World trade in liquefied natural gas (LNG) today is around 240 million tons per year, with 18 nations exporting and 27 nations importing. Forecasts say that by 2020 the number of exporters will rise to 24 and the number of importers to 40, and that by 2030 global LNG production could be as high as 550 million tons/year.

The heart of this growing market is, naturally, the LNG tanker. While much talk about these sophisticated ships centers on their cargo containment systems, of no less importance are the cargo handling systems that transfer the precious liquid between ship and shore – and the men and women operating them.

This photo shows the mighty ‘arms’ belonging to the loading/offloading section of the cargo handling system used by the ABS-classed LNG carrier Methane Nile Eagle, a vessel owned by the BG Group. The objects resembling the plate stack on an exercise machine are the counterweights that help control the arms. Altogether, these large LNG carriers, with an average length of 300 meters, contain approximately two miles of LNG cargo piping.

The officers responsible for LNG cargo handling are required by legislation and stringent industry guidelines to have extensive, ongoing training in LNG, including a one to three-month period of intense training (depending on experience) on top of their normal seagoing training. They are the core of the LNG shipping industry’s proud record of safe operation.
COVER:

An ABS surveyor examines the pump tower in an LNG cargo tank. Natural gas has long been seen as the future of the future, but a future that always seemed just out of reach—until today. The US gas revolution has changed minds around the world, driving new commitments to natural gas use in many industries, including maritime, coverage of which begins on page 2 of this issue.

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From commodity pricing to international relations, effects of America’s shale gas boom are echoing around the world.

It is a reality that reads like a glorious fiction from the pen of Ayn Rand: an American entrepreneur bucks the odds and beats the skeptics, sparking a technology-driven upheaval in natural gas production that permanently alters the United States’ energy outlook and creates jobs for millions. Once viewed to be a producer in decline, the US is now being called an energy superpower as global markets, international industries and even the tangled web of world geopolitics feel the mind-boggling effects of America’s unconventional gas and oil revolution.

Behind the revolution is an evolution of the extraction technology called hydraulic fracturing, or ‘fracking’. Originally developed in the 1940s to extract natural gas trapped in shale rock formations deep underground (shale gas), fracking involves drilling a well hole and flushing it with a high-pressure fluid, which cracks the underground rock formations and releases their trapped hydrocarbons. For half a century it remained too difficult and costly to do large-scale gas recovery by this means, until Texas entrepreneur George P. Mitchell combined it with new directional drilling techniques and advanced underground survey technology to stunning effect. Producers jumped on the fracking bandwagon and today shale gas accounts for around 37 percent of all US natural gas production, up from near zero percent in 2000. It is predicted to account for about half of US gas output by 2030.

Fracking is also used to extract oil from rocks (called ‘tight oil’) and has been so effective that, on the strength of this technology, North Dakota now produces more oil than Ecuador, the smallest member of OPEC (the Organization of Petroleum Exporting Countries). Even better, thanks in part to tight oil, US oil output rose by about 2.2 million barrels/day from 2008 to 2012 inclusive – the increase alone is almost equal to the output of Nigeria, OPEC’s seventh-biggest producer.

The most striking effect of the fracking revolution has been in the LNG world. In 2008, US gas production had been relatively flat for years and was expected to decline. The absolutely certain outlook was that the country would be importing 20 percent of its gas needs by 2020, becoming in the process the world’s number one liquefied natural gas (LNG) consumer. All the big brains were on board with that belief; even Federal Reserve Chairman Alan Greenspan said “our limited capacity to import LNG effectively restricts our access to the world’s abundant supplies of natural gas” and that “we need to get in place, as soon as we can, the capability of fairly substantial imports that enable our manufacturers who use natural gas to compete internationally.”
Accordingly, between 2002 and 2007 the US tripled LNG imports, reaching more than 2 billion cubic feet per day (bcf/day), and it appeared as if that was only the beginning. Then shale gas happened and, amid its flood of pipeline gas, between 2007 and 2012 US LNG imports dropped to 0.4 bcf/day. In 2010 the US Energy Information Administration (EIA) released estimates putting proved US natural gas reserves at their highest level in four decades, and in 2012 the US pushed past Russia to become the number one gas producer in the world.

As that scene unfolded, many major LNG exporters who had spent years building business plans around a hot US import market suddenly found themselves out in the cold. For example, the outlook on growing US LNG imports was so certain that energy majors Total and Chevron, when they wanted to import LNG through the Cheniere Energy terminal at Sabine Pass in Louisiana, saw no problem in helping Cheniere raise construction funds for the facility by guaranteeing years of import payments. The terminal opened in 2011, took no deliveries in 2012 and today is not importing, but Total and Chevron will compensate Cheniere annually for the right to do so until 2029.

Then there’s the experience of Qatar. The number one LNG exporter and owner of the world’s biggest LNG tankers, Qatar and its partner ExxonMobil had counted on the US market for a sizeable chunk of the country’s gas output. In its 2007 annual report, ExxonMobil pointed out that Qatar was building an export facility capable of shipping 1 bcf/day to the US. On the other end of the line, Qatar Petroleum had a 70-percent stake in Texas’ Golden Pass terminal, an LNG import facility that has capacity for 2 bcf/day gas. Today Golden Pass is not receiving, and the owners have petitioned the US Department of Energy for a permit to install export capability.

**Fracking Geopolitics**

The fracking revolution has rippled outwards to touch even the world of geopolitics. For example, 2006 forecasts had most future US LNG imports coming from suppliers in the Persian Gulf; today any such dependence has been all but eliminated. On top of that, the 14 gas exporting nations that rattled their methane sabres and talked about forming an OPEC-like gas cartel just six years ago are now scrambling for customers in a newly pressurized market. The fastest scrambling has been in Europe, where US gas has helped
pressure the putative leader of that cartel, Russian state-owned gas giant Gazprom. Gazprom supplies about a quarter of Europe's gas and depends on the European Union for some 80 percent of its income; its Soviet-era pipelines remain Europe's principal gas supply but the company is no longer the commissar of the street. European power authorities first used cheap US coal to start wriggling free of Gazprom's grip; the coal undermined gas demand, reducing prices and volumes, the impact of which flowed back to the supplier. Then, with eyes on even cheaper US gas, they began building LNG import terminals to diversify supply and replace declining domestic production. In response, Gazprom renegotiated many contracts, dropping prices to EU customers during the past two years.

Even as gas markets slow down in Europe, Asia remains a powerfully growing user, particularly with China's latest Five-Year Plan calling for an increase in natural gas usage, Japan replacing lost nuclear capacity with gas-fired plants, and Indonesia committing to increased gas use for power generation, road vehicles and ships. Much of Asia's overall imports will be in the form of LNG and, according to market analysts Wood Mackenzie, China and Southeast Asian countries will become increasingly important components of overall Asian demand through 2025, which, led mainly by Indonesia, Thailand, Malaysia and Singapore, will account for an increase of 45 million tons annually.

Despite the opportunity for American businesses, how much of Asian need will be slaked by US gas remains an open question. Under US law, the Department of Energy (DOE) must determine whether an LNG export proposal will serve the national interest; definitive answers to questions of exports affecting trends in domestic gas use, the drive for energy security and the growth in the domestic economy are still being pursued.
In the National Interest

Desire for the US to hold onto its gas is understandable, since the gas revolution, in just these early years, has already done much to help the country’s economy. This was underscored in Congressional hearings on energy security in February, when industry analyst Daniel Yergin told the Subcommittee on Energy and Power of the House Energy and Commerce Committee that “the United States is in the midst of an ‘unconventional revolution in oil and gas’ that goes beyond energy itself,” pointing out that the industry currently supports 1.7 million jobs and could bring that up to 3 million by 2020. “In 2012 this revolution added $62 billion to federal and state government revenues, a number that we project could rise to about $113 billion by 2020,” he added.

Some of those jobs are in revitalized domestic industries that had given up hope of any more building at their home bases. The most noteworthy example of such turnaround may be in the chemicals sector, where analysts predict the gas revolution could help add a million jobs by 2025 while also cutting overall manufacturing costs by $11.6 billion.

This is happening because natural gas liquids are a basic raw material, or feedstock, used in industrial processes that produce everything from house paint to semiconductors. The abundant US gas supply is not only making many major manufacturers switch from oil to natural gas as their feedstock source, but also inducing them to build new plants in America and renovate old ones.

LNG, the Public Interest & FERC

Wherever in the world a project to build an LNG terminal is advanced, its proposed location raises questions and concerns regarding public health and safety, land and sea security and environmental stewardship – a critical triad in the collection of concerns called ‘the public interest’ that must be always addressed before the relevant authorities give the green light for construction. In the United States, the agency that makes the public interest determination on LNG projects is the Federal Energy Regulatory Commission (FERC).

Section 3 of the US Natural Gas Act grants FERC the final word on siting LNG projects on land and in state waters. LNG projects beyond state waters are approved by the Maritime Administration and the Coast Guard.

This map shows existing North American LNG terminals, import and export, noting which were approved by FERC and which by MARAD and the Coast Guard.

LNG is just one of the areas in the Commission’s brief. An independent regulatory agency of the US Government, FERC is charged with overseeing and regulating energy industries in the interests of the American public and making the licensing and siting decisions on important US energy projects.

