Energy Policy 132 (2019) 332–343

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Electricity tariff reforms, welfare impacts, and energy poverty implications

Romeo Pacudan[a,b,*], Mahani Hamdan[a]

[a] Institute of Policy Studies (IPS), Universiti Brunei Darussalam (UBD), Brunei
[b] Brunei National Energy Research Institute (BNERI), Brunei

ARTICLE INFO

Keywords:
Electricity tariff reform
Increasing block tariff (IBT)
Declining block tariff (DBT)
Welfare loss
Energy poverty
Brunei Darussalam

JEL classification:
D10
D40
D60
H20
L94
Q40
Q48

ABSTRACT

Like other energy-exporting countries, Brunei Darussalam has pursued an energy pricing policy that sets energy prices below market rates. The country introduced tariff reforms replacing the declining block tariff (DBT) scheme by an increasing block tariff (IBT) structure in 2012. The reform, however, was a rate structure change and not a subsidy removal, and electricity tariffs in the country remained lower than the long-run marginal cost. The study investigated a subsidy removal scenario, setting the tariff rate at the short-run marginal cost which is around 200% higher than the current average tariff rate. The results show that with IBT, welfare losses and the increase in electricity expenditures would be high for non-poor households; for those living in urban areas and for those engaged in white-collar jobs, and it would have been the reverse had the government not introduced tariff rate structure reforms. Under price elasticity scenarios, welfare losses would be high under inelastic than elastic demand case for both IBT and DBT cases. Electricity expenditures, however, would remain below 5% level – far lower than the energy poverty threshold level of 10% of household income. The tariff structure reform, therefore, shielded the lowest-income households from potential impacts of subsidy removal.

1. Introduction

Prices of energy commodities in Brunei Darussalam, like other net energy-exporting countries, diverge from market-based prices and do not fully reflect supply costs. Electricity tariffs do not reflect the long-run marginal cost (LRMC) of electricity production. Other energy commodities in the country are highly subsidised.[1] In addition, petroleum product prices have not changed in the last 10 years and electricity tariff for residential consumers also remained unchanged since the introduction of tariff structure reforms in 2012, which replaced the declining block tariff (DBT) scheme with the increasing block tariff (IBT) structure. The OECD/IEA (2017) estimated that total subsidies in 2015 represented around 1.5% of the country's gross domestic product (GDP).

Energy subsidies, as experienced by several countries globally, have adverse economic and environmental consequences. Subsidies crowd out social spending (health, education, public infrastructures, and others); benefit mainly higher-income groups; and cause significant local and global environmental damage (OECD/IEA, 2014; World Bank, 2010; ADB, 2016; Christensen et al., 2006). Many energy-exporting countries such as members of the Gulf Cooperation Council (GCC), as well as those in Southeast Asia, such as Indonesia and Malaysia, have introduced energy tariff reforms and have gradually reduced subsidies on energy products and services (IMF, 2015; Charap et al., 2013; Pacudan, 2014). Several studies have shown negative impacts of subsidy removal on consumer welfare, wages, prices, and GDP, in both short and long term. However, the reallocation of subsidies to targeted sectors could offset the negative impacts of subsidy to a large extent (ADB, 2016; IMF, 2015).

One impact of tariff and subsidy reforms is on energy poverty, which is the focus of this study. Energy poverty in the context of developed countries refers to the ability to afford the energy one needs; for developing countries, this refers most often to lack of access to energy services (Šajn, 2016; Pacudan, 2006). In the UK, energy poverty is defined as the situation in which a household spends more than 10% of its income on all energy services (Boardman, 1991; Moore, 2012).

Brunei Darussalam, as a net energy-exporting country, is one of the countries in Southeast Asia with the highest per capita income and have reached universal access to energy services. The concern of energy poverty in Brunei Darussalam, if any, would be like that of developed countries rather than those of developing countries. On the other hand, instead of heating, space cooling which is fuelled by electricity is the

* Corresponding author. Institute of Policy Studies (IPS), Universiti Brunei Darussalam (UBD), Brunei.
E-mail addresses: romeo.pacudan@ubd.edu.bn, romeo.pacudan@bneri.org.bn, romeo.pacudan@gmail.com (R. Pacudan).

[1] Energy subsidy arises when government intervention reduces the price of a product below the market price that would otherwise have prevailed (Sdralevich et al., 2014).

https://doi.org/10.1016/j.enpol.2019.05.033
Received 11 October 2018; Received in revised form 7 May 2019; Accepted 18 May 2019
Available online 03 June 2019
0301-4215/

primary energy end-use in households.

Electricity price increases associated with subsidy reforms could significantly increase household's electricity expenditures. Studies in transition economies such as Albania and Bulgaria (Waddams Price and Pham, 2009), Hungary (Bouzarovski et al., 2016), Montenegro (Silva et al., 2009), Poland (Freund and Wallich, 1997), and Turkey (Waddams Price and Pham, 2009; Bagdadioglu et al., 2007) show that price reforms could considerably affect consumers' welfare and push some members of the society towards energy poverty.

This study investigates a scenario where electricity subsidy reform is implemented in Brunei Darussalam. The choice of electricity as the focus of the study is associated with the energy poverty analysis which involves household energy consumption and affordability issues. Petroleum products are also highly subsidised and that a subsidy removal policy analysis would be equally important. Gasoline and diesel fuels are the dominant petroleum products consumed in the country; however, their consumption is associated with the transport sector which is not relevant to the energy poverty debate.

The key questions raised in this paper are the following: (i) To what extent should the price rise? (ii) Would it significantly affect consumers' welfare and lead to energy poverty of poor consumers and vulnerable members of the society? (iii) Would the recently introduced tariff rate structure perform be better than the long-standing DBT structure? (iv) What policy measures are needed to mitigate impacts on energy poverty from such reforms?

This paper is structured as follows. Section 2 reviews the objectives, rationale, and lessons learned in implementing subsidy reforms; presents the recently introduced electricity tariff rate structure in Brunei Darussalam; and reviews the energy poverty implications of subsidy reforms as implemented in other countries around the world. Section 3 presents the household electricity demand and structure, and expenditure patterns in the country. Section 4 presents the methodology used in estimating the electricity subsidy level and the concepts in measuring welfare loss and energy poverty associated with price increases. Section 5 discusses the study results and policy perspectives while Section 6 presents the conclusion.

2. Energy pricing and reforms

2.1. Energy pricing policy objectives

Domestic energy prices in Brunei Darussalam are set significantly below international energy prices. Electricity tariffs, as mentioned earlier, are set below the long-run marginal cost (LRMC) and, as shown in Fig. 1, Brunei Darussalam has the lowest electricity price in the region (Pacudan, 2018a). Energy pricing policies pursued in the country are like those of other energy-exporting countries rather than those in net-energy importing Southeast Asian countries (Pacudan, 1998). Low energy prices are not often considered subsidies in many oil-producing countries due to the low cost of domestic energy production. From a theoretical point of view, however, subsidisation in these cases arises from the double opportunity cost of not exporting the oil or gas at international prices (now or in the future) and not taxing it[2] (Sdralevich et al., 2014; Clements et al., 2013). These countries also incur losses from the importation of refined petroleum products.

Governments often pursue subsidy policies to meet various objectives such as (i) supporting real incomes and fighting poverty through low prices on widely consumed products; (ii) shielding the population from shocks caused by large swings in commodity prices; and (iii) boosting certain industries and supporting employment in the private sector in the form of producer subsidies (Freund and Wallich, 1997; Sdralevich et al., 2014; Clements et al., 2013). In oil-producing countries which include Brunei Darussalam, subsidies are seen as distributing natural resource wealth amongst the population as an added rationale (Sdralevich et al., 2014; Lawrey and Pillarisetti, 2011).

2.2. Rationale of pricing reforms

If pricing policies of energy-exporting countries could be a reference for Brunei Darussalam, it is important to note that GCC countries have recently introduced fuel pricing reforms (IMF, 2015) based on arguments that are similar and relevant in the country. GCC countries had recently increased the domestic prices of petroleum products, electricity, and natural gas. The main arguments supporting price reforms are discussed below.

Energy-exporting countries spend substantial amounts of national budgets annually to maintain low energy prices (below international prices for petroleum products and below LRMC in the case of electricity). GCC countries, excluding Saudi Arabia, on average spent around US$16.2 billion in 2015 or 2.1% of their aggregate GDP as budget fiscal cost to pay the difference between the cost of energy production and domestic selling price (IMF, 2015). If the opportunity costs[3] of energy products are considered, this amount would be much larger. For GCC countries, this represents around 5.2% of the region's GDP. In Brunei Darussalam, the International Energy Agency estimated using the price-gap methodology that around US$178 million were spent on fuel subsidies in 2015, which accounted for about 1.5% of the country's GDP (OECD/IEA, 2017). These resources could be alternatively used for investments in public infrastructures and human capital development.

