Venture
into the world of industrial turbomachinery and oil and gas solutions

Issue 12 | December 2009

Focus
The dawn of sustainable clean energy

Monitor
New cogen package for largest Greek wastewater plant

Spotlight
CO₂ — Taking the bull by the horns
Dear Readers,

This issue of Venture reflects on customer solutions based on our range of core products, illustrating the variety of applications and global distribution of the projects. These range from a less-than-glamorous but undeniably essential and well-functioning sewage works in Greece, powered by one of our gas turbines, to a solar thermal power plant basking in the sun of Andalusia where our steam turbines spin their lucrative power from Apollo’s gold. We also have our own solution to the reduction of CO₂ in carbon capture and sequestration plants: here an integrally geared compressor makes its contribution to sustainable technology.

Meanwhile, back at base, amid normal production and delivery, we are streamlining our organization for a sharper market and customer focus. The merging of previously separate units and infrastructures into two single operating units will enable us to respond more quickly to customer requirements and exploit synergies in our business, particularly in the crucial areas of purchasing, project management, and Research & Development. This will enable us to provide you, our customers, with swift response and greater added value and to drive our business purposefully into the future.

Donald Weir, CEO of the newly created business unit Compression and Oil & Gas solutions, gives you some insights into this development within these covers.

So without further ado we hope you enjoy your trip around the world of the Siemens Oil & Gas Division!

Tom Blades, President
Siemens Energy Sector, Oil & Gas Division
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Cover photo: The intriguing beauty of a parabolic-trough solar farm near Seville, Southern Spain.

IMPRINT
Publisher: Siemens AG, Energy Sector, Oil & Gas, Wolfgang-Reuter-Platz, 47053 Duisburg, Germany  Responsible: Dr. Uwe Schütz  Editorial team: Lynne Anderson (Head), Manfred Wegner  Contact: lynne.anderson@siemens.com  Contributing editor: Colin Ashmore, Andreas Kleinschmidt  Design: Formwechsel Designbüro, Düsseldorf  Photography: Florian Sander, Jochen Balke  Lithography: TiMe GmbH, Mülheim  Printing: Köller+Nowak GmbH, Düsseldorf.
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Around the world

1 Siemens control systems will provide important offshore-onshore links for StatoilHydro

Siemens has secured two new contracts with StatoilHydro for the delivery of control systems to subsea fields in the European North Sea. The first delivery includes four additional subsea control units (SCC) for the Snorre A subsea production system. The SCC units monitor temperature, pressure and sand-production ratio from dedicated wells and will contribute to increasing the production ratio from subsea wells in accordance with StatoilHydro’s Increased Oil Recovery program.

The second contract includes a complete acoustic sand-monitoring system for the Snorre B subsea-production system. The system consists of two SCC units mounted in frame structures, together with slave panels, jumper cables and necessary wet-mate connectors. All of the SCC systems control 16 production wells.

Siemens has developed a high-performance, flexible concept for monitoring and control of down-hole and subsea installations. The SCC concept offers a wide variety of standard interfaces to conventional and smart instrumentation. Advanced application and diagnostic software ensures excellent system responses and reliability. The SCC is fully integrated with Siemens PCS7 systems. A topside data server integrates the SCC unit with third-party systems and otherwise includes the necessary applications for commissioning, operation and remote maintenance.

Providing the vital link between the offshore SCC and StatoilHydro’s onshore facilities, the Siemens-developed Digital Power-Line Modem (DPM) is a patented, field-proven digital modem featuring communication on power lines up to 200 km with a transmission rate ranging from 9.6 kbps to 3 Mbps. This is the first modem ever giving broadband-level capacity on long subsea-cable step-outs.

2 Sweden’s largest biomass plant to be powered by a steam turbine from Görlitz

Sweden is not just a popular holiday destination with breathtaking scenery. It is also a country aiming to become independent from fossil fuels by the end of 2020. In order to achieve this aim, power generation companies are focusing more and more on renewable energy. One example is the Igelsta biomass power plant to which Siemens delivered an S5T-800 steam turbine in summer 2009.

For this project, SPPA-T3000, a new electrical and control technology from Siemens, will be introduced in a cogeneration plant for the first time. The turboset has an energy output of 90 megawatt (MW), with live steam at a temperature of 540 degrees Celsius and pressure of 90 bar entering the turbine. It is a so-called tandem compound turbine, which has the inherent advantage of consistently splitting heat capacity between the two preheaters, even if the turboset is running at part load.

