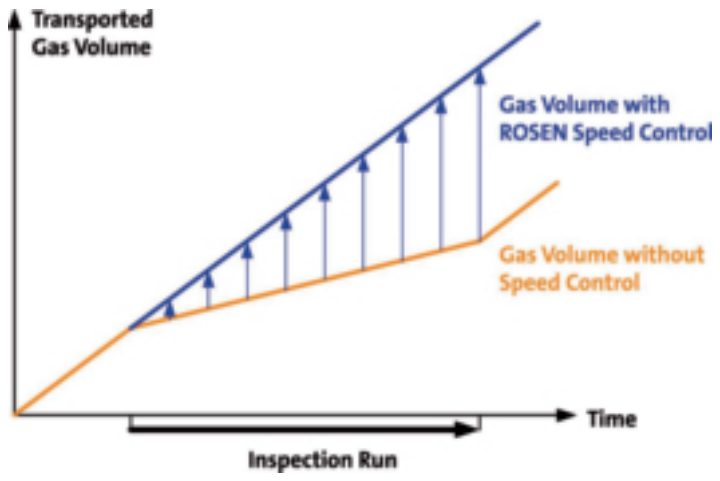
inspected with off-the-shelf inspection tools. However, the remaining 40% are classified as unpiggable to varying degrees, meaning that a standard pig cannot pass unobstructed along the whole length of the pipe. The reasons for this are many, and include bends that are too tight for the pig to go around, mitred bends, tee (or other) junctions and changing diameters. Diameter changes can be either the result of thick-wall pipe installed along a certain length – for instance, at a river crossing, or where a fitting such as a valve has been downsized – or as a result of a design decision to change the diameter of the whole pipe by one or two size increments. A large proportion of the unpiggable pipelines fall into this latter category, and common internal diameter changes are 18-24 inches, 28-42 inches, or 40-48 inches.

The approach recently taken by Rosen Inspection in work for Statoil offshore Norway and on a North American cross-country gas pipeline show how such a problem can be solved using a combination of experience and application of available technology. Typically, many pipelines were constructed and laid at a time when in-line inspection was not available or not a design or operational requirement. Many of these older lines have special fittings, such as unbarred tees or heavy-wall 1.5D bends and, while these pipelines are an important asset to their owners, integrity assessment based on ILI technology has become mandatory, since it guarantees safe and efficient operation.

BELOW
Figure 3.

GAS VOLUME TRANSPORTED, WITH AND WITHOUT A SPEED-CONTROL UNIT



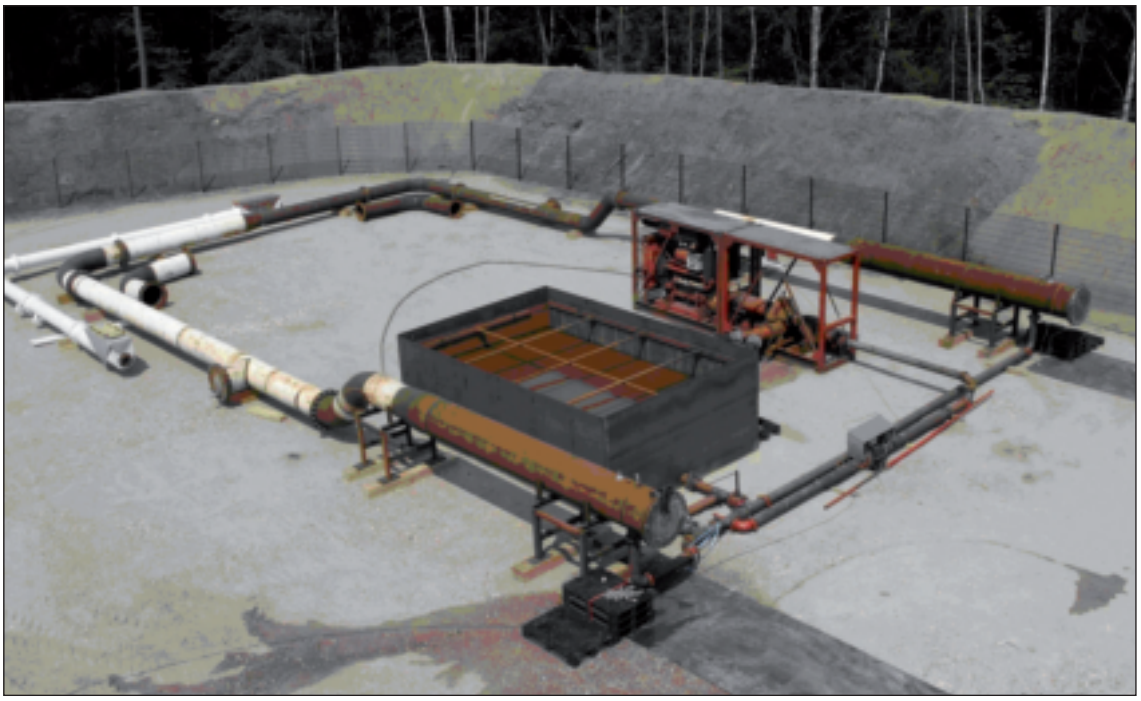
Source: Rosen.

Offshore Norway

In 2006, Statoil awarded Rosen the contract to inspect a 150-km long multi-diameter (26-30in) offshore gas pipeline in the North Sea. The main challenge of this project was the combination of a multi-diameter MFL tool with a speed-control unit, required as a consequence of the high gas flow rate in the line. Since offshore pipelines usually have a higher wall thickness, the 26-30-in tool had to be designed in such a way that it could magnetically saturate a wall thickness of up to 23mm in the 30-in section of the pipeline, and have a minimum bend-passage capability of 3D. The project was started in April, and by October, the 3.244-m long specially-designed multi-diameter ILI tool was ready for operation. The pipeline has now been successfully inspected.

As mentioned, multi-diameter tools can be combined with a speed-control unit, which is frequently necessary nowadays due to increased speeds of gas flow. The function of a speed-control unit is to provide controlled by-pass to maintain an optimum tool velocity for its inspection function; this is usually between 0.5 and 5m/sec. The speed control system works by intelligently controlling the flow of the gas (or fluid) through the tool (the by-pass), making it possible to achieve the planned target speed. This is particularly important for the inspection of gas pipelines that are operated at high flow rates, where speed control allows the operator to maintain high gas flow during the inspection process. The benefits of a speed-control unit on the volume of gas transported over a given time are shown in *Figure 3*.

