ABB Group Annual Report 2000

Technology Report

Brain Power.™

ABB

This is ABB

ABB (www.abb.com) serves manufacturing, process and consumer industries, utilities, and the oil and gas sector, with 160,000 employees in more than 100 countries.

Robots achieving the highest precision of laser cutting with specialist software.

Perfect control saves millions in oil and gas exploration.

Tuning ship and vessel systems to save time and money.

ABB networks with a number of top universities, developing software, ideas and talent.

Consistent and reliable power, even in remote locations.

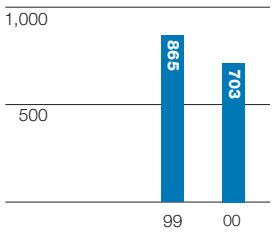
Smart solutions for fresh air can cut energy bills by 65 percent.

Industrial IT software product families.

Contents

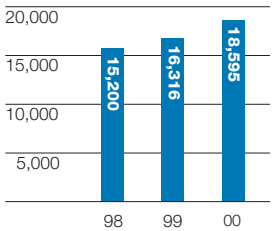
Key figures

Group investment in research and development*
($ in millions)

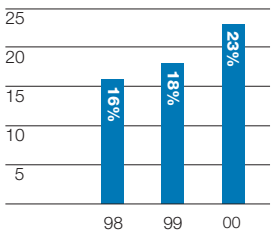


*per US GAAP Reporting

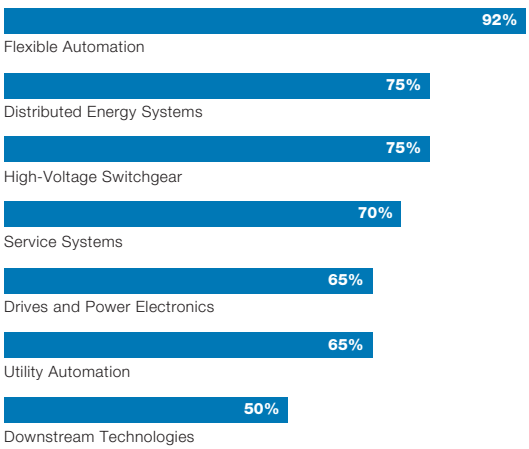
Total number of patent applications



Percentage of software-related first filings to total first filings
(%)



Intensity of innovation:
Percentage of business based on products developed in the past five years



Innovating for customers around the world

Among the hardest – and therefore most stimulating – challenges for business is devising the right responses to fundamental shifts in the business environment – not only what to change in the company's strategy, business portfolio or organizational model, but also how to implement the change.

Our new, customer-oriented organization, is a response to what we call the silent revolution. In a nutshell, the silent revolution is the combined impact of globalization, deregulation, privatization, industry consolidation, new information technologies – and more. In other words, more and faster change.

We asked ourselves how we should change to help our customers become more competitive. Let me structure the answer in three parts – what we offer customers, how new technologies invigorate our offerings, and how we organize ourselves to become easier to do business with.

ABB is a business-to-business supplier, in more than 100 countries around the world. We have world-class products, systems and services that boost efficiency and productivity while minimizing energy consumption, raw material usage and environmental impacts. And we have deep insights into the market conditions, business dynamics and competitive success factors of our customers.

As to innovation, technology is key in our industry. Our own research naturally focuses on providing the next generation of products and services, responding to as well as anticipating customer needs. But in addition to that, we are embarking on a mission to create one single Industrial IT architecture for our entire range of technologies and products. This, briefly, means that we aim to seamlessly integrate ABB's offerings wherever they are used. Plug and produce is the catch phrase – giving customers the power to manage complexity in real time, all the time.

A great enabler here is the Internet, and new Web-based technologies that allow the forming of dedicated online communities along the whole value chain – linking suppliers, manufacturers and customers in real-time collaboration. That is one additional advantage of an integrated Industrial IT architecture.

So what could we do to become easier to do business with, and better enable our customers to capitalize on technological advances and the developments in their markets?

To build on the power of being close to customers, we're organizing into six customer divisions. Four of them focus on customers who are end-users, wrapping all ABB products and services into their portfolios – Utilities, Process Industries, Manufacturing and Consumer Industries and Oil, Gas and Petrochemicals – while the other two serve external channel partners like wholesalers, distributors, original equipment manufacturers and systems integrators – Power Technology Products and Automation Technology Products. In addition, we have created a business area called New Ventures, to incubate opportunities even faster.

We are making these changes to our organization alongside the drive toward a single Industrial IT architecture to fulfil our vision of ABB as *The* Value Creator, where customers have easier access to ABB's entire range of technologies through one common interface.

In these pages, we are proud to share with you how our technologies support this vision. How Brain Power is put to work, and how ABB builds knowledge for tomorrow's world.

Jörgen Centerman

President and Chief Executive Officer

Creating value through technology

The traditional image of a researcher or developer is often one colored by solitude and anonymity – the lab-coat wearing, persistent and bespectacled professor toiling away with gadgets and computers, test tubes and microscopes.

It is an image that isn't entirely incorrect. We do work hard and we do work long into the night to develop breakthrough technologies that change the way the world works and the way industries do business. And, often we are fanatical in the way we strive to improve our rates of innovation and maintain our scientific integrity.

What needs to come through more clearly in these days of rapid globalization and feverish competition, is value. Delivering value to customers, shareholders and ourselves is a simple concept – but it is often poorly executed. What we've learned inside ABB is to pursue research and development that delivers solid returns for the customers who buy our products and systems. At the same time, we must continue pushing the limits of convention.

In the pages that follow, you will see only a snapshot of what we do here inside the laboratories of ABB. But, I think this simple snapshot reveals a portrait's worth of information. It is culled from our business areas and our 15 corporate programs, which you will also see outlined in this book, from the many university cooperations we have around the world, and even from some of our most intensive joint ventures.

We have grouped this year's achievements around four main platforms of development. They are:

- Industrial IT and its applications
- Electrical systems technology
- Oil, gas and petrochemical technology
- Sustainability and alternative energy technology

This platform approach allows our finest minds to concentrate on research that has tangible values across all our businesses – to meet customer demands for everything from windfarms and robots to power electronics and Industrial IT enabled systems for asset management.

In the Industrial IT section, you will see the concept as a vision, an architecture, a business model, and an integrated technology strategy. This report outlines the technology behind Industrial IT and shows it at work in 19 or 20 technology applications. In the future, every single ABB technology will be Industrial IT enabled.

Electrical systems technology is the study and development of power electronics (devices and components), power products and systems, high-voltage electromagnetic systems, micro-electromechanical systems (MEMS) and sensors and actuators.

Oil, gas and petrochemical technology includes, but isn't limited to, upstream separation and control, both on the seabed as well as on platforms and downstream; catalysis and chemical processes, mechatronics – using advanced materials and smart controls; and nanotechnology, which I will come back to later.

Industrial IT and its applications

Page 8

Electrical systems technology

Page 32

Oil, gas and petrochemical technology

Page 46

Sustainability and alternative energy technology

Page 62

ABB has grouped this year's achievements around four main platforms of development.

And, last you will read about ABB's sustainability and alternative energy technology. This platform covers innovative distributed power solutions – from wind power to fuel cells, microturbines and combined heat and power – straight through to new solutions for online engineering systems and specialized meters for energy management.

Some further highlights of the report:

- ABB's most recently developed Industrial IT software products.
- ABB's high precision robot control system for laser cutting.
- The Compact Azipod ship propulsion system cuts the time needed to build and fit to a ship and allows for underwater maintenance.
- The intelligent communication sensor searches for faults in power lines in remote areas.
- Superconductive current limiters – using materials that allow electricity to flow through them with no resistance at all.
- ABB's coalescer and cyclone, offshore oil technologies for purifying the oil stream.
- Hydrocracking technology, developed with a joint venture partner, to produce cleaner fuels.
- The Motorformer cuts energy losses in motors, reduces the need for polluting oil insulation and saves space. This invention builds on ABB's other Former family products like Powerformer and Windformer.
- Armada software – for condition-based predictive maintenance in plants and utilities.

■ ABB's advanced silencer cuts out noise in buildings' heating, ventilation and air conditioning systems.

You will note throughout the report this year that we outline some of the work we do with universities around the world in each technology platform area. In Industrial IT and its applications, for example, you will read about ongoing work at Carnegie Mellon in the United States. In electrical systems technology you will read about our cooperation with the Massachusetts Institute of Technology (MIT) in the United States and Cambridge University in the United Kingdom. Similarly, in the area of oil, gas and petrochemicals, you will read about our clean fuels programs with several leading academic institutions.

More, each section of the report outlines the strategic, long-term corporate programs that are in place to support the technology platform you are reading about. Last, we've tried to outline some of the interesting technology joint ventures we have with other leading companies. For example, in sustainability, ABB is cooperating with Volvo to develop microturbines (page 66) and DuPont to develop fuel cells (page 74).

Looking ahead, some areas of emerging technology fit with the way that ABB approaches the development of innovative new systems and products. They are software, nanotechnology, wireless communication and micro-electromechanical systems, or MEMS.

Software – both related to our products and as an enabler to our processes – is the technology that will make us tick going forward. We will continue to pursue promising areas of software development like component, middleware and integration technology, data mining, agent technology, Internet applications and software engineering.

Nanotechnology is about creating and understanding materials and structures on a much smaller scale. Once we understand how materials are comprised on a molecular level it becomes possible to re-engineer them so that they are easier to control. We can enhance certain properties, like electrical conductivity or heat resistance, to tailor-make the materials for new applications.

Catalysis is a prime example of nanotechnology in action, where ABB is already finding ways to optimize the production of petrochemicals (page 46). But it applies equally to electrically conducting or insulating materials, or to components for fuel cells or solar cells – advances that will be crucial in the development of more efficient and environmentally friendly energy production.

Nanotechnology is also critical in the development of sensors and control systems, particularly in building measuring systems that operate faster, more efficiently and reliably in different production environments. This microscopic understanding holds the promise of making systems that can be shrunk so that they are easier to integrate.

The next level up is micro-electromechanical systems (MEMS). This is the technology for inte-

Research and development inside ABB means delivering tangible results for customers – making them faster, more efficient, and more profitable.

grating intelligence – computer and communication – with mechanical structures at the microscopic level.

Since chip technology is the driver for MEMS, we can expect enormous cost savings, as the number of components that can be fitted on a chip doubles every 18 months. Other benefits are easily noticeable: increased functionality, greater energy efficiency, less use of consumables, higher reliability, etc.

Wireless promises to be the technology to watch in the next year. We are on the brink of a revolution in wireless technology which will for the first time – whether in short-range radio systems like Bluetooth or wireless local area networks (LAN) or in longer range mobile systems – allow for efficient connectivity, all of the time. We are getting closer to realizing the vision of the fully-linked enterprise – one needs to look no further than our Industrial IT platform to see the potential of powering our engineers with wireless monitoring and testing devices.

The mobility and responsiveness that this will allow in a whole range of industrial applications – from remote system operation and data transmission, to supporting sales, maintenance and servicing – are only now becoming apparent. Combined with broadband and collaborative technologies, wireless will enable us to further develop a range of customer-oriented solutions.

The speed of innovation, both inside companies like ABB and in the world of academic research, means that any technology company worth its salt must be serious about stimulating inventiveness. And it must be earnest about getting its scientific experts and engineers to work quickly to realize the value of their work and register their inventions. ABB dedicates huge energy to making that process work effectively.

Increasingly, we are inventing the information technologies needed to track the value of research and development and to speed up the processes of the customers we serve. This clear strategy, marked by our strong and early move into advanced industrial software development and into the provision of value-added services, has given us a step up on the competition. We aim to stay ahead.

Investments like these, coupled with what we consider a great team of multicultural scientists and engineers, are helping to pave the way for increased customer and shareholder value.

Enjoy.

H. Markus Bayegan

Chief Technology Officer, ABB Group R&D and Technology

Industrial IT and its applications
Technology for plug-and-produce

ABB's customers, from pulp and paper manufacturers to power plant operators, are using a large and increasing variety of information systems for different parts of their operation. They track data for control functions, maintenance, security, planning, administration; almost every part of the operation is controlled and monitored. Integrating these separate systems has long been difficult – no surprise given that many parts of those systems are often based on different standards and software.

Some time ago, ABB invested heavily to build a series of products, systems and associated software geared toward burgeoning customer segments. At the time, in the late 1980s and early 1990s, this series was targeted at utilities, the oil and gas market, metals and minerals, pulp and paper, chemicals, consumer goods, the automotive industry...you get the picture – much the same customer segments we now divide our businesses into. What those first developments led to was the foundation for what we call Industrial IT – a powerful set of products, systems and software designed for plug-and-produce – the linking together of all objects and IT in a factory, plant, utility or building.

Generally speaking, integrating IT systems to bigger and bigger systems can, however, create big risks and new problems. Large systems are complex. It is increasingly difficult to find the right information at the right time. For example, searching for the maintenance data about a specific valve or the quality data for a production batch is a very specific requirement amidst the clutter of thousands of other data.

Simple approaches to dealing with this

Strategic, long-term corporate research programs to support Industrial IT and its applications

Manufacturing technologies
Supporting the growth of manufacturing with emerging eTechnologies. More, setting the foundation for flexible, customer-oriented, demand-supply networks with improvements from the design phase to the actual manufacturing process.

Engineering and service technologies
Developing new Web-based software solutions to ensure a collaborative engineering environment. This means better linking information systems and interfaces in design as well as service and maintenance. Internet technologies also allow customers to directly influence the fully-customized design of their products and systems.

Software technologies
Boosting the ABB Industrial IT platform by emphasizing software development and technologies to allow maximum reuse of information, especially in complex environments. Developing additional software components to further support and enable full integration of data from device to enterprise level.

Control and optimization
Developing information technologies as part of advanced control schemes. Using algorithms and optimizers to offer new possibilities in total plant management and asset optimization; this is a key technology platform for future needs.

Wireless communication technologies
Wireless communication is a booming technology in many areas. ABB is working to combine technologies from telecom and office applications with robust industrial technologies. This research lends itself to increasingly profitable industrial applications, such as wireless sensors and controls.

See also **MEMS** and **Mechatronics** in areas two and three.

complexity – like search engines and sorting along the time-axis – do not meet the more stringent requirements of today's customers.

The basic idea behind ABB's Industrial IT architecture is to group all the information of a plant around the "Objects" important to an operation. Objects can be anything from the installed equipment, for example, robots, vessels, valves, transformers, switches, motors or drives. Objects can also be products produced in the plant, like automobiles, pharmaceuticals or even electricity. Objects are in many cases intangible things, such as sales or manufacturing orders or even recipes for a certain product.

By clicking on an Object icon, for simplicity's sake a robot, a menu appears which shows all the information connected to that Object. This includes, but isn't limited to, design drawings, control diagrams, maintenance information, location, and quality information. These different pieces of information, consisting of data and programs performing specific functions, are called the "Aspects" of this specific Object.

A typical industrial plant is made up of a very large number of such Objects (a large plant has some 50,000 Objects) and each of them has a certain number of Aspects (typically, each Object has less than 100 Aspects). These Aspects are often covered by third-party software – an often difficult integration scenario. To tackle this problem, ABB's Industrial IT software supports the Aspect Objects structure in a way which is totally invisible to the user. It is based on open standards, namely Microsoft component object model (COM) and object linking and embedding for process control (OPC), to ensure data consistency, flexible

Teaming with top universities

ABB works closely with many of the best universities and research institutes around the world. Describing these links as "a strategic tool of technology management," the company is involved in projects with such renowned universities as Carnegie Mellon and the Massachusetts Institute of Technology in the United States, and Cambridge University in the United Kingdom. In all, ABB works with some 70 academic establishments.

Industrial IT and its applications

ABB's links with Carnegie Mellon continue to bear fruit. A key project is the development of a tool to test the reliability and robustness of software.

Robustness in software is critical, especially in industrial applications. Can it take the repeated and non-stop load of data processing typical of, for example, industrial monitoring and control applications? How often does it "hang up" or crash on users? These issues are key factors in software development and deployment and in system maintenance and costs.

Carnegie Mellon and ABB have developed a test code-named Ballista – a reference to the ancient siege weapon Ballista that "tested" the robustness of military defenses – that measures the ability of software to handle exceptional and repeated inputs. ABB software developers have used the test to significantly reduce the overall failure rate of an ABB program and the number of system "hangs" by 88 percent.

expandability and third-party software integration, among other things.

Staying with the industrial plant analogy a little longer, you can see how the plant operator can access information in exactly the way he is used to thinking about the plant. If the operator wants to see the maintenance data of a valve, he just clicks on the valve icon and goes in the menu appearing in the maintenance aspect. Similarly, if a utility operator wanted to see the performance data of a transformer or a set of transformers, he would only need to click on the transformer. An Object can also be a more complex part of a plant, composed of a number of smaller Objects. Take a production line, which can be monitored as a whole, or as it would look broken down into its functional parts, robots, conveyors, sorters, flow meters, etc. Industrial IT software supports the building of such complex structures and maintains consistency throughout the architecture. One huge benefit here is that the stored data enables an operator to perform powerful simulations – to enact a robot's movements, or test the changeover to a new batch of pharmaceuticals, for example.

In many ways, ABB's Industrial IT concept is for industrial use what Microsoft technology is for desktop applications. Customers can map their plant and their processes into this structure and describe the plant in the language they are used to.

Industrial IT – powerful plant engineering

Industrial plants are subjected to continuous improvements. Modifications are made, extensions built and equipment added to existing systems. Traditionally, modifications required a lot of engineering before the new parts fit into the existing system – and often errors occurred during this tedious work.

Now, a plant operator who wants to install a second production line can "engineer" the IT system just by copying-and-pasting the existing line. If the second line needs some modifications, those can be added – and the Industrial IT system in the background does the rest, ensuring data consistency and full connectivity to all aspects of the system. This copy-and-paste operation can be done for a single piece of equipment, for a subsystem or a complete part of the plant. Additional Aspects can be added as needed and all this is done in the natural language used by plant personnel: The plant Objects are described as what they are – pumps, actuators, valves and meters, cars, paper, pills and pallets, and their Aspects – range, capacity, speed, output, productivity, capacity, cost of ownership – are collected in an easily used environment.

Naturally, this information allows faster device installation, sets the Object in context – so an operator can simulate the flow of a line of pharmaceuticals, for example, or determine the number of staff an operator might need to deliver a large pulp or paper order.

Industrial IT – future solutions for asset management

Asset management, the follow-up of actual data from the many valuable pieces of equipment operating in a utility, is a core activity during these days of deregulation and privatization. Competition, the demand for cheap energy, mergers and acquisitions – all factors demanding comparative data from transformers, switchgear, cables; in short, from all parts of a modern utility.

Today, these data are typically stored in dedicated and proprietary IT systems. The systems, from SCADA to a variety of monitoring applications, usually provide limited data exchange functionality with other applications. Take for example, maintenance data from a transformer, which ordinarily can't be exchanged with geographical information systems (GIS) indicating the transformer's location.

Industrial IT, with its underlying Aspect Objects framework, is particularly suited to this task. The reason for this is simple: Many utility installations have the same type of devices, whether they be switches, transformers, tapchangers, or converters. This highly repetitive structure is ripe for analysis. Once a structure – Industrial IT's Objects and Aspects – is defined for a transformer, for example, this can be multiplied by copy-and-pasting to the thousands of transformers the utility is using. The Industrial IT software ensures consistency and connectivity between each part. And, the Aspect Objects framework allows existing IT systems to integrate and share applications with new IT systems – no reengineering is needed.

Once the asset data is collected and integrated, the utility operator will have a very powerful information tool at his disposal. He can monitor which equipment is due for maintenance, how many transformers are delivered by a certain supplier, or which correlation exists between failures and operational overload. More complex problems can also be addressed. It is easy to see that an operator can schedule automatic maintenance based on Aspects that evaluate operational data, analysis and planning of retrofit and replacement strategies.

ABB's most recently developed Industrial IT software product families:

Control^{IT} – Integrated process and plant control.

Engineer^{IT} – User-friendly tool for efficient system configurators.

Operate^{IT} – Seamless information exchange across an entire enterprise.

Produce^{IT} – Unprecedented levels of batch control and electronic record-keeping.

Inform^{IT} – Turns production statistics into production knowledge.

Optimize^{IT} – Improves production processes.

Fine-tuning factories

Imagine how many factories, big and small, there are in the world today – hundreds of thousands? Probably millions (there are more than 350,000 in Japan alone). Most of the world's factories are running at no more than 60 percent efficiency – an almost unimaginable amount of wasted energy, wasted material, wasted money, wasted human effort.

Of course, especially in today's competitive environment, companies work very hard to reduce this waste, and even small increases in efficiency can have huge benefits over the lifetime of a plant or even a single machine. But these savings come at a price – new equipment, expensive upgrades, more service. At some point the improvements become too expensive to be economically feasible.

ABB devotes much of its research and development to finding new ways to lift industrial efficiency. This can be done by making new machines that are more energy efficient. It can also be done by using advanced IT solutions to measure and analyze the performance of existing machines to get much more productivity out of them.

This second approach is behind the development of a new software tool called Scoope. Scoope is a Windows NT-based software product that can be hooked onto a production line to measure its overall productivity – an important Aspect – and show where the most cost-effective improvements can be made.

