A view to the future
Innovation at Siemens
For close to 170 years, groundbreaking technologies, and the business models built on them, have been the foundation of our success – innovations that do not simply remain inventions but set new benchmarks and achieve market success as products, solutions and services. They are what have transformed our company from a start-up in a Berlin backyard into a leading global group. And they will enable us to build a successful future for our company, our customers and society.
Innovations that set standards for the future

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1816–1892
Founder of Siemens, visionary businessman, pioneer in electrical engineering and an initiator of the modern economy.

Werner von Siemens

Siemens innovations covering about 170 years

1866
Conversion of mechanical energy into electrical energy – the Siemens dynamo is steadily putting electricity into people’s daily lives.

1847
In the pointer telegraph, Werner von Siemens created a reliable system for transmitting messages and also laid the foundation stone for the Siemens & Halske Telegraph Construction Company and therefore for the global company Siemens.
1975
Breakthrough for Siemens in high-voltage direct-current (HVDC) transmission – first used along the 1,400 km route from Mozambique to South Africa.

1983
The MAGNETOM was the first magnetic resonance imaging scanner from Siemens to go into service in Germany.

1959
In launching the SIMATIC controllers on the market, Siemens laid the foundation for a leading position in automation technology, which lasts until today.

2010
The next stage in automation technology: Siemens introduced the Totally Integrated Automation Portal (TIA Portal), which improves all operating, machine and process flows.

2014
Siemens presents its digitalization strategy. One result is that all Siemens digital services will run via Sinalytics (platform for industrial data analytics) in the future.

1925
The Irish Free State awarded Siemens the contract for electrification of the entire country. The core was the hydroelectric power plant on the river Shannon with three 30 MVA generators.

2012
Siemens started field testing of the world’s largest rotor at the six megawatt offshore wind farm near Østerild in Denmark, allowing 6,000 households to be supplied with clean electricity.

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In the Center of Knowledge Interchange (CKI) program Siemens collaborates with world-renowned universities on long-term research projects on key technologies.

**Research and development (R&D) expenses**

- 4.5 bn €

**R&D intensity**

- Ratio of R&D expenses and revenue
- 5.9%

**Employees in research and development**

- 32,100

**Operating figures relating to Siemens’ innovative capacity in financial year 2015**

**Patents granted**

- 56,200

**Patent first filings**

- 3,700

**Inventions**

- 7,650

**Principal Partner Universities**

Siemens maintains an intensive strategic cooperation with top universities in the area of research and development.

**9**

**In the Center of Knowledge Interchange (CKI) program Siemens collaborates with world-renowned universities on long-term research projects on key technologies.**
Worldwide

Australia
China
India
Israel
Japan
Mexico
Republic of Korea
Russia
Turkey
USA

171 major research locations\(^1\) in 27 countries

Europe

Austria
Belgium
Croatia
Czech Republic
Denmark
France
Germany
Hungary
Italy
Netherlands
Norway
Romania
Sweden
Switzerland
Slovakia
Spain
United Kingdom

\(^1\) With 15 or more employees
Digitalization is changing the world. And it is changing Siemens, too. Whether it’s smart factories, decentralized energy systems or tomorrow’s mobility systems, Siemens engineers are increasingly closing the gap that once separated hardware from software. Cloud technologies and data analytics are helping in this process. So are agile start-ups – and our legendary entrepreneurship. Joe Kaeser and Siegfried Russwurm discuss Siemens’ innovative power and our ideas for the future.
Is Siemens still innovative?

JOE KAESER  Of course. The Company has been living from good ideas that have earned us money for almost 170 years. We have only stayed profitable because we have reinvented ourselves several times. We can’t afford to slacken when it comes to our innovative power, and won’t! That is why we invested an extra 400 million euros in research into our core lines of business – electrification, automation and digitalization – in the past fiscal year.

SIEGFRIED RUSSWURM  Pioneering technologies and the business models that build on them are the foundation of our success. Without a doubt, the speed of innovation has increased dramatically. That affects the way we develop new things. Our innovation processes are much more open nowadays. Instead of hatching ideas behind locked doors, we are now collaborating with external partners, including small start-ups that have little money but good ideas.

Siemens matured in a world of hardware, in other words of tangible products. However, today, exciting growth business is increasingly arising in the digital world.

JOE KAESER  That’s right. We have therefore devised our own digitalization strategy and are implementing it consistently. At seven to nine percent, we expect the greatest growth potential for Siemens to be in the field of digitalization. And we want to achieve that over our entire portfolio, for example with our digital services for remote maintenance of a wide range of systems. Our software for design, prototyping and simulation in the virtual world was even used successfully in the development of the Mars rover Curiosity, and also helped the Italian car manufacturer Maserati to bring a new vehicle to market in just 16 months.

SIEGFRIED RUSSWURM  As a broad-based technology group, we have a key advantage: we can leverage our size, for instance by investing once and building uniform platforms for our Divisions and Business Units. This includes an extensive IT security concept, a plan for using cloud technologies and with Sinalytics a platform for industrial data analytics that everyone at Siemens will be able to use. And our customers will be the primary beneficiaries of these steps.
Our energy business, in particular, has been subject to major changes all over the world. What are the innovations with which you want to bring Siemens forward here?

JOE KAESER  The market has indeed changed dramatically in recent years. Energy systems are becoming decentralized. We must be self-critical and recognize that we did not always keep up with these developments in the past. We have learned from that. We want to become a leading player in the area of decentralized energy supply. The acquisition of Dresser-Rand and Rolls-Royce’s turbine business is a significant step. We have set our sights on optimum interplay between various energy sources in a multimodal energy system. This includes new ways of generating electricity as well as new chemical energy storage systems for surplus green power, innovative transmission technologies, smart grid concepts and information and communication technologies. After all, digitalization is also gaining ground in the energy sector.

Siemens has a strong position in the industry automation business. Can this lead be extended?