The new biomass power plant is operated by the energy group Söderenergi AB, which is owned by the combined municipalities of Södertälje, Botkyrka, and Huddinge, south of Stockholm. It will supply 100,000 households with 170 MW of district heating and 90 MW of electricity.

3 Siemens introduces new system to ensure high-quality water in offshore applications

Siemens Water Technologies has developed a new second-pass reverse-osmosis (RO) water-treatment system for the offshore oil and gas industry. The new system can be used on offshore platforms and drilling rigs to generate high-quality water on board — water normally transported to the platform. By generating water in situ, costly transportation charges are eliminated and water volume can be adjusted according to need.

Reverse osmosis is a process in which pure water is produced by forcing waste or saline water through a semi-permeable membrane. The Siemens RO system is a rugged, pre-engineered, pre-assembled, standardized system that minimizes expensive installation and start-up costs. Built as a compact, single-skid unit for easy installation, the new second-pass RO system is ideal for offshore applications.
The dawn of sustainable clean energy

Southern Spain is seeing a boom in solar power, where government subsidies have made the production of clean, CO₂-free electricity from Concentrating Solar Power (CSP) economically viable. It is anticipated that future enhanced efficiency of the plants will enable them to produce at competitive prices, rendering subsidies superfluous. Siemens’ innovative technology is helping here, as can be seen at the Solnova 1 CSP 50-megawatt (MW) plant near Seville.

The collection of mirrors has been erected on several sites. Solnova 1, 3 and 4 are three 50-MW capacity CSP trough plants, the first of a total of five plants currently under construction at the Solucar platform. The mirrors are arranged in the form of parabolic troughs, focusing the sunlight on receiver tubes and thereby heating a fluid that runs through them. The fluid — until now a special synthetic oil — eventually heats water, creating steam to drive a turbine, which in turn powers an electrical generator, creating electricity.

The Spanish company Abengoa Solar is developing the Solucar platform with the Solnova 1, which is due to produce energy for the grid from late 2009 onwards. The Spanish government subsidy has led to numerous Concentrating Solar Power (CSP) plants being built on many sites in Andalusia. As market leader in turbine technology for solar thermal plants, Siemens is involved in many of them. The

Southern Spain is a place where great ventures and adventures have been started in the past; under the patronage of Spain, the explorers Amerigo Vespucci from Italy and Ferdinand Magellan from Portugal planned their voyages here. Circumnavigating the globe in their sailing ships, they discovered new territories and scientific knowledge, leading to the opening up of previously undreamt-of opportunities for trade and economic development. Some 500 years later, another exciting commercial and technical venture is taking place in the southern peninsula. This time, however, golden riches are being sought onshore: in the plains of Andalusia, where the sun beams down onto the earth relentlessly. On more than 200 days a year, not a single cloud blemishes the clear blue sky.

Near the small town of Sanlúcar la Mayor, a few kilometers outside Seville, a futuristic
specially adapted 50-MW modules, favored by legislation, and which can be configured in multiple complexes, are favorites for implementation in the region.

Meanwhile, in Sanlúcar la Mayor, when Venture arrives on site, the morning sun is rising above the horizon, and the air is already warm from the sun as Valerio Fernandez, Director of Operations and Maintenance at Abengoa Solar, inspects the plant construction site where workers are busy tightening bolts, assembling equipment and polishing mirrors. Several birds have landed on the glassy receiver tubes, which are still wrapped in their protective plastic packaging. The first CSP plants were built some twenty years ago, but to a certain extent building an efficient CSP plant is still a combination of science and art. While the technologies and the required components are readily available, making them work together without losing too much of the primary energy during the production process is the key task for the coming years. Siemens technology provides a vital coordinating role here. At Solnova 1, for example, the Siemens SST-700 turbine is being used together with Siemens control systems. This particular model has been successfully installed in many CSP plants all over the world and has achieved a market share of around 90 percent in parabolic trough construction. This is thanks to a combination of the turbine reliability and their flexibility and specifications related to the size of plants currently in operation.

Blue skies — mostly 

“In Seville, we have light cloud cover on about 90 days a year. The plant’s output fluctuates considerably on such days, and the turbine must be flexible enough to make up for these fluctuations”, says Fernandez. In addition, at dawn, the turbine has to start very quickly in order to “harvest” the energy from the sun as early as possible. At some plants the turbines can run late into the night, because they are equipped with heat storage units that conserve some of the heat stored during the day and release it after dusk. These energy storage units are, however, particularly expensive, constituting a large proportion of the cost of currently around 300 million Euros for erecting a 50-megawatt CSP power plant. Valerio Fernandez expects the initial investment needed per megawatt of installed generating capacity to decrease soon: “So far, with our power plants we have been producing mostly one-of-a-kind equipment and procuring special components like the receiver tubes from small production series. When mass production for solar thermal plants reaches its full scale, the investment costs will fall drastically — along with the costs of power generation.”

