# Energy systems

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An energy system is a system primarily designed to supply energy-services to end-users.[1]: 941  The intent behind energy systems is to minimise energy losses to a negligible level, as well as to ensure the efficient use of energy.[2] The IPCC Fifth Assessment Report defines an energy system as "all components related to the production, conversion, delivery, and use of energy".[3]: 1261 

The first two definitions allow for demand-side measures, including daylighting, retrofitted building insulation, and passive solar building design, as well as socio-economic factors, such as aspects of energy demand management and remote work, while the third does not. Neither does the third account for the informal economy in traditional biomass that is significant in many developing countries.[4]

The analysis of energy systems thus spans the disciplines of engineering and economics.[5]: 1  Merging ideas from both areas to form a coherent description, particularly where macroeconomic dynamics are involved, is challenging.[6][7]

The concept of an energy system is evolving as new regulations, technologies, and practices enter into service - for example, emissions trading, the development of smart grids, and the greater use of energy demand management, respectively.

Viewed in engineering terms, an energy system lends itself to representation as a flow network: the vertices map to engineering components like power stations and pipelines and the edges map to the interfaces between these components. This approach allows collections of similar or adjacent components to be aggregated and treated as one to simplify the model. Once described thus, flow network algorithms, such as minimum cost flow, may be applied.[10] The components themselves can be treated as simple dynamical systems in their own right.[1]

Conversely, relatively pure economic modeling may adopt a sectoral approach with only limited engineering detail present. The sector and sub-sector categories published by the International Energy Agency are often used as a basis for this analysis. A 2009 study of the UK residential energy sector contrasts the use of the technology-rich Markal model with several UK sectoral housing stock models.[11]

Energy systems can range in scope, from local, municipal, national, and regional, to global, depending on issues under investigation. Researchers may or may not include demand side measures within their definition of an energy system. The Intergovernmental Panel on Climate Change (IPCC) does so, for instance, but covers these measures in separate chapters on transport, buildings, industry, and agriculture.[a][3]: 1261 [15]: 516&#820

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The concept of an energy-service is central, particularly when defining the purpose of an energy system:

It is important to realize that the use of energy is no end in itself but is always directed to satisfy human needs and desires. Energy services are the ends for which the energy system provides the means.[1]: 941 

Energy-services can be defined as amenities that are either furnished through energy consumption or could have been thus supplied.[18]: 2  More explicitly:

Demand should, where possible, be defined in terms of energy-service provision, as characterized by an appropriate intensity[b] - for example, air temperature in the case of space-heating or lux levels for illuminance. This approach facilitates a much greater set of potential responses to the question of supply, including the use of energetically-passive techniques - for instance, retrofitted insulation and daylighting.[19]: 156 

A consideration of energy-services per capita and how such services contribute to human welfare and individual quality of life is paramount to the debate on sustainable energy. People living in poor regions with low levels of energy-services consumption would clearly benefit from greater consumption, but the same is not generally true for those with high levels of consumption.[20]