SIEGFRIED RUSSWURM  We are the only company in the world that already unites the real and virtual manufacturing worlds under one roof – one of the key aspects of Industrie 4.0. We began to orchestrate all components and closely integrate software and hardware 20 years ago, the buzzword being “smart factory.” At our Amberg Electronics Plant, products and machines communicate with each other and all processes are optimized and controlled in terms of IT. The plant has achieved a quality rating of 99.99885 percent. And at the Electronics Manufacturing Plant in Erlangen, we have devised new concepts for highly flexible manufacturing systems using lightweight robots and 3D printers.

Is it sufficient to expand existing business? Shouldn’t Siemens also be experimenting with disruptive innovations?

JOE KAESER  We not only need disruptive ideas but also the courage to realize them. But here, too, we have made considerable progress. We are more daring. And we are actively looking around. Many concepts for new technologies originate at start-up companies. And they, in turn, are often looking for financially strong partners with expertise
in extensive development work – partners like Siemens. That is why
we deploy specially trained technology scouts in Silicon Valley, Shanghai,
Munich and soon in Tel Aviv.

SIEGFRIED RUSSWURM At present, we have intensified our search for very
young companies working on 3D printing and robotics. We have a
specific support program for this. For example, one of the companies
is developing software that optimizes 3D designs. By supporting such
companies, we get very early access to new technologies in return.
But we also found start-ups ourselves, make use of the entrepreneur-
ship of external managers and later bring applications of strategic
interest into the Group.

Should Siemens act more like
a start-up itself?

SIEGFRIED RUSSWURM We can certainly learn a lot about innovative power,
inventive spirit and speed from start-ups, and we do. – We are working
on making the Group faster and more open – both internally and
externally. But we can’t pretend to be a start-up company. We have
customers all over the world and some 350,000 employees. We need
processes and an organization that are in line with this and underpin
it. Incidentally, that is what makes us a sought-after partner for start-
ups. And that is precisely where I see our role.

JOE KAESER Many start-ups want to become as big as Siemens; they don’t
want to stay small. But no matter whether big or small, it is important
for a company to act in an entrepreneurial manner. I keep telling our
employees to act as if Siemens were their own company. We call it Owner-
ship Culture. Siemens itself began as a start-up in a backyard in Berlin.
A piece of this entrepreneurship is inside all of us. And in the future, we
will be even more focused in terms of putting it into effect.

Thank you very much for this interview. ←
Fueling the new age of power
The requirements for a stable electricity supply have been evolving ever since Siemens got started in a Berlin backyard about 170 years ago. Today, however, faced with climate change and the need for decarbonization, they have become far more urgent. Siemens is introducing technologies that will help to make a transition to a sustainable energy economy possible.

Siemens is facing up to the challenges posed by climate change. For instance, our researchers have designed a simulation model called the “Energy System Development Plan” that illustrates how things would change if 80 percent of energy were generated from renewables. What impact would such a change have on the generation and transmission of power and on energy markets? Their answer: In the future, the energy landscape will be characterized by countless decentralized, distributed and networked power generators.

In view of this prediction, Siemens is looking to innovative transmission technologies such as direct current full bridge technologies and smart grid concepts as well as information and communication technologies (ICT). We also want to become the leading vendor and partner in tomorrow’s decentralized electricity supply system. We are therefore working in parallel on new chemical energy storage systems – to make use of surplus green power and to stabilize the grid. At the same time, Siemens committed itself to cut its global CO₂ emissions in half until the year 2020 and to achieve a net-zero carbon footprint by 2030.
Electrification

Autonomous driving on electricity super-highways

An energy system in which a majority of electrical power comes from renewable sources will place very high demands on the supply structures of the future. High-voltage transmission lines that transmit direct current across long distances have a vital role to play in a distributed and volatile environment. Three Siemens engineers have worked on the important pieces of the puzzle that make this possible. →
Siemens developers Michael Vieth (left) and Dr. Günter Ebner

Heart of an HVDC transmission system

These special modules make it possible to transmit the power generated by entire wind farms from the north of Germany to the south without interruption.
A world in which leading economic powers proclaim the age of decarbonization. A European energy landscape in which a highly developed, very densely populated country turns its back on nuclear power. And a national supply network in which the number of power suppliers has increased from some hundreds to several millions. That is a world in which the demands placed on a stable power supply for production plants, public infrastructure, and private households are greater than ever. That world is — a reality.

**The future is now**

Siemens researchers got ahead of the future years ago with the “Energiewende 2.0” project. That’s why they can already say what exactly this energy environment will look like and what this means for infrastructure and markets. The core question that everything comes down to in the end is how to guarantee the stability of a grid in which most of or even all of your energy comes from fluctuating sources.

One thing is clear: It’s not enough to build more wind turbines, solar installations, and combined heat and power plants — the energy produced by these sources must reach the consumer. Storage media, including chemical technologies, are an essential part of the equation. Power electronic components will also play an important role, including new converter technologies. The time window for finding the technologies that will transform the complex structure of our future energy landscape into a reliable, flexible power supply system is closing. In other words, the long term is very quickly becoming the short term.

**Small size, enormous impact**

Michael Vieth, Christian Siegl, and Günter Ebner are part of a development team that is already one step ahead. Based scenarios of a future power supply, the three Siemens engineers from Nuremberg and Erlangen have worked for the past two years on hardware, software and an operational management concept. Part of it is power electronics the size of a shoebox with a silver sheen. But don’t let the small size fool you: Integrating thousands of such boxes into the overall system will make it possible for population centers and industrial clusters throughout Germany to receive precisely the amount of energy they need in precisely the right dose from external sources whenever their local sources are not currently meeting demand.

Vieth holds one of these boxes in his hands. He knows exactly what’s inside this piece of the puzzle. But he wouldn’t quite say that this is a sensation. Innovation is “just his job,” he says. He prefers to talk about the technical specifications. Once you strip away the technical jargon, what he has achieved actually sounds almost simple: “If one of these modules malfunctions, it cannot be allowed to interrupt the power transmission.”

