IN BRIEF
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GAS PROCESSORS ASSOCIATION EUROPE

# LARGE-SCALE DECARBONISATION BY HYDROGEN

**Adrian Finn & Terry Tomlinson, Costain, Manchester UK**

Ensuring reliable energy supplies with reduced carbon emissions is of global importance. The use of less carbon-intensive energy is increasing but more cost-effective energy generation systems need identifying and developing urgently to meet stipulated carbon emission targets. By considering the UK, this article discusses why hydrogen, sourced from natural gas, is a leading decarbonisation solution.

### Progress to decarbonisation

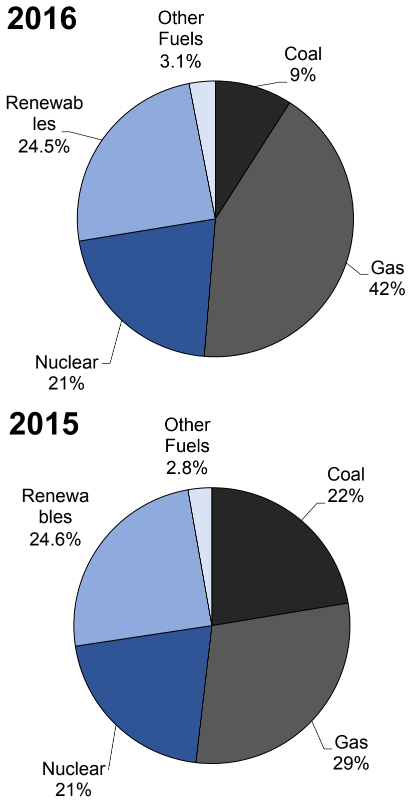
Reduction of carbon emissions to the atmosphere is critical to avoid increased global temperatures and the consequential effects of climate change. As a result, most developed nations have reduced their use of coal for electricity generation and increased the use of natural gas, nuclear and renewable energy.

The UK is typical in having legislation to meet a 2050 target for carbon emissions (the Climate Change Act 2008 requires an achievement of at least 80% reduction from 1990 levels). Renewables and nuclear power generation are important in a diversified electricity supply mix. In 2016, 17% of UK primary energy came from low-carbon sources, with nearly half of that from nuclear and a third from bio-energy (ref. 1). Such changes in electricity generation, decline in energy intensive manufacturing and greater energy efficiency have all helped reduce carbon emissions by 42% since 1990 (compared to the Climate Change Act target of 26% reduction by 2020) (ref. 2). Use of gas for electricity generation has risen dramatically (Fig. 1) (ref. 3). Other countries are applying similar approaches to decarbonisation. However, much more needs to be done to meet stipulated carbon emissions targets (ref. 4).

### Natural gas

Natural gas is a suitable 'bridging fuel' for decarbonisation from coal, while other low-carbon energy generation systems are being developed. The UK and other countries have used natural gas for 50 years for heating and electricity generation and have well-developed infrastructure. Increased liquefied natural gas (LNG) production and trading means many nations can now access low cost natural gas.

Fig 1 - UK Electricity generation by source

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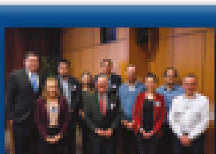



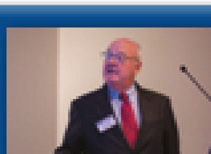

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## 'New' energy generation technologies

To meet global climate change targets, alternative low-carbon energy sources are needed at competitive cost. Both wind power and solar power are being used more for electricity generation, but both require energy storage to ensure electricity is available on demand, and large-scale solutions are not currently available. In addition, whilst renewables support electricity generation, unlike natural gas they do not provide fuel for heat or feedstock for chemicals and petrochemicals production.

## Hydrogen

The UK has an extensive gas distribution network. So how to use this asset and existing gas reserves (and relatively low-cost imported gas) to decarbonise fuel for heating and power generation? Hydrogen, derived from natural gas, deserves consideration. To meet 2050 emissions targets work must start now (ref. 5, 6). Reforming natural gas to produce hydrogen for electricity generation is significantly cheaper than using wind power or nuclear power and could save the UK £160 billion compared to alternatives (ref. 4).

Pure hydrogen burns to produce only water. However, natural gas reforming produces carbon dioxide. The effective capture and disposal (or usage) of this carbon dioxide is key to the potential take-up of hydrogen as a large-scale fuel source.

Compared to carbon capture from (low pressure) flue gas from natural gas combustion, major cost savings could be made by reforming natural gas to separate carbon dioxide from hydrogen.

Hydrogen use as fuel requires long-term strategic planning and government support and subsidy, including for incentivisation of carbon capture and storage (ref. 7). It should also be considered that greater availability of hydrogen could help decarbonisation of the transport sector, by the uptake of fuel-cell electric vehicles (FCEVs), and improve air quality in built-up areas.

Pure hydrogen can be produced by electrolysis of water. This also produces pure oxygen which has several important medical and industrial uses. Large-scale electrolysis is much more expensive than natural gas reforming (ref. 8) but is relevant to smaller applications.

## Natural gas reforming

Hydrogen production by high temperature reforming of natural gas with steam has been practised for almost a century, to provide synthesis gas for manufacture of chemicals such as methanol and ammonia, and for refinery operations. Over 90% of industrial hydrogen is produced this way. Reformer technology is mature and well-proven.

Reforming with steam is performed using a catalyst according to:

$CH_4 + H_2O \leftrightarrow 3H_2 + CO$

With carbon monoxide being converted to carbon dioxide by the water gas shift reaction:

$CO + H_2O \leftrightarrow CO_2 + H_2$.

Steam methane reforming (SMR) gives (dry basis) about 70% hydrogen and up to 10% $CO_2$ (before CO 'shift' to $CO_2$ and hydrogen). Autothermal reforming (ATR) uses oxygen in lieu of air to produce higher pressure hydrogen (up to 100 bar). ATR is used for modern large capacity methanol, ammonia and gas to liquids (GTL) plants. More technical studies are needed on which reforming technology is optimal for hydrogen production when combined with carbon capture. So far, no plants have been built with ATR and carbon capture; very few SMR facilities have carbon capture.