Besides siting LNG facilities, the Commission’s authority includes, among other things: siting and licensing interstate natural gas pipelines and storage facilities; regulating interstate gas transportation rates and service; siting and licensing all non-Federal hydroelectric projects; regulating rates and services of oil and product pipelines; regulating interstate electric transmission rates and services; and siting electric transmission lines in areas designated as congested. FERC also inspects the hydroelectricity projects and LNG terminals it approves to make sure its orders and the conditions attached to such orders are being followed. ◆
Take Dow Chemical for example. Just eight years ago, when the price of natural gas was at $14 per thousand ft³ – up from about $2 during the 1990s – its CEO told the US Senate Energy and Natural Resources Committee “This price of $14, simply put, renders the entire US chemical industry uncompetitive,” adding that “when faced with gas at $2 to $3 elsewhere, how can I recommend investing here?” Soon after, Dow announced plans for major expansion in Kuwait and Oman. Now those dark days are a thing of the past, as major manufacturers including Dow, Formosa Plastics and Royal Dutch Shell have started a wave of capital investment in North American petrochemical facilities that, according to reports from the American Chemistry Council, will reach beyond $51 billion by 2017.

So far, the biggest increase in US natural gas demand has come from the power generation sector. By last year, according to the EIA, natural gas accounted for 30 percent of US power generation and coal’s share had declined to 34 percent, down from near 50 percent in 2005. Analysts credit the new gas bonanza with stabilizing natural gas prices to the point where gas-fired generators – previously used mostly for ‘peak shaving’ (boosting electricity supplies during periods of high demand) – could be used for baseload power generation.

With natural gas taking new importance in the domestic, commercial and even political life of the country, it is small wonder that many people are reluctant to see it exported. At the same time, with so much of it around it is also understandable that many others see no reason not to ramp up production, build export terminals and start selling it abroad.

Challenges to US Export

LNG trade today is around 240 million tons per year, with 18 nations exporting and 27 importing. Multinational energy provider GDF Suez has forecasted that by 2020 the number of exporters will rise to 24 and the number of importers to 40, and that by 2030 global LNG production could be as high as 550 million tons/year.

While the US considers adding export capacity, hungry competitors are making aggressive plans and pinning hopes of economic development on the LNG business. One such place is Mozambique, where Italian energy giant ENI and Anadarko have announced plans to jointly develop an LNG export facility. The project, which ENI has said could cost up to $50 billion, is planned to be operational by 2018 and will eventually be producing some 50 million tons of LNG per year, making it the largest single LNG...
facility outside of Qatar. To put that in perspective, all 24 proposals for major LNG export terminals in North America (as of this March) total more than 230 million tons/year.

Overall, East Africa has emerged as a gas exploration hot-spot, with some 110 trillion cubic feet (tcf) of gas discovered offshore Mozambique and Tanzania to date. The region's proximity to Asia makes it potentially an important supplier of LNG to some fast-growing economies. According to Wood Mackenzie, Mozambique and Tanzania potentially have the same size gas resource as Australia, which has discovered 200 tcf of gas and is expected to become the world's largest LNG producer by 2020.

Altogether, such potentially immense developments around the world raise challenges for those planning new US LNG export terminals, most of which would likely come online after at least some of the mega projects already in the works.

On the other hand, when the new Panama Canal is completed in 2015 it could open the gateway to another gas market revolution. Only a small percentage of the world's LNG carriers can pass through the Canal as it is, but when most of the fleet has easy cross-ocean access, the gas market might break wide open and the present separation of natural gas prices by region – where North America, Europe and Asia have widely different pricing – could vanish, possibly resulting in a global market structure for gas analogous to that of oil. Where that could lead is anyone's guess.

With such wide-open future possibilities, there has been intense debate in the US as to whether stepped-up LNG exports will be good or bad for

B y freeing vast, previously inaccessible reserves of natural gas from their shale prison, the unconventional gas and oil revolution in America has caused fundamental changes not only in energy markets, but also in worldwide petrochemical manufacturing. Today, for the first time in many years, the US has become an ultra-competitive supplier of the natural gas liquids that manufacturers use as feedstock, particularly ethane.

Just a handful of years ago, the US bulk chemicals business seemed to be in decline, and major manufacturers, in planning new facilities, saw their futures in the Middle East and other places where feedstock supplies were cheapest. Now, thanks to shale gas and tight oil, economic US feedstocks are reshaping global competition in petrochemicals. Costs are lower in the US than in Europe, Latin America and China and, say analysts, may soon be beating even those in the Middle East.

As a result, major chemical manufacturers are investing in new US chemicals facilities and bringing old ones back to life. By last year, the US industry group the American Chemistry Council (ACC) could count 17 new projects dedicated to the processing of ethane (known as ‘cracking’) to make ethylene, the chemical from which numerous plastics such as polyethylene are made.

Ethylene accounts for some 40 percent of world trade in chemicals by volume. About half that is based on naphtha, a hydrocarbon produced from crude oil – and, consequently, its costs are tied to the price of crude. Cheap US gas has changed that business model and is changing the industry. The ACC says that if all proposed ethane crackers get built, US ethylene production could be 40 percent greater by 2018, bringing the US a dominant role in chemicals manufacturing.

In the ACC’s latest report, Shale Gas and New Petrochemicals Investment: Benefits for the Economy, Jobs and US Manufacturing, the organization estimates that ‘a modest increase in natural gas supply from shale deposits would generate more than 400,000 new US jobs, $132 billion in economic output and $4.4 billion in new annual tax revenues.’

The ACC analyzed the impact of a hypothetical (but, it says, realistic) 25-percent increase in ethane supply in the petrochemical sector, and found that such would generate: 17,000 new knowledge-intensive, high-paying jobs in the US chemical industry; 395,000 additional jobs outside the chemical industry (165,000 jobs in other industries related to increasing US chemical production and 230,000 jobs from new capital investment by the chemical industry); $4.4 billion more in annual tax revenues ($43.9 billion over ten years); $32.8 billion in increased US chemical production; $16.2 billion in capital investment to build new capacity; and a $132.4 billion boost in US economic output ($83.4 billion related to increased chemical production plus $49.0 billion related to capital investment).
the country’s long-term interests. While there is general agreement that some expansion of LNG exports will be good business and enhance US influence abroad, there are also concerns that too much export will raise the price of gas at home, undercutting job growth and industrial expansion.

To address the matter, the DOE commissioned a study on the effects of LNG exports on the US economy. The analysts evaluated 63 economic scenarios and their report, released in December, concludes that, while large LNG exports would slightly raise natural gas prices (for example, by about $1 per thousand ft³ over five years) and thus have a negative impact on utilities and 'energy-intensive' manufacturers (such as those whose energy expenses exceed 5 percent of their output), it would nonetheless produce a net economic benefit to the country. Energizing both proponents and opponents, the report is seen as paving the way for export terminal approvals.

Natural gas is becoming an increasingly important fuel for industrialized and developing nations alike. The steadily growing global demand for it has driven equally steady growth in the worldwide trade of its fluid form, liquefied natural gas (LNG). With the majority of gas demand coming from the Asia-Pacific region, major energy developers have begun building LNG mega-projects in and around that part of the world. Among the new approaches in getting gas to market is BG Group’s Queensland Curtis LNG project (QCLNG), the first installation in the world to convert coal seam gas (or coal bed methane) directly to LNG.

As the name implies, coal seam gas (CSG) is a natural gas deposit found in underground coal seams – not big pockets of trapped vapors, but very thin layers bound to the granular surface of the coal through a chemical process known as adsorption. These seams are often permeated with water, the pressure of which keeps the gas in place. This water is pumped to the surface via the CSG well, relieving the pressure to allow the gas to flow and be collected.

First extracted in the US, CSG is an energy source of growing importance in Australia, where it is plentiful in the eastern part of the country. The Surat Basin in the northeastern state of Queensland is considered to hold one of the most abundant CSG reserves in the Pacific Basin.

BG Group began working in Australia in 2008 in partnership with Queensland Gas Company (QGC), which it soon absorbed. Focusing on CSG exploration and development in Queensland’s Surat and Bowen Basins, over the past five years the company has achieved proven CSG reserves totaling more than 23 trillion cubic feet. The potential of these reserves, combined with low domestic demand, low gas prices and a rising need for gas overseas, inspired BG Group’s original approach of converting some of it to LNG.

The multi-billion-dollar QCLNG project calls for a substantial expansion of BG Group’s existing CSG production, with some 6,000 new gas production wells to be developed during the project’s life. These will feed a pipeline network of 540 km, comprising a 340-km buried export line and a 200-km gas collection header. The underground pipeline links the Surat Basin gas fields to the port city of Gladstone on the Queensland coast.
Looking Forward on LNG Export

In the race to export approval, there are several advantages held by ‘brownfield’ proposals (for sites that have at least some infrastructure in place) over ‘greenfield’ applications (for undeveloped sites). For one, brownfield sites – particularly new import terminals – attract investors because they typically need just one major capital improvement to get to work, that being the addition of liquefaction systems (called ‘trains’). For another, these sites can generally expect a quicker permitting process because their environmental impact statement has already been accepted and a much simpler environmental assessment may be all that is necessary.