**The heart of the electricity superhighway**

Combined in packages of six, built into tower-like converter stations, and interconnected by the thousands, the modules make it for example possible for the cumulative energy of Germany’s offshore wind farms to be transmitted into more southern areas without interruption. They are the heart of the high-voltage direct current transmission, or HVDC.
HVDC lines are overland electricity superhighways that span great distances. The new Siemens technology that the three brilliant engineers in Nuremberg and Erlangen worked on achieves this through a “full bridge,” known in technical circles as “HVDC PLUS with full bridge topology.” Unlike its half bridge counterpart, the full bridge makes it possible to discover and clear up faults more quickly and keep them from spreading in web-like transmission systems. And it does so during live operation, even in branching grid structures, while taking up very little space.

**When lightning strikes**

Full bridge technology offers crucial advantages, especially with overhead lines. Because the power needs to keep flowing even during rain, snow, and storms – and it needs to come back online quickly even after a direct lightning strike. Siemens engineers came up with an idea for keeping the direct current superhighways moving even in this scenario. Or to stay with the highway metaphor: to ensure that an accident on one section of road does not lead to a multivehicle pile-up – or even a traffic jam. If lightning strikes a line, the clever new converters in Erlangen allow the system to attempt up to three restarts in just 450 milliseconds and keep faults local.

Vieth’s modesty is also shared by his two colleagues in Erlangen who gave the silver shoebox this capability. Christian Siegl was responsible for the control technology – in other words, adapting the software code. “In the end,” he says, “it works using algorithms, as always.” The algorithms ensure “that power and voltage are regulated and kept within limits across the entire system.” He sees no need to mention that these algorithms can be rather tricky. Last but not least, Günter Ebner’s job was to ensure “that the overall system works.” How many of these modules need to be interconnected? Which main components are needed? Which voltages can the overall system accommodate, and what happens when there are faults? He "optimized, using as little material as possible.” Together, the trio made it possible for the mass of electrons moving from A to B along the direct current superhighways to do something akin to autonomous driving.

Thinking one level further, from the technical to the abstract, this means: Together, they are responsible for technical realization of a requirement brought to a company like Siemens as a result of political targets, and for ensuring that it works and is cost-effective. An important piece of the puzzle – for the sustainable power supply of tomorrow.

**Against the domino effect**

**Unimpeded flow of power in any weather**

Unique selling point: if lightning strikes the power line, a full bridge system will bring about a restart within 450 milliseconds.
Gigantic converter stations

**Tower of Nuremberg**

Bundled in packages of six and with thousands of them interconnected, the modules are part of a sustainable energy supply for the future.
At the beginning of the 1990s, only a few hundred medium-sized and large power plants were operating in Germany. In the meantime, the number of electricity suppliers has increased to several millions. And this trend is set to intensify around the globe. Future electricity supply systems will consist of millions of small and larger decentralized generation units. The result will be a vast increase in complexity, thus demanding an infrastructure based on an advanced clean energy model that will make “Energiewende 2.0” possible.

From sustainable generation through resource-saving transmission to demand-oriented distribution in networked buildings, production facilities and mobility applications – Siemens’ portfolio already includes electrification solutions that cover the entire energy value chain.

In parallel to this, the company’s researchers have developed technologies that support energy stability and resource conservation in tomorrow’s energy landscape. That landscape will consist of millions of small and larger decentralized generation units. To ensure these cover demand reliably, electronics, power electronics and information and communication technologies will be integrated more than ever, for example through new converter technologies and ever more powerful software.

The more volatile power generation becomes as a result of renewables, the more urgently we will need technologies in the future that enable large volumes of electricity to be stored over a long period. Siemens is focusing on chemical solutions and is also developing electrolytic methods for converting CO₂ into compounds such as ammonia, carbon monoxide or ethylene, which are valuable for the chemical industry.
All fired up for supplying electricity and heat

Dr. Ghenadie Bulat
Combustion specialist at Power and Gas, Lincoln, United Kingdom

That Siemens’ gas turbines work so efficiently is partly due to the young engineer and his inventions: “Only when the burner is functioning perfectly can electricity and heat be generated reliably.”
From the land of fjords to the deep sea

Ove Bø
Head of Development at Energy Management, Trondheim, Norway

Supplying electricity to deep-sea oil and gas rigs? No longer a problem thanks to the subsea technology of Ove Bø. The components have been designed to withstand the pressure of huge masses of water. “Our country is too small to invent mass produced items. We have always had to look for innovative solutions.”
Shaping the Fourth Industrial Revolution
The technologies that drive industrial competitiveness forward are the foundation for innovation, growth and even social stability. But they are also being subjected to intense competition. As product cycles continuously shrink, customers are demanding higher-quality products and more customized options. The solution lies in smart, digital automation culminating in the vision of a high-tech strategy for the future of industry – in other words, Industrie 4.0.

For Siemens, Industrie 4.0 means connecting the real and virtual manufacturing worlds through integrated solutions. This includes innovative automation and drive technologies, industry software, and services and solutions for resource efficiency. After all, only those industrial companies that get by with fewer resources and make manufacturing more efficient and more flexible can boost their productivity sustainably and stay ahead of the competition.

The name Siemens is inseparably linked with the future of industry. With our Simatic controllers, in particular, we have been consistently driving technological progress in the field of industrial automation for over 50 years. Our automation systems cover all requirements in industry and set benchmarks in their respective application areas.

As they were in the past, automation solutions from Siemens are still the future-proof answer to the steadily growing demands placed on machinery and systems in all sectors – and also within our company itself. For instance, Industrie 4.0 has already become reality at our Electronics Manufacturing Plant in Erlangen.
Simulation, 3D printing, lightweight robots – these are some of the innovative technologies driving the Fourth Industrial Revolution – or Industrie 4.0. And they are already a reality at Siemens’ Electronics Manufacturing Plant in Erlangen, Germany. A key reason for the success of this plant is that people and machines work hand in hand.
Stefan Krug, responsible for digital planning methods at Siemens’ Electronics Manufacturing Plant in Erlangen, Germany

“Before we build a new product, we create and optimize its digital twin.”

