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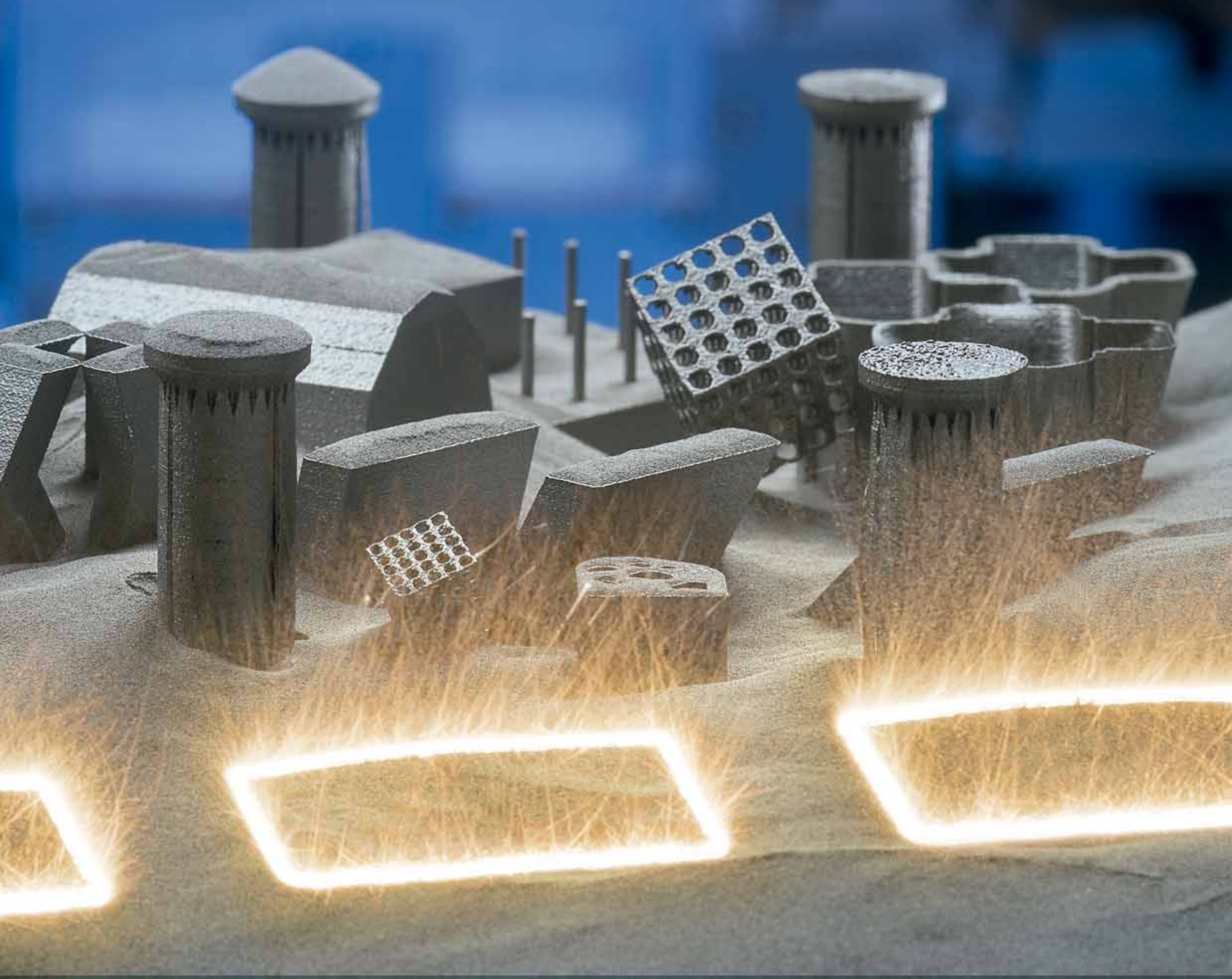
Pictures of the Future

