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The notion of Iran as 'high energy-intensity-country': a critique

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Abstract

This is a critical note on the international comparative assessment of the energy dependence of countries based on measures of energy intensity that are employed to contrast and analyse peer sectors or firms. Energy use per unit of GDP or GDP produced per unit of energy are inspired by measures that are constructed to compare coequal firms/sectors' value-added relative to their consumption of energy. While the measure seems innocent, it is questionable to apply it as a metric for comparison without considering other contextual factors. To obtain credible results, the incorporation of contextual factors such as stage of development and the structure of the economy is essential for a meaningful macro-comparison across countries.

JEL: O57, Q40.

Keywords

High energy intensity country, Iran, energy consumption, critique, energy use per GDP.

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Acronyms

GDP	Gross Domestic Product
IMF	International Monetary Fund
PPP	Purchasing Power Parity
SCI	Statistical Centre of Iran
Toe	Tone of oil equivalent
WB	World Bank
WDI	World Development Indicators

The notion of Iran as ‘high energy-intensity-country’: a critique

1 Introduction

> Iran’s energy products are amongst the most heavily subsidized in the world. This has encouraged excessive use of energy (both in per capita terms and per unit of GDP), as reflected by Iran’s move from being one of the lowest energy intensity users in the world in 1980 to one of the highest in 2009. (IMF, 2010:14)

> Iran’s fuel prices were among the very lowest in the world, only ahead of Venezuela. This has encouraged excessive use of energy (both in per capita terms and per unit of GDP) ... (Vagliasindi, 2012:8)

> Iran’s energy intensity is among the highest in the world, which has been increasing during the recent decades, originating from the channels related to the efficiency and structural changes. (Farajzadeh and Nematollahi, 2018: 161)

> Iran has the highest energy intensity in the world. […] Iran’s primary energy intensity has reached 0.59 tons of oil equivalent per $1000 of GDP in 2008, while the world average is about 0.2. Iran’s high energy intensity emphasizes the low productivity issues of the country’s energy system. (Houri Jafari et al., 2016: 686)

These quotes are a small collection of many similar statements in the literature pertaining to Iran’s energy sector. The message is that Iran is a high energy-intensive country. This message seems so obvious that hardly any Iranian citizen or energy experts doubts it. The objective of this research note is to examine to what extent the statement about Iran being energy-intensive is valid and can be substantiated with data.

When we refer to high-energy intensive industries, firms, or sectors the concept is well-defined. We express that the high energy consumer employs more energy compared to the average of counterpart industries, firms, or sectors. Within a country this metric is useful since the overarching parameters are similar. However, comparing energy-intensity across countries demands a frame that comprises a vast range of determinants that feed into the level of energy consumption of a country. These parameters include but are not limited to climate conditioning, geopolitical parameters, size of the country, population, population density, degree of urbanization, stage of economic development, structure of the economic sectors such as for example the composition of the manufacturing sector, and access to energy resources.

In what follows I do not intend to build a model to analyse energy-intensity across countries, rather I put forward a critique of the naïve comparison of countries without considering the aforementioned parameters. Questioning the label of energy-intensive country is important for two reasons. First, being a high energy-intensive country comes with a negative connotation as a higher energy consumption is equivalent to more pollution and CO_2 emission. Second, the label is associated with unrealistic expectations about potential consumption reductions in response to price increase for countries such as Iran that have traditionally provided heavy energy subsidies. Underlining this aspect, even foreseen international sanctions did not prevent the government from postponing the 2010 energy subsidy reform as it was believed that the energy price increase would substantially decrease energy consumption and release the country from importing refined oil products. Ironically, the energy subsidy reform was taken as a policy to partially defuse the upcoming sanctions.[1]

2 Data and method

Since I intend to compare countries, regions, and income classes, I opted for the World Bank's freely available online dataset, the World Development Indicators that is a very comprehensive databank that rests on input from different datasets. I have chosen the year 2010 as a reference point to exclude the potential impact of the Iranian energy subsidy reform that started in December 2010.

The main variables included in the analysis are the following: (i) per capita GDP which is measured in constant 2017 international dollar using Purchasing Power Parity (PPP) conversion factors, (ii) access to clean fuels and technologies for cooking measured as the share of the population that has access to clean fuels, (iii) access to electricity measured as the share of the population that has access to electricity, (iv) the agriculture, industry, and service share measured as shares of each of the three economic sectors in GDP, (v) energy use per capita measured as total energy use divided by the total population and denoted as Ton of oil equivalent (Toe) per person and, (vi) the energy use per access; this is the total energy use divided by the population that has access to energy. It is measured in Toe per person. Finally, I employ (vii) the energy use per GDP which represents the total energy use divided by GDP. It is measured in Toe per million dollars.