Countries that have relatively abundant energy resources tend to have large energy-intensive sectors and export energy–intensive products (Schott, 2003). The development of skill-intensive industries, which could be the main engine of economic diversification, is relatively slow in countries that favour low domestic energy prices (IMF, 2015). Also, higher-income households tend to benefit more from the subsidies than lower-income households in regimes with low energy prices (Charap et al., 2013; Sdralevich et al., 2014; Coady et al., 2006; Del Granado et al., 2010). The middle- and high-income groups of the population receive the largest share of subsidies partly because of higher consumption levels and higher rates of car ownership and connection to the national grid. In addition, low energy prices create opportunities for smuggling to neighbouring countries that have higher

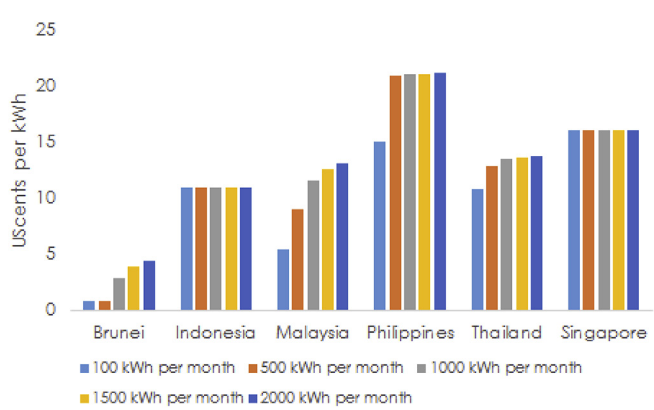

Fig. 1. Average electricity tariff rate of selected ASEAN CountriesSource Pacudan (2018c).

[2] For energy-importing developing countries, subsidies can be in the following forms: (i) setting prices of goods and services below the cost of importation or domestic production, and covering the ensuing pre-tax subsidies through fiscal or quasi-fiscal resources; or (ii) setting prices high enough to cover the supply costs of goods and services but not enough to be consistent with prevailing tax rates, giving rise to a post-tax subsidy in the form of foregone tax revenues (Sdralevich et al., 2014; Clements et al., 2013).

[3] The opportunity cost is estimated as the difference of a benchmark price, often the US price, and the domestic energy price (Koplow, 2009; Charap et al., 2013).

energy prices (IMF, 2015; Sdralevich et al., 2014). In Brunei Darussalam, around 1 million Brunei dollars (B$) per month were lost in the past due to smuggling (Norjidi, 2012). Environmental impacts associated with fuel subsidies that are relevant to Brunei Darussalam include inhibiting the development of renewable and clean energy technologies since these technologies could not compete with subsidised fossil fuels in power generation as well as discouraging investments to improve energy efficiency (Pacudan, 2018a; APEC, 2013; Pacudan, 2016).

Because of deliberate setting of prices below market rates, oil-producing and oil-exporting countries such as GCC countries and Brunei Darussalam are amongst those with highest energy consumption per capita and subsequently high greenhouse gas emissions per capita (IMF, 2015; APEC, 2017).

2.3. Lessons learned in pricing reforms

The lessons learned from 22 country case studies analysed by the International Monetary Fund (IMF) that implemented major subsidy reforms are all relevant to Brunei Darussalam and other energy-exporting countries. If prices must increase, it should be gradual to provide time to households and industries to adjust and help reduce the impact of reform on inflation (IMF, 2015). On the other hand, a large increase in prices can generate opposition to reform.

Phased and sequenced price increases, to be successful, should be accompanied by (i) a comprehensive reform plan formulated in consultation with stakeholders, (ii) a well-planned communications strategy to help generate broad political and public support, (iii) a well-targeted measure to mitigate the impact of energy price increases on the poor to build public support for subsidy reforms, and (iv) a depoliticised and rules-based mechanism for setting energy prices (Clements et al., 2013).

2.4. Electricity tariff reform

Brunei Darussalam introduced residential electricity tariff reform in 2012, replacing the long-standing DBT scheme (Fig. 2a) with a progressive increasing block tariff structure (Fig. 2b). Prior to this, residential tariffs had not been changed since 1969 (Lawrey and Pillarisetti, 2011).

DBT is often used for promotional pricing and is suited to conditions of decreasing costs while IBT is used to discourage higher usage and accommodates an increasing cost situation (Conkling, 2011). DBT is thus associated with promoting higher consumption and putting higher burden on poorer households while IBT is known to promote energy efficiency and protecting the welfare of lower-income households. In fact, policymakers have used IBT as a tool to subsidise targeted utility customer groups since the scheme can be targeted to subsidise low-volume consumers (assumed as poorer households and vulnerable members of society) and can provide all households access to limited (or a lifeline) quantity at a subsidised rate (Komives et al., 2005).

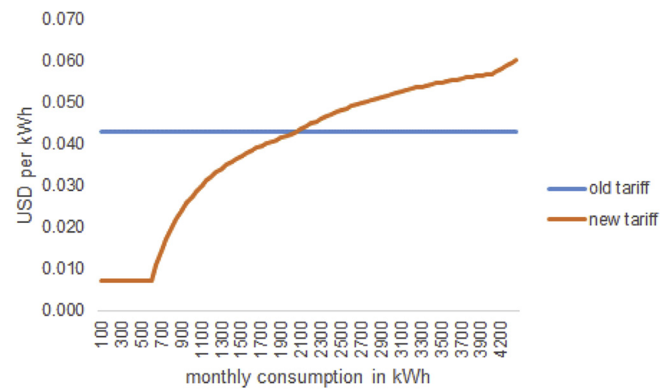

Fig. 3. Average Tariff Rate per Consumption LevelSource of data: Department of Electrical Services (2018).

Fig. 2 shows the tiers of both the declining and increasing block tariff structures in Brunei Darussalam. For IBT, the first 600 kWh is at a subsidised rate of US$0.714 (B$0.01) per kWh. This means that poorer households with lower consumption (below 600 kWh) will pay at this very low rate. All other households with much higher consumption will also have access to this 600 kWh subsidised rate. Under DBT, on the other hand, households that consume below 100 kWh per month will pay a much higher rate than those consuming higher electricity volumes.

As shown in Fig. 3, the old tariff structure (DBT) generates an average tariff rate of around 4.3 US cents (B$0.06) per kWh for consumption level above 100 kWh. Under the new rate structure (IBT), the average tariff is US$0.714 (B$0.01) per kWh for consumption level below 600 kWh. However, this rate increases significantly when consumption rises above 600 kWh. With the new tariff structure, the Department of Electrical Services (DES) reported that based on 2012 number of household consumers, 14% would pay lower than in the old scheme, 79% would pay more or less the same, while 21% would be paying higher than the previous pricing structure (APEC, 2013).

2.5. Tariff reforms and energy poverty

As mentioned earlier, energy poverty refers to two different socio-economic issues depending on the geographic scope of its applications: energy affordability in more developed and high-income economies; and inadequate access to modern energy services in low income developing countries (Maxim et al., 2016; Pye et al., 2015; Bouzarovski, 2014). This paper focuses on potential affordability issue in Brunei Darussalam since the country has already achieved universal access to modern energy services. The literature on energy poverty (concerning affordability) could be broadly grouped into those focusing i) issues in the United Kingdom (UK), and ii) those in Europe and other high income countries.

The United Kingdom is the first country that introduced strategies to

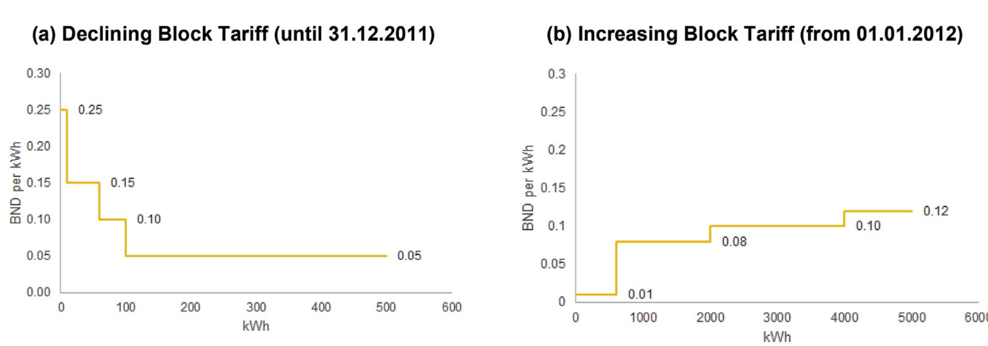

Fig. 2. Regressive vs Progressive Tariff SchemesSource of data: Department of Electrical Services (2018).

address energy poverty. The terminology used in the UK is fuel poverty, which is generally understood as the condition that a household is unable to purchase affordable warmth (Bouzarovski, 2014). The widely discussed and officially accepted definition of fuel poverty is derived from Boardman (1991) which describes a situation in which a household needs to spend more than 10 percent of its income on all fuel used to heat its homes to an acceptable level (Bouzarovski, 2014).

At the European Union (EU) level, while there is a recognition of the existence of energy poverty by the European Commission, there is no single agreed definition of energy poverty at the community level (Pye et al., 2015). Earlier European Commission Directives, such as Directives 2009/72/EC and 2009/73/EC, recommended that member states have to introduce measures to address energy poverty and protect vulnerable customers. These Directives however left member states to make their own definitions of energy poverty and vulnerable customers. Fuel poverty and energy poverty are used interchangeably in Europe, though energy poverty is the preferred terminology (Thomson, 2014). The hesitance in the EU to deal with energy poverty is due to lack of strong advocacy and initiative centre; lack of systematic scientific research on the topic; and, the unwillingness of some member states to acknowledge the existence of fuel poverty within their territory (Bouzarovski et al., 2012). Without a clear guidance from the European Commission, various policy studies have put forward their own definitions of energy poverty.[4]

Fuel poverty in the UK is understood to be brought by the interaction of low household incomes with thermally inefficient homes (Nevin, 2010). Studies in Europe identified three factors that cause energy poverty: household incomes, energy prices, and dwellings, appliances and heating systems efficiency (Liddell et al., 2012), and that the risk of becoming energy poor involve changes in affordability levels, deterioration in the quality and energy efficiency standard of the housing stock, as well as modifications in policy or regulatory settings (Bouzarovski et al., 2016).