Maintaining a high gas flow rate during the inspection process means that there is little loss of



The Rosen test loop.

throughput as a result of the inspection. The resulting cost savings are not the only advantage of using a speed-control unit, however, as speed control can also ensure scheduling flexibility for the operator. The tool's constant velocity, which can be optimised to accommodate specific pipeline conditions, also leads to a significant increase in the quality of the data collected. Rosen has tested its speed-control unit at velocities up to 8m/s, and satisfactory inspection performance has been achieved.

Onshore North America

In January 2006, Rosen was contracted by a North American gas pipeline operator to develop, build, test and run an 18-24-in multi-diameter corrosion-inspection tool. The 48-km long pipeline starts with a 24-in diameter section, which decreases to 18in diameter for 7.2km after 24km, and then expands to 24in diameter for the remaining pipeline length. Moreover, there were numerous 1.5D bends in the 18-in section. However, the real challenge of this project was the thickness of the pipeline wall in some of the bends, which reached 21mm, thus reducing the effective internal diameter to 16.2in. Standard 18-24-in multi-diameter tools cannot pass 1.5D bends with this wall thickness. Therefore, it was important to calculate the passage ratio on the basis of the internal diameter of the smaller pipe and the outer diameter of the larger pipe to ensure the tool would pass through all the sections.

Rosen consequently determined that one of its most complex tools was required. Since the pipeline was located in a high consequence area (HCA) in that it crossed some major interstate highways, nothing could be left to chance in the development and testing of the tool. A test loop was built at the company's facility in Germany, making it possible to simulate all the challenges of the pipeline, including the heavy-wall 18-in diameter 1.5D bend.

Consisting of three units, the resulting inspection tool had a length of 3.2m, could be easily launched by means of either a launch cassette or

by using the pulling eye at the front of the tool and was designed to be capable of continuous inspection of internal diameters between 16in and 24in. In September 2006, the tool was successfully tested in the test loop, and was released for service in late October; the actual inspection was successfully completed in early November. A cleaning tool was launched first, with a pipeline data logger on board to collect information on pressure and temperature, and low-resolution gyro data. It showed that the line had 27 24-in diameter 90° 1.5D bends, and several 45° bends in the 18-in heavy-wall section. Despite these difficult conditions, the tool passed through the line without any damage, and a subsequent examination of the inspection data confirmed smooth running conditions and a suitable rotation rate; the specified levels of tool performance and defect detection were achieved in all areas.

● Combined metal loss and crack inspection for gas pipelines

Surveying a pipeline for both metal loss and cracks has, up to now, required the use of different in-line inspection tools and therefore separate runs, including all the associated preparatory work and operational issues. However, a new inspection tool, based on its modular LineExplorer range of intelligent pigs using ultrasound technology, has now been introduced by NDT Systems & Services of Germany. This tool has been designed to enable a pipeline to be inspected for both metal loss and cracks in a single run: the major advantages of this are increased efficiency in pipeline preparation, cleaning and operation during the inspection run. An added value is the enhanced data quality obtained by the tool, based on the optimised correlation of metal-loss and crack-inspection measurements, and the data obtained is easily incorporated into advanced integrity-assessment and defect-growth analyses.

Two of the critical categories affecting the integrity of a pipe wall are metal loss – wall thinning due to corrosion or gouging – and cracks. Metal loss and cracks can appear in a large variety of flaw geometries and at any time during the lifecycle of a pipeline: for example, during production of the steel plate, manufacture of the pipe, or construction and operation of the pipeline.

Ultrasound has proved to be the most suitable and reliable technology for pipeline crack detection. A new generation of ultrasonic tools was introduced by NDT in 2002, incorporating a modular design that enabled the same tool to be used for both metal loss and crack inspection. The same basic tool assembly and electronic modules are used for each configuration, with only the sensor carrier being changed for each application. While providing considerably savings on mobilisation and demobilisation costs, as one tool could be used for both inspection tasks, two separate runs were still necessary. This technology has now been developed further and, using a newly-designed and optimised sensor carrier, quantitative metal loss and crack inspection can be performed in a single run.

Combination tool design

Ultrasonic ILI tools are, in general, fitted with a sufficient number of ultrasonic transducers to ensure full circumferential coverage of the pipe, and the sensors work in a "pulse-echo" mode with a high repetition frequency. Straight incidence of the ultrasonic pulses is used to measure the wall thickness and 45° incidence is used for the detection of cracks. In terms of data processing, ultrasonic tools represent one of the most-challenging tasks in ultrasonic non-destructive testing: depending on the pipe diameter to be inspected, up to several hundred sensors have to be controlled, their echoes recorded, on-line data processing applied in order to reduce the total amount of data, and the resulting data stored.

Figure 4 shows one of NDT Systems & Services' 24-in crack-detection ultrasonic in-line inspection tools: the major difference, compared to other inspection tools using ultrasound, is the modular

Accurate Solutions for Measuring Gas flow

By Michael Carr, Head of Dept. MTV, Endress+Hauser Flowtec AG

Over the past 10 to 15 years, the trend in gas flow measurement has seen a move from purely volumetric to that of mass flow. The cost of energy has risen dramatically over that same period with, as a prime example, natural gas tripling, with the long-term trend indicating ever upwards. With rising costs comes the need to measure this resource. However, as Endress+Hauser has discovered from its customers, flow measurement requires a wide range of support for gas to be accurately monitored and costs controlled.

Meter selection .... mass

As there is no perfect meter for gas flow measurement Endress+Hauser has developed a wide portfolio with varying features and benefits. Ranging from true and direct mass measurement to corrected volume flow, the products provide solutions to suit most customer needs.

- Coriolis mass flowmeters offer mass flow directly measuring the phase shift of a frequency imposed onto the measuring tubes. Typically used in high pressure (>5 bar) applications such as Natural Gas and CNG with custody transfer often a requirement. Unaffected by upstream piping and high accuracies (0.35% o.r.) are key features of this principle.
- Thermal mass flowmeters, based on the thermal dispersion principle. are able to measure dry, clean gases with accuracies of up to 1.5% o.r. Typically used in low pressure gas applications (<10 bar g) such as Compressed Air, Natural Gas, Biogas etc. Minimum pressure drop (<2 mbar) and 100:1 rangeabiltity are two key factors to consider.