The method I employ is exploratory. I compare the figures across countries and use data visualization of energy-related variables to visually explore energy consumption across countries.

3 Discussion: Country level energy intensity measures

3.1 Per capita and per access measures

Energy consumption and the economic characteristics of Iran are presented in Panel A of Table1. Panel B provides similar average information for countries in different income classes based on the World Bank's classification. In terms of income, Iran is classified as an upper-middle income country by the World Bank as it has an annual per capita income of nearly 13,800 dollars (constant 2017 international dollar, PPP conversion factors). The income classification of Iran contrasts with the energy-access indicators of the country. In terms of access to energy, Iran rather matches the records of high-income countries. More than

[1] This statement issued by several political figures, among them by the then minister of finance and economy. Reported by Islamic Republic News Agency (IRNA) https://www.irna.ir/news/6538902 , accessed on 31-08-2021.

97 and 99 percent of Iranians have access to clean fuels and electricity, respectively. The rate of access to clean fuels of high-income countries is 99 percent while this rate for the group of upper-middle income countries is only 66 percent. As can be seen from Panel B, there are substantial differences in access to energy across country income classes. This suggests that another metric for comparing the energy intensity of a country could be energy use per population that has access to energy (i.e., per access energy use measure). The per capita and per access figures are presented in the last columns of Table1 and show that based on these metrics Iran, albeit slightly higher in absolute terms, is similar to the average upper-middle income countries.

Visually, Figure 1 presents the dynamics of *per capita* and *per access* energy use across country income groups. A consistent association between the income level of a country and access to energy as well as energy use per capita is evident. In other words, the higher the share of the population with access to energy, the more energy is consumed. Also, the richer a country the more energy it uses and vice versa. As mentioned before, I do not attempt to draw any causal relationship. I rather explore the relationships using a descriptive approach. Figure1 illustrates how per capita energy use and GDP go hand in hand and proportionally move together indicating the significance of affordability of energy for energy use. Comparing Iran with the presented income classifications shows that Iran is slightly higher than the upper-middle income group in terms of per capita GDP as well as per capita and per access energy use. But the per capita and per access figures also show that Iran consumes far less energy compared to high-income countries. Figure 2 scatters countries with respect to per capita GDP and per access energy use. Income groups are illustrated with different colours and Iran has been tagged. This figure supports the earlier identified strong positive correlation between income and energy use between and within income groups. Moreover, the often-claimed extraordinary energy-intensity of Iran is not apparent. Iran, in the two-dimensional space of per capita GDP and per capita (and per access) energy use, not only is not an outlier, but on the contrary, its position is close to the fitted curve.

The dispersion of energy-related indicators across geographical regions as adopted by the World Bank are reported in Panel C of Table 1 and Figure 3 compares the regions with respect to their average per capita GDP and their average per capita energy use. A strong correlation between income and energy use is evident across regions, as well. North America that includes the two countries of Canada and the United States has the highest energy use per capita and per access, namely about 7.2 Toe per person for both measures. Apart from North America, per access energy use of the regions varies in the range of 1 to 3.4 Toe per person. Iran's per access energy use is 2.8 Toe per person that is 4% more than the World average which is 2.7 Toe per person.

3.2 Per GDP measure

After having established that in terms of per person and per access energy use Iran is not an outlier we turn to another metric, namely the energy use per GDP. This index measures how much energy (million Toe) is used to produce one-million-dollar worth of GDP (constant 2017 international dollar, PPP conversion factors). Obviously, this index is tightly connected to the determinants of GDP. Exploring these factors is beyond the scope of this chapter/note. Yet, the composition of the economic sectors (agriculture, industry, and service) may provide a hint for examining this index.

It is evident from Panel B of Table1 and Figure 4 that there is an association between the shares that the three sectors hold in their contribution to GDP and the country income class. The higher the income class the smaller the share of the agricultural sector and the larger the share of the service sector. Figure 5 shows that there is an inverted U-shaped relationship between income and per GDP energy use. In other words, the energy use per GDP increases as income increase and then it reverses. This inverted U-shape strongly correlates with the share of the industry contribution in GDP (Figure 4). The share of the industry sector grows with income but then it shrinks in favour of the service sector for the highest income countries.