This comment is corroborated by Prof. Hans Müller-Steinhagen from the German Aerospace Center. For more than 20 years, the institute has been developing and refining technologies for use in CSP plants, collaborating with Siemens on many components. “Electricity from solar thermal plants will become cheaper as we produce it”, he states. In other words, by applying the relevant technologies, economies of scale as well as enhanced experience derived from running the plants will drive efficiency gains and further innovation, thus incrementally reducing costs.

The result of a Spanish Royal decree in 2007, giving producers a 27.8 euro cents per kilowatt-hour subsidy for solar energy from the government, has led to a real ‘bonanza’ in applications to participate. Currently applications up to a 50-megawatt cap are pending for plants with a total capacity of 4 gigawatts including the 1.5 gigawatt capacity currently under construction.

There is continuous discussion around the continuation and extent of the Spanish government subsidy, which may be reduced in the near future. This stimulus for the “gold rush” was deliberately limited in time and scope in order to lay the foundations for a sustainable industry that will learn to produce competitively, at least in the medium term. “In around 15 years — depending, of course, on the oil price as well — I would expect CSP plants to produce competitively at market prices”, explains Müller-Steinhagen.

The revolutionary idea — to complement our energy mix with a considerable and growing amount of power from regenerative sources — is being helped by the evolution of the very technology needed to make this happen. This evolution is now being driven by a visionary project of truly global dimensions — DESERTEC.
Focus

At the heart of solar-thermal power generation: Siemens’ eminently successful SST-600 steam turbine.

Trailblazing project for sustainable energy supplies
The vision of DESERTEC is as simple as it is daring, building a large number of networked solar thermal and wind power plants distributed throughout the deserts of North Africa and the Middle East. The aim is to produce sufficient power to meet around 15 percent of Europe’s electricity requirements in 2050 and a substantial portion of the power needs of the producer countries. The sheer amount of energy to be produced in this context — 700 terawatt-hours — contrasts with the relatively modest area of the Sahara desert that will eventually have to be covered with mirrors: around 2,500 square kilometers, that’s about the size of tiny Luxembourg. The 3,000-km transmission of the energy from the south to the north is envisaged by means of low-loss high-voltage transmission lines (HVDC).

€400bn Desert Energy Plan
The visionary DESERTEC project can only be undertaken by a strong global coalition, uniting determination, scientific and engineering expertise with financial strength. The estimated cost of the project is up to 400 billion euros. In this sense, things have not changed much since the days of the Spanish patronage to explorers, whose vessels needed to be financed up front before they could sail. The powerful coalition needed to get things moving was formed in July 2009, when the Desertec Industrial Initiative (DII) was founded in Munich by a number of companies, including Siemens, one of the major technological drivers of the initiative, and financial institutions like Munich Re and Deutsche Bank. The first CSP plants in Africa under this regime will serve the local market and will contribute, for example, to the energy-intensive desalination of seawater in arid areas. However, once critical mass is achieved, the export of energy will begin, using efficient high-voltage direct-current (HVDC) transmission lines, whose energy losses are less than ten percent. Beyond turbines and power transmission solutions, Siemens has a host of other components in its portfolio which are needed to build CSP plants. In March 2009, Siemens acquired a 28 percent stake in Archimede Solar, an Italian company that produces innovative receiver tubes in which salt circulates rather than oil. This allows for higher temperatures of up to 550 degrees Celsius and enhanced efficiency, because the salt can be used as a storage medium as well. October 2009 Siemens further reinforced its presence on the growing solar power market when it announced the acquisition of Solel Solar Systems Ltd., one of the world’s two leading suppliers of solar receivers. Closing is anticipated before the end of 2009.

The Andalusian sun near Seville also shines on the site of one of the world’s first solar tower plants, Solar Tres, owned by the Spanish company Sener. Here, the sunlight will be bundled by sun-tracking mirrors and reflected directly to a receiver located on top of a tower, filled with salt for heat transfer in the interior of the receiver. The steam for the 19-MW electricity output will be produced in a Siemens SST-600 steam turbine. The same technology is used in what will be one of the largest solar thermal plants in the world — Ivanpah Solar Energy Complex in the Mojave desert, on the border between California and Nevada, USA. The plant will consist of three solar towers, with a total output of 400 MW. Siemens has received the order for the first steam turbine, a 123-MW SST-900.