The academic community has assessed a broad range of research areas in order to shed light on the causes and consequences of energy poverty. To name a few, this includes the interactions of poverty with household incomes, housing tenures, nature of heating systems, energy consumption patterns, energy efficiency, socio-demographic circumstances and spatial aspects, health consequences, social exclusion, energy prices, subsidies and market liberalisation, etc. This paper focuses on the price and energy poverty nexus.

Studies that explore impacts of reforms on energy poverty are quite limited. Freund and Wallich's paper (1997) on welfare effects of raising household energy prices in Poland initiated an influential debate on the causes and consequences of household energy deprivation (Bouzarovski, 2014). A number of country and regional studies that analyse the impacts of tariff or subsidy reforms on energy poverty focused on transition economies – economies that undergo structural transformations to establish market-based institutions from centrally-planned economic systems. Former socialist countries, before reforms, used price and wage controls, provision of free social services, and subsidisation of many private goods as distributional tool (Freund and Wallich, 1997; Bouzarovski et al., 2016). During the transition period to market economies, household incomes had fallen while prices had been increasing, resulting in increasing share of energy expenditures in household incomes.

Subsidy reforms and price increases without mitigation measures, as discussed in Section 4.1, will reduce consumer welfare and increase the share of energy expenditures in household incomes. This study focuses on whether such reforms would lead to energy poverty of poor households and vulnerable consumers. Freund and Wallich (1997) have shown that poorest households in Poland would experience the highest burden and that electricity expenditures would rise to over 10% of the household budget if electricity prices would be increased by 80%. Waddams Price and Pham (2009) have shown that in raising electricity price levels in Albania and Bulgaria to LRMC, the poorest households (1st decile) in Albania, and 1st, 2nd, and 3rd deciles in Bulgaria would have their electricity expenditures increase above 10% of their total expenditures (the study used household expenditures instead of disposable income). In the case of Montenegro, Silva et al. (2009) have shown that the poorest households spent more than 10% of their budget on electricity and that their welfare losses would be high if prices would be increased to LRMC. Also, these households would most likely shift to fuelwood for space heating. In Turkey, increasing electricity prices at par with the average tariff level of the Organisation for Economic Co-operation and Development (OECD) would not lead to energy poverty, but the poorest households would experience the highest burden (Bagdadioglu et al., 2007).

3. Household energy demand

3.1. Household energy consumption patterns

As an overview, Brunei Darussalam is divided into four districts: Brunei-Muara, Belait, Tutong and Temburong. Brunei-Muara is the northernmost district containing the capital city, Bandar Seri Begawan, government ministries and majority of private businesses. Belait is situated west of the country and home to the oil and gas industry. Tutong is located at the middle separating the Belait and Brunei-Muara districts. Temburong is an exclave and separated from the rest of the country by the Malaysian district of Limbang. The country's virgin rainforest is located in this district. The socio-economic profile of the districts are shown in Table A1 of the Appendix.

Electricity demand in Brunei Darussalam hovered between 3500 GWh and 4000 GWh during the last 5 years (Fig. 4a). Among the energy-consuming sectors, the residential sector accounted for the highest share, averaging around 37% of the total energy consumption between 2012 and 2016. The shares of the commercial and industry sectors slightly declined while that of the public sector moderately increased during the same period.

In terms of energy consumption by energy service, based on the recently completed study of the Brunei National Energy Research Institute, space cooling (air conditioning) accounts more than half of the residential electricity demand. At the national level, air conditioning represents almost 60% of the average household energy demand (Fig. 5a) though its share varies from 61% in Brunei-Muara district to 54% in Temburong district. Other major electricity-consuming services are refrigeration, lighting, and water heating accounting for 18%, 7%, and 6% of the national household electricity demand, respectively.

Households in high-income districts have high electricity demand shares of air conditioning and water heating compared to those in low-income ones (also in Fig. 5a). Conversely, shares of refrigeration and electric fans tend to be higher in low-income districts than in high-income districts. The same pattern can be observed when comparing demand shares of richest and poorest households (Fig. 5b).

Electricity represents around 76% of the total residential electricity demand in the country in 2014 (Fig. 4b). Natural gas and liquefied petroleum gas (LPG) accounted for around 11% and 13%, respectively.

[4] For example, Grevisse and Brynart (2011) in their review on energy poverty understanding in Europe, defined energy poverty as the impossibility (or the difficulty) for a household to gain access to the energy it needs to ensure dignified living conditions at an affordable price from the point of view of its income; Pye et al. (2015) on the other hand, in their analysis of policies and measures in the EU on energy poverty and vulnerable customers, defined energy poverty as a situation where individuals or households are not able to adequately heat or provide other required energy services in their homes at affordable cost; Maxim et al. (2016), in their study on the implications and measurement of energy poverty across the European Union, defined energy poverty as a situation in which a household lacks a socially and materially necessitated level of energy services in the home.

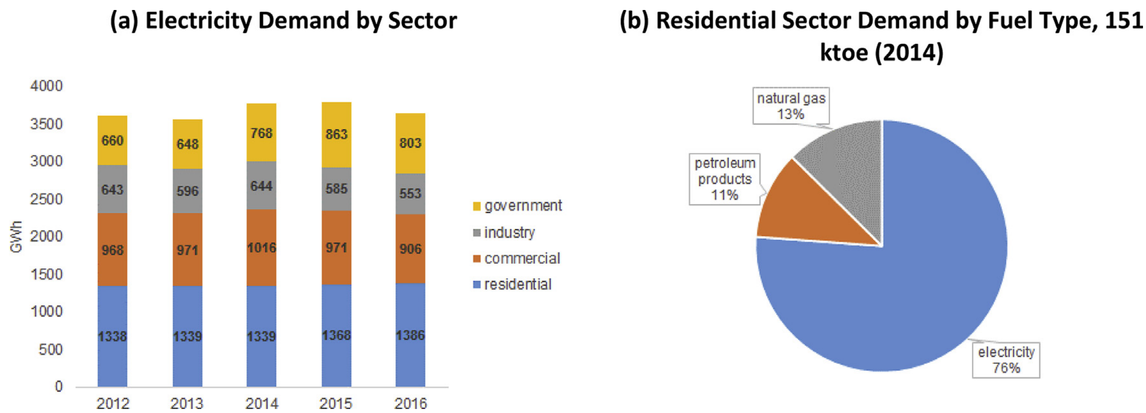

Fig. 4. Energy Demand Sources of data: DEPD (2017), APEC (2017).

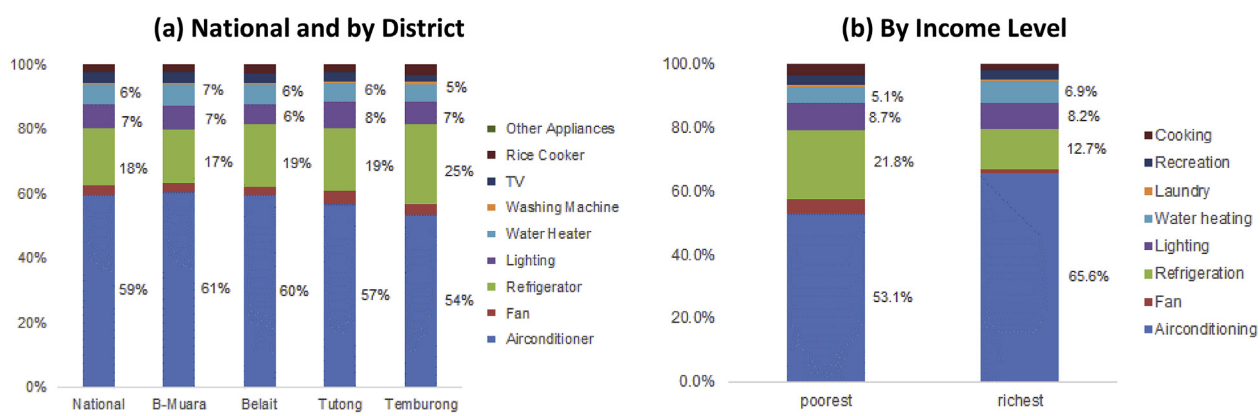

Fig. 5. Residential Electricity Consumption by End Use Source of data: BNERI, 2018.

Natural gas and LPG are mainly used for cooking and water heating. Natural gas is mainly available in Belait district due to its proximity to gas-processing plants.

3.2. Household electricity expenditure patterns

Household electricity expenditures were taken from the Household Expenditure Survey (DEPD, 2011) carried out in 2011 by the Department of Economic Planning and Development under the Prime Minister's Office. Figs. 6–8 show household expenditure patterns (as percentage of household income) for various socio-economic parameters in Brunei Darussalam. At the national level, the average household spends around 1.6% of its monthly income for electricity services.

Comparing electricity expenditures by income level, the lowest-income households spend almost 4% of their monthly income on electricity services while the richest households at only around 1% (Fig. 6). On the other hand, urban and rural households on average spend almost the same ratio of their incomes. Among districts, Belait households spend 1.8% of their monthly income to pay their electricity bills while those in Temburong, at only 1.3% (Fig. 7). In terms of occupation of household head, farmers/craft workers spent the highest share, around 1.8%, of their income on electricity consumption (Fig. 8).