Panel C of Table 1 and Figure 5 show the dispersion of per GDP energy use across regions. Panel C presents data showing that the dispersion of per GDP energy use across regions ranges from 88 million Toe for Latin America and the Caribbean to 198 in Sub-Saharan Africa. This index shows that Sub-Sahara Africa is the most energy-intensive region. These figures clearly identify the trap we are faced with when talking about the energy intensity of a country or region. This region suffers the most from deprivation of access to energy services and also from lack of affordability of energy services due to poverty (Nussbaumer et al., 2012). Thus, the region uses less energy than other regions. Yet, at the same time, it produces less GDP per unit of energy use. At the other extreme we find North America. Per capita energy use of this region is approximately 4 times that of the world average and 1.5 times that of high-income countries. However, the per GDP intensity measure shows no difference compared to the world average (nearly 135 Toe per million-dollar GDP). These examples clearly display that naively comparing regions and countries with energy intensity indices particularly with the per GDP energy use index can be misleading.

To further explore this line of argumentation, Table 2 presents the energy-related indicators of selected countries. The contradictory results of comparing countries with per GDP measures is evident here too. For example, India that suffers from widespread energy poverty (Sadath and Acharya, 2017) is similar to the Unites States and the United Arab Emirates in terms of per GDP energy use. This simplistic comparison does not take into account the composition of the economy and the type of the income generation. High income countries enjoy better term of trades for high-tech products and high value-added services that is reflected in their GDP and per GDP energy use.

Returning to Iran, per GDP energy use of Iran is nearly 201 Toe per million dollar that is 25% more than the average of the upper-middle income countries. If we divide the upper-middle income countries according to the size of the industry sector (see Table 3), the variation in per GDP energy use measure surfaces. Upper-middle income countries with a share of the industry sector of more than 40% consume nearly 188 Toe for each million dollar of GDP that roughly matches Iran's per GDP energy use of 201 Toe with an industry sector that makes up 44% of the economy.

4 Conclusion

To conclude, Iran is frequently identified as a high energy-intensive country in the literature. This gives the impression of excessive use or waste of energy and causes unrealistic expectations about the extent to which energy price policy and regime shifts in energy policy can reduce energy consumption. This note analysed World Bank country-level data and explored and contrasted two common measures of energy-intensity: (i) per capita energy use and (ii) per GDP energy use. Both are commonly used to reflect the energy intensity of a country. The main conclusions resulting from the analysis are threefold:

First, per capita energy use is highly related to the two factors of availability and affordability of energy. Lack of access to (clean) energy resources lowers the per capita energy use of countries. Therefore, to appropriately compare the per capita energy use of countries, at least the accessibility of energy resources has to be incorporated. Regarding affordability, there is a proportional and positive relationship between income and energy use. A high-income country resident uses 2.5 times the energy of a citizen in an upper-middle-income country.

Second, contrary to most of the existing literature on the energy intensity of Iran (IMF, 2010; Vagliasindi, 2012; Houri Jafari *et al.,* 2016; Farajzadeh and Nematollahi, 2018), per capita/per access energy use of Iran is not an exceptional outlier but it is close to the average level of those countries with similar income and similar access rates to clean fuels and electricity.

Third, comparing countries' energy intensity based on the measure of per GDP energy use results in absurd conclusions. Based on this measure Sub-Sahara Africa that generally suffers from energy poverty (Nussbaumer et al., 2012) turns out to be the most energy-intensive region. Similarly, the energy intensity of India appears slightly higher compared to that of the United States and the United Arab Emirates. Application of this measure only makes sense if the characteristics of the underlying economies are similar; for example, for countries operating in the same range of per capita GDP and with similarly sized industrial sectors.

In short, based on the above findings I challenge the labelling of Iran as 'high energy-intensity' country.

