the Promotion of Cogeneration (COGEN Europe), leading manufacturers and managers, researchers and decision-makers from the main EU gas companies);

- The high standard of presentations made by leading experts in the field of μCHP; and
- The excellent organisation by Gaz de France.

The workshop produced a valuable summary of the state-of-the-art of the technology and of the different on-going projects worldwide. One of the aims was to initiate common action to accelerate the integration of the new technology into the market. This target was achieved: together with the manufacturers, the gas industry agreed to take action and the ideas discussed at the workshop will soon turn into collaborative projects within the EU and also worldwide.

The workshop was organised into five different sessions including one dedicated to manufacturers.

Setting the scene

The introductory session was chaired and opened by Marc Florette (Director of Gaz de France R&D).

BELOW
Table 2.

PRESENTATIONS IN SESSION "GAS INDUSTRY ACTIVITY"

1	The Japanese experience K. Nishizaki (Tokyo Gas Co.)
2	The Netherlands H. Overdiep (GasTerra) and H. Sijbring (Smart Power Foundation)
3	The UK M. Orrill (British Gas)
4	Germany M. Wilmsmann (E.ON Ruhrgas) presented by S. Ramesohl
5	French field tests D. Le Noc (Gaz de France)
6	Denmark: Gas industry support to fuel cell development J. de Wit (DGC)
7	USA: μCHP as a strategic business tool in the US S. Bernstein (National Grid)

He demonstrated that μCHP is competitive even in countries like France with relatively cheap production of nuclear electricity.

Stephan Ramesohl (E.ON Ruhrgas) outlined the positive impact of μCHP and the opportunity it represents for the gas industry to maintain the role of gas in the residential sector. In Germany due to the new regulations, he said, a condensing gas boiler is no longer an option and gas either has to be combined with renewables or be used in new technologies like μCHP to have a chance in the market.

Guido de Wilt (European Commission Directorate-General for Energy and Transport – DG TREN) emphasised that for the Commission primary energy savings and reductions of greenhouse gas emissions are the leading principles. Therefore, the Commission will not promote a given technology as such or prefer one fuel over the other. In order to realise the potential for μCHP, he invited the industry to make the best possible use of the existing tools that are available in the EU. These include: Directives on CHP (including guarantee of origin and national potentials in the Member States), eco-design, labelling, the energy performance of buildings (being revised), energy services and end-use efficiency (including national energy efficiency action plans), and financial support through various programmes such as Intelligent Energy Europe and the Strategic Energy Technology Plan.

Gas industry activity

Chaired by Jean Schweitzer (DGC/IGU), this session sought to list current activities in the field of μCHP in the gas industry to facilitate collaboration and synergies. There were eight presentations (*see Table 2*) including valuable input from two leading countries for μCHP outside Europe: Japan and the USA.

The fuel cell introduction programme of Japan is an example of how the integration of the tech-

SPEAKERS AT THE SESSION ON GAS INDUSTRY ACTIVITY

Jan de Wit of DGC

Kunihiro Nishizaki of Tokyo Gas

Martin Orrill of British Gas

Henk Sijbring of Smart Power Foundation

Sam Bernstein of National Grid

David Le Noc of Gaz de France

nology is possible when the government, gas industry and manufacturers are working together toward the same goal. The presentation of Kunihiro Nishizaki (Tokyo Gas Co.) highlighted the high motivation of the local gas industry in pushing μCHP both in the development phase and integration phase to get the products into the homes of consumers.

At the present time, most of the work is being carried out at national level without coordination between the different initiatives. The type of projects and degree of effort vary from country to country. While Japan is looking into the long term with heavy support for fuel cell technology, European industry seems in general to be looking at the shorter term with e.g. Stirling engines. However, the picture is not quite that clear-cut as there are European initiatives in, for example, fuel cell development (in Denmark) and energy service with μCHP (in the UK).

It was also interesting to see that, in some countries, the whole industry has chosen to federate efforts. Examples include the Smart Power Foundation in The Netherlands and the Combined Heat and Power Association (CHPA) in the UK. But again this cooperation is at the national rather than international level.

One of the main activities of the gas industry in supporting the technology is via field tests (to evaluate if the appliance is mature to enter the market), and while such national activities in Denmark, France, Germany, Japan, The Netherlands and the UK, were outlined in various presentations, there was no form of coordination.

The presentations outlined a number of ways for the gas industry to support manufacturers:

- Helping to make sure that μCHP technology is within the EU research policy and programmes;
- Helping with the development of standards;
- Demonstrating appliance qualities (such as low CO_2 impact), modelling and performance assessment;
- Informing the customer and developing marketing tools;
- Working to offer affordable packages for installed appliances; and
- Helping to develop a network of installers and training.

R&D and laboratory assessment/evaluation of the appliances (for safety and performance) are also undertaken in some countries. However, in many instances, the gas industry is reluctant to help a specific manufacturer and to give him a commercial advantage over competitors.

Conditions for the success of μCHP

Five presentations were made during this session (*see Table 3*), which was chaired by Henk Ensing (GasTerra).

To succeed in developing the market it is not sufficient for appliances to be available, reliable and cost effective, we also need to ensure that the overall operating environment is ready. What will be the requirements for the installation and installers? Will traditional gas installers do the job? Will available units cover heat, hot water and power for houses? Or will there be a need for additional/backup traditional gas appliances as well? Connection to the grid raises many questions, as does product certification. Which European Directives do μCHP products have to meet to obtain the "CE" mark?

It is possible today to get a CE mark for the commercialisation of μCHP in the EU. However, the basis for getting the mark is far from being clear. Many Directives are relevant to μCHP and many standards can apply, so clarification to avoid duplication of norms would be very useful. Also the standards for the performance evaluation of the appliances are missing (e.g. for the application of the Eco-design Directive). It was stressed that those

BELOW
Table 3.

PRESENTATIONS IN SESSION "CONDITIONS FOR SUCCESS OF μCHP"

1	Certification of μCHP appliances: What is the present situation? Standards, CE marking	F. Thuis (Kiwa Gastec)
2	Commercial and marketing aspects: How do we convince the users to invest in μCHP?	H. Ensing (GasTerra)
3	Interactive website presenting technologies and products	T. Formanski (ASUE)
4	Connecting μCHP to the grid: Challenges, advantages, costs? (European Distributed Energy Partnership project)	J. Deuse (Tractebel)
5	Subsidising μCHP: What is the situation? Impact of different models	A. H. Pedersen (DONG)

GasTerra

www.gasterra.nl

Henk Ensing of GasTerra chaired the session on conditions for the success of μCHP (ABOVE LEFT) and Jacques Deuse of Tractebel gave one of the presentations (ABOVE RIGHT).

should comply with the existing procedures for the testing of e.g. condensing boilers. Guido de Wilt informed the session that the Commission will issue a mandate to the European Committee for Standardisation (CEN) to tackle the issue of measurement methodology for energy efficiency in μCHP.