Product development and production planning are tightly interlaced thanks to end-to-end 3D visualization.
Schorsch assembles small converters. Hannes does the big ones; he inserts a fan and a heat sink in the housing and fastens them with four screws – several hundred times a day. When Hannes takes a break, Schorsch keeps on working unwaveringly. When Hannes goes home, Schorsch goes on working. Hannes is a temporary factory worker. Schorsch is a lightweight robot.

At Siemens’ Electronics Manufacturing Plant in Erlangen, Germany (GWE), people and machines work hand in hand. Manfred Kirchberger, Plant Manager, says the efficiency there is unique: “We produce industrial drives and controllers for manufacturing equipment. At our customers’ plants, the quantities often reach millions.” At the GWE, however, annual output lies between 5,000 and a quarter of a million. That is not enough to warrant investments in a fully automatic production line. But manual work on its own would be too expensive.

Production planners in Erlangen are therefore constantly looking for the optimum course for each product line. What should a worker do? What should a machine do? How can their interactions be optimized? “There is no economical off-the-shelf automation system for production on our scale,” says Kirchberger. “As a result, we have to systematically build up experience and share it with other Siemens plants all over the world.”

Why flexible production is a must

On top of that, customer requirements are changing faster than ever, making it increasingly important for production lines to be flexible. “Here in the production halls, nothing is where it was just a few years ago,” Kirchberger points out. The GWE is a classic example of the art of
change in manufacturing. Constant and rapid adaptation is only possible as a result of the workforce’s willingness to embrace change, coupled with state-of-the-art technologies such as product design and production planning simulation, 3D printing and intelligent evaluation of data from end to end. At the GWE and other plants, for example at Siemens’ “Digital Factory” in Amberg, Germany, the company is setting new benchmarks for advanced manufacturing.

In a plain building next to the Erlangen plant, product developers, production experts and “old hands” from manufacturing immerse themselves in the virtual world together. Stefan Krug, responsible for digital planning methods at the GWE, explains the approach: “Before we build a new product, we first create and optimize its digital twin using Siemens’ PLM software.”

Product developers and production experts can view the digital twin—a realistic representation of a product or process before it is produced in the real world—in detail as a three-dimensional animated model. In this digital space, they can rotate and turn it and test associated assembly processes in a simulated manufacturing environment. The upshot is that design teams can identify problems and make improvements at the earliest stage.

Anton Huber, Head of Siemens’ Digital Factory Division, puts it this way: “No phase of the value-added process will be implemented in the future without first developing and testing its digital counterpart, starting at the idea phase and extending to product and production engineering, commissioning, use and new services.” As a result, products will reach their market faster and in a more targeted manner. But no matter how good a model is in the digital world, a person or a machine or a combination of the two will ultimately put the components together.

Robots that work with people

In the Electronics Manufacturing Plant Michael Brucksch, a Technical Business Administrator, is guiding the arm of a lightweight robot called R2-D2 and teaching it a new task in the facility’s robotics experimental lab. A major advantage of lightweight robots is that even skilled production workers can program them. In addition, the robots do not have to work in areas cordoned off from humans. Thanks to their design and smooth movements, they pose no hazard to people.

Nearby, Sebastian Wiemann is building a gripper device—the robotic equivalent of a hand. “We used to utilize milled components for projects like this,” he says. “Now we print them. That is faster and cheaper than conventional methods. Last week, this enabled us to reduce the cost of a part from about 500 euros to around 80.” Plant Manager Kirchberger does not need to instruct his employees to make improvements like this. “Our people like to try things out. We give them the scope to come up with innovative ideas and turn those ideas into a success,” he states.

Many processes associated with factory automation that have undergone successful trials in Erlangen are entering everyday use at Siemens’ factories throughout the world and at Siemens’ customers’ facilities. Many of these developments are examples of the Fourth Industrial Revolution which Siemens is helping to shape—with determination, courage and the necessary vigor. But in spite of all this, experts expect that human beings will continue to play a major role in production for the foreseeable future. “We are not automating like crazy but with common sense,” says Michael Brucksch. And his colleague Florian Riedrich, who is responsible for robotic technology at the Electronics Manufacturing Plant, adds: “We don’t want a factory that is devoid of people. What we foresee is a combination of people and machinery.”

R2-D2, A lightweight robot

Lifting 7 tons a day

Employees were skeptical initially. Even more robots? But now a lightweight robot has relieved them of heavy loads they would not like to do without it.
Ownership Culture

Trying things out

Employees at the Electronics Manufacturing Plant in Erlangen have the scope to come up with innovative ideas and turn them into successful projects.
Automation

Manufacturing’s evolving paradigm shift

In order to increase industrial value creation, leading companies are working at top speed to realize the next stage of manufacturing – with the aid of digital automation. Companies are aiming to achieve advantages through networked, flexible manufacturing operations that dynamically organize themselves to create extremely customizable products.

Over the course of the next 15 to 20 years, Industrie 4.0 is expected to bring about a paradigm shift that can justifiably be called the Fourth Industrial Revolution. Long before Industrie 4.0 became a buzzword, Siemens recognized that manufacturing companies needed to reduce their throughput times drastically and increase their flexibility massively. The reason for this is the ever growing trend toward customized mass production coupled with the need to reduce the use of raw materials and energy – demands that are being driven by competition.

Our Company set a course for such digital automation of production systems back in 1996 when we introduced the Totally Integrated Automation (TIA) portal. It enabled companies to orchestrate the components of their production activities and tightly integrate software and hardware using, among other things, our programmable Simatic controllers, the global leaders ever since the first system was launched in 1958.

Since then, Siemens has not only constantly enhanced its Simatic range and the features of the TIA portal but is now also pursuing complete digital representation of the physical value chain as its ultimate goal. Specifically, this means providing a portfolio of hardware and software products that supports seamless connection of development, production and suppliers in all areas that are based on data interchange.

