Original Research Article

Application of Portfolio approach towards Energy Security: A case study of Japan and implications for India.

ABSTRACT

Adequate and affordable energy supplies are lifeline of modern economies. Security of energy supplies constitutes the core of strategic concerns of consuming countries in ensuring national defense, economic development and social cohesion. Energy policy planners face a diverse range of institutional challenges in generating dynamic energy strategy which can guarantee uninterrupted supplies at affordable prices. This study aims to describe policy enablers in finding a framework that allows policymakers and researchers to conceptualize the status of current energy arrangements, then analyze the risks therein and measures of mitigation. Data was analyzed using descriptive statistics to describe portfolio approach as a function of state policy for energy security. The case study of Japan has been analyzed to bring out the key lessons for India's energy security pursuits.

Key Words: Energy Security, framework, portfolio approach, Japan, India

OBJECTIVE

For this article on portfolio framework for energy security, the State and its policymakers are the focal point. The topic of energy security is analyzed by first defining energy security in its key dimensions and proposing a portfolio approach for conceptualizing the energy security at the policy level. The study describes the underlying portfolio theory ideas and illustrates how within the portfolio approach, the principles of source and supply diversification benefit energy security. Energy resource deficient country Japan is taken as case study to illustrate how portfolio model can aid in the development of policy options to address issues of energy supplies, and what could be the lessons for India.

INTRODUCTION

Energy has a fundamental role in a country's structure, economic consolidation and survival. Country's ability to control energy directly influences its capacity to transform energy resources into wealth and power. Those countries with the most control of energy resources have the biggest power advantage in international system [1] Interruptions to energy supplies cause financial, economic, social losses and also cause adversity of military strengths. From a politico-military dimension energy security is to fulfil the energy needs of military forces but in the light of contemporary political-economic international system, energy security is much broader and larger [2]. Oil shocks have had macroeconomic consequences in both exporting and importing countries. In oil exporting countries, crude oil is the major revenue source whereas in oil importing countries it is a major input for production system. For such significance, a great number of researches have studied effects of oil price variations on economic activity and proposed theories for monetary and fiscal policies. These studies established the relationship between oil price volatility, fiscal policy and macroeconomic performance of both oil importing as well as oil exporting countries. In oil exporting countries, government is the direct recipient of oil revenue and government's behavior in spending oil revenue indicates the most important characteristic of its economy.

PERCEPTIONS OF ENERGY SECURITY

Given its significance in national affairs, energy security has evolved as a prime theme in universities and research institutions, international think-tanks, and government ministries dealing with economics and strategic matters. Research literature broadly captures the four dimensions while dealing in energy security, i.e. (1) disruptions in supply, (2) uninterrupted availability, (3) price shocks, and (4) affordability. There are several factors influencing supply situation, like reserves, ability of an economy to acquire supply, level of resource diversification, accessibility to resources, and geopolitical concerns surrounding resource acquisition. An economy that is capable of decoupling economic growth with energy use – through energy efficiency and conservation – will have an advantage in terms of its energy security.

Research literature also dwelt on the query of who is primarily responsible for energy security - consumer or producer. The prevailing perception is that "energy security" is the primary responsibility of consumer state. But now theorists support the argument that energy security is obligation of both consumer and producer (Janardhan & Fesmire, 2011). For some, energy security is matter of survival (Andreas, 2013) rather a tool of enhancing hegemony. In some other cases it can be an instrument to contain the influence of certain interest of the state and to ensure sustainable economic growth rate (Leal & Voudouris, 2013). Summarily, the main aspects of energy security emerges as security of supplies, environment and economy (Mitchell & Watson & Whiting, 2013, p. 13).

LITERATURE REVIEW

Research literature establishes the principle of diversification in addressing issues of energy security in both small and big countries alike. Winston Churchill declared, "*Safety and certainty in oil lie in variety and variety alone*" - while he was articulating the fundamental principle of energy security. Diversification is a good guarantor of security and is the starting point. Similar to having a broad portfolio of stocks and bonds with levels of risk and return, diversifying supply sources lessens the impact of any particular disruption [Daniel Yergin, 2005]. A number of previous studies assert that the diversification of a country's energy importing policies is effective in increasing energy security and stimulating the economy [Vivoda V.2009]

Government of India's 'India Hydrocarbon Vision 2025' (**Planning Commission, 2000)** articulated the need for deregulation of oil and gas and empowering national oil companies to compete with international oil companies with provision of fiscal and tax benefits. The Integrated Energy Policy (**Planning Commission, 2006**) further laid emphasis on expanding India's energy resource base to meet energy demand.

Supply diversification attempted by China was by hedging against disruptions through investments in overseas equity oil, thereby building up a large equity oil portfolio across the world. By 2015 Chinese national oil companies overseas oil and gas production reached 1.7 million barrels of oil per day [Michal Meidan] in this study established that supply diversification became a national priority of China's leadership concerned with vulnerabilities of import dependence as China's crude oil imports increased from 2.5 million barrels of oil per day in 2005 to 6.7 million barrels in 2015.