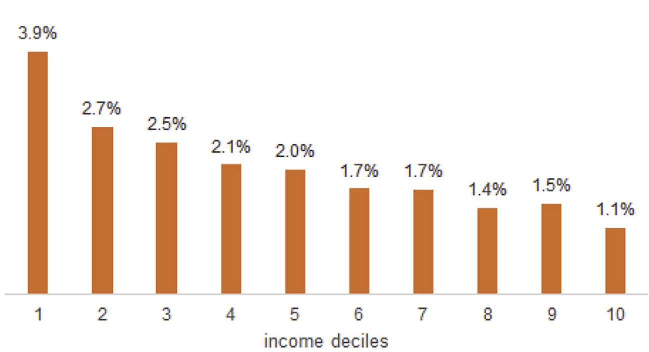

Fig. 6. Household Monthly Electricity Expenditures by Income Deciles as Percentage of Household Income
Source of data: DEPD (2011).

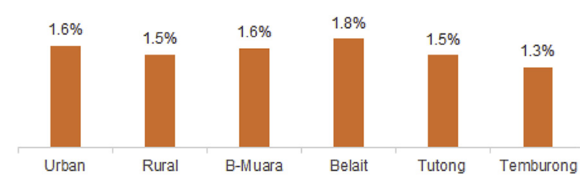

Fig. 7. Household Monthly Electricity Expenditures by Urban/Rural and Districts as Percentage of Household Income. Source of data: DEPD (2011).

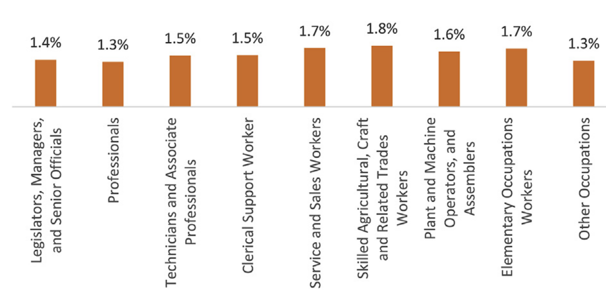

Fig. 8. Household Monthly Electricity Expenditures by Occupation of Household Head as Percentage of Household Income Source of data: DEPD (2011).

This is followed by sales workers (1.7%), basic workers (1.7%) and plant and machine operators (1.6%). The occupation of household heads and their average monthly income in Brunei Darussalam are shown in Table A2 of the Appendix.

Based on the earlier definition of energy poverty at the 10% threshold level, households do not appear to experience energy poverty in Brunei Darussalam on average.

4. Methodology

4.1. Estimating energy subsidy level

The electricity tariff reform introduced in 2012, as discussed in Section 2.4, is mainly a rate structure reform. Residential electricity tariff rate in Brunei Darussalam remains relatively low averaging, around US$ 0.039 per kWh.[5] This is because fuel inputs, mainly natural gas, are priced below their market price and infrastructure costs are not fully reflected in electricity tariffs.

To determine the level of subsidy, the LRMC of power generation should be estimated and that the divergence between the LRMC and the current prices would represent the subsidy level.[6] LRMC-based pricing has been adopted globally and, in practice, strict LRMC (estimated using electric utility's least-cost expansion plan) is calculated and adjusted to meet other economic, environmental, social, and financial considerations (Munasinghe, 1981; Munasinghe and Warford, 1982). Optimal pricing also requires peak-load pricing. During off-peak periods, the short-run marginal cost (SRMC) of fuel and operating and maintenance (O&M) costs represent the optimal price while during peak periods, the optimal price includes the SRMC and the LRMC of adding to capacity (Munasinghe and Warford, 1982; Rotoras et al., 2002).

This study estimated the SRMC, which consists of fuel cost (FC) and variable O&M cost ($O\&M_{variable}$) (equation (3)). FC was derived as the product of fuel cost (P_m) and power plant's heat rate (HR) (equation (1)). The FC was based on Japan's spot market price of liquefied natural gas (LNG) minus the transport cost. The average LNG spot market price for 2018 was projected to be about US$8.8 per mmbtu (World Bank, 2018) while the transport cost used in the study was US$1.0 per mmbtu. The study considered an open cycle gas turbine power plant as the marginal plant with heat rate of 12,000 btu per kWh. This yields a marginal fuel cost of US$0.094 per kWh (Fig. 9).

[Fig. 9 goes here]

The variable O&M cost was calculated as the ratio of operational and maintenance cost and power generation (equation (2)). The study used the yearly operational budget of the Department of Electrical Services and the electricity generation as published in the Brunei Darussalam Statistical Yearbook 2016 (DEPD, 2017). The 5-year average variable O&M amounts to US$0.024 per kWh.

Fuel cost (FC)

$$FC = P_m * HR \quad (1)$$

Variable O&M cost ($O\&M_{variable}$)

$$O\&M_{variable} = \frac{yearly\ O\&M\ costs}{electricity\ generation} \quad (2)$$

Shor-run marginal cost (SRMC)

$$SRMC = FC + O\&M_{variable} \quad (3)$$

[5] From the Household Expenditure Survey 2011, the household average electricity consumption is 1640 kWh per month. With current IBT tariff structure, this would amount to 89 Brunei dollars (B$) which translates to B$0.0543 per kWh or 0.0387 US$ per kWh at exchange rate of B$1.4 to US$1.00.

[6] This is known as price-gap approach. See, for example, OECD/IEA (2014).

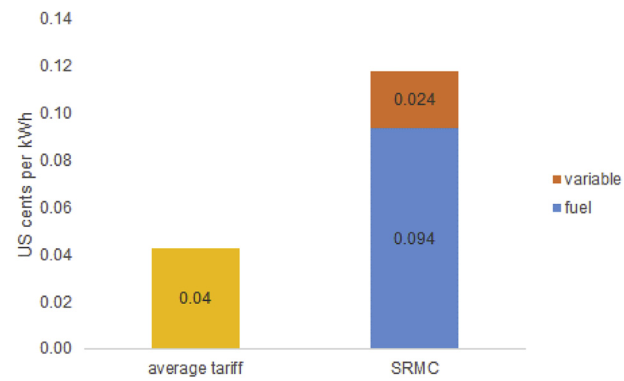

Fig. 9. Average Tariff vs Short-Run Marginal Cost of Electricity Production Source: Study results.

The results show that the average tariff rate is even lower than the SRMC of producing electricity in the country. As shown in Fig. 9, the SRMC amounts to US$0.118 per kWh.

Perhaps, as part of a gradual approach to subsidy reforms, the initial goal could be set to recover the SRMC and the second phase would be aimed at recouping the LRMC of capacity additions. With this, the SRMC represents around 202% higher than the average tariff based on the current tariff rate structure. In this study, a price increase scenario of 200% above the current average tariff was considered to simulate impacts of subsidy reforms.

4.2. Impacts of subsidy removal

When the price of electricity is set below the market price, inefficient market allocation of resources will result. This is illustrated by Fig. 10 using a simplified linear demand function (Charap et al., 2013; IMF, 2015). In the figure, S_s represents the energy supply in a country that sells at subsidised price P_s. which is below the market price P_m. As a result, given the country's demand curve, the energy consumption level amounts to Q_s which is higher than the consumption level Q_m when the price is equal to the market price.

The total subsidy that government provided to electricity consumers is represented by the area A + B + dw (equation (4)). The relation dw is the deadweight loss due to subsidy which represents the area under the demand curve when the administered electricity price is below the market price. The deadweight loss can be calculated using equation (5). The first expression in equation (5) is the total subsidy (opportunity cost) while the second is the change of quantity consumed. For Cobb-Douglas type demand function, the ratio of quantities consumed at market prices and subsidised prices are expressed in equation (6). With this, the deadweight loss would be high when the price elasticity of demand is high (elastic demand).

Subsidy amount

$$A + B + dw = (P_m - P_s)Q_s \quad (4)$$

Deadweight loss

$$dw = (P_m - P_s)Q_s\frac{(Q_s - Q_m)}{2Q_s} \quad (5)$$

Consumer welfare loss

$$\Delta CS = Q_s(P_m - P_s)\left[1 + \beta\frac{(P_m - P_s)}{2P_s}\right] \quad (6)$$

β is price elasticity of demand.

In Fig. 10, if the subsidy is removed (price is set at P_m), the area A + B + dw would be saved. Consumers' welfare, however, would be reduced since they are consuming less and paying more for every unit of electricity.

The study estimated the welfare loss following Freund and Wallich

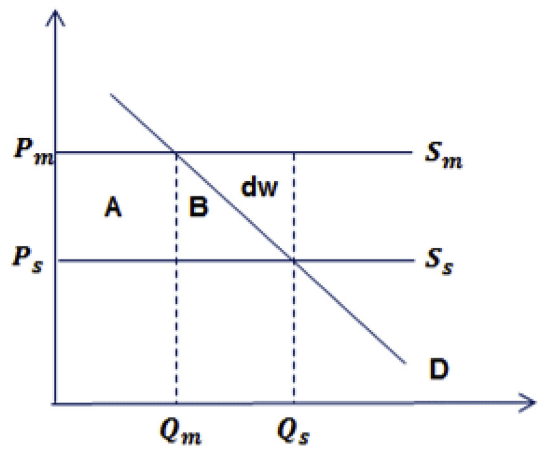

Fig. 10. Cost, deadweight loss from subsidies, and welfare loss from removal of SubsidiesSource: IMF (2015).

(1997), Bagdadioglu et al. (2007), and Charap et al. (2013), which is the loss in consumer surplus from the price change (equation (6)). This is area A (the additional amount of money the consumer pays for the electricity that he or she continues to consume at P_m) plus area B (the amount the consumer would be willing to pay above the old price P_s to consume the old quantity) in Fig. 10.