Different technologies are employed in CSP, starting with the shape of the mirrors all the way along the process-chain to the power block. Some CSP plants, like the Hassi R’Mel plant in Algeria, to which Siemens is providing
one SST-900 steam turbine and one SGT-800 gas turbine, even incorporate a combined-cycle plant; this allows the expensive heat storage unit to be eliminated. At night, the steam turbine can simply be propelled by the hot exhaust from the combustion gases. The capacity of new CSP plants is also going up incrementally, an output of 250 megawatts should appear quite normal in the coming years. It won’t take very long and the birds will prefer to avoid the receiver tubes at Solnova 1 in Andalusia at dawn. Once electricity production begins, the oil inside the receivers will reach almost 400 degrees Celsius during operation to drive the powerful Siemens turbine, producing electricity without causing CO₂ emissions.

Looking back, Christopher Columbus — another Italian with Spanish patronage, colonizer and explorer of the 15th and 16th centuries, who brought awareness of the Americas to Europe — is said to have started a new age. Maybe, one day, looking back, the solar thermal boom in southern Spain will also be regarded as nothing less than the dawn of a new era. The age of cleaner energy, which, many feel, has finally begun.
Greek wastewater plant powered by Siemens’ new cogen package

Factory-packaged power plants designed and engineered on the basis of the long-established SGT-400 industrial gas turbine are recognized as the benchmark for rugged, reliable operation in mission-critical applications. The latest SGT-400 package, redesigned, optimized and simplified is now supplying independent power and process heat to one of Europe’s largest wastewater treatment plants, the island-based installation at Psyttalia off the coast of Athens.

Prior to 1994, most of the municipal wastewater and sewage produced by the citizens and industries of the Greek capital Athens was poured, without treatment, directly into the coastal waters of the Saronic Gulf in the Mediterranean. Facing a growing offshore environmental catastrophe on a coast designated officially as environmentally ‘sensitive’ and lacking sufficient space in Athens’ densely populated urban environment, the Greek government initiated the construction of a single, giant, wastewater treatment plant on the Psyttalia island. After 1994 the polluted load was reduced by a 35 percent due to the primary treatment works in operation (first phase of works). And some five years ago, the second phase of works — a huge EU funded 200-million euro project — was finished to provide tertiary treated effluents that conform with the strict EU directives before being dumped into the sea.

Practical, not pretty
About as far as can be imagined from a sun-soaked Greek idyll, the 57-hectare island, located in the Saronic Gulf just over 2 kilometers south of the Athens suburb of Keratsini, was until recently a Naval prison island, the mid-20th century Greek equivalent of Alcatraz. Indeed, a rough translation of the Greek name Psyttalia is ‘spat out of the sea’. This unprepossessing piece of offshore rocky real estate subsequently underwent massive re-engineering and construction to provide primary treatment facilities for wastewater pumped, appropriately enough, by nine huge Archimedean screw-type pumps, from Athens’ sewerage system. The citywide system, which includes 46 separate pumping stations on a 6000-kilometer network, is the responsibility of the Athens Water Supply and Sewerage Authority, EYDAP SA, which serves nearly 3.3 million customers with some 1.8 million domestic connections.

Following the completion of the first phase of the treatment plant, a further upgrade was ordered by the Greek government in order to meet EU environmental legislation under the Urban Wastewater Treatment Directive for the discharge of effluent offshore. The extensive civil engineering works for the second phase of the Psyttalia project included the filling-in of an entire bay on the north of the island and the
The new SGT-400 cogeneration package (left) on Psyttallia Island off Athens. The heat of the gas turbine exhausts is used for sludge drying in the facility to the right.
excavation of some 4 million cubic meters of rocky ground to allow the installation of 14 huge bio-reactor basins and 64 sedimentation tanks. The upgrade included biological treatment to remove virtually all environmentally harmful organic compounds from the effluent stream and mechanical de-watering of the sludge, which was shipped in bulk for disposal in landfill sites on the mainland.

