SIEMENS
Ingenuity for life

Self-Optimizing Grid

Intelligent Grid Automation

www.siemens.com/self-optimizing-grid

Self-Optimizing Grid – Intelligent Grid Automation

Self-Optimizing Grid provides precise digital control, automated analysis of faults, and automatic switching competencies that delivers a proven 75 per cent saving on investment compared to grid extension using copper cabling. With a reduction of outage time of over four times that of a copper installation; the progressive Self-Optimizing Grid provides a reassuring solution to modern power generation problems.

Distribution Grid and Innovation of Automation

The power distribution grid is facing a unique set of challenges that are increasing pressure on an already struggling and ageing infrastructure. Distributed power generation, changing political frameworks, fluctuating peak times, and an increase in the number of consumers – or 'prosumers' - producing energy, are key contributors to a worrying trend that is likely to escalate in the future.

As a measure to counteract this trend, Siemens has developed Self Optimizing Grid; an innovative and smart solution that combines automation and decentralized applications to monitor and remotely control the grid.

Application of highest relevance

The self-optimizing solutions use grid automation to enhance reliability and availability of the power distribution system, which increases efficiency of grid management and operation and improves the distribution system operator's Key Performance Indicators (KPIs).

Contents

Levels of Automation in Distribution Grids

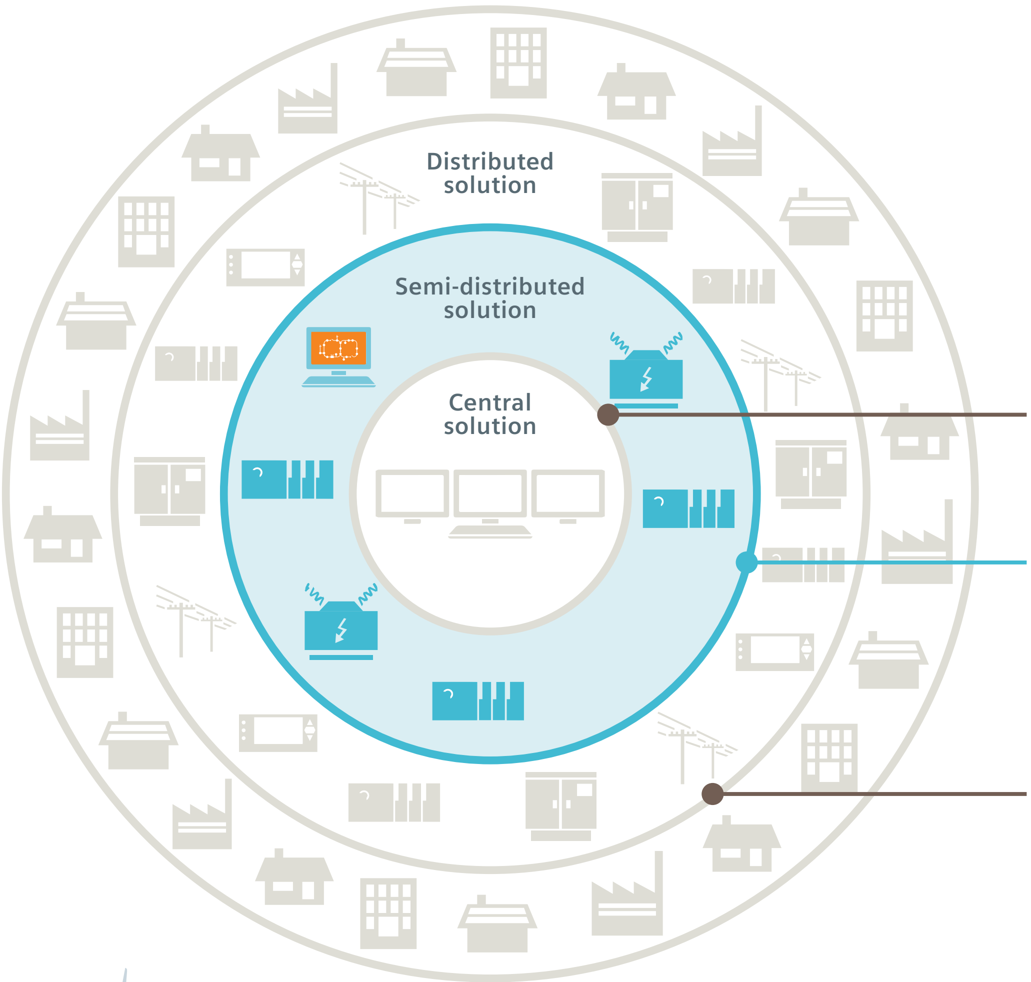
Hierarchy of modern Distribution Grids

Distribution grids are made up of control centers, regional controllers, secondary substations and device groups and the actuation of each of these components depends on its hierarchical position in the grid. A modern distribution grid is divided into three levels: central, where control centers are located; semi-decentralized, where regional controllers are positioned; and decentralized, where secondary substations and device groups are found.

