured by the equation:

$$\Delta Q = Q_0 - Q_1. \quad (4)$$

Finally, the price gap method was utilized, again, to estimate the fiscal gain of the residential electricity subsidies reform accrued by the price and consumption changes.

4. Results and Discussion

4.1 Estimates of Residential Electricity Subsidies

Two data sets with the base year 2017 were used to estimate the bill for the residential electricity subsidies in Saudi Arabia using the price-gap approach: the total electricity consumption and its end-user price and the residential electricity reference prices, which are determined by the average electricity production cost. Detailed statistics related to the distribution of residential electricity consumption were obtained from ECRA (2017). Residential electricity used to be sold to consumers at different prices based on consumption brackets. For example, 1 KWH was sold to consumers for 1.3 cents if the monthly consumption fell within the 1-2,000 kWh consumption bracket (Table 1). Reinforcing the point made by Lin and Jiang (2011) that rich people enjoy significant share of energy subsidies while it is meant to help the middle-income class and the poor, mainly, Figure 4 shows that 1.9% of households, which are assumed to be of a high-income class based on their consumption level, consume 26.2% of the total residential electricity in Saudi Arabia, while 55.6% of households only use 26.2% of the total electricity consumption in the country.
Additionally, Figure 4 illustrates that 11.8% of residential electricity accounts in Saudi Arabia do not consume any electricity, which is confusing, yet explainable. In 2003, a royal decree number 115 was released by the government of Saudi Arabia, which was mainly meant to give residents in the rural areas access to electricity. The royal decree has declared that electricity should be delivered to any building or structure used by any person. Over the years, most of the people living in rural places moved to cities seeking healthcare services, higher education and jobs for their families, and many other reasons, and, thus, the rural houses were left empty, and this explains the 11.8% unused subscriber accounts.

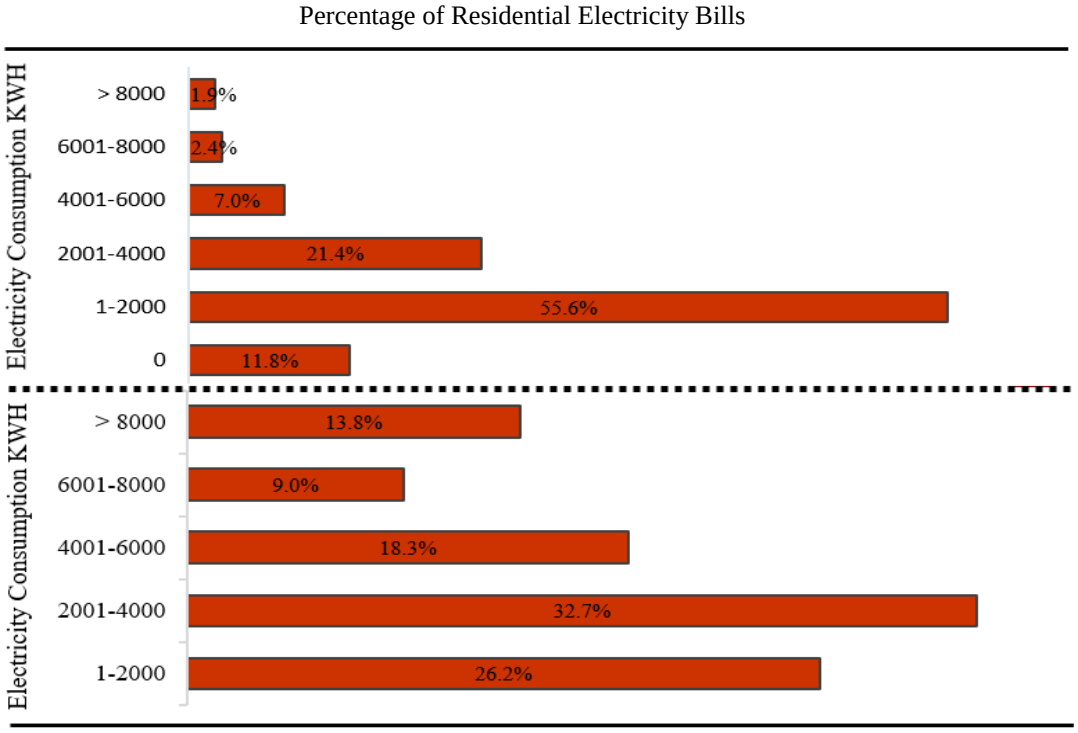

Figure 4. Distribution of Residential Electricity Consumption Based on 2017 Data, ECRA, (2019)

Residential electricity reference price when defined based on the production cost varies depending on fuel prices. Due to data limitations, the reference price for producing residential electricity in 2017 was assumed to be the average production cost of 7.70 cents/kWh, which was originally estimated for 2015 by Matar and Anwer (2017). This assumption is expected to be adequate because the average fuel prices in 2015 were comparable to the prices in 2017.

