

# ICIS Special Supplement

**ETHANE FEEDSTOCK**

## **INEOS RIDES THE SHALE WAVE**

Future secure as US shale economics come to Europe





# Voyage of discovery

A few years ago petrochemical major INEOS embarked on a major strategy to breathe new life into its European operations. Its vision to bring US shale gas economics to Europe, to tap into the vast supplies of gas proved more than just a pipe dream

ANDY BRICE LONDON

Most boardrooms would quickly dismiss a proposed \$1bn investment that would take its business into uncharted territory; a bold plan that would commit the company to working with new partners, on long-term contracts, across continents, and using technology and processes that have never been attempted before.

But with North Sea gas supplies in decline, the pressures of an economic downturn and intense competition from other regions, the executive board of INEOS thought otherwise.

In June 2010, the company embarked on a pioneering venture that would create a 3,800 mile (6,116km) virtual pipeline across the Atlantic and transport 60,000bbl/day of US ethane to Europe for the next 15 years.

"The combination of elements for this project, and what we have achieved, is a first for the industry," says David Thompson, chief executive officer of INEOS Trading & Shipping. "This is quite simply one of the greatest

engineering projects in the world, spanning three continents, and bringing together global expertise.

"We identified an opportunity, brought everyone together and delivered. It's been an exciting journey and a real achievement for everybody involved."

The first of eight specially-commissioned ships set sail on its inaugural voyage on 9 March 2016 – sailing from Marcus Hook, Pennsylvania on the US east coast, to Rafnes, Norway. The giant 180m (591ft) long vessel – named *JS INEOS Intrepid* – is one of eight Dragon-class ships that will transport 800,000 tonnes/year of ethane from US shores to INEOS's cracker at Rafnes and another at Grangemouth in the UK.

Gas supplies into the UK have fallen by about 70% over the past 15 years but the future of both crackers was questioned as the flow of ethane from the North Sea diminished. Difficulty sourcing the vital feedstock meant Grangemouth was running at only 40% of its capacity, and it was anticipated that there would be insufficient supply to meet the future needs of the Rafnes site too.

"North Sea gas supplies were falling so we were looking for opportunities to supplement feeds to our facilities and prepare us for the future," notes Thompson. "There was simply not enough ethane available so this

project was driven by looking at new options and optimising our operations."

"As propane and butane were more freely available, we'd already spent a lot of money on adapting the plant to use heavier feeds



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**DAVID THOMPSON**  
CEO, INEOS Trading & Shipping

– but you can only do so much,” adds INEOS director Tom Crotty. “We just couldn’t see a way of continuing to run the Grangemouth operation successfully without a source of ethane. This proved to be the key driver for this project.

“We started looking around the world to see where we could source feedstock,” says Crotty. “There’s obviously ethane in the Middle East but it gets locked up in crackers straight away. But what had changed since 2008 was the growth of shale gas in the US. Not only was this an entirely new source of feedstock but it was particularly attractive because the US was an oil-based economy and didn’t have a natural home for it all. It was a happy coincidence that we needed the ethane and the US had a lot spare.

### GAMECHANGING PROJECT

“For us it will be transformational for our European business. We believe these two crackers will be the most competitive crackers in Europe and I think it creates a huge opportunity for Rafnes and Grangemouth. The UK industry hasn’t grown much these past few years; in fact it’s contracted – and there is a real opportunity now to regrow the industry in that area based on the fact it’s now got a highly competitive cracker at its heart. This should really stimulate investment and growth.”

Besides commissioning the world’s largest ethane-capable carriers, INEOS’s ambitious plans required plenty of planning and preparation on dry land too. Soon after the initial concept was approved, strategic partnerships were formed with specialist companies in the US to supply, transport, store and export the gas.

In 2012, a deal was struck to access the vast Marcellus shale formation in Pennsylvania, process and fractionate the gas streams, and use the new 300-mile Mariner East pipeline to move it through Philadelphia to a previously disused oil refinery at Marcus Hook on the coast. Docks and storage tanks were also built, ready for its transfer to the Dragon ships and a 10-day crossing to Europe.

There was substantial investment on infrastructure there too, with INEOS building two of

the largest ethane gas storage tanks in the region.

Around \$160m was spent on the 19,000 tonne capacity expansion at Rafnes, along with new pipelines and fractionation plants. The overhaul of Grangemouth, however, was a little more complex.