Different models of subsidy were also presented and it is clear that support from government would help as it did for the introduction of the condensing boiler. Rather than waiting for public support to materialise, however, some manufacturers preferred to develop appliances with competitive prices and performances on their own account.

The Commission stated that it does not support specific categories of appliances like μCHP, but it certainly allows Member States to use instruments (such as financial support and building regulations) that will lead to energy savings and emissions reduction through μCHP. Indeed, governments can influence the economic balance of μCHP technology by acting on CO_2 emission taxes and the electricity feed-in tariff. There are technical and cost issues in connecting appliances to the grid but they can be offset if the feed-in tariff is set at a level that offers a strong incentive.

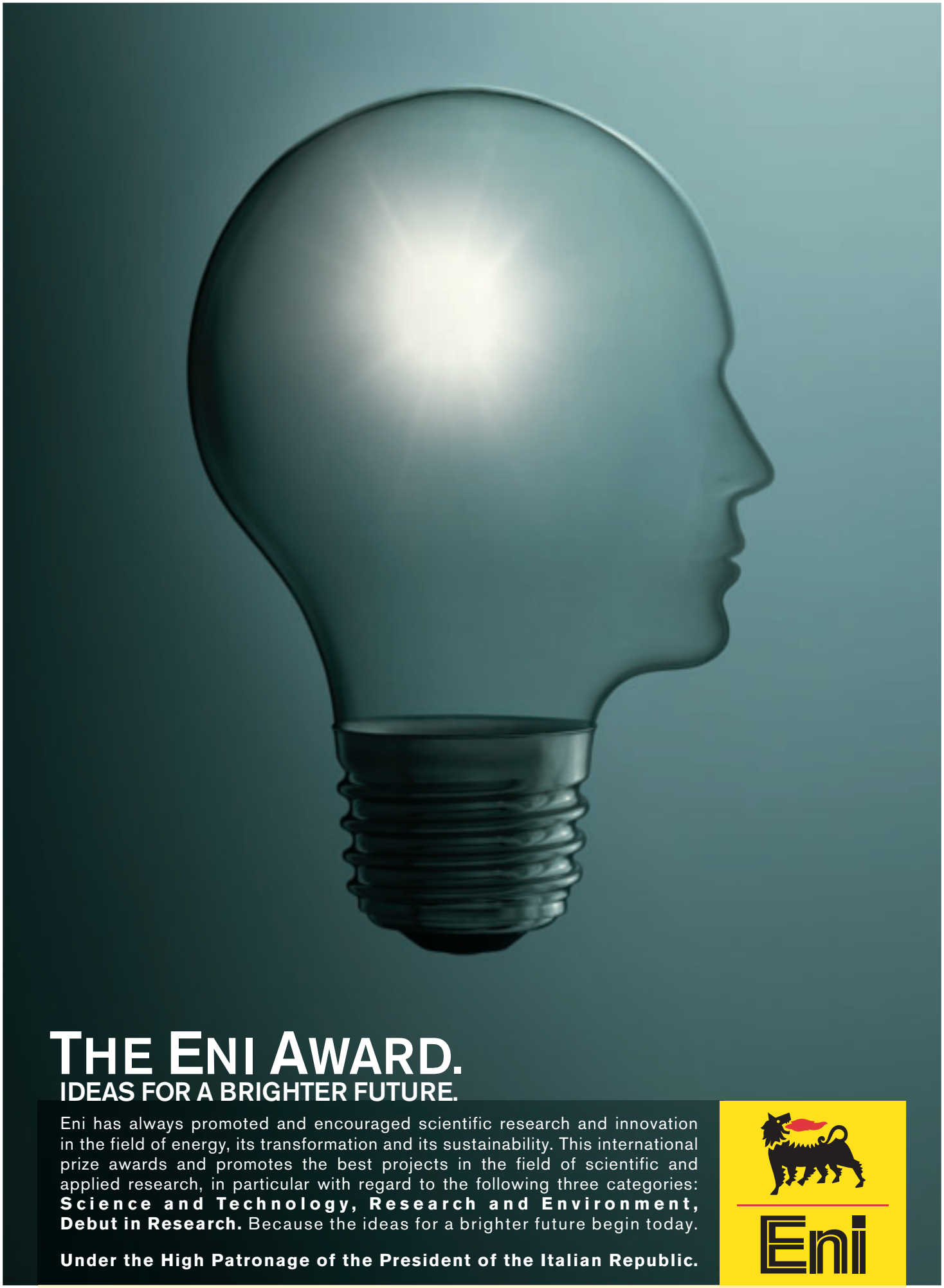
During discussion of the CO_2 emission issue the fact that μCHP will operate in the non-regulated sector of CO_2 certificates was highlighted. This means that there needs to be some transfer mechanism so that credit for reductions in domestic CO_2 emissions may be taken for production in the regulated sector or sold elsewhere. Support for μCHP could also be linked to guarantees of origin for CHP appliances under the CHP Directive.

Marketing was also on the agenda with presentations from GasTerra and ASUE. More and more consumers want to show that they are green and μCHP might not be as visible as solar panels on a roof. Here also, guarantees of origin as available under the CHP Directive (possibly linked with green certificates) could be useful. Some customers are also conscious of the argument that μCHP gives them a degree of energy independence. In Germany, efforts are being made to find a different name to describe the technology as the term "μCHP" was thought to be too obscure for many customers.

● μCHP – state of the art

Chaired by Thorsten Formanski (ASUE), the aim of this session was to shed light on the state-of-the-art of the technology and the current market status of μCHP systems. One overview presentation and several presentations given by manufacturers of μCHP units answered many questions and brought workshop participants up to speed in these areas.

Dr Formanski presented the benefits and the state-of-the-art of μCHP, the current market situation and the requirements for μCHP units, especially of the 1 kW electrical (kWel) class. Reliability, reasonable pricing, easy handling and installation in newly-built and existing buildings together with convenient operation for the end-user are the key requirements. Honda's 1 kWel "Ecowill" system with more than 60,000 units sold in Japan and Senertec's 5 kWel "Dachs" with nearly 20,000 units sold in Europe are the current market leaders.



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APPLIANCES

Appliances made by Baxi (FAR LEFT), Remeha-De Dietrich (SECOND LEFT), Gennex (THIRD LEFT), and WhisperGen (LEFT).

There are also several developments based on internal combustion engines, Stirling engines and fuel cell technology underway, which are either close to reaching the market or offer potential in the near future. Generally speaking, given the potential for μCHP systems and the interest of the customers, the market needs reliable systems for a reasonable price supported during the market introduction by all involved groups.

Guido Gummert (Baxi Innotech, Germany) presented the whole range of products with the available "Dachs" system, the Stirling engine based "Ecogen" system and the fuel cell development with the current beta field test unit. Gummert mentioned that a pre-series of the "Ecogen" is expected for 2009. For the fuel cell development the market introduction is scheduled for 2013.

Marco Bijkerk (Remeha, The Netherlands) presented the combi boiler with a Stirling engine, which is based on the former Microgen development as are the developments of Baxi and Viessmann. The commercial availability of the 1kWel and with the integrated condensing boiler up to 28 kW thermal output system is scheduled for 2009.