The carbon dioxide can be removed from the hydrogen by several well-proven gas processing technologies: solvent, pressure swing adsorption (PSA), semi-permeable membrane and cryogenic (ref. 9). Costain has designed many hydrogen related facilities, including for synthesis gas purification and hydrogen recovery. A hydrogen purity of 99+% can be economically achieved with a combination of technologies being optimal for some scenarios.

## Hydrogen projects

The 2017 Clean Growth Strategy (ref. 2) is an opportunity for project developers, consultants and engineering companies to help develop a compelling case for government funding to support increased hydrogen use and carbon capture, usage and storage.

Leeds has been proposed to use pure hydrogen as fuel for industrial and domestic heating (ref. 10). Hydrogen would be supplied from reformers on Teesside, with 1.5 million tonnes per annum (mtpa) of carbon dioxide piped to the North Sea for storage. Salt caverns would be used for hydrogen 'buffer' storage. This project could act as a template for wider implementation of hydrogen.

Leeds has been proposed to use pure hydrogen as fuel for heating

An alternative approach (HyNet North West) has been proposed by Cadent for the North West England conurbation (ref. 11). ATR equivalent to 890 MW capacity will provide hydrogen to chemicals manufacturers and industrial heat consumers and supplement the natural gas network to a hydrogen content of 10%. This content is significantly more than current limits for UK natural gas and the effects are being assessed, including by the HyDeploy project which is assessing the viability of natural gas containing 20% hydrogen (ref. 12). HyNet North West has carbon dioxide being piped to the Hamilton gas field, Liverpool Bay, to store about 1.5 mtpa of carbon dioxide.

HyNet North West would not require modification to existing users' gas systems. It provides only partial decarbonisation of the gas network but would demonstrate key elements of a fully decarbonised scheme. The economic feasibility of changing industrial and particularly domestic gas systems from natural gas to hydrogen, so important to the Leeds proposal, is currently being evaluated.

## Technical issues with hydrogen

The advantages of large-scale production and utilisation of hydrogen (over other proposed carbon reduction technologies) include:

- Most key technology elements and equipment are well understood and established.
- Leading engineering companies and consultants have strengths in gas processing and transportation, design safety capability, understanding of key legislation and economic modelling capability, and can deliver large-scale technology intensive projects.
- Established supply chain for critical equipment.

As an example of the necessary skills, Costain has worked extensively on the national gas grid and underground gas storage; undertaken plant design and supply projects for hydrogen and carbon dioxide capture; owns intellectual property to reduce the cost of carbon capture from hydrogen; worked on hydrogen injection into the national gas grid; identified optimal locations for carbon capture and storage in offshore UK depleted gas fields; and defined optimal carbon dioxide transportation schemes.

## Some technical concerns with hydrogen include:

- It is volatile and highly flammable and has inherent safety concerns that require key management and mitigation, including prediction of dispersion.
- Pipelines and infrastructure for hydrogen transport are more likely to leak than with natural gas.
- Pipeline embrittlement (though the UK low pressure gas distribution system is being upgraded to be 100% polyethylene pipe by 2032).
- Hydrogen combustion characteristics (such as flame speed) are different to natural gas (though Wobbe Index is within 10% that of natural gas).
- High flame temperatures with hydrogen promote $NO_x$ formation.

The technical and engineering issues associated with high-pressure hydrogen need detailed evaluation.

## Conclusion

Gas processing technology and engineering capability exists to progress large-scale hydrogen deployment. Today's challenge is to organise and manage key techno-economic studies and evaluations to optimise hydrogen-based energy supply to ensure that critical targets for carbon dioxide emissions can be met.

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# REASONS FOR THE GAS INDUSTRY TO BE CHEERFUL

***Steve O'Donnell, GPA Europe Chairman discusses the future of the gas industry***

**Reasons to be cheerful – three parts**

For our younger readers, I plagiarised the title from a one hit wonder of the seventies. There is a prize for the first one who can guess who.

This will be my last address to the members of GPA Europe. After two years as your chairman I hand the baton to Martin Copp shortly. I thought I would take the opportunity of this last note to do the most foolish of things: ...to try to predict the future of the gas industry and the role of GPA Europe in making it a success.

Here goes!

**It's bouncing back – we said it would**

It's an old and trusted adage that recoveries are more easily seen in the rear view mirror than through the windscreen. Our industry turned a corner almost 30 months ago, although at the time not many noticed. Those who regularly follow the GPA will know that we did, *we noticed.*

Steve O'Donnell

The winter is over. Everyone knuckled down, curbed their spending, sold their assets, and reduced their numbers. Those assets were snapped up by a flotilla of small, nimble, but new companies who have joined the industry, many aiming to milk aging assets for their residual value. While most companies survived, several had no choice but to eat their seed corn. Their seed corn being the intellectual muscle of their employees. The industry demograpics have changed radically.

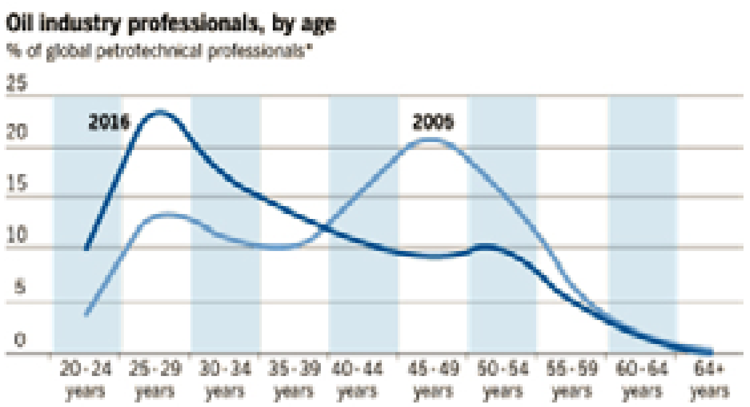
Before the bust fully 70% of industry employees were over 40; now 70% are under 35.

We find ourselves today in a period of stable growth, although many would not agree. Deepwater exploration is back, as too is capital investment and recruitment. The future for our industry is as exciting as I can recall. I firmly believe that climate change is real, threatening and a problem for *today.* It cannot be addressed without the creativity and innovation of the employees of this industry.

At the GPA we bring the creative and innovative together. The future is exciting, oh yes, but it is far from certain.

