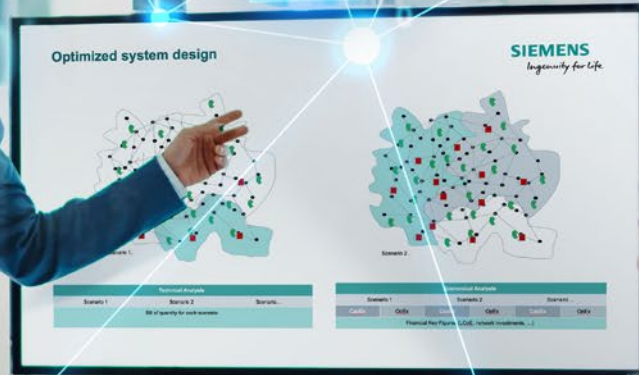


SIEMENS



Shaping viable energy infrastructures

Trusted expert advisory service
in a transforming energy sector

siemens.com/power-technologies

Energy transition is now – and it has just started

There is a worldwide need for integrating growing capacities from renewable energy sources and new loads, such as electromobility charging infrastructures, into our energy supply network. At the same time, more and higher quality power needs to be supplied to end customers. Our power grids are transforming into increasingly digital, decentral, and sustainable energy systems. These changes are no longer just ambitions for a distant future, but are backed by practice-proven technical capabilities that are not only already available, but also largely economical today.

Whatever the situation in a specific system, all have one challenge in common: The expectations on energy systems, both from legal entities and the public, are rising. New technologies and concepts offer new possibilities and potentials, both in technical and in economic spaces. And the energy transition has only started. More advances at shorter intervals are to come.

Already today, the changes in regulatory requirements and technologies are often very significant.

Consequently, the adaptation and development of the physical energy systems – especially of the networks – cannot keep pace. System operation is pushed closer to technical, often even to economic and regulatory, limits. At the same time, our modern, fully digitalized societies and economies are highly dependent on a secure, reliable, and cost-effective power supply. How can we ensure that our energy systems can fulfill these demands? As our energy systems grow increasingly complex and safety margins are being reduced, “traditional” power engineering and

economics ingenuity are becoming more important. Today, this expertise must be complemented by a detailed understanding of how we can leverage digitalization to create real benefit in practical applications, such as concepts for digital twins of energy systems. For the development of low or zero-carbon strategies and concepts, capabilities such as forecasting and extrapolating relevant operating scenarios provide planning and investment security. And with energy being more than just electricity, it is important to look into coupling the power system with different sectors such as mobility or heat.

Only the knowledge of all relevant stakeholders and a deep understanding of existing and emerging business models can ensure a profitable business case. This rising complexity makes it important to take an integrated planning approach considering strategic as well as technical aspects in order to achieve the flexibility and efficiency that is needed in future-proof energy systems.

Establish the foundations for flexible, efficient, and resilient digital grids

From strategic advisory service and technical consultancy to state-of-the-art software: Siemens Power Technologies International (PTI) provides a holistic view to master the technical and economic challenges of today's and future energy systems.

Our strategic consultants help optimize value by providing guidance in the fields of business transformation, infrastructure development, as well as market and transaction advisory service. Drawing upon more than 60 years of international experience and continuous innovation in power system planning, Siemens PTI addresses the full scope of

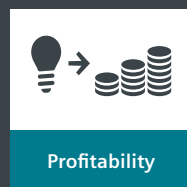
analysis, design, and optimization studies. Latest user requirements and our project experience continuously shape the design of the comprehensive PSS® portfolio for power system planning, simulation, and model management.

Managing industry change and leveraging digitalization while safeguarding system performance is our key mission. As your long-term partner, Siemens PTI will continuously focus on your needs and value-add, and innovate for the greater needs of the power industry.

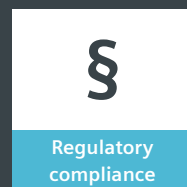
Knowledge base for digitalization and innovative solutions to manage increasingly complex power systems



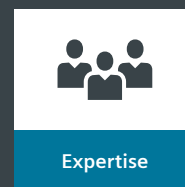
Mitigation of risks and ensuring profitability of investments based on strategic planning



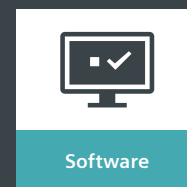
Regulatory compliance support driven by global best practices, local knowledge, and dedicated software functionality



Leading expertise, backed by active engagement in national and international committee work and R&D projects



Trusted software for simulation and modeling accuracy covering over 70% of the world's energy consumption



Partnership



Partnerships for long-term training programs, grid planning, and software support

Flexibility



Vendor neutrality for independent decision-making and tool flexibility in consulting

Experience



Broad experience secures success: ~1,000 international projects per year

Support



Local support for project development, execution, and beyond

Manage complexity and increase efficiency

Dynamic markets, changing regulations, digitalization, and an increasing number of grid interconnections multiply the aspects and the number of projects that need to be addressed to remain competitive. In Siemens you have the right partner, with profound strategic and technical expertise to make your grid sustainable and future-proof.