Such was the case with Cheniere Energy, whose Sabine Pass terminal in Louisiana was the first of the pack to get its export license. Now under construction, the facility expects to start export in 2015 – and already has lined

From Gladstone, about two km of the pipeline is buried in a sea-floor trench, emerging at the QCLNG liquefaction facility on nearby Curtis Island. BG Group began construction of QCLNG in 2010 and expects to export its first shipments in 2014.

The LNG plant will cover about 270 hectares on Curtis Island. The initial facility will have two LNG trains with a combined capacity of 8.5 million tonnes per year (mt/y). There is potential to expand the plant to a third train, which would take capacity to 12 mt/y. With supply agreements with customers including China National Offshore Oil Corporation, Tokyo Gas, Chubu Electric and the Energy Market Authority of Singapore, BG Group has committed LNG sales to China of 8.6 mt/y – making the company the largest supplier of LNG to the world’s fastest growing energy market.

QCLNG is not the only LNG export project proposed for the Queensland coast. If all current projects and proposals are fully developed, the state will have an LNG export capacity of more than 50 mt/y, according to state authorities.

An important part of energy development in Australia is environmental protection (The Great Barrier Reef is close to the proposed LNG projects). The Queensland government has worked with residents, landholders, industry and resource developers to create environmental protection legislation that also promotes effective, sustainable CSG development and LNG production.

For its part, QGC has worked to mitigate environmental impacts and create benefits from QCLNG development with investments of more than A$150 million by 2014 in areas including health and safety, local employment and training, economic development, roads and housing. Much attention and resources are trained on water issues.

The QCLNG project is subject to more than 1,500 Queensland and Australian Government environmental conditions. Under Queensland legislation, gas companies are permitted to extract groundwater during gas production. With this ability to extract groundwater comes the obligation to treat the water for beneficial use, as outlined in the state’s Coal Seam Gas Water Management Policy, and to ‘make good’ any impact on existing water users. QGC has almost completed the first of a proposed two reverse-osmosis water treatment plants (the ‘Kenya’ facility) that will have a combined daily processing capacity of up to 200 megaliters (equivalent to 80 Olympic-size swimming pools).

By 2014, QGC will have invested more than A$1 billion in water treatment, research, monitoring and management. When the second phase of the Kenya water treatment plant comes online in 2013, the scheme will supply up to 85 megaliters of treated CSG water a day to irrigators, industries and municipal supply. Some Surat Basin farmers are already growing crops using treated CSG water.

Water from the coal seams is separated from the gas at the wellhead. Gas and water run through separate networks of gathering pipelines, with the water currently held in storage ponds. QGC aims to make up to 97 percent of all produced CSG water available for beneficial use.

In addition, QGC and other CSG operators are investigating beneficial uses for the salt extracted from the CSG water.

Australian LNG Export

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◆
up 20-year contracts for its entire 2 bcf/day output capacity.

The application process is just the first step in a long journey — once approved, even brownfield sites have to sign on customers in order to draw investors into the multi-billion-dollar commitment to build liquefaction trains. Excitement over LNG export may be greater than belief in import once was, but there are some industry leaders that expect the majority of today’s proposals will not come to be. One of these is BG Group, a top player in the gas game with a broad portfolio of exploration and production activity and a particular interest in LNG. BG Group was the first company to sign on for export with Cheniere when Sabine Pass got its permit.

“In our view, many of the proposed LNG export projects will fail for reasons specific to the individual project, such as local opposition or developer capability,” says Betsy Spomer, a 30-year energy industry veteran and Senior Vice President of Global Business Development for BG Group.

“On a global basis, according to analysts PFC Energy, one-third of new capacity being proposed is by developers with no existing LNG capacity — quite a stark picture considering that LNG is a highly capital-intensive industry and experience in managing mega-projects on time and on budget is a prerequisite for sustainable success in this industry,” she says.

“Such a significant proportion of ‘new LNG’ effectively in the hands of newcomers is an execution risk that has to be factored into any forecasts concerning new LNG capacity. That isn’t to say that new export facilities will not be built, but if you look at the import boom in the US, of the 40 or so proposals for import terminals, only eight were ultimately built. We believe history is likely to repeat itself with LNG export facilities in the US,” she explains.
The US gas revolution continues to ripple outward. Already, such major industrial sectors as chemical manufacturing and power generation are turning increasingly to natural gas as feedstock and fuel, the first gas-powered containerships and service vessels have been ordered and the first LNG fueling networks are being established. Now the freight rail industry appears ready – or, at least, not unwilling – to embrace the idea of the gas-powered locomotive.

Last year, Canadian National Railway retrofitted two locomotives to run on an LNG-diesel mixture. A spokesman for the company said at the time there would be “mechanical and fuel logistics challenges” to widespread conversion, and that it was too early to determine if the pilot program was successful. This year, major US railroad BNSF Railway announced plans to begin experimenting with natural gas-powered locomotives.

“The use of liquefied natural gas as an alternative fuel is a potential transformational change for our railroad and for our industry,” BNSF Chairman and CEO Matthew K. Rose said at the time. “While there are daunting technical and regulatory challenges still to be faced, this pilot project is an important first step that will allow BNSF to evaluate the technical and economic viability of the use of liquefied natural gas in through-freight service.”

A switch to natural gas locomotives by North American freight railroads would likely have worldwide impact, but it is necessarily a rather long-range vision. Any switchover would call for LNG storage aboard the trains, LNG fueling depots, specially-trained crews and – not the smallest concern – approval from Federal regulators.

She also points out that the US gas revolution is but one of several epicenters of change on the natural gas landscape, which include market evolution, such as rising demand for natural gas in Asia, and technology advances, such as floating LNG and floating regasification. “There has also been an increasing flexibility in LNG trade based on the introduction of traded markets in the US and North Europe. Such forces have been reshaping the LNG industry into a more dynamic industry in recent years – although it is still far from being commoditized like the crude oil trade,” she notes.

“The extent to which US exports will have an impact on the global industry is currently uncertain,” Spomer says, “but it appears likely they will continue to drive change and evolution.”

Will the Gas Revolution Change the World of Rail Freight?

When you consider this against the number of export applications, with their inherently more challenging considerations, we think it’s reasonable to predict that nowhere near all the applications and associated export capacity will be given the green light. Ultimately, we believe that brownfield sites in the Gulf of Mexico will be most likely to succeed in terms of cost and local support – resulting in up to 45 million tons per year, or about 6 bcf/day by 2020,” Spomer says. “Based on data from Wood Mackenzie and the EIA, we estimate that 6 bcf/day of LNG exports would use less than 2 percent of the available resources in the US Lower 48 states through 2030.”

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First On Board The Future Of Ship Propulsion

A bold order from US-flag shipowner TOTE may mark the long-awaited breakthrough of natural gas as a main engine fuel for the global merchant fleet.

For a very long time, any hope that a meaningful portion of the world’s merchant fleet would adopt natural gas as fuel has been stymied by a grand conundrum: shipowners haven’t wanted to order gas-powered ships without a bunkering network available to supply them, and industry hasn’t wanted to build that network without the ships available to buy the product.

Now that logjam may finally have been broken. Last year, US-flag operator Totem Ocean Trailer Express (Totem) became the world’s first shipowner to sign on to the future of ship propulsion by committing its fleet to natural gas fuel. In December, the company’s parent organization, TOTE, Inc., ordered two 3,100-teu natural gas-powered containerships from the General Dynamics National Steel and Shipbuilding Company (NASSCO) shipyard in San Diego, California. The groundbreaking project is being closely watched by the international shipping community, which has waited years for someone to step forward and start the ball rolling on what many see as the most sensible,
but also most challenging to implement, response to a growing body of regulatory pressure to reduce air emissions.

The growth of emission control areas (ECAs) around the world places an increasing number of key ports and near-shore shipping lanes within antipollution zones that demand very tight restrictions on the content of ship stack output. Many of the world's shipping companies are still trying to figure out corporate strategies for dealing with their technical, operational and economic consequences. For at least some, TOTE's switch to an all gas-powered fleet as the North American ECA enters into force may be the beacon forward they have been seeking.

The North American Emissions Control Area, which became enforceable on 1 August 2012, requires that ships subject to MARPOL Annex VI operating in the new ECA, which extends for 200 nautical miles off the US and Canadian coasts, to burn low-sulfur fuel oil (not exceeding 1.0 percent or 10,000 ppm sulfur) or make use of equivalent means of compliance approved by their flag State – for example, installing emissions treatment equipment, such as exhaust gas scrubbers, or burning natural gas as the ship's fuel.

Using natural gas as a fuel is, in concept, a very attractive option because it is extremely clean-burning; by nature, gas combustion produces no particulate matter, almost no SOx emissions and 85 to 90 percent lower NOx emissions than regular marine oil fuels, making it the simple response to the strictest emissions requirements. That said, for big ships to burn gas they would have to carry it on board in liquid form, something that would be difficult to commit to in the absence of a global supply line for liquefied natural gas (LNG) bunkering. Among other surprises, TOTE's ship order is revealing that such a supply line has been ready to form and just waiting for its first customer to show.

TOTE's newbuild containerships will be built to ABS class by NASSCO, following designs by Daewoo Ship Engineering Company (a subsidiary of Busan-based shipbuilder DSME). Measuring 764 ft (233 m) in length and driven by MAN/B&W dual-fuel ME-GI series diesel engines, but using DSME's patented LNG fuel-gas delivery system, the new ships will operate in TOTE's Puerto Rico routes, where they will replace three older ships that need to be removed from service by 2019 under North American ECA regulations.