Table 1
Energy related indicators – Income and geographical classification

		Characteristics						Energy intensity measures		
		GDP per capita	Clean fuels access (%)	Electricity access (%)	Agriculture (%)	Industry (%)	Service (%)	Per capita	Per access	Per GDP
Panel A	Iran	13,806	97.4	99.7	6.5	44.2	51.1	2.77	2.81	200.60
	Income category averages									
Panel B	Low income	2,017	12.8	28.1	26.5	25.5	40.7	NA	NA	NA
	Lower middle income	4,699	35.3	71.5	16.7	30.3	47.2	0.60	1.12	127.96
	Middle income	8,440	51.0	85.2	9.1	36.0	49.2	1.28	1.88	151.78
	Upper middle income	11,986	66.4	98.4	7.2	37.4	49.7	1.93	2.34	160.58
	High income	43,734	99.0	100.0	1.3	23.6	69.0	4.88	4.91	111.65
	Geographical classification averages									
Panel C	East Asia & Pacific	11,893	55.5	95.5	5.6	35.9	57.0	1.92	2.54	161.67
	Europe & Central Asia	30,711	96.2	100.0	2.0	23.5	64.1	3.31	3.37	107.53
	South Asia	4,065	32.0	73.2	1.5	22.4	66.1	0.52	0.98	126.75
	Sub-Saharan Africa	3,484	12.3	33.7	17.6	29.0	46.6	0.69	3.01	198.46
	Middle East & North Africa	15,164	93.9	95.8	16.0	28.0	50.6	2.12	2.23	139.72
	North America	53,420	100.0	100.0	4.7	46.3	47.5	7.22	7.23	135.22
	Latin America & Caribbean	15,173	85.0	96.1	1.1	20.0	75.2	1.33	1.47	87.96
	World	13,887	56.1	83.3	4.7	29.1	55.8	1.87	2.70	134.96

Source: Author's calculation based on World Bank databank -World Development Indicators dataset (2010).

Table 2
Energy related indicators - Selected countries

	Characteristics						Energy intensity measures		
	GDP per capita	Clean fuels access (%)	Electricity access (%)	Agriculture (%)	Industry (%)	Service (%)	Per capita	Per access	Per GDP
Brazil	14,868	93.7	99.4	4.1	23.3	57.6	1.36	1.41	91.4
China	8,885	54.9	99.7	9.3	46.5	44.2	1.95	2.53	220.0
Egypt	10,340	96.0	99.4	13.3	35.8	46.2	0.88	0.90	84.8
Gabon	14,415	73.6	89.5	3.9	55.2	30.8	3.13	3.84	217.1
Germany	46,900	100.0	100.0	0.8	26.8	62.3	4.00	4.00	85.2
India	4,227	34.4	76.3	17.0	30.7	45.0	0.56	1.01	132.9
Indonesia	8,287	40.2	94.2	13.9	42.8	40.7	0.88	1.31	105.8
Iran	13,806	97.4	99.6	6.5	44.2	51.1	2.77	2.81	200.6
Netherlands	52,033	100.0	100.0	1.8	19.7	68.4	5.03	5.03	96.6
Pakistan	3,907	35.6	70.8	23.3	19.7	52.8	0.47	0.89	121.3
Russia	24,035	97.2	100.0	3.3	30.0	53.1	4.82	4.89	201.1
Saudi Arabia	44,037	96.0	100.0	2.6	58.4	39.2	6.76	6.90	153.6
South Africa	12,452	76.7	82.9	2.4	27.4	61.0	2.77	3.47	222.3
Turkey	20,028	NA	100.0	9.0	24.5	54.5	1.47	1.47	73.6
United Arab Emirates	54,922	98.4	100	0.8	52.5	46.7	7.22	7.27	131.4
United Kingdom	42,002	100.0	100.0	0.6	18.9	70.6	3.23	3.23	76.9
United States	54,400	100.0	100.0	1.0	19.4	76.2	7.16	7.16	131.7

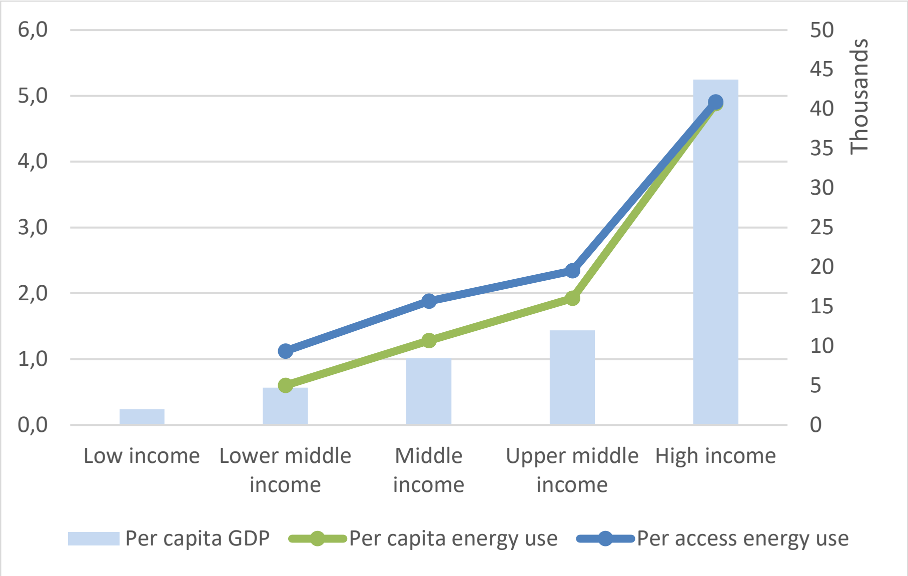
Source: Author's calculation based on World Bank databank -World Development Indicators dataset (2010).