1 Grid access and grid code compliance

When connecting new generation units to the transmission grid, interconnection criteria and grid codes have to be met in order to safeguard the system's operational performance. Our services include:

- Verification of grid code compliance considering all relevant operating scenarios
- Assessment of dynamics and interactions with the power system
- System design and verification, e.g. cable sizing and transformer design verification
- Support certification process by creation and/or validation of the performance of simulation models of generating and control units for acceptance tests

2 Smart city scoping and planning

With rising environmental awareness, technological complexity, and cost pressure, urban centers need innovative and integrated infrastructure scoping and planning. We can support with:

- Smart city scoping studies to examine all available options and technologies to create future-ready, sustainable, and smart cities
- Scenario and simulation-based planning of urban energy systems leveraging digitalization and innovative technologies
- Integrating smart buildings, decentral energy structures, storage systems, demand side management, Power2X, eMobility, and more



3 Strategic grid planning

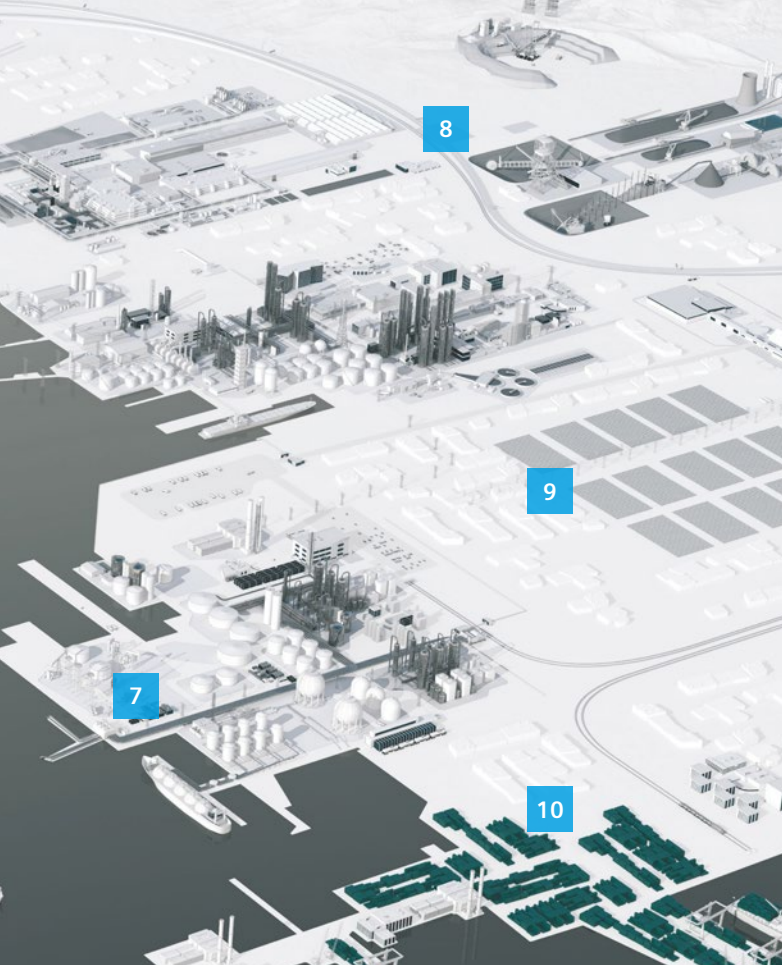
Energy transition is challenging the secure and economic operation of our power grids and calls for various adaptations in planning and operation. Our services include:

- Identifying weak points and bottlenecks in systems
- Designing resilient and compliant grid concepts based on predefined design priorities, e.g. cost-efficiency and environmental concerns
- Deriving optimized grid development and investment plans to avoid stranded investments and identify no-regret-measures
- Integrated resource planning
- Transmission compass: development of technology adoption road maps