The Scottish site was proving unprofitable, with the situation exacerbated by a long-running union action, says Crotty. Before committing to this new strategy and the huge investment, INEOS wanted to reconcile the dispute.

“With this project, we knew we’d found a possible way forward but we needed to start discussions with the unions to address the labour issues to make the site competitive. Once that got resolved, we were able to progress plans and secure the future of the plant.

“We should see an immediate effect on the business – as soon as shipments start arriving in Grangemouth as we’ve been running the plant at less than half rates. Once it’s running at full capacity, we’ll literally see an overnight transformation from a loss-making business to a profitable one.”

Gas had previously been piped to the site so, unlike Rafnes, Grangemouth had no dedicated port facilities to receive the newly-acquired ethane, he says. The required investment was therefore significantly higher – part of the £450m (€580m) site programme – as a jetty facility and pipeline connections were needed in addition to the 40m-high storage tank.

Geographically, Grangemouth is also very large site, says Crotty, with the jetties 8km (5 miles) from the plant, so it was a huge logistical challenge.

### INNOVATIVE SHIP DESIGN

Danish ship owner and operator Evergas won the tender to design the ships, agreeing a long-term and extendable 15-year lease with INEOS. Ethane had previously only been shipped in small vessels on short routes so that in itself was a challenge.

“When the project started, there were a lot of pieces of the jigsaw puzzle to put together but we’ve now got long-term contracts in place, building in that flexibility and ensuring security of supply for our crackers for the next generation,” says Thompson.

Close collaboration between the teams resulted in a fleet of extremely efficient vessels boasting capacities of 27,500cbm – all designed to fit the very specific size requirements of the Grangemouth docks.

“This is truly a first – nobody’s ever built ethane tankers like these before. The engines run on ethane so the cargo is also the fuel. If you take a look at the investments we’ve made on the sites themselves plus the com-

mitment we’ve made on the ships, then this is the biggest investment we’ve made outside of an acquisition, amounting to around \$2bn,” says Crotty.

“The design and size of the ships was a matter of cost and efficiency.



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**TOM CROTTY**  
Director, INEOS

We carefully modelled how big the storage capacities needed to be and the working capital required – and were very happy with the outcome,” says Thompson.

“We tested different scenarios across a range of oil prices when we were planning this project. When we were sitting at \$120/bbl oil, we didn’t envisage we’d be looking at prices falling to \$25/bbl – but even when we did get there, the comparative economics of other products meant that the project still made sense. At higher oil prices we obviously have a bigger advantage but the most important thing is that we’re securing additional feedstock and that we’re improving our flexibility going forwards. It was a wonderful opportunity and strengthened our business for the future.

“This has been a truly multinational effort. It has taken us five years. I really believe that a project like this could only have happened at INEOS. The entrepreneurial culture of the company means that we have the freedom to get things done with the minimum of bureaucracy. The feeling that we’ve done something that will make a real and positive difference to the business, and indeed to the European chemicals industry, is hugely fulfilling.” ■

To find out more about the project, as well as the design and construction of the Dragon ships, visit <http://ineos.com/big-boats/>



**The eight specially-designed vessels form a virtual pipeline from the US to Europe**

# Enter the Dragon

The fleet of vessels that proudly carries the image of mythical creatures synonymous with strength, power and good fortune has become the standard-bearer of INEOS's new vision

ANDY BRICE LONDON

INEOS is not afraid of a challenge, asserts chairman Jim Ratcliffe. Yet it had been suggested that the petrochemical producer's new strategy to capitalise on the shale gas boom in the US and transport ethane feedstock across the Atlantic was impossible.

"At INEOS, we believe anything is possible," he says. "We know that shale gas economics revitalised US manufacturing and for the first time Europe can access this important energy and raw material source too.

"This is an incredibly exciting project; the scale and complexity are breathtaking. It should underpin European economics in chemicals for a long time to come. Everyone said it couldn't be done. Well, we've done it."

Arguably the biggest hurdle lay in the expanse of water dividing the two continents.

Laying a subsea pipeline to transport the gas was implausible, and no one has ever shipped ethane over such a distance or in the quantities required.

