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Ingenuity for life

Energy Research in Aspern

Europe’s most innovative and sustainable energy efficiency project.

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Photo Simonis

Wolfgang Hesoun,
Chairman of the Managing Board of
Siemens AG Österreich

Together with strong partner agencies of the City of Vienna, Siemens Austria has been running the largest and most innovative energy efficiency demonstration project in Europe since 2013: Aspern Smart City Research (ASCR). The second phase of this project kicked off in 2019 and centers on the targets set by the European Union under its highly important climate strategy and on the smart city strategy that the City of Vienna has adopted on this basis. Using real-time data collected at the Seestadt Aspern multi-use development zone, innovative solutions are being created for the future generation and utilization of energy in urban areas.

During the first phase of the project, around 70 research questions were answered, 15 prototype solutions developed in the fields of smart buildings and grid infrastructure, and 11 patents filed. The results generated to date show that highly complex solutions will be needed to accomplish the energy transition and to leverage efficiency potential and market potential. The prototype building systems and grid solutions that were developed and optimized in the first project phase must now be turned into economically viable solutions for residents, grid operators, building operators, and energy brokers.

The second project phase will focus on communication between buildings and their occupants, the smart grids, the weather services, and the markets (for example in the form of energy brokers) and on the question of the smart charging of electric and hybrid cars and the potential for using these vehicles for energy storage. Further buildings will also be added to the field test environment, the nucleus where innovative technologies are researched, findings validated, and prototypes tested. An additional €45 million will be committed to research into the energy system of the future through to 2023.

Using energy efficiently has become a decisive competitive factor. Political objectives and the expectations of society are requiring governments and businesses to fundamentally rethink how they handle energy resources. It is only by using the available resources more efficiently and investing in modern technologies that we will be able to preserve the high quality of life in our cities and reduce the negative impact that our energy system has on the climate and environment.

Wolfgang Hesoun

Researching the future of urban energy

Cities must learn to think

The population in cities will continue to grow as we move forward. According to current projections, around 70 percent of the world's inhabitants will live in urban areas by the year 2050. As this trend progresses, we will need to increase investments in infrastructure projects for smart cities around the globe. The population in Vienna will also continue to grow, with a projected 2 million inhabitants in the city in the year 2030.

Working in close collaboration with research partners from Wien Energie GmbH, Wiener Netze GmbH, Wirtschaftsagentur Wien, and Wien 3420 Holding GmbH, researchers from Siemens have been testing and refining sustainable and innovative products in the areas of energy, environmental protection, building technologies, and smart grids in the "living lab" at Seestadt Aspern since 2013.

Project phase objectives

The development of optimally coordinated sensors, control components, and IT solutions for the management of renewable energy sources was concluded in the first project phase.

Now, it is time for the buildings to communicate, namely with energy grids and markets. In the future, smart buildings will provide rapid flexibility in response to grid loads. The current research activities are focusing on 17 use cases.

High quality of life in the Seestadt Aspern Smart City

Solutions for the new world of energy

* ICT: Information and communication technology

CO_2 emissions must be minimized if we are to reach the global, European, and national climate goals. Austria has set the goal of having an electricity system based entirely on renewable sources (flexibility requirements) by 2030. This will require the optimal interplay of smart buildings, smart users, smart grids, and information and communication technology for data collection and integration across all domains.

The development of end-to-end solutions for perfectly coordinated building management will also lead to the optimized and transparent use of energy by all systems in the building. This will in turn make a key contribution to the energy transition.

Smart building communication

Smart buildings communicate with energy grids, weather stations, and energy brokers

The interplay of buildings, users, grids, and information technology

Smart buildings
The buildings of the future have independent electricity and heat generation capabilities such as heat pumps, photovoltaic systems, and solar thermal systems, and can therefore significantly reduce their CO_2 footprint when used in conjunction with thermal and electrical storage technologies. Storage solutions can balance out energy supply and demand. The goal is to find optimal control mechanisms to reduce energy costs and consumption. A key focus is on weather- and consumption-based projections for internal generation and energy consumption, time-variable energy prices, and the marketing of the available flexibility.