Compensated volume

- DP flowmeters need no introduction and are still today's most popular measurement principle. Offering a wide range of construction (orifice, Pitot, venture etc) and an almost limitless range of materials, the principle is supported by many years of experience.
- Vortex flowmeters measure volume flow directly using a well established principle. Rugged and robust by design, the meter offers excellent immunity to many of the field related issues. This concept of "fit and forget" offers excellent cost of ownership levels.

Competence in gas calibration

As the demand for continued improvement in meter performance is felt by instrument designers, so the need for calibration facilities to be improved, in line with developments, grows.

The recently completed Endress+Hauser air calibration facility in Reinach/Switzerland sets new conceptual and technological standards. An Adapter Revolver enables rapid and precise clamping of the devices under test into the measurement section. The facility operates from 0.02 kg/h through to 10,000 kg/h and a specially designed climate control keeps the air in the calibration room at 21 °C (+/-0.5°C) – day and night.

Verification of meter performance

Most flowmeters produced world-wide come calibrated using a fluid other than the process fluid. Customers often require additional tests to prove the validity of such a calibration.

Third party testing

In today's business climate, there is an ever increasing requirement for manufactures to demonstrate meter performance credentials under plant conditions and with a specific gas in mind.

This dual expectation has caused Endress+Hauser to identify the need to work more closely with international calibration houses (NMI, NEL etc.), as well as to undertake wider and more frequent on site field trials.

This combination of in house facilities, third party testing and closer links with the established calibration authorities ensures a better understanding matched with improved performances.

Visualise and evaluate your process!

Measuring gases alone will not save money – you will have to visualise, evaluate and analyse the data gained. Endress+Hauser offers a complete range of specialised software packages that have proven themselves in practice over many years. These can be used for:

- Display of all measuring locations and measured variables
- Reporting (usage per hr/m/d/y)
- Assigning consumption to cost centres
- Efficiency comparisons

Conclusion

It is clear that metering gas flow alone is not the whole answer. In the future, ever closer ties between meter design, data collection and reporting will ensure the effective control of this valuable resource.

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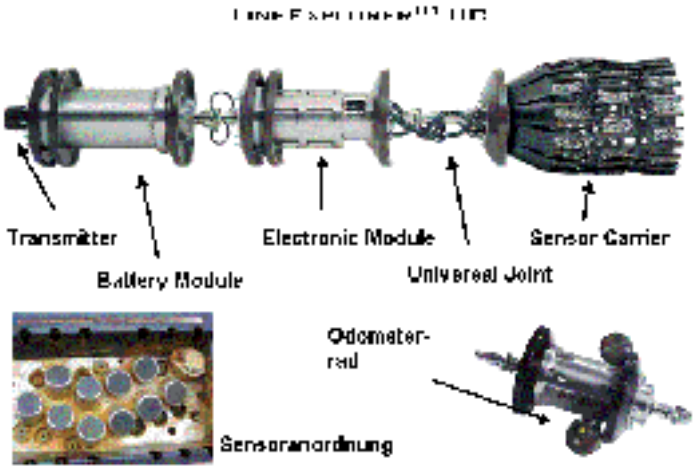
ULTRASONIC CRACK-DETECTION TOOL



Source: NDT Systems & Services.

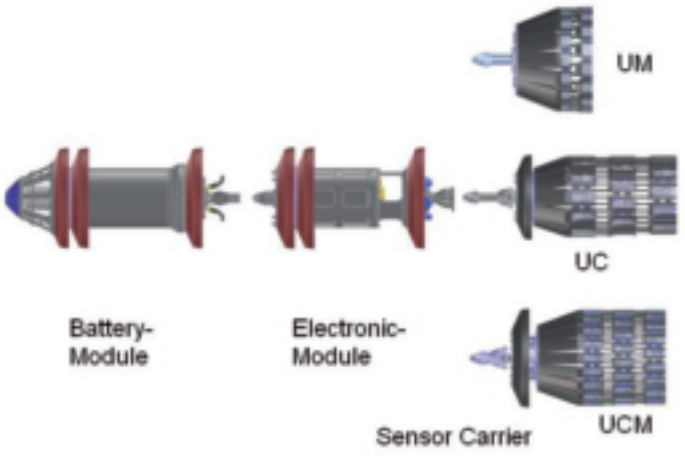
ABOVE
Figure 4.

BELOW
Figure 5.

design, as it was the goal to develop a single tool type which could be configured for a variety of inspection tasks. This has resulted in a family of tools equipped with electronics which can be used for tasks including wall-thickness measurement as well as crack detection. The number of channels is sufficient to always ensure full circumferential coverage for any chosen inspection task, including special applications such as surveying for pitting-corrosion, and the mechanical layout is such that the tool components can be scaled up or down. The advantage of this approach is that a minimum number of different components needs to be built in order to cover a wide range of pipeline diameters and inspection tasks.

This modular design approach is illustrated in *Figure 5*, which shows the individual sensor carriers configured for wall thickness and crack inspection, as well as for combined inspection. As shown in *Figure 4*, the 24-in tool is – typically – made up of two pressure vessels housing the power supply and the electronics, and a trailing sensor carrier housing the ultrasonic transducers. The data obtained during an inspection are stored on solid-state memories that are the safest and most reliable means of storing data in such a hostile environment.

MODULAR DESIGN APPROACH



Source: NDT Systems & Services.

Inspection of a 36-in gas pipeline in Canada

This inspection project was carried out in September 2006 on the Western Alberta System Extension (WASE) of the TransCanada Pipeline (TCPL) system. This pipeline section is 168km long, and runs from Clarkson Valley (close to Grand Prairie) to Windfall Junction (nearby Edson). Prior to this survey, MFL tools for metal loss, and crack inspection tools using electromagnetic acoustic transmission, had been run; the reason for choosing ultrasound technology a further time was the fact that NDT's new tool combines inspection capabilities to detect and size cracks and crack-like features. The operator's decision to use the combined technology, requiring only a single tool run instead of two (although running in a water batch), was based on the considerable cost saving involved together with the enhanced correlation between wall thickness and crack data that would be achieved, which would have a direct impact on the usability of the inspection data in terms of integrity assessment for the pipeline.