"This was on a completely different scale to anything INEOS has done before in terms of shipping, admits Louise Smith, shipping business manager. "The project scope meant we had to consider safety, longevity and value for money to create this floating pipeline. We gave an open brief to various suppliers but selected Evergas in 2012 – the Chinese Year of the Dragon – to work with us on the project.

**"We had to consider safety, longevity and value for money to create this floating pipeline"**

**LOUISE SMITH**  
Shipping business manager, INEOS

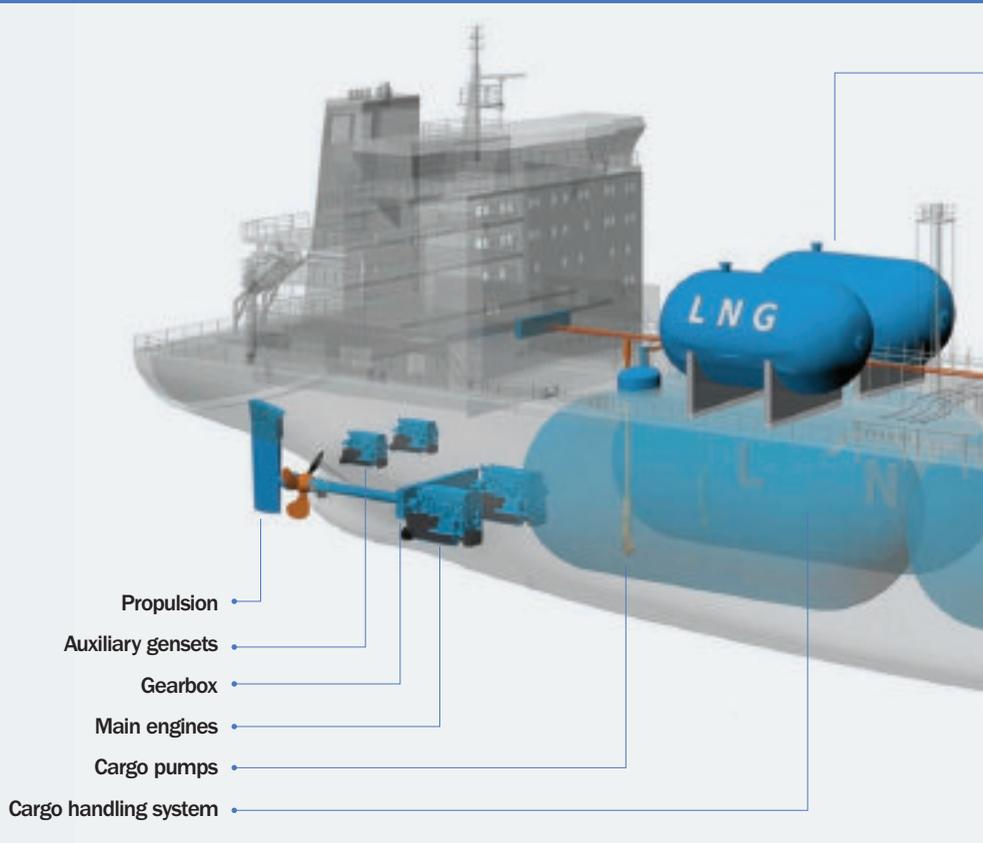
"An ethane carrier in itself is not unique but Evergas added a lot of new systems to our ships," she says. "This was a long-term investment for INEOS so we wanted something that was state of the art and would last for 20-25 years. Evergas took our brief and optimised the hull, propellers, cargo system, and the engines, and came up with this leading edge solution."

Initially, only four boats were commissioned, but this was soon raised to six and then eight – to provide a steady and constant flow of gas shipments.

"It was a challenging project and we had to make sure the shipping supply chain fitted in with our infrastructure and the size of tanks that were being built. We were moving from a two-day supply position, when we were taking ethane locally from Karsto in Norway, to a 10-12 day position with these ships. We

## THE DRAGON SHIPS – FACTS AND FIGURES

<b>Class</b>	Dragon Class
<b>Capacity</b>	27,500 cubic metres
<b>Length</b>	180.3 metres
<b>LBP</b>	170.8 metres
<b>Width</b>	26.6m
<b>Weight</b>	21.5 kte
<b>Draft</b>	9.4 metres
<b>Speed</b>	16 knots (20 knots max)
<b>Purpose</b>	Transportation of ethane. Flexibility to carry a wide range of alternative petrochemical gases and LPG.
<b>Tanks</b>	3 x bi-lobe optimised tanks Ethane cooled to -130 degrees F
<b>Engines</b>	2 x Wärtsilä 50DF dual-fuel engines 13.8kW combined engine / generator capacity 2 x Wärtsilä 20DF auxiliary generating sets
<b>Propulsion</b>	Single prop, 6.4 metres
<b>Fuel System</b>	Wärtsilä LNG
<b>Crew</b>	19
SOURCE: INEOS	



wanted to make sure there would be no disruption to our crackers even with the longer supply chain.

