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The challenging economics of energy security: Ensuring energy benefits in support to sustainable development

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ABSTRACT

Energy is a key-resource to economic development and is required to be available continuously and in adequate amounts. Also, it is expected to be affordable and environmentally friendly. Ensuring this is a challenge, yet strategic to maintain economies running under a sustainable pattern. Energy security is neither a new concept, nor a new concern. However, because of new issues, it requires a novel, broader approach. Such an approach should address both demand (security of supply) and supply (security of demand) sides, as well as take into account energy scarcity situations and surplus opportunities. In addition, it should allow for both private (markets) and public (policies and regulations) initiatives. This paper presents a theoretical and practical basis for the economics of energy security. Energy security is defined, in this context, as the ability of an economy to provide sufficient, affordable and environmentally sustainable energy services so as to maintain a maximum welfare state, even when issues would press it otherwise. We introduce the notion of energy security gap to represent the economy's failure to show such ability. Additionally, we also propose a framework to support the evaluation, planning and implementation of energy security in an economy. This framework relies on the concepts of resilience, adaptability and transformability (Walker et al, 2004) to prescribe indicators to assess the energy security of an economy. Furthermore, it proposes mechanisms to enhance energy security, as well as a continuous process to increasingly achieve this.

1. Introduction

Energy and development are closely related: while abundant, energy can support economic and welfare growth; when scarce, it may limit economic expansion and lead to changes in technological and consumption patterns.[2] Energy availability hence sets the development path of a society (Martin, 1992). That explains why energy security has been a recurrent issue since the rise of industrial society (Yergin, 2002), a "pillar of energy policy for about a century," (IEA, 2007) and, especially after the 1970s oil shocks, part of most countries' political and development agendas.

Constantin (2005) points out that there are two schools of thought concerning energy security. The first takes a "realist" or strategic view of the matter, under which economies would "struggle to control the sources of a strategic energy resource, oil." It would lead to recommendations like self-sufficiency, or diversification of supply sources and of the energy mix. The second, more "liberal" school of thought argues that "oil is becoming less strategic and should be considered as a normal commodity." Government should thus intervene only in the face of externalities. Both approaches are supply-oriented and focused on oil, and consider that protecting the environment is "a goal competing with security" (Constantin, 2005) The energy security concept, however, has been evolving, from ensuring oil supply and dealing with the macroeconomic consequences of oil disruptions and/or price changes, to include many other concerns. Among these, we may list: availability of resources to meet future demand; political conflicts and terrorism; natural disasters and other severe weather events; and environmental—particularly climate change—issues (WEF, 2006). Further, it has now several meanings[3] (Alhaji, 2008) which typically depend on the size of the economy, its energy self-sufficiency level, and the role it plays in the globally interrelated energy system. Evaluating, planning and implementing energy security in an economy are therefore currently a challenge.

The literature on the subject, which ranges from theoretical to applied approaches, provides a large set of proposals covering not only

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[2] Energy is also vital to national security since it is a key factor to keep military forces in movement. Yet this paper does not deal with national security issues.

[3] Chester (2010) presents a broad analysis of the concept, and argues that it is "inherently slippery because it is polysemic in nature." For a summary of energy security definitions see Egenhofer et al. (2004) and UNIDO (2006).

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indicators to evaluate but policy measures to enhance energy security as well.[4] Indicators help in measuring energy security levels and are useful for international and inter-temporal comparisons. Policies seek both at reducing the exposition of an economy to the risk of energy shortages or disruptions, and at minimizing their impacts. Most of the literature, however, is influenced by local, regional, or temporal factors, and tend to prioritize some specific aspects in detriment of a broader view of the problem. Alhaji (2008) points out the lack of a discussion about interactions among the various dimensions of energy security, and the weight given to them in the formulation of energy policies. As per our analysis, the existing proposals are mostly asymmetric in the sense that they typically concentrate on: (a) security of supply, disregarding the relevance of the security of demand in dealing with the issue; and (b) the idea that only energy scarcity matters, thus ignoring lost opportunities of not taking advantage of energy surpluses in the economy. Nevertheless, the indicators and mitigating measures proposed are undoubtedly consistent with the vision their advocators have on the matter. Further, as von Hippel et al (2011) argue, despite basic differences found in the concept of energy security, "energy security policies in various countries are now showing trends of 'convergence' rather than 'divergence'." Indeed, we observe the existing proposals share a common, general rationale for energy security, which is ensuring that energy is physically and economically available to support economic growth. Here we elaborate on additional aspects of this issue.

Energy security, in this context, represents the guarantee that individuals and firms in an economy are able to benefit from the welfare that energy can create.[5] It is actually a good,[6] which is produced and consumed in any modern economy, either by agents in the energy supply chain[7] or in energy end-use sectors. Whenever an agent in the energy supply chain implements a mechanism that reduces the risk of supply shortages or disruptions, or yet ensures that higher levels of demand can be met, it is providing energy security to all further agents downstream in the economy.[8] Likewise, if an energy consumer agent accepts the risks associated to maintaining a regular level of energy consumption, or ensures that higher levels of energy supply can be absorbed, it is also producing energy security for all further agents upstream in the economy. In addition, similarly to any other good, the production of energy security raises concerns about its environmental footprint. So does its affordability, given its inherent relation to energy, an essential good.[9]

This paper presents a theoretical and practical basis for the economics of energy security. Energy security is defined, in this context, as the (desirable) *ability of an economy to provide sufficient, affordable and environmentally sustainable energy services so as to maintain a maximum welfare state,*[10] *even when issues would press it otherwise*. We introduce the notion of *energy security gap* to show the economy's failure to present such ability. Additionally, we develop a general approach which: (a) addresses the matter from the perspective of both demand and supply sides, with no spatial, temporal or sectoral constraints; (b) complies with any energy system (economic and physical) structure, regardless of either the energy security risk factors to which it is exposed or the mitigating measures it has available; (c) supports inter-economy and inter-temporal benchmarking.