Alice de Jonge [15] studied diversification through potential for strategic alliances and analyzed the "triangular cooperation" amongst investors from Australia, China and African nations to contribute to the economic development in Africa. The Africa focus study concludes there is much to be gained by

encouraging existing and potential synergies between Australian, Chinese and local investors in African settings.

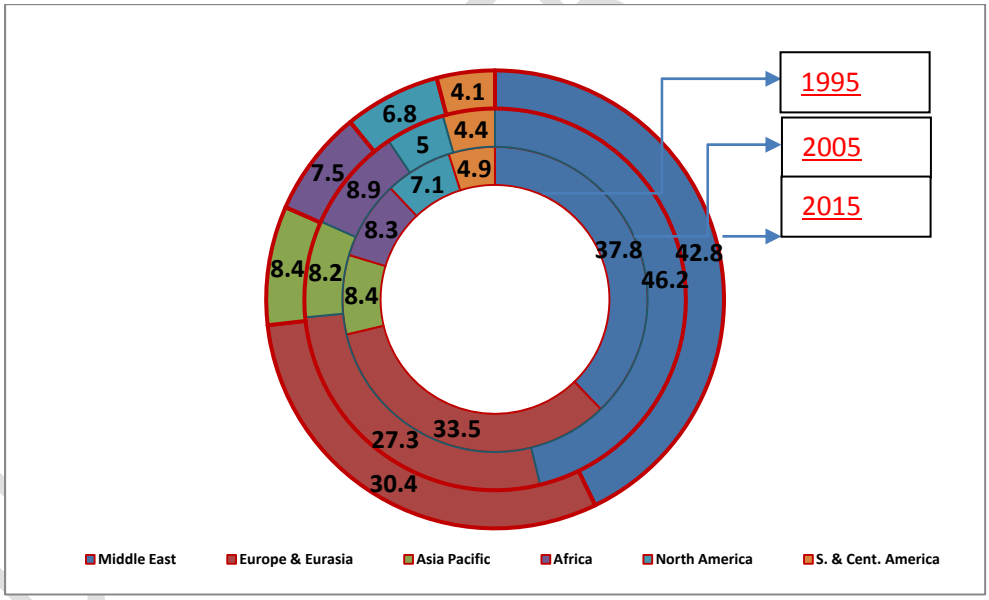
METHODOLOGY

This study is based on descriptive statistical analysis of data and aims to describe energy security portfolio approach from institutional and international competitive perspectives. Data was obtained through study of available literature and are from sources like the BP Statistical Review, EIA, IEA, Energy Policy research publications, IDSA research notes, Ministry of Petroleum and Natural Gas of government of India and India's leading national oil and gas companies.

GLOBAL ENERGY OUTLOOK

Enhanced awareness of energy vulnerability is leading countries to search for means to enhance security of energy supplies. The United States has now emerged the world's largest oil producer with its shale fluids revolution, beating the traditional supply hegemonies of Saudi Arabia and Russia. Together, these three countries account for 40% of global oil production. Adding Canada and China, the percentage rises to 50%. In natural gas resources, Iran and Russia between them hold a third of total global gas reserves. Adding Qatar and Turkmenistan, the percentage of global gas reserves rises to 60% in these four countries. United States, Saudi Arabia, UAE, Nigeria hold the balance significant gas reserves [Figure 1]

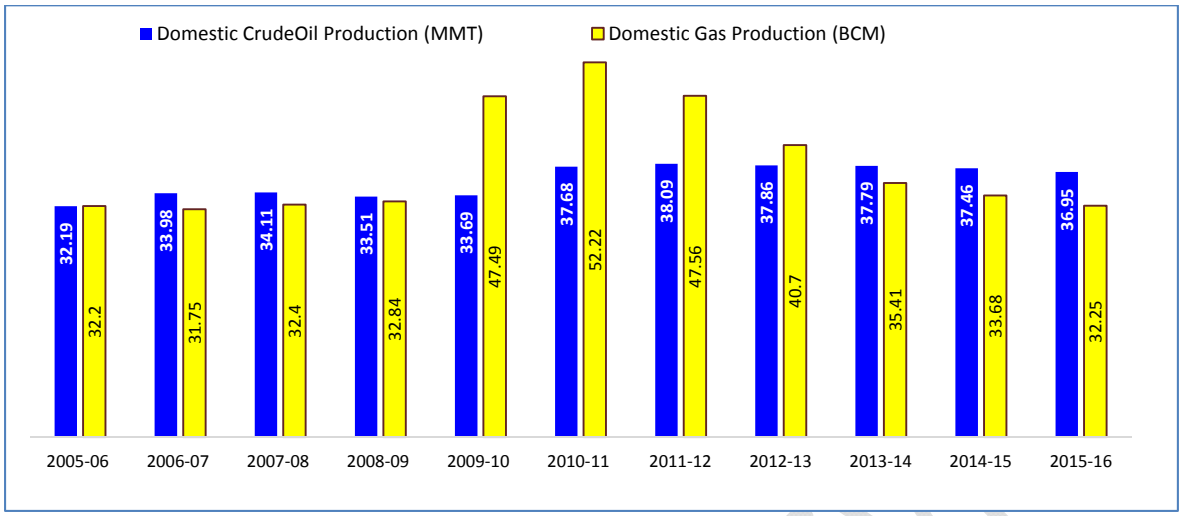
Figure 1: Distribution of Proved Reserves of crude oil: 1995, 2005 and 2015



