Abstract – Authors surveyed the recent literature on energy security along with commonly cited approaches to the issue and studied various models of energy security reflecting both long term and short term security issues. The models were critically analyzed and authors observed that except for IEA’s MOSES and Oil Venerability Index (OVI) all the models have insufficient indicators or parameters while analyzing the isolated case of oil security with respect to both short and long term oil security. Based on the critical analysis of these models authors suggested IEA model of Short Term Energy Security (MOSES) as the ‘best fit’ model in the Indian context to determine the short term energy security profile of each energy constituent of the country. Author also suggested that the insight from the individual energy constituent profile will assist the policy makers to develop long term energy security strategies. Periodic analysis of energy constituents on this model is also suggested so as to make necessary shift in the long term strategies.

I. INTRODUCTION

After, more than 40 years of OPEC oil embargo, Energy Security still remains a delusive concept. There is no clear definition of definitions of 'Energy Security' which can accommodate producers and consumers perspective. The definition of ‘Energy Security’ differs as the context in it is used changes.

(IEP, 2006) provided the definition of Energy Security in the broadest form with respect to Indian perspective as; “ ...ensuring the continuous availability of commercial energy at competitive prices to support its economic growth ..... “

The key takeaways in the definition are “Continuous Availability” and “Competitive Price” which indicates the supply side economic dynamics. To ensure supply side security (Harris et.al 2008) suggested diversification of sources, energy saving and efficiency measures, and understanding between producing and consuming areas as long term strategies and strategies based upon emergency actions plans and stock management as short term strategies.

(Tønnesson and Kolås, 2006), in their report to Norwegian Ministry of Foreign Affairs highlighted the importance of energy security of foreign policy agenda of India and China and as the countries are increasingly dependent on the imported oil there is the possibility of “Resource War” but they are presently being involved in economic competition to maximize each country’s position on the international energy map. Report highlighted that India as its short term and long term energy security policy has adopted four pronged approach to energy security which includes

- Diversification of import source
- Acquisition of equity oil
- Building of strategic petroleum reserves (SPRs)
- Increased domestic exploration, and production

(Cherp et al, 2007) suggested robustness, sovereignty, and resilience of energy systems as three cornerstone of energy security where resilience is linked to diversity of supply and infrastructure options, redundancies and spare capacities, and institutions capable of adequately adjusting to disruptions and flexibility in demand. Report also suggested that countries like China, India, and Japan, have begun aggressively and investing overseas to then export energy fuels back to their mainland.

Diversity of Energy Sources, Supplier Diversity, Level of Imports, Security of Trade Flows, Geo-politics & Economics, Reliability, Market/Price Volatility, Affordability, Energy Intensity, Feasibility were the 10 key energy security factors suggested by (Deloitte, 2013) for long term energy security of the country.

II. ANALYZING ENERGY SECURITY- MODELS

The approach of quantifying security of energy supply and developing indicators for monitoring can serve as guidelines for policy makers to draw long term
strategies which will reduce short term vulnerabilities and mitigate risk to the energy supply.

Authors studied the prevailing model of energy security and try to identify the ‘best fit’ model to develop energy security profile of India on all the individual energy constituents with special focus on oil security.

(Cherp, 2011) suggested Sovereignty, Robustness and Resilience as three perspective on energy security.

(Jain et al, 2010) explored the concept of energy security for India through a survey that tested the importance of energy security on 16 dimensions and observed that of fossil fuel supply, R&D in new technologies, centralized energy systems emerged as important dimensions in ensuring energy security of the country.

(Sovacool et al, 2011) suggested an energy security index for evaluating national energy security performance of the 18 countries based on dimensions related to availability, affordability, technology development, sustainability, and regulation. Model was developed by disintegrating these dimensions down into 20 components and correlate them with 20 metrics and applied within time frame of 1990 to 2010. Authors observed that Japan, Brunei, and the United States as top three performers of these indexes and Vietnam, India and Myanmar as the worst performers with reduction in their energy security profile in 20 years time. The model however, does not provide stand alone security profile of individual energy constituent. Retail price of 100L of unleaded Gasoline and Energy Stockpiles are the two parameters which can be related to Oil security if measured on individual basis.