“One of the main constraints we faced was the width of the Grangemouth entrance lock,” she notes. “We therefore needed to design a long, thin ship that would fit the infrastructure at the site but one that could carry as much cargo as possible.”

### MULTIGAS CARRIERS

The resulting Dragon class ships measure the length of two football pitches and boast the world’s largest bi-lobed tanks to carry 27,500cbm of liquefied gas at -90°C (-130°F).

These are the largest, most flexible and most advanced multigas carriers ever built, adds Evergas CEO Steffen Jacobsen, capable of transporting liquefied natural gas (LNG) and liquefied petroleum gas (LPG) as well as ethane.

“It’s fair to say this was an industry first in many ways,” he says. “These ships are truly unique, designed and built around INEOS’s business.

“We’ve combined a lot of proven technologies in a brand new way. No-one has ever tried to ship ethane in these quantities and over this distance before. To do this, we had to invent completely new ways of doing things.”

More than 5,000 people worked on the

ships’ construction, each requiring around 1.6m man-hours to complete.

“Efficiency was one of the key criteria in the design,” says Jacobsen. “INEOS was clearly looking at the cost per tonne on a round voyage basis and of course the driving factor was to push down this cost. There was a real focus on energy efficiency, speed and fuel consumption.”

The carefully designed hull and shape of the propeller help to reduce fuel consumption, with two Wartsila 50DF dual-fuel engines providing speeds of

16-20 knots – particularly fast for a tanker of its size. Wartsila also supplied the LNG fuel system and cargo handling system.

These highly advanced propulsion



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**STEFFEN JACOBSEN**  
CEO, Evergas

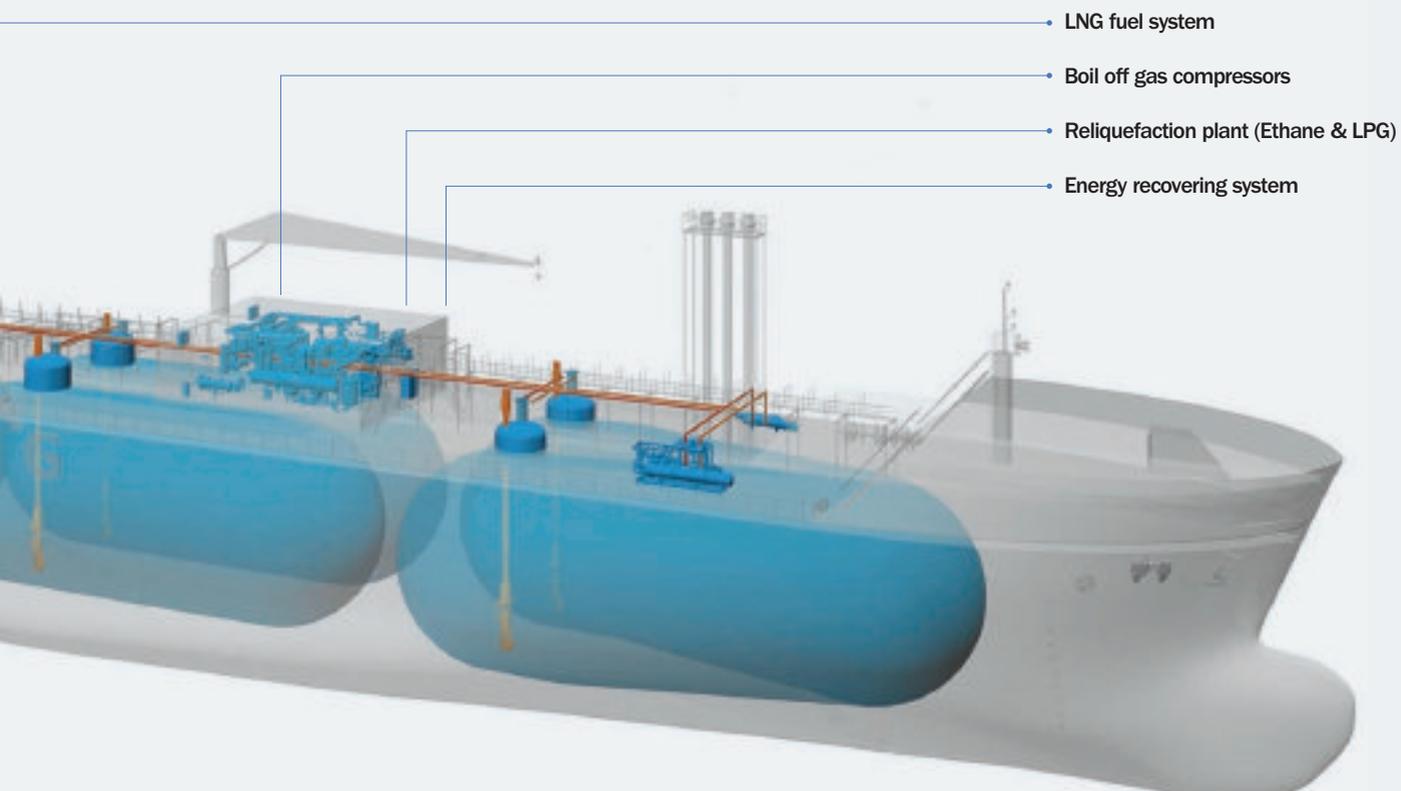
sion systems offer the ability to run the engines on diesel, LNG, or on the very gas that is being transported as cargo. The engine can instantly change between fuels without any loss in speed or power.

