RESEARCH ARTICLE OPEN ACCESS

Comparing Natural Gas Energy Security in Asia and Europe: The Impact of the Paris Agreement on Import Countries' Indicators of Diversity

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ABSTRACT
According to the IMF (International Monetary Fund) , Asian economic growth is driving the world's economy, accounting for more than 60% of the global economy. The Asian economy also accounted for more than 70% of the world's increased energy demand from 2000 to 2017. According to WEO 2018 (World Energy Outlook 2018), issued by the IEA, Asia will account for 46% of total global energy demand in 2040. In a new policy scenario (NPS), even in 2040, 74% of energy demand will rely on fossil resources, of which 34% will be natural gas. A key element of energy security in natural gas importing countries is the diversification of importing partners. While natural gas diversification in Asia is advancing at a rapid pace, the diversity of natural gas importers has decreased in recent years in some European countries. The 2015 Paris Agreement affected countries using natural gas in many ways. Because of environmental measures taken in some European countries, renewable energy has already becoming cheaper than natural gas in electricity market.
Keywords-Asia and Europe, diversification, energy security index, natural gas

Date Of Submission: 22-06-2019 Date Of Acceptance: 08-07-2019

I. INTRODUCTION

International energy demand is steadily moving from Europe to Asia. The primary energy supply in China, India, Japan, Korea, and ASEAN countries, which comprised only 19% of the world's total in 1973, increased to 41% in 2016 (4.8 times greater in volume) [1]. In addition, the IEA has published The IEA's WEO 2018 [2], a forecast of future energy until 2040, showed core "New Policy Scenarios (NPS)." According to these NPS, fossil fuels will constitute 74% of total primary energy demand in 2040. Natural gas usage will more than double compared to 2000 and account for 34% of global fossil fuel supply in 2040.

The purpose of energy security in natural gas is to reduce transport risk. CO_2 emissions, gas prices, while increasing energy efficiency, stockpiling, self-sufficiency, and the diversification of importing countries is more important. Stirling (2010) [3] published a detailed report about the impact of energy diversity on energy security. Sourcing natural gas resources from many countries and large areas can lessen political and environmental risks.

Many prior studies have quantitatively analyzed energy security. Lefevre (2010) [4] noted that energy instability and potential dangers are caused by uneven distribution of resources, which increases the risk of price fluctuations. He also advocated an index (ESPI: the Energy Security Price Index) that quantifies price fluctuation risk and country risk [5]. However, neither ESPI nor ESMC have been included in a quantitative analysis comparing Asia and Europe.

Vivoda (2017) [6], who explored major Asian importers' approaches to LNG import diversification between 2001 and 2017, explained why patterns of LNG imports differ across countries. His paper assessed the diversification of LNG imports in five Asian countries, using the Herfindahl–Hirschman Index.

Chang (2013) [7] studied the diversity of imported energy, using Taiwan's energy supply structure as an example, and created a comprehensive energy security price index that improved both the Herfindahl–Hirschman Index and the Shannon-Wiener Index. However, neither Vivoda nor Chang's research incorporated European countries, which are advanced natural gas importers. As a result, the declining diversity of European natural gas-importing countries is not mentioned.

Neumann (2004) [8] analyzed gas supply security in the liberalized European natural gas market. He used the Shannon-Wiener Index to create a new energy diversity indicator, the Shannon–Wiener–Neumann Index.

Jansen, et al. (2004) [9] invented four indices that added more elements to the Shannon-Wiener Index. However, neither Neumann (2004) nor Jansen, et al. (2004) used the Shannon-Wiener Index and did not use the Herfindahl-Hirschman Index for their respective analyses.

Hauser (2018) [10] developed six scenarios that combined a European natural gas model with a German energy system model. According to his analysis, long-term maintenance of the natural gas infrastructure, such as developments of new pipelines and construction of LNG bases, is important for energy security, and switching to gas thermal power generation is necessary to reduce CO_2emissions. However, Hauser's paper does not mention that natural gas, because of the rapid development of renewable energy, is exposed to price competition in the wholesale electricity market.

As mentioned above, although the literature includes many studies on energy security, no research has conducted a quantitative comparison between importing Asian and Western countries considering the diversity of importing countries.

The purpose of this paper is to clarify how the Paris Agreement signed by 196 countries and regions in 2015 impacted a multilateral comparison of diversification indicators for natural gas-importing countries. Regarding the importation of natural gas, which is important as a bridge energy source to future renewable energy, it is necessary to analyze the impact of the Paris Agreement on the diversification of import partners countries, of great significance for Japan's future energy security.

In Section 2 of this paper, we discuss the relationship between economic growth trends and energy consumption in Asia and Europe, note the increase in CO_2 emissions associated with economic growth, and analyze energy diversity indicators. Section 3 considers the situation of Asian and European countries with regard to natural gas diversity, calculated using the diversity index. Section 4 summarizes the paper and discusses future research directions.

The survey's target countries are the top seven Asian LNG importers (Japan, China, Korea, India, Taiwan, Thailand, and Singapore), as well as the eight largest importers in Europe (Germany, Italy, Turkey, the Netherlands, France, the UK, Spain, and Poland), and the U.S. These targeted 16 countries account for 74% of the world's natural gas imports. The study covered the years 1993 to 2017.

The study uses public data, regularly issued by official entities, that public energy agencies and government agencies use as a basis for policymaking.