Source: BP Statistical Review of World Energy 2016

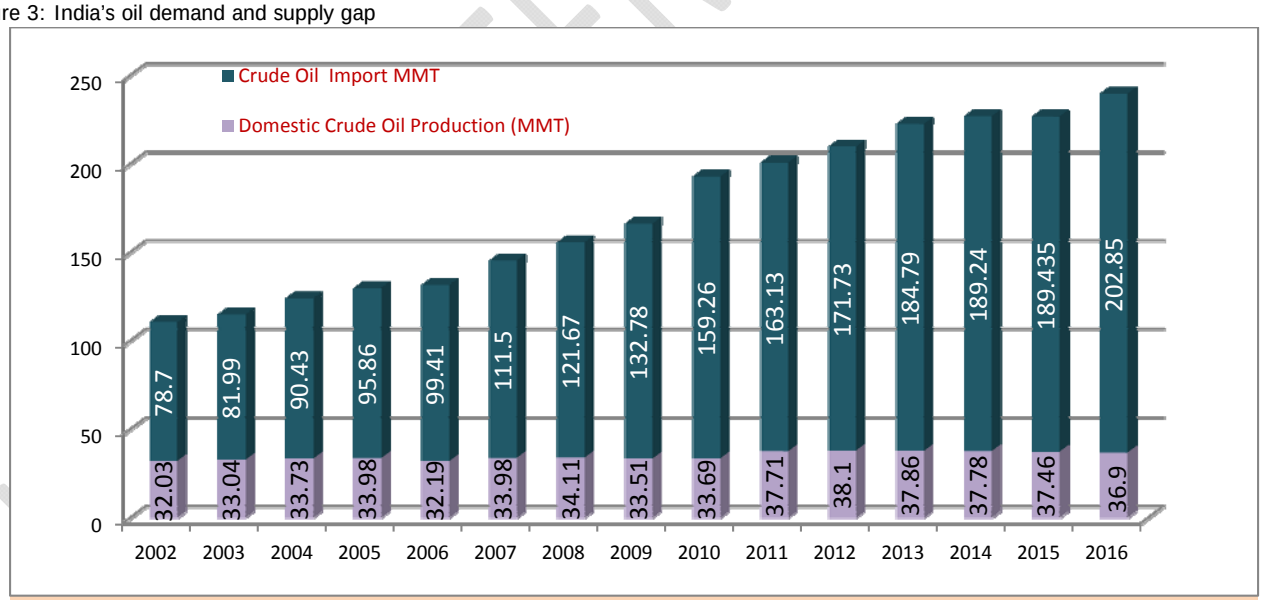
In 2016, India consumed 5.5% share of the world's primary energy consumption, thereby emerging the third largest energy consumer after China and USA. Almost three-quarters of Indian energy demand is met by fossil fuels. Coal accounts for the largest share of 57% followed by oil and gas share of 36%. India produced 36.95 Million Metric Ton crude oil during 2015-16 which was 1.36% less than the production of previous year. Domestic Gas production was 32.25 Billion Cubic Meter in 2015-16, almost stagnant or declining for decades [Figure 2].

Figure 2: India's crude oil and gas production



India depends heavily on oil imports for its steadily widening demand supply gap. EIA predicts India's oil demand to more than double to 8.2 million barrels per day (mb/d) by 2040, while domestic production expected to remain flat hovering around 1 mb/d. The historic demand supply situation of oil in India [Figure 3] evidently establishes the rising demand and higher import dependency.

Figure 3: India's oil demand and supply gap



The high import dependence prompted Indian Government and policy makers to embark on multi-faceted energy strategy, including diversification of supply sources. To this end, the Government of India has encouraged Indian national oil companies to acquire equity stakes overseas. The acquired oil and gas fields of Indian national oil companies are spread across South America, South East Asia, Far East Asia, West Africa, North Africa, Russia, CIS and the Caspian Sea region.