The software marks an important step forward from established monitoring systems that tend to churn out a raft of disorganized statistics, readings and signals which need to be sorted and assessed before any coherent productivity profile can be created.

Scoope, by contrast, zooms in on just six key factors, such as equipment failures, idling time and losses from re-starting production. Then, using existing monitoring equipment, Scoope carries out sophisticated data analyses to locate precisely where the bug in the system lies. Afterwards, the system can be quickly fixed or fine-tuned to boost output.

Scoope has already been applied in a wide range of industries, from pulp and paper, to pharmaceuticals, packaging, metal production, and car assembly. The results have ranged from the mundane to the amazing.

In one plant, Scoope discovered that running a packaging machine at the speed recommended by the manufacturer resulted in a sharp

ABB's Scoope software saved one European customer an entire month's worth of production.

increase in breakdowns compared to running it at a slower speed. In another case, Scoope showed that a brand new machine tool had been stopped dozens of times with the emergency stop button during its first two weeks in operation. An untrained operator didn't know any other way to stop the machine, almost destroying it in the process.

Scoope has been deployed in 70 plants in Europe, South America and Asia. One European customer says Scoope gained his plant an entire month's additional production. Now imagine that in another million factories around the world…

Getting to the root of the problem

Correcting a problem in a factory can be a lot like treating a disease in people. You can treat a symptom without curing the underlying disease. In a factory or plant, this can be like tuning a motor or drive to perfection, but failing to see the inefficiencies of the complete system.

ABB has mobilized its entire industrial knowledge into a Web-based analytical tool that will make it much easier to diagnose problems in industrial processes and provide blanket solutions quickly anywhere in the world.

Using the technique of root cause analysis (RCA), ABB's Web tool consists of an easy-to-navigate database of industry-specific models and a step-by-step procedure to help engineers identify the likely root causes of a deficiency.

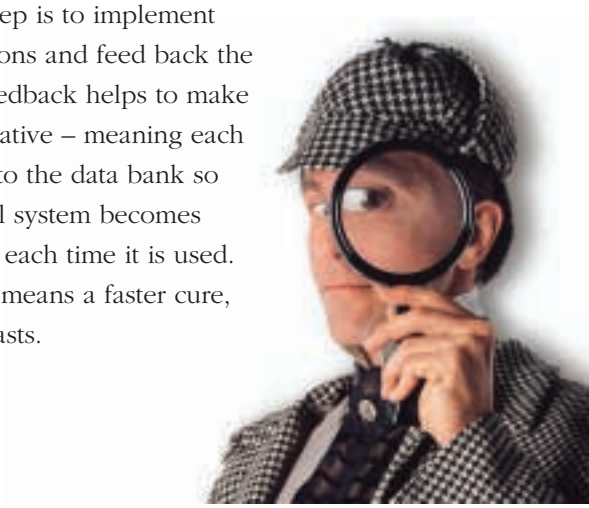
The analysis has four layers, beginning at the top with a process model, then moving to an equipment model. These two layers allow an analyst to specify the nature of the process and identify critical equipment used in the process.

The next two layers help identify specific failures and guide a user through checklists that help to verify the failure.

An engineer uses the system by first choosing a set of common evaluation criteria, then selecting a process model from the library or data bank. This library of information is based on actual products, processes and operating conditions amassed by ABB over many years of experience and in virtually every industrial sector in all parts of the world.

The engineer then navigates the system using a series of checklists contained in a fault tree – a step-by-step system to mine possible problems and their origins – to arrive at the root cause of the failure.

The final step is to implement recommendations and feed back the results. The feedback helps to make the system iterative – meaning each case is added to the data bank so that the overall system becomes more effective each time it is used. Fast diagnosis means a faster cure, and one that lasts.



Ship shape

Equipping a high-powered ship with a propulsion system is not a simple matter. Each ship has different hydrodynamics, and as such, each engine has to be tailor-made to fit the vessel.

Typically, it can take a year to develop, build and fit a new propulsion system to a high-powered vessel. But these days the market requires much faster solutions, particularly in the range of lower powered ships like ferries or supply vessels for the oil industry. Often, shipyards are looking for delivery times of less than three months.

ABB set itself the task of building a propulsion system which was both small and modular, an engine for all vessels that could be built and fitted within a matter of weeks and that would still offer improved performance and better steering capabilities.

The result is the Compact Azipod, a propulsion system designed to power ships requiring between 500 kilowatts and five mega-watts of propulsion power.

The compact azipod, which will be fully Industrial IT enabled, incorporates a permanent magnet synchronous motor with a fixed pitch propeller that is mounted directly on the motor shaft. The electric motor is controlled by a frequency converter and is cooled by seawater. All this leads to a much more slender design and better hydrodynamics.

The system, which rotates when the ship's wheel is turned, offers the sort of excellent manoeuvrability that is required for ferries operating in tight harbor spaces and for supply vessels swinging into exact position around oil rigs.

The chief challenge for ABB was to cut the time it took to build and fit a new propulsion system. It did this by coming up with a plug-and-produce design for the engine that comes in three parts: a steering module and block; a housing module; and a motor module with a propeller.

The resulting system offers shipyards a

range of benefits, including fast installation and the ability to trim costs by scheduling the fitting of the modules to cut production costs. One clear operating advantage is that the engine can be maintained underwater, reducing the time a vessel needs to spend in dry dock.

The compact azipod uses well-proven ACS600 direct torque control drive technology. Although used in many vessels, the new water-cooled version of this drive offers considerable space saving inside the ship without any loss of performance or reliability.

With the compact azipod, ABB intensifies the success of its overall azipod concept, and conquers the entire marine propulsion market – including offshore service ships, drilling vessels, river boats, tankers, fishing ships, among others.

Versions of the new system have been deployed on oil supply and survey vessels and will be used on a double-ended ferry operating in Finnish coastal waters around Helsinki.

Fast track to station control

Power grids are large and complex systems, with many components and interconnections. Managing one efficiently takes huge amounts of information and analytical power. Traditionally, this has been achieved with dedicated electronic equipment mainly located at nodal points of the electrical grid (for example, substations). Electronics gathered data and sent them to larger and sophisticated control rooms equipped with powerful computers. Control signals were sent back to the substations to open or close connections to adapt the grid configuration to operational needs. Recently, substation monitoring data were sent to these control rooms to assess the physical status of the equipment for predictive maintenance.

The Internet and wireless communications are changing all that, and ABB is at the forefront of these changes. New digital technologies allow substations and power grids to be monitored and analyzed from a laptop computer anywhere access to the Internet is possible.

An example of this technology is ABB's SCU2000, a control and protection device for substations. By building a Web server into a substation, for example, SCU2000 allows grid engineers to watch the status of substations in their field of responsibility from wherever they may be. In a later stage, they will be able to perform remote operations over the Internet.

By using wireless technologies, such as a Bluetooth communications link, information can be gathered from all the components in a substation without the need for a hard-wired network. The engineer simply stands in front of the equipment he or she is checking.

This decentralized approach to power grid control is also a perfect fit with the growth of decentralized, distributed power systems – based on a network of many small-scale power plants using microturbines or fuel cells instead of one large power plant. Wireless Web-based control systems will make these easier and more economical to manage.

Precision robots on the cutting edge

Precision means computerized control and mechanical perfection.

ABB was among the first to realize the revolutionary effect robots could have in industry and has established a world lead in developing robot control systems for a mass of applications on the shop floor.

Robots must be able to make manufacturing faster and more cost-effective, while maintaining higher product quality. This principle lies behind recent groundbreaking work on a high-precision robot control system for laser cutting which offers ten times more precision than any other robot on the market today.

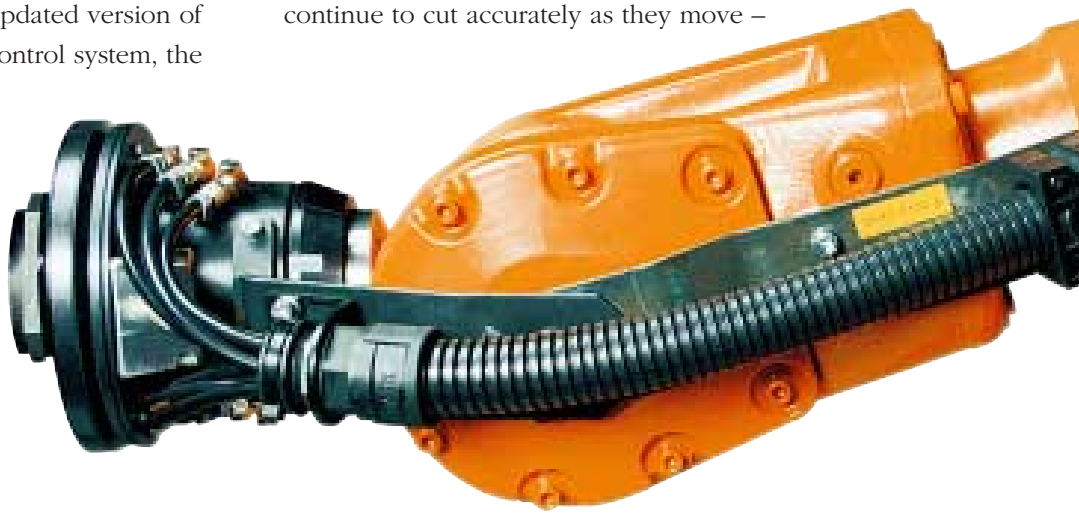
ABB's new system offers manufacturers cutting precision down to 0.1mm using a standard medium-sized robot. Normally, a small, specialized robot or more likely an expensive and inflexible numerical-controlled milling machine would be needed to achieve that level of precision.

ABB's system blends an updated version of its S4C computerized robot control system, the S4Cplus, with a standard medium-sized ABB robot, the IRB2400.

The S4Cplus is a control box that sits at the base of the robot. It incorporates a highly advanced dynamic model of the mechanical characteristics of the robot arm. This allows the controller to work ahead of the arm and anticipate the next move the arm must make to complete a task, thus guaranteeing a more precise outcome.

ABB researchers working in close cooperation with Professor Lennart Ljung and lecturer Svante Gunnarsson, control and identification experts at the University of Linköping in Sweden, developed "iterative learning" algorithms that are combined with the dynamic robot models.

They set out to tackle two main problems that have hindered the effectiveness of robot cutting machines. Laser cutting robots tend to be accurate only in a small part of their operating envelope. They may be good at cutting at a fixed point, but it is difficult to ensure that they continue to cut accurately as they move –



the so-called “path accuracy” of the machine.

The groundbreaking system is iterative, meaning that as the robot controller goes about its work, it is gathering more information and making more measurements so that it continually improves its performance and remains on precise track.

ABB believes the system will offer cost savings of up to 50 percent to industry simply by giving manufacturers the choice of a more flexible and less expensive cutting machine.

Currently many manufacturers use expensive milling machinery that offers precision cutting down to about 0.001 mm to do all of their cutting jobs.

But about half of the jobs currently carried out on machines like this do not require that level of accuracy. Manufacturers use the highly accurate and expensive machines because, up to now, there simply has been no alternative.

The new high precision robot controller offers a solution to that dilemma. It will give manufacturers a system that can carry out the more routine laser cutting tasks at a lower cost. The system comes with Industrial IT software packages for cutting – called CutWare – and for molding components – called ShapeWare. It can be coupled with ABB’s RobotStudio, which allows users to simulate a robot’s actions onscreen without taking it offline. ABB believes the new controller will be of particular interest to car manufacturers and the auto-parts industry.

Software packages from ABB allow robots to laser cut ten times more accurately than before.

Rewards from managing energy risks

Electricity is a commodity we generally take for granted. Turn on a switch and we have light. We don't often think about how electricity makes it to our homes and our workplaces. The bills come and we pay them – there is little to contemplate.

However, that is all starting to change. Electricity is increasingly being supplied in deregulated marketplaces today and that means it is being bought and sold competitively 24 hours a day. It can't be stored to a large extent, so its price is very volatile. Sophisticated ways of trading this commodity are emerging which are proving a challenging task for utilities to manage. Soon, we too will be managing this task – in our own homes, from the front of an Internet trading platform, perhaps.

In the meantime, a foundation for this future scenario is being set. The bidding of power stations against the demand at any one given moment can result in the price of power swinging wildly from US$ 20 per megawatt-hour (MWh) to US$ 300 MWh. Making sure that very expensive assets – power stations worth hundreds of millions of dollars – earn an adequate return in markets dominated by price spikes of this sort, is a job of mind-boggling complexity.

It involves an increasingly sophisticated system of financial and hedging instruments as well as clever ways of scheduling the availability of their plant. The more so since, until now, there has been no adequate software programs to help companies manage both the financial and the physical risks of running their businesses. In response to growing demands from utilities around the world, ABB has developed the world's first integrated energy portfolio management (IEPM) system.

The biggest challenge behind creating the new software packages was to find a way to model the unique behaviour of this valuable commodity. Derivatives trading packages already exist for other commodities like coal. But power is different.

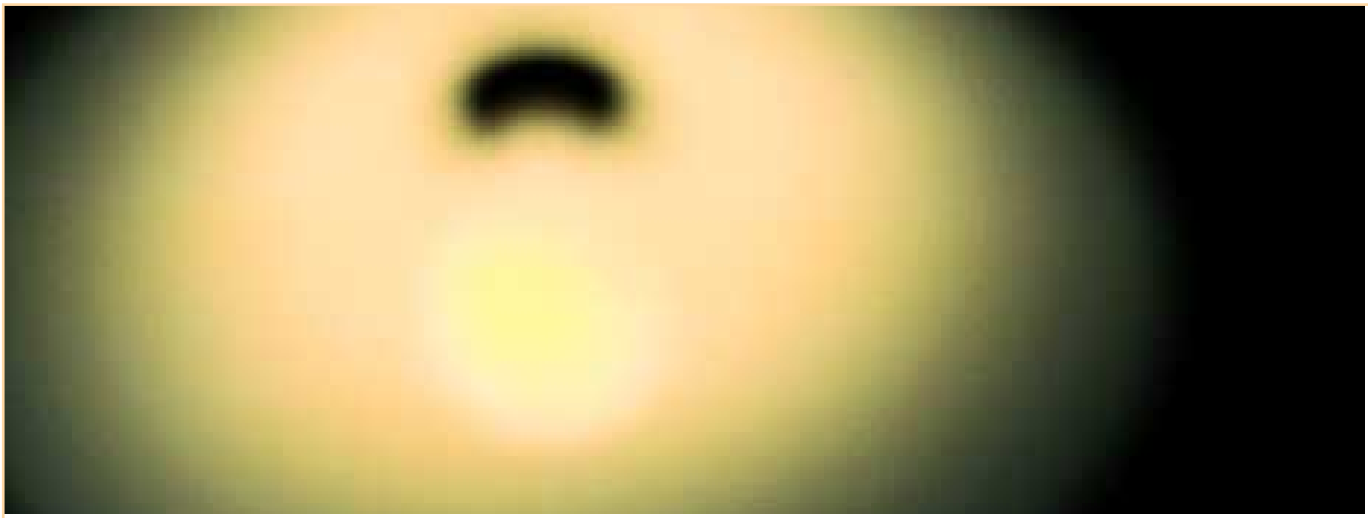
It is highly seasonal. It can also be affected by some unique physical problems – the failure of generating stations, or the breakdown of transmission networks.

So the first challenge for ABB scientists and trading experts in creating the IEPM was to devise a complicated series of algorithms and mathematical models to mirror the real financial and physical workings of electricity markets.

The system, scheduled to be available on the market at the end of 2001, fulfils four separate but complementary functions: It offers profit tracking so that the utility has a fast and accurate way to receive reports on the physical and financial performance of the company; it carries out risk assessment to expose the utility's financial exposure; it offers trade support to help the company trade its power effectively and profitably; and it offers a way to optimize the operation of the company's portfolio so that plant is scheduled to maximum effect – the right plant, the right fuel, set at the right levels at the right times.

ABB predicts huge demand for its IEPM software, a Web-enabled, Java script system with specially created storyboards to give the system a unique and easy to use visual appearance, which it plans to offer both as a system and as a service.

Furnace flicker banished



The first sign that your power supply is in danger of failing is often a flickering of the lights. Flicker doesn't necessarily mean a blackout is imminent. But it does point to a major disturbance on your local grid.

If you are running a sensitive system – say a cardiac machine in a hospital – or if you are an Internet company that depends on a constant and even supply of power, such disturbances can have serious side effects. Persistent flicker in electric light can also be dangerous for people with specific medical conditions, like epilepsy.

It is a problem that particularly occurs close to steel mills where electric arc furnaces create a constant problem of disturbance in the local grid affecting communities around the smelting plant.

Getting rid of flicker has become an increasingly urgent task for the electricity industry. Today it is seen by consumers, and regulatory authorities, as a form of pollution and therefore unacceptable.

Up to now, high-voltage switching systems called thyristors have been used to try to correct flicker. But thyristors alone are not capable of counteracting the problem. The way they are controlled allows only about two corrections per cycle.

ABB has now developed a system that is fast enough to make the problem of flicker negligible.

ABB's new SVC Light system provides a solution which is much more powerful than the thyristor. The system is based on High-Voltage Direct Current (HVDC) Light technology and uses a range of sensitive power quality control technologies, including the extremely fast switching capabilities of Integrated Gate Bipolar Transistor (IGBTs, see page 40). These powerful semiconductor switches allow the system to correct flicker close to 20 times per cycle.

In an SVC Light installation near a steel mill in central Sweden, ABB has proved that it is now possible to reduce flicker radically. In operation for just over one year, the Hagfors system has proven that SVC Light offers much more sensitive measurement of voltage and far better compensation, on average five times more powerful in counteracting flicker.

Far away fault finder

Despite the huge sophistication of modern distribution grids, most of the lines that feed us our electricity have no real-time system for locating faults, such as short circuits. It has just been too expensive to install all of the sensors and communications equipment that would be needed. So when things go wrong, finding the fault can be like hunting for a needle in an extremely large haystack. It makes for unhappy customers and it costs time and money.

ABB has now developed a simple solution to the problem – a relatively low-cost wireless system that can monitor lines constantly in real time from a remote location.

Today, an electricity company will often be totally unaware that a fault has occurred in a remote area unless someone calls in to report it, such as a farmer who has lost his power supply.

Once a fault has been reported, the next step is to send out a service team to pinpoint the problem. When the team has narrowed it down to a particular part of the line, the system needs to be taken out of service, earthed and inspected. Only then can the engineers accurately diagnose the problem and fix it. This can take hours and is very costly in terms of time, manpower and maintenance.

ABB's answer is the intelligent communicative sensor (ICS). ICS requires no wires to power it and no wires to communicate with the central control center of a grid. The sensor is simply hooked onto a power line using an insulated stick. There is no need to turn off the power as the system is being installed. The sensor is powered by the electricity in the line itself so there is no need for batteries.

The sensor measures the line for faults, whether a short circuit, an earth-fault, a variation in voltage, or network overload. Constant, real-time monitoring yields a precise picture of the entire line.

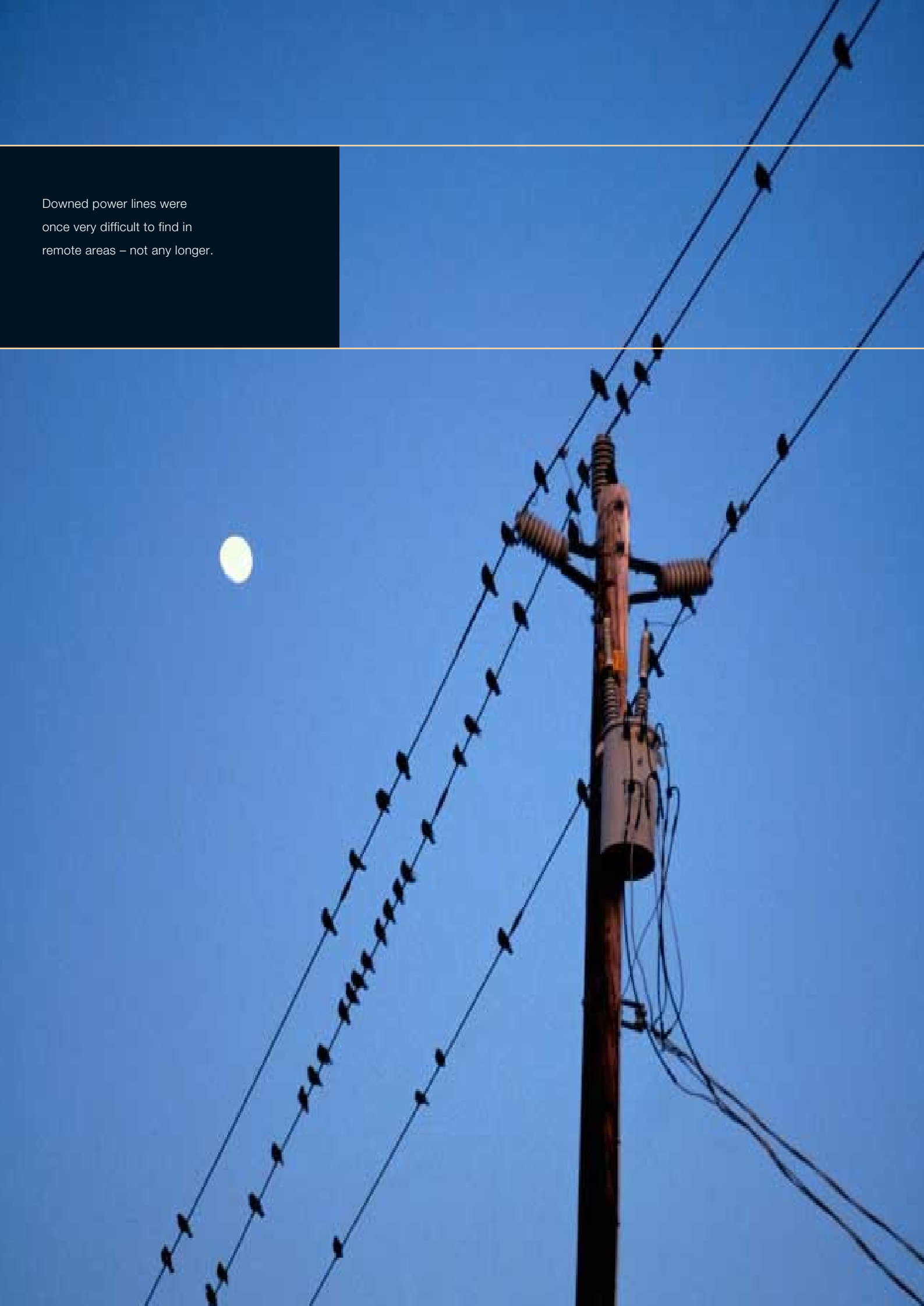
The sensor collects this information and sends a short-range radio signal to a small computer device on the ground beneath the line. From here the information is transmitted to an operating center via satellite, the Internet or other form of communications. When a fault occurs, operators can dispatch a maintenance team to the precise point where the fault lies.