II. ANALYSIS METHOD AND DATA

2.1 The Energy Self-Sufficiency Rate

The energy self-sufficiency rate is the ratio between national primary energy output and consumption of primary energy in a given year. According to the IEA classification, nuclear power is included in the self-sufficiency rate as "quasi-domestic energy." The same applies to this paper.

$$SS=EP/TPES\times 100, \quad (1)$$

where SS is the energy self-sufficiency rate and EP is energy production, including nuclear power generation, and TPES is the total primary energy supply.

2.2 Energy Efficiency

While energy consumption per unit of work measures energy savings, energy savings in an entire country often uses the GDP base unit of energy. Since purchasing power parity GDP may overestimate GDP in developing countries (Suehiro, 2007) [11], we used real GDP and the 2010 USD market exchange rate. We also investigated the relationship between per-capita energy consumption and per-capita GDP (real GDP, 2010 USD).

Total energy supply efficiency：

$$EE_{TPES} = TPES/GDP_{2010USD} \quad (2)$$

Total energy consumption efficiency：

$$EE_{TFC} = TFC/GDP_{2010USD} \quad (3)$$

Power energy consumption efficiency：

$$EE_{ETFC} = ETFC/GDP_{2010USD} \quad (4)$$

Per-capita energy consumption efficiency：

$$EC_{PC} = TFC_{PC}/GDP_{PC,} \quad (5)$$

where TPES is total primary energy supply, TFC is total final consumption, and ETFC is the electricity total final consumption (kwh).
$GDP_{2010USD}$: GDP (2010 USD)

2.3 Resource diversity

The diversity of resources important for energy security is represented by the following RD (Resource Diversity), using the Herfindahl-Hirschman Index (HHI).

$$RD_f = \sum_i S_{if}^2, \quad (6)$$

where S_{if} is the share of energy resources f of country i. f means the type of energy resource (fossil fuel, nuclear power, hydropower, geothermal energy, solar power, wind power, or electricity).

2.4 Choke Point Risk for Crude Oil and Natural Gas Transportation

The U.S. EIA defines seven straits, such as the Holmes Strait and the Malacca Strait, as "choke points" [12]. The Ministry of Economy, Trade, and Industry cited three indicators for risk assessment in resource-providing countries. As one of them, "Risk of transportation of resources" (how many times it pass through choke points, such as the Holmes Strait, where conflicts may occur) is used as an evaluation index [13]. In this paper, choke point risk was analyzed for crude oil and LNG tankers. The formula is as follows:

$$CP_r = \sum_j (\alpha \cdot S) / \sum_i T, \quad (7)$$

where CP_r is choke point risk, α is the number of choke-point passes, T is total crude oil (or LNG) imports of an importing country i, and $\sum_j(\alpha \cdot S)$ is the amount of exporting country j's crude oil (or LNG) passing through a choke point.

2.5 Energy Prices

Energy prices were represented by the Paasche Price Index, which was based on 2010 industrial and household energy prices. Table 3 shows the indicators of industrial energy prices.

2.6 CO_2 Emissions

One of the largest environmental problems caused by energy is the global warming. Energy-derived CO_2 emission indicators were calculated using TPES, TFC, population, and kWh in addition to total amount, but Table 3 shows the total amount..

CO_2 emissions per total energy supply

$$=CO_2/TPES \quad (8)$$

CO_2 emissions per total energy consumption

$$=CO_2/TFC \quad (9)$$

Per-capita CO_2 emissions

$$=CO_2/population \quad (10)$$

Amount of CO_2 emitted to generate 1 KW

$$=CO_2/KWh \quad (11)$$

2.7 Diversification of Natural Gas-Importing Countries

Among the energy security evaluation indicators, the indicator IRD (Import Region Diversity) used for the diversity of resource importing countries is the same as 2.3 "Resource diversity RD" and uses the Herfindahl-Hirschman index.

According to Chang (2013) [7], the diversity index most often used in energy security is the Herfindahl-Hirschman Index (HHI: the same as Simpson's λ), the Shannon-Wiener Index (SWI), or the Deformation Indicator. The Herfindahl-Hirschman Index and the Shannon-Wiener Index are expressed by the following formulas.

$$IRD_{if}^{HHI} = \sum_i P_{if}^2 \quad (12)$$

$$IRD_{if}^{SWI} = \sum_i P_{if} \ln P_{if} \quad (13)$$

Where i = 1… N: N is the number of exporting country I, f=1 or 2: 1 is crude oil, 2 is natural gas, and P_{if} is the share of fossil resource f in exporting country i : $0 \leqq P_{if} \leqq 1$

As shown in my paper [14], these two indexes have different characteristics. Compared to HHI, SWI responds more to low-share factors. Ogaki (2008) [15] said that "in SWI, the smaller the probability of occurrence, the larger the information content of the event." HHI can be expected to produce better results when share represents diversity due to large factors. Therefore, we used HHI in this paper.

III. ANALYTICAL RESULTS

Figure 1 shows the diversification of importing countries in targeted Asian countries [16].

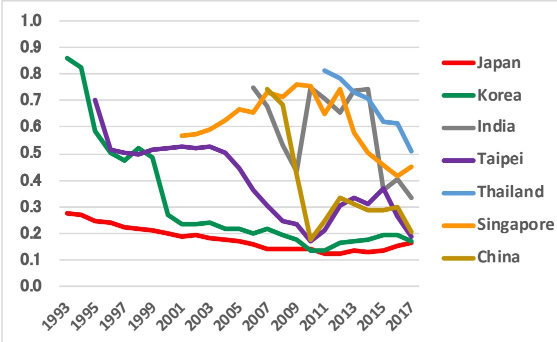

Fig.1 Natural gas import region diversity of Asian countries

Japan, Korea, Taiwan, and Singapore began importing natural gas before 1993, while India imported it from Qatar in 2004, China imported it from Australia in 2006, and Thailand imported it from Myanmar in 2000. When one country begins importing natural gas, IRD is high. However, all countries, for energy security, look to diversify their sources of fossil fuels. As a result, IRD in all the Asian targeted countries is decreasing (diversification is progressing).