PORTFOLIO APPROACH FOR ENERGY SECURITY

Portfolio theory was initially conceived in the context of financial portfolios where it relates **$E(r_p)$,** the *expected* portfolio return, to **σ_p,** the total portfolio risk, defined as the standard deviation of periodic portfolio returns. Under the modern portfolio theory developed by Harry Markowitz, diversification aims to create a portfolio that includes multiple investments for reducing risk of failure in individual elements. Diversity aspect can be with regard to energy sources, supplies and infrastructure. Stirling [16] argued that if knowledge is lacking on the likelihood of an event occurring and on the possible outcome, then ignorance prevails and the best hedge option is to diversify in order to spread the risk as much as possible. Measures of diversity level have been developed in literature to assess all three dimensions of diversity, i.e. variety, balance and disparity.

An approach often used to identify energy systems that are less risky from economic view is to use financial portfolio theory. It also takes its starting point that diversity is a way to reduce risks but base the analysis on historic price volatility of assets and their co-variance in order to construct 'optimal' portfolios and hedge fuel price risk. According to Awerbuch and Berger [17], the Mean Variance portfolios can be used if the average portfolio cost is minimized (instead of maximizing profit as is typically the objective.

$$E(Cp) = \sum_i \mathrm{WiE(\,Ci)}$$

where Cp is the average cost of the portfolio, Wi is the share of asset i in the mix and Ci is the average cost of asset i.

Use of financial portfolios make it easier to separate specific risk items from systematic risk. Four different techniques have been used in literature to value portfolio variance: mean variance, semi variance, VaR (value at risk) and CVaR (conditional value at risk) [18]. Mean variance uses the entire variance to calculate risk, whereas other three methods only consider price increase as risk. By depicting a country's energy sources and suppliers in a portfolio, this theory can be used to explore the risks of individual assets comprising a portfolio and the aggregate risk of portfolio. The conclusion is that diversification can enhance security by reducing risks of unexpected supply disruptions or price increases. The theory provides a view to the current source and supplier dimensions of diversification and enables decisions making concerning adjustment of the energy mix to achieve the optimal sourcing of energy while reducing risks in the failure of any one source or supplier. However, the methods have limitations when used to assess the consequences if disturbances do occur, partly because the capacity to take advantage of diversity during a strain is not assessed.

ENERGY PORTFOLIO OF JAPAN – A CASE STUDY

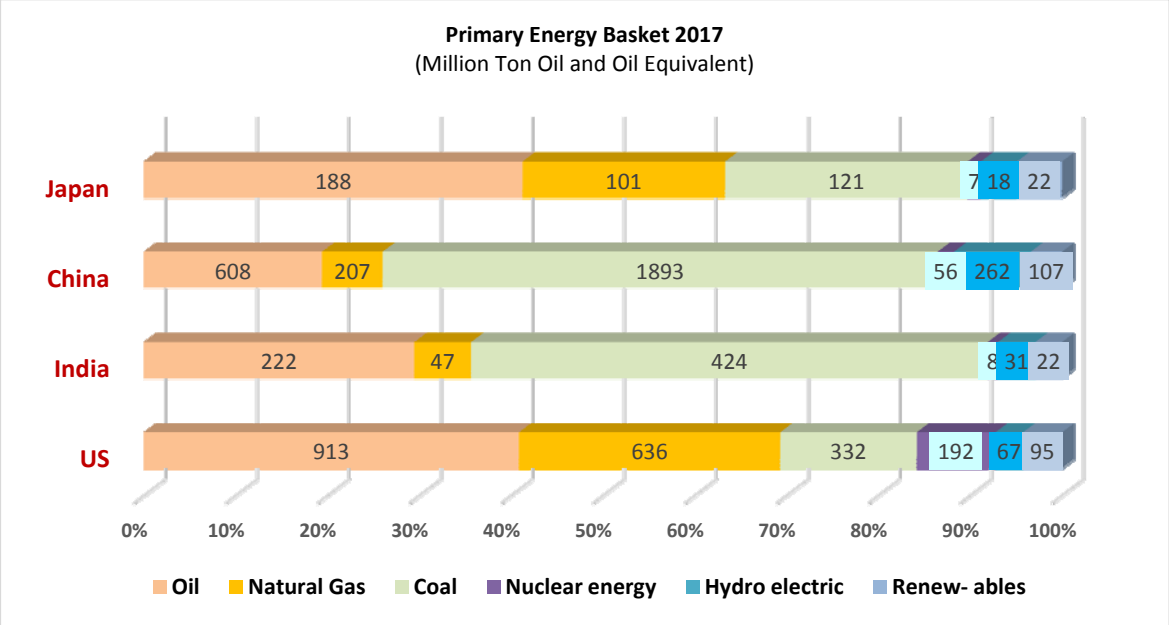
Japan's Energy landscape

One of the largest world economies, Japan has long been a major consumer and importer of energy. In April 2014, Japan government approved its latest energy policy - 'Strategic Energy Plan 2014' with objective that the latest plan would form "*the basis for orientation of Japan's new energy policy, considering the dramatic changes in energy environments inside and outside Japan, including those*

caused by the Great East Japan Earthquake and the subsequent accidents at Tokyo Electric Power Company's (TEPCO) Fukushima Daiichi Nuclear Power Station[1]"