4 A’s Framework suggested by The Asia Pacific Energy Research Center (APERC, 2010) encompasses Availability, Acceptability, Affordability and Accessibility as four pillars of energy security in 21st Century. The model provides four energy security indicators as Level of diversification of primary energy on scale of 0-100, Level of supply import dependency by identifying 2 clusters, diversification towards alternative fuel source and identification of potential risks associated with acquisition of oil supply sources. The report undertook case study for Oil supply security on Oil Supply Risk indicators of per capita oil consumption, Oil demand elasticity, economic risk of imports, political risk of imports and refining capacity and Oil Supply offset Indicators of Domestic resource capacity, Industry structure, SPR and Non Carbon Fuel switching. Report provides relative ranking of 10 APEC countries on these indicators thus falling short of developing standalone oil security profile of the country.

(Gupta, 2008) developed a composite oil vulnerability index (OVI) of selected countries for the year 2004 on the basis of four major risk divided into seven parameters or indicators and assessed the relative oil vulnerability of 26 net oil-importing countries for the year 2004 on the basis of these indicators and observed that India has emerged as the world's third most oil vulnerable country. The model provides good information regarding the vulnerabilities associated with oil, which is one of the most used and transferrable energy sources available. It observed that the geopolitical oil market concentration risk (GOMCR) of India which is the combination of net oil import dependence, diversification of supply sources and political risk in oil supplying countries is substantially high as compared to developing nations.

\[
OVI_k = \lambda_1P_{1k} + \lambda_2P_{2k} + \lambda_3P_{3k} + \lambda_4P_{4k} + \lambda_5P_{5k} + \lambda_6P_{6k} + \lambda_7P_{7k} / (\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 + \lambda_5 + \lambda_6 + \lambda_7)
\]

OVI= Oil Vulnerability Index for country K
\(\lambda = \) Principal Component (VAR (Pj))
\(P = \) Product of standardized indicator vector and Fj

There is strong use of quantitative data providing good base in terms of matrices used to create the model. However, the model like 4 A framework provides the relative indicator and not absolute oil vulnerability profile of the country. Model is very well justifiable for Oil security and has been used for India for the year 2004 as discussed above. Therefore, authors deliberated not to use the index in their study to avoid repetition and quote the results wherever required.

Willingness to Pay model based on four variable of dependency on oil & gas, the share of fuel in total basket, energy intensity per unit of GDP and the investments to improve level of energy security forms the small part of energy model developed by (Bollen et al, 2010). The model however, it does not identify the state of energy system nor the security of energy supply rather attempts to put in monetary terms the willingness to pay in order to avoid energy supply risks.

(Roupas et al, 2009) compare the security of oil supply of the 27 European Union (EU27) member countries throughout the measurement of the vulnerability that their economies have exhibited to oil during the period from 1995 to 2007. The future vulnerability till 2030 is estimated for indicative scenario of low oil and high price projections. For the development of the synthetic index the principal component analysis (PCA) was applied as net energy import dependency has emerged as most important factor affecting vulnerability. Research presents the relative oil vulnerability per country for every year till 2007.
(Jansen 2004), suggested Shannon index as the best indicator of diversity and introduced additional 4 aspects of long-term energy supply security which includes; Diversification of energy sources in energy supply, Diversification of imports with respect to imported energy sources, Long-term political stability in regions of origin and the resource base in regions of origin, including the home region/country itself. These indicators were applied to the reference year 2030 to access the regional energy security. However, the paper did not provide enough analysis to establish energy profile of individual constituents as the case observed with similar other studies referred in the research paper.

(IEA, 2011) Model of Short Term Energy security (MOSES) is a quantitative tool based on set of indicators that measure energy security in term of;

a) Risk of supply disruption and
b) Resilience to cope with such disruption

MOSES resembles recent approaches in considering risks and resilience related to imported and domestic sources.