**Clean, but expensive**

Operated and maintained on behalf of EYDAP by Aktor SA, part of Ellaktor the leading Greek-based international contractors group in Joint Venture with Athena SA, also a Greek contractor company, the upgraded Psyttalia plant was completed just prior to Greece’s hosting of the 2004 Olympics and currently can treat an average of 12 cubic meters of wastewater per second, equivalent to 1 million cubic meters per day, meeting all relevant EU environmental requirements. However, shipping some 800 tonnes of dewatered sewage sludge per day from the island for disposal in scarce landfill represented both an environmentally and financially costly solution. Under an additional 40-million euro of EU funding, the Ministry of Public Works commissioned a new sludge-drying plant on the island, fueled by natural gas. In commercial operation since 2007, the plant converts the sludge into a granular product, dried to less than 10 percent water content and supplied to cement industries to be used as a low-calorific value fuel.

**The cogen solution**

In the face of on-going hikes in the price of natural gas, the water and sewage authority invited tenders for the construction of an on-site ‘total energy’ plant using gas-turbine-based cogeneration technology, raising efficiency, cutting costs and increasing its commercial competitiveness. The new plant was designed by EYDAP to be capable of not only meeting the thermal load requirements of the sludge drying plant, but also to cover the major part of the electrical-load requirements for the entire island. By capturing the ‘waste’ heat from the turbine’s exhaust gases to substitute the drying plant’s gas-fired heaters, improving fuel efficiency could give significant savings in total operating costs. Also in a future upgrade, the
J/V Aktor-Athena on-stage with Siemens

Aktor SA, the construction arm of the parent company Ellaktor, in Joint Venture with Athena SA, bid successfully against some six other domestic and international groups for the EYDAP cogeneration project, with a design based on Siemens’ very latest packaged gas-turbine power generating system, the SGT-400. With an ISO-rated power output of 12.9 MW (electrical) and simple-cycle electrical efficiency of 35 percent, it is regarded as one of the most efficient of its type currently available. The Lincoln-built Siemens machine, designed to operate under baseload conditions, was ideally matched both to the drying plant’s thermal power needs and to the wastewater treatment plant’s total electrical load. Through the use of cutting-edge materials technology, the high exhaust temperature of the gas turbine of more than 550 °C was regarded by Aktor’s engineers as one of the key features of this machine. Capable of generating in excess of 136 tons per hour exhaust gases at these high temperatures, the gas turbine offered a major advantage for the cogeneration application, by enabling the size of the heat exchangers for the sludge-dryer to be kept small, as the available space on the island is limited, whilst achieving a guaranteed thermal efficiency of 46.7 percent.

On-spec solution

The combustion system for the twin shaft, 2-stage turbine is based on six reverse-flow can-annular combustors and features Siemens’ Dry Low Emissions (DLE) technology. This provides a very significant reduction in exhaust emissions of carbon monoxide and nitrogen oxides, a potentially polluting ‘acid-rain’ gas, to levels far below even the minimum statutory requirements. “We looked at a number of other gas turbine-based packages from competing companies for this combined heat and power application,” commented Pericles Iatrou, Aktor’s project manager at the Psyttalia site, “but although this would be the first time we had actually installed a complete gas turbine-based power plant, we had worked with Siemens in Greece before on previous projects so we had a very high level of confidence in selecting their latest version of the SGT-400, which met our design specifications perfectly.” Iatrou pointed out that a key advantage was also the full compatibility of the new cogen plant’s power-monitoring and control system with the existing computer-based SCADA network, covering the wastewater treatment automation systems.

New approach

As Tom Schjerve, Engineering and Packaging Director for gas turbines at Siemens’ Lincoln factory explained, “The latest SGT-400 package, chosen by our customer J/V Aktor-Athena for their cogen application on Psyttalia, was a bit of a radical departure for us from the usual evolutionary development of our factory-packaged industrial units.” “The original SGT-400 had actually progressed through a continuous
Monitor

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series of through-life upgrades. However, this latest version represents a completely new approach to machine development.” Tom went on to explain that the overall re-design was driven by the need to reduce the total time from initial order to final installation, to provide a simplified package with greater standardization and to reduce non-conformance costs by increasing quality. “Increasing numbers of our customers around the world require a significant level of ‘domestic’ content in their installations, so, to meet the demands of global manufacture, our design team drew on the experience of their opposite numbers at other Siemens’ manufacturing plants to create a benchmark design,” said Schjerve.