Unlike India, crude oil is the largest source of primary energy in Japan's energy basket, followed by Coal and Natural Gas [Figure 4]. Coal accounts for the second largest share of total energy consumption of Japan, followed by natural gas which occupies the third largest share, and is increasingly catching up as a lead fuel source. In mid-2012 Japan was forced to take steps to replace some of the lost nuclear power generation with heavy crude oil from West Africa region, (primarily from Gabon, Angola and Nigeria) and Southeast Asia (Vietnam, Indonesia, and Malaysia). After the U.S. began permitting export of light condensates in 2014, Japan was one of the first countries to import U.S. crude oil cargoes.

Figure-4: Comparative scenario of Primary Energy Basket of major consumers 2017



Data Source: BP Statistical Review 2018

Vulnerability of Japan energy supply

Japan's contemporary energy policy is dominated by concerted efforts to overcome the fallout from 2011 earthquake and the subsequent Fukushima nuclear accident. Japan was one of the pioneering countries to adopt portfolio approach diversification of energy sources through increased use of nuclear energy, natural gas and coal, as well as promotion of energy efficiency and energy conservation. However, despite the early focus on diversification, crude oil still accounts for about 40% of Japan's primary energy supply. In 2014 Japan was the world's third-largest net importer of crude oil and petroleum products after the United States and China. Japan has made concerted efforts to spread out its oil import source, though had limited success [Table 1].

Table 1: Country wise distribution of Japan's crude oil import volumes

1. [1] *METI, "Cabinet Decision on the New Strategic Energy Plan 2014," http://www.meti.go.jp/english/press/2014/0411_02.html, 2016.*

Countries/ Region	Nov. 2016		Nov. 2015	
	Volume (kl)	Share (%)	Volume (kl)	Share (%)
Saudi Arabia	5,876,777	39.2	5,659,392	36.4
UAE	3,676,071	24.5	3,339,924	21.5
Iran	1,133,516	7.6	802,656	5.2
Qatar	1,123,615	7.5	1,068,372	6.9
Russia	798,005	5.3	1,286,432	8.3
Kuwait	781,866	5.2	1,436,248	9.2
Mexico	475,649	3.2	174,016	1.1
Iraq	374,712	2.5	462,268	3.0
Oman	276,231	1.8	-	-
Indonesia	103,588	0.9	357,769	2.3
Africa	99,526	0.7	346,924	2.2
Colombia	96,956	0.6	-	-
Australia	66,587	0.4	178,609	1.1
Viet Nam	45,100	0.3	31,715	0.2
Malaysia	49,179	0.3	119,189	0.8
Venezuela	-	-	150,498	1.0
Ecuador	-	-	106,992	0.7
Brunei	-	-	31,741	0.2
Total	**14,977,378**	**100**	**15,552,745**	**100**

Source: Policy Planning Division, Natural Resources and Fuel Department, Agency for Natural Resources and Energy, METI Japan

The high vulnerability and potential disruption risks are also due to the fact that for Japan, the prospects for importing electricity from neighboring countries are poor because Japan is an island nation. To ensure Japan's stable electricity supply it was crucial to establish an optimal combination of power sources that could concurrently deliver energy security, efficiency and environmental conservation, while placing top priority on safety.

Japanese diversification patterns: Historical 1970–2000

The 1973 Arab–Israeli war and the subsequent world-wide oil crisis had significant impact on Japan. In response to shooting oil prices Japan institutionalized a policy which had two pillars designed to enhance supply security over the longer term. The policy sought to reduce import dependence though diversifying into coal, LNG, and nuclear power; while simultaneously aiming to reduce dependence on Middle East oil by diversifying into alternative oil import sources. According to Japan's Ministry of Economy, Trade and Industry Ministry (METI), the share of crude oil in Japan's primary energy basket steadily declined from a level of 77.4 percent in fiscal 1973 and reached 43.7 percent in 2010. At the same time period, share of natural gas increased from 1.5 percent to 17.3 percent. The share of nuclear power during the period increased phenomenally from 0.6 percent to 10.8 percent. Expansion of nuclear power generation in Japan played significant role as the country resumed its economic growth. Japan switched to nuclear power for electricity consequent to which share of nuclear power increased to produce about 30 percent of Japan's total electricity supply by 2010.