Figure 2 shows the diversification of natural gas import partners in targeted European countries. Because all these countries have imported natural gas for a long time, many have low IRD. However, the United States produces a large quantity of natural gas, and 97% of its imports are from Canada. Even with high IRD, natural gas producers do not have the problem of importer diversity.

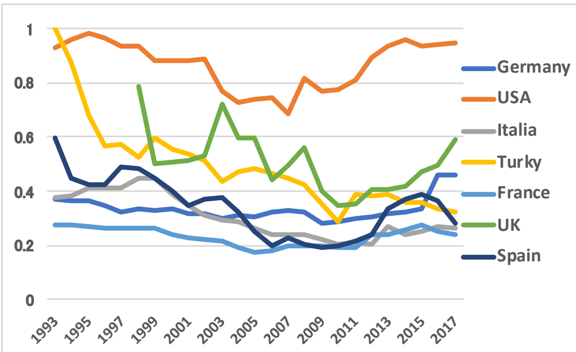

Fig.2 Natural gas import region diversity of Europe countries

IRD values in the UK and Germany declined (deteriorated) since 2015, since around 2010. As a whole in Europe, it has been rising (deteriorated)since the 2000s in recent years. What does this mean? We will analyze each country in the next section.

3.1 Germany

While Natural gas importers in Asia have diversified their sources in recent years, In Europe, the trend is towards lower diversity.

Although Germany became the world's largest importer of natural gas in 2017 [17], its IRD has gradually increased (deteriorated) since 2012. Germany stopped its imports of natural gas 34,000 Mcm (2015) from the Netherlands, halved its imports 22,0000 Mcm (2015) from Norway, and began importing from Russia in 2012 via a natural gas pipeline (NS) [18]. The increase in natural gas imports from Russia from 2012 to 2017 reached 39,000 Mcm, for a total of 72,000 Mcm (2017), exceeded 60% of Germany's imported natural gas. As a result, HHI worsened to 0.46 (2017). 2.7 times higher than that of Japan. Furthermore, with the German-Russian Nord Stream 2 pipeline [19] scheduled to start operating in 2019, the influx of Russian natural gas is expected to increase.

Germany has set high targets for reducing greenhouse gas reductions to date. [20]. Germany's renewable energy has grown significantly over the last 16 years, and has further raised its target for the ratio of renewable energy to primary energy demand (30% currently) to 45% by 2025. In Germany's liberalized electricity market, wholesale electricity prices fell as renewable energy increased. Wholesale prices, about 50 euros per MWh until five years ago, dropped to 20 euros. At this price, not only natural gas with high resource prices, but also low-cost lignite-fired power plants may become less competitive options. Renewable energy has almost zero fuel costs, and does not emit carbon dioxide during power generation. In the electricity wholesale market, such power sources are preferentially purchased. In other words, renewable energy is bought first, and high priced thermal power fills in the remaining demand not covered by renewable energy. Natural gas thermal power plants lost price competitiveness and their profitability deteriorated, so their capacity factor also declined. The total power generation cost, including the cost of operations, sometimes exceeded the transaction price, so the competitiveness of the natural gas thermal power plant was almost lost [21]. Under these circumstances, Germany has to choose costs over natural gas security.

3.2 The United Kingdom

In 2003, Britain was the third-largest exporter of natural gas in Europe after the Netherlands, but after peaking (115,400 Mcm) in 2000, its production began to declined. Production in 2015 has dropped to 41,300 Mcm, or 36% of the peak. On the other hand, Britain, the world's first liquid natural gas (LNG) importer, began importing LNG from Algeria in 1964. The UK now imports natural gas from Norway via three pipelines (Langeled, Vesterled, and Tampen), totaling 36,000 Mcm in 2017, that accounted for 75% of its total natural gas imports [22]. In 2011, the UK imported 22,000 Mcm of LNG from Qatar, and because it competed with Norway's natural gas, its IRD was as low as 0.35. However, as LNG from Qater decreased by 28% from 2011, IRD rose to 0.59 (2017). The ratio of natural gas delivered by pipeline to LNG in 2017 was 85:15, or 5.7 times that of LNG.

UK, like Germany, is one of the European countries where the natural gas import region diversity has been deteriorating over the past seven years. Even if diversity declines, Britain has determined that natural gas is cheaper and easier to handle than LNG.

3.3 China, India, Asia Pacific

In the Paris Agreement, China peaked around 2030 in carbon dioxide emissions, and promised to increase the share of non-fossil fuels in primary energy consumption to 20% by 2030. China is strongly promoting the conversion of coal to natural gas for decarbonization under the Paris Agreement. (The Energy Development 13th Five-Year Plan, announced in 2016 [23]). Certainly, the amount of natural gas used in 2016 increased to 8.2 times [24] that in 2000, but in the same period, coal, which accounts for 65% of the country's total energy supply, also expanded by 2.9 times. China, the world largest CO_2 emitter, remains dependent on coal.