4.3. Price elasticities

Consumers respond to electricity price changes by adjusting the level of their electricity consumption. The study used the price elasticity of demand as the measure to demonstrate the responsiveness of the quantity of electricity demanded to a change in its price. Ideally, price elasticity of demand is derived from the data of household electricity consumption at different price levels. Unfortunately, these data are not available in Brunei Darussalam since residential electricity tariffs have been rarely adjusted.

Following the studies of Freund and Wallich (1997), Silva et al. (2009), and IMF (2015), this study adopted three price elasticity scenarios in analysing the potential impact on consumer welfare of electricity tariff reform. Residential electricity demand is relatively inelastic. Based on the Asian Development Bank (2013) survey of price elasticities of electricity demand in the residential sector, the minimum elasticity value for Asian countries is −0.15 (relatively inelastic) which indicates that households slightly change the quantity of electricity they consume when they face higher prices; maximum value is −0.75 (relatively elastic) which means that households' response to price changes is moderately proportional to the magnitude of the price change; and the average value is −0.430, which means that the demand is inelastic but relatively responsive to higher electricity prices. These values were used in the study as price elasticity scenarios.

4.4. Measuring energy poverty

As discussed in Section 2.5, the UK at present is the only country that has an operational definition of energy poverty, which is used as basis for determining who could avail government's safety net measures related to energy poverty. The accepted measure on energy poverty is based from Boardman (1991) which defines energy poverty as households whose fuel expenditure on all energy services exceeded 10% of their income.

This official definition was subject to various political and academic scrutiny, and that several alternative definitions and indicators were proposed. One of the well-known proposals is that of Hills (2012). In a government sponsored review on definition and target of energy poverty, Hills (2012) concluded that the accepted measure of energy poverty is sensitive to movements in gas and electricity bills as well as on the definition of adequate household temperatures and reported household incomes. He proposed that for households to be considered energy poor, their required fuel expenditure should be above the median level for the entire population, and spending that amount would leave them with a residual income below the official poverty line. This proposal has however attracted political controversy since the proposed measure, if applied, would result in the reduction of number of households to be considered fuel poor (Bouzarovski, 2014).

The lack of a clear definition of energy poverty in the EU has generated various proposals from researchers for proxy indicators to measure and compare energy poverty in a consistent way across various countries or regions (Maxim et al., 2016). Example of these proposals are those of Nussbaumer et al. (2011) and Bouzarovski and Tirado Herrero (2015). Nussbaumer et al. (2011) proposed a multidimensional indicator to provide an accurate image of energy poverty at the national level. The proposal used a set of proxy indicators,[7] assigned a weight, and defined a deprivation threshold for each to determine the multidimensional energy poverty indicator (MEPI). Bouzarovski and Tirado Herrero (2015) proposed an energy poverty index (EPI) which is based on the weighted average of three proxy indicators: percentage of people unable to keep their homes adequately warm, having arrears in utility bills, and living in a home with leaking roof.

This study, as mentioned in Section 2.5, focuses on the interaction between energy price change and energy poverty. Studies that assessed impacts of price reforms on energy poverty have used indicators that are consistent with those used in the UK, which are functions of price and household income or household budget (expenditure). Papers reviewed in this study (presented in Section 2.5), used data from household expenditure surveys as a basis for simulating energy consumption change (due to change in energy price), and estimated the new household expenditure as a percentage of either household income or household expenditure. In addition, some of these studies have considered electricity and other fuels, and that the energy poverty threshold used for electricity is 10% of household income. This study adopted the above measure used by similar past studies as the basis for assessing energy poverty in Brunei Darussalam.

In this study, following the analysis of Freund and Wallich (1997), and Bagdadioglu et al. (2007), the household electricity expenditures before and after the reform, as shown in Fig. 10, are designated as P_sQ_s and P_mQ_m, respectively. Using a Cobb-Douglas-type demand function shown in equation (7), electricity expenditure (EE) as percentage of household income (HI) could be expressed as in equation (8).

Cobb-Douglas type demand function

$$\left[\frac{Q_m}{Q_s}\right] = \left[\frac{P_m}{P_s}\right]^{\beta} \tag{7}$$

$$Q_m = Q_s\left[\frac{P_m}{P_s}\right]^{\beta} \tag{7a}$$

Electricity expenditure (as % of HH income)

$$EE(HI) = \frac{EE}{HI} \times 100 = \frac{P_mQ_m}{HI} \times 100 = \frac{1}{HI}P_mQ_s\left[\frac{P_m}{P_s}\right]^{\beta} \times 100 \tag{8}$$

5. Results and discussions

5.1. Welfare impacts of subsidy removal

The study estimated the household welfare losses that could be caused by price increases due to possible subsidy reforms. Table 1

[7] modern cooking fuel, indoor pollution, electricity access, household appliance ownership, entertainment/education appliance ownership, and telecommunication means.

Table 1
Welfare Losses of Increasing Electricity Price to SRMC by Income Decile (loss in consumer surplus as percentage of household expenditure).

	Increasing Block Tariff (IBT) (Current)			DecliningBlock Tariff (BDT) (Past)		
	Price Elasticity					
	−0.15	−0.43	−0.75	−0.15	−0.43	−0.75
1 (poorest)	1.67	1.12	0.49	5.78	3.88	1.70
2	3.44	2.30	1.01	5.79	3.89	1.70
3	4.31	2.89	1.27	5.68	3.81	1.67
4	4.56	3.06	1.34	5.66	3.80	1.67
5	5.29	3.55	1.56	5.75	3.85	1.69
6	4.98	3.34	1.46	5.32	3.57	1.56
7	5.81	3.90	1.71	5.58	3.74	1.64
8	5.08	3.40	1.49	4.87	3.27	1.43
9	7.31	4.90	2.15	5.78	3.88	1.70
10 (richest)	6.51	4.36	1.91	4.73	3.17	1.39
All	5.24	3.51	1.54	5.34	3.58	1.57

Source: Study Results.

presents the results under the 200% price increase scenario for both IBT and BDT tariff structures. In both tariff schemes, welfare losses would be high under the inelastic demand case (elasticity of −0.15) compared with those under the elastic case (elasticity of −0.75). For inelastic case, household welfare losses would be more than 3.4 times higher than those under the elastic case for both tariff structures.

Under the current IBT structure, the effect of price increase would be higher in non-poor households. The welfare loss of the lowest decile would be 1.67% of the households' expenditure while that of the highest decile would account for about 6.51%. The losses of the poorest households would be almost four times lower than those of richest households for all price elasticity scenarios.

The situation, on the other hand, is opposite under the DBT scheme. Losses of poorer households would be high compared with those of the wealthier households. Welfare losses of households under the poorest decile would amount to 5.78% of their budget while those households under the most affluent households would lose only 4.73% of their budget. For all price elasticity scenarios, the burden of households under the poorest decile would be 1.2 times higher than those under the highest decile.

Welfare losses, shown in Table 1, are not proportionately increasing (under IBT) or decreasing (under DBT) since average electricity consumption are not proportionately increasing by income decile and that the tariff increment (under IBT) or reduction (under DBT) by consumption block is not uniformly increasing.

The current IBT design shielded the poorest households more than the non-poor households from excessive burden of possible price increases. In this case, the burden would be highest on the more affluent members of the society.

With respect to geographic locations of households, almost the same pattern can be observed as in the above in terms of welfare losses. As shown in Table 2, welfare losses would be high under an inelastic demand scenario compared with those under an elastic demand case. In addition, welfare losses of urban households would be higher than those in rural areas in both IBT and DBT structures. This is because electricity demand is high in urban areas and there are more affluent households in urban areas than in rural settings. For a price increase of 200%, welfare losses of urban households would amount to 5.54% of their total household expenditure compared with 4.52% for rural households.

Similarly, households in more affluent districts would have higher welfare losses with increasing electricity prices compared with those in poorer districts. Losses of households located in highly urbanised Belait and Brunei-Muara districts would be high compared to those in Tutong and Temburong districts.

Table 2
Welfare Losses of Increasing Electricity Price to SRMC by Urban/Rural Areas and Districts (loss in consumer surplus as percentage of household expenditure).

	Increasing Block Tariff (IBT) (Current)			Declining Block Tariff (BDT) (Past)		
	Price Elasticity					
	−0.15	−0.43	−0.75	−0.15	−0.43	−0.75
Urban/Rural						
Urban	5.54	3.72	1.63	5.47	3.67	1.61
Rural	4.52	3.03	1.33	5.10	3.42	1.50
District						
Brunei-Muara	5.44	3.65	1.60	5.34	3.58	1.57
Belait	5.58	3.74	1.64	5.91	3.96	1.74
Tutong	3.89	2.61	1.14	5.05	3.39	1.49
Temburong	2.48	1.66	0.73	4.31	2.89	1.27
All	5.24	3.51	1.54	5.34	3.58	1.57

Source: Study Results.

When comparing IBT and DBT structures, except for households in Brunei-Muara district and urban areas, the same pattern emerged; that is, welfare losses under BDT would be higher compared with those under the IBT scheme. For the case of Brunei-Muara district and urban areas, the IBT structure would result in higher welfare losses than the DBT structure since electricity demand in those areas are very high and have reached a much higher block tariff level under the increasing block scheme.