In the period preceding formulation of current Strategic Energy Plan 2014, a number of studies examined the implications of Fukushima disaster for Japanese energy policy. Some studies examined specific

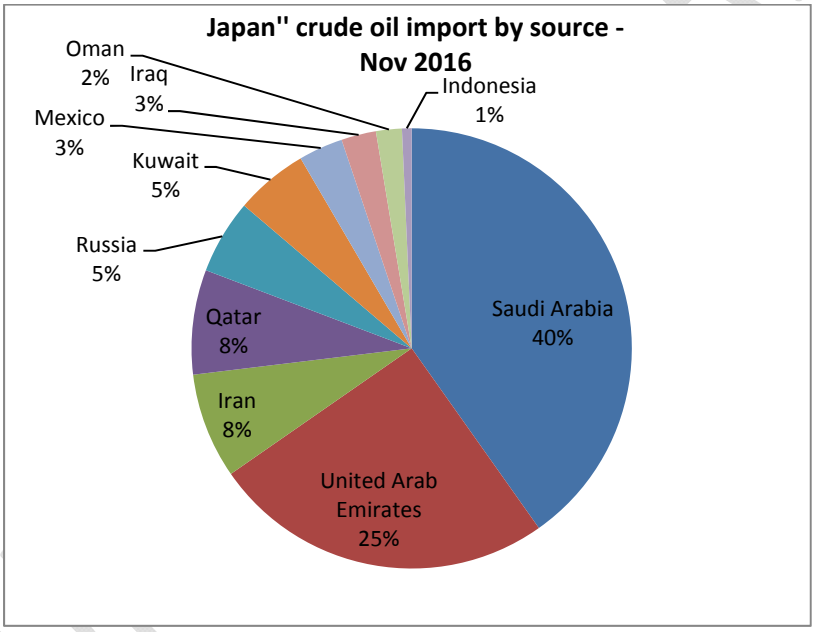
policies including fuel cell and hydrogen development, climate change, nuclear power and energy system resilience [19]. The latest energy policy of Japan has been formulated with the main objective of:

a. Establishing a "multilayered" energy supply system by creating an "optimal portfolio" of energy sources and securing them in a stable and economical manner.
b. Self-sufficiency is to be enhanced by promoting domestic energy sources including nuclear power, renewable energy, and fossil fuels.
c. Create a "demand-side led energy supply-demand structure" and accelerate energy efficiency initiatives in all industry sectors
d. Increase the introduction of renewables to higher levels
e. Enhancing environmental performance and efficient use of fossil fuels
f. Enhance demand-side systems to respond to emergency situations, and
g. Build international energy cooperation frameworks through strategic energy cooperation.

PORTFOLIO SPREAD

Japan's regional dependence on imported energy has been concentrated in specific regions, i.e. on the Middle East for oil and LPG, and on Asia-Pacific for LNG and Coal. Japan has been able to diversify away from the Middle East into the Asia-Pacific as a source of energy imports [Figure 5]

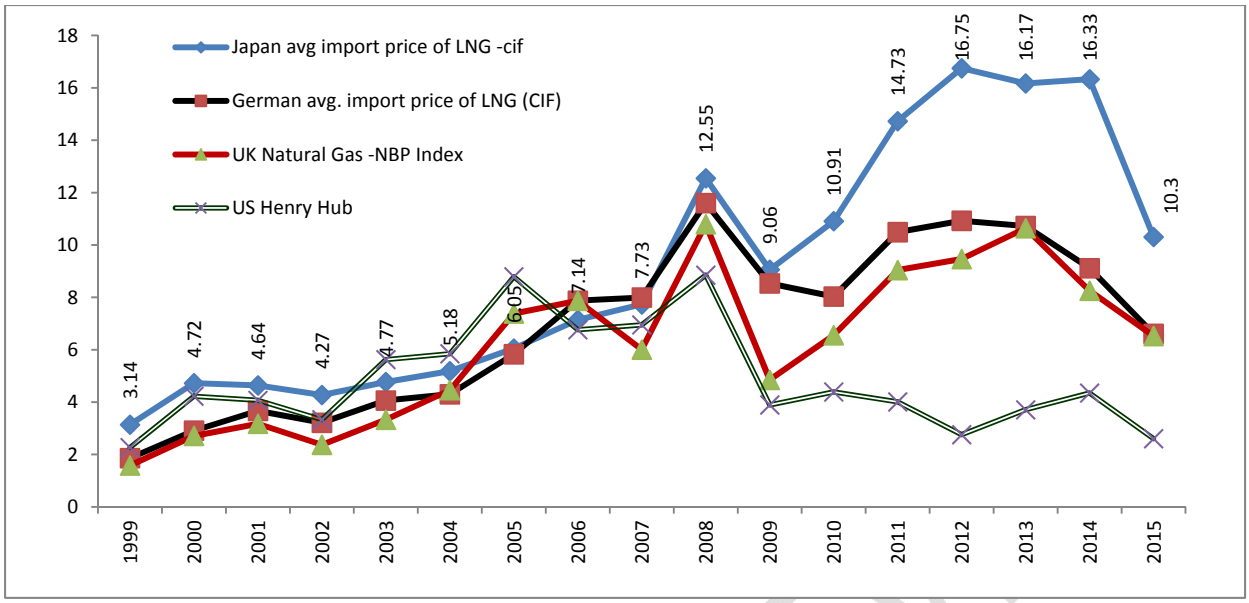
Figure 5: Japan's crude oil imports by Source



Data Source: Natural Resources and Fuel Department, Agency for Natural Resources and Energy, METI

Japan began importing LNG from Alaska in 1969 making it a pioneer in the global LNG trade. Japan, the world's largest LNG importer, accounted for 37% of the global market share of LNG demand from 2012 through most of 2014. Japan operated 23 major LNG import terminals with a total annual capacity of 9 Tcf in 2014 [Chart 1].