Fig 1 - The price of oil

Fig 2 - The new crew has arrived



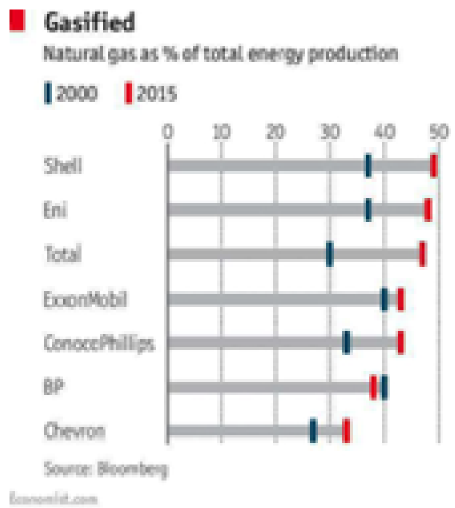




Figure 3 - The new crew has arrived

The generation of energy from wind will carry on growing but from a very small base

**The future is exciting, the future is gas**

The future of the industry will be driven by climate change, the Paris Accord and whatever comes beyond. In among the uncertainty, are some certainties (well, almost!).

If you haven't already, take a look at a quite fabulous publication by Shell with a range of possible outcome for this industry of ours:

https://www.shell.com/energy-and-innovation/the-energy-future/scenarios/shell-scenario-sky.html

It is not a forecast, it models scenarios. You can be sure that they are all wrong, but I challenge anyone to say it is not thought provoking. Regardless of outcome, certain items are not in dispute.

There is little dispute that there are no magic bullets. Solar and wind will carry on growing but from a very small base. Electrical cars will arrive but take decades to displace the internal combustion engine. Hydrocarbons are here for decades. Demand has not yet peaked.

Few dispute that gas is the hydrocarbon of choice for the short term future. Take a look at the recent publication by the IEA:

https://webstore.iea.org/market-report-series-gas-2018

Why else have the oil companies of the world been gasifying their portfolios (see Fig 3).

There is little dispute that gas will increasingly displace coal in power generation and oil in the transport sector. This at a time when Europe is running out of gas: the North Sea continues its slow decline, and Groningen, Europe's largest and almost oldest, gas field approaches closure. The hydrogenation of our gas networks is increasingly likely (see our lead article). LNG imports from a United States, with no outlet for its surplus gas, are inevitable, as well as LNG and gas imports from Russia. Look at the mighty Yamal and Arctic LNG projects executed from Europe with help from many GPA members.

There is little dispute that the Paris Accord agreements will not be met by limiting emissions. The world will have to increase carbon capture too. In our industry Carbon Capture and Storage (CCS) is as inevitable as the tides. This is an enormous opportunity for the chemicals and equipment suppliers of Europe.

Finally to fracking, where there is much dispute. A single technology that has transformed the global gas market but largely through application in the US. Europe continues to view it with suspicion and prevent its development through legislation and complex planning processes. On this I make no predictions but it is beyond doubt that domestically produced gas feeding an existing gas network is both more carbon friendly and of lower cost than gas liquefied 5000 miles away, shipped and degasified. Those who understand have a responsibility to explain to those who don't, why this is so.

Oh yes, the future is exciting but it is far from certain.

This leads me nicely to the third reason to be cheerful.

**GPA Europe can help and you can help us to help you**

Europe has its unique set of challenges and, in the capability and breadth of our companies, the power to not only solve the problems of Europe but to reach out to the Middle East and North America and help with theirs.

At GPA Europe we bring the creative and innovative of this industry together, through our conferences and enormous library of technical papers. If you are part of the solution, get involved, follow us on social media, and attend our conferences. At GPA Europe we bring together the experienced and those new to the industry. Come along to a conference, and rub shoulders with the giants of the industry over the last four decades.

If, like Desert Island discs, I can leave you with only one thought it is this

**MAY 2019, AMSTERDAM: Shell-hosted GPA conference. Something for operators and suppliers. Something for those new to the industry. Something for those thinking about their careers. Get it in your diary.**

So it's goodnight from me.

And on that note I must leave you. It has been an honour to chair GPA Europe these last two years. I leave as the industry rebounds and the future is one of excitement and opportunity. I wish my successor the very greatest of good fortune and pledge my unqualified support.

# YOUNG PROFESSIONAL TRAINING DAY
# PARIS, 27 MARCH 2018

## MORNING SESSION

### Chaired by Marieke Maenhaut, TechnipFMC

In a packed room filled with an attentive audience, we had an exciting morning session of the Young Professional Training Day, on the subject of Natural Gas. The full session comprised five mind-stimulating presentations.

John Campbell - John M Campbell/PetroSkills

### Overview of Global Natural Gas Industry

We started with an overview of the Global Natural Gas Industry by John Sheffield. John is an ex-chairman, and honorary member of GPA Europe Ltd. An expert on LNG projects, he made the perfect introduction for this session, with an overview which gave us excellent background information on the topic. Telling us about the Natural Gas global market, John showed us how natural gas is a major actor in the mix of the world's primary energy supply. Representing 24% of it, natural gas has strong competitors in renewable energies, which represent up to 30% of the energy mix for power generation in some countries. However, natural gas is the most efficient, and environmentally friendly fossil fuel. The presentation was highly interesting and although we lacked time, the passionate subject of LNG and its application as a transportation fuel was also broached.

Once John had set the scene, we moved onto flow assurance in gas systems with two complementary presentations:

YP Training Day Speakers and Chairpersons

Delegates take a break

### Gas Dominated Systems: Main Flow Assurance Challenges for Design and Operability

Martin Gainville from IFP told us about the challenges of flow assurance in deep offshore gas systems, with a focus on slug management and hydrate prevention. Hydrates are a tricky problem to solve, and so it was very informative to learn more about prevention systems, such as the various types of inhibitors, and the flowline heating technologies. Good to know also is a method to get rid of the plugs when they arise, by means of the flowline heating blanket system! Through instructive pictures, schemes, and useful background information on the hydrate formation, Martin showed us how a better understanding of flow behavior, proper prevention and good monitoring are the keys to a robust offshore gas system design at better cost.