Assessing the welfare losses by occupation type of household head and with current IBT structure, the non-poor, professionals, skilled professions, and other highly paid occupations would be hurt most than those engaged in low-paying occupations (Table 3). For a 200% increase in average tariff, welfare losses of those under the category of elementary occupation workers would be 3.40% of their expenditure while those under the category of legislators/managers, professionals, and associate professionals would lose 5.51%, 4.98%, and 5.07%, respectively. In addition, welfare losses under inelastic case would be high compared with those under elastic case. Losses in the former would be more than double than that of the latter.

Welfare losses under the DBT structure, except those of legislators/managers and professionals, would be higher compared with those under the IBT scheme (Table 3). Also, the losses under the inelastic demand case would be higher compared with those under the elastic case. The main reason legislators/managers and professionals would have slightly higher losses in IBT than DBT scheme is like that of urban areas and the Brunei-Muara district. Their consumption levels are very high and have reached a higher block tariff level.

5.2. Energy poverty implications

The study estimated changes in electricity demand under different price elasticity scenarios and increases in electricity expenditures as percentage of household income that would be triggered by electricity price increases due to possible tariff subsidy reforms.

Table 4 shows the expenditure levels by income deciles under IBT and DBT structures. Under the IBT, the highest expenditures would be from non-poor households at 4.7% of their income while the poorest households would spend the least 2.9%. It is interesting to note that the richest would also spend a relatively low rate of 3.8% compared to other non-poor households. This is because the average monthly income of the richest household is very high, which results in a relatively low percentage share of household expenditure. Under the DBT structure, the reverse would happen with the poorest reaching the energy poverty threshold (spending 10% of their income on electricity) and the richest household paying the least at 2.7%.

Expenditures as a percentage of household income are not

Table 3
Welfare Losses of Increasing Electricity Price to SRMC by Occupation of Household Head (loss in consumer surplus as percentage of household expenditure).

	Increasing Block Tariff (Current)			Declining Block Tariff (Past)		
	Price Elasticity					
	−0.15	−0.43	−0.75	−0.15	−0.43	−0.75
Legislators/Managers	5.51	3.70	1.62	4.55	3.05	1.34
Professionals	4.98	3.34	1.47	4.65	3.12	1.37
Technicians/AP	5.07	3.40	1.49	5.17	3.47	1.52
Clerical/Support	3.79	2.54	1.11	4.70	3.15	1.38
Service/Sales	3.94	2.64	1.16	5.03	3.38	1.48
Agriculture/Craft	4.87	3.26	1.43	5.67	3.80	1.67
Operators/Assemblers	4.33	2.90	1.27	5.45	3.65	1.60
Elementary	3.40	2.28	1.00	4.82	3.23	1.42
Other	2.67	1.79	0.79	3.95	2.65	1.16
All	5.24	3.51	1.54	5.34	3.58	1.57

Source: Study Results.

Table 4
Household Electricity Expenditures by Income Deciles for an Increase of Electricity Price (as percentage of household income) to SRMC.

	Increasing Block Tariff (IBT) (Current)			Declining Block Tariff (BDT) (Past)		
	Price Elasticity					
	−0.15	−0.43	−0.75	−0.15	−0.43	−0.75
1 (poorest)	2.9	2.1	1.5	10.0	7.4	5.2
2	4.1	3.0	2.1	6.9	5.1	3.6
3	4.7	3.5	2.4	6.2	4.6	3.2
4	4.3	3.2	2.2	5.4	3.9	2.8
5	4.7	3.5	2.4	5.1	3.8	2.7
6	4.1	3.0	2.1	4.4	3.2	2.3
7	4.5	3.3	2.3	4.3	3.2	2.2
8	3.7	2.7	1.9	3.6	2.6	1.8
9	4.7	3.5	2.5	3.8	2.8	1.9
10 (richest)	3.8	2.8	1.9	2.7	2.0	1.4

Source: Study Results.

Table 5
Household Electricity Expenditures by Urban/Rural Areas and Districts for an Increase of Electricity Price (as percentage of household income) to SRMC.

	Increasing Block Tariff (IBT) (Current)			Declining Block Tariff (BDT) (Past)		
	Price Elasticity					
	−0.15	−0.43	−0.75	−0.15	−0.43	−0.75
Urban/Rural						
Urban	4.2	3.1	2.2	4.2	3.1	2.2
Rural	3.4	2.5	1.8	3.9	2.8	2.0
District						
Brunei-Muara	4.2	3.1	2.2	4.1	3.0	2.1
Belait	4.2	3.1	2.2	4.5	3.3	2.3
Tutong	2.9	2.2	1.5	3.8	2.8	2.0
Temburong	1.9	1.4	1.0	3.3	2.4	1.7

Source: Study Results.

proportionately increasing (under DBT) or increasing (under IBT) since the increase of household consumption and household income by income decile are not proportional while increases (under IBT) or decreases (under DBT) in tariff blocks are also not proportional.

Electricity expenditure levels would be higher in inelastic demand case than in elastic case for both IBT and DBT schemes. The simulation analysis also shows that electricity expenditures would be very low and not reaching more than 5% of the household income under the current IBT scheme and for all elasticity scenarios. Under the DBT, on the other hand, and under the inelastic demand case, the expenditure of the poorest household could go up at the very high level of 10%.

In terms of geographic location, households in urban areas would spend more than their rural counterparts when price increases to SRMC for both IBT (4.2% vs 3.4%) and DBT cases (4.2% vs 3.9%) (Table 5). Similarly, households in Belait and Brunei-Muara districts would also spend more than those in Tutong and Temburong districts. Electricity expenditures under inelastic demand case would be higher than under elastic demand scenario. Under the DBT, all households, except those in urban areas and in Brunei-Muara districts, would have higher electricity expenditures compared with under the IBT case. For urban areas and the Brunei-Muara district, as explained earlier, the average consumption level is already very high, and that with increasing block tariff rate, the consumption at the margin would have reached a higher level of the block tariff rate. In all cases, expenditures are below 5% of each household's income, which is far below the 10% energy poverty threshold level.

The same pattern emerged for household electricity expenditures by occupation of household head as in welfare losses presented in Section 4.1. High-income households and skilled professionals would spend more of their income than those of low-paying occupations when the price of electricity would increase under the IBT scheme (Table 6). Legislators and managers would spend 4.2% of their income when price increases by 200% while those of clerical and support professions would spend only 3.1%. Under the DBT, on the other hand, households engaged in agriculture and other crafts, service and sales, and elementary occupation levels would be spending more of their income when prices increase. Also, expenditures under the DBT case would be slightly higher than under the current IBT case. In both IBT and DBT cases, however, expenditures would be higher under an inelastic demand case than under an elastic situation. Also, the level of expenditures with 200% price increase would still be very low and would not exceed 4% of the average household income.

5.3. Household and policy responses

The results show that given the current IBT structure, though a subsidy reform scenario would affect all households, it would be the non-poor households (high-income households, the urban dwellers, and high-income professionals) that would bear the higher impact of reforms. The recently introduced IBT structure provides a lifeline rate of B $1 (US$0.714) for the first block of consumption (600 kWh) which is aimed at supporting marginalised customers. The tariff structure reform implemented in 2012 has, therefore, protected the low-income groups and vulnerable members of the society on the impacts of potential price increases.

Despite the lack of data on price elasticities and with reference to

Table 6
Household Electricity Expenditures by Occupation of Household Head for an Increase of Electricity Price (as percentage of household income) to SRMC.

	Increasing Block Tariff (Current)			Declining Block Tariff (Past)		
	Price Elasticity					
	−0.15	−0.43	−0.75	−0.15	−0.43	−0.75
Legislators/Managers	4.2	3.1	2.2	3.5	2.5	1.8
Professionals	3.6	2.6	1.8	3.3	2.4	1.7
Technicians/AP	3.7	2.7	1.9	3.8	2.8	1.9
Clerical/Support	3.1	2.3	1.6	3.8	2.8	2.0
Service/Sales	3.4	2.5	1.7	4.3	3.2	2.2
Agriculture/Craft	3.8	2.8	2.0	4.5	3.3	2.3
Operators/Assemblers	3.2	2.4	1.7	4.1	3.0	2.1
Elementary	3.0	2.2	1.6	4.3	3.2	2.2
Other	2.3	1.7	1.2	3.4	2.5	1.8

Source: Study Results.

various country studies in the literature (see, for example, Freund and Wallich, 1997; Silva et al., 2009; Bagdadioglu et al., 2007; ADB, 2013), there is anecdotal evidence that household electricity demand in Brunei Darussalam is relatively inelastic. With the present pattern of household electricity demand (presented in Section 3), there is no alternative fuel for space cooling. The use of electric fans for space cooling is significant in poorer households, but richer households may not resort to this ‘technological’ downgrading. The use of electric fans for space cooling may, however, remain a technological option for low-income households.

Non-poor households may, however, resort to investing in more energy-efficient air conditioners and adopting best practices in the use and operation of electrical appliances. When the Energy and Industry Department at the Prime Minister's Office and the Brunei National Energy Research Institute carried out the national energy consumption survey in 2015, it was observed that richer households had already invested on more efficient inverter air conditioners as their response to the introduction of increasing block tariff structure.

As electricity prices approach the marginal cost, rooftop solar photovoltaic (PV) systems may become competitive with grid electricity and that it would be financially viable for households to invest in distributed solar technologies as in the case of the Philippines and Singapore (Pacudan, 2018b, 2018c).

Higher electricity prices and energy deprivation may also result in households delaying or not paying their electricity bills (Bouzarovski et al., 2016). Non-payment of electricity bills in Brunei Darussalam was prevalent before the shift from post-paid to prepaid payment schemes. This is, however, no longer the case in the country since all residential consumers have been installed prepaid metering systems.