The ICS has undergone full prototype testing in the laboratory, and extensive field trials were conducted last year. ABB believes the product will be ready for launch by the middle of 2001.

The product should have a dramatic effect on the operation of networks. For the first time it will be able to monitor all branches of the network – even the most remote feeder lines – in real time. Faults will be tracked down faster and brought back to service with only short interruptions.

ICS should make grids much more efficient, more reliable, with fewer and shorter outages and much lower maintenance costs.

Downed power lines were
once very difficult to find in
remote areas – not any longer.



Armada comes into view

Predictive maintenance is increasingly used as a productivity tool because it helps eliminate unscheduled downtime of expensive equipment and reduce the overall cost of maintenance.

This approach, sometimes called "condition-based maintenance," aims to assess the condition of equipment with online tests, so avoiding disruptions to production which occur when machines have to be examined separately. Its effectiveness has been hampered, however, by segregation of information and uncertainty in the diagnosis of test results.

ABB has developed an approach that overcomes both these shortcomings.

Condition-based maintenance analyzes the performance of machinery to determine its condition and predict when it will need attention. Typically, different parameters of a machine are examined separately. For example, both mechanical and electrical engineering teams monitor the performance of the same motors and handle necessary repairs individually. Similarly, suppliers tend to specialize in one area or another.

As a result of this specialization, each team uses its own specific tools. Software developed to analyze machine conditions focuses only on one type of data – such as current and voltage measurements, vibration analysis, infrared thermography oil analysis.

These software tools, developed separately by different suppliers, do not talk to each other. The result is a mass of uncoordinated data and a lack of overall control. Yet the condition of a piece of equipment is a combination of mechanical and electrical factors and effective analysis requires a combination of data.

Armada – Advanced Rotating Machines Diagnostic Analysis – is a software tool built on standard databases, to analyze data gathered from a battery of tests.

The presence in the same database of the complete range of data – currents, temperatures, drive system analysis, etc. – presents a much more accurate picture of a machine's condition than would be available from the separate components.

ABB has developed software to analyze this data by comparison with a wide range of real-life machine situations that has been gathered in the development of the system. The analysis is presented clearly and simply so that users can immediately see the nature and seriousness of any problem.

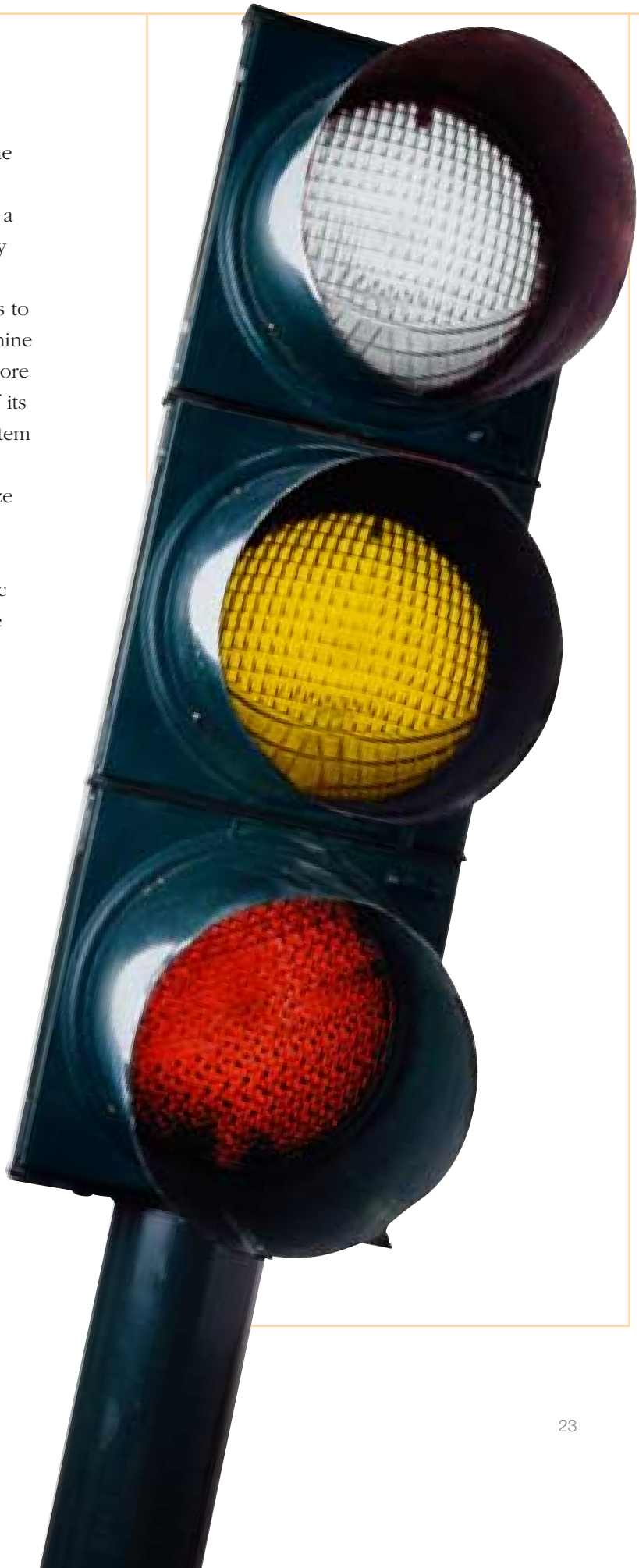
The output consists of a "traffic light" signal indicating the seriousness of the problems (white, yellow, red) and a simple message indicating the problem which has been diagnosed.

Vibration and bearing-related failures account for roughly two-thirds of electric motor problems. The Armada database contains a huge library of defects collected from operating machines, each of which generates a particular type of spectrum when analyzed. Using Armada to identify problems requires only four point measurements per motor (compared

to five or six in traditional analysis). Then the spectra from this data are compared to the library to identify the fault. And since this is a living library the database can be continually improved.

Armada also uses current spectra analysis to detect broken bars in rotors, and can determine the exact rotating speed of a motor much more accurately than existing methods because of its broader data fed into the algorithms. The system can also use direct current (DC) absorption tests and other traditional methods to analyze the state of winding insulation.

The purpose of Armada is not to replace experts, but to carry out the analysis of basic problems, allowing engineers to concentrate on more complex situations.



Predicting when a machine needed maintenance was once a mystery – Armada software makes it possible.

Slugging it out for better pipes and wells

Extracting oil and gas from under the ground or seabed continually stretches the boundaries of technology. ABB has contributed to these advances with a number of innovative developments that will help to significantly improve the flow of oil and gas and therefore the efficiency of oilfield production.

One is the Admarc intelligent control solution to help manage oilfield production in real time. Admarc's brain is a sophisticated control and communications electronics system packed into a 100-millimeter (four-inch) gap between the walls of a valve situated in the well bore to control the flow rate and pressure.

The electronics have to perform reliably at temperatures of more than 150 degrees Celsius, while the valve has to withstand the erosion effect of sand and other materials in the well stream pouring through at high pressures and temperatures.

Several innovations are included in the choke assembly to enable it to operate reliably at such high temperatures. Integrated circuits have been developed specifically for this application and specifically for resistance to high temperatures. An extremely rigorous testing program has identified the most suitable materials, down to special metallization layers on top of thick film circuits, high temperature solders or adhesives not normally used in the oil industry. The cabling system has also been carefully selected for high temperature operation, while the communication system which transmits information from the bore hole to the oil platform has also been developed using advanced silicone on insulator technology to improve reliability.

Another example of intelligent control systems is Wellocate, a computer modeling system that controls flows from each of several wells in a field. This is done without using special sensors to measure flows from each well directly, which is often prohibitively expensive. It also avoids the traditional approach of separating the flows to measure one well at a time, which is a time-consuming exercise.

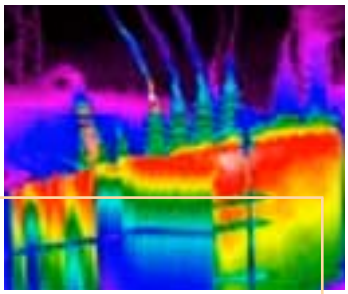
Instead, ABB has developed a process modeling system, using a mathematical algorithm, to calculate flow rates based on existing pressure and temperature measurements, combined with an understanding of well characteristics.

Wellocate will be used to optimize flow from each well and from the whole field in its entirety.

SlugCon is another ABB software product that has been developed to improve oil flow efficiency. Previous techniques for dealing with uneven flows have focused on managing the consequences of disruptions. SlugCon prevents the disruptions in the first place.

Take, for example, the occurrence of blockages in pipeline flows called slugs. A slug is a build-up of oil and water that often occurs when pipeline pressure drops. Under these conditions, the smooth flow of liquid and gas is knocked off balance by the accumulation of excess liquid that effectively blocks the flow of gas through the pipe.

In turn, the pressure builds again, eventually driving out the slug, at anything from five to ten times the normal flow rate. The resulting oil surge can cause loss of product and pollution incidents.



SlugCon reduces the disruption caused by slugs. The software uses algorithms based on pressure information from sensors installed in pipeline systems, combined with knowledge of well characteristics, to control the flow rate of the oil and water. The resulting assessments of liquid flow rates are used to control chokes and valves that manage the fluid flows. By controlling the flows from the well, the creation of slugs is minimized.

This approach has been proven in theory and in the laboratory, but ABB is the first to develop the necessary algorithms to make it work in practice.

At your service

Internet technology is about access, information and the management of knowledge. What it does best is bring together communities of interest that would otherwise find it difficult to communicate and interact.

ABB was quick to realize that the Internet could help it give customers the very highest standards of service.

For example, ABB has developed a service Web server that enables ABB experts to interact directly with customers in real time to help them maximize the efficiency of their process applications and control systems. The Service Web Server is a dedicated Internet-based solution that allows ABB engineers to view customer systems online and to fine-tune them for optimum performance.

Based on open standards, including OPC, XML, HTTP and HTML, the system is completely Web enabled. It means that ABB experts can respond to customer problems immediately without the need for time-consuming and expensive travel, give customers access to the very best engineers all the time and means that ABB can keep regular tabs on customer equipment as it goes about its business.

This new remote working environment means that the engineers can log onto the customer's operation remotely, and collect data on connected pieces of equipment. By doing this they can perform analysis and diagnose problems so that there is a constant effort to improve the working of equipment.

Although designed for ABB products, the system can be adapted to some third-party equipment. Because open standards are used throughout, there is no need for the customer to use specialist software.

The perfect control

ABB's process optimization technology can deliver an offshore oil production savings of US$ 8 million a year for a 160,000 barrel-a-day operation.

Many products that we consider staples of modern life are the result of complex production processes. The list is long but includes oil, chemicals, pharmaceuticals, paper, metals and processed food. They can involve many ingredients processed, blended and refined through many steps.

But finding the most efficient way to make these products is tricky. The processes involve a huge number of interacting variables that need to be understood, measured and controlled – the different feedstock components, the way they interact with each other, the effect of different temperatures and pressures.

As systems are subject to disturbances the operation becomes even more challenging. Large disturbances in the feedstock supply can easily cause a shutdown of a plant and become expensive due to the resulting production loss.

ABB has developed a new highly sensitive and robust way to measure and control the dynamics of crude oil separation and to optimize the dynamic production process: ABB's 3dMPC product, a model-based predictive controller (MPC). The system allows operators to carry out a whole range of dynamic functions including simulation, modeling, measuring and prediction.

So-called model predictive control (MPC) technology is commonly used to help analyze and optimize production processes and is at the heart of this system. But ABB has taken the technology a step further to create a unique patented system, the 3dMPC, which calculates optimal operation set points of the complex production systems and recalculates them online.

Conventional MPC technology uses expensive step response models. This means that every time a new process is tested each input has to be tested and measured separately, a process which is both expensive and lengthy.

One of the main advantages of ABB's new 3dMPC system is that it uses a mathematical model which allows the process to be modeled and identified in its entirety. Disturbances in the system feed forward and indirect control is possible. 3dMPC can even be applied to unstable plants. This offers huge cost savings in engineering and operation compared to conventional technology.

The system is used to estimate the present state of the process and to predict the likely future behaviour of it. As many as 32 controlled and 16 manipulated variables, plus 16 disturbance variables can be handled by one 3dMPC controller at one time. The system is packaged with a range of offline engineering tools to help analyze and fine-tune the controller.

Using process optimization technology of this sort promises huge savings for operators. ABB predicts that in offshore oil production an annual benefit of US$ 8 million is possible for a 160,000 barrel-a-day platform.

Spreading protection far and wide

If the manager of a large electricity network was a general waging a battle to supply power to consumers, then his most effective weapons might well be early warning and a powerful command and control system.

Up to now, utilities have had a range of protection tools at their disposal, many of them developed and produced by ABB. But early approaches focused on protection of the individual equipment of a whole power system, which no longer is sufficient for deregulated markets. In addition, grid operators need to be much more cost competitive than in the past. For one, that means they need to deliver more power more reliably through their existing systems.

From the beginning of this new protection era, ABB has offered consulting, services and automation systems for the modern grid manager. To consolidate many of these needs under one innovative umbrella, ABB has started to develop a product called PSGuard.

PSGuard is a wide area protection and optimization system that complements existing control and protection and improves the power system performance. PSGuard will have modules, involving a whole series of components allowing a utility to recognize instabilities that increase power availability and operate the system much closer to its peak efficiency. It will also cut the number of load shedding incidents.

In addition, PSGuard will offer a way to measure the performance of the entire system. Voltage and current phasors, information on magnitude, angle and time stamp of the power are all measured at strategic locations over the whole network. These data are transported via fast communication channels to local, station and network level in order to identify power system instabilities and to evaluate most effective actions against disturbances.

Communication links are provided to existing control and protection systems for the optimum utilization of this information. The challenge is to make sure all the phasors around the system work in perfect coordination as they measure the magnitude and angle of the current. To ensure that they are in complete harmony, they are synchronized by satellite – using the accuracy of the global positioning system (GPS).

The main benefit of this approach is the early recognition of problems when systems are operated too close to their stability limits. Knowing those limits is the prerequisite to optimize the complete power system and increase the power transmission capability.

With PSGuard and other systems for fault diagnosis and fault localization, ABB will be able to offer a whole range of tools to support customers operating in traditional and deregulated markets.

Holistic design boosts offshore vessel efficiency

Drilling platforms and other offshore oil and gas vessels have heavy and complex power requirements to fulfil two different needs.

One is electricity for sophisticated and powerful positioning systems to deal with water currents, waves, wind and shifting loads on board. The other is power for onboard operations, such as drilling, pumping, water separation or oil processing.

Marine power system design has traditionally treated these two requirements separately – one as an issue of ship design and the other as onboard production capacity. And the aim has been to make sure there is enough electricity to get through peak load periods in either area, even if these are relatively rare. As a result, marine power systems are usually underutilized, a costly luxury in today's highly competitive oil and gas market.

ABB engineers, using the company's expertise in automation and designing efficient onshore power installations, have created a computer simulation called Marinetronics that integrates the power needs of both positioning and onboard operations. In effect, peak loads in one system can be met by unused capacity in the other system, which allows designers to reduce the overall power generating capacity needed on board. This, in turn, means lower up-front capital costs for building bigger power generating facilities, and lower operating costs – up to ten percent, depending on the size of the vessel and the nature of its operations.

The key is a simulation program to accurately calculate the combined peak load requirements for both positioning and production. For example, being confident that a one megawatt (MW) load will be required by a production operation for only a few seconds per week can allow a designer to specify a 0.8 MW generator – the brief overload being perfectly acceptable within normal design criteria. Previously, the fear of lengthier overloads in the combined systems might have caused a designer to specify a more expensive one MW generator, which would then be underutilized.

Similarly, integrating positioning and control systems can lead to lower variations in the load on the propeller shaft, and consequently more stable power requirements. Avoiding previous peaks and troughs can allow lower rated, less costly equipment to be used.

The simulator can also deliver benefits in testing and commissioning. It allows any hypothetical situation to be modeled, providing a way of testing situations that would otherwise be difficult to assess. This kind of extensive testing should also reduce commissioning time because all basic tuning of the vessel systems can be done at an early stage in the project. This includes demonstrating the system to operating staff and taking account of their feedback, thereby reducing the need for changes at the installation stage.

The simulator can also be used for training purposes. Basic training can therefore be completed before the vessel is built, saving time during the commissioning and installation phase.

Blackouts become a remote possibility

Despite modernization of electricity networks, power failures and blackouts remain a common bugbear. And when they occur they tend to be pretty indiscriminating in their effects, sweeping thousands of households, offices and factories up in their wake.

ABB has developed an automated power protection package for medium-voltage distribution networks that not only allows faults to be detected and sometimes fixed remotely, but also keeps the problem of failures as localized as possible.

Its new network automation system uses sophisticated electronics and telecommunications to keep the grid operating more consistently. When faults occur they can be diagnosed more accurately from a distance and put right much more quickly.

The problem is that grid operators currently rely on manual systems to find and isolate faults – either visual inspection of warning lights attached to the wires or mapping the dispersal of customer calls about power failures. Crews are then dispatched to sort the problem. It is necessarily slow work.

ABB's automated feeder system changes that equation. It is a combination of activated switching and fault closing devices that are controlled by radio or telecommunications from a central control room or from a series of dispersed control centers.

The distribution company can choose different levels of automation. If it wants simply to use the technology to detect faults, it can fit communications devices only to the switches. If it wants to control the switches remotely it must choose to deploy further building blocks – switches fitted with communications, electronic activation and motors so that they can be controlled remotely. ABB is also developing plug-and-produce wireless sensor systems for analyzing the status of the lines, providing the input for protection systems like the Far away fault finder (page 20).

Depending on the level of sophistication required, the system can shorten power outages by 25 to 67 percent.

One option open to utilities is to deploy remotely controlled re-closers at key points around the network. The re-closer opens when a fault occurs to shut down the part of the network affected. Within seconds it is automatically re-closed to test if the fault is transient. If re-closing fails three times, or any number of times designated by the utility, then the switch locks open until the fault is fixed and power can be safely restored.

The automated re-closer has other advantages beyond cutting the average time of blackouts. When fitted to a communication device and a sensor it can be used to take remote readings of the status of the system by measuring voltage and current and feeding the information back via the communications channel. ABB's automated feeder system uses all the normal communications systems common to electricity utilities including phone, radio and satellite.

Other systems available in the building blocks kit include circuit breakers and sectionalizing switches which allow a utility to divide up the network so that the effect of faults can be localized, protecting more customers from the threat of blackouts.

The sectionalizing switches cannot detect fault current and so have to be deployed when the automatic closer is fixed open. By positioning the sectionalizing switches to key areas of the grid above and below the closers, power can then be restored progressively to customers not directly affected by the fault.

Driving the search for smarter air

Think of the constant, annoying drone of an old-fashioned heating, ventilation or air conditioning unit. It is often an annoyance we learn to live with.

But that uninterrupted background noise points to something there really is no need to tolerate.

Old-fashioned systems are often driven by motors that run at a constant power setting even when the machine does not need to operate at maximum. It's simply a waste of electricity – the sort of waste that would rarely if ever be tolerated with any other more visible commodity than electricity. And it points to a lack of control – rather like running a car by putting the foot on the accelerator and operating the emergency brake at the same time.

Variable speed motors have offered an alternative, more efficient way of powering such systems for nearly 20 years but have in the past been relatively expensive. This means it takes a long time to save enough energy to pay back the investment.

The difference today is that these drives are increasingly simple and need not be either very big or very expensive thanks to advances in technology and materials. The systems can be more compact with smaller circuit boards and casings made of lighter recyclable plastics.