Manufacturing: the heart of a strong economy

<table>
<thead>
<tr>
<th>As manufacturing evolves, complexity and benefits increase</th>
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<tbody>
<tr>
<td><strong>MARKET</strong></td>
</tr>
<tr>
<td>Growing desire for individual products.</td>
</tr>
<tr>
<td><strong>1908</strong></td>
</tr>
<tr>
<td><strong>2015</strong></td>
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<tr>
<td><strong>TECHNOLOGY</strong></td>
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<tr>
<td>Digitalization is the deciding factor for success or failure.</td>
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<tr>
<td><strong>52%</strong> of CEOs worldwide expect digital technology to cause a significant change in their industry.</td>
</tr>
<tr>
<td><strong>IMAGE</strong></td>
</tr>
<tr>
<td>Becoming a growth engine in the global economy.</td>
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<tr>
<td><strong>17,500</strong> Software developers</td>
</tr>
<tr>
<td><strong>SOCIETY</strong></td>
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<tr>
<td>Industry is creating jobs and thus making an important contribution to society.</td>
</tr>
<tr>
<td><strong>1</strong> Job in manufacturing creates</td>
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</tbody>
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Source: Siemens

The road to the Fourth Industrial Revolution

1.0 1784 based on mechanical production equipment driven by water and steam power.
2.0 1870 based on mass production enabled by the division of labor and the use of electrical energy.
3.0 1969 based on the use of electronics and IT to further automate production.
4.0 tomorrow based on the use of cyber-physical systems.

Source: Siemens
A safe connection for machines or wind turbines

Steffen Fries
Principal Engineer at Corporate Technology, Munich, Germany

Innovative security solutions are needed to make Industrie 4.0 and smart grids work. They do not arise in an ivory tower but through the exchange of information with colleagues. “We shoot ideas back and forth like ping-pong balls to really put them to the test.”
Introduce innovations to the marketplace quickly

Ming Li
Director of Venture Technologies at TTB (Technology to Business), Shanghai, China

Ming Li and her colleagues in Shanghai, Berkeley and Munich monitor the world of start-ups. If their technologies are relevant to Siemens, the TTB experts, together with Siemens’ business units, quickly introduce them to the marketplace.
Digitalization

Shaping the digital enterprise
The world has never been as networked as it is now. Whether it’s gas turbines, manufacturing systems or medical imaging technologies, our real world is being enriched with a digital dimension. The ongoing convergence of the real and digital worlds is giving rise to previously undreamed-of potential in both technology and business. Siemens is in a good position to exploit these opportunities.

For Siemens, digitalization is not just a line of business but our biggest growth driver. With it, we are leading our company to a successful future. We do not need to fear comparison with our competitors. We have a broad basis along the electrification and automation value chains – a world of hardware and physics. With our IT expertise, we are linking this real world with the virtual one. We are ideally positioned to shape the digitalization age.

What is good for Siemens is also good for our customers, as their business cannot be imagined without digitalization. That they are using our products is proof of their trust in our innovative power. For instance, more than 77,000 customers throughout the world are working with our PLM software, enabling them to plan products faster on a digital basis. That is just one example we are proud of. Part of the reason for this success is that our development teams consistently take one of the traits of the digital age to heart – they enjoy trying things out.
Digitalization

Thinking beyond the next bend in the road

Product Lifecycle Management (PLM) software from Siemens makes it possible to digitally plan products long before production begins – a business worth millions for Siemens. Part of Siemens’ success comes from a start-up mentality – as a visit to a PLM workplace in Tel Aviv illustrates. →
Tali Segall, Head of innovation for Siemens PLM Software’s Manufacturing Engineering solutions business segment in Israel

“It’s always fun to learn new things.”

A company that simply continues to rely on whatever was successful in the past can no longer survive in today’s business environment. Those who are standing still will soon be left in the dust.
available to everyone involved. Simple as it may sound, this process is crucial. An engineer who has all the data he or she needs in a single, secure system can make faster, smarter, information-driven decisions at every stage in the product lifecycle.

Thanks to simulation using digital twins - virtual objects that are identical to their real-world counterparts - PLM makes it possible to test all kinds of objects in realistic situations ahead of time and to optimize their production processes. This applies to high-volume parts, such as those produced in the automotive industry, as well as special fabrications, such as a catamaran that competes for the America’s Cup title, a rocket such as an Atlas V, or a space taxi such as the Dream Chaser, all of which were created with PLM software. It even applies to winning cars on the Formula One circuit, which share a characteristic with the competition-level catamaran: Each is a constantly-changing prototype that continues to be optimized during use, which means that it is continuously redesigned.

Companies that wish to thrive on global competition must implement digital technologies.

“The same technological advances that drive and enable product innovations also lead to new ways of producing products; we call this digitalization,” says Chuck Grindstaff, President and CEO of Siemens PLM Software. “For manufacturers who wish to take advantage of digitalization’s opportunities, the journey begins with establishment of a solid PLM backbone. Considering the rate of change going on today, companies are under pressure to innovate not only their products but their business models as well. Becoming a truly digital enterprise with PLM software lets manufacturers do just that, regardless of their industry, and to develop the very innovations that will give them a crucial competitive edge,” he adds.

But the underlying software must in principle also be designed just like a Formula
One car: as a constantly-evolving prototype, a race car that cannot be left in the dust by competition from smaller, more agile start-ups. “We have to think beyond the next bend in the road,” says Segall.

Segall, the mother of four children, is the ideal person for handling the task of helping give a large business the agility of a start-up. More than twenty years ago, while still a computer science student, she began working with Tecnomatix, which at the time was a small start-up in Tel Aviv. Today, the technology that the company brought to Siemens through an acquisition has become a comprehensive product portfolio of digital manufacturing solutions and an essential facet of Siemens’ overall PLM offerings. The hackathons, five of which have already been held worldwide, are only one of the ways in which she has turbocharged the creativity of her team. But they are the methods that deliver the most results. At the same time, they reflect the two maxims that Segall holds up to her staff: “Everything is possible in software. And it’s always fun to learn new things.”

Taking a page from the start-up scene, hackathons are turbocharging innovation.