India is currently the fourth-largest LNG importer in Asia, after Japan, China, and Korea. The IEA (WEO, 2018) predicted that India will see the largest growth in primary energy demand, rising in 2040 to 2.1 times that of 2017. However, India's current energy supply is still 44% coal, and only 5.5% LNG. In China, India, and other Asian countries, natural gas continues to expand rapidly, primarily for environmental reasons, but it has not yet caught up with the use of inexpensive coal [25].

There is no doubt that the Asian countries' brisk energy consumption requires more energy resources [26]. Figure 3 shows the relationship between energy supply and CO_2 emissions from China, India, Korea, Indonesia, and Japan [27].

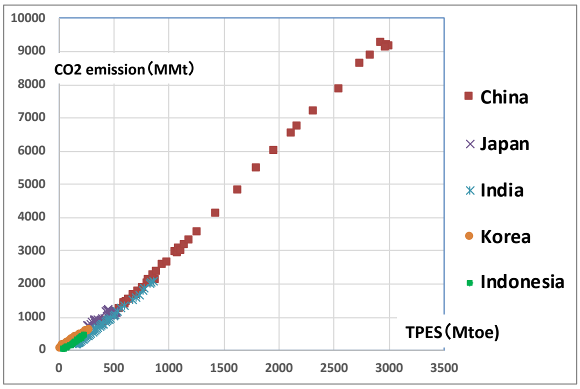

Fig.3 Energy consumption and CO2 emissions

Table 1 Energy consumption and CO_2 emissions, statistical table

	China	Japan	India	Korea	Indonesia
CMC R	0.99957827	0.91376345	0.99878509	0.99770395	0.99467662
CD R2	0.99915672	0.83496364	0.99757166	0.99541317	0.98938158
Adjusted R2	0.99913756	0.83129617	0.99751647	0.99530893	0.98914026
Intercept	-611.43402	342.429864	-277.23353	39.5403165	-63.205608
X Value 1	3.32143452	1.5949681	2.688549	2.02135369	2.19288638

CMC: coefficient of multiple correlation
CO: coefficient of determination

As shown in table 1, the coefficient of determination exceeds 0.9 for all target countries. Therefore, these Asian countries have a large correlation between energy supply and CO_2 emissions. In developing economies in the Asian region, it has been shown that energy supply will continue to increase and CO_2 emissions will also continue to increase. [28] The coefficient of X, which shows a high relationship with CO_2 emissions, is 3.3 in China, followed by India's 2.7, Indonesia's 2.2, Korea's 2.0 and Japan's 1.6.

3.4 Japan

Japan began importing natural gas (LNG) from Alaska in 1969. Since then, demand has increased year by year, and in 2017, natural gas constituted 24% of Japan's primary energy supply. In Japan, natural gas is mostly used for electricity and city gas. All imported natural gas is LNG; no natural gas is imported by pipeline.

As shown in Figure 4, Japan has diversified its energy imports by also obtaining LNG from Brunei (beginning in 1972), the UAE and Indonesia (1977), Malaysia (1982), Australia (1989), Qatar (1997), and Oman (2000) [29]. As a result, IRD was successfully diversified into 0.25 in 1995, 0.20 in 2000, 0.17 in 2005, 0.15 in 2010, and 0.14 in 2015.

In Japan, all 54 nuclear power plants were shut down for two years because of the Fukushima accident. Japan has compensated for the energy shortages caused by the Fukushima nuclear accident by increasing LNG imports by 30% from 2010. Japan switches natural gas from Asia to the Middle East and bought more at the highest price (Figure 4).

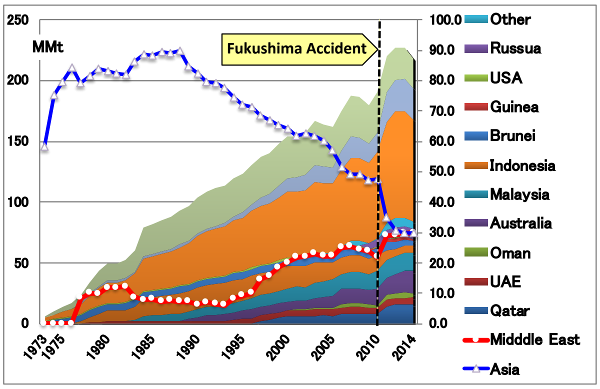

Fig.4 Japan's share of Natural gas import

As a result, natural gas security was maintained, but at the expense of higher costs. Because of the Fukushima nuclear accident, Japan's natural gas import partners increased by six, totaling 20 countries, and IRD decreased by 0.13 (diversity increased). [30]

IV. CONCLUSION

Countries that have imported greater quantities of natural gas over longer periods of time generally have more diversified portfolios. In addition to Japan, countries such as Korea, and Taiwan, which do not having pipelines in particular, tend to have high diversity.

Although China has relatively little import experience (13 years), it is strongly promoting the switch from coal to natural gas to meet its burgeoning demand and serious PM 2.5 issues. China installed a natural gas pipeline from Western China, Central Asia, and Xinjiang (producing areas) to southern cities such as Shanghai, Guangdong, and Fujian (consuming areas). An LNG import terminal was built along the coast of China, and contracts were signed with 21 natural gas suppliers to increase diversity.

In the ASEAN countries, a plan called the "Trans-ASEAN Gas Pipeline (TAGP)" was launched [31] in the 1990s. This included a 9,000 km completed pipeline, with another 5,000 km pipeline under construction. Fewer than ten countries have import contracts with Thailand and Singapore. Therefore, although these countries' IRD of about 0.5 is high, a pipeline network connecting gas fields in the region with nearby consuming countries ensures diversity and secures supply stability.