“With more and more restrictions on how much sulphur is allowed in fuel, in the longer term it will be even cheaper to run the engines on gas,” he says. “We tried to make the ships futureproof.”

Construction of the first four carriers is already complete, while those remaining are scheduled to leave dry dock later this year and early 2017. Each vessel has its own distinctive dragon emblazoned on its superstructure, representing a specific Chinese element or symbol – a nod to the vessels’ development in shipyards on the banks of the Yangtze River.

Each ship has been given a name that embodies a core value of INEOS: Insight, Ingenuity, Inspiration, Innovation, Intuition, Invention, Independence and Intrepid – the latter having set sail in March for the fleet’s first journey across the Atlantic. They also boast a 100m message relating to the benefits of shale gas to Europe, to the chemicals sector, to jobs and progress.

Bound for Norway with its precious cargo of ethane, it marks the start of a new era both for INEOS and the wider European petrochemicals industry. ■



# A collaborative effort

Forging the right partnerships was integral to the success of this project, with teams working across the globe

ANDY BRICE LONDON

Right from the outset, it was clear that the success of INEOS's new plan would only have been possible with contributions from a multinational team of specialists.

First contact was made in the third quarter of 2010, when natural gas exploration and production company Range Resources was approached to provide access to the abundant supplies of shale from the gas fields in Pennsylvania.

This was followed by approaches to Mark West to collect, process and fractionate the gas streams and separate the ethane.

By the end of 2011, another agreement had been struck with Sunoco to develop the infrastructure to transport the gas to the coast. The deal would see the development of the Mariner East pipeline to get the gas to Marcus Hook – an old decommissioned oil refinery – and new terminal and storage facilities, ready for export to Europe.

“It wasn’t envisaged from the beginning that the project was going to involve Marcus Hook and the pipeline but it’s a tribute to all the parties involved that this was possible,” notes David Thompson, chief executive officer of INEOS Trading & Shipping.