4 Digitalization strategies and grid model management

Digitalization is key for the planning, operation, and management of increasingly complex energy systems and utility companies. Siemens PTL supports with:

- Development of a strategic vision and road map to improve operational excellence and reshape existing business models
- Recommendation of a grid data management concept based on individual requirements and the existing software landscape
- Data quality check of data within and across different domains
- Implementation of digital twin concepts across all domains as the foundation for advanced analytics and future digitalization use cases



5 Designing of microgrids and distributed energy systems

If properly designed, microgrids and distributed energy systems allow for a more efficient, resilient, and sustainable power supply. Our offer includes:

- System and strategy definition to develop business models and scenarios
- Simulation and optimization of an energy supply portfolio including DER sizing and storage, as well as emissions reduction
- Grid studies and concepts to leverage local generation and storage for highest resilience and cost-efficiency
- Detailed implementation plan to define operational tasks and responsibilities and evaluate financing options

6 eMobility consulting

The rapid development of electric mobility requires stakeholders to transform their businesses models and planning principles. We help on that pathway with:

- eMobility strategies and implementation road maps to define roles and business models
- Demand modeling for eMobility patterns at the city and district level according to regulative and market developments
- eDepot concepts to identify the optimal charging infrastructure and electricity supply, as well as IT/OT integration and process concepts
- Stress tests to assess the impact of eMobility on the grid impact and develop measures in line with the existing asset management strategy
- Customized eMobility workshops for best practice exchange and curriculum training on technologies and regulation

7 System protection concepts and parameterization

Reliable operation of protection systems is crucial for the overall reliability of electrical power systems. We assist in:

- Designing clear, system-wide protection concepts
- Dimensioning of instrument transformers and parameterization of protective relays according to the defined concept
- Support for NERC PRC-027-1 compliance including creation of audit-ready documentation
- Protection security assessment: automated evaluation of the selectivity, sensitivity, and speed of the protection system performance for different operating conditions

8 Power electronics

As more and more generation and appliances are based on inverters, power electronics characteristics are becoming predominant for system operation. We provide:

- Assessment and verification of inverter solutions for different applications
- Solutions for grid coupling and system stability improvement
- Analyses of the impact on frequency and voltage stability and definition of suitable control strategies
- Dynamic analyses of inverter-based islands and microgrids and verification of black start capability

9 Integration of renewable energy sources

Successful integration of renewable energy sources (RES) into transmission and distribution grids relies heavily on effective planning and operational strategies. Our offer includes:

- Techno-economically optimized RES sizing, placement, and integration
- Hosting capacity study to ensure reliability and stability
- Voltage control concepts for increased reliability and cost-efficiency
- Business case studies to leverage (new) businesses, roles, and applications
- Business operation model definition according to regulative and market framework

10 Energy supply concepts for industry

Industrial power supply deals with conditions that are more extreme than in typical public systems. Still, high power quality is key to ensuring reliability of the industrial processes. Our studies include:

- Utilization of equipment according to relevant standards
- Determination of appropriate circuit arrangements, voltage levels, switching, and protection devices
- Evaluation of arc flash, motor start, harmonic resonance, shunt compensation, series compensation, power quality, voltage flicker, insulation coordination, stability, and efficiency
- Design and assessment of islanding and island operation

Creating sustainable value

For the success of any consulting project, trusted collaboration is key. Close alignment ensures that all strategic, technical, and financial targets are met. New insights gained during project execution empower you to actively address and manage future demands. At the same time, they help us to continuously improve our offer to you. Learn about some of our customers' challenges, and how our experience has helped them to achieve their goals.

"The Masterplan project performed by Siemens PTI not only gives insight into the future development of the Egyptian transmission grid, but also supports EETC engineers in their planning tasks through knowledge transfer."

Eng. Khaled Abdelkareem H. Mohamed, EETC,
Board Member for Studies and Design, Egypt



Strategic road map for Egypt's national transmission grid

- Digital model for simulating grid scenarios for the expansion of the Egyptian power system
- Grid expansion improving overall performance and dynamic stability
- Full-spectrum system approach




"Together with Siemens, we developed new, innovative business ideas based on our long-standing experience in the field of network operation and digital technologies. With their techno-economic knowledge and methodological competence Siemens supported us to achieve a transparent view on possible business opportunities."

Giorgio Di Lembo, Enel Global I&N,
Head of Remote Control and Protection Solutions, Italy

Development of customer-oriented business models

- Increasing digitalization of low-voltage networks offers new business opportunities
- Guided business ideation and modeling, identification of new value propositions for consumers
- Analysis of business model costs, revenue streams, and viability



"Siemens PTI delivered a comprehensive project report. The study results provide valuable information and verified measures for further improving our power system's reliability."