Smart users
Smart users, in other words the residents of a smart building, set various environmental conditions for the living space, such as the room temperature, based on their individual needs. A smart building fulfills these conditions while optimizing the costs required for this. To this end, the smart user is given corresponding setting and control options that can also be accessed through an app on a smartphone or tablet.

Smart grids
The spreading conversion of electrical energy and the use of heat pump technology in smart buildings are causing significant changes in the way that the electrical grid is being used. Surplus energy is being fed into the grid, and the switch from oil and gas heating to heat pumps is causing increased electricity demand, which will rise further as a result of the growth of electromobility going forward. Following the principle of using renewable energy when it can be generated will lead to increased synchronization of energy use and thus to the potential overloading of the grids. The research team is developing solutions that maximize the capacity of the existing grid infrastructure while maintaining the expected supply quality and supporting needs-based grid expansion.

Smart ICT (information and communication technology)
In a market environment that has been changed by the energy transition, market participants increasingly require additional information. They must exchange significantly more data to facilitate complex market processes. To this end, a communication and IT architecture that also provides plenty of scope for data and business analytics is being developed in the research project. In this way, processes within a single domain and processes affecting multiple domains can be supported optimally. The analysis functions allow processes to be improved on an ongoing basis and new business models to be found.

Smart buildings - the key figures from the research project

Optimized energy use in the building – two exemplary results from the first project phase (as of April 2019)

Project phase 1
Energy costs
• € 10,000 per year savings (development lot D18) • Through energy recovery from exhaust air

Project phase 1
CO_2 emissions
• 70 % reduction (development lot D12) compared with energy generation using a gas boiler heating system • Through a combination of photovoltaics, solar thermal, and heat pumps

Legend – development lots

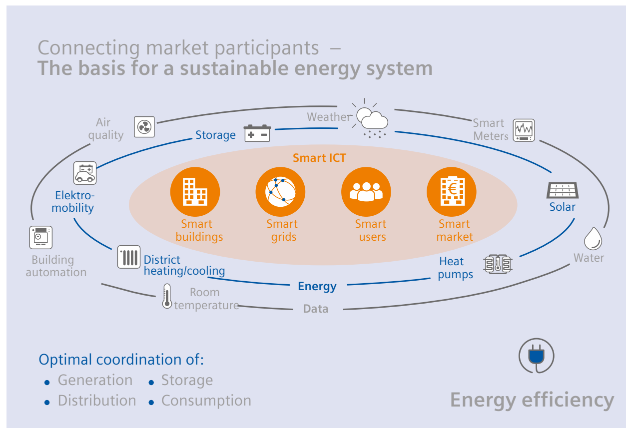
- Development lot D5b: student housing
- Development lot D12: residential building with 213 rental apartments
- Development lot D18: educational campus
- Development lot C4: technology center (under construction)
- Development lot J14C: Seehub multi-use center (under construction)

Digital twin and smart maintenance – Key figures at the beginning of the second project phase (as of April 2019)

Project phase 2
IFC*-3D model
• 14,000 m² already digitalized (development lot D18) • 42,000 m² to be digitalized (development lots D5b, D12)

Project phase 2
Sensor data
• 260 MB of live data per day (95 GB per year) • From 5,600 data points at present (development lots D5b, D12, D18)

* The Industry Foundation Classes (IFC) are an open construction standard for the digital description of building models (building information modeling)



Reducing greenhouse gas emissions over the long term, significantly cutting operating costs, and meeting higher demands for comfort at the same time?

While this may sound like an impossible task, these were the requirements for the first phase of the project.

The systems that were developed make buildings fit for the future.

Tapping into building intelligence

In the first project phase, prototypes were tested to determine whether buildings are capable of using the available energy in a way that minimizes CO_2 emissions and the energy costs for operation. But how does that work? Buildings analyze information such as weather forecasts, energy needs, and internal energy generation in detail. The available or needed energy is then provided from batteries or thermal storage systems in the best manner possible on the basis of the results. This higher building "intelligence" makes it possible to leverage substantially more information to operate a building in an energy efficient manner.