In this report, we investigated the Paris Agreement's impact on the indicator of import natural gas region diversity, which is an important of energy security (Table 4). While Asian countries are promoting natural gas to achieve both rapid economic development and to improve the environment, the situation in Europe is completely different. Europe's natural gas pipeline network was developed in the

1940s–60s, and natural gas imports in Europe have existed an average of 10 years longer than Asian imports, and the top eight natural gas importers mentioned in this article all have pipeline import ratios exceeding 50%. Like the European countries picked up in this paper, as the pipeline networks developed, IRD gradually rose, and diversity was lost.

As noted above regarding Germany, European countries have strongly promoted environmental measures in the wake of the Kyoto Protocol and the Paris Agreement. Germany's introduction of renewable energy resulted in a significant drop in renewable energy costs in the electricity wholesale market. As a result, natural gas became less price competitive compared to renewable energy, and natural gas no longer was used for power applications. The number of natural gas producers exporting to European countries is less than in Asian countries, and IRD is higher. In the fully liberalized European natural gas electricity market, prices is becoming a more important factors than diversity.

For all natural gas importing countries, what is happening in Europe and Asia should be watched closely. In Asian countries where the introduction of natural gas has been greatly promoted as an environmental measure, it is likely that natural gas will continue to increase while the diversity of natural gas will improve. On the other hand, in European-type countries where the power market develops simultaneously with the progress of environmental measures, price competition between natural gas and renewable energy occurs, so natural gas is not used and the diversity of natural gas will be lost. Japan, the world's largest importer of natural gas, has the potential to inherit both of these bad points. In other words, a large increase in demand for natural gas in the Asian region will lead to a rise in prices, neither an increase in renewable energy nor development of the electricity market will occur, and the diversity of natural gas may be lost.

Table 2 Asian and European Natural Gas Import Region Diversity Indicators and Related Values

	Country	Pipeline ratio (%)	HHI	Import Country (countries)	Total Import (Mcm)	Import Histry (year)	Major natural gas exporter : Percentage of total %				
Asia	Japan	0	0.17	18	115,285	40	AUS:32.0	MYS:17.0	QAT:11.8	RUS:8.4	IDN:8.0
	Korea	0	0.17	15	48,651	32	QAT:31.4	AUS:18.5	OMN:11.6	MYS:10.1	IDN:8.9
	India	0	0.33	13	24,435	15	QAT:54.1	NGA:16.4	AUS:8.3	AGO:5.3	GIN:4.9
	Chinese Taipei	0	0.19	13	19,974	29	QAT:33.2	MYS:18.0	IDN:13.9	PIG:12.1	RUS:8.6
	China	40.3	0.21	21	89,789	13	TKM:35.9	AUS:22.7	QAT:11.4	MYS:6.2	IDN:4.6
	Thailand	67.8	0.51	10	16,371	21	MMR:68.2	QAT:19.5	AUS:4.2	MYS:3.1	NGA:1.2
	Singapore	74.7	0.45	7	11,253	27	IDN:64.4	MYS:12.0	AUS:11.6	QAT:9.8	EGY:0.8
	Asia Ave.	26.1	0.29	13.9	46,537	25					
Europe	Belgium	50.7	0.27	5	18,103	53	NLD:23.3	NOR:15.6	DEU:8.1	GBR:8.1	QAT:3.2
	Italy	52.8	0.26	13	69,651	45	RUS:39.4	DZA:29.4	QAT:10.1	LBY:7.0	AUT:4.1
	Spain	52.8	0.28	11	34,627	48+	DZA:48.3	NGA:12.5	PNG:10.2	QAT:10.0	NOR:9.9
	France	64.8	0.24	10	48,708	52	NOR:42.3	RUS:18.9	NLD:10.2	DZA:7.9	NGA:6.2
	UK	85.3	0.59	10	47,765	55	NOR:75.4	QAT:12.9	BEL:5.6	NLD:3.9	
	Turkey	89.0	0.32	11	55,121	34	RUS:51.9	IRN:16.8	AZE:11.9	DZA:8.4	NGA:3.8
	Netherlands	99.7	0.32	6	53,795	41+	NOR:47.3	RUS:28.0	BEL:13.2	GBR:2.9	DEU:2.9
	Germany	100.0	0.46	2	119,471	53	RUS:60.3	NOR:11.0			
	EU Ave.	50.3	0.32	11.2	51,221	36					

AUS:Australia MYS:Malaysia QAT:Qatar RUS:Russia IDN:Indonesia OMN:Oman NGA:Nigeria AGO:Angola GIN:Guinea
PIG:Papua New Guinea TKM:Turkmenistan MMR:Myanmar EGY:Egypt NLD:Netherlands NOR:Norway AZE:Azerbaijan
DEU:Germany GBR:United Kingdom DZA:Algeria NGA:Nigeria PNG:Papua New Guinea BEL:Belgium IRN:Iran