Residential electricity prices and consumption levels for different consumption brackets were compared with the reference price using the price-gap approach. Using the consumer prices listed in Table 1 and the distribution of residential electricity consumption illustrated in Figure 4, the estimates of the incurred subsidies bill of residential electricity in Saudi Arabia for 2017 were divided into different consumption brackets as seen in Figure 5. The results in Figure 5 show that the high electricity consumers, which are assumed to be of the high-income class, are not enjoying residential electricity subsidies as had been thought. Electricity is sold to them at just about the production cost and only a minor profit margin is acquired. On the other hand, the electricity consumers in the 1-2000, 2001-4000, and 4001-6000 consumption classes received 44.7%, 43.6%, and 11.7% of the total residential electricity subsidies, respectively. Therefore, it is believed that the recent residential electricity subsidies reform was targeting the lowest three consumption brackets because of their significant influence on the electricity subsidies bill. Additionally, these three consumption brackets amounted to 77.2% of the consumed residential electricity in Saudi Arabia, as shown in Figure 4, which means that the responsive reduction of electricity demand to prices reform would be significant.

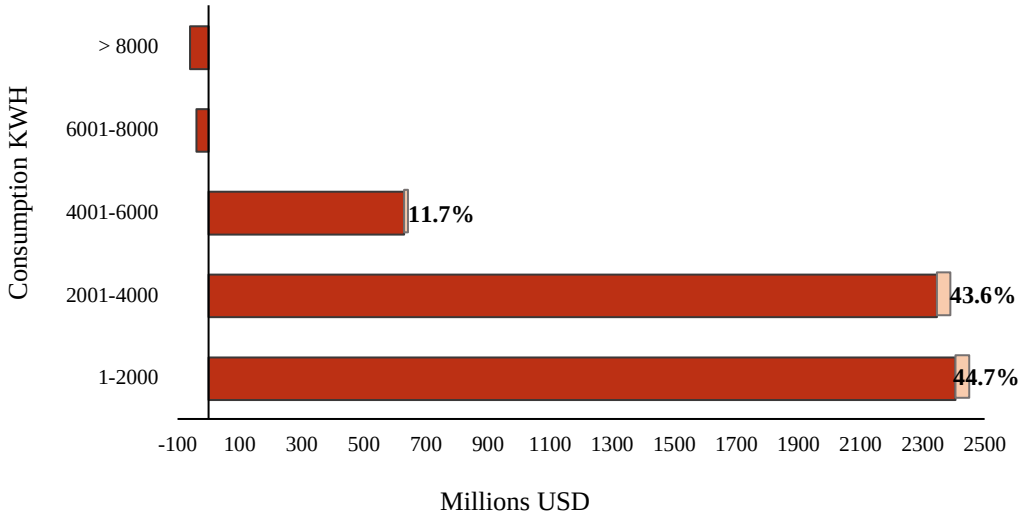

Figure 5: Pre-Subsidy Reform Residential Electricity Subsidy Bill Distribution

4.2 Price Elasticity of Residential Electricity Demand and its Impact on the Saudi Arabian Residential Electricity Subsidies Bill

Atalla and Hunt (2016) estimated the price elasticity of residential electricity demand in Saudi Arabia to be equal to -0.16. Therefore, a 100% increase in electricity prices is estimated to yield a 16% reduction in electricity demand, which is insignificant and of limited impact. Nevertheless, a residential electricity demand elasticity to electricity prices analysis was carried out in order to quantify the fiscal gain of the electricity subsidies reform.

The results in Figure 6 show that the electricity prices reform did not have an influence on the highest two consumption brackets, 6001-8000 and >8000 KWH, which was expected because the electricity prices remained the same for these two consumption levels. On the other hand, the recent electricity prices reform was expected to have a negative impact on the 4000-6000 KWH consumption bracket because its price would be decreased and, thus, might motivate inefficient consumption behaviors. The greatest benefit of the electricity prices reform was expected to take place in

the lowest two consumption brackets: 1-2000 KWH and 2001-4000 KWH. The electricity prices reform should bring a total of 22,031 GWH reduction in residential electricity demand as illustrated in Figure 6.