Meanwhile, 500 units of the Bosch Thermotechnology Stirling system are being field tested in Germany, The Netherlands and the UK, according to the company's Gary Mitchell. The tests will run to 2010 and, if successful, roll-out could start in 2011.

WhisperGen, the Stirling engine based system which is closest to the market, will be manufactured in Spain under a joint venture of WhisperGen, New Zealand and Mondragon Cooperative Corp., Spain, said Len Damiano from WhisperGen. After intensive testing and system improvement over several generations production is now starting. Damiano was one of the speakers who pointed out that the setting of fair and collective standards will be a common challenge for manufacturers and all interested parties.

Bob Flint, CeresPower, UK and Brandon Bilton, CFCL Europe, UK, presented the solid oxide fuel cell (SOFC) development of their companies, the current technical status and future activities in order to bring their products to the market. They also described the alliances and the partners who will support them during development, field testing, production planning and preparation of manufacturing.

Per Balslev, Danfoss, Denmark, described a joint demonstration project by fuel cell manufacturers, energy companies and component manufacturers to test low and high temperature fuel cell-based

Ian Manders of CHPA (ABOVE LEFT) and Fiona Riddoch of COGEN Europe (ABOVE RIGHT) introduced the Round Table session.

μCHP systems for private homes. Both the operation in a single-family house and the connection/interaction of different μCHP systems are aspects of the project.

The session showed that more and more μCHP systems are getting close to market entry so that in the near future μCHP could be an alternative for the customer. In order to be successful the systems must fulfil different requirements regarding the specifications, installation and operation. In addition, all manufacturers pointed out that fair standards must be set, with respect to national circumstances, and different kinds of support have to be given to ensure a smooth market introduction of μCHP systems within the next few years.

Key points from the Round Table

The Round Table session aimed to summarise the results of the workshop. It was introduced by Ian Manders (CHPA) and Fiona Riddoch (COGEN Europe), who emphasised the importance of prioritising energy efficiency and energy saving in a debate where renewables were discussed at many occasions during the workshop.

The Round Table chaired by Daniel Hec was organised with the participation of G. de Wilt (DG TREN), F. Riddoch (COGEN Europe), D. Hec (Marcogaz), J. Schweitzer (DGC, representing IGU and GERG), H. Sijbring (Smart Power Foundation) and S. Bernstein (National Grid).

From the discussion, a number of pragmatic suggestions were made in order to solve some of the problems identified:

- A fair methodology to establish performances is needed (energy efficiency, energy savings, CO_2 savings etc.) to bring some consistency to the information on performances given for the appliances. This could be done very soon with the knowledge and experience already available.
- No appliance can be put on the market without respecting the safety requirement of the Gas Appliance Directive. In that regard a standard is being prepared (by the CEN/European Committee for Electrotechnical Standardisation Joint Working Group on Fuel Cell Gas Heating Appliances chaired by Jörg Endish), and the industry should support the work by sending experts to the group.

- In order to execute a mandate to assess performances of μCHP appliances, pre-normative studies will be undertaken to adapt the testing procedure to the specificity of the appliances, and it was recommended that existing expertise from laboratories within the networks LABNET and LABTQ be drawn upon.
- Standardisation work should be clarified and harmonised which seems not be the case today. To a certain extent this will also apply to Directives and a clarification of which Directives apply to which products would be useful.
- μCHP is typically sold by installers; new business models may be needed.
- The industry is demanding field tests. The gas industry could coordinate those tests at EU level through GERG. Collaboration with the Japanese Gas Association could be possible on this topic as well as on measurement and testing aspects.

In order to coordinate the action needed to promote μCHP efficiently, it was decided to establish a joint μCHP voice/representation for dealing with the EU. Marcogaz will soon take the initiative and send an invitation for a meeting to organise this with delegates representing manufacturers, the gas industry, Notified Bodies, laboratories and associations dealing with the topic. A preliminary list of topics that could be included in the programme is given in *Table 4*.

Conclusions of the workshop

The main feeling at the workshop was that the whole industry was highly motivated to introduce the technology into the market. The fact that gas sales are decreasing in important markets is making μCHP technology more important than ever. Even though μCHP is still costly compared to alternative technologies, there is a clear potential for improvement and the Japanese model shows that it is economically sustainable. Moreover, there is a new young industry with products that are already available and also with a lot of new products to come.

μCHP, therefore, seems to have a promising future. Fuel cell technology can also be a technological bridge from natural gas to renewables, when in the long term natural gas may gradually be replaced by hydrogen produced by cheap renewable sources.

The workshop was a first initiative for a global and common action within the gas industry associating all partners. This action will now continue with the above-mentioned joint representation.

All communications and papers can be downloaded from www.marcogaz.org.

Jean Schweitzer is the Chairman of IGU's Working Committee 5 and prepared the bulk of this report. Dr Thorsten Formanski of the German Association for the Efficient and Environmentally Friendly Use of Energy (ASUE) contributed the section "μCHP – state of the art".

BELOW
Table 4.

TOPICS FOR PROGRAMME TO PROMOTE μCHP

Technical
- R&D
- Demo
- Sharing information.
- Establish courses and training
- Pre-normalisation
- Models, calculation of CO_2 impact of μCHP compared to traditional heating etc.

Standards and regulations
- Development of standards
- Harmonisation/coordination of relevant standardisation activity

Marketing
- Offering packages for installed appliances to customers
- Integrating μCHP in energy service? (energy services company – ESCO)
- Incentives
- Raising awareness/identifying a message

Coordination lobby
- Follow up and lobby, representation

Managing complex LNG risks

Risk management for LNG is critical to success in this capital-intensive, technologically evolving and politically unpredictable business. It is all about taking a holistic approach to the inherent risks in the complex LNG value chain.

The LNG industry is investing heavily to meet the world's hunger for natural gas, which is expected to exceed the demand for oil by 2030. Billions of dollars are being poured into gas exploration, production, liquefaction, shipping, regasification and technology development, as both traditional and new players strive for promising opportunities worldwide. Developing the LNG infrastructure is also one of the ways to increase or diversify the energy security of supply.

Manage risks to succeed

A complex matrix consisting of market conditions, regulatory regimes and policy considerations affect LNG project developments. Understanding and carefully managing these conditions will determine whether a project developer succeeds or fails in bringing new LNG capacity online.

Savvy companies therefore realise the critical need to effectively manage risks in every link of the LNG value chain. They know this is crucial to success. Risk management for LNG is all the more complex given the financial co-dependency that exists from the wellhead, across the oceans, to the receiving terminal export flange and the gas market.

Identify and analyse the individual risks

DNV's approach emphasises that each transaction in the LNG value chain has its own inherent risks that can impact on business objectives, both upstream and downstream. Therefore, for each proposed transaction or investment, risk management requires that each risk be identified and understood, quantified or assessed meaningfully, and mitigated to reduce potential financial exposure.