Work by ABB in the field of variable speed drives has shown that by offering a way to match the power setting to the task at hand, these motors offer a simple, efficient and cost effective solution and incredible savings. ABB research shows that running a variable speed fan as opposed to a traditional motor can cut

the energy bill by as much as 65 percent.

The reasons for the savings come down to physics. To increase a centrifugal load, like a pump or fan, requires a three times larger increase in power. So to double the load means a six-fold increase in power. Put that into reverse, and it is easy to see that when you cut load the savings are similarly dramatic.

Drives developed by ABB, like the ACS 600 series, can be used to give the right power setting and also offer the advantage of intelligence. They can be programmed to deal with changing atmospheric conditions.

Take a system, for example, installed in a Heathrow airport terminal in London near the boarding gate area. This is an area that is either extremely crowded or almost empty. The dual drive system has three sensors detecting temperature, occupancy and air quality. The operation of the system varies according to these atmospherics. During tests, the ability to alter the settings of the system automatically resulted in energy savings of between 77 and 89 percent.

ABB is developing other smart solutions for heating, ventilation and air conditioning (HVAC) systems that will help manage energy consumption and provide users with intelligent solutions that precisely meet the demands made upon them.

ABB brings together its expertise as one of the biggest producers of HVAC systems and as an expert in control technologies to provide customers with smart solutions for fans, chillers and other air control systems. By combining new technologies in fieldbusses, micro-controllers and sensors and the use of software algorithms, ABB is concentrating on creating ways to control air systems more accurately.

One prime example of the new approach is the development of a modular fieldbus concept. The fieldbus is a piece of equipment that allows systems, in this case air quality systems, to talk to each other and respond automatically to changing ambient conditions.

Most fieldbus systems are optimized for working with local area network communications. But some customers want to look to other communication tools, like use of an Ethernet in a building. ABB's modular fieldbus allows a customer the flexibility to plug in the communications system they want – a tremendous advantage during planning and installation.

Industrial IT and its applications: Examples of major product launches 2000

- **RobotStudio 3D.**
- **Industrial IT software suite: Operate^{IT}, Control^{IT}, etc.**
- **Utility and warehouse system (SPIDER).**
- **Voltage stability analysis (Ranger).**
- **Database upgrade and analysis system (Everest V1.0).**
- **Substation monitoring system (SMS530 V1.1).**
- **Compact voltage regulator for small synchronous machines (UNITROL 1000).**
- **Industrial robot (IRB3405A) with PickMaster.**

Electrical systems technology
Powerful technologies for changing times

In 1999, US$ 20 billion was spent on mergers and acquisitions by electric utilities in Europe alone. Worldwide the figure was nearer US$ 38 billion, spent on some 120 transactions.

What does this tell us about the world of electricity generation, transmission and distribution?

Well, it tells us that this vital sector of the economy is in a state of dramatic change.

A floodtide of restructuring has hit the international electricity industry. The gates of change have been thrown wide open by deregulation and privatization. It is a process which has taken place first in the United States and Europe. But most other markets – notably the Asia/Pacific region and Latin America – are being swept up in the deluge.

The business landscape has changed from one where a little over ten years ago, large state-owned, vertically integrated monopolies ran the power industry. Now the ground has been given over to private sector suppliers – horizontally structured with generation, transmission and distribution broken off as separate economic functions – who are trading in competitive markets and being controlled by increasingly tough regulatory authorities.

This market change has opened the door to a no less radical revolution in the technology that power companies can use to serve their customers securely, safely, environmentally and efficiently.

This silent revolution is being led by ABB. ABB was quick to recognize that the new market model would kick-start demand for a wide range of new technologies. Indeed, we quickly saw that the new market would demand a new mind-set. And ABB has directed its efforts to becoming the supplier of choice for a whole range of systems that would make the new market function efficiently.

The scope of our activities in this area shows great promise. They span everything from environmentally friendly micro-generation

Strategic, long-term corporate research programs to support Electrical systems technology

Power electronics
Boosting the performance of a variety of products and systems – making drives and motors more efficient and power networks less prone to losses while operating at higher voltages.

Power products, systems and solutions
Developing the technology platforms of electrical insulation, current conduction and current interruption – to further enhance environmentally friendly electrical power, while continuing to deliver the highest efficiency.

High-voltage electromagnetic systems
Applying innovative cable technology to electromagnetic systems. This has led to the ABB Former family: Powerformer, Dryformer, Windformer and Motorformer.

Micro-electromechanical systems (MEMS), sensors and actuators
Shrinking dimensions down to the micro-level to develop new generations of sensors and actuators. These smart instrumentation solutions are spawning a long list of new applications for better control.

Insulation, current conduction and limitation
Introducing new materials and system solutions to manage high current and voltage in circuit breakers, cables, transformers, substations and other equipment.

systems, to new models for constructing highly efficient micro grids and smart solutions to monitor power quality and to control it remotely. They include pioneering work in the field of highly sensitive semiconductors to improve and synchronize switching, new developments in cable technology and oil-free technology so that power can be safely made in the places it is most needed – densely populated areas – and transported safely to the end user.

But ABB's innovations do not stop at the production and delivery end of the industry. They include the world's first Web-enabled systems to help competitive companies trade electricity without disrupting supplies or going bust. And increasingly ABB technology is branching into areas where power, heat and light are managed with extraordinary sensitivity as a holistic energy package, with the accent on security of supply and energy efficiency.

The convergence of new powerful measurement and control technologies and exciting developments in the world of Internet, wireless and satellite communication are also spawning systems that will in the near future offer utilities a way to manage their networks at levels of unprecedented sensitivity.

This convergence has massive implications for distributed generation systems through centrally controlled virtual utilities. It is also vital in improving the reliability and maintenance of networks and providing better security at lower cost.

In this dynamic environment, ABB has one aim. To be the leading provider of technologies, systems and solutions that will make deregulated electricity markets work to their best ability.

University cooperations to boost electrical systems technologies

ABB's links with eminent and ambitious research scientists across the world's academic institutions are well illustrated in the field of electrical systems and the power industry.

Notable projects include far-sighted approaches to power distribution and to high temperature superconductivity (HTSC), subjects under the respective microscopes of the Massachusetts Institute of Technology (MIT) in the United States and Cambridge University in the United Kingdom.

At MIT, ABB and its academic partners are studying the future of the distributed power industry with particular emphasis on technological architectures and asset management strategies.

Projects address the fundamental structural changes in the electrical utility industry brought about by deregulation. In this "new world," utilities, suppliers and equipment manufacturers like ABB have a common interest in understanding how the future may develop. MIT is perfectly placed to explore the potential effects of the change.

The goals are: to analyze alternative, future distribution systems – both from the institutional and technological perspective – by drawing comparisons between various performance criteria and optimal architectures against consumer choice and technological efficiency; to determine how utilities' asset management processes could change with deregulation, and to study the potential for a cooperative approach to operations, maintenance and investment.

In the field of conductivity, ABB is working with Cambridge University to investigate the potential of high temperature superconductivity (HTSC), a conduction mechanism of particular interest to ABB.

New ways of manufacturing HTSC could herald important implications for the future of the electrical industry, believes ABB. Projects include an investigation into possible routes towards a substantially lower cost method of manufacturing HTSC films and an exploration of spin injection into HTSC structures to study the potential beneficial effects on current conduction.

Truly intelligent
high-voltage circuit breakers

Researchers inside ABB push the limits of conventional thinking in search of what a layman would call the "Edison moment" – the moment when a light goes on above a person's head, and a common problem plaguing the world can be solved.

And when that light goes on, sparks fly – throughout the organization and in the markets we serve. In the field of high-voltage circuit breakers, for example, ABB researchers have hit upon a unique and innovative solution for preventing dangerous power overloads and short circuits.

High-voltage (HV) AC transmission circuit breakers perform an essential role in the safe and secure operation of electric power networks. ABB has continually led the industry in the development and supply of the highest performance HV circuit breakers to network operators for the past one hundred years.

Despite the low maintenance, long life and high reliability of ABB's existing circuit breaker drives, they remain relatively complex mechanical devices with limited application flexibility. A prime focus of ABB's switchgear development has been a reduction in the number of total components per solution and the use of functionally modular designs.

After intensive research and development, ABB is now able to deliver a drive that breaks through the limitations of conventional mechanical drives: the "Motor Drive."

As the name implies, the central component of this drive is a motor, linked directly to the operating rod system of the circuit breaker. As such, the number of moving parts in the drive is reduced from more than 50 to just one – the rotating motor shaft.

The motor is powered from a local energy storage pack, and the whole system is controlled and monitored by a robust, modular electronic control system. The electronic control system provides a level of function and flexibility not possible with previous mechanical drives.

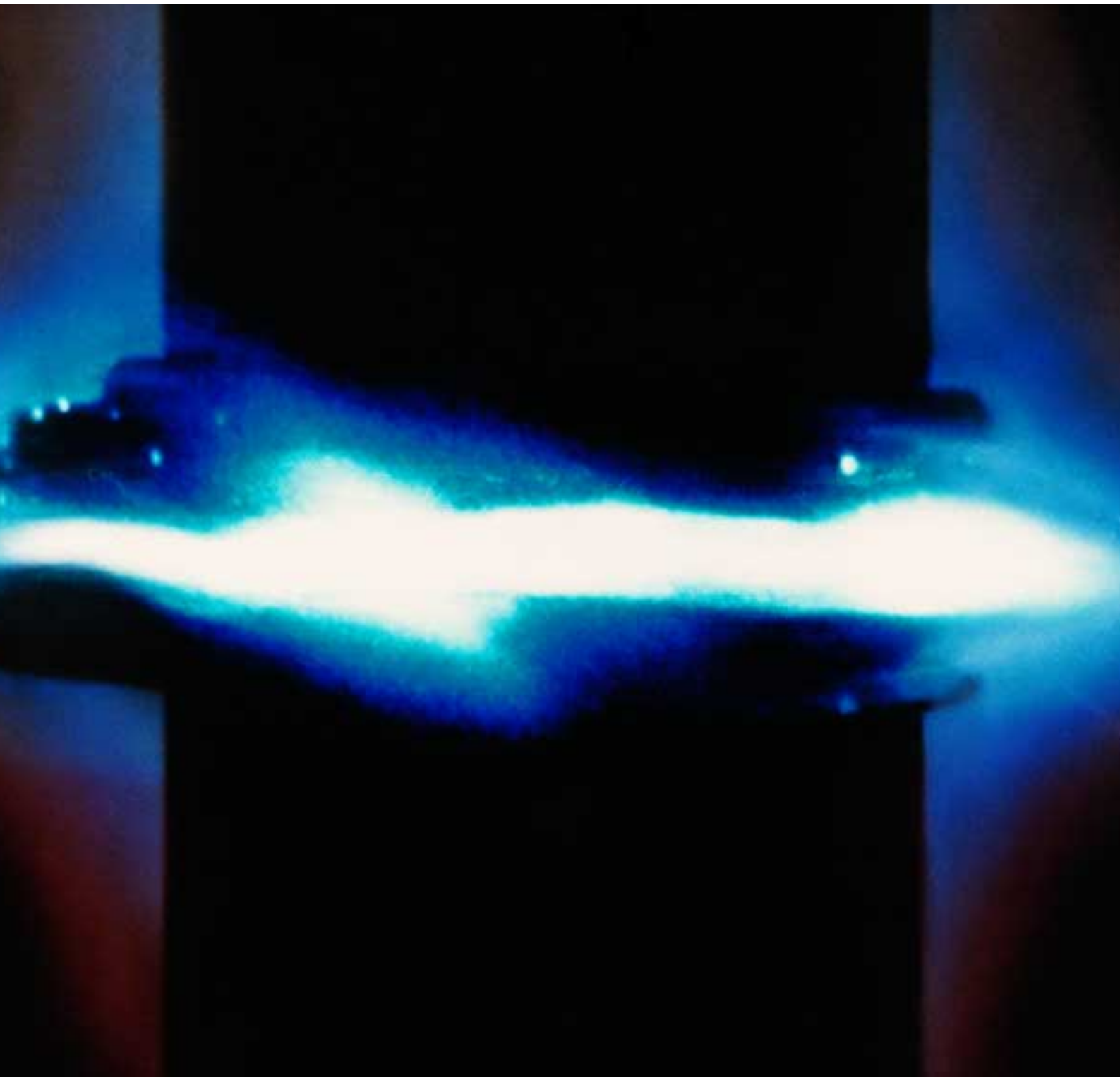
A direct, smooth control of breaker contact operation is possible, all drive modules can be monitored remotely on a continuous basis, and the power consumption is extremely low, 90 percent less than for existing drives.

In addition, the drive offers potential to make routine online checks of the complete contact drive motion – which has not previously been possible.

The modular electronic design, and use of software control allows for a high degree of flexibility to meet specific customer demands. The system also offers considerable scope for advanced circuit-switching concepts in the future.

Motor Drive will initially be available for breakers up to 170 kV and 40 kA. ABB's development of Motor Drive for higher rated breakers is continuing towards implementation across the complete range of transmission HV circuit breaker applications.

ABB is convinced that this new work on Motor Drive will open up a completely new approach to the further development of high voltage circuit breakers. And with that Edison moment, a revolution in circuit breaker technology has begun.



Defining the limits

A pylon crashes to the ground at the height of a devastating winter storm. Hundreds of meters of power lines are pulled down sparking a massive short circuit with severe effects for the entire local network.

Electricity companies invest heavily to protect their networks and systems from such devastating events. But managing such extreme power fluctuations can be tricky – you need to build in "shock absorbers" that limit the flow of power in an emergency without hindering the flow during normal operation. Getting this balance right has been difficult – and so engineers have continued to dream of a device which has negligible electrical resistance under normal operation and high resistance under fault conditions.

Superconductivity offers an alternative approach to more traditional current limiters. Superconducting materials are the only materials through which electricity can flow without any resistance at all – so long as they are kept at low enough temperatures. Creating the extremely low temperatures in which they can operate has made these materials too expensive for wide application in large power grids.

ABB has now developed a way to protect networks with superconducting current limiters that are commercially viable.

Superconductivity is known to occur at extremely low temperatures close to absolute zero (-273° C), difficult to operate in view of economic use. The so-called high temperature superconductor, still operating in very cold environments (-196° C), are much cheaper to cool down with simple liquid nitrogen: a very cost-attractive solution.

One conventional approach to building a high temperature superconductive limiter is to use a wire winding. The difficulty is that it requires some 200 meters of specially fabricated silver-coated ceramic filament in order to achieve the right levels of conductivity. When wound, the ceramic material is easily cracked, damaged or dislodged.

ABB researchers have focused instead on flat superconducting materials that can be easily manufactured in large sheets. The ABB system has at its heart a sheet of ceramic material mounted on a supporting metallic base that protects it from cracking. The sheet is about a quarter of a square meter big and three millimeters thick.

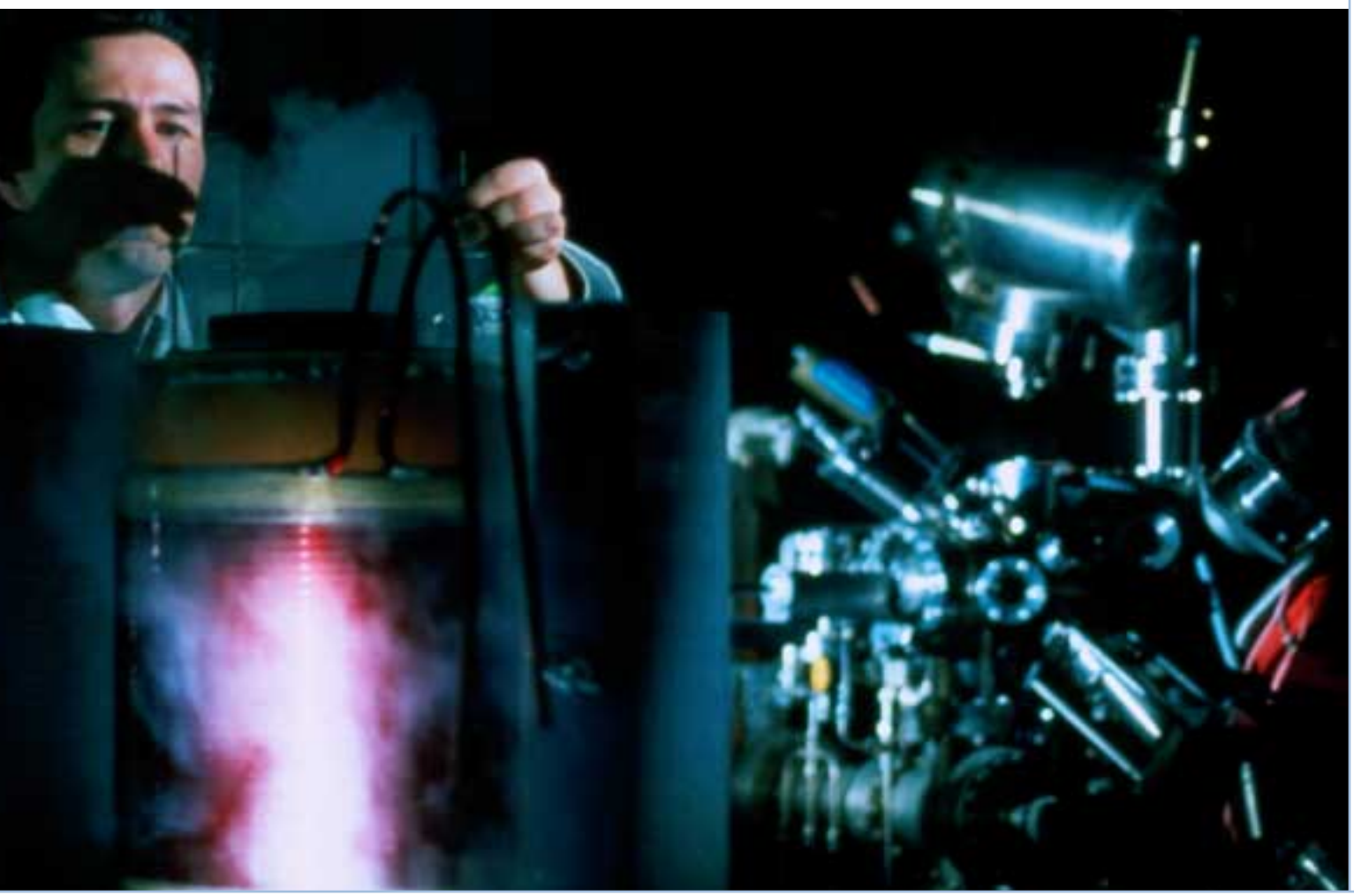
To duplicate the effect of running a current overload through 200 meters of coil, as in the conventional approach, ABB uses lasers to carve a long series of meandering channels onto the metal-ceramic sheet. The current travels through the channels and generates a magnetic field. If the current gets too high, the magnetic field gets too high, and the ceramic layer loses its superconductive behavior. Now the current has to flow through the metal part of the meander structure which has the well known resistance of metals.

This superconductive current limiter has the advantage compared to other conventional ways of limiting a current that it does not influence the normal flow in the grid and that it can be switched on by a too high current and automatically switched off when the current is low again.

This flat-structure approach has already been proven in research for more than 6.4 MVA. Compared to earlier superconductive limiter types, the volume of the device has been reduced by a factor of five, resulting in a core system of less than 50 kg.

ABB expects to be making the system available to electricity operators within two to three years.

Superconductivity requires extremely low temperatures – and enables ABB to limit current without influencing the power grid.



Very high-voltage motors

From factories, to pulp and paper plants and utilities, virtually every operation is speeding up, increasing efficiency and looking for cleaner ways to do business. To meet these demands, and to apply an innovative and homegrown technology, ABB has developed a new range of high voltage motors.

The new motor, called Motorformer, is the latest in a family of high-voltage equipment that uses cables rather than conventional square-shaped conductors.

Motorformer follows a line of innovative products from ABB, which started with the Powerformer generator, and now includes Dryformer, an oil-free transformer, and the Windformer wind turbine for offshore and coastal generation of electricity using the wind.

All these products are based on the concept that the most efficient way to carry high voltages in electrical systems is by using cables. Conventional generators could – due to their limited capability of insulating high voltages – only operate at a lower voltage level. This meant having to add transformers to increase the voltage high enough for transmission over a power grid, and inevitably meant high-energy losses in shipping the high current power through the transformer.

When ABB introduced the Powerformer in 1999, the company created a generator that operated at a high voltage level with very low energy losses (most acute in high current systems). More importantly, the transformer – a costly and environmentally risky piece of equipment since it depends on potentially hazardous oil for insulation – became redundant. Voltages would already be high enough.

Motorformer employs the same basic principle. But unlike the Powerformer generator, Motorformer is working in reverse – taking power from the grid rather than feeding it out to the network. Taking power directly from the grid comes along with a range of technology challenges. First of all, a high-voltage motor needs to be started. Starting uses huge amounts of energy that can drain a grid momentarily and affect the supply of other nearby systems dramatically.

In a normal five to ten second starting operation, the voltage on the grid can drop by up to ten percent, a margin which is unacceptable to distribution companies supplying power in many areas, particularly where sensitive buildings like hospitals are located.

Although 50 percent of industrial motors are not in such sensitive areas and can be started direct online, ABB has developed special delayed starting techniques for the other 50 percent of settings so that starting does not disrupt supply. This is done by using reactor equipment to reduce the voltage drain by extending the starting time to around 20 seconds. Capacitors are also added to strengthen the grid during the start process.

