SIEMENS

Integrated energy system planning and **decarbonization strategies**

At a glance

Utility executives and planners are increasingly asked what, when, and how to invest in a wide variety of supply resource technologies, often driven by decarbonization goals. But with the ability for new resources to be installed at any level (transmission, distribution, or customer) on the grid, traditional planning practices and processes are no longer suited to investigate all energy carrier options and ensure high investment security.

Siemens PTI Consulting combines latest market and technology expertise with more than 60 years' experience in grid planning and optimization. Our global team of strategic and technical consultants assists utilities in evaluating different options for grid development based on the utility's individual targets and within the given regulatory and market frameworks, including:

- Generation planning with a holistic view on energy carrier optimization
- Long-term T&D grid infrastructure investment planning
- Integrated system planning considering generation and grid infrastructure
- Decarbonization roadmap considering all energy efficiency relevant areas

The challenge

Traditional utility planning tools and methodologies were designed to support bulk power supply serving distribution load, optimized for cost and reliability.
Now, utilities are increasingly requested to justify decisions based on cost, reliability, resilience, efficiency, and sustainability. But current planning processes and tools are no longer suited to forecast and assess the full implications of the deployment of new resources.

The transforming energy landscape requires changes to distribution system design, changes in the dispatch of utility-scale generation, and changes to load flows across transmission systems. Historically, each of these utility grid elements were planned by different departments, using different objectives, tools, data sources and planning horizons. With increasing system complexity, the investment decisions across GT&D system elements can no longer be determined in their respective planning silos. Utilities require an evolution in the methods and tools of historically separated GT&D planning domains.

Our solution

Siemens PTI provides vendor-agnostic strategic and technical consulting services for utilities, independent system operators and the industrial sector worldwide. Our offering is a unique combination of industry leading energy market analysis, power system planning expertise and grid simulation software (e.g. PSS®SINCAL or PSS®E). We support utilities, grid operators, industrial customer and power producers to find solutions to the challenges resulting from the transforming energy landscape.

Our approach uses updated supply and demand inputs and forecasts, such as generating unit operating characteristics and costs, demand factors, zonal transmission capabilities and existing and proposed legislations/regulations. This allows us to offer you snapshots of the resources mix and costs projections for various decarbonization strategies.

Generation planning

In a classical generation planning approach, the power generation pool is typically optimized for lowest cost. Both the investment and operating costs are taken into account, considering technical boundary conditions such as ramp rates. In the current framework of decarbonization and renewable resources, the challenge at hand becomes somewhat different and more complex. Typical questions that need to be answered by the generation planning are:

- Given a minimum amount of renewable energy resources, what should the rest of the generation fleet look like to make it work?
- If x% of the thermal power plants are replaced by renewable resources, will the overall system still work adequately?
- What is the maximum amount of renewable energy resources that can be integrated in the system?

Based on our extensive experience in the field of renewable recourse and by making use of suitable optimization algorithms, Siemens PTI can tackle a variety of such challenges.

Going one step further, discussions tend to be generalized to a more fundamental level, where the planning of the energy system is considered, rather than the electrical power system. In the Energy System Development Plan (ESDP) optimization framework, detailed conversion processes between energy carriers such as power-to-heat, power-to-hydrogen and power-to-methane are included in an optimization approach over different forms of energy and energy carriers, the total amount of installed capacity per technology can be identified.

Benefits:

- Holistic view on energy carrier optimization
- Adaptable approach allowing the solution of a wide range of challenges