Once a project is found to meet safety and environmental criteria, the financial exposure and potential costs of business interruption must be properly analysed and mitigated. Following this, the range of risk management solutions runs the gamut of creative business solutions. This requires analysis of the infrastructure design and location, insurance and contract risk allocation, the adoption of alternative shipping movements, and even managerial or organisational reform.

Reduce risky surprises

Risk management practices will not eliminate unpleasant surprises, but companies that adopt the principles will have fewer and smaller surprises. Models that take on board all relevant experiences and lessons, both qualitative and quantitative, are more robust and less likely to leave planners at a loss to explain the so-called "unexpected" events that characterise almost any major undertaking. It is therefore imperative that each developer study these historical lessons when analysing LNG projects.

Global LNG leader

With its network of 300 offices in 100 countries, DNV is a global provider of risk management services, helping customers to safely and responsibly improve their business performance. DNV has been involved in the LNG industry since the 1960s, and today DNV is involved in more than one third of the ongoing LNG projects and classifying more than one fifth of the LNG carrier fleet on order.

To deal with the complexity facing the LNG industry, DNV provides a broad range of services which includes risk-based verification, technology qualification, public safety assessment, environmental impact assessment, asset risk management and technical analysis, as well as enterprise risk management to pull all these together. This involvement leverages a highly qualified workforce with expert knowledge of the LNG industry's different technical disciplines and overall commercial drivers.

Significant Potential for Biomethane

By Rich Piellisch

Biomethane has perhaps the highest potential yet is the least recognised of the biofuels. In the form of biogas it has long been used for heating and for generating electricity near its sources, which include sewage treatment plants, landfills and animal farms. Today the higher-purity variant is getting new attention as a viable source of "natural gas" for pipeline distribution or for fuelling vehicles.

Higher prices for conventional fuels are turning biomethane into an increasingly attractive alternative. Global warming and the resultant drive for "green" fuels provides natural gas providers considering biomethane a means of saying that their product too, is a renewable. Biomethane holds the potential to end the foods-versus-fuels argument. No food or land need be displaced, and when biomethane is made from manure or municipal sewage, a key byproduct is a useful fertiliser.

A study last year involving the Institute of Chemical Engineering at the Vienna University of Technology found that biomethane from sources including non-food crops could accommodate a stunning 94% of the energy demand of road traffic in Europe.

Indeed, Sweden has committed itself to large-scale biomethane use for vehicles, and is being followed by Austria and Switzerland. In the Swiss capital of Berne, local transit operator Bernmobil has bought natural gas buses with the express intent of operating them on biomethane derived from the city's municipal wastewater. And in the UK, a groundbreaking LNG-from-landfill-gas project was announced in June.

In the US, the San Francisco-based Pacific Gas & Electric utility, which serves some 15 million people in California, has publicised several new

Bernmobil's buses are switching to biomethane.

projects to upgrade dairy biogas into biomethane and inject it into the pipeline grid. At least two projects in California are drawing landfill gas and processing it into LNG for vehicles, and there is one in Ohio offering CNG to fleets.

Biomethane is a wonderfully effective greenhouse gas reduction tool. Its use involves no liberation of fossil carbon. Although carbon will eventually reach the atmosphere, the atoms that started in methane molecules will be emitted as less harmful CO_2. They will have accomplished useful work on their way, displacing fossil fuels.

Sweden is the leader in biomethane implementation with thousands of buses and this train running on the fuel.

Spreading the message

"Biomethane is probably the least known and least understood of all the biofuels," says Steve Ellis of American Honda, the sole remaining US supplier of factory natural gas passenger cars. "It's the cleanest of all the alternative fuels. It's a tremendous opportunity to do for natural gas what renewable electrons (i.e. wind and solar) have done for electricity."

"Although not well understood," Ellis adds, biomethane "is gaining attention in the climate change and smog emissions arena. It proves that 'natural gas' doesn't have to be considered just another fossil fuel."

"I don't think it's cost that's holding it back," says Steven Sokolsky of WestStart-Calstart, an advanced transportation consortium with offices outside Los Angeles and San Francisco, and in Denver. "It's unfamiliarity."

Calstart has organised several fact-finding trips to Sweden, and has arranged for Swedish biogas experts to meet with interested parties in the United States. Sweden, which has been actively pursuing biomethane for vehicles for more than a decade, remains the undisputed leader in biomethane implementation, as thousands of buses and at least one train run on the clean renewable fuel there.

Biomethane fuel is cheaper than gasoline in Sweden, says Bernt Svensén, Project Manager for Biogas Väst (West) with Business Region Göteborg in Gothenburg. He cites a price of approximately 14 Swedish krona per litre, or about $2.32 for gasoline, but says that grid-delivered biomethane can cost as little as 9 krona per equivalent litre ($1.49). The Biogas Väst initiative this year won a Calstart "Blue Sky" award for contributing to the use of biomethane in some 7,000 cars, trucks and buses.

Biomethane accounts for some 6% of all fuel use in the city of Linköping, according to Sven-Göran Sjöholm, Sales Manager of Swedish Biogas International AB, which is based there. The long-term potential of biomethane, he says, is for replacement of 10% or even 15% of today's fossil fuels. Swedish Biogas International is working with officials in Flint, Michigan to establish biomethane production based on municipal wastewater.

"Biomethane could replace 20% or more of the transport sector fuel in Europe if the relatively modest investment in the production infrastructure was made at the local community level," says Dr Jeffrey Seisler of Clean Fuels Consulting in Brussels. "The investment," Seisler says, "needs more motivation by policy makers who believe that biomethane is not just a fuel for electricity production. And the gas industry needs to recognise the economic and political virtues

Purifiers such as this QuestAir M-3100 process raw biogas into high quality biomethane.

of adding this valuable renewable resource to its energy offerings of fossil natural gas."

In France, an organisation called Biogasmax is coordinating efforts in Lille and elsewhere in Europe, including Rome and the Polish regions of Torun and Zielona Góra. Biomethane advocates in Madrid hope to fuel the city's fleet of some 450 CNG refuse trucks on landfill-derived biomethane.

A recent EU report states that: "The overall effects on emissions from converting organic biomass to biogas through anaerobic digestion are absolutely positive..... First and foremost, an EU Directive on biogas production is needed."

In addition to the above, biogas and biomethane projects have recently been reported in Australia, Bangladesh, Canada, Chile, China, Estonia, Georgia, Hungary, India, Indonesia, Israel, Jamaica, Korea, Nepal, Norway, Pakistan, the Philippines, Russia, Thailand, Uganda, Vietnam and Zimbabwe. The UK's Organic Power promotes biomethane derived from waste food. The US Environmental Protection Agency is backing dairy-based biomethane projects in California, where the state Energy Commission is expected to fund the renewable fuel aggressively when so-called AB 118 monies begin to flow next year. AB 118 is a California law that will provide more than $100 million per year for efficient energy projects in the state.