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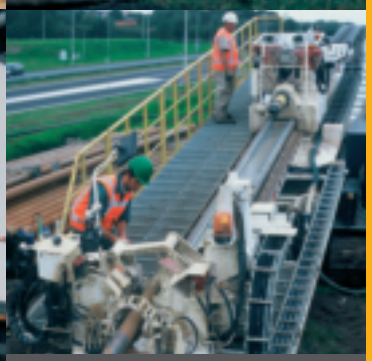

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The WASE pipeline was constructed in 1976 and coated with a single wrap of Polyken tape at the time of construction. It has an elevation rise from 680m at the launch site to 1270m at the receiver, with four major river crossings in between. There are 21 reception points along the line where gas feeds into the system, as well as five block valves with 12-in by-passes, and three compressor stations, one at Clarkson Valley, one at Windfall Junction, and one near the centre of the line. Normal flow in the line is 800m ft^3/d, although during the inspection the gas flow was throttled back to 75m ft^3/d; the liquid-batched inspection run took 74 hours.

This project presented a number of challenges that needed to be met in order to ensure a successful inspection, and a team was formed that included personnel from TCPL and its contractors, Tuboscope and NDT. Among its tasks, the team had to determine the size of the batch and how to maintain its integrity throughout the inspection run while maintaining the desired inspection speed of the tool. The elevation profile of the pipeline was a factor in determining that a batch of 850 m^3 and tool speed of 0.75m/sec would be adequate. The addition of temporary metering stations at the 12-in by-passes of the mainline valves allowed TCPL to control the gas volume within around 30km of each valve; this, combined with feedback from the teams tracking the inspection tool, was instrumental in controlling the tool speed.

The elevation changes along the pipeline created a potentially difficult situation, but the satisfactory results from the project were evident when the inspection results were reviewed. Areas of tool over-speed were seen in the anticipated places, but were minimised as much as possible; the integrity of the batch was held throughout the run and the tool was received undamaged.

All members of the team agreed that the preparation of the pipeline and the planning to carry out the ILI with the combined LineExplorer tool involved an increased and more challenging workload than originally anticipated, partly because of the requirements of the liquid (water) batch necessary to run the tool. However, after an ultrasonic crack inspection in 1999 and the combined wall thickness and crack inspection in 2006, TransCanada has a considerable amount of useful data which can be compared and correlated in order to prove the reliability of the technology, especially for crack detection, compared to other inspection technologies such as circumferential MFL (transverse field) and electromagnetic acoustic transmission (EMAT). Interactions between metal loss and cracks were found, and are important indications for TCPL in terms of risk evaluation and integrity management. The reliability and precision of detection and sizing of the defects by the tool was confirmed during excavation of the features after the preliminary report.

Conclusion

A programme of gas pipeline cleaning, maintenance and inspection using a variety of tools is a pre-requisite for operators worldwide in the increasingly-regulated environment in which they work. Fitness-for-purpose assessments and integrity-management plans are frequently required, if not mandated, for all types of hazardous pipeline, and particularly for those transporting natural gas. In the past, pipeline design has not always allowed tools to pass through the lines, rendering upwards of 40% of pipelines worldwide to be unpiggable. The modern approach that combines vendor companies' advances in both technology and outlook, though, means that there are – in practice – very few pipeline problems that cannot be resolved by pigging. Sometimes, however, a balance has to be made between the investment required for this as opposed to the use of other emerging and increasingly-credible techniques which fall under the generic title of direct assessment.

John Tiratsoo is the Editor of Global Pipeline Monthly *(www.globalpipelines.com).*

Swissgas, an exceptional service provider

Switzerland's co-operative gas supply pooling

With an annual gas demand of 3.3 bcm, Switzerland accounts for less than 1% of European gas consumption. The approximately 100 Swiss utilities and local distributors realised early on that they would have little chance of securing profitable access to the international wholesale markets on an individual basis. The idea of pooling together the regional supply was obvious. To maintain their autonomy in accordance with the principles of Swiss federalism four regionally organised supply companies were founded. Soon after it was recognised that additional pooling on a national level would be even more advantageous. Keeping to federalist principles Swissgas was founded in 1971 as a co-operative non profit company to ensure the supply of the four regional companies. Swissgas covers 75% or 2.5 bcm of their annual demand while they source the remainder directly. The amount of natural gas supplied is charged to the shareholders at cost prices. This structure provides long-term stability as well as cost optimisation. Cultivating bilateral contacts with our customers on site simultaneously ensures the necessary strong position for supplying them. Swissgas provides its services through a team of highly qualified specialists. In order to fulfil its objectives, Swissgas is not only owner of a high-pressure pipeline network of about 260 kilometres, but also shareholder in the pipeline network of Transitgas Ltd and makes use of international transport rights.

Diversification is irrevocable

Swissgas and the regionally organised companies rely on a highly diversified purchase portfolio. Supply is ensured through about ten differently structured middle- to long-term contracts with five reliable and potential suppliers, allocated to points of delivery on different transport routes along the Swiss borders. Combined with situational, short-term sourcing, this portfolio offers numerous opportunities for efficient exploitation. Nevertheless, Swissgas intends in future to strengthen this diversification to enlarge its portfolio. As a consequence Switzerland will be well prepared to ensure tomorrow's security of supply.

Ruedi Rohrbach, *CEO Swissgas*
www.swissgas.ch

LNG-15: The Challenges of Growth

By Mark Blacklock

Global LNG trade surged 11.8% in 2006 to 154 million tonnes and is set to at least double by 2015. The tremendous growth in this sector of the gas industry was reflected in a record attendance at the triennial International Conference and Exhibition on LNG, the 15th in the series of which took place in Barcelona, Spain, April 24-27. This time it was the turn of an LNG importing country to host the event, which is sponsored by IGU, the International Institute of Refrigeration and the Gas Technology Institute; Spain is the world's third largest LNG importer while Barcelona is home to the longest continually operating regasification plant.

With some 3000 delegates and the largest exhibition in the history of the event, LNG-15 offered an unparalleled forum for the LNG community to meet and exchange information. Keynote speeches, paper and poster presentations and workshop debates covered all aspects of the sector's dynamic development, from globalisation and geopolitics to studies of individual plants and processes, but the common concern underlying discussions was the issue of cost escalation.

From the 1990s until LNG-14 in 2004 technological developments brought a steady reduction in costs throughout the LNG chain, but since then the trend has reversed sharply due to rising raw material prices and competition from other industries for engineering and contracting services. The impact has been greatest on the liquefaction stage where the cost of building plants has doubled and construction lead times have increased.

"Costs for new projects have far exceeded earlier estimates leading sponsors to defer their investment decisions due to concerns that current LNG prices may not be able to support the project development costs," said Tan Sri Dato Sri Mohd Hassan Marican, President and CEO of Petronas, at the opening ceremony.