Table-3 Energy Security Indicators Summary Table

Security Index				2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Aian Country	Japan	*Self-sufficiency rate*	%	20%	20%	19%	17%	19%	20%	20%	18%	18%	20%	20%	11%	6%	6%	6%	7%	8%
		Energy efficiency	*TPES/GDP*	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07
		Resource diversity	*HHI*	0.26	0.25	0.25	0.26	0.25	0.26	0.25	0.27	0.27	0.25	0.24	0.26	0.28	0.29	0.28	0.29	0.28
		Price Index		79.8	83.1	80.8	84.2	85.7	91.5	96.7	97.3	110.2	100.8	100.0	110.7	118.3	127.8	134.2	121.0	109.2
		CO_2 Emissions	*CO_2/TPES*	51.9	52.3	54.2	54.9	52.9	53.3	52.4	54.9	53.4	53.1	52.8	60	63.6	64.6	64.7	63.9	64.4
		Import diversity	*HHI*	0.20	0.19	0.19	0.18	0.18	0.17	0.16	0.14	0.14	0.14	0.14	0.12	0.12	0.13	0.13	0.14	0.15
	China	*Self-sufficiency rate*	%	99%	101%	98%	97%	95%	94%	92%	91%	91%	89%	88%	88%	85%	85%	85%	84%	80%
		Energy efficiency	*TPES/GDP*	0.51	0.48	0.47	0.49	0.50	0.50	0.48	0.46	0.43	0.42	0.42	0.41	0.39	0.38	0.36	0.34	0.31
		Resource diversity	*HHI*	0.41	0.41	0.42	0.44	0.45	0.48	0.49	0.50	0.49	0.50	0.50	0.51	0.49	0.48	0.47	0.48	0.46
		CO_2 Emissions	*CO_2/TPES*	65.5	66.6	67.3	68.4	70.1	72.5	73.1	73.7	73.9	74.1	73.4	75.2	74.7	75.4	73.5	72.7	73.1
		Import diversity	*HHI*	0.27	0.23	0.24	0.24	0.22	0.22	0.20	0.22	0.20	0.18	0.14	0.14	0.16	0.17	0.18	0.20	0.19
	Korea	*Self-sufficiency rate*	%	18%	18%	18%	19%	18%	20%	20%	19%	20%	19%	18%	18%	18%	17%	18%	19%	18%
		Energy efficiency	*TPES/GDP*	0.27	0.26	0.25	0.25	0.24	0.24	0.23	0.22	0.22	0.22	0.23	0.23	0.23	0.22	0.22	0.22	0.22
		Resource diversity	*HHI*	0.53	0.49	0.40	0.39	0.42	0.43	0.44	0.41	0.41	0.38	0.37	0.39	0.38	0.37	0.37	0.40	0.40
		Price Index		65.2	70.0	72.3	76.8	78.5	84.3	92.5	95.8	102.5	98.6	100.0	104.0	112.4	117.2	120.0	112.2	109.5
		CO_2 Emissions	*CO_2/TPES*	54.8	55.7	52.4	51.6	52.7	52	51.9	51.3	51.4	52.3	52.6	52.6	52.2	52	50.1	51	49.8
		Import diversity	*HHI*							0.75	0.68	0.53	0.43	0.75	0.71	0.65	0.73	0.74	0.36	0.40
	India	*Self-sufficiency rate*	%	80%	80%	80%	80%	79%	78%	76%	75%	74%	73%	72%	71%	68%	67%	65%	64%	65%
		Energy efficiency	*TPES/GDP*	0.55	0.53	0.53	0.50	0.49	0.46	0.44	0.43	0.43	0.44	0.42	0.42	0.41	0.39	0.39	0.36	0.35
		Resource diversity	*HHI*	0.29	0.30	0.30	0.30	0.31	0.30	0.31	0.31	0.32	0.33	0.33	0.33	0.34	0.35	0.35	0.34	0.34
		CO_2 Emissions	*CO_2/TPES*	47.9	47.9	48	47.7	48.9	49.8	51.2	52.9	53.1	53.7	53.9	54.2	56.1	56.8	58.4	57.8	57.5
		Import diversity	*HHI*	0.52	0.53	0.52	0.53	0.50	0.44	0.37	0.31	0.25	0.24	0.17	0.21	0.31	0.34	0.31	0.37	0.26
	Chinese Taipei	*Self-sufficiency rate*	%	14%	13%	13%	13%	12%	12%	12%	12%	12%	12%	12%	12%	12%	13%	12%	11%	10%
		Energy efficiency	*TPES/GDP*	0.29	0.30	0.30	0.30	0.29	0.28	0.27	0.27	0.26	0.26	0.25	0.24	0.23	0.22	0.22	0.22	0.21
		Resource diversity	*HHI*	0.35	0.35	0.35	0.40	0.43	0.45	0.42	0.39	0.37	0.40	0.33	0.32	0.36	0.34	0.33	0.33	0.34
		CO_2 Emissions	*CO_2/TPES*	60.3	59	58.4	58.8	58.6	59.3	59.7	57.8	57.3	56.1	55.3	55.8	55.5	54.8	54.3	54.9	56.2
		Import diversity	*HHI*												0.81	0.78	0.73	0.71	0.62	0.61
	Thailand	*Self-sufficiency rate*	%	61%	58%	56%	55%	53%	56%	57%	57%	61%	60%	60%	58%	60%	58%	59%	56%	57%
		Energy efficiency	*TPES/GDP*	0.33	0.33	0.34	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.35	0.34	0.34	0.36	0.35	0.34	0.34
		Resource diversity	*HHI*	0.41	0.42	0.41	0.41	0.41	0.40	0.40	0.39	0.39	0.41	0.38	0.38	0.38	0.37	0.36	0.39	0.37