The second project phase is under way

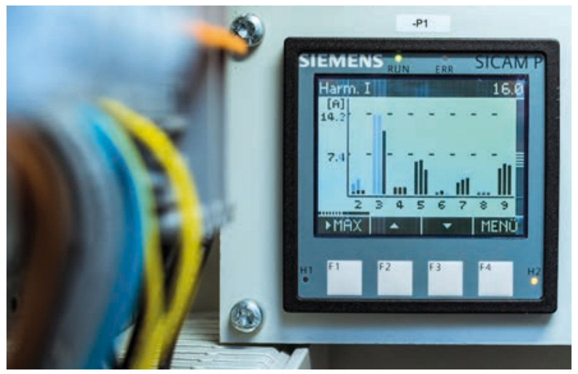
In the second project phase, a series of additional buildings such as the Seestadt technology center will be researched. One of the selected buildings is equipped with concrete core activation (which uses the building mass for storage) and systems for the generation of heating and cooling energy. It will be possible to implement this technology with the necessary functions for a broad range of applications at a relatively low cost.

In addition to focusing on optimized energy use, the buildings that have already been the subject of research and new buildings will be used to test and develop key topics such as "smart maintenance" and the "platform for the digital building twin."

Multi-faceted capabilities

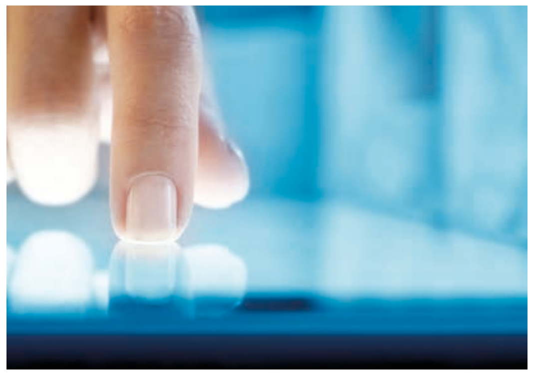
In order to make effective use of the multi-faceted capabilities of the buildings during their operation, the "platform for the digital building twin" must ensure that the relationship between the dynamic building systems data (measured values) and the static data (design plan, data sheets) is kept up to date over the entire lifetime of the building.

Using a digital planning and execution process that integrates the work of all parties involved in the project – called building information modeling or BIM – allows data to be turned into added value.
Building information modeling can be used to leverage numerous functions of the digital building twin for existing buildings, as well.



If smart users are to be motivated to act for the benefit of the energy transition, the apartments and technical systems must be a suitable high quality. Builders, housing operators, power utilities, and technology providers must all work closely together to ensure the energy supply in a smart city.

A platform of the digital building twin



In addition to BIM-based planning, the actual construction of the technology center at Seestadt Aspern was also documented in detail by way of 3D scanning during realization and uploaded to the "platform for the digital building twin." This lifecycle documentation also supports the "smart maintenance" research focus, which is being addressed in the second project phase. Analyzing the wealth of collected building data with corresponding tools allows the buildings to be managed more intelligently.

Smart maintenance

Preventive and predictive maintenance ensures the comfort of the building users. The early detection of problems gives the building operator time to take appropriate measures. In addition to existing sensors, tests are being conducted to ascertain how additional sensors can be used to enhance predictive maintenance. Combined with the "platform for the digital building twin," this opens up wide ranging possibilities in building operation. Augmented reality will allow virtual building inspections so that a service technician can rapidly find faulty systems, especially when they are hidden by suspended ceilings, wall elements, or hollow floors.

The platform at a glance

The "platform for the digital building twin" integrates all product, planning, execution, and change data as well as historical and real-time measurements. This paves the way for a wide range of new methods for optimizing the CO_2 footprint, lifecycle costs, and comfort of a building.

Work is focusing on the development and implementation of algorithms and methods that will serve as the interfaces to and from the platform and its prototype applications.

The plan is to create the specifications for and to implement interfaces from the platform to the underlying building systems and planning tools. Different use cases can collaborate in this and have access to BIM data.

Research at Aspern is not only being continued and intensified, but also expanded to cover additional topics. The smart building infrastructure at Aspern offers ample approaches for this. Findings are applied to new functions that allow energy efficiency to be improved further with the existing building automation systems.

