



**HOW TO ENSURE ECONOMICALLY EFFICIENT,
RESILIENT AND SUSTAINABLE ENERGY SUPPLY**

Economic analysis

At a glance

The transformation of today's energy systems leads towards more dynamic and diverse systems with various actors and multilayered energy, information, and money flows. In consequence, existing strategies, approaches and business models need to be revised and innovated. These should reflect impacts of technological and social change, new customer needs as well as the changing regulatory framework and competition in evolving markets.

Siemens Power Technologies International (Siemens PTI) is a world leader in transmission, distribution and industry system analysis. Our experts have performed extensive technical and economic studies in key energy supply disciplines for a diverse client base around the globe. Key services provided by Siemens PTI include economic analysis in the context of

- transmission and distribution system development ('master plan'),
- integrated resource planning including effects and opportunities resulting from Distributed Energy

Resources (DER), utility scale renewable and DER integration,

- network simplification and automation measures,
- Microgrid and storage applications,
- integration of new loads and change of load patterns, e.g., electromobility, electrical cooling/heating and energy efficiency,
- technical-economical optimization of energy supply and network tariffs.

The challenge

Due to various driving forces in the energy sector, an innovative and integrated infrastructure planning becomes more and more important. These are on the one hand an increasing share of distributed energy generation and on the other hand new loads like charging points and heat pumps, the emergence of utility scale storage as well as increasing liberalization of energy markets and environmental awareness of today's customers. In parallel, the existing principles of an

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efficient, economic and sustainable energy supply remain as important as ever.

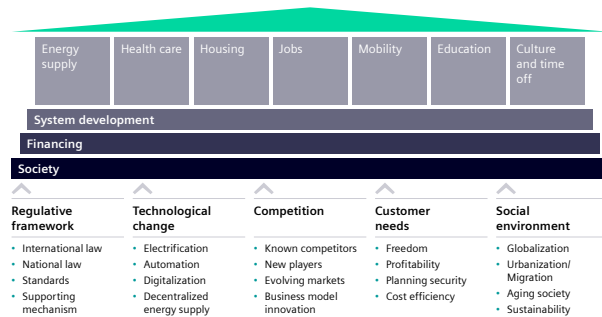


Figure 1: Impact factors on conceptual system development

As part of today's developments and the trend of digitalization, paradigms across all sectors are changing. Especially in the energy sector, system operators and stakeholders are facing disruptive opportunities and risks which cause the need for transparent evaluations of potential value propositions and new market actors.

As more and more consumers turn into prosumers, communities decide to supply themselves (partly) independently, and new service models are installed and integrated. The amount of interactions and data available increases, and so do the chances and risks in the course of this transformation.

Due to the ongoing energy transformation today's network infrastructure is facing more and more challenges in order to provide state-of-the-art security of supply under increasing cost pressure. Requirements of distribution grids are changing, and existing networks have to be transformed into more intelligent grids to ensure technically appropriate and economically efficient operational performance. On the other hand, the existing infrastructure must continue to be maintained, replace or expanded.

Our solution

The drivers for change in energy supply systems (see figure 1), together with new concepts for equipment, planning and operation, motivate the transition of today's networks into future-oriented energy systems.

Cost-benefit assessment

In order to ensure the feasibility and sustainability of a proposed target system, techno-economical assessments are important key factors. The technical planning criteria

and the planning approach form the basis for an economic analysis leading towards a master plan for the future energy system. By allocating mandatory and optional measures and related investments over the considered time period, a detailed understanding of the future cost structure and revenues streams can be derived. The cost-benefit evaluation calculates key economic figures, such as net present value (NPV) and/or return on investment (ROI), and enables decision makers to select and implement investments on a reasonable.

Siemens uses advanced tools to formulate generation expansion plans, if required, and evaluate expected market behavior in terms of key performance parameters, such as locational marginal prices, unit dispatch levels, adequacy of spinning and operating reserves, operating costs, renewable curtailment, congestion costs, and emissions.

Scenario comparison

In addition to the economic cost-benefit evaluation of different scenarios, further objectives, like the reduction of fuel and CO₂, share of renewable generation, and degree of independency are rated, to consider the full spectrum of possible value and decision factors (see Figure 2).

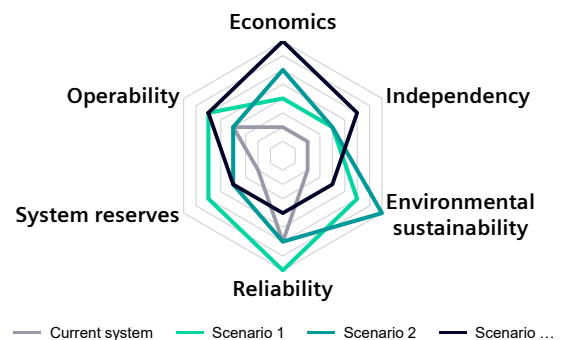


Figure 2: Scenario comparison

This task also includes the evaluation of possible operation models of new generation and storage systems, as well as (new) business models arising from the foreseen infrastructure projects in form of exemplary show cases:

- Who owns and operates the new components?
- What are the value propositions of (increased) renewable energy supply?
- What are the critical factors of the foreseen scenario?

By means of a sensitivity analysis, critical variables can be identified. The sensitivity analysis assesses the effects of possible changes in the key project variables on the project's financial performance indicators (see Figure 3).

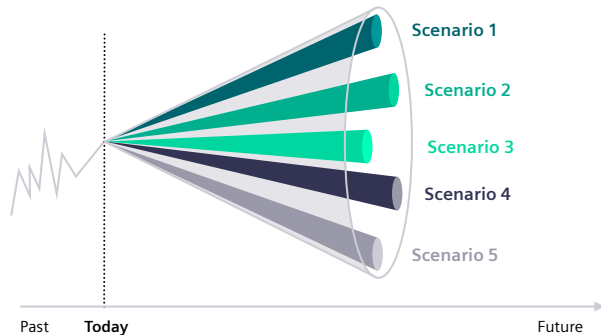


Figure 3: Sensitivity analysis

The analysis is carried out using aggregated and selected disaggregated variables (i.e., demand and prices separately) to better identify possible critical variables. Siemens uses a dual approach using Trade Off Risk and Minimum Regret. Trade Off Risk is a procedure to identify the Decision Set – a set of plans that result in best performance in at least one performance indicator (e.g., maximum B/C ratio, minimum CO₂ emissions, minimum renewable curtailment, etc.). The Decision Set is then evaluated based on Minimum Regret to identify the plan that

minimizes the exposure to risk under all scenarios and, if applicable, the formulation of hedging strategies (e.g., postponement of certain decisions).

Congestion analysis

Foremost on the mind of the resource owner or operator is the possibility of being curtailed due to transmission limitations. Coupled with power flow analysis, Siemens PTI can evaluate the anticipated limitations, the contingencies driving those limitations, the possibility that the limitation will impact the site over the years, etc., and thus provide the network owner or operator with an estimation of the full impact of transmission congestion.

Summary

While we can be sure that the described transformation will not be the first predictable (r)evolution, the concrete value of electrification, decentralization and digitalization is something which needs to be identified, specified and evaluated by every actor in the energy sector. With our industry leading expertise and software, Siemens PTI offers a broad spectrum of studies that build on a thorough understanding of processes and an alignment with the need for enhanced planning capabilities and can support our customers in improving their performance.

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