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Concept for Energy Security Matrix

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HIGHLIGHTS

- Energy security should be analysed in technical, economic and political terms;
- Energy Security Matrix provides a framework for energy security analyses;
- Applicability of Matrix is limited due to the lack of statistical data and sensitivity of output.

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ABSTRACT

The following paper presents a discussion of short- and long-term energy security assessment methods and indicators. The aim of the current paper is to describe diversity of approaches to energy security, to structure energy security indicators used by different institutions and papers, and to discuss several indicators that also play important role in the design of energy policy of a state. Based on this analysis the paper presents a novel Energy Security Matrix that structures relevant energy security indicators from the aspects of Technical Resilience and Vulnerability, Economic Dependence and Political Affectability for electricity, heat and transport fuel sectors. Earlier publications by different authors have presented energy security assessment methodologies that use publicly available indicators from different databases. Current paper challenges viability of some of these indicators and introduces new indicators that would deliver stronger energy security policy assessments. Energy Security Matrix and its indicators are based on experiences that the authors have gathered as high-level energy policymakers in Estonia, where all different aspects of energy security can be observed.

1. Introduction

Assessment of the quality of energy policy has been the topic for a number of recent studies. The most prominent general assessment of energy policies has been issued by the World Energy Council (WEC) in association with Oliver Wyman [1], another recent energy policy assessment has been issued by the World Economic Forum (WEF) in association with Accenture [2]. Both of these assessments regard energy security as one of the main dimensions of energy policy. Table 1 provides the dimensions and indicators used in these two reports to assess energy security.

Also International Energy Agency has described the approach to assess the short-term energy security of the country [3] with its MOSES model. IEA has also analysed in detail oil and gas supply security in its member states [4] and has described a general framework to assess governance and electricity market arrangements, power system security and adequacy by looking at external and domestic risks and resilience of the power system. However, as IEA admits, their frameworks “cannot be used to compare the overall energy security of different countries, although specific sources and fuels can be compared”. European Commission has used Energy Import Dependence as the main numerical indicator for energy security in its communication on energy security [5].

However, if energy policymakers would try to use these sets of indicators in their national strategic planning activities in order to improve their country's situation, they would find that these indicators would depend on several unpredictable factors. Even worse: some of these indicators may even incentivise policy makers to take national decisions, which would have negative

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Table 1
Main characteristics of the energy security policy assessment methodologies by WEC and WEF.

WEC energy sustainability index	WEF energy triangle
1. Diversity of electricity generation (Shannon index)	1. Diversity of total primary energy supply (Herfindahl index)
2. Ratio of total energy production to consumption	2. Electrification ratio (%)
3. Distribution losses as percentage of Generation	3. Quality of electricity supply (Survey)
4. 5-year compound aggregated growth rate of the ratio of TPEC (Total primary energy consumption) to GDP	4. Percentage of population using solid fuels for cooking (%)
5. Days of oil and oil product stocks	5. Import dependence (%)
5a. Exporters: fuel exports merchandise value as a percentage of GDP	6. Diversification of Import counterparts
5b. Importers: net fuel imports as a percentage of GDP	

regional or global impact. For example, in order to calculate Energy Import Dependence, official statistics uses for some energy resources primary or secondary energy (coal, crude oil and oil products, biomass), but for some resources tertiary energy (as electricity from nuclear, wind and solar). This misleading statistics delivers that final energy produced from primary energies always has a bigger weight in these calculations: for example electricity originating from biomass (counted in statistics as used primary energy of biomass) has much higher weight than electricity produced from wind (counted as tertiary energy of electricity produced) due to the technological losses of transformation. Therefore Energy Import Dependence delivers very misleading signals to the policy makers that try to decrease the dependence of a country.

The aim of the current paper is to discuss the approach to energy security indicators and to provide some additional viable indicators that should be considered by the policymakers for higher quality of energy strategies. Following observations are based on long-term experience of the authors as energy policymakers in Estonia. Nevertheless, current paper does not intend yet to provide an exhaustive methodology for full assessment of energy security of a country, but discusses the components for such methodology.

However, it is understood that the main problem is associated with the availability of data: indicators which are currently collected and available in world-wide energy-related databases are not providing adequate background for energy policymakers. This is another issue for the policymakers to address: in the absence of data, which would provide right incentives, it is extremely difficult to make adequate energy policy decisions.

2. Materials on energy security

In addition to the studies by World Energy Council and World Economic Forum, several national approaches have been also applied to energy security assessments. Most interesting ones have been applied by the USA [6] and Lithuania [7]. There is also a number of scientific assessment methods used to approach the energy security from different angles. Christie [8] has approached energy security from the perspective of the vulnerability of the energy infrastructure, Chester [9] and Ciuta [11] have described the multiplicity of the definitions and indices of the energy security, Rogner [10] and Makovich [12] have approached energy security from the perspective of costs to the society. Hughes [13] has described a generic framework for IEA conceptual approach to short term energy security [3] and Winzer [14] has defined energy security as the continuity of energy supplies relative to demand. All of these references have in turn used a number of earlier studies in this regard.

Nevertheless, if energy policymakers would try to use these different assessment methods for the development of their national energy policies, they would soon find that the application of energy security indicators from these investigations is quite difficult. These reports provide variety of retrospective indicators and overviews about the energy security levels and its changes over the years in history, but it is nearly impossible to provide plausible forecasts of these energy security indicators. And as far as energy security is one of the main pillars of the Energy Trilemma [1], it is a constant struggle for policymakers to find proper indicators, which would help them to prepare stronger energy policies in this respect.

For example, it would be rather difficult to forecast the energy mix of power production in the liberalised energy markets, especially in case when there is a high share of variable hydro power in the power system or strong interconnections to neighbouring countries, which can be used to import or export substantial volumes of power. And it is even more cumbersome to predict the geopolitical or national political changes, which may also influence national energy security.

The definition of energy security is another widely disputed matter in the literature. One of the most comprehensive set of energy security definitions is provided by Winzer [14]. From the variety of definitions one could come to the conclusion that we should distinguish between short- and long-term energy securities. Short-term energy security can be largely assessed by the potential of an energy system to deal with disturbances (in other words by describing the Operational Resilience of the energy sector). In case of long-term energy security (which should aim to describe the investment climate to tackle energy security issues), one could distinguish three layers, which should be part of every energy security policy: Technical Resilience and Vulnerability, Economic Dependency and Political Affectability. So all in all there are four layers to energy security:

1. Short Term Operational Resilience should describe the ability of the current infrastructure of the national energy system to cope with different disturbances of energy supply and demand from seconds to days. The question one should ask here would be "how flexible is the current infrastructure to cope with potential disturbances? " This layer is usually described by the characteristics of technical infrastructure and its operations (power capacity margin, diversity of power and heat production, oil stocks, SAIDI, etc.). To capture the level of technical resilience the WEC [1] measures in its methodology Ratio of Total Energy Production to Consumption, and Days of Oil and Oil Product Stocks for transport sector. The WEF [2] uses for similar purposes in its assessment indicator on the Quality of Electricity Supply for electricity sector (based on their Survey). IEA [4] looks in terms of electricity in general to the power system operating practices, situational awareness, coordination, communication and other such aspects, which subjectively can describe the power system resilience to shocks.
   However, majority of these indicators show only the result of the operations (subject to market situation, weather impacts, unexpected outages etc.), but they do not describe the capabilities of the infrastructure (capabilities of different production