Meanwhile, in Idaho, a company called Intrepid Technology and Resources delivered its first trailer load of manure-derived fuel to a commercial customer this year, noting that the biomethane will offset traditional use of propane in fertiliser production. "We believe the economics of taking [biogas] to pipeline quality gas are better than the economics of converting it and selling it as electricity," Intrepid Vice President Brad Frazee says in a report cited on his firm's website.

Need for purification

A continuing challenge is economical purification of abundant biogas into versatile clean biomethane. Biogas from feedlots and sewage plants is only around half methane, and removing water and CO_2 can make the biomethane product expensive. Landfill gas, sometimes referred to as LFG, tends to be contaminated with siloxanes, which pose additional problems in combustion: think sand in the cylinder block.

"The gas is complex in terms of its contaminants and variable in terms of its contaminants," says Rhonda Howard of California's FirmGreen, Inc. FirmGreen has gone through a laborious, multi-year permitting process and is now marketing fuel from a landfill operated by SWACO, the Solid Waste Authority of Central Ohio. The facility near Columbus can produce CNG at a gasoline gallon equivalent cost lower than $2.75 per gallon, FirmGreen says, pointing this past June to diesel costs of about $4.75 per gallon.

Southern California's Orange County Transportation Authority (OCTA) operates hundreds of natural gas buses, both CNG and LNG. OCTA satisfies a portion of its daily 20,000-gallon (76,000 litres) LNG requirement with fuel from the Bowerman Landfill in the town of Irvine. "It's really

cruddy gas, but the feedstock is totally free," says facilities manager Ryan Erickson. OCTA's contract, through Earth Biofuels/Applied LNG Technologies in Texas, is for 91 cents per LNG gallon, compared with $1.17 to $1.19 for conventional LNG. Municipal and transit officials expect to pay less for biomethane, Erickson says, because the raw gas is a waste product. His agency allows product that is 97% methane, although it requires 98% for conventional LNG. Seattle-based Prometheus Energy, the firm that is purifying the LFG prior to sale by Earth/ALT, had problems with moisture in the product when ramping up output, but in June installed new dryer vessels employing a vacuum pressure swing adsorption (PSA) system.

Landfill initiatives

In late April, in northern California, partners including Waste Management, Inc. and Linde-BOC announced a project, long in the works, to produce LNG and fuel refuse trucks serving the Altamont Landfill in Livermore, east of San Francisco. "When the facility begins operating in 2009 it is expected to produce up to 13,000 gallons [49,000 litres] a day of LNG," the partners said, proclaiming it the world's largest LFG-based installation for vehicle fuel. Linde says it is responsible for the engineering of the plant and for the cleaning and subsequent liquefaction of the landfill gas.

In a similar project announced in June, Gasrec, Linde-BOC and Sita UK have teamed up to make LNG at the Albury landfill site in Surrey, UK. The Albury plant, claimed to be the first of its kind in Europe, will produce approximately 5,000 tonnes of LNG per year, enough to fuel as many as 150 heavy duty NGVs or perhaps 500 light-duty NGVs.

"We have produced electricity from landfill gas for many years but we believe there is a big future for generating fuel from waste," said Sita UK's New Markets Business Development Manager

Bowerman Landfill in Irvine, California is operated by Prometheus Energy, which is ramping up production with a target of 5,000 US gallons of LNG a day.

Gasrec, Linde-BOC and Sita UK have worked together to launch a liquid biomethane production facility at Albury to supply fuel for vehicles such as this refuse truck pictured with Richard Lilleystone, Chief Executive of Gasrec (in the cab) and Sita UK Fleet Manager Paul Shipman.

Stuart Hayward-Higham. "We have another waste-to-fuel project in Hong Kong and have been keen to see this type of technology take off," he added.

In Spain, the Greenlane Biogas unit of Sweden's Flotech has installed equipment to upgrade LFG from Madrid's Valdemingómez Landfill to pipeline quality. Capacity is in place to upgrade about a quarter of the 40 mcm of biogas from the facility, according to Manuel Lage of the engine manufacturer Iveco. Upgrading all of it would yield about 22 mcm of biomethane, he reckons, putting consumption by the Madrid refuse truck fleet (all of the trucks have CNG-fuelled Iveco engines) at about 10.5 mcm. Thus the Valdemingómez Landfill alone could support all of Madrid's refuse trucks and around a quarter of its 2,000-strong bus fleet. When the Valdemingómez Landfill is depleted in five years or so, biogas can be tapped from the city's Las Dehesa facility, Lage says.

The gas from Valdemingómez is now going into the pipeline grid, he notes. So although the Madrid refuse trucks are not running directly on biomethane, they are almost certainly burning some biomethane molecules, and that is enough to argue that they are running on renewable fuel.

Increasing use

NGVAmerica, the natural gas vehicles advocacy group in Washington DC, has long pushed for increased use of biomethane. A key impediment in the United States, notes NGVAmerica President Rich Kolodziej, is "a huge tax credit" for using biogas to make electricity. The 1.9 cent per kilowatt-hour credit translates into nearly 70¢ per gasoline equivalent gallon of biomethane, he says, noting that its repeal is one of NGVAmerica's legislative priorities.

Peter Boisen, a former Volvo executive and Chairman of NGVA Europe, reports that a key United Nations working group decided in Geneva this past June that there is no need to differentiate between biomethane and conventional natural gas, as chemically they are the same. At the same time, he says, there is growing opposition to "agrofuels," which are crops grown for fuel on land that could be used for food.

"The new signals are good news for the NGV industry," Boisen says. "Already natural gas provides superior performance in terms of emissions of pollutants and greenhouse gas emissions, and the potential to add a gradually increasing share of biomethane will step-by-step increase the environmental advantages for the methane fuel alternative.

"Conversion of waste into biomethane using anaerobic digestion technology provides high fuel yields, and simultaneously residuals which can substitute for artificial fertilisers. Lignocellulosic (woody plant) waste can also – via a low temperature gasification process – be turned into biomethane at efficiency rates which are considerably higher than for alternative synthetic fuels.

"All in all the opportunities for promotion of the biomethane alternative have never been as good as they are right now," Boisen says. "Increased use of this option will also generally support increased use of natural gas as a transportation fuel."

Rich Piellisch is the Editor of the San Francisco-based newsletter Fleets & Fuels *(www.fleetsandfuels.com).*

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GTL Finally Heads for the Runway

By Mark Blacklock

In the early 2000s it seemed that the gas-to-liquids (GTL) sector was about to take off. Qatar started planning the first of what was expected to be a series of plants, other countries were looking at exploiting the technology on a large scale and the smaller-scale GTL barge was touted as a means of monetising stranded gas reserves. Projects totalling some 900,000 b/d were under evaluation. Although the take-off has not happened yet for a number of reasons, including spiralling construction costs, geopolitical issues and technological problems, GTL should be heading for the runway by the end of the decade.