The second challenge was to provide the required internal protection for the motor so

that it could handle much higher voltages. The key issue here was to boost the insulation capability of the system so it could operate at elevated temperatures. This is done by supplementing conventional air cooling with water cooling.

Like Powerformer and Dryformer, modern cables, particularly cross-linked polyethylene (XLPE) coated cables, are again a key component because they provide much better insulation and are the most cost-effective way to carry high voltages. The use of these cables is common to the entire ABB Former family.

ABB expects the new motors to be used in a range of industries, including pulp and paper – particularly in the crushing machines used to produce newsprint; in chemicals; oil and gas; and in air separation and other industrial settings – where pumps and compressors are a vital part of the process.

Grappling with electricity gridlock

ABB has come up with a groundbreaking solution that for the first time will allow for a new model of electricity supply – called distributed power solutions – to be implemented safely and efficiently on a much wider scale.

The system is called SIDU Advanced – the smart integrated distribution unit. It allows a range of distributed power units to be connected to the grid at a single point. As each source feeds its power through the SIDU system, the electricity is converted into a useable form that is compatible with the grid. In effect, it acts like a single gearbox for a number of cars.

But SIDU Advanced works the other way too. If electricity users are to depend on a range of smaller distributed sources of power, then these different sources all need to be managed so that they can work in unison. The power generation units need to be controlled and protected. They need, in simple terms, to be switched on and off, both to meet demand and in case of emergency.

SIDU Advanced incorporates a Web server and uses Internet technology to allow this complicated process to be handled remotely from a single control point.

Powerful electronics housed within the SIDU container allow power sources to be activated and shut down when necessary. The system also includes sophisticated override functions to ensure that there is an uninterrupted power supply when faults or shorts occur. The whole system can be monitored from a PC where the operator is alerted to any problems by a hazard-warning lamp signal.

SIDU Advanced incorporates a metering system, which logs the amount of power used by the client and how much is exported to the main grid for general distribution. It therefore allows the operator to monitor usage, sell surplus power into an electricity trading system and bill the customer.

SIDU Advanced looks likely to vindicate ABB's belief that advances in electronics and Internet technology allow for new, more efficient ways to produce power – the key to creating a more sustainable balance of energy production in the immediate future.

Switching to micro-power

The new generation of small-scale and micro-electricity generating technologies promises a new era of cleaner power. ABB is among many companies developing systems for the new era, including wind generators, microturbines and fuel cells.

But the power produced by these systems often presents problems, particularly in power management and in tackling how to feed power from them into a larger electricity grid.

Microturbines, for example, rotate at extremely high speeds and produce electricity with a correspondingly high frequency that is incompatible with the grid. At the other end of the scale a wind generating system may have a very low frequency which is similarly at odds with the larger electricity network.

Tidying up this power so it can be fed into a larger grid is vital if these alternative ways of producing power are ever to become truly viable and move into the mainstream.

To do that requires specialist technology where ABB is in the lead. One key area where ABB is ahead is in large semiconductor devices that can convert electricity from one frequency to another – even very high or very low frequencies – cost effectively. ABB's Integrated Gate Bipolar Transistor (IGBT) is an important device in this context.

The benefit of this system is that it offers the same power handling capabilities of normal bipolar transistors and thyristors while also offering higher impedance or resistance for lower power making. This makes it more cost-effective.

Control of the IGBT is achieved by the pattern of MOS transistor cells on the surface of the device. Manufacturing of the cells is crucial and is being continuously updated but draws heavily on technologies developed for making micro-electronic circuits for more mass-market products.

Early applications of IGBTs in switching devices concentrated on lower voltage equipment ranging from 600 volts (V) to 1,200 V. It was not until the early 1990s that it became clear that these systems could be adapted for much higher voltages.

ABB has developed a portfolio of IGBTs to address the voltage range spanning 1,200 V to 4,500 V, positioning itself among the leaders in the field. Researchers have discovered that the losses from an IGBT are proportional to the thickness of the device. In basic terms, this means that the thinner the device, the lower the losses.

ABB has now developed a manufacturing system which produces IGBT silicon wafers that are 70 percent thinner than previous versions of the same device. As such, the new ABB devices are now the thinnest chips currently on the market.

This allows for superior performance in terms of switching speed and conversion efficiency. The devices are particularly well suited to controlling modern electricity networks like the new generation of small grids that depend on input from small wind turbines, fuel cells and other environmentally friendly power generators.

In many ways, power semiconductor R&D is uncharted territory. Only recently did it become known that cosmic radiation can have a damaging effect on high power systems. Cosmic radiation, created in deep space, travels to Earth and can charge a semiconductor and cause spontaneous damage with subsequent device failures.

ABB has been conducting detailed research into this phenomenon and has been working

to produce robust systems in the 4,500 V range where semiconductors are big enough to be susceptible to the effects of the rays. We have now created systems that have minimal sensitivity to these damaging particles.

A third key area of development is ABB's development of power modules – series of IGBTs packaged together to provide highly efficient synchronized switching that can handle even higher voltages.

ABB has developed a way of manufacturing these power packs so that the individual chips are in perfect geometrical alignment without weak spots that could cut the overall performance of the pack. In simple terms this has two benefits. First high power levels can be handled. But, just as important, the alignment means that the system can be switched off and on uniformly so that no part of the system comes under excessive strain.

Very high voltage power modules developed by ABB are already being used in traction vehicles and power transmission applications. Modules able to handle 6,500 V – power ranges that would normally require more bulky equipment like traditional thyristors – are currently being tested. This research promises the introduction of much more compact switching systems in a range of applications from trains to electricity generation and distribution systems.

ABB's IGBT silicon wafers will make renewable energy solutions economically viable.

The common touch

For more than 30 years, ABB has been perfecting the design and development of circuit breakers and is today the world's biggest producer of these systems. It has concentrated on two dominant technologies – the vacuum breaker and the breaker equipped with sulfur hexaflouride (SF_6), a nearly inert gas.

Both technologies have been adopted widely and continue to be refined. Vacuum systems have been most popular in China, Japan and the United States, and SF_6 breakers tend to be most popular in Europe and the Middle East. Once a technology takes hold in a region it tends, for reasons of commonality, to become the chosen system in all applications.

But the two systems do in fact have specific advantages in certain operating environments. For example, vacuum circuit breakers are considered better for use in steel making arc furnaces because of frequent switching at high current levels.

Similarly, SF_6 breakers are better suited to voltages higher than 27 kilovolts (kV) in capacitor banks.

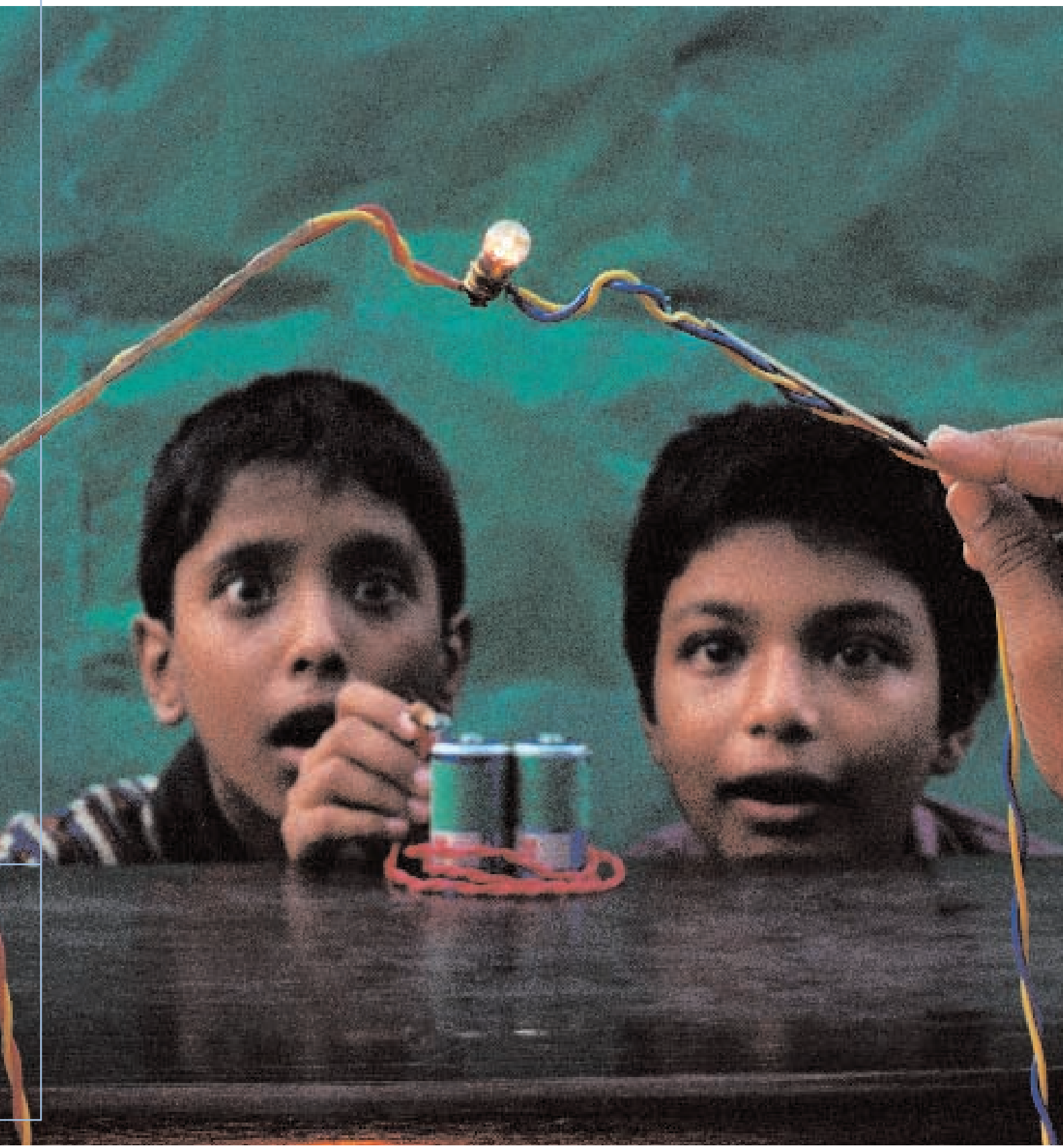
ABB's equal expertise in both systems puts it in a position to make informed recommendations about matching the best technology with an application. But its starting point has been to create a common platform for both to make sure that advances in one can be cross-pollinated with the other so that the two can operate happily, side by side.

ABB has, for example, developed ways to fit the breakers with electromagnetic rather than bulky mechanical operation systems. The magnetic system uses two types of magnets. A permanent magnet holds the contact in open position. To close the contact the electromagnets are energized so that the direction of the magnetic field is changed.

Use of magnets cuts the number of parts in the breaker considerably when compared with conventional mechanical systems. Fewer parts mean less risk of faults and therefore far better maintainability.

Thanks to the common platform approach, both the vacuum and SF_6 breakers now share a mechanically actuated system and are therefore fully interchangeable.

Now customers can for the first time ask which type of circuit breaker best fits the job in hand.



High-speed revolution in motors and drives

The future of alternating current (AC) drives is clearly about speeding up, cutting costs and improving the environmental performance of all motors, compressors, pumps, blowers and test stands – the lifeblood of any industrial process. ABB has launched a new range of high-speed drives – marketed under the name HISPIN.

These drives are designed to replace gas turbine drives in a variety of industrial settings, whether they be on gas pipelines, onshore or offshore gas platforms or compressor stations. Currently, gas turbine drives are the technology of choice in these settings, but switching to an electrical system will bring huge cost and environmental benefits.

The HISPIN drives are made up of a high-speed induction motor and an AC drive, both of which are standard components, easy and quick to bring to market. The key difference between the new drives and the gas turbine systems they are designed to replace is that they use magnetic rather than oil bearings.

Magnetic bearings incur negligible friction because the shaft and bearings within the system are not touching. In a gas system, these components are in close contact separated only by oil. The absence of high levels of friction in high-speed motor drives means they are less likely to get damaged through operational wear and tear and are therefore more reliable. Energy losses are also dramatically reduced.

Oil-based systems are also more cumbersome, requiring additional supporting equipment to function. They need an oil unit, for instance, to ensure oil is flowing at the right rate and the right pressure to the different bearings within the machine. The unit will need redundant pumps and pipes.

These additional pieces of infrastructure mean added weight and bulk. They make the system more costly to build, install, operate and maintain and make it much harder to control remotely. Where there is oil, there is also a risk of fire.

Another benefit of using magnetic bearings is that they are controllable, can be run at optimum settings and monitored at all times. By contrast, oil bearings are passive and not controllable.

The new high-speed systems are a great deal quieter than gas turbine equivalents, cut-

Electrical systems technology: Examples of major product launches 2000

- **HVDC Light B 300 MW ± 150 kV (equivalent to 300 kV) including cables.**
- **PS1: A standardized and simplified Substation in AIS and GIS technology for 145 kV and max. 2 *40 MVA.**
- **LTB-G breaker for 145 kV 25 kA , compact, modular.**
- **Combined: A combined disconnector circuit breaker for 145 kV and 300 kV / 40 kA.**
- **PASS M0 classic: The PASS solution to connect to conventional control and protection systems.**
- **SIDU classic: A distribution unit equipped with electronic controls and protection, remote controlled.**

ting noise levels by, on average, ten decibels. They are also cleaner. Since they produce no polluting emissions like nitrogen oxide, they are emission-free at the point of operation. With no oil, they are also free from the risk of polluting oil spills. This means they can be sited in or near urban settings.

Tests have also shown that they beat gas turbine or other oil-based electrical drives on a range of important efficiency measures – offering electrical efficiency of 98.5 percent and motor efficiency of 96.5 percent. Thermal efficiency has been shown to be five percent better in the high-speed induction drive than in a single-cycle gas turbine.

Importantly, the new systems are much more economical to buy, operate and maintain since they are free of the supporting infrastructure and components that go with gas turbine drives. Indeed, ABB estimates that annual maintenance costs for the new machines are a quarter of those for an equivalent gas turbine system.

Net gains for deregulated electricity markets

Deregulation of electricity markets is snowballing. Month by month, more countries are embracing the open market for electricity supply where end-users can choose from whom they want to buy power, when and how it should be delivered, and at what price. It can be a very fast-moving market too, as electricity becomes a commodity that is easily and quickly traded, like pork bellies or stock futures.

Making a system like that work efficiently requires immense amounts of information – how many customers are buying how much power from whom? When did the purchase happen, and what was the price? It requires not only sophisticated measurement and communications technology, but also the software brains to analyze it so that people can use it. And designing the software requires deep knowledge of how open power markets actually work.

ABB has a long track record in power network measurement and control systems on which the open electricity market in many countries is built. Now the company is pioneering the software needed to create a transparent and efficient market.

ABB has developed a Web-based system called Netplus that allows electricity distribution companies to maintain a market that is both orderly and fluid. Netplus handles all the tasks required to make deregulated markets work, from tracking power flows to different customers, to forecasting demand, managing data, and billing.

Netplus – which has already been launched in Germany – handles data that is changing not only day by day, but hour by hour. It tracks customers as they move from one supplier to another. It estimates power consumption from users without metering. It adjusts demand forecasts in different markets and different geographic areas – for instance, demand in southern Sweden is vastly different than in the north, where it is colder and the days are shorter.

Now a distribution company deploying Netplus can offer all the market information suppliers need to compete. Netplus works across the entire marketplace, integrating information from all companies and users. And it uses the Internet, so the information is easily and economically accessible to all participants. It is part of ABB's strategy to combine its knowledge of markets, its advanced technology offering and the latest advances in information technology to provide more value to customers.

Oil, gas and petrochemical technology
From well to consumer

It will be many decades before the world's populations cease to depend on fossil fuels. Oil and gas exploration and production cannot be accurately termed "a sunset industry" because demand continues to far outstrip supply. The truth is that as the industry works to bring new production facilities onstream, the old oil fields of yesteryear are closing down.

In this environment, ABB expects that production from offshore fields in deeper water will lead the way, and that production from traditional onshore and shallow waters will dramatically decrease.

Despite the technical challenges of finding and recovering oil from much more difficult environments, we anticipate many bonuses for oil producers. The result of a range of exciting innovations will be safe and economic access to deep-water fields, a considerable increase in recovery rate and total recovery – both from fields already producing and from new fields.

New technology promises to offer guaranteed production availability of 99.9 percent, or better.

All this must be achieved, of course, with due respect to the most obvious parallel challenges: continuous efforts to reduce both capital expenditure and operational costs. Just as importantly, these extraordinary leaps in technology must be achieved while working to ensure we design, build and leave a heritage of environmental excellence for future generations.

This report covers many examples of our state-of-the-art technologies, technologies that already give us a leading edge. These are some of our priorities in the upstream area:

- Subsea production systems for safe and efficient deep-water production.
- Deep-water floaters with solutions that combine technical expertise with environmental considerations.
- Tie-back of subsea fields to existing infrastructure or to shore.

Strategic, long-term corporate research programs to support Oil, gas and petrochemical technology

Oil and gas upstream technologies

Equipping high-pressure systems with advanced sensors, developing novel separation technologies and sophisticated controls for more compact and efficient production systems, both on the seabed as well as on platforms.

Catalysis and chemical processes

Researching advanced reaction and separation systems for the refinery and petrochemical industry. R&D activities range from the nanoscale level, e.g. catalyst synthesis, to the macro-scale level, e.g. optimization of total plant integration and process intensification.

Mechatronics

Highly-flexible mechanical structures based on advanced materials and animated by smart control systems. This pioneering research is leading to new classes of adaptive, intelligent and controllable products.

Nanotechnology

By understanding materials and structures down to molecular structure it becomes possible to re-engineer materials to achieve new properties and functionalities. Nanotechnology has a potential to impact several areas of interest for ABB, from electric power products to oil and gas processes.

- Compact and efficient process systems for topside, subsea and down-hole applications.
- Intelligent well systems for ultimate reservoir management.
- Advanced integrated control systems for optimal total field management.
- Distribution of electrical power to offshore, subsea and topside locations.

Tackling the downsides downstream

Human activity and rapidly growing productivity have enabled large sectors of the world's people to move out of poverty and into prosperity.

Society will continue to look to the oil and gas industry as a key source of energy and raw materials. And consumers will enjoy the benefits of lower cost products brought about by improved manufacturing and higher levels of success at the research and development stage.

But there is a price to pay. One of the downsides associated with prosperity and increased human activity is the generation of unwanted emissions and their effect on air quality. Governments, industry and those citizens concerned for green issues have all joined the battle for clean air.

ABB has focused much of its R&D in exactly this area. We would particularly like to draw your attention to two projects with partners Chevron and Equistar, where ABB has formed partnerships with other industry leaders. We are actively spreading these technologies through a novel approach to licensing world-class technology that is, at the same time, built to meet much more stringent environmental controls.

Our unique attribute at ABB is our ability to understand the value of new technology and to quickly implement its use through R&D as well as fast-paced collaborations with leading-edge technology partners.

Tapping universities for cleaner fuel solutions

University-based projects are often embryonic and long term in scope, enabling a company to support projects that would otherwise not be feasible in a commercial setting.

In the petrochemicals field, for example, one of the major areas of focus is ABB's "Clean Fuel Program."

Scientists at the Technology University of Delft, located in the Netherlands, have been working with ABB for more than three years to produce "novel catalyst materials." The aim is to invent ways of making new materials with highly unusual characteristics and far-reaching commercial applications. Details have not yet been made public but pilot studies show much promise in the area of environmentally friendly gasoline.

At Eindhoven University, also in the Netherlands, another project seeks to produce olefins – the building blocks of polymers – via catalysts. Conventional production of olefins rests on an expensive ethylene and propylene-based thermal process, a market in which ABB is an established and dominant player. The company is now working with the university to engineer a research project to provide a more cost-effective, higher yield catalytic alternative to traditional technology.

Driven again by the demand for cleaner fuel, ABB is continuing to work with a leading professor at the acclaimed Massachusetts Institute of Technology (MIT) in the United States. This project is using developed catalysts to reorganize heptane molecules to significantly increase octane levels in hydrocarbon products. Success would commercialize a process not yet available within industry.

Catalyst development is also high on the agenda at the National University of Singapore, where ABB is involved in a project that additionally focuses on the use of membrane technology as a method of highly selective separation. Membranes act as porous walls with nanosized pores that enable recovery of very high-octane components from hydrocarbons. The company believes the environmental implications of this could specifically benefit refineries.

Purifying the oil stream

Oil and water, as we all know, don't mix. Try making a salad dressing and you'll see that a mixture of oil and other ingredients – if left to lie long enough – will naturally separate into the components you started with. But this separation takes time.

This has significant implications for the oil and gas industry. When oil is pumped out of the ground it is highly mixed with not just water but also sand and other impurities. One of the most vital operations in oil production is the speedy separation of these elements. Indeed, oil cannot be sold commercially unless the proportion of water in it is less than 0.5 percent.

So once oil is pumped out of the ground it must go through a rigorous and fast "cleaning" process. ABB has developed two new process components to provide oil companies with a purer oil stream.