Sankey diagram

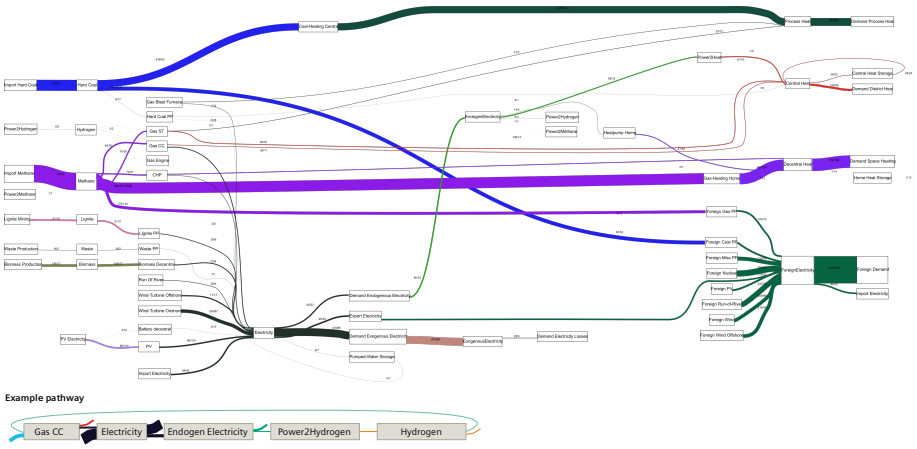

Figure 1:
Consideration of all energy carriers and conversion technologies

Transmission and distribution planning

With our market-leading grid simulation software packages PSS®E and PSS®SINCAL, Siemens PTI carries out a large number of transmission and distribution planning projects every year and for a large variety of customers around the globe.

A typical brown-field planning approach is to determine how the current grid topology will perform under a set of future generation and load scenarios. Bottlenecks are identified with respect to steady-state and dynamic performance, and corresponding solutions are drafted, assessed, and ranked according to their performance and cost-efficiency. The investigated scenarios are typically predicted highest and lowest demand. But this is not always adequate, especially in systems with high amounts of renewable energy where the highest system loading does not necessarily coincide with peak demand. This challenge can be tackled by means of automation, so that the number of investigated scenarios can be significantly increased.

A special case of brown-field planning is the assessment of the performance of distribution grids under the rapid growth of eMobility. In the so-called stress-test methodology, a high-level investment roadmap is developed for distribution utilities under a projected increase of eMobility demand.

Benefits:

- Guideline for grid infrastructure investment plan
- Long-term planning avoids stranded assets
- Evaluation of different scenarios, with variations in boundary conditions

Integrated system planning

In an integrated system planning approach, the generation and transmission and distribution planning tasks are combined. This is however more than performing one after the other. For each generation plan, the impact on the required transmission and distribution network topology is assessed. When the main goal is decarbonization, the optimal generation mix to achieve this goal may however lead to prohibitive grid investments costs. Hence, an iterative approach is to be adopted where a good trade-off over a set of KPI's is found, for example between decarbonization and network reinforcement cost. It is important to understand that the set of target KPIs and their individual prioritization is different for every customer and project, and that a clear alignment on this needs to take place.

The described planning process is of course subject to uncertainties. It is therefore key to make sure that the proposed investment plans are as robust as possible.
This can be done by a basic sensitivity analysis. When the number of variables makes such an approach unpractical, Siemens PTI uses the "Gridmaster" approach, where statistical algorithms are adopted to explore the performance of an investment plan in a "scenario space".

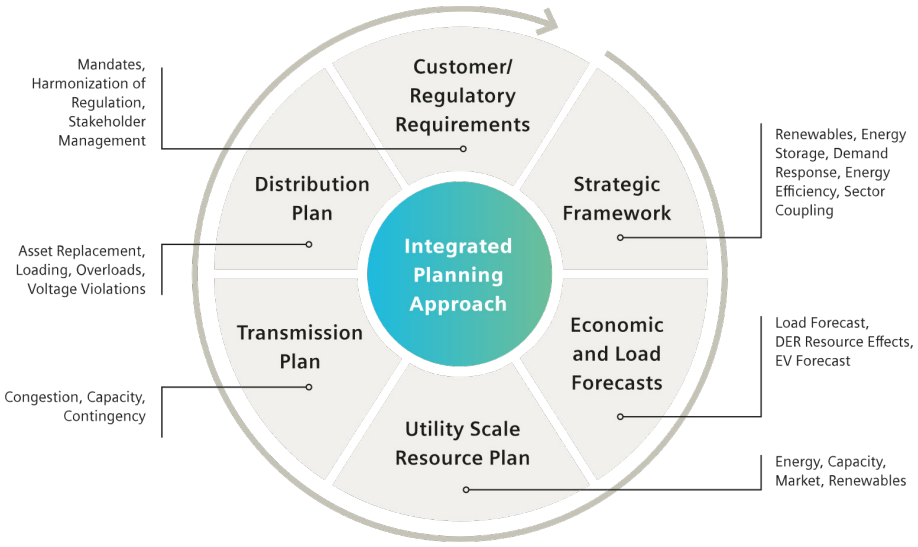

Figure 2:
An integrated planning approach eliminates planning silos by offering a global view on system optimization

Siemens PTI does not adopt a single standardized toolchain for every task at hand. Depending on the specific requirements of each project, a custom combination of tools is selected to maximize efficiency. For example, when a transmission system planning task should be combined with a multi-carrier energy optimization, the Energy System Development Plan (ESDP) is combined with PSS®E to achieve this goal.