Martin Gainville - IFP

Eduardo Luna-Ortiz - Pace Flow Assurance

### Management of Flow Assurance Constraints in a Fast-Track Gas Development

Eduardo Luna-Ortiz, from Pace Flow Assurance, then introduced a fast-track early production facilities project, which comprised three gas wells, flexible flowlines and trunk line, to onshore processing facilities. He drafted us the development from concept to execution, and we understood the challenge of flow assurance studies in such fast-track projects, when key information is missing and assumptions need to be made, and comparative studies need to be done. Indeed, fluid definition, fluid phase behaviour, safety trip (HIPPS) settings and early identification of all operating scenarios are key parameters that sometimes get missed at the beginning of a fast-track project. Eduardo shared a wealth of instructive data from the studies of this project, showing how these parameters and assumptions are used to model the system and study the key flow-assurance topics such as line packing, liquid management, wax formation, and MEG injection, aiming at producing a robust and safe design for the subsea system.

We then turned to more process-related presentations, about two key technologies of the Natural gas treatment processes.

Tony Hood - Johnson Matthey

### Fixed Bed Absorbent Systems – Design Best Practice

Tony Hood from Johnson Matthey presented a paper on behalf of authors Peter Martin, Raul Llorens and Panayiotis Theophanus, also of Johnson Matthey, entitled "Fixed Bed Absorbent Systems – Design Best Practice". The paper reminded us of the principles of fixed bed absorption as used in Natural Gas treatment. The shapes of absorbents, as well as the types (regenerable, non-regenerable, and catalytic) were presented. The applications of fixed bed absorbents span from gas dehydration to Claus Process or organics removal, and involve simple physical adsorption, chemical reaction, depth filtration etc. Fixed bed absorption is a robust and well-proven technology, but there are still and there will always be challenges, as for all technologies. One of the important things to do is to use the operation troubleshooting data as early as possible in the design stage. For fixed bed absorption, problems include: plugging; poisoning by heavy hydrocarbons (for catalysts); chemical interaction (from amine carry-over for example); contamination; masking; and wetting. Tony explained to us how these issues can be addressed in the design of fixed bed absorbers, for example by decreasing the pressure drop through the bed, adding a sacrificial volume of absorbent, adding pre-treatment, and heating of the inlet gas. Indeed, such optimisations can save the operator cost in the long-term and lead to an ever-better design.

### CO2 Removal on Amines – Important Design Issues to Consider

Another robust and well-proven technology in Natural Gas treatment is absorption of impurities with regenerable liquids. Matthew Bailey from Optimized Gas Treating Inc. presented instructive data about a problematic subject: pinch in amine absorbers. The types of pinches (lean-end, bulge, rich-end) were presented and several case studies (with MEA, MDEA, promoted MDEA, CO2 and H2S removal, and carbon capture) were very clearly explained and illustrated through data and curves. We learned that if a pinch exists, adding trays will not help. Matt gave guidelines on how to predict and locate the pinch phenomenon, and advised which the key parameters are that enable controlling the absorption for an optimum absorber design and better performance.

One thing is sure, targeting technical excellence and developing new markets will ensure a bright future for Natural Gas. We saw throughout the morning that extracting, transporting and treating natural gas requires knowledge, experience and innovation. This session of the Young Professional Training Day proved by the quality of the presentations, the experience and passion of speakers, the interest and questions from the audience, that we are all ready to face the challenges of this industry.

Matthew Bailey - Optimised Gas Treating

# YOUNG PROFESSIONAL TRAINING DAY
# PARIS, 27 MARCH 2018

## AFTERNOON SESSION

**Chaired by Stacey Wilding, Genesis Oil and Gas**


French cuisine for lunch

After lunch, Stacey Wilding of Genesis Oil and Gas Consultants Ltd took over as chairperson.

The afternoon session comprised of three papers being presented on the themes of low temperature process design and extreme ambient design.

### Low Temperature Process Design

The first paper of the afternoon was presented by Adrian Finn, of Costain entitled "Low Temperature Process Design". Adrian has spent 35 years with Costain, mainly on cryogenic projects, has authored over fifty technical papers and holds over twenty granted patents. Adrian provided the delegates with a comprehensive overview of the principles of optimal cryogenic process design.

In his presentation, Adrian first covered the basics of cryogenic processing and the types of cryogenic processing plants. He delved deeper into the many processing design choices and emphasised the importance of evaluating, screening and identifying the optimal design in the initial process that is taken forward for detailed evaluation and costing.

He noted that good cryogenic process design relies on understanding the relationship between energy and power (or "work") and ensuring the machinery system is adequately designed and optimised. Adrian highlighted the proven rules of thumb from thermodynamic principles and process evaluation techniques (especially for multicomponent distillation) which are crucial in selecting and screening options prior to detailed process simulation work being carried out. He finished off his presentation with examples of where this process had successfully been applied to projects on which he has worked.


Adrian Finn - Costain

Education continues over coffee

### Commissioning Amine Plants in Extreme Environments

The afternoon's next paper was presented by Philip Le Grange, of Amine Experts (a division of Sulphur Experts International), on the subject of "Commissioning Amine Plants in Extreme Environments", co-authored by Mike Sheilan and Ben Spooner, also of Amine Experts. Phillip has been in the oil and gas industry for 10 years and has performed troubleshooting, optimizing, commissioning and training on more than 50 amine systems across 23 countries.

Philip's presentation examined the challenges faced in commissioning three amine plants operating in extreme ambient heat, extreme ambient cold, and locations with restricted access (offshore). He described the technical and procedural solutions implemented to resolve them as well the environmental hazards for staff and the logistical problems they encountered.

Philip explained that very warm environments can pose a challenge in terms of cooling the lean amine to a sufficiently cool temperature to meet the product specification. Whereas, in extremely cold environments preventing freezing-related blockage of pipes during commissioning and operation is critical. He highlighted these challenges with examples of projects he has worked on.

In all three of the case studies presented, the start-up dilemmas were predominantly caused by the failure to correctly design the system. Philip stressed the importance of an accurate design basis and the implications of procedures not being followed correctly. He explained how essential it is to provide operators with system-specific training and ensure health and safety risks associated with working in these unusual locations are adhered to.


