Deep Energy
Arctic Technologies
CRYOMAX®
Ethylene
Welcome to this new issue of Tomorrow, which includes a focus on our onshore technologies.

Technip’s expertise and leadership in onshore activities dates back to the early 1960s, when we designed and built the world’s first LNG plant, using our proprietary technology in Arzew, Algeria. Already proprietary technologies were a key asset and differentiator, and over the years we have ensured innovation was at the forefront of our concern to keep developing, and acquiring, technological solutions, most particularly in ethylene, hydrogen and cryogenic applications such as Cryomax®, with patents registered in our own right.

The acquisition in August 2012 of Stone & Webster process technologies, and associated engineering capabilities from the Shaw Group, has strengthened and widened Technip’s offering, with the consolidation of our licensor offering under Technip Stone & Webster Process Technology business unit and brand name.

With this move, we have substantially enhanced our position as a technology provider to the refining and petrochemical industries. For example Technip as part of the Fluid Catalytic Cracking Alliance, alongside Total and IFPEN, has been selected for more grassroots resid FCC units than any other licensor, providing licenses to date to 55 grassroots.

The acquisition has also visibly complemented and widened Technip’s technology and alliances in ethylene. We thus now offer two proprietary and cutting-edge ethylene technologies to our clients worldwide, making the Group an ethylene frontrunner, as you will discover in this issue.

Finally, this strategic move has also anchored Technip’s presence in the United States on the long-term, by widening our products portfolio locally, while also reinforcing our positioning in the downstream business, strengthening our EPC capabilities boosted by shale gas discoveries.

Overall, the Stone & Webster process technologies acquisition has clearly contributed to further diversifying our onshore activities, in line with the Group’s permanent strive for know-how, diversity and innovation.

Regardless the activity, be it subsea field developments, offshore facilities or onshore infrastructures, technology and innovation will remain at the heart of what differentiates Technip, and makes us unique. Looking ahead, our proprietary technologies, alongside our alliances, will carry on contributing to our success and that of our clients. Further, our constant investment in innovation and our understanding of our business will help us deliver safe and sustainable projects.

All in all, I hope you will thoroughly enjoy reading this new edition of ‘Tomorrow’.

Philippe Barril
President & Chief Operating Officer

“The Stone & Webster process technologies acquisition has clearly contributed to further diversifying our onshore activities.”
The Deep Energy - Technip’s newest state-of-the-art pipelay vessel - was commissioned for service and operations in the third quarter of 2013 for her first projects in the US Gulf of Mexico. Let’s take a closer look at one of Technip’s flagship vessels.

Supporting subsea developments from ultra-deep waters to shore

The detailed engineering for Technip’s Deep Energy was developed by Vik-Sanvik AS Norway (now Wartsila Ship Design), with the vessel being built initially in China, then completed in Florø, Norway using a team of highly skilled national and international personnel.

The Deep Energy pipelay architecture was developed in-house using pipelay tower designed by IHC-EB in Newcastle, United Kingdom, with assistance from other key pipelay equipment designers, and incorporates Technip’s extensive experience gained from previous pipelay systems and operations. While the vessel is primarily built for reeled pipeline installation in water depths ranging between 16 to 3,000 meters and from 4” to 18” outside diameter (OD) she is also well configured to carry out the installation of umbilicals and flexible pipe products of up to 24” OD if required. She is therefore able to support subsea developments in both shallow and ultra-deep waters.

The Deep Energy’s striking hull shape was specifically designed for speed optimisation and roll reduction, which gives a very stable work platform and makes her one of the biggest and fastest pipelay vessels ever built. With a maximum transit speed of 19.5 knots and a pipe payload capacity of 5,600 tons (Te), the vessel is able to move rapidly from one region to another, minimising mobilization time and maximising availability for clients.
An outstanding pipelay system

The vessel is fully dynamically positioned (DP) with a Kongsberg Class 3 DP system, incorporating a unique layout of three separate DP zones, providing enhanced redundancy and safety, meeting, and in some cases exceeding, all class and industry requirements.

Careful selection and optimisation of the propulsion equipment, systems and arrangements give the Deep Energy excellent DP capability and manoeuvrability, which have been confirmed during her first pipelay projects in the field.

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This global pipelay control system, designed and developed in-house, was fully calibrated during vessel commissioning using a real-time numerical simulation system.