The Magazine for Research and Innovation | Spring 2013

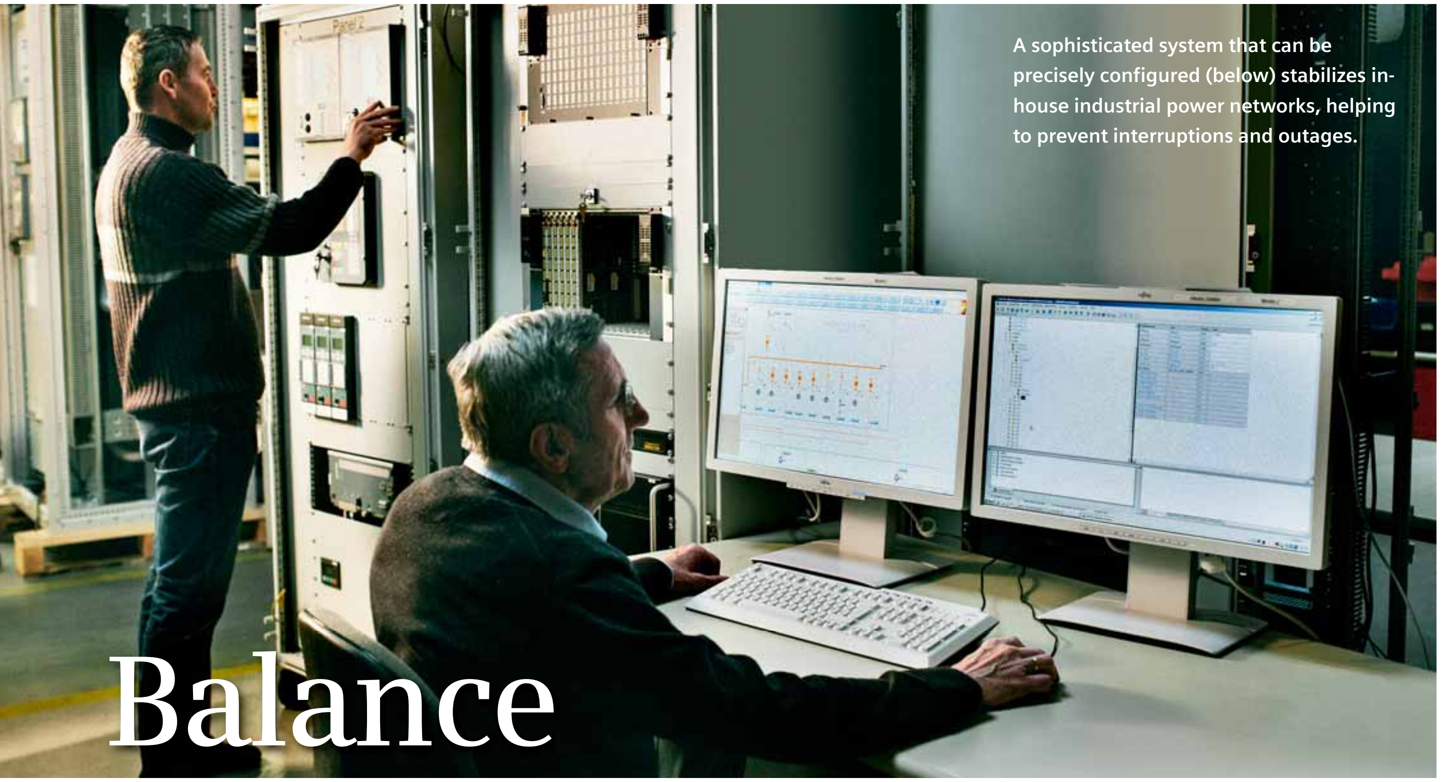


Solutions for Tomorrow's World

Manufacturing and Innovation
How the digital, virtual, and real worlds are merging

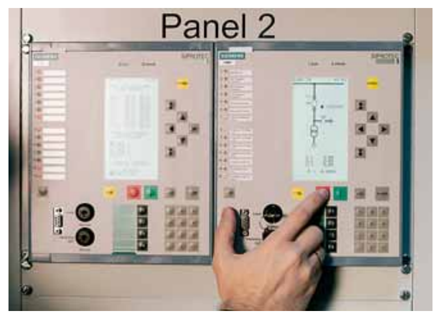
Maximizing Efficiency
Making better use of all types of resources

Where Mobility Is Going
By road or rail, in the air or on water — efficiency rules



A sophisticated system that can be precisely configured (below) stabilizes in-house industrial power networks, helping to prevent interruptions and outages.

Balance or Blackout?



If an industrial facility's internal power plant fails, non-essential systems can be switched off in order to reestablish balance in the network. A new Siemens automatic load-shedding system reacts at lightning speed to prevent any instability in such situations.

A high-pitched whistle announces that something bad is about to happen. A generator bearing has overheated and several megawatts of power disappear from an oil refinery's grid within a second. The grid voltage falls and the alternating current (AC) frequency drops below 50 hertz, the line frequency that forms the basis of a reliable power supply. If heaters, cooling units, and machines continue to run, the grid will collapse completely. And that means production losses, damage to production equipment, and costs that could quickly run into millions of Euros.

The incident described above is fictitious — but the impact it would have is very real. If a power plant and the grid it feeds at a large-scale industrial facility were to fail, the resulting downtime and associated financial losses would be huge. Certain processes, such as those for compressing liquid gas or melting steel, should never be interrupted. Correspondingly, they have to be protected against outages in the public grid. Many energy-intensive industrial facilities such as refineries and steel mills therefore operate their own partially autonomous power networks to compensate for the effects of potential blackouts in the grid. They also pursue such a strategy because peak load electricity from the grid is very expensive. In other words, it pays to operate an in-house power plant. "You have to expect disruptions now and then — and more often in older systems," says Michael Eckl, an expert for grid automation at Siemens Energy Automation Solutions in Vienna, Austria. Eckl provides advice to companies that operate their own power plants. However, the grids at such facilities tend to expand haphazardly, and eventually consist of a mix of old and new equipment and safety technologies.