Scheduled to enter into service in late 2015 and early 2016, the new vessels will hit something of a green trifecta, burning gas as fuel full-time, having ballast water treatment systems on board and being of double-hull construction. When in service they will be the world's cleanest-operating large ships, outside the LNG carrier fleet. The order gives MAN the opportunity to demonstrate the viability of its dual-fuel slow-speed marine main engines, and NASSCO the opportunity to put some shine on the reputation of US shipbuilding by claiming a world leadership spot in the construction of gas-fueled commercial ships.
The new ship order was the second big surprise TOTE sprung last year. Four months earlier, the company announced plans to convert its two vessels in the Alaska trade to full-time use of natural gas fuel with onboard LNG bunkering. Named Orca and Midnight Sun, the ABS-classed ships were built by NASSCO in 2003 and sail fixed routes between the ports of Tacoma, Washington and Anchorage, Alaska. The switchover to gas would be accomplished by converting their existing conventional diesel main engines to dual-fuel use. TOTE reported at the time of the announcement that the engineering, design and installation of the conversion kits and construction of the LNG handling systems are expected to cost some $84 million and take up to five years to complete.

**Surprising an Industry**

The conversion plan developed by NASSCO will allow TOTE to overhaul the ships with minimal impact on the company’s service schedule – a very important aspect of the project, because container shipping through the port of Anchorage is Alaska’s consumer products lifeline, and TOTE is one of two principal companies providing the service.

To make possible this groundbreaking project, the US Coast Guard issued TOTE a conditional waiver of the ECA emissions restrictions under authority granted by the ‘Exceptions and Exemptions’ provision in MARPOL Annex VI, Regulation 3. The permit gives TOTE four years to convert its existing ships to gas fuel, rather than forcing an immediate switch to costly low-sulfur marine diesel oil (MDO). TOTE had previously estimated that switching to MDO would raise its fuel expenses by at least 30 percent, which would have meant a continuing financial burden passed on to Alaskan consumers.

The permit has been widely praised not only for allowing TOTE to adopt a breakthrough technology, but also for helping minimize the economic impact of the regulation on the people of Alaska – and in the process, maybe, sparking an environmental revolution in Tacoma and the surrounding Puget Sound region. One of the hoped-for spinoff benefits of the ship conversions is development of a...
shoreside LNG supply infrastructure, which may encourage other transportation industries in Puget Sound to begin using natural gas as fuel and, in turn, lead to a significant improvement in regional air quality.

Such promise prompted US Senator Mark Begich of Alaska to issue a statement commending TOTE for innovative thinking and applauding the US Environmental Protection Agency and the Coast Guard for summoning the flexibility to work out the waiver agreement. “The effects of expanded natural gas use, more economical shipping and cleaner air will be multiplied many times over. I was happy to help bring the three parties together,” Begich said when the agreement was announced. “Instead of endless litigation, this is the kind of teamwork, creativity and regulatory flexibility that we truly need,” he added.

AN ENVIRONMENTAL DECISION

Although there is much discussion today about the low cost of natural gas being a driving force for its widespread adoption as ship’s fuel, such talk had little to do with TOTE’s choosing to go for gas, says Anthony Chiarello, President and CEO of TOTE. The decision, he says, was triggered solely by emissions considerations.

“In the Alaska trade, our ships are in an ECA zone for the entire voyage; in the Puerto Rico trade they’re in ECA zones for about 35 percent of the voyage – that’s why addressing ECA compliance issues became the driver for us,” Chiarello says. “We weren’t looking at it from a fuel cost perspective because we don’t know what the price of gas will be three years down the line when the conversions are complete and the new ships are built,” he explains. “In fact, the decision really came down to meeting requirements on emissions not only three years from now, but fifteen or even twenty years from now. I can’t speak for the rest of the industry, but for us and the Jones Act trades we’re in, LNG quickly became the best answer to all our questions.”

One sticking point for shipowners considering a switch to gas-fueled operations has been the potential loss of cargo space due to the larger fuel tank requirements of LNG. The calorific energy difference

A US Shipping Company Evolves

In January 2012 TOTE announced a dramatic step in its corporate evolution. The American Shipping Group (ASG), a provider of US domestic liner, ship management and logistics services, under the umbrella of Seattle-based Saltchuk Resources, reorganized and rebranded itself as TOTE, Inc. Headquartered in Princeton, New Jersey, TOTE, Inc. is a holding company that oversees the performance, management and operation of Saltchuk’s bluewater enterprises. These independently managed businesses are organized in three business lines: Maritime, Logistics, and Shipholding and Services. TOTE Maritime includes Totem Ocean Trailer Express (Totem) and Sea Star Line, while the Logistics line includes two primary firms and the Shipholdings and Services line stands alone.

The announcement marked a big step in TOTE’s history. The company began with Totem Ocean Trailer Express, founded as a subsidiary of Sun Shipbuilding & Dry Dock, itself a business unit of Philadelphia, Pennsylvania-based Sun Oil Company. In the late 1960s, Sun built a series of ten ro/ro ships on speculation. Named the Ponce class for the lead vessel PONCE DE LEON, they were among the last significant US series shipbuilding projects. Six of the vessels would enter trades to Puerto Rico and the Middle East, while four found their way to the US West Coast where Sun offered two to US-flag carrier Sea-Land for its routes between Puget Sound and Alaska.

When Sea-Land refused the offer, Sun decided to enter the Alaskan trades, opening Totem Ocean Trailer Express as a competitor and its ship Great Land as the trailblazer. Today, TOTE splits the growing Tacoma-Alaska trade with Sea-Land’s descendant, Horizon Lines. Sun sold the company in 1982 to Totem Resources, a group formed by Totem’s then President and CEO and seven associates. Over time, Totem Resources developed into Saltchuk Resources, which today is a billion-dollar group of over 20 independent companies organized in six operating groups.

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between gas and oil fuels means that LNG bunkers can, as a practical matter, require upwards of four times the space taken by conventional fuel tanks – a serious concern particularly in the bulk trades. Indeed, the gas tanks for TOTE’s newbuildings will take out a little cargo capacity, but NASSCO was able to develop a conversion plan for the existing ships that will have no cargo volume impact at all. Those fuel tanks, which will carry enough LNG to power more than a round-trip voyage, will be located behind the deckhouse in what Chiarello describes as, more or less, an unused area.

The existing vessels’ auxiliary engines will be replaced, but TOTE will use MAN-designed conversion kits for the main engines. It will be the first conversion MAN has performed on this particular engine model, but the manufacturer has produced conversion kits for similar models and has assured the owner its technicians are very comfortable with the job – fortunately, as the conversion plan for the engines calls for much of the work done while the vessels are underway.

“We’ll be able to have only minimal impact on the ships’ scheduled service, by doing a good portion of the engine conversion at sea – that’s one great thing about having main engine redundancy,” Chiarello says. “We can run on one engine while the crews are working on the other. The part of the conversion that can’t be done at sea will be done during the vessels’ normal drydocking period, but instead of one to two weeks for drydocking, we’re estimating that they will require around two to three weeks.”

Choosing the Future

Reflecting on TOTE’s leadership position in shipping’s gas revolution, Chiarello says that, altogether, the decision to order the first-ever LNG-fueled containership was not actually as daring a choice as it may seem.

“Being in the Jones Act trade, it may have been somewhat easier for us to choose gas-fueled ships than it would have been for, say, an international carrier, because we have fixed runs between set ports in each state – two in Alaska and three in Puerto Rico,” Chiarello says. “In international trades where the assets move around more freely, LNG supply issues would raise bigger question marks for the shipowner.”

The stumbling block of an absent LNG supply chain may be slowly fading. In the US, an LNG supply infrastructure is beginning to form in support of a developing fleet of gas-powered offshore supply vessels for the Gulf of Mexico region, and suppliers are already lining up with proposals for TOTE’s ships on both the Puerto Rico and Alaska runs. Meanwhile, in Asia, Singapore is leading the way with its Maritime and Port Authority announcing last October that the country would have LNG bunkering in place by 2015.

Impatient to see Europe mirror this activity, the European Commission released in January its ‘clean fuel strategy’, a legislative package pushing hard for, among other things, LNG supply stations in key Continental container ports. Currently, regional LNG infrastructure in Europe for fueling vessels is at a very early stage – only Sweden has an LNG bunkering
facility for seagoing ships, while several EU member States are in various stages of planning them.

That said, it’s one thing to note the world’s readiness to welcome a new technology and to acknowledge the compelling arguments for its adoption, and quite another thing to be the first to say ‘yes’ to it.

“In a sense, we’re not venturing so far into the unknown,” Chiarello says. “LNG storage and handling are well-established; LNG carriers have used dual-fuel main engines for years, with the cargo boil-off as their fuel source; and all that technology has worked very well for quite some time. So, what we’re doing is taking tried and tested technologies and putting them all together in a containership – and that’s what hasn’t been done before. The only
gamble – and it’s not a gamble, but may seem that way to people looking from the outside – was that we would not adversely affect cargo volumes and that there would be an adequate LNG fuel supply for the ships,” he says. “In the newbuilds there will be a small effect on cargo volume and in the conversions not at all; for us, the decision was about believing we would get fuel supplies within our set trades to Puerto Rico and Alaska, and we are confident that we can.”