The Deep Energy is presently operating in the Gulf of Mexico (January 2014), and completed the installation of her first project with good feedback from the client and the vessel offshore management team.

The Deep Energy’s first project was the installation of 10” rigid flowlines for Enbridge while also completing the installation of umbilicals for Anadarko on the Lucius field. She will transit to the North Sea in the first quarter of 2014 to commence a campaign of works in Norway and the United Kingdom.

Deep Energy
Umbilical installation in Lucius field

Technip’s latest vessel is following in the proud tradition of our industry leading vessels, Deep Blue and Apache II. Her advanced technological capabilities will enable her to best support our clients’ projects and meet their needs, while supporting the industry’s ambition to go ever deeper.
Of course, developing oil and gas reserves in the Arctic is not straightforward. The area is remote and the severe climate results in a high cost of extraction.

Drilling offshore wells in the Arctic is particularly difficult with a restricted weather window for mobile offshore drilling units (MODUs) and the requirement for two MODUs in any drilling campaign to be able to drill a relief well if needed. Environmental protection is also more demanding due to the fragility of the ecosystems and oil-spill response is more complex due to remoteness and the presence of ice. Nevertheless, with a significant increase in energy demand forecast over the long term, it is highly probable that the Arctic region will be further developed at some stage in the future.

To meet future demand for Arctic infrastructure safely, Technip is building on its extensive track record of relevant projects and is developing the skills, design tools and installation equipment likely to be needed to execute these forthcoming frontier projects. Technip has already operated its vessels in ice-prone areas of the Arctic and the sub-Arctic such as on the Sakhalin Phase 1 project, and currently has 6 ice-classed vessels in its fleet.

In Arctic regions, production facilities must be protected against the cold environment which is called “winterisation”. Technip has good experience of modularising and winterising facilities from projects performed for Horizon in Northern Canada, and these skills will be similarly required on the new Yamal LNG project in Northern Russia.

In the offshore domain, Technip has developed the Arctic Spar and has topside winterisation experience from the Shtokman deep-water project.

Five years ago the United States Geological Survey published a landmark report on Arctic oil and gas reserves. It estimated oil reserves of 90 billion barrels, gas reserves of 1,670 trillion cubic feet (Tcf) and natural gas liquids of 44 billion barrels which account for about 22% of the undiscovered, technically recoverable resources in the world. About 84% of these estimated resources are expected to occur offshore. Given that very large oil and gas field developments may recover one billion barrels of oil or 10Tcf of gas, these reserves could represent hundreds of future major projects.

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Breakthrough in Arctic technologies
The presence of ice complicates the design of offshore structures and Technip, together with its partners Cervval (a specialist software company in Brittany, France) and Bureau Veritas (BV) is developing an ice-modelling simulation program. The long term aim is for the simulator to predict the flow of ice around both fixed and floating structures and calculate the ice-loadings on these platforms. The program will ultimately allow platform structures to be optimised, to minimise ice loadings and ice rubble build-up, prior to final design verification in an ice test basin.

Although not subject to ice conditions, the Aasta Hansteen Spar is the first Spar platform to be located within the Arctic Circle. It is also the first production Spar to incorporate liquid product (condensate) storage which makes it well suited to future deepwater gas/condensate developments that are potentially abundant in the Arctic region.

For shallow water applications, Technip has developed a conical foundation suitable for use in the ice-prone North Caspian Sea, such as offshore Kazakhstan, and which is under consideration for a current project in this region.

Arctic conditions are particularly onerous for steel structures and concrete is a good alternative material for platform construction. Since Technip is looking at all Arctic solutions it is in discussions with concrete platform designers and is keen to develop its capability in this area.

Whilst the timing of future offshore projects in the Arctic is uncertain, Technip is ensuring it is well prepared for when they do develop.
Ethane, propane, butane and C5+ condensates have high calorific value and at the same time are valuable petrochemical feedstocks. NGL is recovered from natural gas primarily to generate revenue from the sale of ethane for ethylene production or from propane as petrochemical feedstock and as fuel. Other reasons are for heating value adjustment of the residual methane rich natural gas and to avoid condensation in high pressure natural gas pipelines. An NGL recovery unit is where pre-treated natural gas, free of carbon dioxide, sulphur, mercury and water, is separated into a methane rich “residue gas” and NGL, usually at low temperature. The NGL stream is often fractionated into ethane, propane, butane and heavier hydrocarbon condensate. Liquid Petroleum Gas (LPG), which commonly refers to any mixture of propane and butane is part of NGL.