Benefits:

- Determination of a global optimum, both for generation and for grid infrastructure
- Adaptable toolchain, optimized for particular use cases

Energy efficiency/ Decarbonization roadmap

Decarbonization and decentralization of the power systems also need to be planned with a holistically economical approach and within a clearly defined regulatory framework. New revenue streams from energy management, electric vehicle charging infrastructure, energy efficient solutions etc. are contributing to the decarbonization of energy systems and need to be fitted into the existing and future regulatory and economic framework. Siemens PTI applies the Siemens Energy Efficiency Reference Regulatory Architecture methodology in order to baseline the existing regulatory regime, policy instruments and execution measures, conduct a gap analysis, initiate measure design and create a roadmap for implementation.

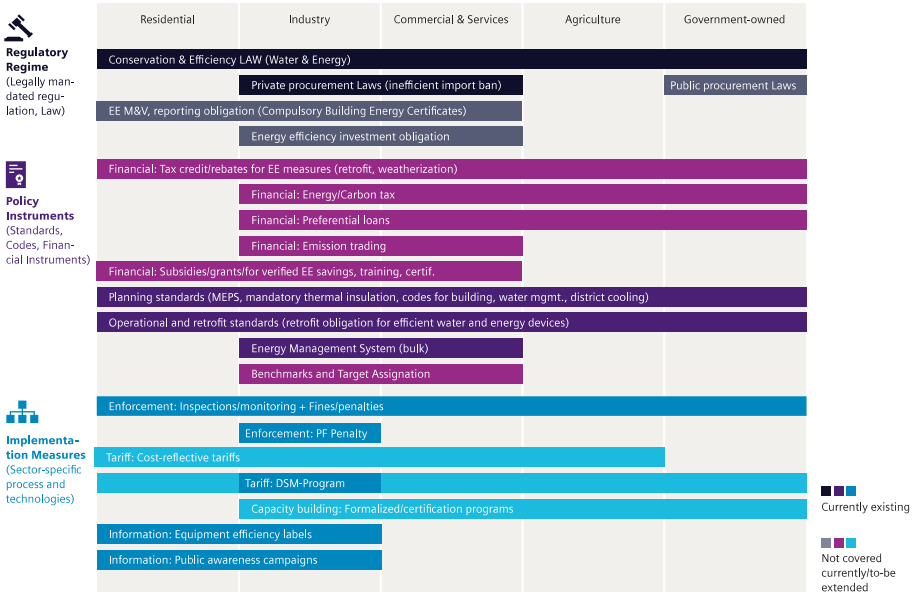

Figure 3:
Project example: Application of Siemens Energy Efficiency Reference Regulatory Architecture

Benefits:

- **Transparency**: Broad understanding of levers and impact factors towards a decarbonized energy system – including energy consumption part
- **Exhaustiveness**: Consideration of all energy efficiency relevant areas – including all relevant sectors (industry, commercial, residential etc.)
- **Best-practice approach**: Application of international standards and policy benchmarks to ensure the best-value for effort in terms of energy efficiency implementation measures

Conclusion

Siemens has developed a well thought out, structured process to guide utilities through an evolution to integrated generation, transmission, and distribution planning capability, regardless of their current tools, capabilities, and what they may be seeking to achieve. Siemens integrated GT&D planning roadmaps, business processes, and technologies can assist any utility in navigating and achieving a successful and efficient transition to enhanced planning capability for "no regret" planning investment strategies.

Published by

Siemens AG
Smart Infrastructure
Digital Grid
Humboldtstrasse 59
90459 Nuremberg, Germany

For the U.S. published by

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