“We spent a great deal of time studying LNG as an alternate fuel source and feel comfortable enough – and responsible enough – to do it,” Chiarello adds. “After that, we can only hope that, years from now, the industry will look back and say, good going TOTE, thanks for being the first and for pushing us all to a new set of operating standards.”

MAN/B&W will supply low-speed, dual-fuel 8L70 ME-GI series diesel engines for the groundbreaking gas-powered containerships – two newbuilds and two conversions – ordered by Totem Ocean Trailer Express from US shipyard National Steel and Shipbuilding Company.

The ME-GI is a gas-injection, dual-fuel, low-speed diesel engine that can run on anything from heavy fuel oil to natural gas, with liquefied propane gas (LPG) operation planned for the future. MAN demonstrated the first commercial ME-GI engine at an event in November 2012 at the facilities of Hyundai Heavy Industries in Korea; the unit achieved 100-percent load under gas power using a minimal amount of pilot oil for ignition. The experimental version of the engine had been revealed a year before at the company’s Diesel Research Center in Copenhagen, where it was greeted as the result of a product development program that began when the manufacturer installed an early prototype in a power plant near Tokyo in 1994.

MAN has pointed out that, technically, there is very little difference between their oil- and gas-burning engines, and that ME-GI technology can be retrofitted to all existing ME series prime movers – in fact, the demonstration engine was a conversion. With MC/ME series engines on the market since 1982 and installed throughout the world fleet, the TOTE conversion project is a very important win for the manufacturer, as it will provide a model of the future for just about any ship at sea.

Dual-fuel operation requires the injection of both pilot fuel-oil and gas fuel into the engine’s combustion chamber via different types of valves arranged in the cylinder head. The ME-GI engine head is fitted with two valves for gas injection and two for pilot fuel, with the pilot-oil valve being a standard ME fuel-oil valve. According to MAN, its key differentiating components are a modified exhaust receiver, modified cylinder cover with gas-injection valves and gas-control block, an expanding top gallery platform, high-pressure fuel-supply pipes and mounted gas-control units.

When TOTE announced its decision to build MAN-driven gas-powered containerships, Ole Grøne, MAN Diesel & Turbo Senior Vice President, Low-Speed Sales and Promotions, spoke to the press about the project. “We have been advocating the GI concept for decades – in fact, the first presentation for a GI engine was at the CIMAC conference in 1983,” he said. “With current developments in fuel prices and multiple customer requests for a solution, the momentum towards development of a commercial, low-speed dual-fuel engine became unstoppable. We see this order and the ME-GI, as the beginning of a significant new era in ship propulsion.”

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INNOVATION SPOTLIGHT:
Fueling the Fleet of the Future

Shipowners whose operations take them into emissions control areas (ECAs) have for some time been contemplating the long-term costs of ECA compliance, trying to decide between running on low-sulfur fuel oil, installing exhaust gas scrubber systems or using main engines that burn natural gas. Recently, two shipowners operating in the North American ECA chose to christen the future of ship propulsion by committing to vessels fueled by natural gas – TOTE with containerships and Harvey Gulf with offshore support vessels. The lanterns are hung and the path pointed out, but for the gas-burning diesel to become the marine main engine of the future, owners must be certain it will never lack for the fuel of the future.

Gas-powered ships carry as their bunker fuel liquefied natural gas (LNG), and owners contemplating green propulsion have long been held back by fears that LNG bunkering may not always be available. Now Houston, Texas-based Waller Marine proposes to alleviate that concern with a fleet of floating fuel stations for a gas-powered world.

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Founded in 1974, Waller Marine is an EPC (engineering, procurement, construction) contractor with a long record in both the marine and offshore energy industries. The company’s vision for fueling the future includes: strategically located LNG liquefaction and storage facilities; regional distribution of the fuel by barges and bunkering vessels; and local fueling services at anchorages, ports and terminals. It is, in fact, a vision of a complete production to distribution network reliably supplying LNG to natural gas-burning ships, power plants, vehicles and other users throughout the US coast and main waterways.

Through subsidiaries Waller Energy Holdings and Waller LNG Services, Waller is taking its first steps in that direction, developing a natural gas liquefaction facility on a 175-acre site at the entrance of the Calcasieu Ship Channel in southwest Louisiana’s Cameron Parish. Named Waller Point Terminal, it is the first of seven planned small-scale LNG terminals. In each facility Waller plans to install several LNG trains with nominal capacities of 500,000 gallons per day, so as to be able to match production to what is expected to be a steadily growing demand for the fuel. As this issue went to press a second LNG plant, to be located on an 85-acre site along the Baton Rouge barge canal, was in development.

To haul the fuel of the future Waller has developed a concept family of seven small LNG-carrying service vessels. These range from 2,000 to 10,000-m³ capacity barges and boats, for river transport and bunkering, to 10,000 to 30,000-m³ articulated tug/barge (ATB) units for fueling services and coastwise transport to strategically located terminals.

The company’s innovative LNG storage and regasification ATB design has been granted approval in principle by ABS. The versatile concept vessel is able to load and discharge cargo at storage tanks, liquefaction plants or LNG carriers; to fill the bunker tanks of gas-burning marine vessels; and to re-gasify LNG for direct input to a pipeline or power plant. Adding green to green, the ATB’s tug is equipped with dual-fuel engines that can burn natural gas as the principal fuel.

Waller’s LNG ATB RV (for regas vessel) is the key piece in this ‘gas station shipping’ concept. The hull is fitted with an IMO Type C independent tank LNG containment system, located along the vessel centerline as longitudinally-arranged bi-lobe tanks. Each tank is supported by a structure to isolate it from hull loads and will be constructed of 9-percent nickel steel. This fuel tank design is to be used principally for combined storage and regas services, according to David Waller, founder
David Waller, Founder and President, Waller Marine, Inc.

and President of Waller Marine, Inc. The company also has designed a 40,000-m³ ATB using a GTT membrane containment system, which will be used for LNG transport services coastwise and in the Caribbean region.

For owners wishing to ‘futurize’ their fleets, Waller has initiated what it refers to as a ‘vessel conversion strategy’ for existing marine engines. “Prior work in the field of engine conversions has been carried out on locomotives, principally on EMD two-stroke engines,” Waller explains. “This work has proven the concept, and we shall use the data gathered to marinate the idea.”

This initial work will be done on two 5,000-hp ocean tugs that Waller Marine owns, constructed to ABS class, that are powered by twin EMD engines. (EMD is a line of diesel engines manufactured by General Electric.) The company plans to convert them to natural gas fuel with onboard LNG storage in order to prove the marine concept and obtain required regulatory approvals.

Working with engine manufacturers and equipment suppliers, Waller is engineering shipboard LNG storage and supply systems for a range of horsepower, and is in the process of developing pre-manufactured engine conversion kits. “We’re designing a generic model kit with associated selected components for various horsepower ranges that will be customized to a particular vessel after a detailed survey,” Waller says. “From this, we shall produce preassembled components and piping spools to reduce downtime during conversion.”

Looking to help other shipowners develop the fleet of the future, Waller is also working with partners on a method of providing funding, through financial institutions, for ship conversion to natural gas fuel. Regarding this investment in the future, although each business case is different, Waller anticipates the payback timeline for conversion costs can be as low as six months. “The fundamentals of the savings are the cost differentials between ultra-low-sulfur fuels and the LNG that we will supply,” he says.

As this vision for a coast-wide LNG fueling network starts coming together, it will raise hopes and at least one big question in the international community: can the model be repeated around the world?

“One of the fundamentals of our business plan is, of course, the price of natural gas in the US, which was created by the advent of shale gas supplies,” Waller explains. “This situation is a game changer for the US, insofar as US gas pricing has created new opportunities in the country’s energy markets. We are seeing previously constructed LNG import terminals converted to export and, in fact, our Cameron Waller Point LNG terminal will function as an export hub for delivery of LNG to the Caribbean Islands in our ATB LNG RV vessels, principally for fueling power plants. We have determined that, in some instances, we can reduce electrical utility cost on certain islands by 40 percent, when this service is combined with our floating power plants,” he says. “I can see the idea of LNG marine bunkering taking off in the major ports of the world as owners gain confidence in supply and delivery systems.”
From the Front Lines:

Turkish Yard Sees New Hope in OSV Construction

As a shipbuilding nation, Turkey has experienced some tremendous ups and downs in the past decade. The country’s builders saw their exports rise from $500 million in 2002 to $2.65 billion in 2008, then fall to $1 billion in 2010. During the great times between 2005 and 2008, Turkey’s shipbuilding sector expanded by 360 percent. Then, under the effects of the global financial crisis, between 2008 and 2011, the number of operating Turkish yards decreased by 60 percent and, according to the Undersecretariat for Maritime Affairs, shipyard employment dropped by 80 percent. The impact of the crisis was felt most strongly in the Tuzla district of Istanbul, which accounts for 40 percent of Turkey’s total shipbuilding capacity.

Although this year’s shipbuilding export revenues are projected to be in the neighborhood of only $850 million, Turkey’s shipyards see a new hope dawning in the construction of offshore support vessels (OSVs) and other energy-sector vessels. One of the builders planning to lead this revival is Tuzla-based Selah Shipyard.