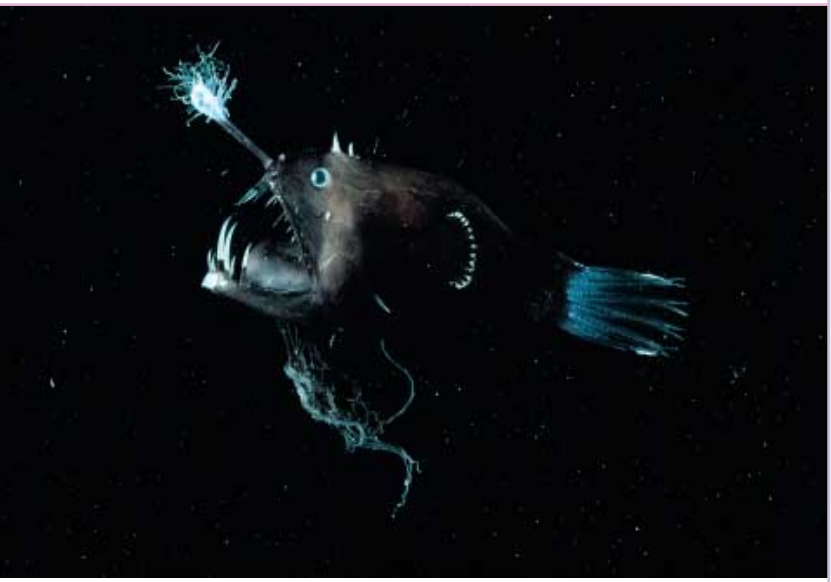
One well-known system is called a coalescer, normally a heavy piece of cleaning equipment which speeds the separation of oil and water by making water droplets join together or coalesce to form larger particles. The larger the droplets of water, the quicker they drop to the bottom of the system so that they can be pumped away, either back into the reservoir or out into the sea.

ABB has now developed a much more compact and efficient coalescer for offshore production systems. The compact coalescer will eventually be able to work at depths of 2,000 meters and greater – very important as the offshore industry pushes the limits of discovery.

The system uses electrostatic fields to promote coalescence of the water droplets. Fully-insulated electrodes eliminate any short-circuiting hazard and the coalescer geometry is based on pipes, ensuring high-pressure service and a small "footprint" (weight and system size).

Another novel feature of the new coalescer is that it operates at moderate turbulence flow, meaning that it allows the droplets to collide with each other more frequently. Finding just the right amount of turbulence in the fluid is tricky. Too little turbulence and the process is slow. Too much and it becomes inefficient. ABB's new machine creates exactly the right amount of turbulence by using the right sized obstacles in the inlet to disturb flow.

The results are staggering. Lab testing of a prototype system shows that only seconds of treatment in the new coalescer increases the size of water droplets by ten times. What would take an untreated emulsion



24 hours to separate takes ABB's system only ten minutes.

This has huge advantages for the offshore oil industry. Even on traditional heavy platforms, space is at a premium. Now that the industry is moving to much smaller floating vessels and to putting essential systems on the sea bed itself, weight and system size (footprint) are becoming an increasingly important feature of production equipment.

The new system has a footprint of only two by three meters, making it extraordinarily compact.

A cyclone of a solution

ABB has employed the same drive to reduce the size of essential offshore equipment in its development of a new desanding cyclone.

Although called a desander, the cyclone is actually a machine designed to separate water, oil, sand and gas. All four components enter the system mixed together during oil recovery and the cyclone splits them into separate entities, producing one stream of gas, one stream of oil and water and one stream of sand.

A normal gravity separator uses the forces of gravity alone to separate solutions, whereas a high-pressure desander uses high pressure to do the job of separation. ABB's new cyclone is a compromise – a trade-off of performance versus economics and scale. It aims to achieve 80 to 90 percent sand removal, still a very high figure, but using much lower pressure, which is more cost-effective to create.

The force at work in the cyclone is centrifugal. As the solution is rotated, the heavy and lighter particles travel to the outer core of the machine, while the very lightest – the gas – travels to the center.

Another challenge that the cyclone team had to overcome is the perennial problem of "slugging." In normal operating circumstances, big volumes of fluid can suddenly surge through the system and into the desanding equipment. These big surges of fluid are called slugs.

The challenge here has been to control the slugging process so that the cyclone is not flooded. Traditionally, fluids would go through a first stage separation process before desanding to introduce a measure of control to the flow rate of the fluid. ABB is now working on a system that will control the flow rate so that if slugging occurs, the sudden surge in volume can be contained. Once this is perfected, the cyclone will be able to cope with much higher volumes of fluid, significantly improving its economic performance.

Field tests of the system will be carried out in early 2001.

Rigged out for low-cost oil production

Oil exploration is moving into ultra-deep waters, and getting deeper thanks, in large part, to new ideas from ABB engineers. One of these ideas has led to the development of a new generation of deep-sea oil floater for oil production that is both safe and economical

When exploration began in the North Sea in the 1970s the challenge was to work in previously unheard-of depths of just 150 meters (490 feet). Now the industry wants platforms that can operate at up to 3,000 meters and beyond.

The challenge is to develop solutions that operate safely at such depths without being prohibitively expensive. A new concept developed by ABB will slice US$ 20 million to US$ 30 million off platform costs, tipping the balance towards economic viability in some deep water fields.

The new approach is a variation of the tension leg platform (TLP), which has been used in deep water fields since the mid-1980s. TLPs differ from conventional platforms in having tensioned legs which anchor the hull firmly to the sea bed rather than using traditional moorings which allow greater movement.

The legs are constructed of immensely strong and hollow steel tubulars, about 66 centimeters (26 inches) in diameter. A platform is anchored with between eight and 12 such legs.

Once these steel structures are in place, they are stretched, or tensioned, by pumping out the ballast water in the hull of the oil platform. As the water is pumped out, the legs are stretched. The result is very limited vertical platform movement – less than ten centimeters (four inches) at a water depth of 1,000 meters (3,300 feet). Horizontal movement is also limited to approximately six percent of water depth. Even in the largest hurricane waves, the platform moves only a few centimeters up and down, compared to more than a meter in conventional floating systems.

This limited movement makes TLPs very attractive for drilling and production operations, but it has been uneconomic in very deep water, where the cost of the mooring system becomes excessive. The deeper the water, the stronger (and therefore more costly) the legs have to be. In an area such as the Gulf of Mexico, where wave conditions can be extreme, the cost of TLPs becomes unattractive at about 1,500 meters (5,000 feet).

ABB set out to extend the water depths at which TLPs can be used. A key to this is reducing the weight of the deck structure, which would reduce the size of the legs needed and thus bring down the cost.

Like most technical breakthroughs, the answer was obvious once it emerged – although it had not struck any other rig designer in the preceding 20 years.

ABB's solution is to move the columns on which the deck is built from the corners of the hull structure 12-15 meters towards the center. This gives a more even dispersal of carrying strength across the whole deck.

Extended tension leg platform with three columns. ETLPs have deck and hull weights which are 40 to 50 percent lighter than comparable TLPs.

Below the columns, an additional extended structure compensates for this central movement allowing the tension legs to remain in the same position below the corners of the deck for maximum stability. It is this modification that gives the new design its name – the extended (base) tension leg platform, or ETLP.

This relatively simple modification to the existing tension leg concept has a dramatic impact on the weight profile. ETLPs are 40 to 50 percent lighter than TLPs and correspondingly less costly to the tune of between US$ 20 million and US$ 30 million. The lower cost allows this design to be used in waters down to 2,400 meters with very light platforms.

ABB's innovation has created considerable interest in the oil industry and has gained acceptance from the major regulatory agencies. The concept has been developed in less than two years to the point where ABB is now involved in active bidding – a very swift development program for this kind of engineering challenge. If the first bids are successful, engineering work will start on the first ETLP in 2001 and it should be producing oil from the Gulf of Mexico or West Africa in 2004.

Deep trees

Fossil fuels are getting scarcer but demand for energy derived from oil, gas and coal continues to rise. So the challenge for oil and gas companies is to find new reserves or to tap deposits that were previously too difficult to get to. And increasingly that means going offshore in deeper water depths, more hostile environments and using innovative technology.

One key area of innovation is in the development of underwater wellheads called subsea trees. These are customized valves and flow control systems at the top of the subsea wellhead, which act like a tap to control the flow from the well. As oil explorers go deeper, so ABB has concentrated on finding systems that cope with higher pressure and higher temperature conditions.

The tree valves used to be vertically aligned with the wellhead, which meant that when the well needed repairing the trees had to be removed. To get around this, horizontal trees were developed. ABB has incorporated novel metal sealing technology, first developed for onshore applications, to build a range of modular horizontal trees. The modular system uses standard parts which are quicker and cheaper to build, install and maintain.

The key to the technology is the use of special metals – base alloy steel and tin-indium – to construct the sealing system. When squeezed together at high pressure the metal softens and flows together to make an incredibly strong seal.

Since then the effort has concentrated on using the technology to develop systems that can withstand increasingly high pressures and temperatures. ABB has now developed the first high pressure Horizontal Subsea Tree designed for high flow-rate wells. The result is a system that will allow the development of wells up to 100 Mega Pascal (MPa) and 180°C with 18 centimeter production bores. The technology enables the use of larger production tubing within the normal constraints of existing drilling equipment.

The discovery of a number of large high-pressure, low-temperature reserves in the Gulf of Mexico was the starting point for the implementation of this technology. Under a three-year, US$ 9 million contract, ABB has been asked to build three horizontal trees for a new development in the Gulf and the first tree has already been deployed. First production has already started.

Fast reactions

You have a tight deadline to meet. You swig some water from a plastic bottle, throw the bottle in the garbage bag, hurriedly put in your contact lenses, rush to the car and turn on the engine. As you rush to work you probably won't stop to think that you have a chemical process called catalysis to thank.

All these things are end products of petrochemicals such as ethylene, propylene and styrene. To make them efficient while making sure the environment is protected requires complicated chemical engineering processes and the technology to control chemical reactions efficiently.

ABB has been a leader in developing a unique system to boost the efficiency of catalysis – the process of making two substances react together to form a new substance. Its Micro-Engineered Catalyst (MEC) system has undergone four years of rapid development by a multinational, multi-skilled team and is now beginning to bear its first commercial fruit in a variety of settings.

Early on, ABB realized that it had invented a novel and potentially very valuable approach to catalysis and put the MEC research program on fast track, backed by high-impact/high-risk funding. The research team included a number of universities in Europe and the United States.

In traditional approaches, catalysts are introduced to chemicals in inflexible forms – either as extruded material, in tiny spheres or pellets. Although standard, this approach has many weaknesses.

In a traditional bulk loaded reactor, reactants flow around the solid blocks of catalytic material but interact inefficiently. Either the reactor is packed too tightly, restricting flow and causing pressure to drop or, in an active system, only those catalytic particles close to the surface of the block are available to react.

Either way, the system is working below maximum efficiency – affecting the quantity and nature of the product that emerges.

ABB has found a way to coat micro-fibers – finer than a human hair – with particles of the catalyst material so small that they would normally be flushed out of the reactor's effluent system.

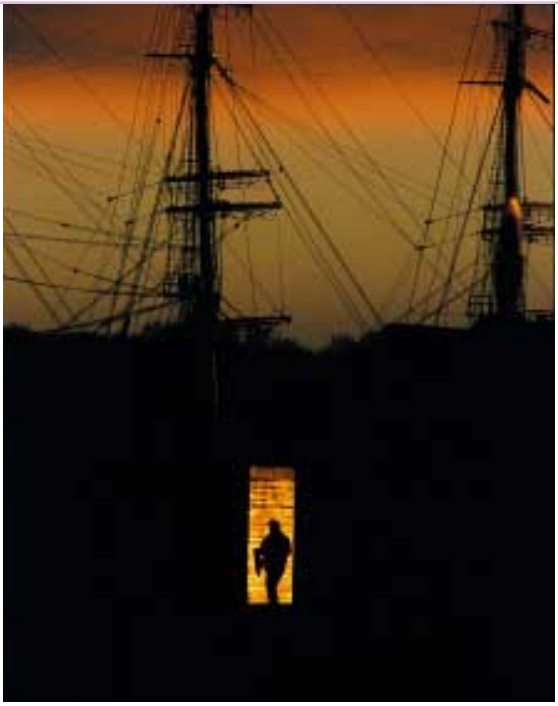
The fibers can be shaped and bent to fit the flow dynamics of the reactor and each particle of catalyst material caught on the fiber is offered up for reaction. This allows the reactant to flow much more freely around the catalyst and to react much more regularly and efficiently.

This complex piece of chemical engineering opens the way for much more efficient and smaller reactors, cutting capital costs and boosting returns.

ABB envisages a number of applications for the technology including use in hydrogenation and in cleaning up emissions, particularly nitrogen dioxide (NOx), from chemical plants and gas turbine power stations. Currently there are no efficient commercial NOx scrubbing systems on the market, despite ever-tougher environmental controls.

ABB is now close to securing its first commercial contracts for MEC systems that should see the system deployed in the fall of 2001. One is with an Asian client, where the process will be used for the hydrogenation of impurities in a propylene plant. The other, with a U.S. client, would see MEC used to reduce NOx emissions from a petrochemical refining plant.

In the eye of oil fields – reservoir imaging



Enhancing oil recovery means better understanding of oil distribution in the reservoir.

Today's operators of deepwater oil fields are increasingly looking for better ways to get more hydrocarbons from their reservoirs – all the while trying to contain costs.

Presently, it is estimated that less than 38 percent of the available oil in a reservoir (on average across the world's oil fields) is recovered during its lifetime. ABB strongly believes that recovery factors in excess of 50 percent can be attained, without drilling additional wells, by applying newly developed reservoir imaging and management technologies.

While the economics of individual fields varies widely, for a "typical" subsea oil field an increase in recovery factor of this size can generate more than US$ 100 million in additional profit to the asset owners.

Enhancing recovery requires a detailed understanding of the oil distribution in the reservoir and knowledge about the way in which oil is stored and flows through the ground. The difficulty in the past has been how to acquire this evasive information, located hundreds of meters beneath the sea.

It is widely accepted that there is a need for time-lapse, reservoir monitoring. This means performing repeated seismic surveys from the ocean surface of the reservoir over the life of the field – in effect, mapping the oil flow in the reservoir and identifying bypassed oil zones. While the information provided by these surveys is valuable in the efficient management of the reservoir, the high cost associated with acquiring this data has stifled the growth of its use.

ABB believes that the next step in reservoir monitoring will entail permanently installing seismic sensors within the reservoir, to provide continuous surveillance, and to make use of naturally occurring seismic signals generated by the reservoir itself. This constant listening inside the reservoir as the ground shifts and cracks can be quite revealing.

ABB has shown in oil field trials that microseismic monitoring can provide real-time 3-dimensional monitoring of pressure changes in the reservoir. It can also identify geological faults, areas of reservoir compaction and potential wellbore instability – feeding all the results back in the form of data and high-resolution reservoir images.

ABB is now moving forward with larger scale field trials of this technology and the development of efficient methods of deploying permanent seismic sensors into the harsh downhole environment.

Deeply powerful

Think of the offshore oil industry and the picture that is most likely to spring to mind is of an ocean littered with heavy, self sufficient rigs and platforms lashed by the waves.

If that is the image that comes to mind, it is already an outdated one. The offshore industry is in the throes of dramatic change. In the first phase, fixed platforms are being replaced by floating production, storage and offloading systems linked to the oil wells by riser systems.

But even this phase is likely to be short-lived. Already the industry is preparing itself for a new model of operation – production on the seabed with much of the equipment placed on the sea floor. The infrastructure we are used to seeing on the surface of the sea is all being reconfigured, reengineered and, in some cases, re-invented to operate below the waves and in very deep water.

One challenge has been to build a system that can transmit and distribute power to a whole range of systems on the seabed and to do it in a controlled way – in short to build an efficient electricity grid under the sea.

ABB has developed a revolutionary underwater transmission and distribution system to address this challenge. It is called the Subsea Electrical Power Distribution System (SEPDIS).

The basic rationale of the SEPDIS project is to allow power to be transmitted at high voltages to the seabed and then distributed locally to consumers. The consumers feed off a hub nearby rather than being individually fed from the sea surface. This cuts down the need for many long cables, with all the problems that creates in terms of power losses and harmful frequencies and harmonics.

In a very short time the project has progressed through concept development and system development and design, and a prototype is now available.

Although the SEPDIS development team has, wherever possible, used existing components that would be familiar to electricity transmission and distribution systems on land, the subsea environment presents unique challenges.

One: The seabed is a harsh environment. Systems sited there must be highly durable, reliable, easy to control and maintain, and strong enough to withstand the extremes of pressure that exist 2,000 meters below the surface. The same rules apply to any piece of equipment under the sea.

Two: Many offshore oil reserves are located in very remote places. Electrical power is the lifeblood of any production system trying to exploit those reserves. To get power to those remote places involves transmitting electricity over very long distances, either from shore or from a supply platform.

The SEPDIS design team is working on transmission distances of up to 160 kilometers in a power range of ten to 20 megawatts (MW) to serve between two and 20 consumers. The team is already looking at extending that distance to 240 kilometers – typical “step-out” distances in fields in the Gulf of Mexico and offshore on the West of Africa – with a maximum power level of 40 MW.

SEPDIS is a modular system comprising four main elements. The subsea system sits on a steel frame that comes in three different variants depending on the seabed conditions. For a small installation the base measures only six meters by 5.5 meters. On each corner of the frame are vertical guide-posts ensuring other components are properly installed.

On to this frame is fitted a high-voltage wet-mateable connector, an ABB design called MECON. This is an underwater connector where the transmission cable coming from the surface feeds into the subsea system. The unique element of MECON is that it has all metal seals facing towards the sea while all vulnerable "female" components are gathered together in one protected piece of equipment within the MECON.

A subsea transformer converts the higher transmission voltages ranging from 11 to 33 kilovolts (kV) to the lower voltages required for distribution to equipment on the seabed, which range from 3.3 to 12 kV. The transformer is basically the same as a conventional machine but ABB has changed the encapsulation, protection, system integration and interface designs to adapt it for the deep-sea environment.

Finally there is a circuit breaker and a subsea converter, whose job it is to provide the equipment with the right frequency. Transmitting power over such distances is perfectly feasible but there are side effects in the subsea environment – particularly over long distances and at great depth. If the frequency range is random and uncontrolled it will lead to over-current and over-voltage in the system. This can cause damage to vital components and impede performance.

ABB needed to encapsulate the components to withstand deep-sea pressure. Many of the components are therefore contained in rounded vessels – cylinders or pods that are more resilient to pressure – rather than the square shapes that are familiar in surface installations.

Cooling is another challenge. ABB has opted for a system that cuts out key cooling equipment, using ambient conditions to do the job instead. With SEPDIS the system relies on passive cooling – using natural convection through the water surrounding the system rather than pumps and fans.

The SEPDIS team is confident that the new system could speed the revolution that is gripping offshore oil production. Its success will not only usher in a new era of oil and gas production on the ocean floor, it will also mark the beginning of the end for many of the large offshore rigs and platforms that we normally associate with the industry.

The low sulfur problem – cracked

Diesel is the fastest growing transportation fuel in the world. Demand for it is rising by three to four percent a year and in the world's most pollution-prone countries – like China, India and Russia – demand is growing even faster.

But as in all other types of fuel, the pressure is on to manufacture diesels that are cleaner. Tough environmental and penal tax systems aimed at controlling the use of the dirtiest fuels means that refiners and petrochemical companies are on a constant search for ways to produce the popular fuels in forms that hurt the environment less. Simultaneously, refiners are trying to improve low profit margins by processing the cheapest and consequently most sour crudes – those laden with contaminants.

ABB has formed a 50/50 joint venture with Chevron (Chevron Lummus Global) to exploit and license a Chevron technology that holds the key to cleaner diesel and to extract other more valuable distillates from the refining process. The technology, a form of hydrocracking, is called Isocracking.

Hydrocracking is the refining process that converts high sulfur and other contaminant-laden heavy molecules to smaller, cleaner compounds that are used in transportation fuels such as gasoline, aviation turbine fuel and diesel. It takes place in catalytic reactors in the presence of hydrogen and usually under relatively high pressure.

The process is extremely flexible and the refiner can modulate the production of gasoline and diesel to suit seasonal and market demands. What distinguishes Isocracking from other hydrocracking processes is its ability to produce higher yields of aviation turbine fuel and diesel starting from the same feed source while consuming the least amount of high-priced catalyst and hydrogen.

Isocracking is also the only significant licensed process to be supported by experience from operating refineries. Chevron operates seven hydrocrackers.

From an environmental standpoint, Isocracking has two important functions. Firstly, it produces high quality diesel with low aromatics. Aromatics are the molecules in fuel that are difficult to burn in an internal-combustion engine. Some, like benzene, are carcinogenic. High levels of unburned material in the fuel come out of the exhaust pipes of trucks, vans, tractors and cars as highly polluting, suspended particulate matter (SPM) in exhaust fumes. Isocracking

reduces the aromatics to very low levels.

Secondly, Isocracking converts harmful sulfur and nitrogen compounds in heavy oils to compounds that can be trapped and removed from the environment. There is virtually no SOx or NOx – gases that cause acid rain – emitted from the plant. The latest generation of diesel and gasoline engine systems requires an extremely low level of sulfur in diesel, an additional driver for the refiner to produce cleaner diesel.