Noting that no new LNG projects were launched in 2006, he also cited a shortage of human resources and growing domestic demand in some of the major gas exporting countries as additional factors leading to "serious concerns that there will be a supply crunch by 2010".

Spain's Minister of Trade, Industry and Tourism, Joan Clos, on the top table and INSET addressing delegates at the LNG-15 opening ceremony.

Other issues raised by Marican included the challenges of exploiting new sources of gas in remote areas with harsh environments, security of supply for buyers, greater contract flexibility and the continuing need to develop strong, long-term partnerships between governments, stakeholders and customers.

The security of supply issue was highlighted by his fellow keynote speaker at the opening ceremony, Fabrizio Barbaso, Deputy Director General for Energy in the European Commission, who also addressed the need for investments in LNG reception and gas transmission infrastructure, and the drive to increase competition in the European market.

Marican called for creativity from the LNG players, sellers and buyers alike, to meet the challenges of growth and there was ample evidence of that creativity at LNG-15. The Programme Committee chaired by Dr Nirmal Chatterjee organised the conference into three plenary sessions, seven paper sessions with a total of 47 papers, four workshops and a poster presentation. The 56 posters were mounted in a wide underground passageway linking the main auditorium with the conference centre for viewing throughout the event, while a dedicated poster session was scheduled on the afternoon of the third day.

This report aims to give an overview of LNG-15 but cannot do justice to the sheer range and depth of subjects covered. Readers can obtain the full proceedings on CD-Rom from the Gas Technology Institute (e-mail: publications@gastechnology.org).

The keynote speakers at the opening ceremony were Fabrizio Barbaso, Deputy Director General for Energy in the European Commission (TOP), and Tan Sri Dato Sri Mohd Hassan Marican, President and CEO of Petronas (ABOVE).

Liquefaction and regas

One way to reduce unit costs is to develop further economies of scale. The largest operational trains (Atlantic LNG Train 4 in Trinidad and SEGAS in Egypt) are at the 5 mtpa mark, Qatar is building six 7.8 mtpa trains and proposals were aired at LNG-15 for trains of up to 11 mtpa.

The 7.8 mtpa Qatari trains are the first applications of Air Products' AP-X process, which adds a third refrigeration cycle (using a nitrogen expander loop) to the conventional Air Products propane pre-cooled mixed refrigerant (C3-MR) process. These trains require some 280 MW of refrigeration compression and use three GE Frame 9E gas turbines, a model previously only used in the power generation sector. Two papers looked at

Regasification: New Challenges for the Automation Supplier

By Martin te Lintelo, Yokogawa Europe

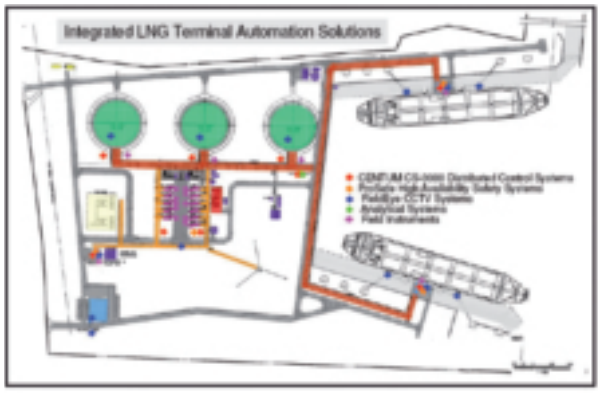
As the demand for LNG increases worldwide, major LNG regasification plants are planned and being built while facing seemingly conflicting challenges. One problem, particularly in Europe, is that many end-users and suppliers are new to the business and do not have the required knowledge and experience to handle integrated solutions for starting up LNG regasification terminals. Some companies have knowledge about the building and construction processes, but lack detailed knowledge of the actual operational practices. Moreover, new terminals in Europe also have to comply with EU regulations that allow third party access for more open energy markets. To meet these challenges head on, advanced automation solutions are required to enable operators and engineers to effectively oversee large LNG regasification terminals while maintaining the quality and safety of operation.

An integrated approach to the implementation of such large-scale automation projects is provided by Yokogawa's VigilantPlant: a concept that brings together the company's products and services to create an environment where plant operators and other personnel are watchful and attentive, well-informed and ready to take action. Through solutions and services designed to help plant personnel 'see clearly', 'know in advance', and 'act with agility', the VigilantPlant philosophy eliminates unplanned downtime, improves asset utilisation, and allows businesses to adapt to shifting market conditions and customer demands quickly and efficiently. Concepts such as asset excellence and plant resource management combine with control and monitoring system to provide a clear path to operational excellence.

One of the values Yokogawa can add to the LNG supply chain is in the area of simulation and modelling technology. At the recent LNG-15 exhibition in Barcelona, the company demonstrated an education/training system that was based on an operator training system (OTS) developed by Omega Simulation Corporation (an 85/15 joint venture between Yokogawa and Mitsui Chemicals). The customer for this system, Osaka Gas Co., Ltd., configured the OTS for use at its Senboku LNG regasification terminal. This system not only trains the customer's operators in a simulated real-life environment, but also allows the testing of proposed improvements without disrupting operations at the LNG terminal. Visitors to the LNG-15 demonstration enjoyed running simulations with this training system and seeing what changes could be made to improve operations at their plant.

With a global market share of 58%, Yokogawa is the market leader with as far as its installed base of LNG regasification terminals is concerned. Besides offering technological expertise in LNG automation solutions, the company can offer engineering and project management expertise for large-scale industrial projects through centres such as Yokogawa System Center Europe (Yokogawa SCE) at Apeldoorn in the Netherlands. Within this centre, a dedicated LNG team is responsible for the co-ordination and implementation of all LNG projects throughout Europe as well as some global LNG projects.

Yokogawa SCE is currently working on Europe's most recent LNG terminals: the South Hook LNG terminal near Milford Haven, Wales, UK, and the Adriatic LNG Terminal (ALT), which will be built on the north coast of the Adriatic Sea in Italy. For both projects ExxonMobil selected Yokogawa as the main automation contractor (MAC). Based on the excellent performance of Yokogawa on the South Hook project so far, Yokogawa SCE has also been appointed by both CB&I and the BG Group as MAC vendor for the LNG regasification project in Quintero, Chile.