Tougher environmental standards in markets around the world are spurring interest in GTL products for use as a blend stock. Typically automotive diesel with virtually no sulphur or aromatics and a high cetane number accounts for around two-thirds of the products slate of a GTL plant, the remainder being mainly naphtha suitable for petrochemical feedstock. And while the environmental benefits at the end-user level are currently partially offset by the higher emissions of a GTL plant compared to a standard refinery, there is scope to introduce carbon sequestration and improve plant efficiency in the longer term. The basic process, which can be used with gas, coal or biomass, sees the feedstock converted to carbon monoxide and hydrogen (syngas) for processing in a reactor to produce paraffinic waxes which can then be refined. The various proprietary technologies use different combinations of catalysts, reactor types and process conditions.

Facing problems

Since Qatar Petroleum and Sasol agreed a $700 million engineering, procurement and construction (EPC) contract in 2003 for their joint venture Oryx

After resolving its start-up problems Oryx expects to achieve full production by the end of 2008.

GTL plant in Ras Laffan, Qatar, rising raw materials prices and competition from other industries for engineering and contracting services have impacted all sectors of the gas industry. The EPC for the similarly-sized Escravos GTL plant in Nigeria came in at $1.7 billion in 2005, while the bill for the four-times bigger Pearl GTL project in Qatar is likely to be more than 10 times higher. Although rising energy prices improve the revenue side of the equation, the higher capital costs have led to the scrapping of several GTL projects.

The cost issue has been compounded by developments on the geopolitical front in two prime GTL prospects – Bolivia and Qatar. Bolivia was the initial focus of interest for GTL projects in South America and feasibility studies were carried out for three plants with a combined capacity of 113,500 b/d. But GTL is off the agenda for the time being as the country's oil and gas industry is restructured following the nationalisation decree of May 2006. Meanwhile, Qatar's moratorium on new gas developments while it assesses the effect on the North Field's reserves of existing projects means that all the post-Pearl GTL proposals have been shelved.

Problems with the introduction of a new GTL process have also played a role. The basic concept is long-proven, dating back to the work of Franz Fischer and Hans Tropsch in Germany in the 1920s on coal liquefaction and further developed in South Africa from the 1950s by Sasol. The first commercial plants using natural gas as a feedstock were commissioned in 1992 by Mossgas (now part of Petro SA) in Mossel Bay, South Africa (using Sasol's Synthol process), and in 1993 by a Shell-led consortium in Bintulu, Malaysia (using Shell's Middle Distillate Synthesis – MDS). The Malaysian plant suffered an explosion in its air separation unit in December 1997 and was closed until May 2000, but this was caused by an accumulation of air-borne contaminants from forest fires and was not related to the GTL technology.

Oryx was the next commercial GTL plant and it marked the first large-scale use of the low-temperature Slurry Phase Distillate (SPD) process

Petro SA's plant in Mossel Bay was the first to begin volume GTL production.

This aerial picture shows work underway on the Escravos GTL plant which is due to be completed by the end of the decade.

developed by Sasol. Following an inauguration ceremony in June 2006, Oryx began start-up testing. An initial failure of the steam super heater in the utility section was resolved and the first product was shipped in April 2007. However, a higher than design level of fine material in the paraffinic wax which then has to be handled downstream of the Fischer-Tropsch units constrained the throughput of the downstream units, and the plant was initially operating below 10,000 b/d compared to a design capacity of 34,000 b/d.

● Working for take-off

Development of the GTL sector has certainly been slower than expected, but the pace is quickening at last. The problems with SPD have been addressed, production capacity is building up and there are interesting new approaches to small-scale production.

According to Oryx GTL, "Huge strides have been made in resolving all issues that we faced during ramp-up and today we are no longer in the 'proving the technology phase' but in the 'optimisation phase'". Full production is envisaged by the end of 2008 when the partners will evaluate expansion. Originally they were talking about increasing capacity to 100,000 b/d, but at this stage they are not committing themselves to a specific figure and will only say that: "As soon as Oryx 1 is settled as a business, both Sasol and Qatar Petroleum will work towards debottlenecking and expanding it".

Sasol's SPD process will also be used at the 34,000 b/d Escravos GTL plant, which is being built 100 kilometres southeast of Lagos as a joint venture between the Nigerian National Petroleum Company and Chevron. Some 200 Nigerians have been trained at Sasol's plants in Secunda and Sasolburg, and Escravos is due to start operations in 2011.

And at home Sasol notched up a notable achievement in April 2008 with international approval for the first 100% synthetic jet fuel. Sasol has been supplying Johannesburg's O. R. Tambo airport with a blend of semi-synthetic jet fuel (up to 50% blend) and oil-derived kerosene from the company's plant at Secunda since 1999. Secunda is essentially a coal-to-liquids (CTL) plant with a small (6%) amount of gas feedstock, and has a capacity of 150,000 b/d. The plant will be

Shell sells blends of GTL fuel from Bintulu in a number of national markets including Thailand under the Pura Diesel brand.

expanded to around 180,000 b/d over the next eight years with most of the new capacity using gas feedstock.

Secunda uses Sasol's high-temperature Advanced Synthol process with an iron-based catalyst to produce distillate fractions which contain aromatic hydrocarbons and have good lubricity. The Sasol SPD and Shell MDS processes yield products without aromatics and the trace organic species that provide lubricity, so these products have to be blended with oil-derived kerosene to be used as jet fuel. A blend with a GTL content of approximately 40% was used in the first civilian trial of a GTL-based jet fuel in February 2008. As part of a research programme into alternative fuels backed by Airbus, Qatar Airways, Qatar Petroleum, Qatar Fuels, Qatar Science & Technology Park, Rolls-Royce and Shell, an Airbus A380 made a successful three-hour test flight with one of its four engines fuelled by the GTL blend from Shell's Bintulu plant.

Meanwhile, work is well underway on Pearl GTL, a joint venture of Qatar Petroleum and Shell, which will have two 70,000 b/d trains. The first four reactors arrived at Ras Laffan in January 2008 and over 20,000 workers are on site. Start-up of the first train is envisaged "around the end of the decade, in line with our expectations at the time of the investment decision", according to Shell. Full production of 140,000 b/d is expected by 2012.

Small scale

In contrast to the two Qatari plants, World GTL and the Petroleum Company of Trinidad & Tobago (Petrotrin) are building a plant with a capacity of 2,250 b/d using some second-hand equipment such as a surplus methanol reactor to keep the capital costs down. Adjacent to Petrotrin's oil refinery at Pointe-à-Pierre, the plant will use World GTL's proprietary technology, which involves the use of a cobalt catalyst in a fixed tube reactor, to convert a gas feedstock of 21 mcf (588,000 m^3) per day and production is due to start by the end of 2008.

For Trinidad, the GTL plant is a way of diversifying the use of its natural gas reserves and producing "green" diesel for use as a blend stock. But clearly such a small-scale plant offers the potential to monetise stranded gas resources or gas that would otherwise be flared. World GTL says that it is "pursuing a number of promising invitations from National Oil Companies to form new joint ventures for GTL developments".