Amaxopoulos Christos, Electrical Department Manager,
Group Engineering & Technology, Titan Cement Company
S.A., Athens

Highly reliable power supply for Titan Cement plants

- Complete data survey, documentation and modeling of the power and protection system with validated high quality
- Performance assessment of the existing system and development of new improved network structures with respect to reliability, power quality, protection, and personal safety
- Know-how transfer and staff education through workshops and customized training



"By partnering with Siemens PTI, we were able to develop an optimal integration strategy and charging infrastructure concept which can be applied to other African markets like Ghana and Ethiopia in the future."

Thomas Schaefer (CEO),
Volkswagen of South Africa (Pty) Ltd

Grid integration for eMobility car-sharing services in Kigali, Rwanda

- Selection of sites for charging hubs and demand forecast to determine required charging points (CP)
- Network analysis to prepare grid connection
- Techno-economic analysis of different hub variants and final implementation road map

Understanding the big picture

To achieve sustainable improvements, it takes a holistic view. At Siemens PTI, experts from the various fields work closely together to meet the requirements of an individual project. Within our global team, we will always find an expert who understands your needs. This enables us to partner with you in a multitude of tasks across the complete infrastructure project life cycle.

Strategic advisory



Digital Business Strategy and Transformation

Digitalization, decarbonization, and decentralization are drivers for change in the energy sector defining the operational, technological, and business models of utility companies.

- Utility of the future strategies
- Business model transformation
- Managed transition programs

Planning and Regulatory Advisory

Adequate models, plans, and strategies to enable clients to not only survive but thrive in challenging regulated markets and environments.

- Strategy and integrated planning
- Energy market forecasting and analytics
- Energy portfolio optimization
- Regulatory strategies

Smart Infrastructure Advisory

Smart technologies and digitalization are defining the requirements for future infrastructure of countries, cities, and districts determined by socio-economic and environmental values and factors.

- Smart infrastructure strategies and concepts
- Strategies for design and operations of decentralized energy systems
- Valuation and transaction advisory

Implementation and Solution Advisory

Complex technologies and solutions need to be integrated into existing operational models and technology stacks in an effective, efficient, and secure manner.

- Cybersecurity services and consulting
- Data structure and integration advisory
- IT/OT implementation advisory



Steady-state analyses

Practice-proven concepts that optimize system performance with respect to technical and economical requirements.

- Calculations and simulations of present grid structures and configurations
- Development and performance validation of alternative structures and configurations
- Neutral grounding concepts and configurations
- Grounding system design
- Techno-economic analyses ensuring profitable business models

Protection and control

Sound concepts for protection and control, and detailed coordination of devices ensure system safety and stability.

- Design of optimized protection concepts and dimensioning of instrument transformers
- Coordination of protection devices and relay parameterization
- Concepts and configuration of equipment for communication, automation, and control
- Analysis of disturbance events and on-site measurements
- Protection security assessment: automated evaluation of the selectivity, sensitivity, and speed of protection system performance
- RTDS-based hardware-in-the-loop tests to verify setting values of relays, measuring equipment, and controllers

Power quality

Measurements, model development, performance assessment, and solution design to ensure reliable system performance.

- Power Quality Analytics service for performance monitoring and outage prevention
- Measurement, evaluation, and analysis of power-quality-related phenomena, especially harmonics
- Filter design and performance validation
- Analysis of interferences from power supply systems on other networks and systems

Dynamics

Modeling, analysis, and optimization of the dynamic system performance for stable and secure system operation.

- Dynamic modeling and stability analysis including rotor angle, voltage, frequency, and small signal stability
- Controller and machine measurements, modeling, and validation
- Positioning of controllers and optimization of control strategies and parameters
- Power electronics modeling and analysis including converters, FACTS, or HVDC
- Assessment of energy storage solutions to support frequency control

Transients

Modeling and analysis of transient aspects to minimize the risk of equipment damage and to increase system resilience.

- Modeling and analysis of transient phenomena, e.g. lightning strikes, switching operations, or overvoltages
- Insulation coordination and overvoltage protection concepts
- Simulation of fast and very fast transient surges
- Studies of circuit breaker stresses (e.g. transient recovery voltage, missing current zero crossings) and recommendation of mitigation measures
- Time-domain analysis of system resonances

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