		CO_2 Emissions	*CO_2/TPES*	50.3	51.4	49.2	47.5	48.1	48.3	47.7	47.5	47.5	45.9	45.3	45	45.2	43.8	43.4	44	42.2
		Import diversity	*HHI*		0.57	0.57	0.59	0.63	0.67	0.66	0.73	0.71	0.76	0.75	0.65	0.74	0.58	0.50	0.46	0.41
	Singapore	*Self-sufficiency rate*	%	1%	2%	2%	2%	1%	2%	2%	2%	2%	2%	2%	2%	2%	3%	2%	2%	2%
		Energy efficiency	*TPES/GDP*	0.14	0.16	0.15	0.18	0.19	0.13	0.13	0.11	0.12	0.10	0.11	0.11	0.10	0.09	0.09	0.09	0.09
		Resource diversity	*HHI*	0.87	0.81	0.73	0.69	0.69	0.59	0.59	0.55	0.58	0.54	0.56	0.57	0.54	0.50	0.49	0.51	0.51
		CO_2 Emissions	*CO_2/TPES*	53.9	47.2	46.6	35.6	30.8	41.9	39.5	43.9	38.1	45.4	41.6	42.5	42.7	43.5	41.5	39.5	39.5
		Import diversity	*HHI*								0.74	0.68	0.42	0.18	0.24	0.34	0.31	0.29	0.29	0.30
Europe Country	Germany	*Self-sufficiency rate*	%	40%	39%	40%	40%	40%	41%	40%	42%	40%	41%	40%	40%	39%	38%	39%	39%	37%
		Energy efficiency	*TPES/GDP*	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.08	0.08	0.08
		Resource diversity	*HHI*	0.23	0.23	0.23	0.24	0.25	0.25	0.24	0.26	0.24	0.24	0.22	0.22	0.23	0.22	0.22	0.22	0.23
		Price Index		64.0	66.3	68.7	74.1	76.1	84.5	91.4	91.8	100.7	95.4	100.0	108.6	110.3	112.2	109.6	101.6	96.3
		CO_2 Emissions	*CO_2/TPES*	57.6	57.3	57.6	58.2	56.6	55.7	55	55.7	55.9	55.4	55.5	56.4	57.2	57.4	56.4	56.6	56.3
		Import diversity	*HHI*	0.33	0.32	0.32	0.30	0.31	0.30	0.32	0.33	0.32	0.28	0.29	0.30	0.30	0.31	0.32	0.34	0.46
	United States	*Self-sufficiency rate*	%	73%	76%	73%	72%	71%	70%	72%	71%	75%	78%	78%	82%	85%	86%	91%	92%	88%
		Energy efficiency	*TPES/GDP*	0.18	0.17	0.17	0.17	0.17	0.16	0.16	0.16	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.13	0.13
		Resource diversity	*HHI*	0.27	0.28	0.28	0.28	0.28	0.27	0.27	0.27	0.28	0.28	0.28	0.29	0.29	0.29	0.29	0.30	0.32
		Price Index		78.6	79.8	72.1	81.8	88.1	103.6	106.9	108.0	124.7	93.6	100.0	108.3	105.3	105.9	106.4	85.4	77.7
		CO_2 Emissions	*CO_2/TPES*	60.2	61.1	58.7	59.3	58.9	58.7	58.3	58.1	57.8	56.5	57.7	56	54.5	55.1	54.5	53.7	53.3
		Import diversity	*HHI*	0.88	0.88	0.89	0.77	0.73	0.74	0.75	0.68	0.82	0.77	0.77	0.81	0.89	0.93	0.96	0.93	0.94
	Italy	*Self-sufficiency rate*	%	16%	16%	16%	16%	16%	16%	16%	17%	18%	19%	19%	19%	22%	24%	25%	24%	22%
		Energy efficiency	*TPES/GDP*	0.08	0.08	0.08	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07
		Resource diversity	*HHI*	0.38	0.37	0.37	0.35	0.34	0.34	0.33	0.33	0.32	0.31	0.31	0.30	0.28	0.27	0.26	0.28	0.28
		Price Index		79.1	85.3	84.9	88.2	89.4	98.7	106.9	104.6	103.1	96.4	100.0	107.7	121.4	120.2	117.4	108.5	102.9
		CO_2 Emissions	*CO_2/TPES*	58.5	58.3	58.9	58.6	59.4	58.5	58.1	57.3	56.4	54	53.9	54.6	54.3	51.9	51.9	51.6	51.5
		Import diversity	*HHI*	0.39	0.35	0.31	0.30	0.29	0.26	0.24	0.24	0.24	0.22	0.21	0.21	0.20	0.27	0.24	0.25	0.27
	Turkey	*Self-sufficiency rate*	%	35%	35%	33%	31%	30%	28%	28%	27%	29%	30%	30%	28%	26%	26%	24%	25%	26%
		Energy efficiency	*TPES/GDP*	0.15	0.14	0.14	0.14	0.13	0.13	0.13	0.14	0.13	0.14	0.14	0.13	0.13	0.12	0.12	0.12	0.12
		Resource diversity	*HHI*	0.22	0.25	0.24	0.25	0.24	0.24	0.24	0.25	0.24	0.21	0.22	0.23	0.23	0.22	0.23	0.22	0.20
		Price Index		77.4	84.7	85.6	82.0	76.0	84.1	85.8	84.7	95.1	96.2	100.0	99.4	107.0	110.4	100.1	90.0	86.3
		CO_2 Emissions	*CO_2/TPES*	63	62.1	62	61.7	61.4	61.4	61.7	63.4	63.7	63.5	60.5	61	60.5	59.2	61.6	59.2	59.2
		Import diversity	*HHI*	0.56	0.54	0.51	0.43	0.47	0.48	0.46	0.45	0.42	0.35	0.29	0.39	0.38	0.39	0.36	0.36	0.34