During the hackathons, the software regularly learns something new. The biggest event to date, which was held in Pune, India with the participation of 600 local Siemens employees, resulted in an application that can be used to control PLM 3D software with voice recognition. “You just tell the product on the screen to turn 90 degrees and it turns 90 degrees,” explains Segall, who still finds this exciting today. The application has not yet been turned into a product. But when that time comes, it will have met Segall’s stated goal: to have produced a new, cool tool that brings value to the customer or possibly even solves a problem the user was not aware of. ➔

Hackathons

Developing something cool for the customer

“Hackathons” involving hundreds of participants can turbocharge the innovation process.
Software development

Everything is possible with software

During the hackathon, Siemens programmers had 36 hours to write a software program for their idea.
Digitalization

Growth engine of the future

Is data the 21st century’s equivalent of oil? Will machines plan their interactions themselves in the production environments of the future? Questions like these are occupying the minds of specialists at Siemens and its customers. What is already clear, however, is that digitalization is the most important growth driver for the future.

Data is not valuable in itself. Only in context is it useful and able to help us reshape the world. What counts is not big data but smart data. One example is Sinalytics, Siemens’ company-wide platform for industrial data analytics, which we are already using to monitor and check some 300,000 systems all over the world – systems such as gas turbines, traffic control centers in more than 200 cities and entire skyscrapers – using advanced IT measures to ensure data security.

Digitalization is one of Siemens’ specialties. Power plant technology, electrification and automation through self-learning programs, self-diagnostics and state-based maintenance – the digital transformation covers all of these businesses.

What’s more, we have given substance to the concept of the Internet of Things for Siemens. In our electrification and automation domains – the real world – we have invaluable expertise that we link to the virtual world of digitalization. In our approach, which we call the Web of Systems, we use web technologies to turn devices and machines into the starting point for digitally-networked industries. Specifically, this means that such technologies do not send unfiltered data to cloud applications, but that they interact with each other and understand each other because the transmitted data includes its meaning. We connect our knowledge from the devices and link it to our expertise from all other sectors. Whether it’s energy suppliers, traffic control centers, buildings, manufacturing or process industries, we can generate added value for our customers with the aid of the Web of Systems.

We want to build on advanced technologies like these. We recently polled hundreds of our customers about this. Many said that Siemens is a thought leader when it comes to digitalization. It is, of course, even better to realize the future than think about it. We are already working on this together with our customers – in the digital and real worlds.

As digital technologies take hold, output in many areas increases

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<th>FUTURE OF MANUFACTURING</th>
<th>NETWORKED ENERGY</th>
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<td>Siemens TIA portal reduces engineering costs by up to 30%.</td>
<td>Smart grid technologies enable the integration of renewable energy sources into the grid at up to 40% lower costs.</td>
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<td>30%</td>
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<td>Thanks to PLM software and automation, products get to market up to 50% faster.</td>
<td>Self-learning software can predict the electricity output from renewable sources over a 72-hour period with 90% accuracy.</td>
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<td>Intelligent building technologies reduce energy costs by up to 40%.</td>
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<td>Thanks to intelligent traffic solutions, there are up to 20% fewer traffic jams, accidents and CO₂ emissions.</td>
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Digital modeling made easy

Douglas King and Howard Mattson
Software experts at Digital Factory, Cambridge, United Kingdom

With synchronous technology, on-screen modeling has become easier and faster. To be really innovative, Mattson and King need their freedom: “Innovative ideas do not only arise in the office but also in the park – or in the pub.”
Finding the code that saves lives

Mamâdou Diallo
Software engineer at Healthcare, Princeton NJ, USA

Ultrasound images that integrate with CT or MRI images: The innovation eSieFusion™ imaging provides physicians with an unparalleled glimpse into the human body. Thanks to Diallo’s invention, biopsies and tissue ablations can be conducted in a safer, more precise manner.
New paths to new ideas and new businesses

Reinventing the way we invent
The research laboratories at which people worked behind locked doors years ago are not where the innovations of the 21st century will come from. Today, a new, more open kind of collaboration is needed.

Crowdsourcing of ideas and, in the field of software, hackathons now belong to day-to-day life at Siemens, as does active cooperation with universities, research institutes and small, agile start-up companies. Not only Siemens profits from this – its partners also benefit from the experience, resources and global presence of an international group.

Start-ups often have a good idea and motivated employees but lack the resources needed to make successful products. The fact of the matter is: most newcomers fail. The money often runs out. And the ideas are not ready for prime time. If, on the other hand, a start-ups ideas are very good, other companies are sometimes faster to market. Here, it is helpful to collaborate with a strong partner. Open innovation processes benefit everyone, including customers and consumers, by letting good ideas turn into products more quickly.
New paths to new ideas and new businesses

Dream it, make it, share it

→ The frames of two half-ready drones are lying in the corner and one of the 3D printers is humming away, building a structure from a thin spray of blue plastic. At the workbench, a young Siemens researcher is assembling a robotic arm from the components. Engraved by a laser cutter in a garish green sheet of acrylic glass, the motto of this high tech lab for tinkerers hangs resplendently at the entrance: “Dream it. Make it. Share it.”

Dream it. Make it. Share it. These words describe the goal of the Maker Space, which Siemens Corporate Technology (CT) has set up at its research site in Munich. All of the company’s employees can use this space with its high tech tools – not just the roughly 32,100 researchers and developers. And it does not matter whether they are tackling a tricky task for a Siemens project or want to print plastic toys for their children.

“The main thing is that people use the latest technologies and have fun,” says Oxana Ryashentseva, a CT employee.

“Here, on the left, are two of our 3D printers for building plastic parts. Back there, in the corner, you can see a printer for larger parts made of gypsum. We also have a computer numerically-controlled mill and a laser cutter. The only thing that’s missing is a couch to relax on,” says Ryashentseva as she adjusts a soldering iron.

The whole environment has the feel of the proverbial garage in Silicon Valley – a place where ideas can be tried out without compulsion, without instructions, and sometimes without a specific goal. But often with amazing success. That is what freedom of research looks like at a large group.