Selah Shipyard was established in 1982 by Selah Industries, well-known throughout Turkey in the automobile and machinery sectors. The shipyard today covers an area of 45,000 m² and features two slipways, three quays for ship repair and outfitting and gantry cranes with 200 tons lifting capacity. During its history, Selah – like many of its brother shipyards – has built a variety of vessel types, including chemical tankers, dry cargo carriers, containerships, yachts and special-purpose vessels for military and civilian clients. More recently, the yard has delivered OSVs, platform supply vessels (PSVs) and anchor handling towing supply vessels (AHTSs) – and therein found its new future.

“OSVs and AHTSs are relatively small vessels, as compared to bulk carriers and tankers, but they are also highly sophisticated vessels and, in some ways, more complex internally,” says Selah Shipyard General Manager Yucel Erdem. “In general, many shipyards make the mistake of underestimating the difficulties in building such vessels. Some inexperienced shipyards come up with unrealistic scheduling, delivery times and pricing that cause major problems in the market,” he notes.

Mehmet Kantarceken, ABS Project Manager for the IEVOLI SAPPHIRE, discusses plans with Omer Faruk Bakaloglu and Yucel Erdem of Selah Shipyard.
“That said, the ongoing exploration of new offshore oil fields all around the world has created increasing demand for high-quality OSVs. In brief, the high demand for dependable, sophisticated support vessels that use advanced machinery systems and high-quality materials has kept prices at Turkish shipyards competitive, at least for certain vessel types,” Erdem explains.

“For Seyfettin Tatli, ABS Country Manager of Turkey since 2008, the energy sector does indeed appear to represent a new future for Turkish shipbuilding. Tatli has been with ABS for 18 years, but knows Turkey’s shipbuilders from the inside: before joining ABS he worked in Tuzla Shipyard, Pendik Shipyard and the IHI facility in Istanbul.

“Turkey has great potential for building and repair of production platforms, drilling rigs and offshore support and service vessels,” Tatli says. “A few shipyards here have now started to build OSVs. I see this activity increasing in the future, as oil companies and offshore contractors bring vessels and drilling rigs to the shipyards in the Istanbul area for repair and modification. I believe this business will continue to grow as oil and gas exploration activities increase in Northern Europe, the Mediterranean and the Black Sea,” he says.

“In general, our customers ask for ‘tailor made’ vessels designed to meet specific requirements, and we are committed to ensuring total customer satisfaction through our quality, safety and environment management systems,” says Erdem. “You can see the proof of this in the simple fact that, despite fierce price competition from other shipyards, the good quality, fair pricing, and relatively short and on-time delivery – plus our short distance from Europe – have attracted European shipowners to order vessels here.”

For Seyfettin Tatli, ABS Country Manager, Turkey

IEVOLI AMARANTH

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With more than 70 percent of the world’s land mass under water, it stands to reason that most of its mineral reserves might also be found somewhere beneath the sea. Although only a relatively small percentage of the oceans’ lower regions has been thoroughly explored, investigations to date do indicate that on the deep seafloor immense reserves of resources ranging from gold to fertilizer are, quite literally, just lying about waiting to be collected. Indeed, science-fiction writers and industry visionaries have for decades dreamt of a day when advanced machines glide silently into the last frontier and, with environmental neutrality, pluck from its greatest depths vast and previously inaccessible mineral wealth.

Widespread industry buy-in on that thought remains a ways off yet, if the 34th International Geological Congress in Brisbane last August was any indicator: of its more than 6,000 delegates only a few dozen showed up for the session on marine mining. That said, there was once great interest in the field; during the 1970s many private and public organizations, spurred by promising research done during the previous decade, tried to develop a marine minerals industry seeking nickel from nodules on the ocean floor, but failed. Now, forces that have been slowly developing since that time are coalescing to make marine mining once again attractive to a wide audience.

One of those forces is a drive to find viable sources of the group of 17 minerals known as rare earths, which are critical to the manufacture of batteries and a wide variety of consumer and military electronics. About 90 percent of current world rare earths production comes from China, which shut down exports to Japan during a 2010 diplomatic dispute and threw panic into that country’s high-tech industries. The move sparked new searches for rare earths around the world, but particularly in Japan, India and Australia. During the embargo, Australia committed to becoming a long-term rare earths supplier to Japan and began developing its own onshore rare earth mines. Japan began searching offshore for the minerals, and in 2011 scientists at the University of Tokyo announced discovery of 78 sites on the Pacific Ocean floor with the potential to satisfy much of world demand – if they could be properly accessed. A year later the country announced a joint venture with Vietnam’s Rare Earth Research
and Technology Transfer Centre in Hanoi. Meanwhile, Toyota Tsusho Corporation became a partner of Indian Rare Earth Ltd. when that company started building a rare-earths processing plant in India’s east coast state of Odisha.

India has had an ocean exploration program investigating deep-sea mining of the Indian Ocean for about two decades, and in 2012 its Science, Technology and Earth Sciences Minister announced that 7,860 km² in the Central Indian Ocean Basin had been identified as a prime mine site for valuable metals including nickel, copper, cobalt, manganese and rare earths – again, if it can be viably accessed. That same year, India’s National Security Council issued a policy paper propounding a program of deep-sea mining in the Indian Ocean and, in support of such efforts, began construction of the country’s second seabed exploration ship.

**Mineral Treasures of the Abyss**

Although their strategic value makes rare earths a topic of much discussion these days, the long-term driver for deep-sea mining has been the need to find new sources of cobalt, copper, gold, manganese, silver and zinc. These occur in deep ocean deposits known as seaﬂoor massive sulﬁdes, manganese nodules and polymetallic crusts.

Manganese nodules are small, lumpy concretions that are believed to form over many millennia as metallic elements leach from the seawater and crystallize around a core. (Polymetallic or cobalt-rich crusts form in a similar fashion, but the minerals crystallize on the slopes and ridges of deep-sea terrain).

The nodules were first found in the 1870s, hauled aboard the British research vessel **HMS Challenger** as it trawled the 15,000-ft depths of the Pacific Ocean between Hawaii and Tahiti. Subsequent investigations over the following century determined that the seafloor was littered with these nodules over an area of some 1.3 million square miles between Mexico and Hawaii a few degrees north of the equator (known as the Clarion Clipperton Zone). Experimental mining operations in this area during the 1970s and 1980s recovered several hundred tons of nodules, but collapsing metals prices canceled the research and sent deep-sea mining into cold storage for three decades. In 2010, amid rising demand for certain key minerals, the International Seabed Authority (a United Nations organization) published a report concluding that the Zone may contain more than 27 billion metric tons of manganese nodules.

Given steadily increasing prices for manganese, nickel, copper and cobalt, the development of advanced subsea construction, maintenance and control technologies by the oil and gas industry and the recovery technologies developed in the dredging sector, it may be time for manganese nodules to become rock stars of a new industrial era.

The other great mineral hope beneath the sea are ore deposits created by hydrothermal vents – deep-ocean phenomena in which geyser-like jets of hot ﬂuid spring from the seafloor in churning plumes. This ﬂuid is formed when seawater, forced through ﬁssures in the seabed by the tremendous pressures of the deep ocean, encounters the extreme high-temperature environment far within the earth. Due to the high pressures...
When this extremely hot liquid leaves a black smoker and hits the very cold seawater at the bottom of the ocean (at temperatures around 2.5°C), its dissolved minerals react with the water to form solid sulfide particles that settle on the seafloor. Right at the vent opening these particles accumulate in the form of tall, stalagmite-like structures called ‘chimneys’ – which can range up to tens of meters in height – and in the area around the chimney settle to the ground in the layered formations known as seafloor massive sulfides (SMS).

The area around a black smoker can be a violent, volatile venue of roiling waters and rumbling geology. The chimneys crumble and re-form in a continuous process of destruction and growth until the collective weight of the deposit collapses the underground spaces responsible for the phenomenon, extinguishing the chimney (and much of the marine life that grew around it) and leaving behind metal-rich fields, now cold and inactive – some SMS deposits can be quite large, occupying an area the size of a sports stadium.

Many of the important minerals deposits found on land were formed in this way millions of years ago. Fossil remains of giant prehistoric black smokers have been found among metals deposits around the world, from the ancient sources on the island of Cyprus to the more modern mines in China’s Wutai Mountains or Japan’s Kuroko deposits.

SMS deposits are diverse in content, with varying grades and mineral associations, but are typically rich in base and precious metals. According to US-based mining company Neptune Minerals, recovered samples can contain: up to 50 percent zinc; 5 to 15 percent copper; 3 to 23 percent lead; up to 1,200 grams of silver per ton; and from 2 to 20 grams of gold per ton. One mining company has noted that a concentration of merely 1 gram of gold per ton would be enough to justify a subsea mining operation.

Still, if these deposits are to be viewed as treasure waiting to be collected, one must do so with the knowledge that some of that treasure carries a curse: according to some mining scientists, the vent fluids of an active black smoker can be so hot and acidic as to dissolve any mining equipment after a short period of exposure – making the creatures that live there all the more remarkable and worthy of scientific study.