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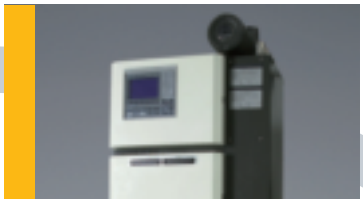

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the design challenges involved, including the adaptation of the Frame 9E from fixed speed to variable speed service. The first of the new trains (phase one of Qatargas 2) is due to start production in early 2008.

In separate papers, Mark Pillarella of Air Products said that the AP-X process could be developed to increase train capacity beyond 10 mtpa, while Wiveka Elion of Shell Global Solutions presented a design for an 11 mtpa train. This is based on Shell's parallel mixed refrigerant process (PMR) with propane refrigerant in the pre-cool cycle, and either the GE Frame 9E (as used in the new Qatari trains) or the Siemens SGT5-2000E (formerly known as the V94.2) gas turbines. By fully utilising waste heat from the gas turbine exhausts, she claimed an improvement in efficiency and a reduction in CO_2 emissions.

However, not all projects have the gas resources to support such large trains and both Elion and Pillarella looked at applying the benefits of their work to medium-sized trains. Elion declared that the Shell design was fully scalable from 11 mtpa down to 6 mtpa with smaller gas turbines, while Pillarella said that the same developments boosting AP-X capacity beyond 10 mtpa could be applied to move the C3-MR process up to 7-7.5 mtpa. These developments include improved main cryogenic heat exchangers and advances in process and machinery integration. He also described how the C3-MR process could be modified for operation in Arctic climates. Indeed, in a paper on the proposed Shtokman LNG project, Giprospetsgaz's Alexander Piotrovsky said that this latest Air Products development was being considered for two 7.5 mtpa trains. If Shtokman LNG gets a final go-ahead the liquefaction plant would be built at Vidyaevo in the Murmansk region of Russia, with an operational target date for the first train of 2013 and 2016 for the second, according to Piotrovsky.

Further down the size scale, the 3.7 mtpa Darwin LNG plant made its first shipment in February 2006 and exceeded its production target for the year. Darwin is the first use of aero-derivative gas turbines (the GE PGT25+) in an LNG plant, and Cyrus Meher-Homji of Bechtel highlighted their greater thermal efficiency and maintenance flexibility. Combined with waste heat recovery from the turbine exhausts and ship vapour recovery equipment, the plant is also reporting reduced emissions.

Cost-effective techniques to reduce CO_2 emissions in LNG plants were directly addressed in a paper given by Technip's Pierre Rabeau, who looked at increasing the efficiency of processes and energy generation systems.

Meanwhile, Norway's Snøhvit project is the second to opt for aero-derivative gas turbines (the GE LM6000). In his keynote address Statoil's Executive Vice President Natural Gas, Rune Bjørnson, said he expected Snøhvit's regular deliveries to start in December and, in general, was optimistic about the cost challenges facing the LNG business. "I believe these changes are cyclical and, in the long term, cost reductions from new technology will prevail," he declared.

Looking at construction costs, one approach is to reduce the amount of fabrication on site, which

Rune Bjørnson: in the long term, cost reductions from new technology will prevail.

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is often remote and increasingly in an environment with harsh working conditions, by designing in modularisation. This allows fabrication to be switched to areas with higher labour availability and productivity. There was an interesting poster presentation on the North West Shelf's 4.4 mtpa Train 5, which is now under construction at Karratha in Australia. Approximately 60% of the structures were designed in modular format with 75 modules ranging in weight from 35 to 1800 tonnes being fabricated in Batam, Indonesia. The first of 17 shipments to the site for assembly was made in October 2006 and production is expected to start by the end of 2008.

Also due to start operations in 2008 is the Adriatic LNG regasification plant, which takes off-site fabrication to the limit and was described in a paper given by the project manager, Lisa Waters. She described how the LNG storage tanks were built in Ulsan, Korea, in six sections and then shipped to Algeciras in Spain for installation in a concrete gravity-based structure built there. The topside facilities are now being installed and then the entire plant will be towed to its location 17 kilometres off Porto Levante, Italy.

Indeed, there was much discussion of offshore terminals at LNG-15 as one way of dealing with public opposition in certain areas to the building of regasification plants. "So it's not in their back yard," as Jerry Wolahan of ExxonMobil Development, put it during a workshop session. The ship mooring and LNG transfer issues related to increased wave and wind effects offshore were covered in papers given by Gaz de France's Guillaume Rombaut, who described work on cryogenic flexible hoses, and Technip's Virginie Lehning, who looked at marine terminal design. Leendert Poldervaart of Single Buoy Moorings also gave a poster presentation on offshore LNG transfer, while one of the issues James MacHardy, General Manager of the Society of International Gas Tanker and Terminal Operators (SIGTTO), covered in his keynote address was ship-to-ship transfer of LNG for which a SIGTTO working group has produced draft guidelines.

Shipping

Cost rises in the shipping part of the LNG chain have not been as great as in liquefaction, with the use of production line techniques and increased productivity in shipyards mitigating the impact of rising raw material costs. But the price of an LNG tanker has still risen about 50% and LNG-15 delegates were keen to discuss the latest developments in the shipping sector.

A key issue is to what extent economies of scale can go. By the end of this year *Tenbek*, the first of the Q-Flex tankers with a cargo capacity of 216,000 cubic metres (m^3) will enter service with Qatargas, to be followed in 2008 by the 266,000 m^3 Q-Max series. These represent a quantum leap from the largest tanker currently in service, *Provalys* (153,500 m^3), and the Q-Max series will have nearly 10 times the capacity of the *Methane Princess*, which made the first commercial delivery of LNG back in 1964.

Such large ships require long-haul markets with dedicated volumes, and while the Qataris clearly have these, other operators need greater flexibility. There are also the issues of draft and berth sizes in harbours and the general consensus was that LNG tankers would not get much larger than the Q-Max series. Presenting a paper on the next generation of large LNG carriers, Peter Noble of Conoco-Phillips felt that they would stabilise in the 180,000-220,000 m^3 range.

There was also much talk about propulsion systems with the predominance of the steam turbine now being challenged by dual-fuel diesel electrics and slow-speed diesels. The latter require an on-board liquefaction plant to deal with boil-off gas (BOG), which can be used as fuel for vessels with steam turbines and diesel electrics. Diesels were felt likely to prevail, especially as the LNG sector is now the only part of the shipping business to use steam turbines and the pool of

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James MacHardy: we need to sell ourselves to the public at large.

experienced engineers to maintain them is diminishing.