The key benefit of the technology is that it allows refiners to use heavy oils – which would normally only be useful for fuel oils used in ships and power plants – to create far more valuable gasoline, aviation jet fuel and/or diesel efficiently and cost effectively. In addition, Isocracking does not have the negative environmental impact of a process such as fluidized catalytic cracking (FCC), the most widely used heavy-oil conversion process in refineries.

The FCC unit has been used for decades to convert heavy oils to gasoline and a product called light cycle oil (LCO). Both these products are very high in sulfur content. The light cycle oil is laden with aromatics. In the past, LCO could be blended into the diesel pool with little or no treatment.

ABB's joint venture with Chevron is providing special technologies to clean fuel and reduce pollution levels.

The refiner's dilemma is what to do with the FCC unit in today's stringent environment that requires gasoline to have less than 30 parts per million (ppm) of sulfur, and diesel to have very low aromatics and sulfur. A combination of an existing FCC unit with an Isocracking process step, called Mild Isocracking, is the answer.

An Isocracking unit is included upstream of the FCC unit to trap most of the contaminants in the heavy oil. The process also produces a significant quantity of clean diesel. The cleaned heavy oil can now be fed to the FCC unit to produce clean fuels from which useful products can be more easily refined. This use of Isocracking has a huge potential in western Europe and the United States.

Chevron has designed more than 50 Isocracking units in the last 35 years, but constant refinements to the process and development of cleverer catalysts in association with ABB ensure that demand for this type of refining process remains strong.

The process now has a family of some 25 different catalysts, used for producing everything from gasoline to distillates. The wide array of catalysts permits catalyst systems to be designed to meet the specific requirements of a particular refiner.

In the last year, important projects have been completed or launched around the world, including one in a refinery near the Taj Mahal in India to prevent pollution destroying the marble of the famous monument.

Applications of mild Isocracking are expected to be particularly sought after in Europe where demand for ultra-low sulfur diesel is high. A recent project in Sweden has called for the production of low aromatic diesel with a sulfur content lower than ten ppm. The feed to the unit is heavy, high-sulfur oil.

Fantastic plastic

Office carpets, car bumpers and dashboards, spaghetti packaging, yogurt cups, suitcases, garden furniture, paint containers and coffee-machines are just some of a wide variety of products that are all made from the same kind of plastic.

The plastic in question is polypropylene, refined and produced to differing strengths and finishes. It is the fastest growing product on the plastics market, with demand expanding by seven percent a year.

To support this fast-growing market, ABB and Equistar have formed a joint venture to develop a polypropylene technology called Novolen.

The Novolen technology combines vertical, stirred gas-phase reactors – tubes where chemical reactions take place with a special mechanical stirring motion inside – and a custom-designed catalyst system. Within the gas-phase reactors a bed of fine polymeric particles is further polymerized (a process whereby smaller molecules are linked together in longer chains) to allow for the broadest possible range of polypropylene products – up to 360,000 metric tons per annum (MTA) – while still remaining economic.

In layman's terms, this polymerization technique is quite fascinating. Inside these tube-like gas-phase reactors, catalysts are mixed with chemical composites in a potent type of soup. Under the right temperature, the smaller molecules link up into the longer chains, causing the soup to get sticky.

Along the way, a unique deoderizing step is added to the process. This reduces the level of smell and odor of the polypropylene products to the lowest levels available on the market.

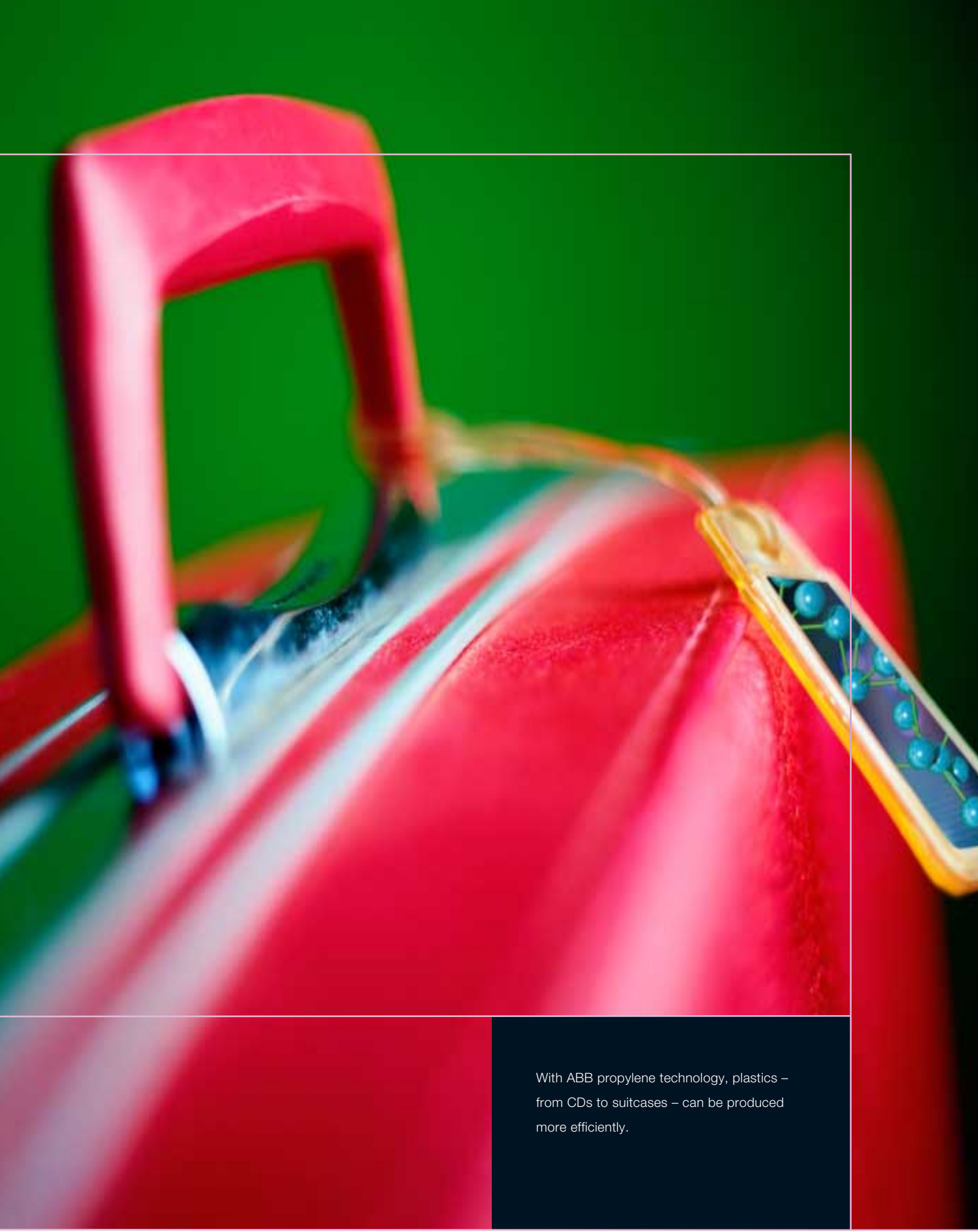
The benefits of this technology are huge to ABB, already a supplier of technology of essential feedstock chemicals, propylene and ethylene. The deal moves ABB into a high growth market that depends on products made with technologies it already supplies to the market.

In general, ABB's petrochemicals business is delivering technologies to produce the feed chemicals for the production of polypropylene in four different ways – propane dehydrogenation via Catofin technology, olefin conversion which combines ethylene and butene, fluid catalytic cracking units producing propylene, and naphtha cracking. Naphtha cracking uses a special chemical – a residue from oil – that allows customers to cut long molecules into shorter pieces.

Market assessments suggest that the global demand for polypropylene capacity, aggregated over a ten-year period, will be worth US$ 15 billion.

ABB's customers can license the Novolen technology to build polypropylene plants anywhere in the world on a modular basis. This is a tremendous advantage for smaller companies who are having difficulty entering the market – a market dominated by larger capacity players. New starters can break into the polypropylene market by licensing a low cost plant for the production of a basic product portfolio. They can then move up the value chain by adding new modules, with each step supported by an excellent group of technologists and scientists that continuously develop the Novolen technology, including not only the engineering part but also product know-how.

Already Novolen has 15 licensees operating around the world, three dedicated plants and seven new projects underway. In total, these account for some 4.3 million tons of dedicated capacity, about a seventh of the world's total capacity.



With ABB propylene technology, plastics – from CDs to suitcases – can be produced more efficiently.

Low-rise composites

Two tough offshore challenges face oil production companies today. The first is to search deeper and deeper for new reserves – often at depths greater than 3,000 meters. The second is to produce oil from these locations at the same cost as, or less than, oil from much easier-to-reach areas.

The depth constraint calls for new, tougher technologies that can withstand much harsher environments, especially extreme pressure levels. The cost constraint calls for affordable solutions that offer high performance and easy maintainability.

ABB has pioneered work in making crucial

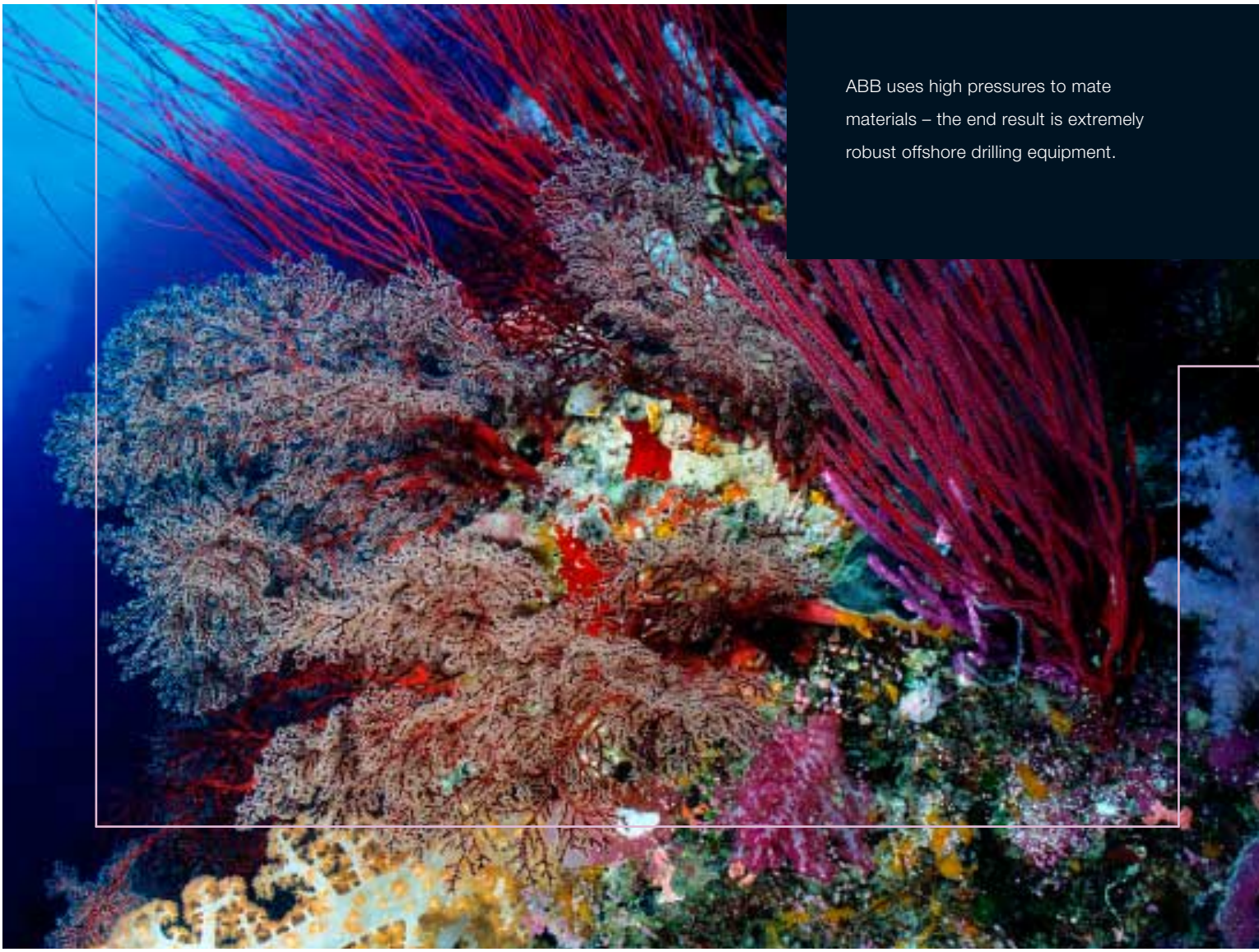


ABB uses high pressures to mate materials – the end result is extremely robust offshore drilling equipment.

seabed drilling and production equipment that meets both challenges including a new family of carbon fiber risers. They replace old heavy steel risers but can connect securely with other metal components. Risers are the pipes that connect the seabed wellhead to the production vessel or rig on the sea surface.

Getting metal and carbon fiber to connect securely had not been successfully achieved before ABB figured out a way to join the two materials. Since composites cannot be used for all seabed equipment, their use would have been severely restricted without this innovation.

The connection is achieved through a special ABB patented interface called the Geometric Trap. This attaches the standard metallic riser end fittings to the all-composite main body of the new riser. The end fittings – the tubes at the end of the body – are pressed to the tube with a higher pressure than they will ever experience in operation. This high pressure leads to a perfect connection between the metal and the composites. The seal is impenetrable and perfectly transfers the bending and tension loads between the two parts.

Laboratory testing of a 21-inch, all-composite riser has been successfully concluded and this will soon be field-tested on a drilling rig for six months. During lab tests the riser has been subjected to loads of two million pounds as well as bending and tension tests. ABB is working on a new system to predict and verify composite riser performance in full-scale lab tests.

Oil, gas and petrochemical technology: Examples of major product launches 2000

- **Combined mild hydrocracking/aromatics saturation for ultra high quality.**
- **Integrated ethylene cracking/olefins conversion technology.**
- **Incorporation of CD Hydro (reactive distillation) into ethylene manufacture.**
- **Optimized ethylene plant via binary refrigeration.**
- **The Single Column Floater (SCF) Deep Water Floating Production vessel.**
- **The Mini TLP, highly-efficient floater for moderate payloads in deep water.**
- **ADMARC, Advanced Down Hole Monitoring and Control.**
- **DOGS, Down Hole Optical Gauge System.**
- **CODEFLO, offshore water purification system.**
- **Compact processing equipment, 4C Cyclones and Electrostatic Coalescer.**
- **8 slot subsea template for Snorre B.**
- **High pressure horizontal tree.**
- **Well Intervention and Test System, WITS.**
- **13" Subsea wellheads.**

Sustainability and alternative energy technology
Testing the alternatives

We are used to electricity being produced in huge industrial-sized power stations and having it fed to us over hundreds of miles of power lines and cables. But increasingly a new model is emerging as a real alternative. In this model, combined heat and power (CHP) stations, wind turbines, fuel cells and other small generating units will be on the doorstep of the user. They will be managed to meet local needs and to feed surplus power into regional and national electricity grids. It will be a case of power at the point, or close to the point, of demand.

The advent of deregulation, privatization, electricity trading systems and growing political pressures to reduce greenhouse gas emissions has created a trend towards the new model of so-called "distributed" electricity production and supply. Large-scale power plants will continue to be vitally important sources of electricity, but distributed power can provide an economical and environmentally preferable alternative in many cases.

For example, around the world some 755 million homes have no access to power whatsoever – 270 million of them in East Asia and the Pacific, 125 million in India, 65 million in sub-Saharan Africa and 29 million in eastern Europe. These are developing regions where new, clean technologies have the power to offer a transformed lifestyle without destroying the environment.

But it is not just the less well-developed nations that need new approaches. In the U.S., some half a million homes have no access to electricity. Each year, about 300,000 homes are built in isolated places where long-distance electricity grids have to be specially extended, at great cost, to reach them. Another 11 million existing homes are in sparsely populated areas where expensive grid connections are needed to bring power to small, isolated communities.

ABB has set itself the goal of being the leader in this exciting new field. As the pages that follow show, we are focusing our expertise and innovation skills in electronics and Internet technology on developing a whole range of products to make renewable and alternative energy systems economically and technologically viable.

Among the challenges: Power from distributed sources, like small turbines or CHP schemes, comes in a form which is often incompatible with the main electricity grid. The smaller a generating unit, the higher the frequency it has to operate at to achieve a level of output. A typical microturbine, for example, will generate power

Strategic, long-term corporate research programs to support Sustainability and alternative energy technology

Distributed power and renewables

Researching systems for alternative energies like solar, wind, fuel cell, biogas, microturbines and combined heat and power (CHP).

Working in several joint ventures and cooperating with leading universities to facilitate the growth of efficient and sustainable distributed power generation solutions.

Working toward sustainable development means making alternative energy – wind power, fuel cells, microturbines and combined heat and power (CHP) – affordable.

at a frequency of around two kilohertz. Most grids operate at much lower frequencies of either 50 or 60 hertz. Somehow that gulf has to be bridged.

Similarly fuel cells, like batteries, produce direct current (DC) power, but grids require alternating current (AC) power. Large wind turbines also produce power in a variable form depending on the speed of the wind. The grid needs the power to come in a predictable, uniform way. It is possible to convert power from wind turbines into usable form but it is expensive to do so at the point of generation – one reason why wind power struggles to be competitive against more established forms of generation.

Technical hurdles such as these have kept alternative and renewable energy in the wings, struggling to compete on price with fossil fuels. Now, for the first time, we have developed the technologies that will allow them to take center-stage.

Simplicity and control deliver savings

Using sensors to monitor the flow of information in heating systems is cutting costs and increasing efficiency.

Using new technology intelligently often leads to less mechanical complexity. Frequently, the key to achieving savings is simplicity and control.

This is clearly illustrated by EcoNet, a new patented heating, cooling and ventilation system.

The main advance in the design of EcoNet is the use of one single energy exchange element instead of separate units for heating, cooling and recovery. This is possible because the design of the system optimizes the flow of liquid through the single heat exchanger, thus producing greater efficiencies and removing the need for separate units as in traditional designs.

The flow is optimized because sensors are used to monitor the liquid conditions and feed back that information to a control box which regulates the flow.

Just as thermostatic domestic radiator valves (the valves that control temperature in a home) are more efficient than traditional on-off valves, this intelligent flow control maximizes energy efficiency compared with traditional systems.

This major design innovation produces a more compact unit (four meters wide instead of 5.5 meters) and has several important consequences that result in significant energy savings.

First, the pressure drop in the system is much lower than in conventional units. This means the unit uses less electricity and so produces immediate savings.

More substantially, the excellent heat recovery characteristics make it possible either to achieve much greater temperature differences between inflow and outflow, or to use inflows at lower temperatures than usual for the same heating effect. This can transform the possibilities for the source of hot water inflows.

For example, in supermarkets it is possible to use outputs from the extensive refrigeration units as inputs into the heating system. In traditional units the refrigeration liquid would not be hot enough to deliver the required heat levels, but EcoNet's greater efficiency makes this possible.

Similarly, waste heat from industrial processes might become the inflow for the EcoNet system.

In district heating schemes EcoNet also offers advantages because the return water is colder than in conventional systems, which improves the efficiency of the power plant. (The same applies, in reverse, in district cooling schemes.)

Already several hundred installations are operating in Scandinavia, and Econet is now spreading throughout Europe and the rest of the world.

Noises off

If you are ever struggling to keep awake at your desk in the office, the chances are you are suffering from the effects of noise.

Barely audible low frequency noise – emanating from air handling units – is a constant bugbear in the office environment. You have to concentrate hard to hear the noise. Most of the time your brain is battling hard to concentrate on what you are doing and, although you are unaware of the irritating sound, this battle of wits can make you feel very weary.

The effects of this sort of ambient noise pollution are only just beginning to be understood. It is the focus of huge amounts of research at the moment, particularly in Sweden. And ABB is on the leading edge of research to invent an advanced silencer system to cut out the noise in office and building heating, ventilation and air conditioning systems.

To date, silencer systems have tended to be heavy pieces of equipment, which depend mostly on using fibrous sound muffling material. The higher the frequency of noise, the more fiber that is needed. Since it is packed into the system it will often block the air flow channels, leading to a loss of pressure in the air unit and therefore reduced performance. Another disadvantage is that traditional methods can do nothing about low frequency noise.

ABB has now developed an advanced silencer that not only reduces high frequency noise with less dampening material, but also for the first time offers a way to get rid of low frequency noise.

The advanced silencer attacks low frequency noise actively. It involves a microphone fitted ahead of the silencer unit that records the low frequency sound. The sound is then fed into a controller, where the phasing of the sound waves is manipulated digitally. The controller kills the low frequency sound by producing a precise opposite of the sound wave formation.

A second microphone, fitted downstream of the silencer, is used to monitor that the sound has been cleaned up. The system is the first to offer a way to kill sounds below 150 hertz.

Higher frequency sounds are tackled using dissipative dampening techniques. The difference here is that fibrous material is replaced by a plastic muffling material called Dacron. This is less bulky, meaning that dampening is achieved for the first time without any constriction of the air flow channels and no pressure drop. A further benefit of using the plastic material is that no micro-fibers are blown into the air to be breathed in – a particularly important feature for units in clean environments like hospitals, laboratories and clean rooms.

The advanced silencer, which will be marketed from the fall of 2001, is designed to work with the latest air units made by ABB but can be retrofitted to older systems already installed in buildings. It is supported by a mass of Web material and software to help operators achieve maximum efficiency.