**WEIRD CREATURES A RESOURCE, TOO**

Hydrothermal vents have been the subject of much study since their discovery in the 1970s, particularly once it was found that these sources of aggressively toxic fluids do not create poisoned wastelands, but instead can create sites teeming with life – and not
just microscopic curiosities. Mouthless tube worms that reach several meters in length, clams the size of dinner plates, eyeless shrimp, bizarre-looking crabs and even other-worldly octopi have been observed in vent communities around the world, all of them relying on bacteria that feed on heat and sulfur as the base of their food chain. Hundreds of new species have been discovered around hydrothermal vents and, say scientists, their diversity is such as to indicate that hundreds more remain to be found. These creatures are more than interesting and rare; their singular evolution has made many of them inspiring candidates for high-tech research.

The smallest of these miraculous organisms were first to yield practical treasures. Twenty years ago, a US biotech firm isolated and cloned an enzyme from vent bacteria that is used to speed certain reactions necessary to the laboratory replication of DNA. This led to a product line marketed under the name Deep Vent, which, among other applications, is what law enforcement forensic scientists use to raise DNA profiles from such microscopic samples as the genetic material left in fingerprints. Other enzymes derived from vent microbes are being used for such purposes as enhancing crude oil flow in deep reservoirs.

The most intriguing example of vent life in product research today may be the scaly-foot snail, which has a unique three-layer shell that may lead to a revolution in protective gear and vehicle armoring. Its outermost layer is made of iron sulfides – the only known creature to use the material that way – while the mid-layer is of a flexible substance that deflects heat and resists prolonged crushing attacks by predators. The US Army and Department of Defense were interested enough in this strange natural armor to fund investigations exploring its potential to improve protection for humans and vehicles in combat, conducted by the Institute for Soldier Nanotechnologies at the Massachusetts Institute of Technology.

When a vent system undergoes its final collapse and the heat turns off, the stationary life around it dies, the ambulatory creatures move on to the next active vent and the pH in the area returns to normal. So it is for sound practical as well as environmental reasons that miners have been looking for extinct black smokers as the places to work, and why they have been going to
the greatest lengths to be as sure as possible that hydrothermal vent communities will be safe from permanent damage due to subsea mining.

UNSTOPPABLE, BUT SLOW
The present level of interest in ocean mining can be gauged in the aftermath of what many industry observers feared would be a death blow to the developing deep-sea mining sector.

For many years the mining world had closely watched the progress of what was fully expected to be the world’s first commercial deep-sea mine, the Solwara I project in the Bismarck Sea offshore Papua New Guinea, where Canadian mining company Nautilus Minerals sought to develop a large SMS deposit at a depth of around 1,600 meters.

Papua New Guinea became the first country ever to issue commercial exploration licenses for SMS mining when it granted the initial permit to Nautilus in 1997. Rather than inaugurating a new field of activity, it initiated an extreme gestation period whose dramatic ups and downs made Solwara I a poster child for the challenges facing deep-sea mining – particularly when, in December 2012, after two years of engineering development and 15 years total study and planning, Nautilus announced the suspension of its project. This came about following a change in the Papua New Guinea government, which delayed the project as the new authorities sought to renegotiate the terms of their equity participation and local landowners applied pressure to secure a better deal. It is a sign of the times that the great disappointment did not reduce the nascent industry’s momentum.

Even as the Nautilus effort was grinding to a halt, others were picking up speed. In November that year, officials from The Sudan and Saudi Arabia announced a joint mining project with Canadian mining major Diamond Fields International for the ‘Atlantis II Deeps,’ a 60-km² SMS deposit in the Red Sea promising some 1.8 million tonnes of zinc, 400,000 tonnes of copper and 3,400 tonnes of silver, work on which could begin as early as 2014. Not long after, Australia’s Northern Territories Mines and Energy Minister announced that the country’s moratorium on seabed mining could be lifted by 2015, and a Sydney-based company applied for exploration licenses in aggregate sands offshore New South Wales. In neighboring New Zealand, Trans-Tasman Resources began looking to develop offshore iron sand deposits and Chatham Rock Phosphate pressed forward with plans to mine a phosphate nodule deposit lying at a depth of about 400 m on the crest of the Chatham Rise, a large underwater plateau some 450 km east of Christchurch.

Altogether, then, deep-sea marine mining remains a dream for now, but only just. Despite the setbacks and disappointments, today’s climate of new incentives and new opportunities is moving the mining world to seriously contemplate following the energy sector into deepwater resource recovery, and for reasons similar to those that drove oil exploration offshore – the need is there, the economics are there and, importantly, so is the technology.
TO HARVEST THE DEEP

Seabed mining itself is nothing new. For over a century, mining companies have been using dredgers to extract minerals from placer deposits (river and near-shore sediments containing concentrations of heavy minerals like gold, tin and iron). The first such efforts were made by Alaskan gold miners around the turn of the 20th century – one of the surviving dredgers has been made a US national landmark – and in Indonesia in 1910 by the Billiton Co., a Dutch colonial predecessor of PT Timah. Today a handful of successful near-shore mining operations are underway, two of the best known being PT Timah’s continuing work offshore Indonesia, where its dredgers recover tin from depths of 45 to 90 m, and offshore Namibia and South Africa, where the De Beers Marine organization recovers diamonds from depths of 90 to 140 m.

Both of these ventures rely on sophisticated vessels and machinery developed in the dredging sector. PT Timah uses several types of high-tech bucket dredgers to scoop up sediments for processing in onboard treatment plants. De Beers, which has been diamond mining offshore since 1991, uses two technologies: vertical mining, in which a drill excavates diamond-bearing gravel that a pumping system brings to a surface vessel for separation; and horizontal mining, using a remotely operated ‘seabed crawler’ whose centrifugal dredge pump sucks up sediment and sends it via flexible hoses to a support vessel where workers remove the diamonds.

The equipment and systems that make possible these operations are contributing important elements to the evolving technology of deep-sea mining. Even more critical contributions are coming from the energy industry, which for decades has led the development of the marine technologies needed to construct, maintain and support deepwater oil and gas projects. On the scientific side, the geophysical companies serving the offshore sector have developed sub-seafloor geological analyses and marine environment mapping into fine arts. On the equipment side, many of the tools that enable deepwater energy exploration and production – remotely-operated vehicles, autonomous underwater vehicles, dynamic positioning, seafloor trenching, and deep pumping, lifting, electrical power supply and systems control – will also make deep-sea mining possible.

With the suspension – or hibernation – of the Nautilus endeavor, it remains unknown whether the first breakthrough ocean mining project will involve harvesting nodules, phosphates for fertilizer or digging up SMS deposits. What is clear to the proponents of deep-sea mining is that it is an idea whose time has come, and that conditions are right enough to put the dream only steps away – big steps, perhaps – from reality.

“Overall, the economic drivers are in place to implement deep-sea mining projects and, I believe, effective systems can be assembled from known technologies – even if there are different thoughts about the kinds of systems that would be optimal,” says Dr. John Feenan, Director of Mining Advisory Services in the Asia-Pacific region for IHC Merwede. A global market leader in the production of custom-made vessels, supplies and equipment for dredging, offshore mining and offshore construction, IHC Merwede has decades of experience supporting offshore mining projects.
– for example, the company designed and built the seabed crawler used by De Beers and recently celebrated a century of equipment supply to PT Timah.

“For recovering nodules, the simplest idea would be to just drive a tractor across the seafloor and scoop them up like golf balls off a golf course,” Feenan says. “This raises quite legitimate concerns about the effects of that kind of operation on the biota – the flora and fauna – of the seafloor and the difficulties of rehabilitating the area once the job is done,” he explains. “With that in mind, we may look to systems that could pick up the nodules without disturbing the mud. For example, because we would be working in water we could look to developing equipment that hovers above the resource and plucks or suctions the nodules with minimal disturbance.”

**Education Will Unlock the Treasure Chest**

Feenan, who founded Neptune Minerals in 2005 and remained its Chief Operating Officer until 2009, first became involved with IHC Merwede in 2008 when his company began concept and feasibility studies on the mining of SMS deposits off the North Island of New Zealand. Working directly with IHC Merwede for the past three years, he has led industry/academic teams on seafloor minerals surveys and conducted educational outreach efforts among the mining community.

“Ultimately, the key to success out there is knowledge,” Feenan says. “There is a huge amount of marine scientific literature that has accrued over the past 30-odd years, in biology, ecology, geology, engineering and so on. That growing knowledge base is giving governmental authorities more confidence to develop and implement regulations and to award licenses for marine minerals exploration and mining. Compared with even the recent past, there is much more confidence and understanding today as to how to move forward in this sector,” he notes.

Only about 3 percent of the seafloor has been thoroughly investigated to date, so it is likely that a significant chunk of the understanding to come will develop through academic-industry cooperation during investigations associated with specific mining proposals. In fact, Feenan, who studied marine biology before turning to geology, always takes marine biologists along whenever he conducts surveys for seafloor minerals. Each group benefits from such teamwork, he says – the academics get access to scientific equipment normally far beyond the reach of their departments, and the industrialists get the benefits of their analytical expertise.

“Ultimately, we’re looking for the biologists to identify the areas that are ‘no-go’ or quarantine in the sense that they need to
be protected," he says. "Then we look for extinct chimneys and areas with mineral deposits that we can mine without an adverse environmental impact."