This market sector had been targeted by Syntroleum, which proposed a GTL barge using its


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The Airbus A380 used in the first civilian trial of a GTL-based jet fuel was powered by four Rolls-Royce Trent 900 engines.

proprietary technology to produce 19,400 b/d of refined products, but there were no takers. The key seems to be making things smaller and simpler, and now CompactGTL is working with Petrobras on a pilot project to deal with associated gas from offshore oil fields. The idea is to monetise the gas (and avoid the environmental cost of flaring it) by including a small GTL plant on floating, production, storage and offloading (FPSO) vessels. Modular GTL plants ranging in capacity from 200 to 1,000 b/d are planned.

Like Syntroleum, CompactGTL's proprietory technology uses air rather than pure oxygen in the first stage of processing (converting the feedstock into syngas) meaning there is no need for a separate oxygen plant and a GTL plant can be accommodated on a vessel. However, whereas Syntroleum's proposal included on-site refining, CompactGTL's will produce a syncrude which will then be shipped with the main crude production to be refined elsewhere.

"The key technical benefits of our solution arise through process intensification (heat management and compact reactors), scaleability (via a modular approach that is not viable using conventional GTL reactors), low process fluid inventory, no requirement for an oxygen supply and a low centre of gravity," says CompactGTL. "Our plants will not take up all the deck space of the FPSO, leaving enough room for the oil processing equipment. Scaleability through modular design is a critical aspect that allows the capacity of the plant to be adjusted to match the declining flow of associated gas throughout the life of an oilfield. As gas flow reduces, plant modules can be shut down and removed for refurbishment and re-deployment elsewhere."

CompactGTL and Petrobras expect to have the pilot plant with a capacity of 20 b/d onstream at the end of 2009 at the Aracaju facility in Brazil. Following that the intention is to move it offshore for further testing.

New developments

Meanwhile, Syntroleum has licensed its technology to Pacific GTL, an interesting new venture in Australia, which will use coal-bed methane (CBM) as a feedstock.

Pacific's first project is SunState GTL in the Darling Downs area west of Brisbane in

Queensland. Budgeted at $1.6 billion, construction of the 17,000 b/d facility is due to start in 2010. The main product will be diesel with naptha and LPG as secondary products. The company is also evaluating a project in the Hunter Valley region of New South Wales called Valley GTL.

Pacific GTL was one of the participants in the 8th World GTL Summit in May, which was organised by CWC Associates in London. During the event, the 2008 award for "Innovation in the Development of the GTL Industry was made to a joint venture of Petro SA, Statoil and Lurgi for their GTL.F1 technology. This is a low temperature process using a cobalt-based catalyst in a slurry bubble column reactor and has been under test since 2004 in a 1,000 b/d demonstration unit at Petro SA's Mossel Bay facility. The partners claim that the technology "allows for the conversion of gas to the clearest wax to date, without the need for secondary clean-up".

As the table shows, global GTL production capacity should reach around 245,000 b/d by 2012. The challenge for the industry is to see how to expand from there.

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

COMMERCIAL PLANTS

Name/Location	*Owners*	*F-T Process*	*Capacity (b/d)*	*Status/Notes*
CTL/GTL				
Secunda, South Africa	Sasol	Sasol Advanced Synthol	150,000	Operational, main feedstock coal with 6% gas. Expansion of 30,000 b/d by 2016 with gas as main feedstock for the extra capacity.
GTL				
Mossel Bay, South Africa	Petro SA	Sasol Synthol	20,500	Operational, plant also processes condensates which brings total design capacity to 36,000 b/d.
Bintulu, Malaysia	Shell Gas, Diamond Gas, Petronas, Sarawak govt.	Shell Middle Distillate Synthesis	14,700	Operational.
Oryx, Ras Laffan, Qatar	Qatar Petroleum, Sasol	Sasol Slurry Phase Distillate	34,000	Operational, should reach full capacity by end-2008. Expansion of 66,000 b/d projected.
Pointe-à-Pierre, Trinidad & Tobago	World GTL Trinidad, Petroleum Company of Trinidad & Tobago	World GTL	2,250	Production due to start by end-2008.
Escravos, Nigeria	Chevron Nigeria, Nigerian National Petroleum Co.	Sasol Slurry Phase Distillate	34,000	Under construction, in service 2011.
Pearl, Ras Laffan, Qatar	Qatar Petroleum, Qatar Shell GTL	Shell Middle Distillate Synthesis	140,000	Under construction, in service 2010 (first train of 70,000 b/d) 2012 (train 2).
SunState, Darling Downs, Queensland, Australia	Pacific GTL	Syntroleum	17,000	Construction due to start 2010, CBM feedstock, commissioning late 2014

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THE ENERGY TO TRANSFORM

ExxonMobil and Qatar Petroleum: An Example of Successful IOC-NOC Cooperation

By Timothy Boon von Ochssée

Gas market integration is the focus of Strategic Guideline 3 of the current Triennium and work in this area is being coordinated by a special Task Force. The last issue of the IGU Magazine included a paper on the energy relationship between Russia and Germany, and in this issue we look at the close cooperation between Qatar Petroleum and ExxonMobil. With a liquefaction capacity of 41.7 bcm/year (at the end of 2007) and a projected capacity of 105.5 bcm/year by 2010, Qatar is the fastest growing LNG producer in the world.[1] Qatar became the top LNG exporter in 2006 with 33 bcm, outpacing large traditional producers, such as Indonesia, Malaysia and Algeria. Endowed with the third-largest global gas reserves (after Russia and Iran) and owing to its geographical location, Qatar is well-placed to play a leading role in the world's evolving LNG market by becoming a driving force for LNG market integration in both the Pacific and Atlantic Basins.

Established in 1974 and responsible for managing all aspects of Qatar's oil and gas activities including exploration and production, Qatar Petroleum (QP) is Qatar's National Oil Company (NOC). Oil and gas revenues provided some 61.9% of Qatar's GDP in 2006, so the oil and gas sector is crucial to the Qatari economy.[2] According to the *Economist Intelligence Unit*, Qatar's economic growth is expected to rise to 12.4% in 2008 from an estimated 7.8% in 2007 due mainly to LNG production and exports.[3] Therefore, LNG exports in particular are a great driving force behind Qatar's economic expansion, while oil has been the more traditional source of Qatar's income (oil exports accounted for 70% of total Qatari government budget revenues and 40% of Qatari GDP).[4]

In order to strengthen its presence along the value chain and enhance security of demand as well as gaining access to technological and marketing know-how, QP turned to US energy giant ExxonMobil (Exxon) as the partner of choice to help develop and expand Qatar's LNG projects from the production platform to the re-gasification terminal. Essentially, the upstream Qatari LNG projects are a joint venture with primarily Exxon, where the latter has a leading position as a foreign investor, owning a considerable share in almost

1 Global Insight, *Global LNG Outlook 2007*, (London: Global Insight, 2007), p. 15 and IEA, World Energy Outlook 2005, (Paris: IEA/OECD, 2005).

Qatargas 1 (ABOVE) shipped Qatar's first LNG cargo in December 1996, while RasGas (OPPOSITE ABOVE) started exports in August 1999.