Philipe Le Grange - Amine Experts


Sandra Thiebault TechnipFMC

### Desig of an LNG Plant in Arctic Conditions

The last paper of the day was presented by Sandra Thiebault of TechnipFMC on the topic of "Design of an LNG Plant in Arctic Conditions". Sandra has been involved in a variety of gas processing projects since she graduated in 2004, and has been working on the Yamal LNG project since 2012.

Sandra began by presenting an overview of the processing facilities that form part of the Yamal LNG project, focusing on the liquefaction train of which she has been working on.

The Yamal LNG project is located north of the Arctic circle in Western Siberia and poses several design challenges based on the extremely cold environment and the remoteness of the site. Sandra explained how TechnipFMC had to adapt the LNG plant design to overcome these challenges. One of the complexities Sandra described was the material selection. She described how they specified a minimum Initiation Temperature for depressurization, used thermal insulation to slow down ambient chilling and used heat tracing to avoid the high cost of stainless steel.

Sandra ended her presentation with a discussion on permafrost preservation and TechnipFMC's complex, first-of-a-kind refrigerant compressor string. Overall, the project was successful with a smooth delivery and all risks managed well.

The conference was brought to a close and delegates were invited to a free bar to continue networking. This was another successful and well attended YP event with students, recent graduates as well as older professionals being able to share their experiences. Many thanks to the presenters for sharing their knowledge and the delegates for their participation..

# GPA EUROPE ANNUAL CONFERENCE
# ROME, 16-18 MAY 2017

## TECHNICAL CONFERENCE – MORNING SESSION 17 MAY

### Chaired by Lorraine Fitzwater, Petrofac

The GPA Annual Conference 2018 in Rome opened with a diverse range of gas processing papers – Small Scale LNG, Odorisation of Commercial Gas, Corrosion in CO2 Removal Units and Affordable Carbon Capture in the ME.

### Small Scale LNG - Is this the future for the LNG Business

The first paper "Small Scale LNG – Is this the future for the LNG Business", was presented by John Sheffield of John M Campbell/PetroSkills. John opened with an outline of the current LNG market. The base load LNG business now amounts to around 300 Mtpa. Small scale facilities volume is now around 30 Mtpa but there is tremendous growth and innovation in the small-scale LNG business and LNG consumption is expected to increase to 100 Mtpa by 2030.

John Sheffield - John M Campbell/PetroSkills

Producing LNG is a great way to monetise stranded gas reserves and flared associated gas. It becomes the starting point of a virtual pipeline which allows LNG to be transported by road, rail or sea to a variety of destinations to be used as fuel for power generation or as a transportation. Small Scale LNG liquefaction facilities range in size from 5,000 tpa to 0.5 Mtpa. The production can be transported in small LNG carriers (1,200 – 30,000 m3) or trucks and ISO containers (15-32 m3) leading to development of 'virtual' pipelines. At this stage all technologies are developed and proven.

LNG is now widely used as a fuel for heavy trucks, but the greatest potential probably lies with the development of LNG as a fuel for marine transportation. There are already more than 100 ships using LNG as fuel and the bunkering of large ships from small LNG carriers is a practice now well developed in Europe. It is also being used as a fuel for trains (in the USA).

John showed us many examples of innovative Small Scale LNG facilities around the world and the routes to market. In China, the Shan Shan LNG Plant is some 4000km from the main users on the China coast and utilises a 'virtual pipeline' of some 100,000 LNG trucks to reach the many Satellite LNG receiving stations. There are similar developments in Australia and Argentina.

LNG Carriers have always used BOG (Boil off gas) as fuel, but this is now being extended for use by other shipping. LNG is lower cost and lower emissions. Emission Controlled Areas (ECAs) have been implemented along costal USA and in Europe around Norway/Sweden and the North Sea and are planned for the Mediterranean. Small LNG carriers are being built as LNG bunker ships to fuel the growing number of LNG ships – including cruise ships.

LNG is also being used as a fuel for trains. LNG from the Reganosa LNG Terminal (Spain) was used in a trial starting in January 2018 and was the first use of LNG on a passenger train. In the USA, FEC (Florida East Coast) Railway has being using LNG fuelled locomotives since 2017.

In conclusion, the small LNG business is expanding in many areas and there are now many reliable technologies. LNG can be competitive with alternative fuels such as diesel and heavy marine fuels and is definitely more environmentally friendly in both power generation and transportation fuel. There is great potential for new business opportunities.

### Odorisation of Natural Gas - the standard solution for safety. What about LNG?

The second paper, "Odorisation of Natural Gas – the standard solution for safety. What about LNG?" was presented by Peter Meyer of Arkema SA, France. This picked up the LNG theme and looked at the safety of possible leaks of LNG when transported and used as a fuel.

Peter Meyer - Arkema France

The paper showed how gas odorisation is used to detect gas leakages and the Safety Standards and guidelines involved. Most important is the requirement for the gas odour to be unpleasant, distinctive and not confusable. To achieve the 'distinctive' recognisable odour, sulphur containing odorants is necessary. Sulphur-free odorants were discussed, but these failed to meet the distinctive and recognisable criteria.

What about LNG? Potential leaks during transport of LNG in large LNG carriers and from storage at LNG terminals is covered by leak detection systems and these are generally located in low population areas. From these coastal terminals LNG is now being transported in trucks through populated areas, to local storage where it may be re-gasified or increasingly used as fuel for trucks and ships. Although odorisation will not prevent any accident with LPG transport, it may provide an early indication of minor leaks, enabling corrective action to be taken.

Arkema has developed an odorisation system allowing to odorise LNG with standard odorants available on the market. To develop an industrial odoriser system, Arkema is still defining the specifications based on a range of market requirements. At this stage, common market specifications should be established in view of specifying the LNG odoriser system and later on translate this in ISO norms.

Currently Natural Gas is odorised as soon as it reaches populated areas. LNG, used as a fuel or a local energy source, should also be odorised. Technical solutions have developed for LNG odorisation. The odorant mixture and dosage can be adapted to respect local regulations for Natural Gas use as fuel for vehicles.

### Acid Gas Removal Corrosion

Following coffee, Justin Hearn of BASF presented Acid Gas Removal Unit Corrosion.

The presentation examined the common causes of corrosion in acid gas removal units. The importance of selecting the appropriate chemistry and metallurgy in grassroots AGRU designs was discussed, and how this would differ depending upon the specific gas sweetening application.