Research area Digital twin

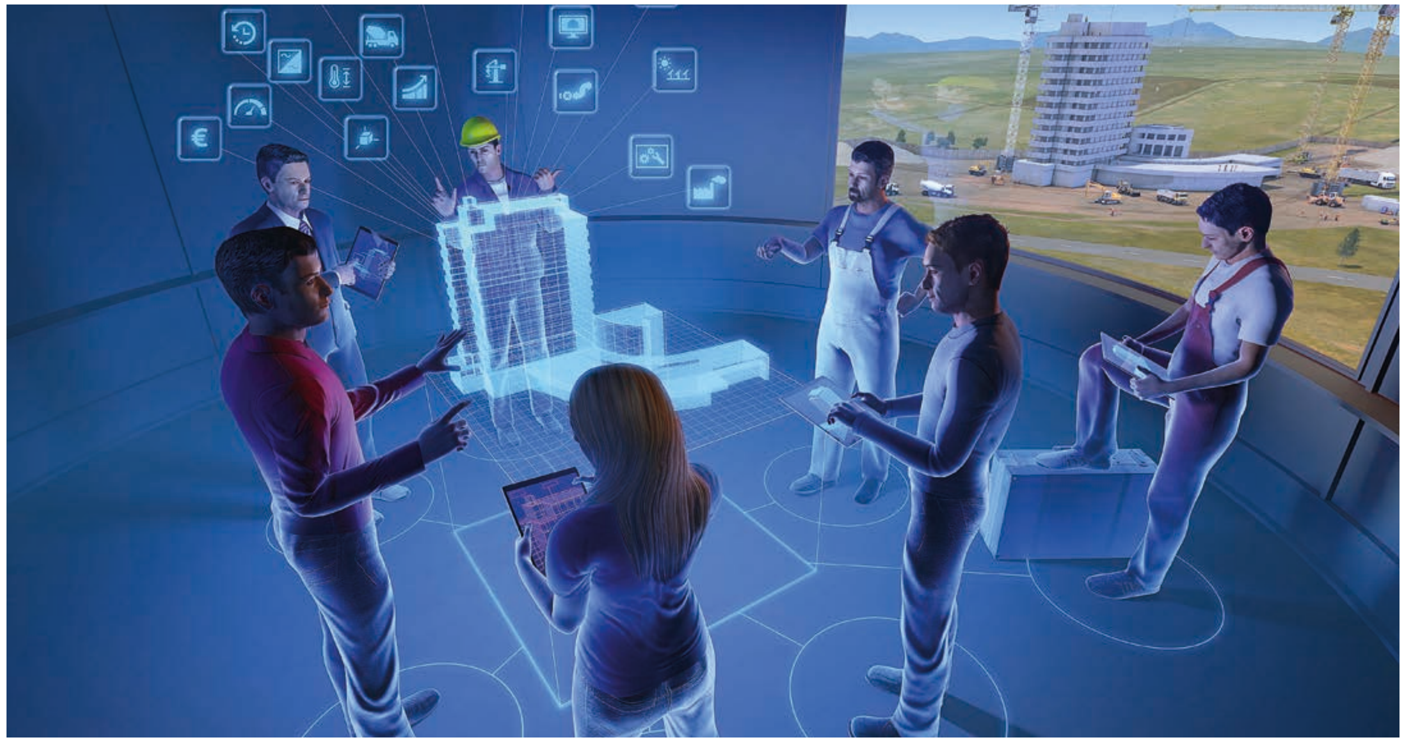
The "digital twin" of a building is the complete information about a building in a standardized digital form. Building information modeling allows for efficient planning and design.