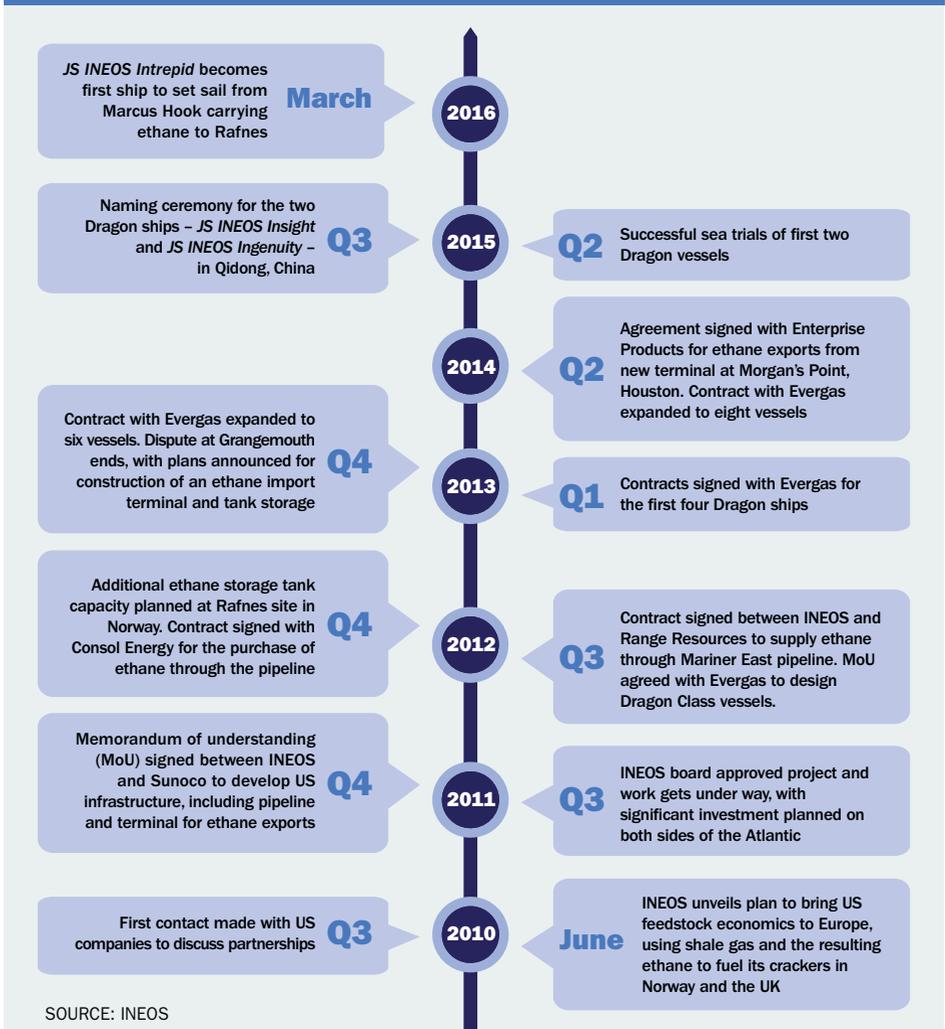
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DAVID THOMPSON  
CEO, INEOS Trading & Shipping

## PROJECT TIMELINE



SOURCE: INEOS

we’d have to use a new series of boats to be able to ship the product economically and we had to find somebody who could work with us to design and build them to our needs – finding those people was key. We needed a leading class of vessel – and had to build it to the size and scale we were looking for.”

Evergas won the contract and designed boats that pushed the boundaries, optimising efficiency and meeting INEOS’s very specific criteria.

“Evergas were innovative. They didn’t just design a standard ship – they thought about what we wanted to achieve, and they designed something brand new that has never been done before,” says Thompson.

Evergas worked with Greenseas Marine Technology to look at the ships’ engineering, fluid dynamics, structural mechanics, power plant and electronic automation. Germany’s

HSVA, a specialist in marine hydrodynamics, then created complex 3D models and rigorously tested the ships’ design, building scale models and testing them for resistance, propulsion, and manoeuvrability.

Once the designs were fine-tuned, China’s Sinopacific Offshore and Engineering (SOE) was appointed to build the ships.

“The relationship between Evergas and INEOS has been extraordinary – positive, cooperative and bold on both sides. I have seldom seen a business relationship this effective and aligned,” says Steffen Jacobsen, CEO of Evergas.

“Our partners in Europe and China have excelled themselves on this challenging project. Wartsila have created some of the cleanest, most efficient engines ever built. Greenseas and HSVA have created cutting-edge designs.” ■

# Europe faces a major sea change

The new Dragon ships and huge investment in infrastructure provide security for INEOS amid growing market uncertainty and fluctuating oil and naphtha values

**NIGEL DAVIS** LONDON

All petrochemical producers have to look to the future. Not just at how they can prosper this year and next but over the much longer term.