Table 3
Per GDP energy use of the upper-middle income class

	Industry sector size (%) <=25	25 <Industry sector size (%) <=40	Industry sector size (%) >40
Per GDP energy use	96.52	104.93	187.46

Source: Author's calculation based on World Bank databank- World development indicators dataset (2010).

Figure 1
Per capita and per access energy use for income classes

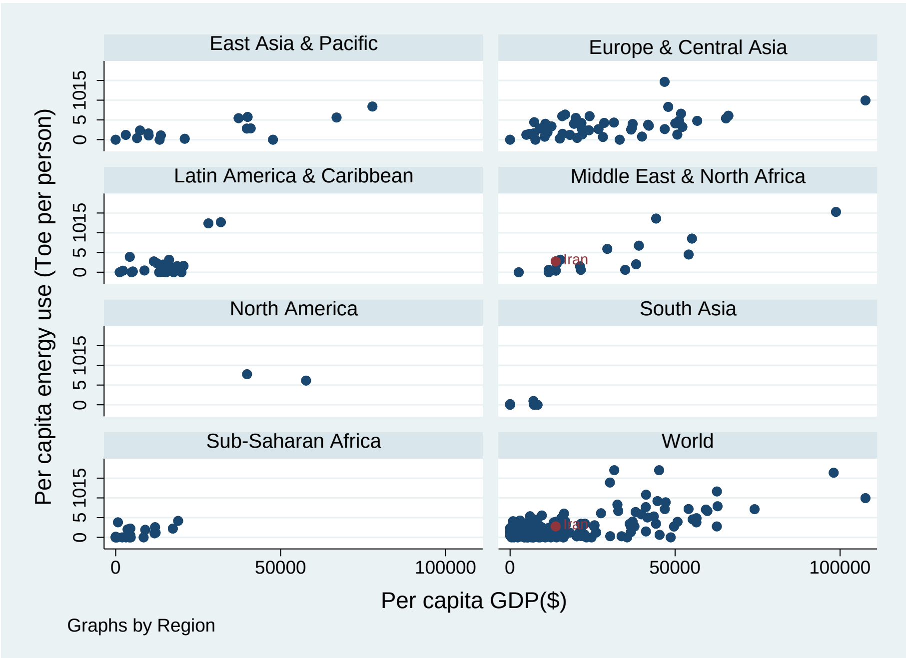


Source: Author's illustration based on World Bank databank- World development indicators dataset (2010)

Figure 2
Per access energy use for income classes

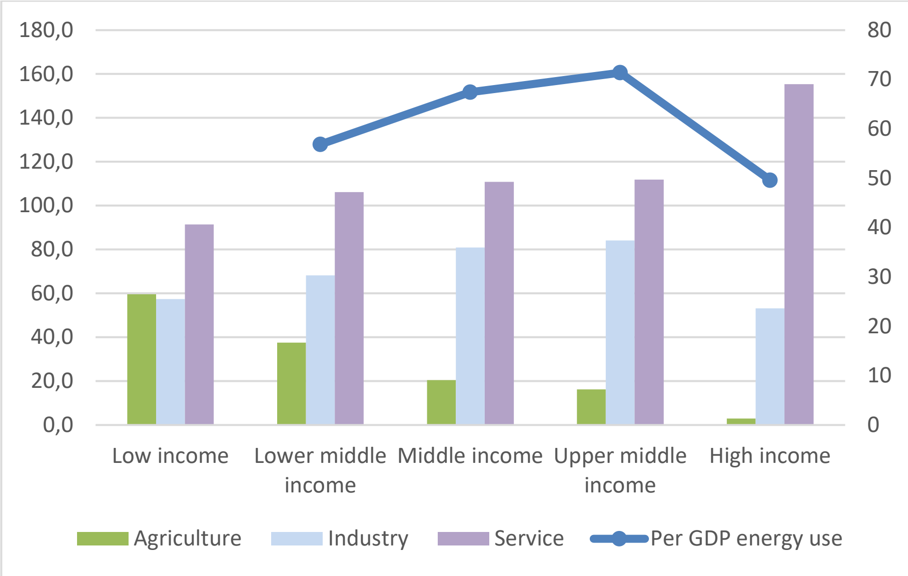
Source: Author's illustration based on World Bank databank- World development indicators dataset (2010).