Project objectives

- The objective is the integration of a digital twin at Seestadt Aspern including the expansion of the existing digital archive with real-time, design, and product data
- Development and implementation of algorithms and methods to serve as the interfaces to and from the digital twin and its applications
- Development of prototype applications
- Specification and implementation of interfaces from the digital twin to building systems and planning tools
- Collaboration with other research fields including product and structure data exchange via BIM

The benefits

- Efficient planning, drafting, design, and management of buildings by establishing BIM
- Increased quality and time and cost efficiency through optimized workflows
- Earlier detection of conflicts and faults
- Availability of information about the elements of a system: geometry, location, inspection intervals, manufacturer, order number, guarantee, etc.
- Provides basic data for the smart maintenance use case
- Consideration of the complete lifecycle



Research area Smart maintenance

Systems should be reliable and fault-free, and smart maintenance is the best way to achieve this. Instead of corrective maintenance, preventive and condition-based maintenance offers this use case founded predictions for early fault prevention and for smooth operation.

Project objectives

- Sensors and data
- Relevant system conditions
- Data models
- Algorithms for predictive analytics
- Maintenance recommendations
- Overlaying of virtual and real objects

The benefits

- Detection and learning process – examples of malfunctions and faults
- System availability – through data-based, condition-dependent maintenance
- System run times – unplanned maintenance is eliminated
- Reduced energy costs – through efficient facility management
  - Identifying and localizing fault sources (with BIM)
  - Technicians can directly access current, supporting information on site (via augmented reality)

Research area
Optimized energy use

Energy use in the building is to be optimized, in part to minimize the energy costs for operation and to reduce CO_2 emissions.

Initial situation and project description

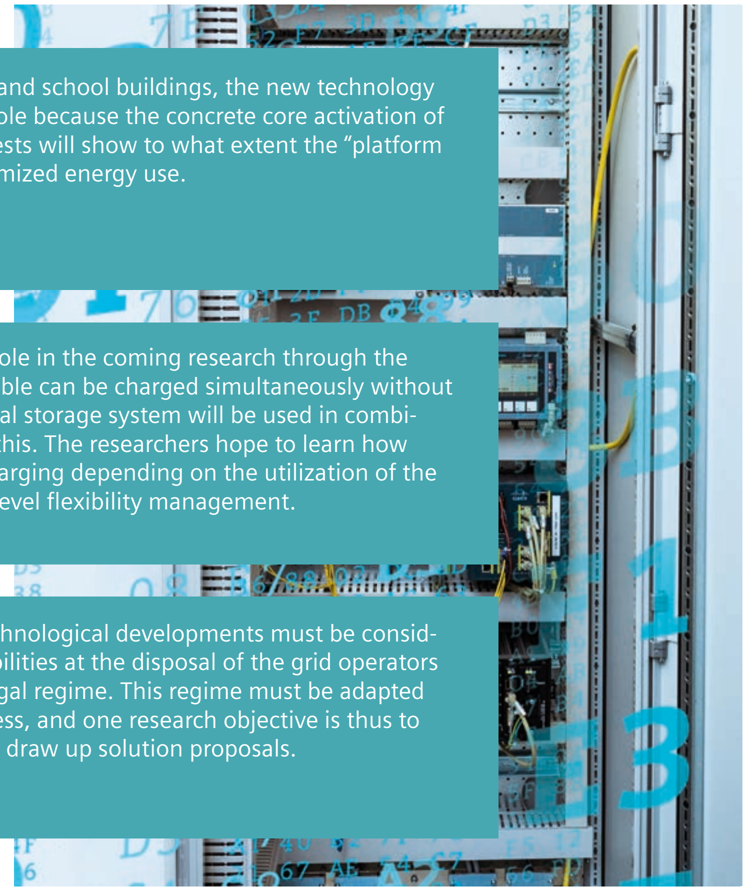
The available energy resources must be used efficiently to minimize the CO_2 emissions of the building. This can be achieved by optimizing consumption in the building on the one hand (by timing consumptive loads to use energy generated by the building when it is available) or by obtaining energy from the power grid when there is a surplus (for example from wind energy) on the other. The building must also support the smooth operation of the grid (minimize load peaks, offer flexibility).

In the first project phase, it was shown that consumption can be optimized and flexibility realized with the help of a building management system when the building is equipped with suitable infrastructure (electrical batteries, thermal storage).

For broad application, it must be shown that these functions can be implemented at a reasonable cost and that reliable operation can be ensured over the long term.

When possible, the building mass is also used as storage to gain additional flexibility without installing additional infrastructure.