Ideas are stress-tested in scenarios, mapping out growth opportunities and potential threats.

Yet, for petrochemical companies operating in Europe the opportunities appear to have diminished and the story has been one of consolidation.

Global competition has increased while Europe's market growth has slowed. New players have emerged in other parts of the world with different, predominantly low cost or market growth-driven, competitive profiles.

For Europe the large petrochemicals market is not as vibrant as it once was. Growth and profitability are constrained.

So maybe re-invention is the key. Or the realisation that chemical companies can thrive and prosper in a market if they think and act decisively and, perhaps, differently.

INEOS has thrived on being different, on pushing its operating model to the limits as it has swept up assets and businesses in mainstream petrochemicals, chemicals and polymers.

## INNOVATIVE AND UNIQUE

Likewise, the INEOS story has continued to be one of innovation and action. The INEOS virtual pipeline that brings ethane from the US to Europe marks another step along the path that uniquely shapes the company. Coupled with plans to develop a gas business based on acquired assets in the North Sea it delivers a robustness that will underpin the INEOS European petrochemical operations for years to come.

"We are nearing the end of a hugely ambitious project that has taken us five years," said INEOS chairman and co-owner Jim Ratcliffe. "I am proud of everyone involved in it and I believe that INEOS is one of very few companies in the world who could have successfully pulled this off. I can't wait for the *JS INEOS Intrepid* to fi-

nally get to Grangemouth and complete the job".

INEOS has grasped the ethane advantage, and run with it, convinced that over the next 15 years it can continue to benefit from competitive landed ethane costs at its two European gas crackers as feedstock supplies from gas fields in the North Sea dwindle.

The new sources of ethane mean that the INEOS gas crackers will be able to run at much higher capacities and run competitively. Essentially, INEOS will be able to produce more ethylene from cost-advantaged ethane. The future of the crackers and of other downstream operations is being secured.

The grand plan to establish the ethane link with the US, which involves the first large-scale export of ethane, was devised when oil prices were much higher and ethane prices were low. But while the subsequent fall in the price of oil has shifted the short-term competitive economics of the project, it has by no means dented the long-term goal.

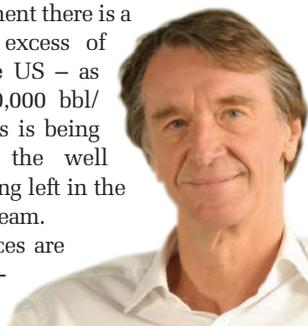
Naphtha cracking and the cracking of other oil-derived feedstocks have become much more competitive with ethane from shale in the US. Naphtha cracking margins have improved markedly.

At the moment there is a considerable excess of ethane in the US – as much as 600,000 bbl/day of the gas is being 'rejected' at the well head. It is being left in the natural gas stream.

Ethane prices are very low because of the

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**JIM RATCLIFFE**  
Chairman, INEOS



**Project improves INEOS's competitiveness**

excess and as ethane begins to flow across the Atlantic so INEOS can still capture a competitively priced cracker feedstock.

What the near-term future holds, no-one knows, but an unprecedented wave of cracker capacity building and expansion in the US and Canada does mean that more ethane will be consumed in North America. Ethane exports to Europe are expected to increase and exports to begin to India and China.

What this means as far as medium-term ethane prices are concerned remains to be seen, but cracking the gas is likely to remain competitive with naphtha and other liquids over the longer term.

In Europe, cracker operators have consolidated capacities in recent years to focus on well-integrated production sites and on feedstock flexibility. The ability to crack ethane without major plant modifications, however, has been open to relatively few.

The opportunity to drive the creation of the virtual pipeline to Europe for INEOS, therefore has been clear. And the company has seized an initiative others have not been prepared to take.

INEOS has moved boldly and with conviction to secure an ethane advantage in Europe that other players can only envy. ■

To find out more about the project, as well as the design and construction of the Dragon ships, visit <http://ineos.com/big-boats/>



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INEOS is a global manufacturer of petrochemicals, speciality chemicals and oil products. It comprises 15 businesses each with a major chemical company heritage. Its network spans 65 sites in 16 countries throughout the world. It has grown to become a leading chemical company with sales today of around \$40bn.

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