On the policy side, various options are available in the policy toolbox that could be pursued to reduce the financial burden of households when subsidy reforms would be introduced. First, the current inverted block tariff structure has already shielded the poor consumers on price impacts. Second, improving the supply-side efficiency would lower the marginal cost of producing electricity. The Department of Electrical Services is currently pursuing an internal policy of improving power plant efficiencies in the medium term to 45% (MEMI, 2018). Also, the current interconnection of the two utilities in the country has been reported to improve the utilisation of the generation assets and resulted in capacity savings (MEMI, 2018). Third, the implementation of demand-side efficiency measures would be crucial for consumers and utilities (Pacudan and de Guzman, 2002). With the recent establishment of the Electricity Authority under the Electricity Order (2017), the implementation of standard and labelling regulation and other measures could be easily facilitated. The draft standards and labelling regulation, as prepared by the Brunei National Energy Research Institute, targets air conditioners as the priority technology for efficiency regulation. Fourth, incentivising households to invest in rooftop solar PV could be a measure to partly offset rising electricity prices. Incentivised self-consumption schemes have been proposed as measures that provide sufficient incentives to residential households and at the same time the least-cost option for electricity system actors (Pacudan, 2018a).

6. Conclusion and policy implications

Brunei Darussalam is currently pursuing an energy pricing policy like that of other energy-exporting countries such as the GCC countries that set energy prices below market rates. Electricity tariff rates are below the LRMC and petroleum product prices are lower than international market prices. Such policies resulted in significant budget fiscal cost in energy-exporting countries including Brunei Darussalam to pay the difference between the cost of production and domestic selling price. This prompted GCC member countries to introduce energy subsidy reforms recently.

In addition to fiscal costs are other arguments supporting reforms, such as a regime with low energy prices (i) would promote energy-intensive industries but hinder development of skill-intensive industries, which is the engine for economic diversification; (ii) the middle- and high-income groups would benefit more from the subsidies; (iii) would promote product smuggling; and (iv) would inhibit development of renewable energy technologies and discourage investments in energy efficiency improvement. Because of this policy, energy-exporting countries are the main countries with the highest energy consumption per capita and greenhouse gas emissions per capita.

This study assessed a scenario that Brunei Darussalam would introduce subsidy reforms and that electricity tariffs would be raised at least close to the SRMC of power generation, which is around 200% higher than the current tariff rates. Subsidy reforms have negative consequences related to wages, prices, and economic growth. This study, however, focused on the welfare impacts and implications of price increases on energy poverty. The study adopted the energy poverty definition of spending higher than 10% of household income on energy commodities or services.

Brunei Darussalam introduced electricity tariff rate structure reforms in 2012 with the IBT scheme, ending the long-standing DBT structure. The study investigated the welfare impacts and implications to energy poverty of potential subsidy reforms under the two alternative tariff structures while considering three possible scenarios of price elasticity of demand.

Results show that under the IBT, welfare losses would be high for non-poor households, for those who are living in urban areas, and for those engaged in white-collar jobs. It would have been the reverse – the poorest households, those who live in rural areas, and blue-collar workers would have highest losses – had the government not introduced tariff rate structure reforms. Under price elasticity scenarios, welfare losses would be high under inelastic than elastic demand case for both IBT and DBT schemes.

The same pattern also emerged under the energy poverty analysis. Increases in electricity expenditures as a percentage of household income would be lowest for the poorest households, for households situated in rural areas, and for those whose household heads are engaged in blue-collar jobs under the current IBT scheme. These household groups would have to bear the highest burden had the government not revamped the residential tariff structure. In addition, even with the 200% price rise, household electricity expenditures under the IBT structure would not rise above 5% of their income, which is far below the 10% energy poverty threshold level.

Restructuring residential electricity tariffs and providing a high volume of electricity under the lifeline rate shielded the poor and other vulnerable members of the society from potential impacts of subsidy removal and was an important tool for redistributing wealth in the country. In addition, current policies being pursued or elaborated by the government could also mitigate impacts of potential subsidy removal, such as improving supply-side and demand-side efficiency levels and incentivising households to invest in solar PV systems. Power plant and electricity distribution efficiency improvements would reduce the overall cost of electricity generation. Introducing standards and labelling programmes for electrical appliances would result in household electricity savings. Encouraging households to invest in rooftop solar PV systems would reduce households' dependence on utility-sourced electricity supply.

Acknowledgement

This study was supported by the Economic Research Institute for ASEAN and East Asia (ERIA) under contract number ERIA-RD/RE-001-001-721/12/2017.

Appendix

Table A1
Land Area, Population and Household Income by District

District	Land Area (square kilometers)	Population in 2016 (number of inhabitants)	Household Income 2010 (B$ per household)
Brunei-Muara	570	292,705	6035
Belait	2727	69,992	4874
Tutong	1166	49,438	4539
Temburong	1306	10,543	4209
Brunei Darussalam	5769	422,678	5670

Source: DEPD (2016 and 2011).

Table A2
Number of Households and Average Monthly Income by Occupation of Household Heads

Occupation Type	Number of households	Average monthly income (BND)
Legislators, Managers and Senior Officials	4841	9351
Professionals	6338	8217
Technicians and Associate Professionals	9162	6158
Clerical Support Workers	3697	4752
Service and Sales Workers	8874	4070
Skilled Agriculture, Craft and Related Trade Workers	2090	4313
Plant and Machine Operators and Assemblers	2592	4380
Elementary Occupations Workers	3329	3740
Other Occupations	2496	4573

Source: DEPD (2011).

References

ADB, 2016. Fossil Fuel Subsidies in Asia. Trends, Impacts and Reforms. Integrative Report. Asian Development Bank, Mandaluyong, Philippines.
ADB, 2013. Cost-Benefit Analysis for Development: A Practical Guide. Asian Development Bank, Mandaluyong, Philippines.
APEC, 2017. APEC Energy Statistics 2015. Energy Working Group, Asia Pacific Energy Cooperation Secretariat, Singapore.
APEC, 2013. Peer review on energy efficiency in Brunei Darussalam. https://aperc.ieej.or.jp/file/2014/2/5/PREE_201311_Brunei_Darussalam.pdf, Accessed date: 10 August 2018.
Bagdadioglu, N., Basaran, A., Waddams Price, C., 2007. 'Potential Impact of Electricity Reforms on Turkish Households,' *CCP Working*. Paper No. 07-8. https://doi.org/10.2139/ssrn.993402.
Boardman, B., 1991. Fuel Poverty: from Cold Homes to Affordable Warmth. Belhaven Press, London.
Bouzarovski, S., Herrero, S.T., Petrova, S., Ürge-Vorsatz, D., 2016. Unpacking the spaces and politics of energy poverty: path-dependencies, deprivation and fuel switching in post-communist Hungary. Local Environ. 21 (9), 1151–1170. https://doi.org/10.1080/13549839.2015.1075480.
Bouzarovski, S., Tirado Herrero, S., 2015. The energy divide: integrating energy transitions, regional inequalities and poverty trends in the European Union'. Eur. Urban Reg. Stud. 24 (1), 69–86. https://doi.org/10.1177/0969776415596449.
Bouzarovski, 2014. Energy poverty in the European Union: landscapes of vulnerability. Wiley nterdiscip. Rev.: Energy Environ. 3 (3) May 2014. https://doi.org/10.1002/wene.89.
Bouzarovski, S., Petrova, S., Sarlamanov, R., 2012. Energy poverty policies in the EU: a critical perspective. Energy Policy 49, 76–82. https://doi.org/10.1016/j.enpol.2012.01.033.
Charap, J., Ribeiro da Silva, A., Rodriguez, P., 2013. Energy Subsidies and Energy Consumption – A Cross-Country Analysis. International Monetary Fund, Washington, DC IMF Working Paper WP/13/112.
Christensen, J.M., Denton, F., Garg, A., Kamel, S.M., Pacudan, R., Usher, E., 2006. Changing Climates. The Role of Renewable Energy in a Carbon-Constrained World. Renewable Energy Policy Network for the 21st Century, Paris. http://www.forskningsdatabasen.dk/en/catalog/2389475465, Accessed date: 10 August 2018.
Clements, B., Coady, D., Fabrizio, S., Dizioli, A., Funke, K., Kapsoli, J., Kpodar, K., Kangur, A., Nozaki, M., Shang, B., Soto, M., Thakoor, V., Sears, L., Nemeth, L., Alleyne, T., Villafuerte, M., Op de Beke, A., Verdier, G., Mira, C., Gwenhamo, F., David, A., Hussain, M., Bauer, A., Sdralevich, C., Demirkol, O., Krishna, K., Moers, L., Ostojic, D., Zouhar, Y., 2013. Case Studies on Energy Subsidy Reform: Lesson and Implications. International Monetary Fund, Washington, DC.
Coady, D., El-Said, M., Gillingham, R., Kpodar, K., Medas, P., Newhouse, D., 2006. The Magnitude and Distribution of Fuel Subsidies: Evidence from Bolivia, Ghana, Jordan, Mali, and Sri Lanka. IMF Working Paper WP/06/247. International Monetary Fund, Washington, DC.
Conkling, R., 2011. Energy Pricing: Economics and Principles. Springer, Berlin. https://