Application on different levels

The Self-Optimizing Grid is fundamentally a holistic solution that combines elements of each level of the distribution grid solution. Flexibility has been built into the solution at every level, which also allows for a modular approach that, through customization and adaption, efficiently meets individual needs.

Self-Optimizing Grid solutions integrate the different levels of the grid and, depending on integration level, can be: centralized, semi-decentralized and/or decentralized. However; the more decentralized the solution, the lower the decision complexity and the faster the decision time.

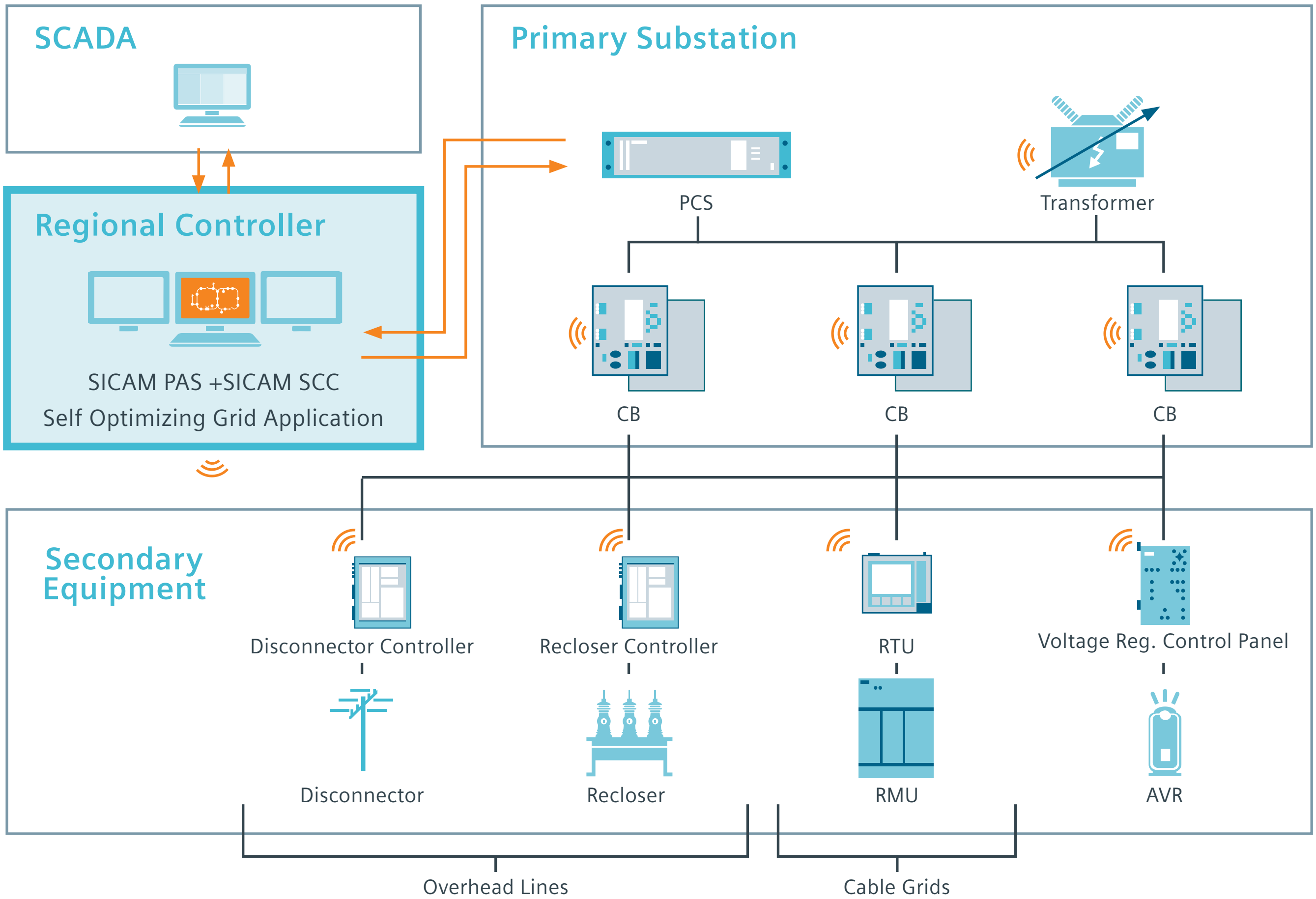


Central solution is implemented in the control center

Semi-distributed solution is introduced to the automation systems at the primary substation and feeder level

The distributed solutions function in the intelligent secondary substations, or pole top installations

System Architecture



In the specific case of a semi-decentralized architecture, the system robustness creates perfect balance with decision complexity, as network data flow is reduced. The system protects the control center from data overload scenarios by pre-processing data and taking decisions at regional control level, while only simple indications and pre-processed information is taken to higher levels in the system architecture. The system architecture also delivers extended cyber security through segmentation of access.

This level of flexibility allows the application to be extended to different sections of the grid without being limited by the maximum capacity of the control center.

Self-Optimizing Grid Relevant Applications

Combination of most relevant Applications

The Self-Optimized Grid solution is comprised of the most relevant applications for semi-decentralized solutions. These applications accurately monitor the grid and remotely control stations to ensure high reliability of supply and improve system performance. The solution integrates the intelligent automation functions:

- Self-Healing
- Load Management
- Automatic Source Transfer
- Overload Reduction
- Area Voltage Control