The companies that operate such plants know this, and have strategies for shedding electrical loads, which means temporarily shutting down power-hungry systems in a targeted manner. Such systems include non-essential machines, cooling and air conditioning units, motors, furnaces, compressors, pumps, and lighting systems. The idea is to balance out supply shortages with demand reductions. To this end, a facility will draw up a priority list that defines which equipment and machines will be shut down at which times under a given set of circumstances. In the ideal case, an outage should immediately be followed by a power-feed cutoff in fractions of a second, thus minimizing the chance that instabilities might lead to a total collapse of a grid.

In the past, control center technicians decided which loads to drop if a generator failed. But this required too much time to prevent disaster. Later, simple automatic load shedding systems were developed that could shut down specific areas of energy demand in line with previously calculated scenarios. The problem here was that either too much or too little power was often removed from a network. As a result, facility operation slowed down or it became necessary to make additional adjustments manually.

The next major advance involved industrial automation systems such as Simatic from Siemens. Here, the system's control units measure both power output and demand, and automatically shed loads in accordance with a predefined priority list. The drawback is that as a separate energy automation feature, the system has its own hardware, wiring, and maintenance requirements, which means it also generates additional lifecycle costs.

Living in the Future. With this in mind, Eckl's team has developed a new load-shedding system known as the Efficient Network and Energy Automation System — a solution for the oil, gas, and metalworking industries that eliminates the separation of energy generation and control automation. The system combines these features in a package that has a common IC network for load-shedding and automation, thus saving time and money.

The system pre-assigns a priority level to each load. Its control unit not only continuously monitors power generation and demand but, for every passing second, also calculates which loads need to be shed if, for example, a generator were to shut down within a few seconds. Obviously, loads with a low priority are eliminated first. The system's software is thus always operating a few seconds into the future so that it can react quickly enough to prevent imminent fluctuations in the network.

In addition, the system sheds only the exact load needed to maintain network stability at a given moment. "But it doesn't regulate every light bulb," says Eckl. "Instead, it cuts off several hundred kilowatts or more per load. Typically, these include auxiliary functions that a facility can do without for a limited time. Examples include heating and air conditioning."

The Siemens system is unique because it combines three different methods. Along with the quick power-based load shedding described above, the system also utilizes traditional frequency-based load shedding. This happens when the alternating current frequency, which should be exactly 50 hertz, begins fluctuating excessively. Such fluctuations can occur if several errors occur at once — for example when two or more generators fail. In such a situation, protective relays cut off predefined reserve loads. The problem is that this method might take either too much or too little power out of a network. As a consequence, it is only used as a last resort.

The third load-shedding technique involves a running reserve — the extra electrical output that can be made quickly available when needed at a power plant. This power comes from generators that are already running (hence the name) and feeding electricity into the network. The extra output prevents demand problems from arising when additional loads come online.

Output and frequency-based load shedding must be carried out at lightning speed if they are to be effective. To this end, Siemens developers put their faith in GOOSE (Generic Object Oriented Substation Events), which is part of the IEC 61850 communication standard. This standard for automation technology ensures that alerts are sent to all power demand systems simultaneously via glass-fiber cables. Once an event that requires load shedding is identified, all demand systems are notified and can react according to a load-shedding plan that was calculated just before the alerts were issued. The signals are received within 70 milliseconds at most, which is fast enough to immediately eliminate any instability .

Completely autonomous, isolated networks that are fully independent of the public grid and generate all their electricity themselves are rare. Nearly all large industrial facilities with in-house power plants and isolated networks also maintain a link to the public grid. This link provides the facilities with much of their power or enables them to feed surplus power into the grid. Automatic load-shedding systems are designed solely to maintain the stability of an internal power network. The latter network is used either to compensate for outages in the public grid or to generate power when the grid's electricity is too expensive due to high demand.

Virtual Power Plants. It's worth considering whether load shedding shouldn't be viewed in a broader connection with the public grid — and combined with other energy automation techniques. One option would be to use DEMS, a decentralized energy management system developed by Siemens that optimizes, for example, the operation of virtual power plants — in other words, the combination of individual distributed power systems (*see Pictures of the Future*, Fall 2012, p. 68). Eckl and his colleagues are developing solutions to improve economic efficiency in order to optimize the costs associated with, for instance, imported, self-generated, and exported electricity. The results could be used to calculate an operating plan for in-house generators.

Two industrial plants — one on Saadiyat, a tourist island in Abu Dhabi and another at a refinery in Turkey — have installed and successfully tested an automatic load-shedding system that uses the fast GOOSE alerts. Thanks to a communications standard, the concept is open to expansion over the long term, and is suitable for existing and new networks. "Industrial customers increasingly require a more secure supply. That's why we expect to see greater demand for our system in the future," says Eckl. ■ *Bernd Müller*