Eliminating background noise with less dampening material – ABB's advanced silencer.

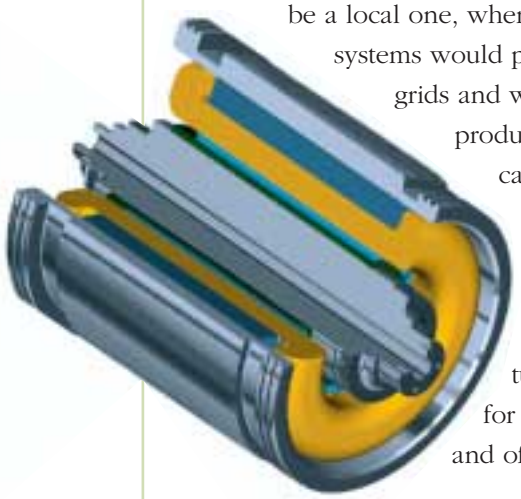
Small is powerful

Power generation is on the brink of a revolution. From the very start of the electricity industry, the guiding philosophy of this important part of the economy has been big is beautiful. We take it for granted that power is created in huge stations and transported over hundreds of miles of power grids to us.

But as the last century closed things began to change radically. Increasingly, small-scale solutions are being seen as an important part of the power generation mix. Now, a good proportion of our power requirements are met by small, highly efficient generating systems that meet our needs for electricity and heat.

Among the smaller systems that are becoming viable is a technology that ABB has been instrumental in making economic. It is the microturbine – a highly compact engine, no bigger than the size of a small room, which is simple to operate, highly efficient and requires minimal maintenance.

ABB is developing microturbines in a joint venture with the Volvo Aero Corporation, called Turbec. Both companies were quick to realize that a new paradigm for electricity generation and supply was taking hold. It would be a local one, where a variety of small-scale systems would produce power for local grids and where heat, the natural by-product of generation, would be captured and put to use rather than squandered.



Because of their ability to work as combined heat and power plants, microturbines are an ideal solution for hospitals, hotels, apartment and office blocks, greenhouses, schools and factories. Yet sales of these systems have only just begun to lift off.

In 1999, only some 500 units were sold throughout the industry – worldwide, with the combined generating power of 15 megawatts (MW) – a fortieth of the size of an average gas turbine power station. In 2000, sales have leapt to 2,000 units with a total capacity of around 100 MW – still only a sixth of the size of a large generating station.

But it is now predicted that some 2,000 MW of microturbine capacity will be sold each year by 2005 – the equivalent of two big power stations.

ABB's work with Volvo in this field has concentrated on creating a very compact system generating 100 kilowatts (kW) of power and 167 kW of thermal power. The system, called the MT100, is very small measuring two meters high, three meters wide and one meter deep so it can be fitted into a small space.

The compressor and turbine of the system are mounted on the same shaft, meaning the turbine has only one moving part and is therefore quiet and low on vibration.

This makes it very easy to maintain, requiring one overhaul for every 30,000 hours of operation, roughly once a year. Early systems are delivering availability of 92 percent. Remote diagnostics built into the system allow early detection of faults so that they can be tackled before escalating into major problems.

The compressor feeds air into the turbine, where it is mixed with hot exhaust gases from the combustion chamber. This causes the shaft to rotate and allows power to be generated.

After leaving the turbine, the exhaust gases preheat the process air in a recuperator and are

Turbec, the ABB-Volvo joint venture for microturbine technology, launched a 100 kW microturbine in 2000.

then fed into a heat exchanger where surplus heat is used to create hot water. Water can be heated this way to between 50 and 70 degrees Celsius. With the addition of an absorption chiller the exhaust gases can be converted into cold air for air conditioning.

The benefit of this system is that it can run on a variety of fuels including natural gas, waste gas, ethanol, methanol and even diesel. The efficiency of the burn means that emissions of NOx and CO_2 are extremely low – an estimated two to eight times lower than conventional burners.

But the uses of microturbines are unlikely to be isolated to self-generation schemes alone. Utilities looking to boost the efficiency of their networks are increasingly looking to distributed generation schemes to meet local needs. Microturbines will undoubtedly form part of a more environmentally friendly generation mix with windmills, fuel cells and solar schemes.

China takes over greenhouse research

ABB has donated an entire laboratory, involving more than US$ 800,000 of equipment and years of research into ways to deal with global warming and greenhouse gases, to the University of Tianjin, 150 kilometers south of Beijing.

The lab – once located in Switzerland but since dismantled, flown to China and reassembled – will carry out research mainly in the area of capturing and reusing greenhouse gases. For example, how can catalysts be used to turn carbon dioxide into fuel, such as liquid methanol? If this could be done economically, it holds the promise of recycling gases that now are pumped into the atmosphere – cutting emissions while providing a new source of fuel.

Processes for this reaction are known, but they require very high temperatures and are expensive to carry out. ABB research has focused on using a high-voltage discharge – a dielectric barrier discharge – to create the proper conditions for the reaction to take place. The lab in Tianjin will continue this research in ongoing cooperation with ABB scientists.

China, as the world's most populated country, one of the fastest growing economies, and a country rich in coal as a fossil fuel, faces a special challenge to control greenhouse gases as its industrial base develops. It is a challenge with global implications – locally produced greenhouse gases spread within just half a year over the entire planet. The ABB lab in Tianjin is an important step in building the partnerships across borders needed to tackle this challenge effectively.

Wind power that works and pays

Technical, economic and environmental problems have disrupted man's dreams to turn the huge natural power of the wind into a viable source of electrical power. But that is now changing.

ABB has developed new wind power technologies that for the first time make this clean source of renewable power economically viable on a large scale and still reliable and environmentally acceptable.

Large areas of the world have ideal wind conditions for generating power. In the 1990s, wind power grew dramatically. By the end of the decade, installed capacity was growing at more than 30 percent per annum.

But developments over the past couple of decades have had only limited success in competing with conventional fossil fuel power sources such as oil, gas and coal. Wind farms struggle to reach the levels of efficiency necessary to supply the cheap electricity which consumers want.

Not everyone sees them as environmentally attractive either. They may offset the environmental damage of carbon dioxide from conventional power stations. But some people object to wind farms, saying that they intrude on the physical environment, disrupt the landscape and cause noise pollution.

For a long time the obvious solution to these problems has been to site wind farms out of sight, out of earshot and out to sea. Offshore farms would answer the complaints of local residents worried about noise and unsightliness, and would also capitalize on the strongest winds.

But the hostile conditions in locations such as the North Sea require especially robust equipment. ABB's new Windformer technology, first introduced in June 2000, is a higher power wind turbine that removes the gearbox – a device in need of regular maintenance – from the equation, working well even in hostile, choppy waters.

In the past, wind power wasn't very efficient. There are several reasons for this. The first is that conventional wind turbines produce relatively low outputs of electricity – typically 500 kW. Efficiency rises with capacity and the target now is for turbines producing more than three MW.

Large wind turbines have been developed but they have suffered from further problems that have pushed up costs. First, this kind of equipment typically requires high levels of maintenance, and secondly it is difficult to handle the variations in power, an inevitable consequence of variable wind speeds that these machines encounter.

The high maintenance overhead is associated mainly with the gearboxes used by conventional wind turbines, and transformers that are traditionally used in connection with the generators.

The gearbox translates relatively low rotor and turbine speeds to the higher speeds used to generate electricity. It is a sensitive mechanism and suffers considerable strain, so frequent maintenance is needed to keep it operating properly.

ABB's solution to these problems is to do away with both these maintenance components. Windformer is designed to operate without a gearbox and a transformer, cutting maintenance costs in half.

It operates at any rotational speed, allowing the turbine to drive the generator directly, without using a gearbox. This is possible due to the

ABB's Windformer technology allows power supply to be linked efficiently to flexible HVDC Light systems.

rectifiers – converters to direct current – that are integrated in the generator.

Secondly, Windformer uses permanent magnets instead of electromagnets. This avoids the need for sensitive mechanisms necessary to provide a magnetic field in the rotor of conventional generators. This simpler design makes Windformer more cost-effective. Add in the economies of scale from higher output levels and the unit cost of the electricity produced becomes much more attractive.

The low-maintenance characteristics also make Windformer more suitable for offshore operation than most wind turbines. In such harsh and often remote environments, sturdy equipment is needed which requires a minimum of maintenance.

A final element of Windformer, which helps meet this need, is an innovative approach to the generator windings. Windformer uses cable instead of normal windings, which makes it more resistant to damage from harsh natural forces which occur offshore, like salt. Using cable also allows higher voltage output, which has added benefits in avoiding large short-circuit forces in low voltage generators.

But the most important and unique element of the Windformer concept is yet to come. Wind turbines produce uneven power with high fluctuations in frequency. But Windformer makes use of the much more flexible high voltage direct current (HVDC) approach to transmission. The principle benefit is that HVDC converts variable frequency power to direct current that has, in effect, no frequency. HVDC cuts transmission losses by 50 percent but has only traditionally been economic for long distance transmission and large power capacities.

That remained the case until ABB introduced its HVDC Light – a compact system able to handle shorter distance transmission and smaller loads. It is an ideal solution to overcoming problems of connecting wind turbines to electricity grids.

Grids can easily be destabilized by the kind of variations in frequency that come from wind farms. But with wind strength naturally varying substantially, such variations are an inevitable aspect of wind power.

HVDC Light solves this problem by decoupling the windmills from the grid. Instead of feeding the alternating current from the generators straight into the power network, the rectifiers in the generator convert it to direct current. This is then fed at high-voltage to a HVDC Light system that returns the power back to alternating current – but at stable frequencies that are more essential for input into the grid if the network is to operate smoothly and safely.

HVDC technology is not new. But until now it has only been suitable for long distance, high capacity transmission. HVDC Light represents a major breakthrough by ABB allowing this technique to be applied to wind farms. With the design breakthroughs already mentioned, it will transform the economics of wind power, making it possible to build offshore wind farms with high electricity output at competitive prices

The first three MW unit will be delivered to the Swedish utility Vattenfall in September 2001 and will begin producing electricity in December on the Swedish island of Gotland.

New blow to wastewater

ABB's High Speed Turbo Blowers are an efficient and clean alternative to conventional equipment used in the aeration of wastewater. They combine innovative design and advanced materials to produce equipment that is simpler and more effective than conventional blowers.

To clean water effectively it is essential to pump oxygen right down to the bottom of the deep basins where the water is stored. That requires high pressures, which are conventionally achieved using compressors. Equipment using fan technology is available but to achieve the required pressures using conventional technology it is necessary to have relatively complex, multi-stage fans.

ABB has developed fan technology that achieves the same pressures as low-end compressors, but in a unified piece of equipment that is simpler, more robust and more controllable.

The secret is the ability to achieve high-speed rotation and to combine the motor and fan in a unified package. That is achieved by using carbon fiber for the fan blades and advanced frequency converter technology instead of a gearbox.

Frequency converters use electronics to control the frequency and thus vary the speed of the motor directly, rather than transforming the basic motor speed through the use of gears.

The absence of a gearbox means the motor operates more efficiently and maintenance costs are much lower. Gearboxes are also a major source of oil pollution, which is important to avoid in applications such as water treatment. The absence of a gearbox also means the fan can be mounted directly on the shaft of the high-speed motor, resulting in a compact piece of equipment.

ABB has developed frequency converter technology to produce exceptionally high motor speeds, breaking previous limits in this approach. But this would still not be fast enough to deliver the necessary air pressures with conventional fan materials. The fan blades are therefore made from plastic reinforced with special carbon fibers rather than steel. The fibers are aligned in the direction of maximum stress to provide added strength.

The result is a fan with the same strength as steel blades but which are 80 percent lighter. As a result, the fans can spin much faster, using simpler, less expensive bearings and rotational structures.

These high-speed blowers do not just represent an intelligent design. They also have intelligence built in. An electronic device gathers information from sensors and communicates it to plant controllers so that the status and performance of the system can be monitored constantly.

A pilot installation began running in January 2001. It is expected that the product will be available by the third quarter of the year.

New fan technology and advanced frequency converters aerate water and feed back results in real time.

Driven to extremes

ABB has developed an Internet-enabled tool to help customers in a range of industries analyze and optimize the performance of a key manufacturing component.

Drive systems often lie at the heart of automated manufacturing systems. Understanding how a drive system is performing – from the total system right down to the individual components like gearboxes – is a vital piece of industrial intelligence.

Currently manufacturers are supported in the task of optimizing drive systems by teams of maintenance experts. Often the task of detecting faults and recommending remedies can take months of site visits and inspections.

Now ABB has developed the first ever automated drive dynamics analysis (DDA) tool, based on software developed by ABB programmers, which takes measurements and analyzes data remotely, with all information sent via the Internet.

The system uses modern optimization algorithms and the latest in simulation technology to analyze performance and disturbances, to project the results of fine-tuning or rebuilding the system and to recommend the optimum settings. It has the power to reduce wear and tear, to boost production by reducing downtime and to improve yield and quality.

The DDA tool includes a full copy of the real-life drive system, including all mechanical, control system and process parts. Using this copy, ABB technicians are able to simulate and test all the functions that would be carried out on the real system without risking damage to the equipment or the need to take it out of production.

The most useful aspect of the DDA tool is an artificial expert tuner that acts as a highly efficient virtual engineer. But not only technicians themselves can simulate the drive dynamics.

A built-in tuner can automatically search for the optimum system performance. This uses algorithms and simulation to auto-tune the system – self-searching for optimal settings. Tests have shown that the virtual engineer automatic optimization system achieves better results than human counterparts, in much shorter time.

The system DDA tool can also be set to make production line reports, providing the manufacturer with a constant stream of information about the running of the drive, its efficiency and any defects that occur.

Energy management gets smart

Energy management is becoming increasingly important for industrial and commercial buildings and homes. Minimizing power use saves energy and money, but doing it efficiently requires accurate and timely information about electricity consumption and conditions.

This can be achieved using communications based on the European Installations Bus (EIB) standard, which allows all kinds of different electrical equipment to communicate with each other using a common standardized protocol so that energy can be metered and controlled.

A consortium of European companies in which ABB is a lead partner developed the EIB standard. It is the norm across Europe and is now gathering increasing acceptance in Asia and the United States.

ABB has developed a huge range of products based on the EIB system, the latest of which is the EIB Delta-meter. It is the first EIB electrical energy meter that allows operators to measure, monitor and control electrical energy consumption and manage the energy of a building. It adds to ABB's products in lighting, heating and security, all of which aim to make building management not only more economical but also to make buildings more secure and comfortable.

The Delta-meter is designed for use in industrial and commercial sites as well as apartment blocks or other domestic complexes where it is necessary to measure electricity use for each dwelling or consumer, so called submetering within a building.

The meter includes an EIB communication interface that enables power consumption, instantaneous power and fault information to be read remotely. This avoids the need for manual readings at a series of meter points.

Among the different types of readings that can be made by the new meter is the actual power usage at any time, which means it can be used to manage the power loads. This can be important where electricity utilities make additional charges for exceeding a contracted maximum load level. If a consumer is in danger of exceeding an agreed energy consumption and moving into a penalty tariff, the meter will order the system to shed load.

Central to the new system is a new chip or integrated circuit called the "alpha-chip," developed by ABB. It lies at the heart of a new technology called DSP – digital signal processing – which measures and filters the voltage and current value.

A microprocessor then processes these measurements, displays the values on a local display of the energy meter, and controls the communication by using the EIB communication interface. The EIB communication inter-

face connects the energy meter to the EIB – a two-wire communication bus – and allows remote reading and parameter setting of the meter.

There are numerous advantages to remote meter reading. With the new system, several energy meters can be read via the EIB communication bus from a central point at any time, day or night. Remote reading is obviously much faster then manual reading.

The system guarantees error-free readings in a digital format which are easy to process for other applications like automatic billing.

Sustainability and alternative energy technology: Examples of major product launches 2000

- **Windformer:** A novel technology platform for wind energy generation including high power / high voltage wind generators with permanent magnetic rotor, variable speed thanks to a DC interface with AC grids and the most modern control and protection systems.
- **Microturbine:** Most compact combined heat and power generator for 100 kW electrical output optimized for distributed power generation applications.
- **SGF 123 - 245 kV:** Independent certificate for environmental product declaration for disconnector type SGF 123 – 245 kV, produced in Poland.

ABB and fuel cell development

ABB and DuPont have agreed to jointly develop fuel cell systems for a variety of applications, in particular a very low emission solution for stationary distributed power generation.

We are initially concentrating our joint development on direct methanol fuel cells (DMFC) for stationary applications with a power output of one to 10 kW. The direct methanol fuel cell has the great advantage of not needing a fuel reformer (from fossil fuel like natural gas to hydrogen). The fuel reforming is done in a complex and expensive reactor sub-system where trace elements such as hydrogen sulfide have to be removed. In DMFC, the conversion from methanol to hydrogen is done directly inside the fuel cell stack by an internal catalytic chemical reaction. Methanol fuel has a very high energy density and can be fed directly to the stack as liquid (a weak solution in water). This is a much simpler and less costly method than in the past.

The collaboration with DuPont started in August 2000. A laboratory prototype will be installed at our ABB lab in Raleigh, North Carolina, in the United States in May of this year and we are scheduled to install two prototypes at customers' sites in the fall of 2001.

The joint development program with DuPont is that they develop the fuel cell stack – including all components, like the catalyst, membranes and electrodes that power the DMFC system. ABB will develop the optimized electrical system for the plant, from power converters and conditioning, to the electric feed and control system, and direct current (DC) and alternating current (AC) power distribution systems. ABB will also develop back-up power systems and other electrical components. The two teams are cooperating most closely to develop the optimized balance of a plant, for example, in the area of fuel feed and the control system, the water and heat management system and other plant sub-systems and components.

ABB will also incorporate features like net electricity metering and local microgrid communications and connectivity as required for certain applications.

Glossary

Absorption chiller A system like a refrigerator that cools down when the working medium is absorbed by a solid substance

Admarc Advanced Downhole Monitoring And Reservior Control system

Direct torque control A drive system that controls the power to the motor in a way that the optimal torque can be provided by the rotating shaft

Fault closing device A system of circuit breakers operating in a way that a fault in a grid is prevented from doing further harm

Frequency converter Electronic device that can generate an alternating current at a desired frequency

Fuel cell A device in which chemical energy released by the oxidation of a liquid (such as methanol) or gaseous fuel is converted directly into electrical energy

Global positioning system (GPS) A satellite communication system that provides the exact position and time at any point on the globe

Greenhouse gases Gases that contribute to the greenhouse effect and global warming. The most significant are carbon dioxide (CO_2), water vapor, methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6)

Hydrodynamics Describes the interaction of moving objects like ships in fluids like water

HVDC Light An ABB system that converts alternating electrical current into direct current and vice versa. Due to the use of efficient conversion systems and optimized components it offers a very economic solution: It is the “light” version of the traditional HVDC systems

Hydrogenation Chemical process to subtract impurities from chemical substances with the help of hydrogen

IGBT Integrated Gate Bipolar Transistor, a power electronic device to provide a desired electrical current with the help of integrated control elements

Infrared thermography A method to measure the status of equipment by analyzing its radiation due to undesired local heat generation

Java A platform-independent software programming language specially suited for Internet applications

Laser cutting A metal processing method using high power lasers for cutting metal sheets

Manifold A container with various connectors for pipelines to distribute oilflow

Model predictive control (MPC) The online control of a process using a process model, run in a computer to predict the next control settings

MOS transistor An electronic switch controlled with the help of a thin metal oxide sheet

Numerical controlled milling machine High precision material processing machines in which the movement of the tools is controlled by a computer

OPC, XML, HTTP, HTML Abbreviations for the most common protocols to exchange data on the Internet

Permanent magnet sychronous motor Electric motor with the magnetic field in the rotor provided by permanent magnets

Predictive maintenance A method for forecasting when the maintenance of a machine or system should be done before a failure occurs

Recuperator A system that can transfer heat from one flow to another. It is used to heat incoming airflow with exhaust heat from the outflow of a process

Root cause analysis A method to find the basic reasons for failures in a process

SVC Power electronic system that without rotating part (static) compensates fluctuations in the voltage and current of an electric grid (VAR)

Template A steel structure positioned at the bottom of the sea to serve as a platform for various components

Web-based Software programs that incorporate the Internet for successful operation

XLPE A special form of polyethylene, in which the molecules are closely linked together: cross-linked polyethylene

Technology management

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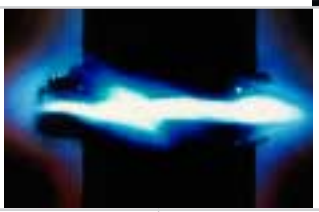
Working with academia to establish long-term technology projects.

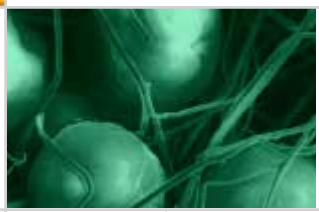
Upstream and downstream oil, gas and petrochemical technology that is driving clean fuel development.

Making meters communicate for efficient energy management.



Truly intelligent and maintenance-free circuit breakers control high-voltage arcs.

Extremely low temperature-enabled super-conductivity.



Microengineered catalyst (MEC) technology helps produce new, more stringent materials for everything from contact lenses to plastic bottles.

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