New buildings in the test environment



In addition to the student housing, apartment, and school buildings, the new technology center development lot will play an important role because the concrete core activation of this building is ideal for energy storage. Here, tests will show to what extent the "platform for the digital building twin" contributes to optimized energy use.

The Seehub garage building will play a central role in the coming research through the evaluation of how as many electric cars as possible can be charged simultaneously without overloading the electricity grids. A large electrical storage system will be used in combination with a separate photovoltaic system for this. The researchers hope to learn how much storage capacity is actually needed for charging depending on the utilization of the garage, and how much can be used for higher-level flexibility management.

To develop an optimized energy system, the technological developments must be considered together with the opportunities and possibilities at the disposal of the grid operators and energy trading system under the current legal regime. This regime must be adapted in some areas to support the optimization process, and one research objective is thus to point out hurdles in the current regulations and draw up solution proposals.

Project objectives

- Prototype implementation for the economical operation of a building energy management (BEMS)
- Use of the building mass for energy consumption optimization and building flexibility, with no reduction in comfort
- Participate in the energy market through the building's flexibility
- Validation of these topics in the corresponding development lots
- BEMS: interface between the building infrastructure and external energy services for a distributed energy system

The benefits

- End-to-end building management solutions for optimized energy use in the building
- Optimal use of the building infrastructure (energy and cost efficiency, performance monitoring)
- Transparent energy consumption
- Reduction of energy costs for the building operator
- Reduction of CO_2 emissions
- Energy transition: building contribution to a distributed energy system

Weather-dependent power generation

The electrification of the energy system and the accelerating expansion of sustainable decentralized generation are gaining momentum and are increasingly becoming core elements in the achievement of the international and national climate goals. New concepts for citizen energy communities are intended to ensure that locally generated energy is also used locally.

Marketing surplus output locally

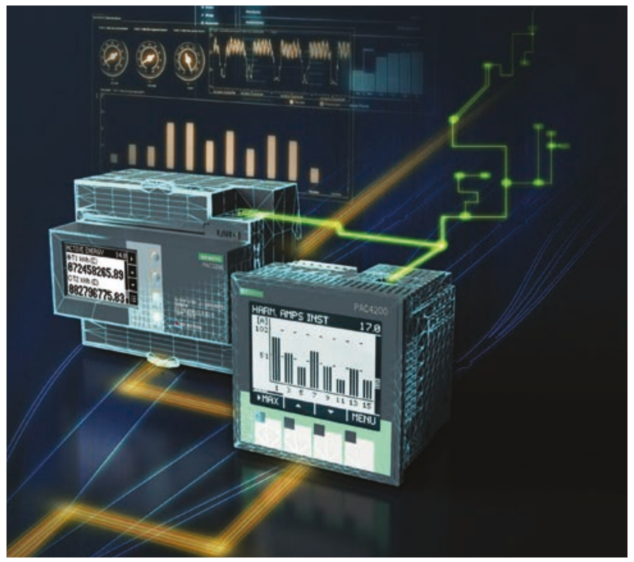
Citizen energy communities aim to facilitate local electricity trading within contiguous grid segments using a local grid tariff. Additional shared storage facilities take on local surplus output, help optimize the energy needs of the participants, and can provide brief output peaks for charging electric cars. It makes no difference whether the participants in the communities have their own photovoltaic system or whether they have rented or bought a share in a photovoltaic system, as is common in urban areas.
This scenario confronts distribution networks with major challenges because they were not built for such a dynamic market structure. For decades, energy consumers could be expected to behave consistently, based largely on their habits. Decentralized generation was not an issue.

Weather-dependent power generation

The fundamental premise of the energy transition is shifting to renewable energy sources and, based on this, making use of energy generated based on the weather conditions. This will result in an increased need for thermal and electrical storage solutions that can bridge the time gap between generation and consumption, but that have to be charged simultaneously throughout the region depending on the weather.