Figure 3
Dispersion of per capita energy use across geographical regions



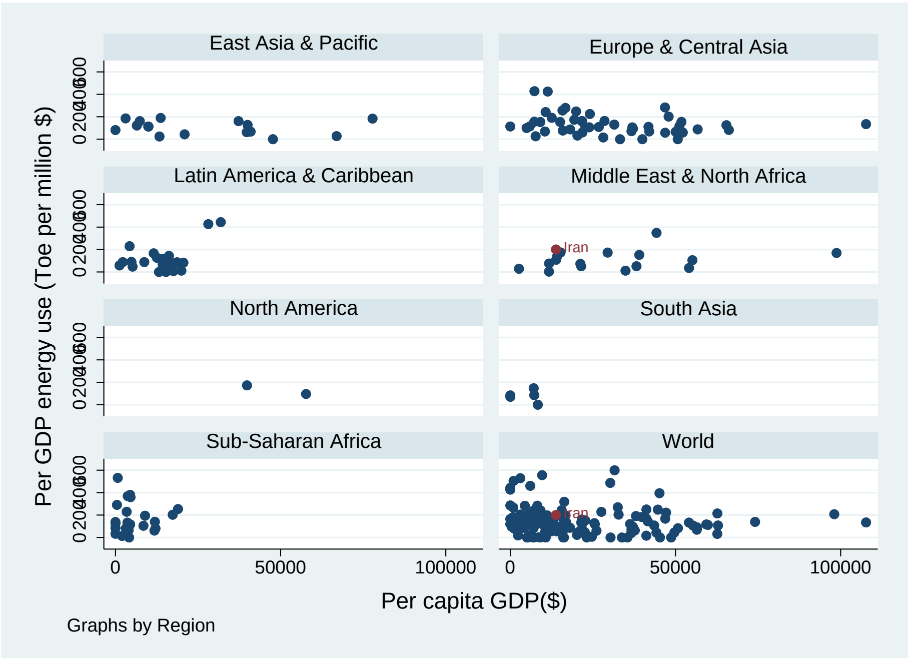
Source: Author's illustration based on World Bank databank- World development indicators dataset (2010)

Figure 4
Per GDP energy use and GDP composition across income classes



Source: Author's illustration based on World Bank databank- World development indicators dataset (2010).

Figure 5
Dispersion of per GDP energy use across geographical regions



Source: Author's illustration based on World Bank databank- World development indicators dataset (2010)

References

Farajzadeh, Z. and Nematollahi, M.A. (2018) 'Energy intensity and its components in Iran: Determinants and trends', *Energy Economics,* 73, pp. 161-177. doi: https://doi.org/10.1016/j.eneco.2018.05.021.

Houri Jafari, H., Vakili, A., Eshraghi, H., Hamidinezhad, A. and Naseri, I. (2016) 'Energy planning and policy making; The case study of Iran', *Energy Sources, Part B: Economics, Planning, and Policy,* 11(8), pp. 682-689. doi: https://doi.org/10.1080/15567249.2012.741186.

IMF (2010) *Islamic Republic of Iran: country report No. 10/74*. Washington DC.: International Monetary Fund. Available at: https://www.imf.org/external/pubs/ft/scr/2010/cr1074.pdf (Accessed: 20-08-2021).

Nussbaumer, P., Bazilian, M. and Modi, V. (2012) 'Measuring energy poverty: Focusing on what matters', *Renewable and Sustainable Energy Reviews,* 16(1), pp. 231-243. doi: https://doi.org/10.1016/j.rser.2011.07.150.

Sadath, A.C. and Acharya, R.H. (2017) 'Assessing the extent and intensity of energy poverty using Multidimensional Energy Poverty Index: Empirical evidence from households in India', *Energy Policy,* 102, pp. 540-550. doi: https://doi.org/10.1016/j.enpol.2016.12.056.

Vagliasindi, M. (2012) *Implementing energy subsidy reforms: an overview of the key issues.* Washington DC: World Bank. Available at: http://hdl.handle.net/10986/11934 (Accessed: 15-05-2021).