MOSES analyzes vulnerability of 7 primary energy source (Crude Oil, Natural Gas, Coal, Hydropower, Nuclear Power, biomass and waste and geothermal energy) and how these affect the security of 2 secondary fuels (Oil Products, liquid bio fuel). It uses all value chain of energy system and measure the vulnerability of these strata of energy system. Domestic Risk, Domestic Resilience, External Risk and external resilience are the 4 dimensions analyzed in MESES using 35 indicators. Each indicator relates to at least one of the four dimensions of energy security Categorization is used to measure the energy security profile for 28 member countries of IEA. Countries are grouped in 5 energy profile for each energy source or fuel. The energy security profiles are marked by letters A to E, moving from lower risk/high resilience profile (higher energy security) to higher risk/lower resilience profile (lower energy security).

### III. CRUDE OIL SECURITY PROFILE-MOSES MODEL

The analysis of crude oil using MOSES is based on eight indicators as below

<table>
<thead>
<tr>
<th>Group</th>
<th>Country that</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>Export Crude Oil or ≤15%</td>
</tr>
<tr>
<td>B</td>
<td>Import 40-60% of crude oil or Import ≥ 80% of crude oil and have&lt;br&gt;• ≥5 crude oil ports, high supplier diversity and ≥ 55 days of crude oil storage</td>
</tr>
<tr>
<td>C</td>
<td>Import ≥ 80% of crude oil and have&lt;br&gt;• ≥5 crude oil ports, high supplier diversity and &lt;50 days of crude oil storage Or&lt;br&gt;• 2-4 Crude oil Ports, high supplier diversity and &gt;20 days of crude oil storage</td>
</tr>
<tr>
<td>D</td>
<td>Import ≥80% of crude oil and have&lt;br&gt;• 2-4 crude oil ports, high supplier diversity and ≤15 days of crude oil storage Or&lt;br&gt;• 2 Crude oil Ports or 3 crude oil P/L, low supplier diversity and &gt;15 days of crude oil storage&lt;br&gt;• 1-2 crude oil P/L or 1 Crude oil Port and either&lt;br&gt;  - Medium to high supplier diversity and ≥15 days of crude oil storage&lt;br&gt;  - Low supplier diversity and ≥55 days of crude oil storage</td>
</tr>
<tr>
<td>E</td>
<td>Import ≥ 80% of crude oil and have&lt;br&gt;• 1-3 crude oil P/L or 1 crude oil port and ≤15 days of crude oil storage Or&lt;br&gt;• 1-2 Crude Oil pipeline, low supplier diversity and &lt;50 days of crude oil storage</td>
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</table>

Source- IEA

**Security Profile:** Overall risk and resilience of individual country is calculated and the countries are placed in five group A to E. A being most energy secured and E being least energy secured nation based on following profile 

<table>
<thead>
<tr>
<th>Domestic</th>
<th>Share of Offshore Pro.</th>
<th>Av. Storage level</th>
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<tr>
<td>Risk</td>
<td>Volatility of domestic Pro.</td>
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</table>
Limitation of MOSES and applicability

MOSES deals with short-term energy security (days to weeks), excluding indicators that are only relevant to the long-term perspective, such as environmental impact, rapid growth in demand and depletion of natural resources. By focusing on physical disruptions, MOSES also excludes economic issues related to affordability and volatility of energy prices.

MOSES Application to Indian Context

Assessment Methodology: India

IEA assigned countries in 5 groups (from A to E) with different crude oil security profile as discussed above. Similar, methodology is followed for purpose of assessment of oil security profile of India. In line with the assessment on the above 8 indicators, (Chopra, 2013) placed India in Group C due to following rationale.

- Import > 80%
- 9 Crude Oil Ports
- High supplier diversity (HHI=0.101)
- 51 days of crude oil storage

IV. FINDING AND DISCUSSIONS

1. Inspite of the limitation associated with MOSES, authors through the literature survey of other models observe that MOSES is relevant model to gauge the energy security profile of each individual constituent of the energy basket which is not the case with other models which rely on the measurement of energy profile in totality or undertaking relative index.

2. The model though being a Short term can be vital tool in developing long term energy security policies of the country on the individual energy constituents which is apparently missing in other models studied during the literature survey.

V. REFERENCES


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