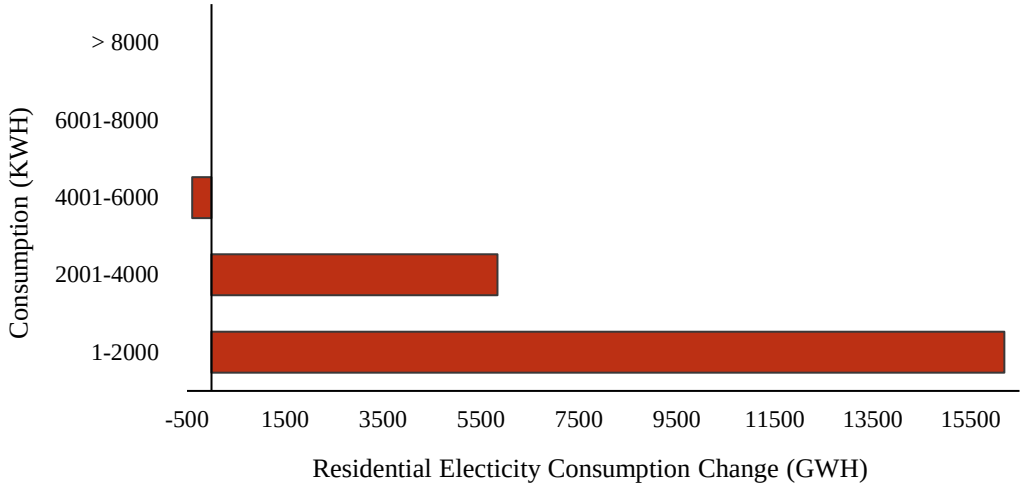

Figure 6: Post-Subsidy Reform Electricity Consumption Reduction Distribution

Next, the price-gap approach was used to estimate the fiscal gain of the electricity prices reform on the residential subsidies bill. Before the reform, the residential electricity subsidies bill was 5.382 billion USD (2017), which was equivalent to 0.8% of Saudi Arabia's GDP. Figure 7 shows the impact of the electricity subsidy reform on the residential subsidies bill. It is estimated that the subsidy reform will yield a 52% decline in the subsidies bill from 5.382 billion USD to 2.584 billion USD based on the 2017 data and the fiscal gain of the electricity subsidy reform program is estimated to be 2.8 billion USD.

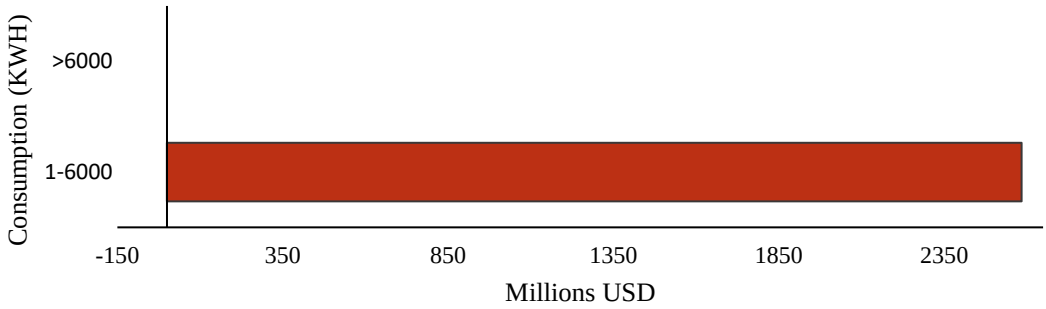

Figure 7: Post-Subsidy Reform Residential Electricity Subsidy Bill

5. Conclusions and Recommendations

Saudi Arabia has recognized the need to increase its energy consumption efficiency and decrease the economic burden of its energy subsidies. To this end, it established an energy subsidy reform program on January 1, 2018. In addition to the economic gains that could occur due to a subsidy reform program, the efficient use of energy results in environmental benefits as it lowers CO_2 emissions released by the generation and use of energy. However, many researchers have suggested that monetary interventions related to inefficient energy consumption has a limited long-term impact on consumption behaviors. Therefore, it has been suggested that non-price interventions, such as providing feedback to the consumers about their consumption, can result in a better long-term benefits. Nevertheless, the energy subsidy reform in Saudi Arabia has certainly yielded significant fiscal gains by reducing the subsidy bill, even if the reform program will have a limited long-term impact on increasing the efficiency of energy consumption.

In this paper, the price-gap approach and price elasticity of demand method were applied in order to study the effectiveness of the residential electricity efficiency incentive subsidy reform in Saudi Arabia. The price-gap approach is widely used to quantify deviations in commodity prices in a country compared with the world. On the other hand, the price elasticity of demand is a popular economic measure used to evaluate the responsiveness of consumer behavior toward price changes on the cost of goods and services. The analysis in this paper shows that the recent energy subsidy reform is expected to yield a decline in the residential electricity subsidy bill and electricity demand by 2.8 billion USD and 22,031 GWh, respectively. For future research, similar studies on other energy sectors are needed in order to assess the overall effectiveness of the energy subsidy reform in Saudi Arabia compared with the two new subsidy programs created in Saudi Arabia.

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Biography

Ramzi Alahmadi is an assistant professor and chair of the Industrial Engineering Department at Taibah University in Saudi Arabia. He earned a B.S. in Mechanical Engineering from Taibah University; Master of Science in Industrial Engineering from the University of Pittsburgh in Pittsburgh, Pennsylvania, in the United States; and Ph.D. in Industrial Engineering from Texas Tech University in Lubbock, Texas, in the United States. He teaches many courses in the engineering management field. His research interests include energy systems management, service and operation management, simulation, and project management.