Self-Optimizing Grid is an innovative and intelligent solution that allows customers to enhance their current infrastructure and optimize the grid, rather than investing in costly new assets. It complies fully with International Standards, such as, IEC 61850, IEC 60870-5-104, or DNP 3 which govern digital communication for regional monitoring and control functions, and existing communication lines and protocols. Cyber Security is the highest priority for Siemens and is a primary focus across all operations; the solution is also in line with the Standard IEC-62443.

To ensure transparency across our solution, all applications are standardized and use the same remote monitoring and control devices of the distribution grid, and support all layouts of grid topology. Self-Optimizing Grid applications will effectively and equally support more rural networks that primarily operate with overhead lines, as well as urban networks that predominantly utilize cable infrastructure. All applications operate successfully across medium voltage and low voltage grids alike.

The platform for the Self Optimizing Grid application runs on proven Substation Automation Equipment combined with intelligent field equipment.

What can a semi-distributed solution offer?

- Reduced fault localization costs
- Optimized deployment of personnel and workload
- Flexibility and reliability due to automated algorithms
- Delay or avoidance of grid upgrades due to overload on lines, transformers and switches
- Higher capacity utilization of the medium-voltage and low-voltage grid
- Optimization of voltage-band utilization with few distributed points of measurement

Self-Healing

The self-healing application reduces outage time through the early detection of fault location. The application's algorithm identifies the location of the fault and isolates the damaged section; it then reconfigures the section by closing the normally open points of the grid to restore supply to consumers. Once the outage is cleared, the system re-establishes the network to its normal state

Self-healing automation supports every type of standardized communication protocol and provides secure and reliable operation for these and essential primary equipment, such as, circuit breakers, load breakers, disconnectors, reclosers and sectionalizers.

Self-Optimizing Grid process time is not reliant on the communication protocols and/or the calculation of the regional controller. It is largely dependent on the motorized mechanical switching time, which is performed in seconds, as opposed to manual switching which takes, on average, 120 minutes.