**Build-time reduced by 30 percent**

Using Siemens’ wide experience in meeting customers’ specific requirements in both land-based and offshore industrial applications around the world, including an analysis of all standardized options on the basic skid-mounted gas-turbine electrical or mechanical drive-package, the team in Lincoln was able to optimize the range of modular ancillaries. This resulted in a reduction in the total number of available options by more than 60 percent, from an almost bewildering choice for both customer and manufacturer of some 2,500 variations on the ‘standard’ package, down to a more manageable number of 829 design variants, but without compromising the ability of the final packaged unit to meet fully the requirements of the customer and end-user. Because almost all optional modules and ancillary systems can be assembled and factory-tested individually as separate systems in parallel with the main build and assembly process, the total build-time of the complete packaged unit has been reduced by 30 percent, the pre-tested systems also reducing on-site installation time very significantly.

**Plug and play**

Working in close co-operation with Siemens’ engineers and utilizing the advantages of the new package to maximum effect, JV Aktor-Athena was able to reduce the project timescale to a remarkable 18 months, from winning the EYDAP contract to first firing of the completed cogen plant on Psyttalia island. As Pericles latrou commented, “You could almost describe your new, simplified package as a ‘Plug and Play’ system!” The good relationship between customer and supplier also helped to ensure that the power plant was not only supplied on time and installed quickly and easily, but that the installation itself was synchronized with the construction of all critical infrastructure and auxiliary systems. Just one week following completion of the new cogeneration plant, surplus electrical power was fed into the grid network.

**Keeping it clean**

Now up and running, supplying baseload power to the treatment plant’s facilities and both electricity and heat to operate the sludge-drying plant, Psyttalia’s SGT-400 packaged cogeneration plant is currently operating at around 75 percent full capacity, and helping the Greek sewage and water authority to keep its Mediterranean coastline clean.

“We had a very high level of confidence in selecting their latest version of the SGT-400, which met our design specifications perfectly.”

Pericles Iatrou, Mechanical-electrical engineer with Aktor
“Getting closer to customers in challenging times”

Dr. Donald Weir, CEO of the Compression & Solutions business unit of Siemens Energy Oil & Gas Division, took time out from a busy schedule to discuss the current commercial climate, opportunities and imminent changes.
Industry journals are full of contradictory signals today. Oil and gas demand is reported as falling due to the financial crisis, but the oil price has surged upwards in the last six months. Cleaner energy sources are very much in focus but the gas price remains low. Depletion of existing resources is accelerating but exploration expenditure is sharply down. What are the sustainable trends, and what do they mean for Siemens?

**Weir** Although energy consumption has been reduced by the crisis in the short term all projections suggest that the global consumption of oil and gas will increase in the coming decade, especially in countries such as China and India. One observation that strongly supports this forecast is that, while these countries are the fastest-growing users of energy, their consumption per head remains less than a third of the average US consumer.

Some commentators believe we are passing the mid-point of the world’s oil and gas reserves, so-called peak oil, and the remaining supplies will be more expensive to produce, either because they are in remote locations, e.g. deep subsea or in a challenging format — such as the oil sands. The amount of technology and CAPEX required to produce the remaining reserves will therefore increase.

Two further trends increase the value Siemens can offer the market: as the population of technical experts reduces, companies like Siemens can offer extended support and our sustainable portfolio is well positioned to meet the increasing environmental requirements placed on operators.

**Venture** What does this scenario mean to the Compression & Solutions Business Unit in financial terms? And what are you going to do about it?

**Weir** In 2009, our market dropped by just over 20 percent from the admittedly overheated level of 2008. Against this background and in contrast to some competitors, our bookings exceeded revenues in the twelve months to September 2009. In the short term, we increased our focus on our procurement. However, we also saw a growing recognition from our customers that value comes not only from lower prices but also reduced risk and complexity. Recognizing that our broad portfolio means we can deliver complete packages based on rotating equipment and electrical & automation equipment, we have re-organized our sales around the structure of our customers’ projects...

**Venture** … which is part of an updated strategy with regard to the financial crisis, but also as a response to findings of a recent customer satisfaction survey. Can you give us some details on your new direction?

**Weir** Initially, we’ve selected six asset types in the oil and gas market to put additional focus on: offshore drilling; offshore production; LNG, both floating and on-shore; liquid pipelines & gas pipelines; and upstream gas production and processing. By combining equipment for these assets into packages, we can eliminate interfaces and optimize the solution for the overall operation. This in turn means better reliability,
lower operational costs and lower project risks. To realize these we need early involvement in projects to identify where an integrated solution adds value, whether this is a power system optimization or a consolidated service concept.