link.springer.com/book/10.1007%2F978-3-642-15491-1.
Del Granado, J.A., Coady, D., Gillingham, R., 2010. The Unequal Benefits of Fuel Subsidies: A Review of Evidence for Developing Countries. IMF Working Paper WP/10/202. International Monetary Fund, Washington, DC.
DEPD, 2017. Brunei Darussalam Statistical Yearbook 2016. Brunei Darussalam: Department of Statistics, Department of Economic Planning and Development, Prime Minister's Office.
Department of Electrical Services, 2018. Electricity Tariff. http://www.des.gov.bn/SitePages/Electricity%20Tariff.aspx, Accessed date: 10 August 2018.
DEPD, 2011. Report of the household expenditure survey 2010/2011. Department of statistics, department of economic planning and development. Prime Minister's Office, Brunei Darussalam.
Freund, C., Wallich, C., 1997. Public-sector price reforms in transition economies: Who gains? Who loses? The case of household energy prices in Poland. Economic Development and Cultural Change 46 (1), 35–59. https://www.jstor.org/stable/10.1086/452320.
Grevisse, F., Brynart, M., 2011. Energy Poverty in Europe: towards a More Global Understanding. ECEEE 2011 Summer Study. Energy Efficiency First: The Foundation of a Low-carbon Society. https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2011/2-current-energy-efficiency-policies-on-stage-and-backstage/energy-poverty-in-europe-towards-a-more-global-understanding/, Accessed date: 7 January 2019.
Hills, J., 2012. Getting the Measure of Fuel Poverty: Final Report of the Fuel Poverty Review. Centre for the Analysis of Social Exclusion, London, UK. http://sticerd.lse.ac.uk/dps/case/cr/CASEreport72.pdf, Accessed date: 10 August 2018.
IMF, 2015. Energy Price Reforms in the GCC – what Can Be Learned from International Experiences? Annual Meeting of Ministers of Finance and Central Bank Governors of the Gulf Cooperation Council. International Monetary Fund, Washington, DC.
Komives, K., Foster, V., Halpern, J., Wodon, Q., 2005. Water, Electricity, and the Poor: Who Benefits from Utility Subsidies? World Bank, Washington, DC.
Koplow, D., 2009. 'Measuring Energy Subsidies Using the Price-Gap Approach: what Does it Leave Out?', *IISD Trade, Investment And Climate Change Series,* Winnipeg. International Institute for Sustainable Development. http://www.iisd.org/publications/pub.aspx?pno=1165, Accessed date: 10 August 2018.
Lawrey, R., Pillarisetti, J.R., 2011. Energy subsidies versus economic efficiency: practical and theoretical issues in the case of Brunei Darussalam. Asian Soc. Sci. 7 (3), 108–116.
Liddell, C., Morris, C., McKenzie, S.J.P., Rae, G., 2012. Measuring and monitoring fuel poverty in the UK: national and regional perspectives. Energy Policy 49, 27–32. https://doi.org/10.1016/j.enpol.2012.02.029.
Maxim, A., Mihai, C., Apostoaie, C.M., Popescu, C., Istrate, C., Bostan, I., 2016. Implications and measurement of energy poverty across the European Union. Sustainability 8, 483. https://doi.org/10.3390/su8050483. 2016.
MEMI, 2018. Brunei Darussalam's Nationally Determined Contribution. Draft Document to Be Submitted to the United Nations Framework Convention on Climate Change.
Moore, R., 2012. Definitions of fuel poverty: implications for policy. Energy Policy 49, 19–26. https://doi.org/10.1016/j.enpol.2012.01.057, Accessed date: 10 August 2018.
Munasinghe, M., 1981. Principles of modern electricity pricing. Proc. IEEE 69 (3), 332–348.
Munasinghe, M., Warford, J., 1982. Electricity Pricing: Theory and Case Studies. World Bank, Washington, DC.
Nevin, R., 2010. Energy-efficient housing stimulus that pays for itself. Energy Policy 38, 4–11. https://doi.org/10.1016/j.enpol.2009.09.013.
Norjidi, D., 2012. Fuel smuggling cases down due to stringent action. https://www.facebook.com/brudirectcom/posts/fuel-smuggling-cases-down-due/384007085000613/, Accessed date: 10 August 2018.
Nussbaumer, P., Bazilian, M., Modi, V., Yumkella, K.K., 2011. Measuring energy poverty: focusing on what matters. In: Oxford Poverty & Human Development Initiative (OPHI); Working Paper No. 42. University of Oxford, Oxford, UK. https://ophi.org.uk/measuring-energy-poverty-focusing-on-what-matters/, Accessed date: 10 January 2019.
OECD/IEA, 2017. Energy Subsidies. International Energy Agency, Paris, France. https://www.iea.org/statistics/resources/energysubsidies/, Accessed date: 20 August 2018.
OECD/IEA, 2014. World Energy Outlook 2014. International Energy Agency, Paris, France.
Pacudan, R., 2018a. Feed-in tariff vs incentivized self-consumption: options for residential solar PV policy in Brunei Darussalam. Renew. Energy 122, 362–374. 2018. https://doi.org/10.1016/j.renene.2018.01.102.
Pacudan, R., 2018b. The economics of net metering policy in the Philippines. Int. Energy J. 18, 283–296. 2018. http://www.rericjournal.ait.ac.th/index.php/reric/article/view/1813.
Pacudan, R., 2018c. The economics of residential solar PV deployment in Southeast Asia: from feed-in tariff to incentivized self-consumption policy schemes. In: Transforming Energy Markets, 41st International Conference of the Association for Energy Economics. Groningen, Netherlands, . https://www.iaee.org/proceedings/article/15160, Accessed date: 10 August 2018.
Pacudan, R., 2016. Implications of applying solar industry best practice resource estimation on project financing. Energy Policy 95, 489–497. 2016. https://doi.org/10.1016/j.enpol.2016.02.021.
Pacudan, R., 2014. Electricity price impacts of feed-in tariff policies: the cases of Malaysia, the Philippines, and Thailand,. In: Han, P., Kimura, F. (Eds.), Energy Market Integration In East Asia: Energy Trade, Cross Border Electricity, and Price Mechanism. ERIA, Jakarta, pp. 283–319. ERIA Research Project Report FY2013, No.29. http://www.eria.org/RPR_FY2013_No.29_Chapter_11.pdf.
Pacudan, R., 2006. 'Power Sector Liberalization and Access to Energy in the Philippines,' in OECD/World Bank, *Liberalization And Universal Access To Basic Services*. OECD/World Bank, Paris, France (Chapter 11). https://openknowledge.worldbank.org/bitstream/handle/10986/13816/765290PUB0libe00Box374383B00PUBLIC0.pdf;sequence=1, Accessed date: 10 August 2018.
Pacudan, R., 1998. Natural gas pricing policies in Southeast Asia. Nat. Resour. Forum 22 (1), 27–36. https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1477-8947.1998.tb00707.x.
Pacudan, R., de Guzman, E., 2002. Impact of energy efficiency policy to productive efficiency of electricity distribution industry in the Philippines. Energy Econ. 24 (1), 41–54. https://doi.org/10.1016/S0140-9883(01)00085-8.
Pye, S., Dobbins, A., Baffert, C., Brajković, J., Grgurev, I., De Miglio, R., Deane, P., 2015. Energy Poverty and Vulnerable Consumers in the Energy Sector across the EU: Analysis of Policies and Measures. INSIGHT_E, Brussels, Belgium. http://www.innoenergy.com/wp-content/uploads/2016/03/INSIGHT_E_PR2_Energy-Poverty-Main-Report.pdf, Accessed date: 15 April 2018.
Rotoras, R.E., Lefevre, T., Pacudan, R.B., 2002. Marginal transmission pricing and cost allocation method: a case of Philippines. Electr. Power Syst. Res. 63 (3), 213–227. https://doi.org/10.1016/S0378-7796(02)00119-0, Accessed date: 14 July 2018.
Schott, P.K., 2003. One size fits all? Heckscher-ohlin specialization in global production. Am. Econ. Rev. 93 (3), 686–708.
Sdralevich, C., Sab, R., Zouhar, Y., Albertin, G., 2014. Subsidy Reform in the Middle East and North Africa. Recent Progress and Challenges Ahead. International Monetary Fund, Washington, DC.
Šajn, N., 2016. 'Energy poverty. Protecting the vulnerable consumers.' european parliament. http://www.europarl.europa.eu/RegData/etudes/BRIE/2016/583767/EPRS_BRI(2016)583767_EN.pdf, Accessed date: 15 April 2018.
Silva, P., Klytchnikova, I., Radevic, D., 2009. Poverty and environmental impacts of electricity price reforms in Montenegro. Util. Pol. 17 (1), 102–113. https://doi.org/10.1016/j.jup.2008.02.008.
Thomson, H., 2014. A brief overview of the EU discourse on fuel poverty and energy poverty. https://www.energypoverty.eu/news/brief-overview-eu-discourse-fuel-poverty-energy-poverty, Accessed date: 28 December 2018.
Waddams Price, C., Pham, K., 2009. The impact of electricity market reform on consumers. Util. Pol. 17 (1), 43–48. https://doi.org/10.1016/j.jup.2008.02.007.
World Bank, 2018. Commodity Markets Outlook. Oil Exporters: Policies and Challenges. World Bank, Washington, DC. http://www.worldbank.org/en/research/commodity-markets, Accessed date: 10 August 2018.
World Bank, 2010. Subsidies in the Energy Sector: an Overview. World Bank, Washington, DC. http://siteresources.worldbank.org/EXTESC/Resources/Subsidy_background_paper.pdf, Accessed date: 10 August 2018.