Significant load peaks that are not taken into account in current grid planning can be the result. This effect will be exacerbated by the anticipated interest in electromobility. Electric cars need peak output that generally far exceeds typical household levels. And statistically, these vehicles are parked 90% of the time, not being used. This makes them suitable for storing fluctuating energy volumes generated depending on the weather conditions. This entails a high degree of simultaneity that can quickly exhaust the grid capacity.

This means that the foundation must be laid for expanding the existing grid infrastructure. In a first step, the current load of all grid assets is being recorded down to the customer connection point. Then, the available grid reserves are to be leveraged by managing charging stations and generation systems. Demographic and market data will also be added to the data collected from monitoring and management processes. This will create a robust basis for the needs-oriented planning of future grids.



The steadily rising demand for energy is a major challenge for the distribution networks. The focus is on weather-dependent energy generation.

Network load monitoring system

In the first research phase, a monitoring system was developed that is able to determine the grid load on the basis of grid sensors, the information from smart meters, and mathematical estimation methods. Based on this, a further module in the smart grid toolkit was created in the form of a flexible field device platform on which a container framework is supported under the Linux operating system. This permits the necessary functions to be uploaded in the form of applications.

A particular benefit of the system is that applications that run in containers have no negative impact on other applications and cannot cause a device crash. This permits needs-based functional expansions for devices in the field without impacting existing functionality. All data collected from the distribution network are validated, linked with the current grid topology, and stored centrally. Initial prototype applications designed to assist with future grid planning are already accessing this data.

Three key focuses

The first focus is operational and aims at automating operating processes and thus at minimizing operating costs. This requires the further development of plug and play functionalities for field devices and sensors and an integration concept for third-party products.

The second focus is the creation of an end-to-end tool chain that meets the requirements of the operating personnel. A system design that simplifies operating processes and provides clear decision-making aids will be crucial for future grid operation.

The third focus covers data-based support for grid operation processes. Optimized data provision for the tool chain and suitable grid planning and analysis applications are especially important for grid planning. Data collection, processing, and provision are handled through the Energy IP powered by Mindsphere platform. This also serves as the platform for the necessary applications and provides a powerful analysis environment.

With intelligent distribution sensors, smart meters, and power quality meters, an existing low-voltage distribution network can be made transparent all the way to the customer connection point without installing a sensor in each grid node. Nodes that are not measured can be calculated on the basis of the grid structures.

The systems that have been developed make buildings "smart grid ready." This will avoid high peak loads in operation and thus expensive grid expansion in future urban development.

Applications for electromobility

The development of applications for the SICAM A8000 platform, which allows the autonomous coordinated charging of electric cars from the transformer stations, is also planned as part of the energy research at Aspern. For this, the currently available capacity in the low-voltage network is calculated, taking any capacity limits set by the transformer stations into account. The capacity calculated in this manner can be made available to charging stations or intelligent buildings as "additional capacity." In the next step, the first applications will be developed for storage management and for managing generation facilities.

This will lead to a smart grid toolkit that will support the needs-based and gradual upgrading of the lowest grid levels from simple monitoring tasks to fully locally controlled citizen energy communities.
Another focus is independent of the grid topics and constrained by the capacity limits of the grid.

It covers the economic combination of manageable loads, generation facilities, and storage batteries into virtual power plants whose energy can be sold on the balancing energy market. This will help move the energy transition forward.

SICAM A8000 at a glance

The SICAM A8000 series is a modular device range for telecontrol and automation applications in all areas of energy supply and can now be functionally expanded in a simple manner with applications.

A8000 is a modular platform for complex automation tasks in energy distribution and transmission and also supports the creation of micro-grids and charging solutions in parking garages. It can also be used as a communication gateway for different networks and protocols.

Future-proof urban power grids require active network management. Coordinated system applications for grid planning and operation that are being developed in the research project can make the economic operation of smart grids a reality.

Research close up:

The Demo Center at the Aspern technology center

Basic information about the ASCR research and demonstration project in the areas of buildings, grids, ICT, and users is presented by means of photos and videos at the Demo Center. The central question is how intelligent networks and efficient management can increase energy efficiency and cut CO_2 emissions in an urban environment.

Promoters present research results and reports from the field in a clear and interesting manner. The target groups are specialists and experts, government officials, technical schools, universities, and the general public.

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