This point and the wider issues of staff recruitment, training and retention were highlighted by SIGTTO's James MacHardy in his keynote address. He pointed out that a few years ago the LNG tanker fleet was expanding by about four or five large ships annually, but that 26 were added in 2006, 32 will have been delivered by the end of this year and 57 are scheduled for delivery in 2008. This has placed unprecedented demands on ship operators and he urged greater investment in human resources.

While new-builds are increasing, the existing fleet is set for a long service life. Already, 34 LNG tankers are over 30 years old and seven of these are over 35 years old. "We need to address longevity," declared MacHardy, saying that not only would careful attention to maintenance be necessary to continue what up to now has been an excellent safety record, but that public opinion had to be prepared. "We need to sell ourselves to the public at large," he said.

MacHardy's last point was taken up by a number of speakers who stressed the need to develop public relations activities by promoting the achievements and benefits of the LNG business and improving public understanding of it. "It's up to the industry to make its own case based on its safety record," BP's Anne Quinn told a workshop session.

Changing dynamics

There was much debate at LNG-15 about the expansion of the Atlantic Basin trade and how its interaction with the Asia-Pacific trade has changed the dynamics of the LNG business.

Typically, Atlantic Basin LNG importers have access to alternative energy supplies such as pipeline gas and other substitutable fuels in contrast to the traditional Asian importers who rely more heavily on LNG. This has fostered the expansion of spot and short-term trading which, according to BP's Suryan Wirya-Simunovic, "is likely to play a key part in helping the industry become more cost efficient".

Greater flexibility in supply contracts is another factor stimulating short-term trading. However, Ping Lim of Lloyds TSB, speaking at a workshop session, warned that while banks were comfortable with the trend for new LNG projects to allocate an increasing proportion of production capacity to short-term trades, they still wanted some long-term contracts to underpin a project.

A key issue when switching the destination of cargoes is the gas specification of the receiving market, with the Asian markets requiring gas with a high calorific value, the US and UK using leaner gas and continental Europe more flexible in terms of the range of calorific values. In an interesting paper on gas interchangeability, David Coyle of KBR looked at the methods of treating gas and the issues involved, at both the liquefaction and regasification stages of the supply chain.

But will increasing market connectivity drive a convergence of regional prices to create a true global LNG market?

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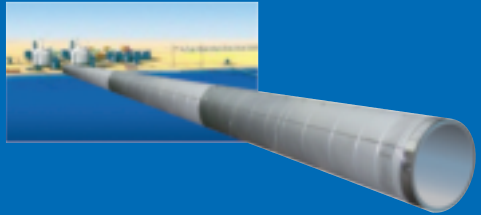

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Guy Caruso takes questions on the growth of US gas demand. On the right is Juan Pons, NOC Chairman for LNG-15 and Secretary General of Sedigas.

BG Group's Martin Houston said there was clear global price communication, pointing out that "cargoes diverted into Asia have been priced in some cases implicitly, but in many cases explicitly, against Henry Hub and other European price markers".

However, Total's Ronan Huitric felt that this convergence trend in the short-term market would not be reflected in long-term contracts, at least for the foreseeable future. "The game will remain very much a long-term contract business with short-term imbalances," he declared.

María Teresa Costa, President of Spain's National Energy Committee, opens the exhibition flanked by Antoni Peris, President of Sedigas, (LEFT) and Antoni Llardén Honorary LNG-15 Chairman (RIGHT).

Markets

A number of presentations addressed specific markets. These included: the host country Spain; China and India, which have more energy alternatives to LNG than the traditional Asian importers; and Mexico, whose Gulf coast Altamira receiving terminal was inaugurated in October 2006. Meanwhile, Brazil's long-awaited debut as an LNG importer was confirmed at a press conference during LNG-15 given by Ildo Sauer of Petrobras, who announced that imports would start in March 2008 at Pecém in the north-east using a chartered tanker with regasification facilities.

It was the potential of the US market, though, that really concentrated delegates' minds. "The US is central to the transformation of the industry," declared BG Group's Houston, "and has emerged as the swing or balancing market."

Indeed, US LNG imports declined 7.3% in 2006 to 12 million tonnes as cargoes were diverted to other markets (Europe's imports were up 20.4% and Asia's rose 10.4%). In the medium to longer term the US market will grow, but the question is by how much. In his keynote address on the final day, Guy Caruso, Administrator of the US Energy Information Administration, presented a range of scenarios for the growth of US gas demand, highlighting the critical determining factors as the price of gas and the impact of potential emissions controls on coal use. In any event, he concluded, "the US is certainly going to become one of the key markets for LNG in the next 10-20 years".

Reflecting this, the day before LNG-15 started the LNG Steering Committee decided that the US would be the next importing nation to host the event, and IGU Charter Member the American Gas Association will organise LNG-17 in either Houston or San Diego in 2013.

A view of the main exhibition hall.

Exhibition

The accompanying exhibition was managed as it has been since LNG-12 by the Australian company Exhibitions and Trade Fairs. It covered a gross area of 17,250 square metres and there were 216 exhibitors on 150 stands. Marking its new position as the world's top LNG exporter, Qatar had the largest and most prominent stand covering 464 square metres in the centre of Hall 1.

LNG-16

At the closing ceremony IGU Charter Member Sedigas, the Spanish Gas Association, was praised for its excellent organisation of LNG-15 and the conference banner was handed to Abdelhafid Feghouli, President of the National Organising Committee for LNG-16, which will be held in Algiers, April 18-21, 2010.

Mark Blacklock is the Editor-in-Chief of International Systems and Communications.

Abdelhafid Feghouli, NOC President for LNG-16 (LEFT) receives the conference banner from Antoni Llardén (CENTRE) and Antoni Peris (RIGHT).

The Offshore LNG Challenge

By Leon Harland, Vice President Gas & Power, SBM Offshore

Traditionally, large national and international energy companies dominated gas markets, but growing LNG demand has attracted a surge of new market entrants. New solutions are being developed for the LNG supply chain, such as: larger LNG carriers; tankers with onboard regasification capabilities; floating storage and regasification units (FSRUs); floating liquefaction concepts; new vaporisation methods; new containment-system designs; subsea pipeline technology; and offshore offloading.

Why take LNG offshore?

The surge in new market entrants and technology developments is a sign that the LNG market is booming. But why take LNG offshore?