	Netherlands	*Self-sufficiency rate*	%	78%	79%	78%	72%	82%	77%	76%	75%	85%	80%	84%	85%	84%	90%	82%	65%	62%
		Energy efficiency	*TPES/GDP*	0.10	0.10	0.11	0.11	0.11	0.10	0.10	0.10	0.09	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.08
		Resource diversity	*HHI*	0.37	0.36	0.36	0.36	0.36	0.36	0.36	0.35	0.35	0.36	0.38	0.36	0.34	0.34	0.33	0.32	0.33
		Price Index		87.6	88.3	83.8	86.9	87.7	94.6	101.5	102.1	106.1	106.3	100.0	98.0	100.0	100.7	103.1	99.5	94.9
		CO_2 Emissions	*CO_2/TPES*	51.2	51.2	50.7	49.8	49.5	49	48.3	48.6	49.3	48.5	48.2	48.3	47.5	48.1	48.4	50.7	50.3
		Import diversity	*HHI*	0.24	0.23	0.22	0.21	0.19	0.17	0.18	0.20	0.20	0.20	0.19	0.19	0.24	0.24	0.26	0.28	0.25
	France	*Self-sufficiency rate*	%	52%	51%	51%	51%	50%	50%	51%	51%	51%	51%	52%	54%	53%	54%	56%	56%	54%
		Energy efficiency	*TPES/GDP*	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09
		Resource diversity	*HHI*	0.33	0.32	0.31	0.32	0.32	0.32	0.32	0.31	0.32	0.29	0.28	0.31	0.27	0.27	0.30	0.30	0.27
		Price Index		72.6	69.6	67.3	69.1	73.7	82.8	86.1	92.2	101.4	91.8	100.0	109.2	112.1	110.9	108.1	103.0	99.5
		CO_2 Emissions	*CO_2/TPES*	34.6	33.8	33.2	32.9	32.5	32.6	32.3	31.9	31.3	31.5	30.9	29.5	29.8	29.7	27.9	28.1	28.6
		Import diversity	*HHI*	0.51	0.51	0.53	0.72	0.59	0.60	0.44	0.50	0.56	0.40	0.35	0.35	0.41	0.41	0.42	0.47	0.49
	UK	*Self-sufficiency rate*	%	122%	117%	118%	110%	102%	92%	85%	83%	80%	80%	73%	69%	60%	57%	60%	65%	67%
		Energy efficiency	*TPES/GDP*	0.11	0.10	0.10	0.10	0.10	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07
		Resource diversity	*HHI*	0.36	0.34	0.36	0.35	0.39	0.36	0.35	0.36	0.37	0.36	0.35	0.35	0.32	0.30	0.28	0.28	0.30
		Price Index		70.7	70.7	69.5	70.7	74.0	84.3	92.5	89.8	102.0	98.2	100.0	104.4	105.6	105.3	103.2	96.1	91.7
		CO_2 Emissions	*CO_2/TPES*	55.8	57.1	56.4	56.8	57.4	57	58.1	59	58.1	56	55.9	55.6	56.9	55.9	54.2	51.7	49.6
		Import diversity	*HHI*	0.40	0.35	0.37	0.38	0.32	0.25	0.20	0.23	0.21	0.19	0.20	0.22	0.24	0.34	0.37	0.39	0.37
	Spain	*Self-sufficiency rate*	%	26%	27%	25%	25%	23%	21%	22%	21%	22%	24%	27%	25%	27%	30%	31%	28%	28%
		Energy efficiency	*TPES/GDP*	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.08	0.08
		Resource diversity	*HHI*	0.30	0.28	0.27	0.26	0.26	0.27	0.27	0.26	0.28	0.29	0.29	0.29	0.33	0.36	0.37	0.39	0.38
		Price Index		76.2	74.6	75.0	73.5	75.0	88.0	92.1	88.0	101.4	93.5	100.0	106.2	112.6	110.2	110.2	99.3	90.9
		CO_2 Emissions	*CO_2/TPES*	54.6	53.4	55.1	54.3	54.9	56.2	54.7	56.1	53.2	51.6	49	50.3	49.6	47.9	48.4	49.6	47.6
		Import diversity	*HHI*	0.30	0.31	0.31	0.31	0.34	0.30	0.35	0.34	0.28	0.28	0.28	0.33	0.37	0.35	0.36	0.32	0.28
	Poland	*Self-sufficiency rate*	%	89%	89%	90%	88%	86%	85%	80%	75%	73%	71%	67%	67%	73%	73%	72%	72%	67%
		Energy efficiency	*TPES/GDP*	0.27	0.27	0.26	0.26	0.25	0.24	0.24	0.22	0.22	0.20	0.21	0.20	0.19	0.19	0.18	0.17	0.17
		Resource diversity	*HHI*	0.46	0.45	0.44	0.44	0.42	0.41	0.41	0.40	0.39	0.38	0.37	0.38	0.37	0.39	0.37	0.37	0.34
		Price Index		53.1	57.8	59.4	62.5	66.4	74.8	77.3	77.8	94.5	90.7	100.0	106.0	109.8	103.0	99.2	92.4	85.0
		CO_2 Emissions	*CO_2/TPES*	77.9	77.1	76.3	77.1	77.9	76.8	76	75.9	73.7	74.1	73.1	71.7	72.7	71.5	70.9	71.1	70.5
		Import diversity	*HHI*	0.37	0.43	0.46	0.43	0.37	0.32	0.27	0.24	0.24	0.24	0.22	0.18	0.22	0.28	0.26	0.22	0.27

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