We are therefore expanding our support for customer projects in their formative stages. It’s not widely known that Siemens has some 1,200 consulting engineers across the globe. These enable us to start the support for a project in the pre-FEED phase, so that different designs and equipment designs can be evaluated for cost across the project lifetime and environmental impact. These staff are supported with simulation tools. For example, the power grid on a floating vessel can be simulated in a variety of operational states and failure modes both to eliminate over-capacity and design out unwanted equipment interactions such as harmonics that trip protection devices and interrupt operations. Our customers confirm that resolving these issues once the project reaches commissioning is orders of magnitude more expensive, underlining the fact that risk and complexity cost money.

In a nutshell, we want to offer our customers a ‘no-worries package’ by combining elements across our portfolio and from project concept through execution to operations and maintenance. However, this does not mean that we will sacrifice the technical excellence we are famous for. On the contrary, we want to package it to have maximum impact on our customer’s project.

Venture Coming back to the contradictory messages in the market, you have painted a picture of a growing oil and gas market, but currently the fastest increases in investment are in the area of sustainability. Weir The green revolution has inspired everyone in the energy industry to look into increasing sustainability. While renewable forms of electricity generation such as wind and solar continue to grab headlines, there are also substantial opportunities on the demand side of the energy balance. For example, in recent years, the fall in the cost of domestic air conditioners has led to a rapid rise in energy consumption from this type of load. This impact is increased as the air-conditioning load is relatively synchronized across consumers, which creates a sharp peak in the electricity load curve, increasing the maximum power required. In the Global Climate Coalition, it is estimated that air-conditioning requirements consume nearly 70 percent of utility electricity supply during peak energy consumption. We have invested in developing district-cooling solutions, where one plant can serve many buildings. The scale effects these bring can reduce carbon dioxide emissions by 50 percent and energy demand by 40 percent compared to residential units. The impact of widespread implementation of district cooling in this region could match or exceed that of renewable sources of energy. However, thinking of the phasing of supply and demand, a district-cooling plant supplier with solar power could be an elegant way to keep both the planet and its inhabitants from overheating.
CO₂ — Taking the bull by the horns

Anthropogenic CO₂ emissions are among the most unwanted side effects of civilization. However, industrial solutions are at hand for capturing and sequestration of CO₂. Drawing on hundreds of front-end engineering and design studies, Siemens analyzed three general scenarios to identify appropriate re-compression solutions.

Man-made CO₂ has raised the level of atmospheric CO₂ significantly beyond historic levels. The scientific community notes a direct correlation between atmospheric concentrations of CO₂ and other greenhouse gases, and increasing average global temperatures.

The challenge now is to ensure reliable, sustainable and economic power supply to match the world’s growing energy demand whilst keeping greenhouse gases within the “acceptable level”, knowing that for decades to come fossil fuels will continue to play an important role.

High-efficiency, fossil-fueled power plants fitted with CO₂ capture and storage (CCS) technology offer a short to mid-term solution to achieve low-CO₂ electricity supply. There are three
Spotlight

CO₂ capture before combustion (Pre-combustion)

Fuel → Gasification → Syngas cleaning → CO shift → CO₂ capture → Combined Cycle with steam → CO₂

CO₂ capture after combustion (Post-combustion)

Coal → Conventional SSP → Flue gas cleaning → CO₂ capture → CO₂

Integrated CO₂ capture (Oxyfuel)

Coal → Steam generator → Flue gas cleaning → Condensation → CO₂

* m³/s synflue gas, typical for 700 MW class

Selecting scenario

All of the above three processes need dedicated compression solutions. Over the past two years Siemens has supported hundreds of projects in different stages, from feasibility concepts to FEED-phase support and firm bids. These projects were primarily for CCS, but also included enhanced oil and gas recovery (EOR, EGR). They provided a priceless basis to design three scenarios that would allow to determine optimum compression solutions for any given set of performance requirements.

Scenario A is characterized by the lowest compression power for CO₂, as can be seen by the high gradient of the depicted compression arrow. However, unless installation is in Artic or Antarctic latitudes providing economically reasonable recooling, (as in the Siemens Hammerfest reference), a dedicated refrigeration cycle will be needed, using up all the power benefits while increasing system complexity.

Scenario B uses ambient site conditions for supercritical recooling. The required compression power is higher than for scenario A, but still lower than for scenario C. From the overall power perspective, this compression path seems to be the most promising. However, the challenge is to properly address the CO₂ behavior, which still shows considerable compressible behavior at high temperature sensitivity.

