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Energy Systems Integration: Economics of a New Paradigm

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Currently there is a debate about the future energy paradigm and its reliance on Energy Systems Integration (ESI) both in developed and developing countries. ESI is based on a holistic view in which the main energy carriers are integrated to achieve synergies and efficiencies at all levels. The main stimulus for the deployment of this concept is the idea that its development will produce some co-benefits that will help to address the objectives of the energy trilemma, i.e., energy security, energy equity, and environmental sustainability. Broadly speaking, it can be described as the process of devising a short-term and long-term management of energy systems through alternative means and at different geographic scales with the aim of delivering energy and other essential services while the energy trilemma goals are achieved.

Recently there has been an emerging literature focused on discussing technical aspects related to ESI. However, such systems require not only physical solutions but also economic, regulatory, and policy frameworks to ensure an efficient performance over time. However, to our knowledge, there is a lack of research that discusses the diverse economic features of integrated energy systems. It should be noted that there is nothing automatic about the benefits of integrated system as opposed to non-integrated ones. The performance of the integrated system and its design will ultimately be determined by the economic and regulatory framework and rules.

While ESI presents obvious efficiency benefits, such as reducing the transaction costs, providing flexibility to meet the demand for energy services, and economies of scope, it also presents some challenges. This paper attempts to be a primer on some relevant economic aspects related to ESI from the point of view of industrial organisation, regulation, business, and technology. First, we discuss how the economies of scope, scale, and coordination may yield changes in the vertically-unbundled and increasingly decentralised (distributed generation, electric vehicles, storage, etc.) utilities sector.

We highlight the potential links between utility networks and discuss examples of 'partially' integrated systems such as smart grids or cogeneration solutions. The evolution of the utilities sector (particularly telecommunications and electricity) is analysed to identify trends and similarities that have led to changes in the products and services provided by these industries while the main changes happened in the regulation of the sectors are described. We also discuss the arising of multi-utilities and new business models, and the pros and cons of multi-sector regulation, along with the essential role that Information and Communication Technology (ICT) will have in these systems.

We conclude the paper by proposing the need for definition and measurement of the current level of integration of energy systems based on real data as a future line of research. ESI will be context-specific and hence will take different forms depending on the particular conditions of each system. However, if we assume the pillars of the energy trilemma as the main goals of ESI, these definitions and measurements will be helpful to perform policy analyses to inform decision-making and the success in achieving the intended targets.

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