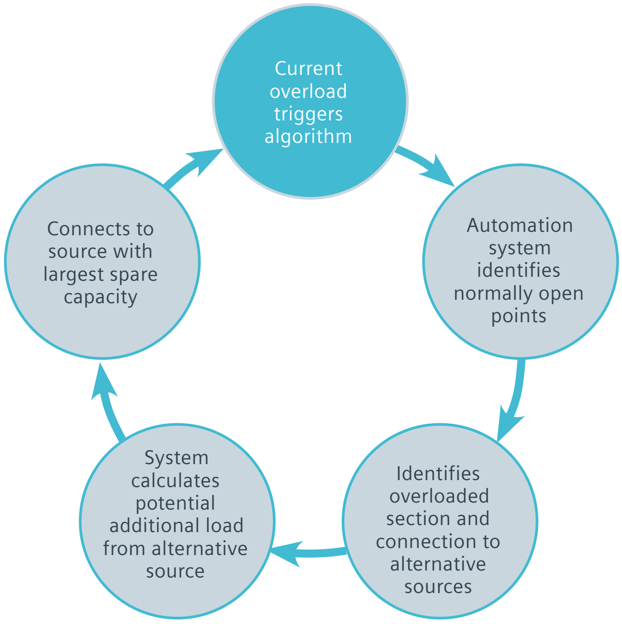
Load Management

The objective of Load Management application is to reduce the number of outages on the grid by automatically reconfiguring the feeder of a load to avoid overload on lines, transformers and switches.

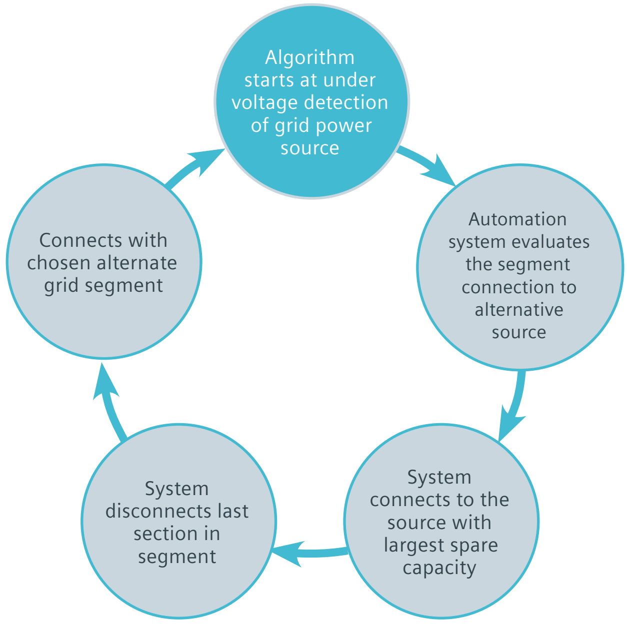
Automatic Source Transfer

The Automatic Source Transfer application automatically transfers critical loads to an alternate source in the event of a loss of voltage incident. Like load management, its main objective is to reduce the number and duration of outages on the grid.

How load management works:



How automatic source transfer works:

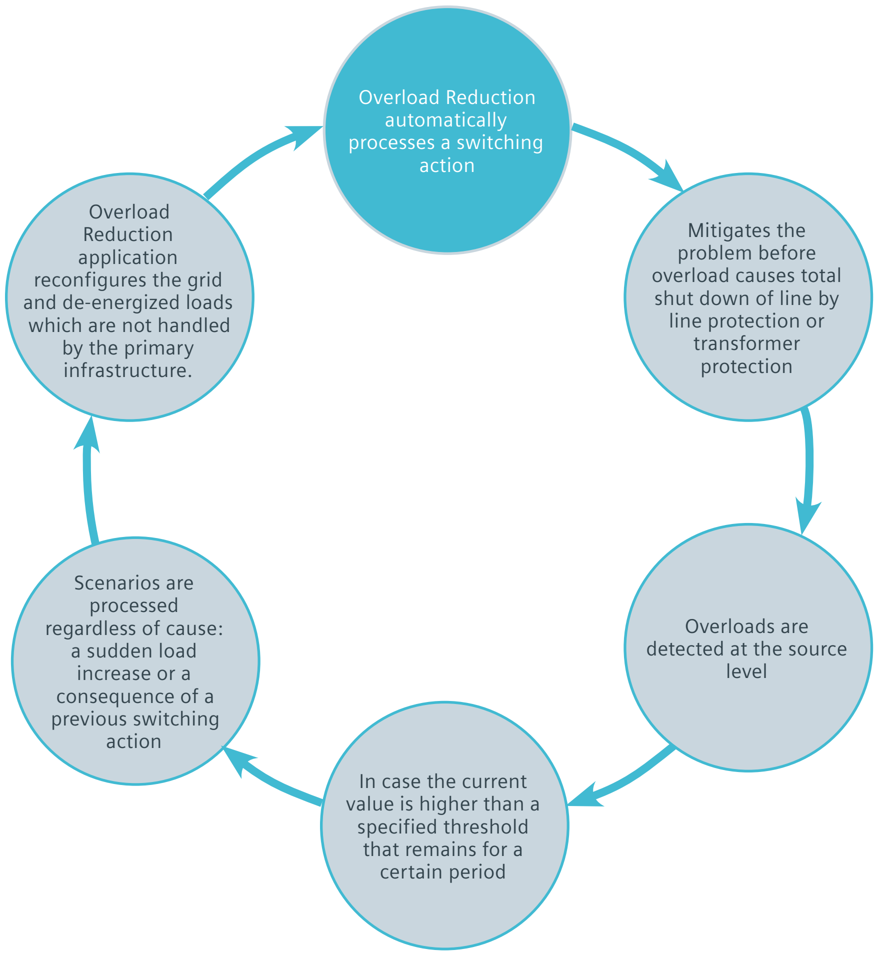


Overload Reduction

The primary function of Overload Reduction is to handle unmanageable loads on the grid. The application considers the load situation of the grid in a similar manner to Load Management Application, but on the basis that load shifting to a different grid section or source is not possible.

Overload reduction is used to cut overloads on lines, transformers and switches and to reduce the unsupplied region to a minimum. It is used in radial grid structures where loads cannot be transferred, or in open ring structures where the interconnected ring is not able to take additional load. It successfully limits outage areas, depending on the possibilities of the operating scenario and the parameters of the objective function.

How overload reduction works:



Area Voltage Control

The Wide-Area Voltage Application uses several intelligent secondary substations to monitor and regulate voltage level by measuring current and power flow to avoid voltage deviation of a minimum and maximum level. The algorithm creates a voltage level map by following the topology of the grid to establish the voltage value the algorithm must monitor, that is, the value required under normal conditions. Stabilization is performed by increasing or decreasing the step position (TAP) of the voltage regulator.

This application is used when load and generation are dispersed consistently in the distribution grid's primary transformer. It allows the line-voltage regulator and regulated distribution transformer to separate the grid into controllable areas, with minimal disruption to the rest of the grid.

The aim of area voltage control is to reduce the cost of expansion of lines, and to support energy management for monitoring and planning purposes, while ensuring that compliance with standard IEC 50160.

Creating Optimal Performance

Peak performance of a Self-Optimizing Grid is ultimately achieved by leveraging the synergies of all intelligent automation functions to develop the most beneficial combination of the components:

- Self-Healing
- Load Management
- Automatic Source Transfer
- Overload Reduction
- Area Voltage Control

Niederstetten: A Showcase for Intelligent Grid Automation Technology

Niederstetten, in southern Germany, has one of the highest ratios of installed photovoltaic (PV) power per capita in the country, averaging at 2.3 kW per inhabitant. Good news for meeting renewable energy targets, but a challenge for distribution system operator Netze BW.