Pictures to illustrate a range of corrosion mechanisms covering erosion and corrosion incidents were shown. The probable reasons for the corrosion/erosion were discussed and potential remedies suggested.

There are several older plants now in operation that may not have been built to today's more conservative guidelines. Operational "necessity" results in many older plants working outside their original design envelopes. Changes in feed gas composition over the years may have incrementally shifted the operational requirements so that they are now far away from the situation twenty years ago, when the plants were first commissioned. All these factors, in addition to staff turnover (loss of corporate memory), and new asset ownership could result in more issues with corrosion and erosion going undetected.

There are several factors that can affect the corrosion of carbon steel by amine solutions including: Amine type; Amine solution concentration; Amine solution contaminants; High operating temperatures; High acid gas loadings and Ratio of $CO_2$ to $H_2S$ in the feed gas.

Solutions of primary amines, in the presence of acid gases, are more corrosive than those of secondary amines, which are more corrosive in turn than tertiary amines. Primary amines, and to a lesser extent secondary amines react instantaneously with $H_2S$ and very rapidly with $CO_2$ – very desirable for AGR. However, they readily form Heat-stable salts (HSS) due to thermal degradation at AGRU operating temperatures. These HSS are believed to contribute to the corrosive nature of both primary and secondary amines.

Wet $CO_2$ corrosion due to the feed gas, in the area above the amine level but below the lower packed bed/tray, is also a potential problem area. Depending upon the type of feed gas, higher grades of stainless steel may be specified. This is particularly relevant in oxo-syngas applications where there is both CO and $CO_2$ in the feed gas, but no $H_2S$ to mitigate the corrosion.

Erosion-corrosion may be described as degradation of the surface of the metal due to mechanical action, including liquid impingement, abrasion by particles in fast flowing liquids or by gas bubbles (cavitation).

Justin Hearn - BASF SE

Another form of corrosion is Flow Assisted Corrosion, also known as Flow Accelerated Corrosion, where the normally protective oxide layer on a CS surface dissolves in a fast flowing liquid stream and the metal surface corrodes to recreate the oxide.

When things have gone wrong, there are a range of measures that can be taken. Firstly, review the current operating conditions and compare with initial operation. Look for the potential causes – contamination, elevated chloride concentrations, high operating temperatures, high acid gas loadings, etc. The possibility of a solvent swap, use of additional filtration, additional equipment can all be considered.

### Affordable Carbon Dioxide Capture in the Middle East

The final paper of the morning, "Affordable Carbon Dioxide Capture in the Middle East", was presented by Gary Bowerbank of Shell Global Solutions.

Many countries in the Middle East are seeking to harness their vast natural gas resources to meet future electricity demand. In some cases, this natural gas, which can contain up to 35% hydrogen sulphide ($H_2S$ ) and 15% carbon dioxide ($CO_2$), may already be needed for enhanced oil recovery (EOR) to sustain crude oil production while $CO_2$ from gas facilities is vented. This creates a unique opportunity to capture produced $CO_2$ from sour gas processing facilities, use it for EOR and free the natural gas currently used for EOR for electricity generation. This change in use may reduce the need to develop new natural gas reserves.

However, the captured $CO_2$ must be affordable for it to be used for EOR. At present, capital costs are high, as low-pressure $CO_2$ sources in natural gas plants require large amine solvent volumes and thus large equipment sizes. Solvent regeneration steam requirements can also be high, which means high operational costs.

This paper highlights three Shell technologies that can help to reduce capital and operational costs, and potentially cut captured $CO_2$ costs by 20–40%:

- ADIP® ULTRA solvent technology uses a formulation containing two amines (MDEA with piperazine as accelerator) for capture at high pressure. This technology achieves bulk removal from the treated gas, maximises solvent capacity and hence reduces circulation rates and regeneration duties.
- Shell Turbo Trays are patented column internals that increase the hydraulic limits of AGRU. These can reduce column diameters by up to 50% and hence costs by 50%. Because of this number of trains can also be reduced further reducing costs. These can also be retrofitted to increase existing column capacity.
- The CANSOLV® $CO_2$ Capture System is a post-combustion system that uses an advanced regenerable solvent and proprietary amine technology to give up to 99% bulk $CO_2$ removal. It is a proven and well-established amine-based technology that is easily retrofitted and highly adaptable to a wide variety of industrial applications. This has lower regeneration requirements and/or fewer capture trains compared with conventional amines.

No single $CO_2$ capture technology is right for all situations. The decision on where to capture $CO_2$ and which technology to use must be made on a case-by-case base.

Gary Bowerbank - Shell Global Solutions International BV

# GPA EUROPE ANNUAL CONFERENCE
# ROME, 16-18 MAY 2018

## TECHNICAL CONFERENCE – AFTERNOON SESSION 17 MAY

### Chaired by John Sheffield, John M Campbell/PetroSkills

After a splendid buffet lunch (with wine!), members slowly took their seats for the afternoon session of the GPA Europe Annual Conference.

Jan-Willem Hennipman - Jacobs

### Balancing Act of Technology Selection within a Natural Gas Plant

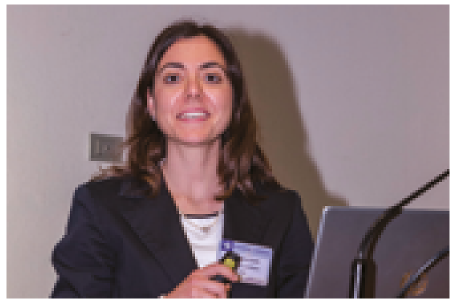
The first paper 'Balancing Act of Technology Selection within a Natural Gas Plant' was presented by Jan-Willem Hennipman, Jacobs Comprimo® Sulfur Solutions.

In process plant design, there is always the need to balance the costs of the technologies needed to achieve the specification requirements and environmental constraints. The technologies Jan-Willem described are necessary when processing sour gas streams containing sulphur species to meet the levels required for pipeline gas or the lower levels required if the gas is to be liquefied.