Scenario C investigates a compression path in the gas phase with consecutive compression in the light-density supercritical area. Along the complete path, the fluid behavior can be modeled via conventional gas dynamics. According to Siemens concept studies power consumption will be about 7 percent higher than with scenario B. Yet, for the first phase scenario C was the chosen focus due to the overall concept evaluation, which takes into consideration such important factors as power balance, performance predictability, performance safety, reliability, up-to-date reference situation and timeline.

Selecting compressor technology

With the compression path of scenario C chosen, it was time to determine the most suitable compressor technology. The choice was between a single-shaft compressor or an integrally geared compressor. For the investigation and comparison, Siemens mirrored all significant parameters for flow, pressure, gas composition, feed flows and gas treatment, control flexibility/speed, driver type and so forth. The compression duty was identical for the two solutions: 300 tonnes per hour of wet CO₂ with a specified pressure ratio of 1.9 bar to 160 bar.

Solution A was a two-casing single-shaft compressor train, totaling four process stages, and driven by a variable-speed drive system directly coupled to the LP casing. The LP and HP casings were selected in back-to-back arrangement providing three intercooling steps — the classic set-up concept for petrochemical installations in fertilizer units with a focus on robustness and highest availability.

Solution B was a seven-stage integrally geared compressor, type STC-GV (80-7), driven by a fixed-speed drive on the central bull gear. Thanks to the speed flexibility of each impeller pair, an optimum flow coefficient for highest efficiency can be achieved for the individual impeller. This concept has its origin in the air separation market with the focus on highest-efficiency solutions and high availability.

The integrally geared compressor wins the day

Computing the performance of the two compression solutions in the three scenarios
determined a clear winner. On three valid counts, the integrally geared compressor showed its superiority for CO₂ re-compression — less OPEX, less CAPEX, and more flexibility.

**Less OPEX**
Both concepts are suitable for wet-CO₂ compression even under sour-gas conditions as specified by the National Association of Corrosion Engineers (NACE). However, power consumption being the key differentiator between the two concepts, there is a striking life-cycle cost advantage for the integrally geared compressor. A benefit of 4,890 kilowatt (kW) or 13.9 percent of installed coupling power can be achieved for the main operating point “Rated”, and of 3,937 kW or 13.4 percent at “Normal” part-load. This part-load advantage is further supported by a larger performance-map turndown ratio using inlet guide-vane control in comparison to the speed control of the single-shaft solution. This benefit is due to higher impeller efficiency with axial flow intake in combination with high head-coefficients and the flexibility to adjust the speed for optimum flow coefficients. Even with a relatively low energy cost of 2.5 euro per watt, 12.225 million euro in added value can be realized by opting for the integrally-geared compressor solution.

**Less CAPEX**
In addition to the OPEX benefits, the investment cost for an integrally geared compressor is lower than for a single-shaft compressor train, due to the compact design with fewer impellers and smaller impeller diameters. This also means that the installation weight is considerably lower and less space is required, cutting expenses for ground, concrete work and civil engineering. An additional advantage is that complete packaged units can be realized with coolers installed in steel frames and completely assembled piping including anti-surge loops. This enables single-lift units, requiring less site-installation time, and reducing piping interfaces to a minimum.

**Better Flexibility**
As far as machine robustness is concerned, permissible nozzle loads, forces and torques of integrally geared compressors require a closer look and will be calculated on a case-by-case basis. If necessary, compensators can be installed on the interfaces to the suction and discharge piping to equalize excessive loading.

Another major advantage of the integrally geared compressor is its flexibility for intermediate control of pressure/temperature or flow, enabling distinct conditions to be controlled throughout the compression chain within one single compressor. This is particularly useful when controlling pressures for feed or extraction flow, or pressures on process-gas treatments like dehydration. The speed-controlled single-shaft compressor has only one degree of freedom. As for availability, both compressor concepts are in the 99-percent range, and both are applied in critical compression services, underlining the credibility of the technology.

Considering CAPEX and OPEX, and following the intense research and development in accordance with current and upcoming CO₂ project requirements, integrally geared turbocompressors incorporate the optimum design concept for economic CO₂ compression. Siemens has the solution and the experience, having to date already installed more than 1,000 integrally geared air turbocompressors.

**At Statoil’s Melkoya Island LNG plant CO₂ from acid-gas removal is compressed to 61 bar for reinjection into the Snøvit natural gas field with the help of a Siemens STC-GV (40-6) integrally geared compressor, rated at 10 megawatt (MW).**