“Innovation cycles have become much shorter,” says Falk Wottawah, Head of Visioning and Scouting at Siemens Corporate Technology. “That’s why we are breaking up conventional research and development processes at many points. We are also mixing teams far more. To get a good result fast, you need more than a single perspective.”
Drones that inspect rotor blades for damage

Another way to open the door to innovations lies in idea contests. Siemens held its inaugural “Quickstarter” contest in 2015. This was not about getting ideas from outside but from employees of Siemens Corporate Technology. The thinking behind the contest was to allow everything, including ideas for which the market seems too small at present or which may never be realized. In all, 111 suggestions were submitted within six weeks. One of them was the idea to have drones fly up close to wind turbines to inspect the huge rotor blades for damage.

The special thing about Quickstarter is that the best suggestions are not chosen by department heads but by employees. Some 250 researchers and developers were able to spread half a million euros over the projects. This gave rise not only to astonishing prototypes but also to real projects that are already in progress, such as a cooling enclosure for cameras inside a gas turbine.

Only a plastic model with fine cooling ducts on the surface exists at present, but when the metal enclosure has been made it will hopefully be possible to film in the interior of a gas turbine, where temperatures can reach 1,300 degrees Celsius. The goal is to optimize these technological wonders and detect damage on the spot. The model of the cooling enclosure came from one of the 3D printers at Maker Space.

Examples like these do not harmonize with traditional innovation processes – which is why they are so valuable. It is not the first time that companies have had to reinvent the way they invent. Innovation models have changed often. Some
Maker Space: Munich’s Creativity Workshop

A place where ideas can fly

That is what freedom of research looks like at a large group. At Maker Space, creative use of the latest manufacturing tools is not limited to the company’s 32,100 researchers and developers. Any employee can give his or her dreams a chance to fly – without pressure – but often, with surprising success.
170 years ago, geniuses like Werner von Siemens could still undertake innovations almost singlehandedly. But just 50 years later, most inventions had become so complex and required so many resources that they could only take shape in the laboratories of large corporations. Now, small and agile start-up companies frequently have the ideas that shake up entire industries. All of this adds up to is a huge opportunity for Siemens. With product lifecycle management (PLM) software, for example, Siemens’ customers can simulate their own products before going to the trouble of making physical prototypes. Many Siemens specialists developing PLM software began at start-up companies themselves.

Golden path to sustained growth

The underlying principle is always the same: creation of the new and destruction of the old. The Austrian economist Joseph Schumpeter described creative destruction as the golden path to sustained growth. New technologies break the ground for superior business models that put an end to the old ones. In days gone by, this was the invention of the steam engine or the automatic loom. Today, we use Internet and cloud solutions and gain knowledge through the intelligent use of smart data and the ubiquity of smart phones. Only by combining these technologies and applying them creatively can companies like Google, Amazon, Uber and Airbnb come about and grow into international giants within a few years.

Such companies have made life easier for all of us in one way or another, and many services have become cheaper. E-mail is free. Books arrive without a delivery charge. Taxis can be ordered by mobile phone. Similar revolutions are emerging in industry and power generation. Product development, manufacturing and logistics chains – technological disruption will not leave these fields untouched either. There will be losers and winners in this process. All of this adds up to is a huge opportunity for Siemens. With product lifecycle management (PLM) software, for example, Siemens’ customers can simulate their own products before going to the trouble of making physical prototypes. Many Siemens specialists developing PLM software began at start-up companies themselves.
Agile, complex, diverse: The new world of innovation

From electrical grids to global social networks – not only the nature of inventions has changed over the past 170 years but also the way we invent. While in the past it was individuals like Werner von Siemens, Henry Ford and other thought leaders who developed pioneering ideas, in more recent decades it has mostly been corporate groups that have created the environment in which innovations thrive.

Today, the world is faster and much more diverse than it used to be. Small, flexible start-ups focusing on very specific business ideas are redefining market rules with trailblazing innovations. For a long time now, universities have not just researched for the sake of it but have been actively looking for ways to realize their findings on the market. Completely new innovation processes now make networking possible to a hitherto unknown extent. And Siemens is creating structures that foster innovation to act as a node in a global research network, thus driving the next generation of innovations.

Werner von Siemens, Henry Ford, Thomas Alva Edison: three names that stand for pioneering inventions that brought about epochal changes in the private and working lives of their fellow human beings. Whether electrical engineering, the production line or the light bulb, what unites these different inventions is the fact that a clever mind came up with them.
Crowdsourcing of ideas

For years, Siemens has been looking for exciting ideas on public crowdsourcing platforms and in internal idea contests. One example is Quickstarter, where researchers and developers at Corporate Technology distribute money to projects for which their colleagues came up with the ideas. Adequately financed ideas are implemented without any further decision by management. In 2015, 111 suggestions were submitted within six weeks.

Interchange and collaboration platforms

Who can help? Innovators at Siemens can use the structure of a large group and, within seconds, request support from more than 44,000 experts worldwide simply by clicking on the company’s TechnoWeb social network. The same applies to protected groups on the Siemens Social Network (SSN), an internal network.

Partnerships with universities and research institutes

Siemens conducts long-term research into key technologies together with universities of global renown via the CKI program (Center of Knowledge Interchange). These strategic partnerships are supplemented by individual scientific work that Siemens commissions at universities and research institutes around the world and by many publicly sponsored joint research projects.

More open innovation processes

Investments in start-ups

The Siemens Venture Capital (SVC) unit identifies young companies and finances them during their start-up phase. Siemens has been investing in innovative start-up companies for 20 years. With more than 800 million euros invested in over 180 start-ups to date, SVC was one of the top 10 corporate venture capitalists in 2014.

Founding start-ups

Siemens Novel Businesses (SNB) founds start-ups in areas that Siemens is not currently active in, but which could be relevant to its activities in the future. SNB also rapidly and flexibly tests new business models that hold the potential to integrate them in the Company if needed. As is the case with Siemens Technology to Business, SNB is part of Innovative Ventures, a unit of Siemens Corporate Technology, which is a key interface between Siemens itself and the world of start-ups.

Cooperation with start-ups

Siemens works closely with start-ups throughout the world via its Technology to Business (TTB) unit, which is based in Berkeley, Shanghai, Munich and soon in Tel Aviv. To find the best ideas with a view to cooperation, TTB scouts contact over 1,000 young companies every year, hold conferences in the context of so-called New Ventures forums, attend network meetings and entrepreneur events, and offer accelerator programs such as Rescale and Frontier.
example, is a small company that offers a simulation environment in the cloud and consequently supplements Siemens’ portfolio of PLM software.