The paper eloquently described a range of solutions which are applicable in the specific circumstances of the processing plant.The costs of the sulphur recovery block dramatically increase as the requirement to achieve an overall sulphur recovery efficiency (SRE) is increased from the minimum standard imposed in the UK of 99.5% to 99.98% which is now being demanded by some authorities. An increase of 20% in the CAPEX and more than 30% in OPEX were indicated. The paper included a case study and detailed equipment listings.

### Comparison Between the Dual Pressure Low - temperature Distillation Process and a Hybrid Natural Gas Purification Technology

We were then pleased to welcome a spirited presentation given by Giorgia De Guido from the Politechnico di Milano entitled 'Comparison between the Dual Pressure Low Temperature (DPLT) Distillation Process and a Hybrid Natural Gas Purification Technology'. Giorgia began her presentation by reviewing the natural gas resources available in the world and highlighting that more than 40% of the proven reserves have high levels of acid gas components. The paper reviewed an analytical study of two processes for producing pipeline gas quality, the DPLT process and the Hybrid low temperature



Giorgia de Guido - Politecnico Di Milano

SPREX process which requires an additional processing step using conventional amine treatment. The DPLT process uses two columns for separation of $CO_2$ from the raw gas thus avoiding the Solid/Liquid/Vapour locus of the $CO_2$-$CH_4$ system. The analytical comparison was made using specifically developed Aspen-plus models and for $CO_2$ levels in the range 20-60%, the DPLT process is shown to be more efficient on an energy basis as determined by Net Equivalent Methane Consumption.

### SCOT ULTRA: Staying Ahead of the Curve with Tail Gas Treating

The third paper was presented by Dr Lydia Singoredjo of Shell Global Solutions and described the 'SCOT Ultra process: Staying ahead of the curve with Tail Gas Treating'. The original SCOT process was introduced in the 1970s and now after five decades of development the SCOT-Ultra process has been developed to give superior performance and lower costs whilst meeting ever increasing stringent emission standards. The SCOT-Ultra process uses a newly developed catalyst, Criterion 834 and an improved solvent developed by Huntsman and Shell, JEFFTREAT Ultra which is highly selective for $H_2S$ giving

Lydia Singoredjo - Shell Global Solutions International BV

superior performance and lower circulation rates which leads to lower CAPEX and OPEX. The paper presents a case study on an 800tpd SRU which demonstrates a potential saving of up to $8Mln/year.

### Optimise your Acid Gas Treatment and Increase Profit

We were then pleased to welcome back Helge Rosenberg of Haldor Topsoe, to present a paper entitled 'Optimise your Acid Gas Treatment and Increase Profit'. The paper focussed on the use of Wet Sulphuric Acid technology as an alternative tail-gas treatment unit to a SCOT process. Helge made the valid point that more than 90% of the sulphur recovered from natural gas eventually gets converted to sulphuric acid by other companies who then benefit from the energy recovered from the process. He presented examples showing that the use of WSA can effectively debottleneck an existing Claus unit and achieve an appropriate level of sulphur recovery to meet the more stringent environmental standards now being imposed. The process is widely used in the refining industry but is novel in gas processing, but clearly there are great opportunities in some locations.



Audience appreciation

Rome speakers and session Chairs

Ralph Weiland - Optimized Gas Treating Inc

### CO2 Removal Unit Performance: When Actual Differs Radically from Design

The final paper of the session was presented by Ralph Weiland of Optimised Gas Treating and focussed on $CO_2$ Removal Unit Performance, when actual differs radically from Design'. Ralph was making a welcome return to GPA Europe's conferences and his paper neatly explained a complex and puzzling situation. It is well known that 80% of the OPEX of an AGRU is the energy supplied for regeneration and on large plants, schemes have been developed to achieve a higher level of heat integrations using an LP flash column. In the example described a unit designed on the basis of 8% $CO_2$ in the feed gas failed to achieve the required 50ppm level in the treated gas during the early operating period when the feed gas contained only 0.8% $CO_2$. The reason for this was that the process relied on the heat of absorption increasing the temperature to that required for regeneration to achieve the required saturation level. The paper demonstrated the use of ProTreat® to analyse the problem and point towards the solution.

The papers were all well received and stimulated many questions and our thanks go to all of the presenters for their work in preparing and presenting their ideas clearly and competently.

## MORNING SESSION 18 MAY

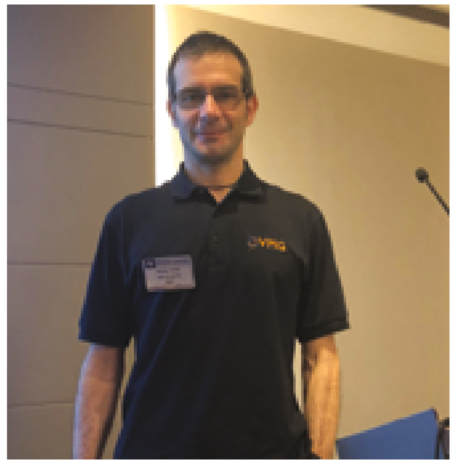
### Chaired by Sandy Dunlop

The last morning of the conference which, given the excellent dinner held the previous evening and the disappearance of some delegates to their home office or to enjoy the sights of Rome, was nevertheless well-attended.

### Integrated Dynamic Flare Analysis Brings Relief

Nicolau Goula from Virtual Materials Group presented a fascinating paper from himself, Alexis Haro of FlareSim and Maria Wulandari (VMG Europe) on work that has been done on dynamically simulating a Flare system to provide considerably better design criteria than Steady State calculations might. The analysis considered several relief sources on a drilling platform connected by a 100 m pipe on a bridge to the flare stack. Depressurisation of the systems could cause a substantial reduction in temperature below the allowable operating level for the bridge pipework and whilst steady state calculations might suggest the whole bridge would have to be designed for conditions below -40 deg C, dynamic simulations showed that, even under the worst conditions, only 75 meters of the bridge needed to be of low temperature material as the gas warmed up against ambient conditions.

Whilst steady state design shows a more conservative solution, other examples of the benefits of simulation showed, for example, that whilst steady state might require a replacement of an existing flare tip, dynamic simulation suggested that this might not be necessary. The paper showed that steady state models (Colebrook and Oliemans) did not foresee the much higher initial flow of liquid and the period of the slug, thus impacting on the separator design. The paper also presented the results of an analysis of radiation levels suggesting that they would be of much shorter duration that steady-state predictions might suggest.