**Natural Gas Liquids (NGL)** is a general term for the mixture of light hydrocarbons that can be recovered from natural gas and maintained in liquid form under moderate pressure. An NGL stream contains components heavier than methane starting with ethane, propane, butane and pentane. **Technip’s experience in NGL recovery projects, alongside its in-house developed Cryomax processes answer client’s needs.**

**CRYOMAX® NGL recovery process**

**Technip’s leading-edge technology**

Adding value to your gas through NGL recovery

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**Cryogenic processes were first introduced in the 1970’s:**

NGL is separated from natural gas by a variety of techniques that have evolved over the past century. Prior to the seventies, lean oil absorption processes were dominant. Technip had a leading role in introducing better processes in the seventies using cryogenic equipment developed initially for the air separation industry. New processes were able to achieve much lower temperatures by precooling the natural gas in a multi-stream plate fin heat exchanger and expanding it through a turbo-expander. It became possible to produce temperatures as low as -100°C without external refrigeration and thereby to recover high levels of ethane and propane.
CRYOMAX® NGL recovery solutions

CRYOMAX® is Technip’s trademark in NGL recovery and covers both open art and patented processes.

Technip’s patented processes under the CRYOMAX® trademark were developed to achieve high recovery rates, typically ranging from 90 to 99%, while reducing the investment cost per tons of produced ethane or propane as compared to conventional expander plants. A CRYOMAX® process scheme is customized for each project, with technology selection and NGL recovery rate influenced by the feed gas composition, inlet pressure and the required product pressures and specifications.

The processes can also be adopted to other methane rich streams such as petrochemical or refinery off-gases.

CRYOMAX® efficient processes

The basic principles used in CRYOMAX® processes are:

- The use of a recovery tower fed with one or more reflux streams that are not obtained by the partial condensation of the overhead vapour.
- A combination of well proven equipment such as turbo-expanders, aluminium plate-fin or shell and tube heat exchangers and distillation columns.
- Thorough thermal integration whereby thermodynamic irreversibilities are minimised by limiting the temperature approaches for heat exchangers and by reducing the thermal gradients for fractionation columns.
- Good recovery selectivity and optimised thermal integration, resulting in lower utility consumption and lower investment costs.

The CRYOMAX® suite includes the Dual Column Propane (DCP) process for C3+ NGL recovery and the High Flexibility Ethane Recovery Process (Flex-e) for C2+ NGL recovery. CRYOMAX® NGL recovery processes can be equipped with a methane compressor (so called “booster compressor”) to enable liquefaction at high pressure. This increases LNG production for a given amount of installed refrigerant compressor driver power. Alternatively it can reduce the power consumed for a fixed amount of LNG product. As it is the most efficient method for fractionation of natural gas it allows production of ethane and propane as make-up for mixed refrigerant processes even when processing very lean gas. CRYOMAX® NGL recovery technology is now proposed on all Technip LNG and FLNG projects.

Today’s CRYOMAX® suite answers the needs for improved processes as the gas market develops and new demands arise:

- High ethane and propane recovery rates,
- Reduced energy consumption,
- Flexible ethane production to match steam cracker feed requirements with consistently high propane recovery,
- Tailor made schemes adapted to natural gas liquefaction.

Development and patenting of new CRYOMAX® schemes is part of our multi-year R&D program which is updated regularly to match market trends.

CRYOMAX® is on offer to our clients for use in projects in which Technip is the process designer of a complete facility. However wherever a client wishes to select technology independently, CRYOMAX® is available under license for development by third party engineering contractors.
Technip is the world leader in designing steam cracking plants (ethylene units) from licensing to engineering, procurement, construction and start-up using its own technologies and proprietary equipment. These units, using oil or gas as feedstock, allow the production of olefins (ethylene and propylene) which do not exist naturally. As the basic products of the petrochemical industry, they have numerous applications, and are used to manufacture consumer goods. The recent acquisition in 2012 of Stone & Webster Process Technologies has reinforced Technip’s leading position in the field.