Since they have no legacy technology or business to protect, start-ups can move quickly in new and disruptive markets. The Frontier Partner program, a collaboration between Siemens PLM Software and TTB, is designed to involve Siemens in some of this fast innovation. The program grants manufacturing-focused start-ups access to Siemens’ industry-proven PLM software. Start-ups selected for the program can build on this software to accelerate their time to market. In addition, they can join the Siemens PLM Software technology partner program and receive additional development resources.

Fifteen start-ups are currently taking part in the initiative, which was launched in June 2015. Sven Scheuble, Head of Siemens Technology to Business, explains the benefits of such cooperation: “We hope the Frontier partners will give us better insight into aspects of the rapidly changing robotics and 3D printing markets. We also hope that they will provide us with valuable feedback regarding the Siemens PLM portfolio. The input from these start-ups means that a greater range of solutions is available for our customers.”

A long time ago, Siemens was a start-up too. Driven by good ideas, hard work and a bit of patience, it evolved into a global company – one that keeps reinventing itself. What’s more, it keeps reinventing how it invents.

We mostly start with a working hypothesis. We trawl the web on the basis of our search algorithms and, when we find something, we approach our research teams as well as the appropriate Business Units. Together, we then clarify whether the trend has business potential for Siemens,” Blumoser explains, adding that if you recognize and pick up trends at an early stage, you can turn them into opportunities. But if one waits too long, they can become a problem. That is one of the basic rules of disruptive innovation.

Start-ups and innovations that fit Siemens

“Start-ups are important for Siemens. For us, they are a look into the future. That’s why we work closely with start-ups throughout the world via our Siemens Technology to Business Centers,” says Rudolf Freytag, CEO of Siemens Innovative Ventures. “And via Siemens Novel Businesses, we establish start-ups outside the Group and can thus test business models that might be relevant for Siemens in the future.”

The Siemens Technology to Business Centers in Shanghai, Berkeley, Munich and soon in Tel Aviv actively approach small technology companies and look for exciting innovations that could foster Siemens’ business. The company’s activities here extend from initial contact through the test phase to cooperation on a contractual basis. Experts at Siemens Technology to Business (TTB) talk to more than 1,000 start-ups each year, resulting in about 20 research partnerships a year.

This enables Siemens to recognize trends and new business models faster and gain early access to promising innovations and to the people behind them. Rescale, for example, is a small company that offers a simulation environment in the cloud and consequently supplements Siemens’ portfolio of PLM software.

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Start-ups with potential for Siemens

Having ideas that can revolutionize existing markets. Generating business that could be relevant for Siemens in the future, particularly with the help of start-ups. This is Claudia-Camilla Malcher’s job description. A venture manager at Siemens Novel Businesses (SNB), Malcher is responsible for disruptive business ideas.
Jerome S. Engel, a player in Silicon Valley’s start-up scene

“Large companies must take a more playful and courageous approach to innovation.”

Large companies have to learn to operate ambidextrously, and continue to pursue their core areas of expertise while experimenting elsewhere.
Wherever new technologies or new trends develop, Siemens is there. An interview with innovation expert Jerome S. Engel.

**Is it possible for large, established corporations to be as innovative as start-ups?**

**JEROME S. ENGEL** No, not in such a disruptive manner. Innovations, such as the ones developed by start-ups in Silicon Valley and elsewhere, don’t fit easily into the relatively rigid structures of large companies, because they rely on constant experimentation, and they’re accompanied by a lot of uncertainty. On the other hand, the innovations supplied by established companies have been incremental, consisting in small steps. They generally only improve on what’s already successful. As a rule, a corporation will also take care not to promote innovations that undermine its own business model. However, large companies are masters at putting plans into action – whether it be for improving their products, manufacturing them efficiently, or global sales and marketing. If companies manage to use this backbone to take a more playful approach to innovation in individual fields – and pursue a strategy of relying on their strengths for support while taking some risk – then they can be very successful too. But courage is needed to take that step.

**How can established companies and start-ups benefit from one another?**

**JEROME S. ENGEL** Corporations and start-ups can complement one another with their own particular strengths. But there is still room for improvement in the open innovation model with regard to the interaction of large companies and recently established market participants. Large companies have to learn to operate ambidextrously, and continue to pursue their core areas of expertise while experimenting elsewhere. Many companies have already started to go this route by acquiring start-ups that might not involve their core business and letting them operate largely on their own. Siemens, for example, does this very well with its Technology to Business (TTB) centers in Shanghai, Munich, Berkeley or soon in Tel Aviv. Whenever new technologies or new trends emerge whose development holds great potential, the TTBs’ scouts are on the lookout for start-up companies that may be of interest to Siemens. There has to be room in established companies for this kind of true open innovation.

**When it comes to innovation in the digital age everyone thinks of Silicon Valley. Many have tried to copy it. Why has no place been so successful as the original?**

**JEROME S. ENGEL** Silicon Valley is not the only innovation cluster, although it’s a very successful one. There are also innovation clusters in Israel, Germany, Taiwan, and other places. They all have similar characteristics. And that goes beyond just a certain set of components and players, such as start-up founders, venture capitalists, and established companies. These ecosystems are characterized above all by a certain behavior: highly mobile resources, money, people, and knowledge. Think, for example, of Mark Andreessen, who founded the web browser company Netscape and is now a venture capitalist. The people involved in Silicon Valley are constantly striving to create and drive forward innovations that have the potential to change the world – and they are willing to experiment and also fail. And ultimately, they’re pursuing goals that they can’t achieve alone but only collectively. Entrepreneurship and innovation are the order of the day here, and it can pay off in a big way for many – not just those at the top. The Twitter IPO created about 1,600 millionaires at one stroke; the Facebook IPO over 1,000. Add to that the ripple effect as that wealth is consumed and you can see that it can have a massive effect in terms of energizing and motivating an entire community.
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Innovation at Siemens

Pictures of the Future