Nicolau Goula - Virtual Materials Group Europe

*Continued on page 14*

*Continued from page 13*

## MORNING SESSION 18 MAY

### A Structured Approach to Energy Optimisation in Projects

Gareth Davies of Costain presented this paper co-written with Grant Johnson, discussing the necessity to adopt a structured approach to energy optimisation in projects as part of the design phase, where up to 40% of potential energy savings can be made. This is becoming increasingly important in the environment of a drive for reduced carbon footprints and the need to demonstrate BAT design. In this way energy optimisation can be part of the lifetime cost analysis of the project. The paper reprised some discussion previously on the subject by Costain but presented perhaps a more structured approach to energy optimisation looking at what approaches were required at the various project life cycle stages, Feasibility, Concept Design, FEED and EPC.


Gareth Davis - Costain


Peter Martin - Johnson Matthey

### Best MRU Location in Gas Plant

Peter Martin of Johnston Matthey presented an insightful paper discussing first the increasing recognition of the problem of mercury contamination in natural gas streams and the forms that such contamination can take: as elemental mercury; particulate contamination; and the presence of ionic mercury in aqueous stream. As a critically poisonous material, mercury discharges entering the environment and particularly the food chain will have severe effects. Further, within the gas processing plants, embrittlement of steel and amalgam corrosion of aluminium, mean that once the plant is contaminated, it will continue to show mercury in product stream even after MRU units have been introduced. Peter showed that optimal conditions for mercury removal are therefore immediately after the three-phase separation units, processing gas prior to acid gas removal and liquids prior to storage. In this position perhaps 95-98% of the mercury can be sequestered, prior to contamination downstream facilities. Both gaseous and liquid streams can be processed by reaction with CuS, but care must be taken to avoid contamination on the MRU with other gas treating chemicals e.g. amines, glycol, methanol and water.

### Streamlining an EPC Project Using Dynamic Simulation

Keith Howell of Bechtel, presented the next paper on the use of dynamic simulation, co-written by David Clark, Giovanni Curci, and Victor Fernando Guso. In this case, dynamic simulation in conjunction with laser scanning of an existing facility which was to be integrated with new plant, was used to highlight any key issues associated with the integration in advance of construction. Laser Scanning enabled detailed pipework and systems to be analysed on the same basis as the 3D design of the new plant to enable dynamic simulation to assess how the combined facility wold operate. The process also enabled an accurate assessment of the operation of reciprocating flash gas compressors under different operating scenarios and design of an effective control system. Another important benefit was achieved through considering the booster compressor relief load, where simulation enabled this to be accurately predicted and negate the need for major replacement of existing flare network piping. In addition to a number of other benefits discussed, the dynamic simulation enabled Operator Training Simulator to reliably model the outcome of various scenarios, making the operators more aware well in advance of actual plant start-up.


Keith Howell - Bechtel


Graeme Ellis - ABB

### The "Watermelon Effect": Does a Green Dashboard Mean a Healthy Facility?

The last paper of the conference and probably the most thought-provoking was presented by Graeme Ellis of ABB Consulting, and discussed the fact that simply providing management with process safety metrics that indicate risks are low, does not imply that safety is not at risk. Graeme discussed the need for a "chronic sense of unease" – to delve deeper into safety behaviour and practice to ensure that accidents are not waiting to happen. By referring to the Texas City and Buncefield incidents, Graeme noted that accidents generating losses of in excess of $500 million are still occurring every year and therefore management should adopt the chronic sense of unease.



# Rome 2018 Partner Programme

**You know, gas processing can be fun but liquid processing is better.**


Our Vineyard


Gastronomic luncheon delights

Several of our delegates came to Rome with their partners. While the delegates listened to talks about fugacity, adsorption and piston rods their partners spent the day in the hills overlooking Rome at a vineyard; la Cantine Santa Benedetta. Well somebody had to do it!

Accompanied by the beautiful and bilingual Cristina Gnecco we made our way into the hills. Along serpentine roads in a barely fitting coach, to a family owned vineyard in Fracati looking down on the city of Rome.

We were greeted by Alberto, the owner and manager of the vineyard, who told us all about grapes and olive trees but more importantly offered a glass of chilled Frascati. There are no pictures of Alberto!

Next we met Fabria, Alberto's wife, who greets and entertains the guests and who was so beautiful that your correspondent could not concentrate on what she said and as a result came last in the pasta making competition.


The beautiful Fabria

But education is what the GPA is about and educated we were. As well as learning how to make pasta badly, we learned how to hold a wine glass correctly, at what temperature to serve Frascati, how to examine the colour, the odour, the surface tension, and the aliphatic content. In fact, such a demanding teacher was Fabria that it was looking as though we had so much to learn we would never get to actually tasting it.


Mimma

Then there was the star of the show, Mimma, who spoke not a word of English but somehow managed to control the, by now slightly tipsy, unruly and inattentive audience with the force of her personality. She browbeat her audience into making pasta and pesto sauce. Your correspondent was in Team B who came a far distant second to Team A led by Sandy Dunlop who, in the view of some, took the competition far too seriously. 🙂

Of course, every silver lining has a cloud. Having prepared our own pasta and pesto sauce we were then invited to eat it. Luckily there was another wine and a 23 course buffet lunch to help to forget the taste.

***Malcolm Harrison***

# FORTHCOMING EVENTS

## 2018 AUTUMN TECHNICAL MEETING

19-21 September 2018

Crowne Plaza Barcelona Fira Center, Barcelona

- Panel Discussion
- Knowledge Session
- Topics on Improving efficiency and availability in the energy industries

## AGM & TECHNICAL MEETING

22 November 2018

Hilton London Paddington Hotel

## 2019 SPRING TECHNICAL MEETING

14 - 17 May 2019

Shell Technology Center, Amsterdam

**BREAKING NEWS**

**Keep your eyes wide for 2019 events. We have agreed with Shell, the world's largest independent gas producer, that they will host a GPA Europe conference in the spring next year.**

**It promises to be VERY special. Be you speaker, supplier, sponsor, operator or exhibitor there will be something for everyone.**

**Block your diary.**

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This listing of current Corporate Members represents the status as at 28 September 2018.

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