For liquefaction (export) plants, the reason for going offshore would be the remote location of the gas reserves, either far from existing pipeline infrastructure and onshore markets, or in deep water or otherwise isolated areas. A floating LNG Production Storage and Offloading facility (LNG FPSO) at stranded gas field can unlock reserves and reduce the overall investment required to deliver gas to market.

For LNG regasification (import) terminals, the reasons for going offshore are due to perceived risks that lead to onshore permitting issues; it is often cheaper to build an offshore terminal, which does not require a shipping channel to be dredged, or a break-water to protect the berth against the open sea.

All floating facilities have a few characteristics in common: they are removable; they can be decommissioned easily; and they are more easily financed because of reduced country risk and redeployment possibilities – this is especially true for LNG production facilities, which carry some reservoir risk.

Offshore LNG production

The key success factor for offshore liquefaction will be whether it is feasible to strike a balance between economic viability (i.e. scale) on one end, and simplicity, operability, safety, and maintainability on the other end. Plant efficiency is important and performance close to that of a baseload plant is desirable, but a small sacrifice may be justified if this results in a significant simplification.

Access to gas reserves is essential for companies trading or selling gas, in order to control the price of the gas supplies. An LNG FPSO may open the door for those companies who do not yet have such access, by partnering with a technology service provider who could provide part of the supply infrastructure, including the LNG FPSO and the FSRU, and with an upstream equity partner for the gas reserves.

Offshore LNG Offloading

For offshore LNG production and regasification to be successful, the technology for offloading LNG between vessels or a vessel and an offloading terminal must be demonstrated.

It is important that all aspects of the berthing and mooring operation are understood, such as tug operations, hydrodynamic effects, the loading-arm envelope and dynamic behaviour. With experience, LNG offloading will become more convenient and will provide higher uptime by the time a flexible/floating LNG hose becomes available – most likely within one to two years.

Offshore LNG Regasification

The challenges posed by offshore regasification are of a different nature: safety and security – for example, spills at sea and gas dispersion to populated areas, or the possibility of a terrorist attack.

FSRUs are safe, versatile and cost-competitive solutions. Their main advantage is their flexibility. In order to minimise the environmental impact, new regasification technologies are proposed by several proponents, such as ambient air vaporisation.

A large number of offshore LNG initiatives are being undertaken and the first are being sanctioned. It is only a matter of time before offshore LNG becomes a logical and trusted part of the LNG chain. Offshore regasification will come first, followed by liquefaction.

As SBM is the world leader in Offshore Floating Production of Oil & Gas, with industry leading safety and uptime performances, it is our sheer ambition to play a pioneering role in offshore LNG offering LNG production, offloading and regasification services in a safe, reliable and economic manner to the industry.

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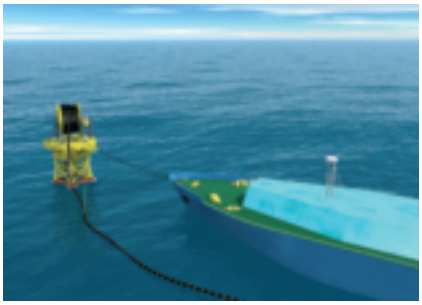

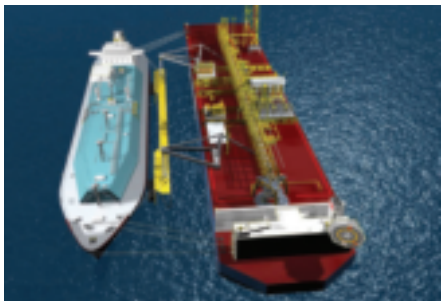

3) Offshore LNG and/or LPG production :

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- LPG Floating Production Storage and Offloading Unit (LPG FPSO)


Local Power – Global Opportunities: Natural Gas and the Emerging Decentralised Energy Market

By David M. Sweet and Jeff Bell

Decentralised energy (DE)[1] is poised to become the next major market for natural gas demand as the power paradigm shifts in favour of generation located at or near the point of use. As this shift takes hold, natural gas is likely to be the fuel of choice for these new power producers, and local distributors of natural gas will be the preferred service providers. The power sector currently accounts for about a third of total natural gas use[2] with a small but growing fraction of this traceable to DE applications. While forecasts predicting future use of gas invariably foresee continued growth in the power sector, the enormous potential for DE as a market opportunity has been, with few exceptions, overlooked.

Gas-fired cogeneration employing a variety of technologies is the most relevant suite of DE technologies for the gas sector. The American Gas Association has identified DE as an "an important emerging market for our member gas utilities". A number of inter-related factors, such as technological innovation, price pressure, environmental and climate concerns, higher consumer expectations and the need for energy security are all making gas-fired cogeneration of heat and power an increasingly attractive business proposition. Existing DE technology offers a powerful solution to the twin challenges of energy and environment that can reduce delivered energy costs and pollution. Simply put, DE offers a win-win proposition for industry, consumers and governments and, as discussed further below, a substantial opportunity for future gas load that needs to be understood and embraced by the natural gas industry if it is to reach its full potential.

The natural advantage of natural gas

In an increasingly emission constrained world, natural gas's popularity is driven by the fact that it is the cleanest fossil fuel. Gas produces less carbon

1 WADE defines DE as the production of power at or near the point of use regardless of size, or the technology employed. The American Gas Association defines DE as the strategic placement of small power generating units (5kW to 25 MW) at or near customer loads.

2 According to IEA's *World Energy Outlook 2006* about 1000 bcm out of the global gas consumption of 2784 bcm were used in power generation applications in 2004 compared to 490/2000 in 1990.

ABOUT WADE

The World Alliance for Decentralized Energy (WADE) is a non-profit research, promotion and advocacy organisation representing global companies as well as industry and environmental groups. Since 1997, WADE has worked to accelerate the worldwide deployment of decentralised energy systems that deliver substantial economic and environmental benefits. WADE's mission is to increase the market share of DE technologies in the global power mix to create a cost-effective, robust and sustainable electricity system.

WADE undertakes a growing range of research and programmes on behalf of its supporters and members:

- Cutting-edge research and analysis on energy and the environment;
- Global advocacy of policies and programmes designed to level the playing field for DE;
- Organisation of events and activities designed to promote and advance the market for DE technology and showcase member product offerings;
- Communications and public relations that delivers the DE message to policy-makers and the general public; and
- Dissemination of market intelligence and breaking news to keep members informed of the latest developments in the global DE marketplace.