2 With a population of around 900,000, Qatari's enjoy a GDP per capita of some $65,500. Economist Intelligence Unit, *Qatar – Country Report*, (London: Economist Intelligence Unit, October 2007), p. 5.

3 Economist Intelligence Unit, *Qatar – Country Report*, (London: Economist Intelligence Unit, November 2007), p. 6

4 IEA, *World Energy Outlook 2005*, (Paris: IEA/OECD, 2005), p. 460.

every Qatari project. While Exxon is allowed to gain access to vital reserves, QP is ensured vital large-scale access to markets as well as technological know-how. This represents a unique cooperative setting between an NOC on the one hand and an International Oil Company (IOC) on the other.

Qatar as a swing producer with large reserves

According to the IEA, Qatar's main advantages as an LNG producer and exporter include: its enormous gas reserves (some 25 tcm) with high liquids content, a well-developed port (Ras Laffan) with space for expansion, quick government decision-making, only two partners in RasGas 2 and 3 and Qatargas 2, 3 and 4 when investment decisions were taken, a stable political climate (in an albeit unstable region) which provides for a favourable credit rating, a well-coordinated commercial and public environment as well as a good geographical location.[5] Indeed, due to Qatar's location between the Atlantic and Pacific Basins, and its harbour facilities, the country is

ideally positioned to become a multi-market "swing" producer through LNG exports. The term "swing" producer pertains in this case to the ability of Qatar to serve both basins, Pacific and Atlantic. Indeed, Gulf LNG producers have historically always enjoyed open access to both the Atlantic and Pacific Basins.[6]

5 IEA, *Natural Gas Market Review 2007*, (Paris: IEA/OECD, 2007), p. 50.

6 Global Insight, *Global LNG Outlook 2007*, p. 14.

IMEX, initially located at the Qatar Financial Centre in Doha, will be moving in 2009 to form the cornerstone of Energy City, a new $2.6 billion business district.

The LNG tanker *Fuwairit* takes on another cargo in the port of Ras Laffan.

At the same time, the Qatar "swing" factor also lies in a new pricing system which it is developing through the International Mercantile Exchange (IMEX) in Doha to 1) expand LNG spot trading and 2) become the leading driver of market liquidity with the creation of an LNG financial derivative and facilities for trading a cargo-based contract. This IMEX system basically boils down to establishing an LNG or energy bourse à la NYMEX to trade LNG spot cargoes.[7] Combining the huge reserves base with vertical integration, access to multiple markets across both LNG trading basins, immense prospective liquefaction capacity and a potential to become a price-making centre, Qatar as such (together with QP) is ideally positioned to become the world's LNG capital and market leader on a global level.

Qatar is a small country with very large gas reserves, endowed with various blessings as described above, but it is located in a region known for instability and for being at the heart of global energy security concerns, at least as regards oil exports. The Straits of Hormuz, already a major bottleneck for some 40% of the world's oil flows, will become even more important in the future for both Qatar and consuming countries as both oil – and notably also LNG exports – from the region grow. With long-standing disputes as yet unresolved between Qatar and its neighbour Iran, and the overall stand-off between the US and Iran, Qatar is in a difficult geopolitical position.

Not the least of Qatar's concerns is the fact that its marine boundary with Iran cuts through the North Field/South Pars gas field in the Arabian Gulf, with the vast bulk of the field lying underneath Qatari waters. These geopolitical considerations along with commercial interests encourage Qatar to pursue a strategy of cooperation with a large external power considerate of its anxiety. The fact that Qatar provides the US with possibilities to station considerable air and ground forces at an American air base in Al Udeid is therefore given

7 *LNG Journal*, "LNG futures contract could emerge as hub plans multiply", June 2007, p. 1.

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QATAR PETROLEUM AND EXXONMOBIL: OWNERSHIP STRUCTURE IN RE-GASIFICATION AND LIQUEFACTION ASSETS

Re-gasification terminal	*Country*	*Re-gasification terminal share*	*Start-up*
Adriatic LNG (Offshore)	Italy	QP 45%; ExxonMobil 45%; Edison 10%	2008
South Hook LNG (Milford Haven)	UK	QP 67.5%; ExxonMobil 24.15%; Total 8.35%	2008
Golden Pass LNG (Texas)	US	QP 70%, 30% shared by ExxonMobil and ConocoPhillips	2009
Liquefaction terminal (Qatar)	*Prod.*	*Liquefaction terminal share*	
Qatargas 1 (Trains 1-3)	10MT/y	QP 65%; ExxonMobil 10%; Total 10%; Marubeni 7.5%; Mitsui 7.5%	1996
Qatargas 2 (Train 4)	7.8MT/y	QP 70%; ExxonMobil 30%	2008
Qatargas 2 (Train 5)	7.8MT/y	QP 65%; ExxonMobil 18.3%; Total 16.7%	2009
Qatargas 3	7.8MT/y	QP 68.5%; ConocoPhillips 30%; Mitsui 1.5%	2009
Qatargas 4	7.8MT/y	QP 70%; Shell 30%	2010
RasGas 1 (Trains 1-2)	6.6MT/y	QP 63%; ExxonMobil 25%; others 12% (Asian players)	1999
RasGas 2 (Train 3)	4.7MT/y	QP 70%; ExxonMobil 30%	2004
RasGas 2 (Train 4)	4.7MT/y	QP 70%; ExxonMobil 30%	2005
RasGas 2 (Train 5)	4.7MT/y	QP 70%; ExxonMobil 30%	2007
RasGas 3 (Train 6)	7.8MT/y	QP 70%; ExxonMobil 30%	2009
RasGas 3 (Train 7)	7.8MT/y	QP 70%; ExxonMobil 30%	2009

ABOVE
Table 1.

more salience, a situation which suits overall US strategic interests in the Gulf region.

● ExxonMobil as one of the largest vertically integrated IOCs

Hence it is not entirely unreasonable to establish a link between Qatar's concerns for its security and its resource wealth along with US military presence and, most notably, ExxonMobil's large LNG upstream stakes. One could see this as a nexus of interests which suit both Qatar and the US. QP dominates the rankings together with other NOCs when it comes to fossil fuel reserves, QP having the third largest in the world (some 175 billion barrels of oil equivalent) after the National Iranian Oil Company (NIOC) and Saudi Aramco, while in terms of gas reserves it ranks second after NIOC.

Exxon on the other hand, is not even listed in the top 10 companies as far as reserves are concerned but is a major gas producer and ranks in the top 10 for liquefaction capacity. Meanwhile, Exxon owns significant shares in three re-gasification terminals in the Atlantic Basin (see *Table 1*), where the bulk of the incremental LNG demand growth is expected to materialise in the next few years according to most projections (including those of the IEA). Exxon is active in upstream exploration and production of oil and gas, gas and power generation, downstream refining and marketing of oil products, and the production of chemicals. The company is known for efficiency and cost effectiveness, leveraging on its financial strength, reputable corporate structure and business brand to make its presence in the global arena felt.

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