### Ethylene: leadership and proprietary technologies

#### Worldwide ethylene market

- The current annual ethylene production is about 155 million tons per annum (Mta), with an average growth of 4% per year, equivalent to a 45 Mta increase over 10 years.
- In the last 10 years, the new installed capacity using Technip and Stone & Webster ethylene technologies represent 20 Mta, about 50% of the increased production, in 18 new facilities. Technip is now able to offer two technologies: Stone & Webster’s, as well as its own. Six Technip centers of excellence specialize in ethylene and are coordinated by the Product Line: Claremont and Houston (USA), Paris (France), Zoetermer (The Netherlands), Rome (Italy) and Milton Keynes (UK). With more than 200 ethylene technology experts, Technip has the largest expertise well distributed worldwide.

#### Technip has significant mega cracker experience using all type of feedstock:

- World’s largest ethylene plant in single line (1.7 Mta ethylene at Yansab KSA)
- World’s largest olefins production (1.5 Mta ethylene and 0.95 Mta propylene based on its own integrated technologies: steam cracking and DCC units at PetroRabigh KSA)
- World’s largest mixed feedstock cracker (ethane, LPG, Naphtha - 1.5 Mta ethylene and 0.5 Mta propylene at Sadara KSA)
- World’s largest cracker based on refinery off gases (1.4 Mta ethylene at Jamanagar India).

#### Proprietary equipment and software

Technip’s extensive R&D program seeks to continuously improve ethylene technology and innovation. Technip developed its own proprietary software (SPYRO®) for prediction of cracking yields, furnace simulation and plant optimization. SPYRO® is used by about 80% of ethylene producers worldwide and is the standard tool for designing furnaces regardless the technology. Cracking furnaces are also a Technip proprietary equipment, of which various types are available depending on feedstocks: gas (SMK™ or USC-M®) or liquid (or GK6® or USC-U® / USC-SU®). Technip has also developed proprietary distillation tray for fouling service (Ripple Tray™) and high performance heat exchanger for cryogenic service (Wieland tubes) to reduce energy consumption.

Latest developed technologies include SFT® tubes (Swirl Flow tubes), designed to improve the performances of cracking furnaces.
All types of hydrocarbons can be used as feedstock: ethane, propane/butane, naphtha or gasoil. Ethane has a high yield in ethylene (80%). The other hydrocarbons produce high yields of ethylene and propylene, respectively: propane/butane (45% and 18%), naphtha (32% and 18%) and gasoil (25% and 16%). The feedstock (1) at an ambient temperature is transformed by thermal cracking (pyrolysis) at a very high temperature (about 820°C) in hydrocarbons which are a mixture rich in ethylene and propylene in cracking furnaces (2). The feedstock is first heated at 600°C in the convection zone and then cracked in the radiation zone. The pyrolysis reaction occurs between 600°C and 820°C; the reaction time is between 0.2s and 0.4s. The hydrocarbons mixture is then sent to the hot section (3) to be cooled down. The process is based on two consecutive distillation towers, allowing the recovery of steam used in the furnaces and heavy hydrocarbons (fuel oil, heavy gasoline).

The gases at an ambient temperature and pressure are then compressed (4) at high pressure (35 bars) to allow downstream cryogenic separation. Here the gases are pre-purified and water is removed (drying), as well as acid gases (CO₂ and H₂S). Cryogenic separation (5) allows high ethylene recovery rate (above 99.7%) in the hydrocarbons mixture, and the gases are progressively chilled and liquefied to -125°C, a process ensured by external refrigerant compressors (ethylene and propylene compressors) and by heat recovery. Further cooling to -162°C could also produce pure hydrogen.

Then ethylene is purified (6) successively using catalysts (chemical transformation) and then by super fractionation (distillation tower of 80 meters tall). This enables to produce ethylene (propylene) at the required quality (99.95% pure) and finally stored (7) at -102°C.

In November 2013, the Group held its first Inaugural Ethylene Forum in Los Angeles, bringing together 300 field experts from 50 ethylene producer and 23 supplier companies, to further reflect on technologies, innovations and project execution.

A true testimony to the Group’s leading-edge approach, while also reasserting Technip’s strive to take its competitive advantage in ethylene to the next level.

For further information, please visit http://www.technip.com/en/our-business/onshore/ethylene or contact jplaugier@technip.com.
For close to fifty years, Technip has been a leader in providing conceptual design, engineering and construction services to the gas industry.

Our references cover grassroots gas facilities, ranging from small individual units to gigantic complexes, in every sort of environment, as well as upgrades of existing installations.

- Liquefied Natural Gas (LNG)
- Floating Liquefied Natural Gas (FLNG)
- Gas to Liquids (GTL)
- Natural Gas Liquids (NGL) recovery