Chart 1: LNG import price of Japan has historically remained on the higher side
Natural Gas Prices (US$ / MMBTU)



Source: METI, Japan

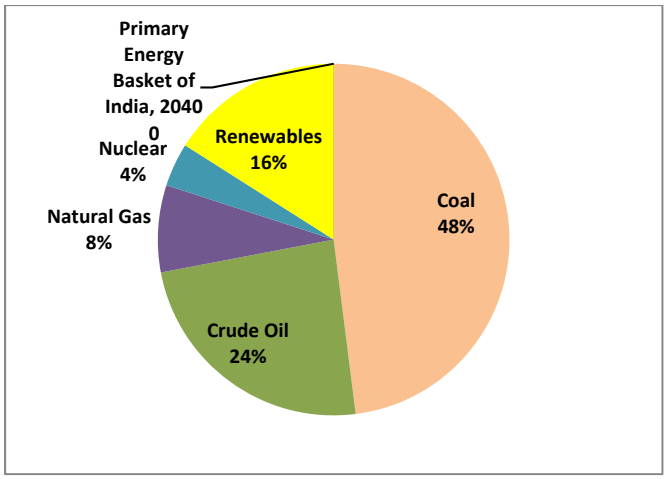
LESSONS AND IMPLICATIONS FOR INDIA

Study of Japan's energy diversification has great lessons for India given its energy landscape and developmental aspirations of billion-plus population. India has the one of world's largest challenges of sustaining the economic growth path with relatively modest energy resources of its own, aka Japan. In the decade from 2004 to 2014, India's economy has grown at an average annual rate of approximately 11% leading the country to emerge as the third-largest consumer of energy in the world. India's energy consumption continues to grow with its nearly 1.3 billion people at about 1.4% increase each year since 2004.

Energy demand forecast of India

IEA's World Energy Outlook 2015 predicts India's total primary energy demand to grow by more than 1000 million tones oil equivalent from 2014 to 2040 to reach 1900 million ton. This growth projection is the larger than the growth anywhere in the world, including Africa, China, South East Asia, Middle East and Latin America. A large part of the growth in energy demand is likely to be met by oil, coal, and gas. India's demand for oil will grow by 6 million barrels per day to reach around 9.8 million barrels per day in 2040. The contribution of transport sector in the oil demand growth will rise substantially from the current 40% to approx. 65% by 2040 [Figure 6].

Figure 6: The share of primary energy for India projected for 2040



Data Source: IEA 2015

INDIA'S IMPORT DEPENDENCY

India is the third-largest importer of crude oil in the world. By value, crude oil accounts for one-third of total imports, averaging to the tune of US $120 billion a year since 2011, baring the global price slump starting the middle of 2014. India has increased its total net oil imports from 42% of demand in 1990 to an estimated 75% of demand in 2015.

Table 2: Top Ten suppliers of India's Crude Oil Imports ('000 barrels per day)

Rank	Country	2001-02	% share of Total	Rank	Country	2010-11	% share of Total	Rank	Country	Jan-Feb 2015	% share of Total
1	S. Arabia	268	17%	1	S. Arabia	549	16%	1	S. Arabia	713	18%
2	Kuwait	240	15%	2	Iran	372	11%	2	Iraq	511	13%
3	Nigeria	235	15%	3	Iraq	345	10%	3	Venezuela	466	12%
4	Iran	170	11%	4	Nigeria	318	9%	4	UAE	416	10%
5	UAE	153	10%	5	UAE	295	9%	5	Nigeria	344	9%
6	Yemen	90	6%	6	Kuwait	231	7%	6	Kuwait	332	8%
7	Egypt	80	5%	7	Venezuela	207	6%	7	Angola	270	7%
8	Iraq	76	5%	8	Angola	194	6%	8	Iran	192	5%
9	Venezuela	71	4%	9	Qatar	113	3%	9	Mexico	124	3%
10	Middle East Neutral Zone	48	3%	10	Oman	109	3%	10	Colombia	97	2%
	Others		9%		Others		24%		Others		13%

Data Source: Reuters

Table-2 above shows the top ten crude oil suppliers to India by volume. The data indicate overdependence on politically vulnerable countries and establishes the criticality of fluctuations in oil price to Indian economy. The increase in energy demand coupled with weak growth rate of domestic energy production is bound to add to the cascading effect of India's import dependency.