The whole idea is organized into a framework intending to support the evaluation, planning and implementation of energy security in an economy. The framework encompasses indicators to assess and mechanisms to enhance energy security. In addition, it prescribes a continuous improvement process to reduce the energy security gap. In the following, Section 2 conceptualizes energy security; Section 3 describes the framework; and Section 4 summarizes the proposal, discussing some of its benefits and limitations.

2. Conceptualizing energy security

The welfare of an economy is determined, among other factors, by the amount, distribution and intrinsic environmental quality of its consumption of energy services. Therefore, to ensure that an economy can reach its maximum level of welfare, it is necessary to ensure the supply and demand of adequate quantities of affordable and environmentally sustainable energy services. The *energy security* of an economy relates to such *assurance* as well as to its *maintenance*. Factors which hinder the achievement of an appropriate level of energy services — thus ultimately preventing the economy from fully realizing its maximum welfare — directly affect energy security. We adopt the expression *energy security gap* to denote an economy's lack of capacity to deal with such factors. This concept represents the deficit of the energy security good in the economy and is used to measure the economy's ability in mitigating the effects of constraining factors and, consequently, in restoring its maximum welfare state.

The energy security gap is commonly perceived from the demand side perspective. It is usually associated to insufficient supply or high prices of energy. It is considered a matter of *energy security of supply* because of the "insecurity"[11] experienced by consumers under those conditions. Yet, under the assumption of a productive efficient economy, any available energy not consumed represents an energy security gap as well. This situation can be seen as an issue of *energy security of demand*, because it reflects a vulnerability of the energy supply chain similar to the one undergone by energy consumers.

Another relevant point concerning the energy security gap is that if we further assume an allocative and environmentally efficient economy, reducing the gap parallels to pursuing a sustainable development pattern. Allocative efficiency reinforces the very role of energy in poverty reduction, and environmental efficiency presumes that energy services are produced from processes that do not exceed, directly and indirectly, the environment carrying capacity. Therefore, under those assumptions, an energy secure economy should necessarily be capable of supplying energy services that are: (1) life-cycle environmentally sustainable; (2) efficiently employed in the production of essential goods and services, which should be affordable to all individuals; and (3) efficiently employed in the production of other demanded non-essential goods and services.

The economy's capability of supplying adequate energy services can, however, be affected by conjunctural and structural factors that influence prices, availability, consumption and quality of consumed energy services (henceforth referred to as *energy related effects*). Such factors

[4] See, for example, Stirling (1994, 1998), Kendell (1998), Alhaji and Williams (2003), von Hirschhausen and Neumann (2003), Williams and Alhaji (2003), Egenhofer et al. (2004), Jansen et al. (2004), Lesbirel (2004), Hogan et al. (2005), Kessels and Bakker (2005), Markandya et al. (2005), Awerbuch (2006), Bahgat (2006), Grubb et al. (2006), Pimentel (2006), Turton and Barreto (2006), APERC (2007), IEA (2007), Leiby (2007), Ölz et al. (2007), Scheepers et al. (2007), Vera and Langlois (2007), Frondel and Schmidt (2008), Kruyt et al. (2009), Löschel et al. (2010), and Cabalu (2010).

[5] Bohi and Toman (1996) and the IEA (2007) also associate energy insecurity to welfare losses.

[6] We refrain from discussing in this article whether energy security is a public or private good. Most studies that consider it as a good see it as a public good (see APERC, 2000; Fortov et al., 2007; Grubb et al., 2006; Hogan et al., 2005; von Hirschhausen, 2005). Rutherford et al. (2007), however, present arguments to viewing energy security as an impure public good (in the sense that it suffers congestion effects), particularly when referring to electricity security of supply.

[7] We consider as the energy supply chain the whole set of industrial and commercial activities that contribute to supplying energy and energy related goods and services, to ultimately provide energy services.

[8] Security of supply can also be provided by consumers. Rutherford et al. (2007) propose a scheme for an electricity security market where both energy suppliers and consumers "are able to symmetrically participate in the market providing the same effective product of a secure supply of electricity." The mechanism is, additionally, an incentive to increase the demand-side energy efficiency.

[9] The Johannesburg Declaration (clause 18) "clearly identifies energy as a human need at a par with needs such as clean water, sanitation, shelter, health care, food security and biodiversity" (Najami and Cleveland, 2003).

[10] The concept of energy security is hence associated to the one of sustainable development. This was stated during the 2002 World Summit on Sustainable Development (IEA, 2002), and is emphasized by the U.N. Industrial Development Organization (UNIDO, 2006) and the G8 (2006).

[11] In other words, the feeling of being unable to consume as much energy as desired.