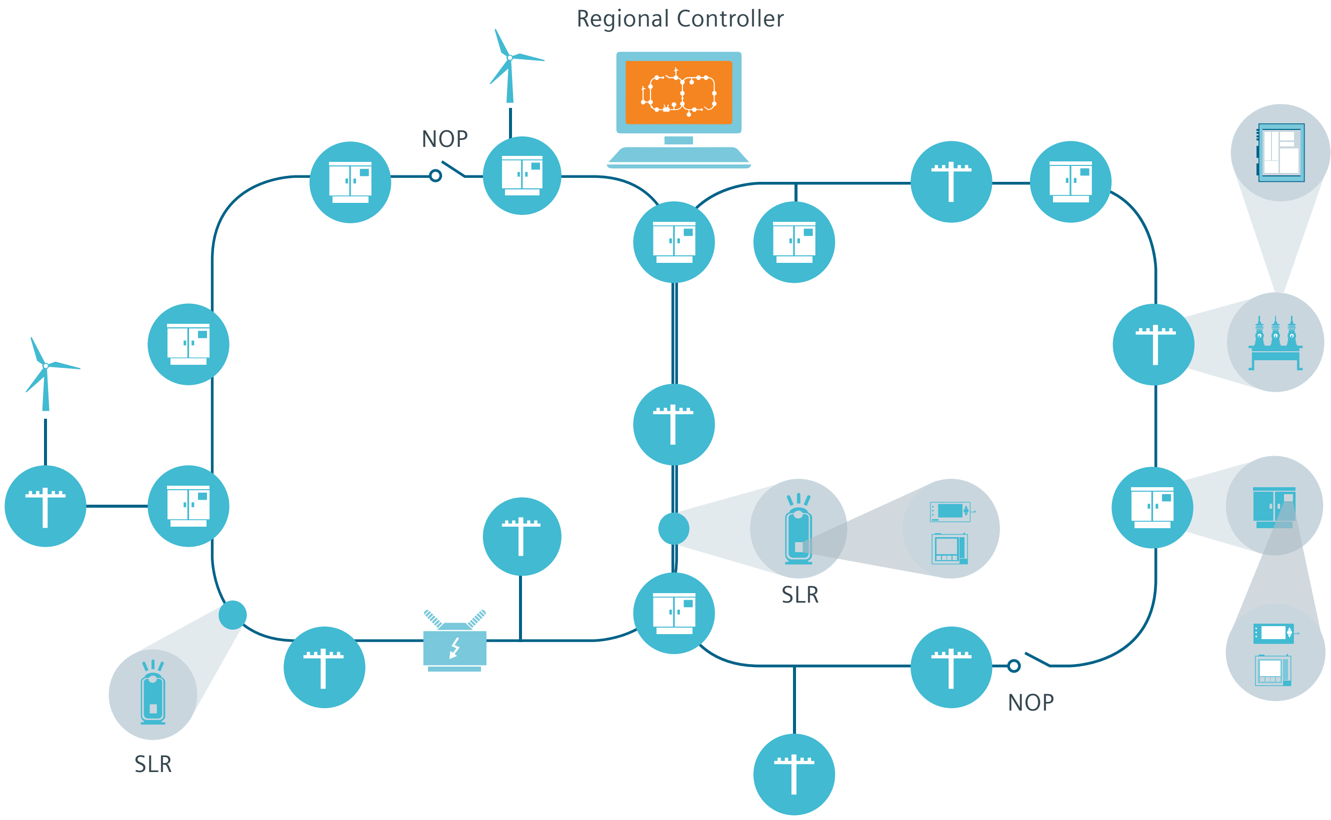
Netze BW, together with strategic partner, Siemens, opted to integrate more decentralized power generation into the existing 20-kV network to improve voltage management. The installation of two three-phase, medium-voltage (20-kV) regulators, connected to two feeder lines allows for automatic adjustment of voltage level in each feeder in real time and are operated remotely by a regional controller.

The regional controller uses a regulation algorithm to determine the best step position for each voltage regulator and can also recognize if measurement values are unavailable or incorrect. The Automatic Source Transfer Application kicks in to ensure a suitable voltage level can be guaranteed if connection to one of the regulators is interrupted.

Siemens' Wide-Area Voltage Application uses secondary substations to monitor and regulate the network's overall status, while its Self-Healing Application detects earth faults and short circuits on the medium-voltage network. The regional controller uses this information to determine the location of a fault and will open and reclose the switches in the secondary substations by remote control to isolate the faulty section of the network. This significantly reduces fault outage time for many customers.

All components that were used in this project are Siemens standard devices. This project was designed to demonstrate the network's capabilities, providing further opportunities for optimization, especially the voltage control algorithm. It has proved that clever voltage regulation increases grid capacity for managing power from renewable sources and ensures supply to customers is highly reliable.

Reference Architecture



75% reduction on initial investment compared to copper installation

Total overall improvement of KPIs: MAIFI, System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI)

Degree of automation of approximately 15% results in more than

80% improvement in availability

Visualized distribution of non-availability without automation – downtime SAIDI

65 minutes

Visualized distribution of non-availability with automation in 11 of 84 local network stations – downtime SAIDI

12 minutes

Requires just

10% of grid automation to achieve targeted results

Stabilizes weak distribution grid with long feeders and long outage times

Reduction of outage times is

over 4 times less

as before

Published by
Siemens AG 2018

Energy Management Division
Freyeslebenstrasse 1
91058 Erlangen, Germany

For more information, please contact
our Customer Support Center.

Phone: +49 180 524 70 00
Fax: +49 180 524 24 71
(Charges depending on provider)
E–mail: support.energy@siemens.com

www.siemens.com/self-optimizing-grids

Article-No. EMDG-B90072-00-7600
ZEST, WS 0518v