The recent statistical tool developed by the Niti Ayog, named 'India Energy Security Scenarios-2047 (IESS-2047)', forecasts an increase in India's import dependence for coal, oil and gas. The

forecasted ranges of import dependency for fossil calculated by the statistical model for year 2027 and 2047 are shown in **Table 3.** The data analysis indicate doubling of demand for natural gas and significant rise in the import dependency of crude oil throughout the projection period till 2047.

Table 3: Import dependency for fossil fuels

	2012	2047
Coal	16%	44-87%
Oil	77%	74-96%
Gas	26%	59-75%
Overall	31%	48-85%

ENERGY STRATEGY OF INDIA – TIME FOR PORTFOLIO APPROACH

Ensuring physical availability of energy and unfettered energy flow is paramount for India's economic growth. Growing import dependency requires that there should be sufficient infrastructure in place for energy imports and domestic distribution of resources. This includes scaling up of port capacity, rail infrastructure, domestic pipelines, cross country pipelines, LNG terminals and storage capacity for crude and LNG. The long term solution of India's energy security lies in self-sufficiency and for that India has to change its energy mix by increasing the share of renewable, non-renewable and nuclear energy resources. Portfolio approach thus become imperative to address impact of a disruption in supply from one source by providing several alternatives, serving the interests of both consumers and producers.

Government of India has been taking several policy initiatives though a national energy security policy is yet to evolve. The Integrated Energy Policy 2008 is an early stage comprehensive document on energy policy which is linked with sustainable development covering all sources of energy; and addresses energy use and supply including energy security, access and availability, affordability and pricing. The amount of energy India needs to sustain high economic growth of 8% to 9% per year over next 25 years was addressed in the policy document by looking beyond the traditional five-year cycle to determine how India could best meet its large energy demand. The policy illustrates scenarios based on energy mixes and implementation of demand-side management. However, the portfolio based energy policy demanding diversification of energy supplies and demand side management is yet to be formulated in India.

KEY LESSONS AND OPPORTUNITIES FOR INDIA

Enhanced energy efficiency scales are required to be supplemented by a conscious push towards renewable energy of solar, wind, and biomass. This will provide the country more secure and clean long-term energy security options. India's commitment at the Paris COP21 to reduce carbon intensity shall call for an increased share of renewables in its primary energy basket. As renewables are localized and geographically distributed, it addresses India's energy independence in two ways - by replacing fossil fuel imports the renewables has potential to strengthen India's balance of payments position, and renewables bring price stability by making power generation less dependent on price vulnerability s of fossil fuels.

Acquisition of equity oil overseas by India's state owned oil companies fill an important element in India's energy security portfolio. India's domestic production has been flat for decades with little chances of material increase in the near future. Acquiring energy assets overseas in geographically spread-out regions is a sensible step to augment energy security as it provides security of supplies and ensure rights of offtake in geo-politically tough times.

A strong regional cooperation between India and its neighbors would give a boost to energy security and regional energy trade. Myanmar and Bangladesh have huge gas reserves whereas India is the largest target consumer. Bringing in natural gas through trans-country pipelines from Myanmar via Bangladesh and from Turkmenistan or Iran via Pakistan, provides a win-win situation to participating countries. Given the uneven spread of natural resources, a practical way to accomplish diversification could be an integrated supply network within a region; such as development of a trans-ASEAN gas pipeline or across sub-Saharan Africa. The integration of energy systems could be instrumental in forging greater global cooperation towards balancing supply and demand.

CONCLUSION AND IMPLICATIONS

The portfolio approach rely on data of the composition of options of what is used in a particular scenario or what has been used historically. Narrowing the approach on delivering secure energy services opens up the possibility to identify different opportunities throughout the energy supply chain; for example, increased energy efficiency, import diversification, and demand side management. Various methodologies are used separately, so energy security issue is best managed as multidisciplinary field where portfolio approach promote solutions and provide options.

The study of portfolio approach application in Japan establishes that at the aggregate level, Japan has diversified considerably with respect to fuel type imports and with respect to regional sourcing. Japan still has remained heavily dependent particular regions, i.e. Middle East for oil and LPG, and the Asia–Pacific for LNG and coal. Within the Asia–Pacific, Japan's imports of LNG are dominated by East Asian imports, while imports of coal are dominated by Australian imports. Yet, there have been quite important changes in the pattern of energy import dependencies both across and within regions.

Energy supply security, as mentioned in case study of Japan, changes as a result of shifts in sectoral contribution to demand and economic development. As such, insight on historical energy security diversification trends can prove beneficial for major economies like India that are following development trends. Accordingly, an effective energy policy will almost certainly rely on application of portfolio approach.

A conclusion can be drawn that there are a number of options that can help offset oil supply security risk. However, a flexible pro-active policy drive based on portfolio approach is recommended since many of the effective options have a significant lag time before they start to have impact on reducing an economy's risk to energy security.

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