As knowledge accumulates regarding the seabed and the technical and environmental issues surrounding subsea operations, suppliers such as IHC Merwede will be able to design equipment specific to the minerals that will be extracted, Feenan says.

“At IHC Merwede, we’re driving towards developing integrated mining systems specialized for each commodity of interest. So, for example, we would have systems dedicated to manganese nodules, to sulfides, to phosphate nodules, to iron sands, to diamonds and so on; each would have its own original design – this is where I see IHC Merwede as a leader – and be fully integrated and optimized for those minerals from the cutting head all the way through the lifting, processing and environmental management stages,” he explains.

“That said, we’re not at the point of having fully optimized systems for all commodities that are proven and tested – there just isn’t that legacy of knowledge and learning-through-doing that comes from operational experience,” he adds, noting that the first deep-sea mining systems will owe their success to advanced engineering and scientific analyses. “I find that engineers, particularly in the offshore space, can deliver excellent system designs within the parameters you define. Operators in the mature oil and gas sector, for example, know their parameters and go to the engineers with the technical challenges of a particular project, and those engineers come up with viable solutions. Marine mining is still in its early stages; there’s a good knowledge base building, but not all the engineering parameters have been defined yet. That’s why being involved early to innovate and raise the bar in engineering excellence is so important.”

ENVIRONMENTAL PROTECTION A KEY CONCERN
One major concern is that large-scale deep-sea mining will leave physical environmental damage analogous to that produced on land – and the track record of many onshore mining operations is no help in allaying such fears.

“Unfortunately, there are many examples drawn from onshore activities – for example,
acid mine drainage or other adverse impacts like scouring of the landscape – that people take as pointers to say that the damage will be similar on the seafloor,” Feenan notes. “It must be remembered that these are very different environments. Compared with onshore minerals, marine minerals are, essentially, inert; exposed minerals onshore can react with air and turn into acids, but marine minerals don’t react with the seawater around them.”

He also points out that mining at sea will generate less waste than mining on land. “Onshore, there are very large open pit deposits where miners have to remove dozens of meters of overburden just to get to the ore body, and very deep reserves that have to be reached by tunneling; these activities often produce ten times more waste than ore. Marine minerals, on the other hand, often lie exposed on the seabed; that alone avoids large volumes of waste rock removal and improves the economic returns on a dollar-per-ton basis,” he explains. “In most cases seafloor mining is, essentially, a dredging or sand mining operation with minimal overburden.”

This raises another element critical to the progress of deep-sea mining: the industry’s ability to minimize impact on undersea life and manage operations in a sustainable way. For example, any seabed operations will disturb sediments and create plumes of dust and debris that will rise to as-yet unknown heights and float for as-yet undetermined distances from the work site. It remains unknown just what effect plume generation will have on life in the abyss – will the plumes prevent creatures from accessing food or otherwise interfere with the cycle of life and, if so, how will that spin out into the grand food chain? If, as some assert, active hydrothermal vents are among the primary keys to the machinery of the planet, one must be very careful to not cut short their ‘working lives’. Then again, since vent systems are unstable in nature and the chimneys and their organism communities pass through their own cycles of destruction and restoration, perhaps a seabed mining operation won’t have more than a momentary impact. There are many such questions and few definitive answers, but also a growing body of scientists and engineers working to sort it all out.

“The more we can build up facts and knowledge about the seafloor, the better equipped we will be to make the best decisions about how to mine there,” Feenan says. “Using computer simulations, for example, we can put together a dynamic 3-D model of a mining operation, with the currents, the seabed topography and all the other factors in place,
and simulate the activity and its consequences before actually going out there. If we can get the right design for the technology, we can mitigate many of the potential impacts by anticipating what a mining system would do on the seafloor and avoiding those issues at the very early stages.”

**ARE WE THERE YET?**

Technology development may be the least of the issues to resolve before the first deep-sea mine gets underway – some of the bigger roadblocks have more to do with mental attitude. In this regard Feenan notes that, although suppliers such as IHC Merwede are confident enough to move forward, the resource owners who will have to back the operations remain largely divided into two camps: those who are unconvinced as to the value to be gained from deep-sea mining and those who might be but don’t know how to get started.

“The biggest challenge I see is a lack of confidence among the onshore miners,” Feenan says. “Onshore miners don’t like to get their feet wet. They’re used to putting a drilling rig on the back of a truck and going out into the bush; they don’t really understand marine operations and are very conservative and risk-averse when it comes to making the commitment to work offshore.”

“Ultimately, for seafloor mining to succeed it must be shown to be sustainable, both environmentally and economically,” he says. “I believe we have enough background information and knowledge to do this – if we can communicate that properly to the appropriate parties, they will see the light and understand the benefits of getting into the marine mining space. That’s why one of my main roles is educational, to give the onshore mining community an understanding of where they can go to access their commodity of interest and then what to do when they get there.”

Questions of where to go and how to progress have dogged ocean mining ever since the first manganese nodules were found. After almost 140 years of scientific endeavor, vain hopes and false starts, are we there yet? Dr. Feenan believes so, and that the breakthrough project is not as far off as it may sometimes seem.

“I haven’t seen any showstoppers in terms of this industry being able to provide the sustainable recovery of seafloor minerals – I do believe we’re at that point,” Feenan says. “I won’t say it could be done tomorrow, but with the right partner, the right project, the right knowledge base and the right appetite to invest and move forward, we could go out there in a very short space of time and start up a seafloor mining system that would be economically viable and environmentally sustainable.”

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**JOINT VENTURE IN DEEP-SEA RESOURCE EXTRACTION**

As the mining sector prepares to follow Oil & Gas into deep waters for exploration and production, a new category of supplier has emerged: the offshore mining contractor offering turnkey solutions. One such company is Singapore-based OceanFLORE (ORE equals Ocean Resource Extraction), a joint venture formed in early 2011 between IHC Merwede, a Dutch supplier of ships and equipment for dredging, offshore and mining activities, and DEME (Dredging, Environmental and Marine Engineering), a Belgian dredging and environmental services group.

The idea is for the company to join a project at the exploration/project definition phase and: perform FEED (front-end engineering and design) studies; assist with project financing; perform equipment design and manufacture; operate the equipment; and handle logistics, maintenance and life cycle support. Under their agreement, IHC Merwede is responsible for development and construction of technical solutions and DEME for operations.
Tanker owners have for years been cooperating closely with other stakeholders, not least classification societies, in a bid to continuously improve operational safety, efficiency and environmental performance. Yet the general public is hardly even aware just how these efforts benefit them on a daily basis.

Tanker shipping is the crucial transport element of various supply chains moving liquid energy and chemical raw materials around the globe. The only time it tends to come into focus, however, is when politics and conflict disrupt trade routes and supplies or accidental pollution hits the headlines. The rest of the time, owners provide a safe, clean and efficient transport service that costs users a tiny fraction of the value of the cargoes carried.

Owners have to deal with a steady stream of increasingly onerous and complex regulations from both flag and port States and new demands from customers. They have also been faced with freight rates so low that generated returns rarely cover even basic operating costs. In the long term, this is not a sustainable situation and one that can threaten the entire supply chain and the provision of its vital services.

To date, Intertanko members have focused their efforts and discussions on offering competitive and efficient transportation, emphasising quality shipping with the development and exchange of best practice, from career development for seafarers to improvement of maritime safety and security, and developing practical solutions for topics of environmental concern such as the reduction, treatment and disposal of solid wastes, effluents and emissions from their vessels.

Tangible achievements have been made that benefit not just owners but other stakeholders in the chain and more often than not, such efforts have been collaborative as the chain of sustainability links together all the diverse players in the tanker industry. As an example, record low oil pollution has been recorded for several years in succession at the same time as the tanker fleet has been growing and tonne-miles traveled have been increasing. The tanker industry is working harder and longer delivering oil and chemicals to an energy-thirsty world, but is getting cleaner at the same time – a win/win for environmental and social sustainability.

Today, the focus of our work together needs to widen to include and address some of the imbalances in trading conditions that have developed over time and which threaten this vital element of the seaborne energy supply chain. Since key stakeholders in the chain are interdependent, this should be of interest to all of us involved.

So while we cannot directly address the reasons for lethargic oil demand or fleet overcapacity, there are aspects of how we do business that can and need to be adjusted for the long-term benefit of everybody in the industry and ultimately society at large.

These include such issues as the erosion of charterparty terms, delays in freight payments, inconsistent vetting and inspection practices, imbalances in bunker purchasing contracts as well as some of the complexities of the Worldscale freight rate calculation system etc. All of these are crucial elements, unrelated to surrounding market conditions and should therefore be addressed whether said markets are strong or weak.

I believe that by coming together to address these issues, we can and will develop solutions for the ultimate benefit of all and Intertanko is seeking a constructive dialogue with key stakeholders.

What can class contribute? It can work with and alongside owners to ensure that regulation, its development and enforcement, is balanced and practicable. It can support systems that minimize administrative burdens without compromising safety and efficiency; and it can work with shipyards to ensure that the latest tanker designs offer owners real value and efficiency without compromising safety and longevity.

We look forward to continuing our work together.
“Men go abroad to wonder at the heights of mountains, at the huge waves of the sea, at the long courses of the rivers, at the vast compass of the ocean, at the circular motions of the stars, and they pass by themselves without wondering.”

– Augustine of Hippo,
354-430 AD